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(54) TRAIN GROUP CONTROL METHOD AND SYSTEM BASED ON AD-HOC NETWORK

(57) A train group control method based on an ad-hoc network, comprising: searching for, by ad-hoc network equipment on a train, communication equipment of another train within a preset distance; determining whether the train is on the same track as another train; if the train is on the same track as another train, determining whether a networking condition is satisfied; if the networking condition is satisfied, determining whether an ad-hoc network exists or not; if no ad-hoc network exists, establishing, by another train satisfying the networking condition, an ad-hoc network with an original train; if an ad-hoc network exists, adding another train satisfying the networking condition to the ad-hoc network; and controlling, by the train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network. The present invention further discloses a train group control system based on an ad-hoc network. By means of the control method and the control system, a train group control is achieved on the basis of a train-to-train communication technology in the ad-hoc network. Trains are automatically networked when the conditions are satisfied, and inter-train data are transmitted between the trains without relying on the ground base station. No central control equipment needs to be arranged on the ground, and no wireless network coverage is needed in a ground section. A train interval is dynamically adjusted according to track conditions, a temporary speed restriction and the states of various trains in the group.

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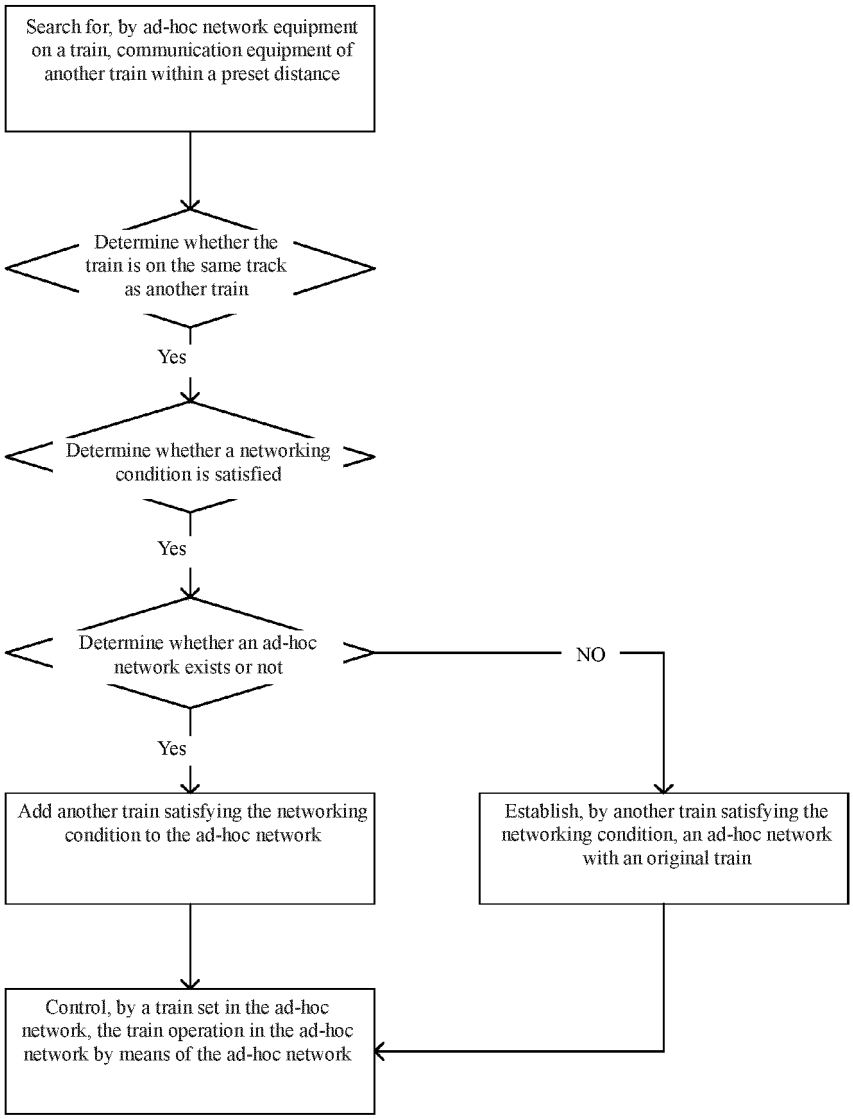
Search for, by ad-hoc network equipment on a train, communication equipment of another train within a preset distance
Determine whether the train is on the same track as another train
Yes
Determine whether a networking condition is satisfied
Yes
Determine whether an ad-hoc network exists or not
NO
Yes
Add another train satisfying the networking condition to the ad-hoc network
Establish, by another train satisfying the networking condition, an ad-hoc network with an original train
Control, by a train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network

FIG. 1

Description

TECHNICAL FIELD

[0001] The present invention belongs to the technical field of traffic, and particularly relates to a train group control method and system based on an ad-hoc network.

BACKGROUND ART

[0002] At present, trains usually operate in a marshalling mode, and a peer-to-peer communication mode or a train-to-ground-to-train communication mode is usually used as a communication mode.

[0003] The peer-to-peer communication mode is as follows:

a train A, after receiving a command from a ground control center, needs to perform peer-to-peer communication with a train B, then the train A establishes communication connection with the train B via a peer-to-peer communication, the train A provides speed and position coordinates information to the train B, and the train B generates a respective train control curve of the train B by combining the respective position and speed information to control the train operation, based on the received information of the train A. By analogy, each of the train C and the train D will generate a respective train control curve to control the respective train operation.

[0004] Such method depends upon the ground center equipment, each train must receive a control common for which train to communication with before establishing communication, and cannot form a formation by itself. The train cannot directly obtain how many trains are in the group and what train it is. Each train needs to calculate a respective movement authority in real time.

[0005] The train-to-ground-to-train communication mode is as follows:

a train A and a train B are subjected to peer-to-peer communication by means of a ground base station, the train A provides speed and position coordinates information to the base station, the base station forwards such information to the train B, and the train B generates a train control valve of the B train by combining the respective position and speed information to control the train operation, based on the received information of the train A. By analogy, each of the train C and the train D will generate a respective train control curve to control the respective train operation.

[0006] In accordance with such method, each train must provide which train to communicate with by means of ground center control equipment before establishing the communication connection with the target train by means of the ground base station. Each train needs to calculate a respective movement authority in real time. Wireless coverage is required throughout the track. A central equipment needs to be provided to manage the position and states of all trains.

[0007] No matter the peer-to-peer communication mode or the train-to-ground-to-train communication mode is used, a train management center needs to be arranged on the ground, continuous coverage of the ground wireless network is needed, and the requirement for network indexes is high. Each train performs communication connection with a specified train according to a command provided by the ground, and each train needs to calculate its own movement authority in real time, but the functions of autonomous management and autonomous networking of the train cannot be achieved. The ground train management center cannot operate normally when having a failure, the construction cost is high, the system is huge and miscellaneous, the reliability is low, and the maintenance cost is high.

SUMMARY

[0008] For the problems above, the present invention provides a train group control method based on an ad-hoc network. The method includes:

searching for, by ad-hoc network equipment on a train, communication equipment of another train within a preset distance; determining whether the train is on the same track as another train;

if determining that the train is on the same track as another train, determining whether a networking condition is satisfied;

if the networking condition is satisfied, determining whether an ad-hoc network exists or not;

if no ad-hoc network exists, establishing, by another train satisfying the networking condition, an ad-hoc network with an original train;

if an ad-hoc network exists, adding another train satisfying the networking condition to the ad-hoc network; and

controlling, by the train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network.

[0009] Further, the networking condition includes:

ad-hoc network equipment is provided in a target train;

the target train is allowed to establish or join the ad-hoc network; and

the target train is in stable communication with a local train.

[0010] Further, the control method further includes:

receiving, by the train, track condition information, wherein the track condition information includes: route information, track information, temporary speed restriction information, and movement authority.

[0011] Further, controlling, by a train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network includes:

a first train control and a following train control,
wherein the first train control is used in the ad-hoc network to enable the first train to control the operation of another train in the ad-hoc network; and
the following train control is used in the ad-hoc network to enable a following train to control itself to operate following a front train.

[0012] Further, the first train control includes:

each of the trains in the ad-hoc network determines a respective position in the ad-hoc network,
if the train is the first train,
the first train receives train data information transmitted from the following train, wherein the data information includes: a speed, a position, an acceleration, a braking performance, and an operating condition;
the first train calculates a target speed of the following train in the ad-hoc network according to the data information, the track information of a current position of each train in the ad-hoc network and a position-speed relation between each train and a front train in the group;
the first train notifies the corresponding train to monitor and operate according to the target speed by means of ad-hoc network communication;
the first train periodically receives real-time train data information of another train;
if the train is the following train,
the following train sends data information to the first train, the data information including: a speed, a position, an acceleration, a braking performance and an operating condition;
the following train receives the target speed transmitted from the first train by means of the ad-hoc network, operates according to the target speed, and periodically sends the real-time train data information of the current train to the first train.

[0013] Further, the first train control further includes:

the first train calculates a target distance between another train and the front train in the ad-hoc network;
the first train calculates a distance-to-go curve of another train in the ad-hoc network;
the first train calculates a target stop point of another train in the ad-hoc network;
the first train sends the target distance, the distance-to-go curve and the target stop point to the corresponding following train via the ad-hoc network communication; and
the following train receives the target distance, the distance-to-go curve and the target stop point.

[0014] Further, the following train control includes:

each of the trains in the ad-hoc network determines a respective position in the ad-hoc network,
if the train is the first train,
the first train periodically transmits the respective train data information to a rear train, wherein the data information includes: a speed, a position, an acceleration, a braking performance and an operating condition;
if the train is the following train,
and is not the last train in the ad-hoc network,
the following train periodically receives the train data information transmitted from the front train in the ad-hoc network, calculates a respective target speed, and operates according to the target speed; and
the following train periodically transmits the respective train data information to the rear train, the data information including: a speed, a position, an acceleration, a braking performance and an operating condition;
if the train is the last train in the ad-hoc network,
the train periodically receives the train data information transmitted from the front train in the ad-hoc network, calculates the respective target speed, and operates according to the target speed.

[0015] Further, the following train control further includes:

the following train calculates a target distance between the respective position and the front train in the ad-hoc network;
the following train calculates a respective distance-to-go curve in the ad-hoc network; and
the following train calculates a respective target stop point in the ad-hoc network.

[0016] The present invention further provides a train group control system based on an ad-hoc network. The system includes an ad-hoc equipment.

[0017] The ad-hoc network equipment is configured to:

search for, by ad-hoc network equipment on a train, communication equipment of another train within a preset distance; determining whether a train is on the same track as another train;
if determining that the train is on the same track as another train, determine whether a networking condition is satisfied;
if the networking condition is satisfied, determine whether an ad-hoc network exists or not;
if no ad-hoc network exists, establish, by another train satisfying the networking condition, an ad-hoc network with an original train;
if an ad-hoc network exists, add another train satisfying the networking condition to the ad-hoc network; and
controlling, by the train set in the ad-hoc network, the train operation in the ad-hoc network by means

of the ad-hoc network.

[0018] Further, the networking condition includes:

ad-hoc network equipment is provided in a target train;
the target train is allowed to establish or join the ad-hoc network; and
the target train is in stable communication with a local train.

[0019] Further, the system further includes:
on-board ATP equipment, a station data server, and a track circuit.

[0020] The on-board ATP equipment is configured to receive track condition information, the track condition information includes: route information, track information, temporary speed restriction information, and movement authority.

[0021] The station data server is configured to send the route information, the track information and the temporary speed restriction information.

[0022] The track circuit sends the movement authority.

[0023] Further, controlling, by a train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network includes:

a first train control and a following train control,
wherein the first train control is used in the ad-hoc network to enable the first train to control the operation of another train in the ad-hoc network; and
the following train control is used in the ad-hoc network to enable a following train to control itself to operate following a front train.

[0024] Further, the first train control includes:

each of the trains in the ad-hoc network determines a respective position in the ad-hoc network,
if the train is the first train,
the first train receives train data information transmitted from the following train, wherein the data information includes: a speed, a position, an acceleration, a braking performance, and an operating condition;
the first train calculates a target speed of the following train in the ad-hoc network according to the data information, the track information of a current position of each train in the ad-hoc network and a position-speed relation between each train and a front train in the group;
the first train notifies the corresponding train to monitor and operate according to the target speed by means of ad-hoc network communication;
the first train periodically receives real-time train data information of another train;
if the train is the following train,
the following train sends data information to the first train, the data information including: a speed, a position, an acceleration, a braking performance and an operating condition;
the following train receives the target speed transmitted from the first train by means of the ad-hoc network, operates according to the target speed, and periodically sends the real-time train data information of the current train to the first train.

[0025] Further, the first train control further includes:

the first train calculates a target distance between another train and the front train in the ad-hoc network;
the first train calculates a distance-to-go curve of another train in the ad-hoc network;
the first train calculates a target stop point of another train in the ad-hoc network;
the first train sends the target distance, the distance-to-go curve and the target stop point to the corresponding following train via the ad-hoc network communication; and
the following train receives the target distance, the distance-to-go curve and the target stop point.

[0026] Further, the following train control includes:

each of the trains in the ad-hoc network determines a respective position in the ad-hoc network,
if the train is the first train,
the first train periodically transmits the respective train data information to a rear train, wherein the data information includes: a speed, a position, an acceleration, a braking performance and an operating condition;
if the train is the following train,
and is not the last train in the ad-hoc network,
the following train periodically receives the train data information transmitted from the front train in the ad-hoc network, calculates a respective target speed, and operates according to the target speed; and
the following train periodically transmits the respective train data information to the rear train, the data information includes: a speed, a position, an acceleration, a braking performance, and an operating condition;
if the train is the last train in the ad-hoc network,
the train periodically receives the train data information transmitted from the front train in the ad-hoc network, calculates the respective target speed, and operates according to the target speed.

[0027] Further, the following train control further includes:

the following train further calculates a target distance between the respective position and the front train in the ad-hoc network;

the following train further calculates a respective distance-to-go curve in the ad-hoc network; and
the following train further calculates a respective target stop point in the ad-hoc network.

[0028] The train group control method and system based on the ad-hoc network designed by the present invention can achieve the train group control based on a train-to-train communication technology of the ad-hoc network. Trains are automatically networked when the conditions are satisfied, and inter-train data are transmitted between the trains without relying on the ground base station. No central control equipment needs to be arranged on the ground, and no wireless network coverage is needed in a ground section. A train interval is dynamically adjusted according to track conditions, a temporary speed restriction and the states of various trains in the group.

[0029] Additional features and advantages of the present invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the present invention. The objectives and other advantages of the present invention will be realized and attained by the structure particularly pointed out in the specification, the claims as well as the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] To describe the technical solutions in the embodiments of the present invention or in the prior art more clearly, the following briefly introduces the accompanying drawings required for describing the embodiments. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings from these accompanying drawings without creative efforts.

FIG. 1 illustrates a flow diagram of a train group control method based on an ad-hoc network in accordance with embodiments of the present invention;
FIG. 2 illustrates a schematic diagram of a system of a train group system method based on an ad-hoc network in accordance with embodiments of the present invention.

DETAILED DESCRIPTION

[0031] In order to make the objective, technical solutions and advantages of the embodiments of the present invention more clearly, the following clearly and completely describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the described embodiments are merely a part rather than all of the embodiments of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

[0032] The embodiment of the present invention discloses a train group control method based on an ad-hoc network. As shown in FIG. 1, the method includes: searching for, by ad-hoc network equipment on a train, communication equipment of another train within a preset distance; determining whether the train is on the same track as another train; if the train is on the same track as another train, determining whether a networking condition is satisfied; if the networking condition is satisfied, establishing an ad-hoc network by the trains satisfying the networking condition; and controlling, by the train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network. The networking condition includes: ad-hoc network equipment is provided in a target train; the target train is allowed to establish the ad-hoc network; and the target train is in stable communication with a local train. The train receives track condition information, the track condition information includes: route information, track information, temporary speed restriction information, and movement authority.

[0033] The current train communication ways are train-to-ground communication and train-to-train communication. The train-to-ground communication refers to that the train communicates with ground equipment. The train-to-train communication is also divided into train-to-ground-to-train communication and train-to-train communication. The train-to-ground-to-train communication refers to that a plurality of trains perform communication by means of the ground equipment, or perform communication by means of information of the ground equipment. The train obtains the information of another train by means of the ground equipment, such as a data interaction center, and then communicates with another train according to the obtained information, which belongs to the train-to-ground-to-train communication. The train-to-train communication refers to that the communication connection is established between trains, and the communication and the disconnection of communication are completely completed by train equipment without relying on the ground equipment. The communication involved in the present invention is the train-to-train communication; the establishment of the ad-hoc network, the use of the ad-hoc network communication and the disconnection of communication are all completed by on-board equipment without relying on the ground equipment. The present invention is mainly used in the field of heavy wagons, and can also be used in the field of another train. All trains in the ad-hoc network are controlled by the ad-hoc network, all trains in the ad-hoc network are called group trains, and are also called a train set. The group trains refer to a train group consisting of two or more real trains, the ground equipment controls control the train group by one train, and various trains in the train group are subjected to coordinated control.

[0034] Specifically, the train receives the track condition information, the track condition information includes: route information, track information, temporary speed restriction information, and movement authority.

[0035] Illustratively, the train operation requires a series of authorities and relevant data, and can be performed only after these authorities and data are obtained. Such data include: the route information, the temporary speed restriction information, and the track information. The authority includes the movement authority. These data may be transmitted to the train using, but not limited to, the following ways: the train receives the data by using on-board ATP (automatic train protection) equipment; a station data server (SDS), which has the function of storing basic data of the station and section track, may complete real-time framing and verification of a wireless message according to the track information stored by itself and information provided by equipment such as CBI (computer-based interlocking) and TSRS (temporary speed restriction server). The station data server sends the information to all trains in the wireless coverage area by means of train-to-ground communication, and may also send the information to a specified train as required. The station data server receives interlocking route information, temporary speed restriction information of the temporary speed restriction server and the track information, generates messages such as the route information, the track information and temporary speed restriction, and provides, within the scope of the station, the in-station messages and section message to the on-board ATP. A track circuit (TC) sends the movement authority information to the on-board ATP. The train can receive the track condition information by means of such way.

[0036] Specifically, the ad-hoc network equipment on the train searches for communication equipment of another train within a preset distance to determine whether the train is on the same track as another train.

[0037] Illustratively, the ad-hoc network equipment on the train searches for communication equipment of another train within the preset distance. When a front train and a rear train operate according to normal tracking, the communication range of the ad-hoc network equipment on the train is large enough, so that the front train and the rear train can normally communicate with each other. The train-to-train communication of the ad-hoc network equipment is performed by means of two radios that are both original train equipment, without adding hardware equipment. One of the radios is configured for long-distance communication, and the other of the radios is configured for short and medium-distance communication. The switching of the two radio stations is completed by the ad-hoc network equipment. After communication is established between two or more ad-hoc network equipment and the networking condition is satisfied, a local wireless broadband communication private network may be established within a short time in an ad-hoc manner. All ad-hoc network equipment in the wireless broadband communication private network communicates with one another by using the wireless broadband communication private network. After the wireless broadband communication private network has been established, new ad-hoc network equipment is communicatively connected to any ad-hoc network equipment in the wireless broadband communication private network, and when networking condition is satisfied, the new ad-hoc network equipment will automatically join the wireless broadband communication private network to form a new wireless broadband communication private network. The communication between the new ad-hoc network and all ad-hoc network equipment under the jurisdiction of the original wireless broadband communication private network is achieved by means of the new wireless broadband communication private network. The ad-hoc network equipment on the train searches for communication equipment of another train within the preset distance, the preset distance, such as the shortest distance between a front train and a rear train in normal tracking operation, the longest distance of long-distance communication of the radio station, may be appointed in advance.

[0038] The ad-hoc network equipment is arranged at a head of the train. When ad-hoc network equipment on the train sends a wireless signal to the periphery, and communication equipment of end of train (EOT) of this train, communication equipment of head of train (HOT) of another train within the preset distance, communication equipment of EOT of another train and the ad-hoc network equipment of another train can all receive the signal. The ad-hoc network equipment has a function of identifying communication equipment of HOT and communication equipment of EOT of a neighboring-line train, thereby preventing the head of the train or the end of the train of neighboring line train from being included in the wireless communication network. The identification may be performed using, but not limited to, the following ways: the ad-hoc network equipment sends networking request information to the periphery and informs the track where it is located; the train on the same track, after receiving the networking request information, replies its corresponding information, and the train on different track does not reply or replies information including the respective track information. The ad-hoc network equipment may determine which trains are on the same track as itself according to the received information.

[0039] Specifically, whether the networking condition is satisfied is determined, if the networking condition is satisfied, the trains satisfying the networking condition establish the ad-hoc network, and the train set in the ad-hoc network controls the train operation in the ad-hoc network by means of the ad-hoc network. The networking condition includes: ad-hoc network equipment is provided in a target train; the target train is allowed to establish the ad-hoc network; and the target train is in stable communication with a local train.

[0040] Illustratively, the establishment of the ad-hoc network between the trains needs to satisfy the networking condition, the networking condition includes: ad-hoc

network equipment is provided in the target train, the target train is allowed to establish the ad-hoc network; and the target train is in stable communication with a local train. The train can join the ad-hoc network only when being provided with the ad-hoc network equipment. Any train provided with the ad-hoc network equipment has a function of permitting or prohibiting the itself to establish or join the ad-hoc network. When a certain train is set to permit itself to establish or join the ad-hoc network by itself, after another train sends an ad-hoc network establishing request or an ad-hoc network joining request to this train, this train establishes an ad-hoc network or joins the ad-hoc network when all networking conditions are satisfied. The train establishing the ad-hoc network needs to maintain stable communication. The communication equipment of EOT of the train plays a communication relay role. When the train is in a tunnel or a cave, the head of the train may communicate with another train via the communication equipment of EOT, and another train may communicate with the head of the train via the communication equipment of EOT of this train. During the establishment of the ad-hoc network, two sets of ad-hoc network equipment may communicate with each other via the communication equipment of EOT, and the stable communication is also considered to be stable communication between the target train and the local train. During the establishment of the ad-hoc network, there may be a plurality of trains in the ad-hoc network, and the ad-hoc network equipment also plays a role of communication relay. When any train in the ad-hoc network communicates with the target train, regardless of direct communication or communication by means of the relay of other one or a plurality of trains in the ad-hoc network, the communication between the target train and the current train is considered to be stable as long as the communication is stable.

[0041] When the networking condition is satisfied, the ad-hoc network equipment on the train determines whether there is an ad-hoc network at present. If no ad-hoc network exists, all trains satisfying the networking condition are configured to establish the ad-hoc network with the original train. If the ad-hoc network already exists, all the trains satisfying the networking conditions join the original ad-hoc network to form a new ad-hoc network.

[0042] After the ad-hoc network is established, the train sets in the ad-hoc network control the train operation in the ad-hoc network by means of the ad-hoc network.

[0043] Specifically, controlling, by a train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network includes: a first train control and a following train control. The first train control is used in the ad-hoc network to enable the first train to control the operation of another train in the ad-hoc network; the following train control is used in the ad-hoc network to enable the following train to control itself to operate following a front train.

[0044] Illustratively, the train set in the ad-hoc network controls the operation of trains in the ad-hoc network by means of the ad-hoc network in two ways: one is the first train control, that is, in the ad-hoc network, the first train controls the operation of another train in the ad-hoc network; one is the following train control, that is, in the ad-hoc network, the following train controls itself to operate following the front train. An operator may select the specific control way according to actual situations.

[0045] Specifically, the first train control includes: each of the trains in the ad-hoc network determines a respective position in the ad-hoc network, If the train is the first train, the first train receives train data information transmitted from the following train, wherein the data information includes: a speed, a position, an acceleration, a braking performance, and an operating condition; the first train calculates a target speed of the following train in the ad-hoc network according to the data information, the track information of a current position of each train in the ad-hoc network and a position-speed relation between each train and the front train in the group; the first train notifies the corresponding train to monitor and operate according to the target speed by means of ad-hoc network communication; and then the first train periodically receives real-time train data information of another train; If the train is the following train, the following train sends data information to the first train, wherein the data information includes: a speed, a position, an acceleration, a braking performance and an operating condition; the following train receives the target speed transmitted from the first train by means of the ad-hoc network, operates according to the target speed, and periodically sends the real-time train data information of the current train to the first train. The first train further calculates a target distance between another train in the ad-hoc network and the preceding train; the first train further calculates a distance-to-go curve of another train in the ad-hoc network; the first train further calculates a target stop point of another train in the ad-hoc network; the first train sends the target distance, the distance-to-go curve and the target stop point to the corresponding following train via the ad-hoc network communication; and the following train receives the target distance, the distance-to-go curve and the target stop point.

[0046] Illustratively, all trains in the ad-hoc network are all on the same track, according to operation directions of the trains, the headmost train in the ad-hoc network is the first train of the group and is also called as the first train, and the trains except the first train are the following trains of the group. Each of the trains in the ad-hoc network may determine the respective position in the ad-hoc network using, but not limited to the following ways: each of the trains in the ad-hoc network sends the respective position information to another train, and may obtain the respective position in the ad-hoc network by combining the position information of all the trains with traveling direction information and track information of the current train. The train may obtain the following information by determining the respective position in the

ad-hoc network: whether it is the first train or the following train, and if it is the following train, what position it is in. If there are four in the ad-hoc network, the train behind the first train is the second position (the second train), and the last train is the fourth (the fourth train).

[0047] The first train in the ad-hoc network receives train data information transmitted from another train, the data information include: a speed, a position, an acceleration, a braking performance, and an operating condition.

[0048] The first train calculates a target speed of the following train in the ad-hoc network according to the data information, the track information of a current position of each train in the ad-hoc network and a position-speed relation between each train and the front train in the group.

[0049] The operating condition refers to different states of the train in operation, the train under locomotive traction includes five types: traction inertia, air braking, electric braking and air-electricity blended braking. The different operating conditions of the train affect a value of a train braking model parameter, and thus affect the determination of the target speed.

[0050] The target speed refers to the highest speed allowed before reaching the target point. The first train notifies notify the corresponding train to operate according to the target speed via the ad-hoc network communication. The first train operates under the control of the ground equipment. In this way, the trains in the ad-hoc network may operate at the maximum speed. During operation, the following train in the ad-hoc network periodically sends the respective real-time train data information to the first train, wherein the data information includes a speed, a position, an acceleration, a braking performance, and an operating condition; the period is calculated according to the target speed of the train, the position of the preceding train, the braking performance, the track condition and the like, and is less than safety braking time. The safety braking time is the maximum time of one-off braking for ensuring that the current train can operate safely after operating according to the target speed.

[0051] The following train receives the target speed transmitted from the first train by means of the ad-hoc network, operates according to the target speed. The first train periodically receives receive the real-time train data information of the following train. The first train recalculates a new target speed according to the real-time train data information and sends the new target speed to the corresponding train, and the thus following train operates according to the new target speed. The first train monitors the actual speed and the target speed of the following train in real time, and controls the traction and braking of the following train by combining a train traction model and a braking model. Finally, the closed-loop supervision of the first train on another train is completed.

[0052] The first train may calculate the target speed using , but is not limited to, the following ways: during operation, a rear train needs to maintain a safety spacing S from the front train to ensure the safety of operation. The first train determines the distance L between itself and the rear train according to the position sent by the rear train (the second train) via the ad-hoc network communication, and obtains a least-favorable braking distance D (including safety protection distance) under the response time according to the information such as the respective speed, acceleration and breaking performance. The safety spacing S of the rear train is equal to the sum of the L and D; the first train calculates the target speed of the rear train according to the safety spacing S data and a safety braking model of the rear train. In a similar way, the first train may calculate a target speed of each of the third train, the fourth train and the like.

[0053] The first train further calculates a target distance between another train in the ad-hoc network and the front train, the target distance refers to the distance between the front end of the train and the target point. The target distance refers to the safety spacing S, namely, L+D, and a calculation way of the safety spacing S has appeared in how to calculate the target speed. The first train further calculates a distance-to-go curve of another train in the ad-hoc network.

[0054] The distance-to-go curve is a one-off braking control curve generated on the basis of the target speed, the target distance, the track condition, and the train characteristics to ensure the safe train operation. The distance-to-go curve may be calculated using, but not limited to, the following ways: the first train acquires relevant parameters of the trains in the set, and the first train calculates the most restrictive speed profile (MRSP) according to the track information of the train in the set, fixed speed restriction, track temporary speed restriction, train construction speed restriction, mode speed restriction and the like. The track information, the fixed speed restriction, the track temporary speed restriction, the train construction speed restriction and the mode speed restriction are provided by the ground equipment. When components of the MRSP change, the first train recalculates the MRSP. The safety braking model takes influences of factors such as a position uncertainty of a train, an initial speed of the train, an initial acceleration of the train, a speed measurement error, a track gradient, a braking delay and an action delay of the train into consideration.

[0055] The initial speed of the train is obtained by a speed sensor. The initial acceleration of the train is obtained by calculating a traction force and the mass according to the *Regulations on Railway Train Traction Calculation.* The track gradient is provided by the ground equipment; errors of the position uncertainty of the train, the braking delay, the speed measurement error and the action delay of the train are stipulated by a system. The first train monitors a difference between a current speed and a current speed restriction of the train in a monitoring set, and according to the current positioning information, a distance-to-go curve of this train is calculated by com-

bining the train safety braking model. The first train further calculates a target stop point of another train in the ad-hoc network. The calculation may be performed using, but not limited to the following ways: the first train calculates the position range of the tail of the train when it stops, based on its own relevant parameter; the closest distance between the tail part of the first train after stopping and the rear train is used as a target stop point of the rear train; and then a braking measure grade, opportunity and the like which should be taken by the rear train are calculated according to the relevant parameters of the rear train, thereby guaranteeing that the rear train does not cross the target stop point of the rear train after stopping. Similarly, the first train may calculate target distances, distance-to-go curves, and target stop points of all trains in the ad-hoc network, and then send such information to the corresponding trains. The following train receives the target distance, the distance-to-go curve and the target stop point. When an emergency occurs, such as inability to communicate, the following train may safely stop or operate according to the information.

[0056] Specifically, the following train control includes: each of the trains in the ad-hoc network determines a respective position in the ad-hoc network; if the train is the first train, the first train periodically transmits respective train data information to a rear train, wherein the data information includes: a speed, a position, an acceleration, a braking performance and an operating condition. If the train is the following train, and is not the last train in the ad-hoc network, the following train periodically receives the train data information transmitted from the front train in the ad-hoc network, calculates a respective target speed, and operates according to the target speed, and then the following train periodically transmits the respective train data information to the rear train, wherein the data information includes: a speed, a position, an acceleration, a braking performance and an operating condition. IF the train is the last train in the ad-hoc network, the train periodically receives the train data information transmitted from the front train in the ad-hoc network, calculates the respective target speed, and operates according to the target speed. The following train control further includes: the following train calculates a target distance between the respective position and the front train in the ad-hoc network; the following train further calculates a respective distance-to-go curve in the ad-hoc network; and then the following train further calculates a respective target stop point in the ad-hoc network.

[0057] Illustratively, the use of the following train control also requires each train in the ad-hoc network to determine the respective position in the ad-hoc network, and the used way is the same as that of the first train control.

[0058] Except for the last train in the ad-hoc network, each train periodically transmits respective train data information to the rear train, wherein the data information includes: a speed, a position, an acceleration, a braking performance and an operating condition. Except for the first train, each train receives train data information transmitted from the front train, calculates respective target speed, and operates according to the target speed. The first train operates under the control of the ground equipment. The rear train periodically receives the train data information of the front train and recalculates a new target speed, and then operates according to the new target speed. The following train monitors its actual speed and the target speed in real time, and controls the train traction and braking by combining a train traction model and a braking model.

[0059] The following train may calculate the respective target speed using, but is not limited to, the following ways: during operation, the rear train needs to maintain a safety spacing S from the front train to ensure the safety of operation. The following train determines a distance L between itself and the rear train according to the position sent by the front train via the ad-hoc network communication, and obtains the least-favorable braking distance (including safety protection distance) under the response time according to the information such as the speed, the acceleration and the breaking performance of the front train. The safety spacing S of the local train is equal to the sum of the L and D; the local train calculates a respective target speed according to the safety spacing S and a respective safety braking model.

[0060] The following train further calculates a target distance between itself and the front train in the ad-hoc network, namely, L+D; the following train further calculates a respective distance-to-go curve in the ad-hoc network; and the following train further calculates a respective target stop point in the ad-hoc network. The distance-to-go curve may be calculated using, but not limited to, the following ways: the following train calculates the respective most restrictive speed profile (MRSP) according to respective relevant parameters by combining train track information, a fixed speed restriction, a track temporary speed restriction, a train construction speed restriction, a mode speed restriction and the like. When the components of the MRSP change, the following train recalculates the MRSP. The safety braking model takes influences of factors such as a position uncertainty of a train, an initial speed of the train, an initial acceleration of the train, a speed measurement error, a track gradient, a braking delay and an action delay of the train into consideration. The following train monitors a difference between its own actual speed and the current limit restriction in real time, and calculates the respective distance-to-go curve according to the current positioning information by combining a train safety braking model. The following train further calculates a respective target stop point. The calculation may be carried out using, but not limited to, the following ways: the rear train calculates the position range of a tail of the train when the front train stops, based on the relevant parameters of the front train; the closest distance between the tail part of the front train after stopping and the rear train is used as a target stop point of the rear train, and then the rear train calculates a braking

measure grade, opportunity and the like which should be taken according to the respective relevant parameters, thereby guaranteeing that the rear train does not cross the respective target stop point after stopping. Each of the following trains calculates a respective target distance, a respective distance-to-go curve, and a respective target stop point. When an emergency occurs, such as inability to communicate, the following train may safely stop or operate according to the information.

[0061] The embodiment of the present invention further discloses a train group control system based on an ad-hoc network. As shown in FIG. 2, the system includes ad-hoc network equipment, on-board ATP equipment, a station data server, and a track circuit.

[0062] The ad-hoc network equipment is configured to: search for, by ad-hoc network equipment on a train, communication equipment of another train within a preset distance; determine whether the train is on the same track as another train; if the train is in the same track of another train, determine whether a networking condition is satisfied; if the networking condition is satisfied, determine whether an ad-hoc network exists or not; if no ad-hoc network exists, establish, by another train satisfying the networking condition, an ad-hoc network with an original train; if an ad-hoc network exists, add another train satisfying the networking condition to the ad-hoc network; and control, by the train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network. The networking condition includes: the ad-hoc network equipment is provided in a target train; the target train is allowed to establish or join the ad-hoc network, and the target train is in stable communication with a train.

[0063] The on-board ATP equipment is configured to receive track condition information, wherein the track condition information include: route information, track information, temporary speed restriction information, and a movement authority.

[0064] The station data server is configured to send the route information, the track information and the temporary speed restriction information. The station data server has the function of storing basic data of the station and section track, and may complete real-time framing and verification of a wireless message according to track information stored by itself and information provided by equipment such as CBI and TSRS. The station data server sends the information to all the trains in the wireless coverage area by means of train-to-ground communication, and may also send the information to a specified train as required. The station data server receives interlocking route information, temporary speed restriction information of the temporary speed restriction server and the track information, generates messages such as the route information, the track information and temporary speed restriction, and provides, within the scope of the station, the in-station messages and section message to the on-board ATP.

[0065] The track circuit sends the movement authority.

[0066] The controlling, by a train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network includes: a first train control and a following train control. The first train control is used in the ad-hoc network to enable the first train to control the operation of another train in the ad-hoc network; and the following train control is used in the ad-hoc network to enable a following train to control itself to operate following a front train.

[0067] The first train control includes: each of the trains in the ad-hoc network determines a respective position in the ad-hoc network. If the train is the first train, the first train receives train data information transmitted from the following train, wherein the data information includes: a speed, a position, an acceleration, a braking performance and an operating condition; the first train calculates a target speed of the following train in the ad-hoc network according to the data information, the track information of a current position of each train in the ad-hoc network and a position-speed relation between each train and the front train in the group; the first train notifies the corresponding train to monitor and operate according to the target speed by means of ad-hoc network communication; and the first train periodically receives real-time train data information of another train. If the train is the following train, the following train sends data information to the first train, wherein the data information includes: a speed, a position, an acceleration, a braking performance and an operating condition; the following train receives the target speed transmitted from the first train by means of the ad-hoc network, operates according to the target speed, and periodically sends the real-time train data information of the current train to the first train.

[0068] The first train control further includes: the first train further calculates a target distance between another train and the front train in the ad-hoc network; the first train further calculates a distance-to-go curve of another train in the ad-hoc network; and the first train further calculates a target stop point of another train in the ad-hoc network. The first train sends the target distance, the distance-to-go curve and the target stop point to the corresponding following train via the ad-hoc network communication. The following train receives the target distance, the distance-to-go curve and the target stop point.

[0069] The following train control includes: each of the trains in the ad-hoc network determines a respective position in the ad-hoc network. If the train is the first train, the first train periodically transmits the respective train data information to a rear train, wherein the data information includes: a speed, a position, an acceleration, a braking performance and an operating condition. If the train is the following train, and is not the last train in the ad-hoc network, the following train periodically receives the train data information transmitted from the front train in the ad-hoc network, calculates a respective target speed, and operates according to the target speed, and then the following train periodically transmits the respective train data information to the rear train, wherein the

data information includes: a speed, a position, an acceleration, a braking performance and an operating condition. If the train is the last train in the ad-hoc network, the train periodically receives the train data information transmitted from the front train in the ad-hoc network, calculates the respective target speed, and operates according to the target speed.

[0070] The following train control further includes: the following train further calculates a target distance between the respective position and the front train in the ad-hoc network; the following train calculates the respective distance-to-go curve in the ad-hoc network; and the following train calculates the respective target stop point in the ad-hoc network.

[0071] The train group control method and system based on the ad-hoc network designed by the present invention can achieve the train group control based on a train-to-train communication technology of the ad-hoc network. Trains are automatically networked when the conditions are satisfied, and inter-train data are transmitted between the trains without relying on the ground base station. No central control equipment needs to be arranged on the ground, and no wireless network coverage is needed in a ground section. A train interval is dynamically adjusted according to track conditions, a temporary speed restriction and the states of various trains in the group.

[0072] Although the utility model has been described in detail with respect to the previously described embodiments, it should be appreciated by one skilled in art, the technical solutions recorded in the embodiments may be still modified, or part of its technical features may be replaced with equivalents; and such modifications or substitutions do not deviate the nature of the technical solutions from the spirit and scope of the technical solutions of the various embodiments in the utility model.

Claims

1. A train group control method based on an ad-hoc network, **characterized in that**, the method comprises: searching for, by ad-hoc network equipment on a train, communication equipment of another train within a preset distance; determining whether the train is on the same track as another train; if determining that the train is on the same track as another train, determining whether a networking condition is satisfied; if the networking condition is satisfied, determining whether an ad-hoc network exists or not; if no ad-hoc network exists, establishing, by another train satisfying the networking condition, an ad-hoc network with an original train; if an ad-hoc network exists, adding another train satisfying the networking condition to the ad-hoc network; and controlling, by the train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network.

2. The control method according to claim 1, **characterized in that**, the networking condition comprises: ad-hoc network equipment is provided in a target train; the target train is allowed to establish or join the ad-hoc network, and the target train is in stable communication with a local train.

3. The control method according to claim 1, **characterized in that**, the control method further comprises: receiving, by the train, track condition information, the track condition information comprising: route information, track information, temporary speed restriction information, and a movement authority.

4. The control method according to claim 1, **characterized in that**, the controlling, by a train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network comprises: a first train control and a following train control, wherein the first train control is used in the ad-hoc network to enable the first train to control the operation of another train in the ad-hoc network; and the following train control is used in the ad-hoc network to enable a following train to control itself to operate following a front train.

5. The control method according to claim 4, **characterized in that**, the first train control comprises: each of the trains in the ad-hoc network determines a respective position in the ad-hoc network, if the train is the first train, the first train receives train data information transmitted from the following train, the data information comprising: a speed, a position, an acceleration, a braking performance, and an operating condition; and wherein the first train calculates a target speed of the following train in the ad-hoc network according to the data information, the track information of a current position of each train in the ad-hoc network and a position-speed relation between each train and the front train in the group; the first train notifies the corresponding train to monitor and operate according to the target speed by means of ad-hoc network communication; and the first train periodically receives real-time train data information of another train; if the train is the following train, the following train sends data information to the first train, the data information comprising: a speed, a position, an acceleration, a braking performance and an operating condition; the following train receives the target speed transmitted from the first train by means of the ad-hoc network, operates according to the target speed, and periodically sends the real-time train data information of the current train to the first train.

6. The control method according to claim 5, **characterized in that**, the first train control further comprises: the first train calculates a target distance between

another train and the front train in the ad-hoc network ; the first train calculates a distance-to-go curve of another train in the ad-hoc network; the first train calculates a target stop point of another train in the ad-hoc network; the first train sends the target distance, the distance-to-go curve and the target stop point to the corresponding following train via the ad-hoc network communication; and the following train receives the target distance, the distance-to-go curve and the target stop point.

7. The control method according to claim 4, **characterized in that**, the following train control comprises: each of the trains in the ad-hoc network determines a respective position in the ad-hoc network; if the train is the first train, the first train periodically transmits respective train data information to a rear train, the data information comprising: a speed, a position, an acceleration, a braking performance and an operating condition; if the train is the following train, and is not the last train in the ad-hoc network, the following train periodically receives the train data information transmitted from the front train in the ad-hoc network, calculates a respective target speed, and operates according to the target speed, and then the following train periodically transmits the respective train data information to the rear train, the data information comprising: a speed, a position, an acceleration, a braking performance and an operating condition; if the train is the last train in the ad-hoc network, the train periodically receives the train data information transmitted from the front train in the ad-hoc network, calculates the respective target speed, and operates according to the target speed.

8. The control method according to claim 7, **characterized in that**, the following train control further comprises: the following train calculates a target distance between the respective position and the front train in the ad-hoc network; the following train calculates the respective distance-to-go curve in the ad-hoc network; and the following train calculates the respective target stop point in the ad-hoc network.

9. A train group control system based on an ad-hoc network, **characterized in that**, the system comprises ad-hoc network equipment, wherein the ad-hoc network equipment is configured to: search for, by ad-hoc network equipment on a train, communication equipment of another train within a preset distance; determine whether the train is on the same track as another train; if the train is in the same track of another train, determine whether a networking condition is satisfied; if the networking condition is satisfied, determine whether an ad-hoc network exists or not; if no ad-hoc network exists, establish, by another train satisfying the networking condition, an ad-hoc network with an original train; if an ad-hoc network exists, add another train satisfying the networking condition to the ad-hoc network; and control, by the train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network.

10. The control system according to claim 9, **characterized in that**, the networking condition comprises: ad-hoc network equipment is provided in a target train; the target train is allowed to establish or join the ad-hoc network, and the target train is in stable communication with a local train.

11. The control system according to claim 9, **characterized in that**, the system further comprises: on-board ATP equipment, a station data server, and a track circuit, wherein the on-board ATP equipment is configured to receive track condition information, the track condition information comprising: route information, track information, temporary speed restriction information, and movement authority; the station data server is configured to send the route information, the track information and the temporary speed restriction information; and the track circuit sends the movement authority.

12. The control system according to claim 9, **characterized in that**, the controlling, by a train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network comprises: a first train control and a following train control, wherein the first train control is used in the ad-hoc network to enable the first train to control the operation of another train in the ad-hoc network; and the following train control is used in the ad-hoc network to enable a following train to control itself to operate following a front train.

13. The control system according to claim 12, **characterized in that**, the first train control comprises: each of the trains in the ad-hoc network determines a respective position in the ad-hoc network, if the train is the first train, the first train receives train data information transmitted from the following train, the data information comprising: a speed, a position, an acceleration, a braking performance and an operating condition; the first train calculates a target speed of the following train in the ad-hoc network according to the data information, the track information of the current position of each train in the ad-hoc network and a position-speed relation between each train and the front train in the group; the first train notifies the corresponding train to monitor and operate according to the target speed by means of ad-hoc network communication; the first train periodically receives real-time train data information of another train; if the train is the following train, the following train sends data information to the first train, the data information

comprising: a speed, a position, an acceleration, a braking performance and an operating condition; the following train receives the target speed transmitted from the first train by means of the ad-hoc network, operates according to the target speed, and periodically sends the real-time train data information of the current train to the first train.

14. The control system according to claim 13, **characterized in that**, the first train control further comprises: the first train calculates a target distance between another train and the front train in the ad-hoc network ; the first train calculates a distance-to-go curve of another train in the ad-hoc network; the first train calculates a target stop point of another train in the ad-hoc network; the first train sends the target distance, the distance-to-go curve and the target stop point to the corresponding following train via the ad-hoc network communication; and the following train receives the target distance, the distance-to-go curve and the target stop point.

15. The control system according to claim 12, **characterized in that**, the following train control comprises: each of the trains in the ad-hoc network determines a respective position in the ad-hoc network; if the train is the first train, the first train periodically transmits respective train data information to a rear train, the data information comprising: a speed, a position, an acceleration, a braking performance and an operating condition; if the train is the following train, and is not the last train in the ad-hoc network, the following train periodically receives the train data information transmitted from the front train in the ad-hoc network, calculates a respective target speed, and operates according to the target speed, and then the following train periodically transmits the respective train data information to the rear train, the data information comprising: a speed, a position, an acceleration, a braking performance and an operating condition; and if the train is the last train in the ad-hoc network, the train periodically receives the train data information transmitted from the front train in the ad-hoc network, calculates the respective target speed, and operates according to the target speed.

16. The control system according to claim 12, **characterized in that**, the following train control further comprises: the following train calculates a target distance between the respective position and the front train in the ad-hoc network; the following train calculates the respective distance-to-go curve in the ad-hoc network; and the following train calculates the respective target stop point in the ad-hoc network.

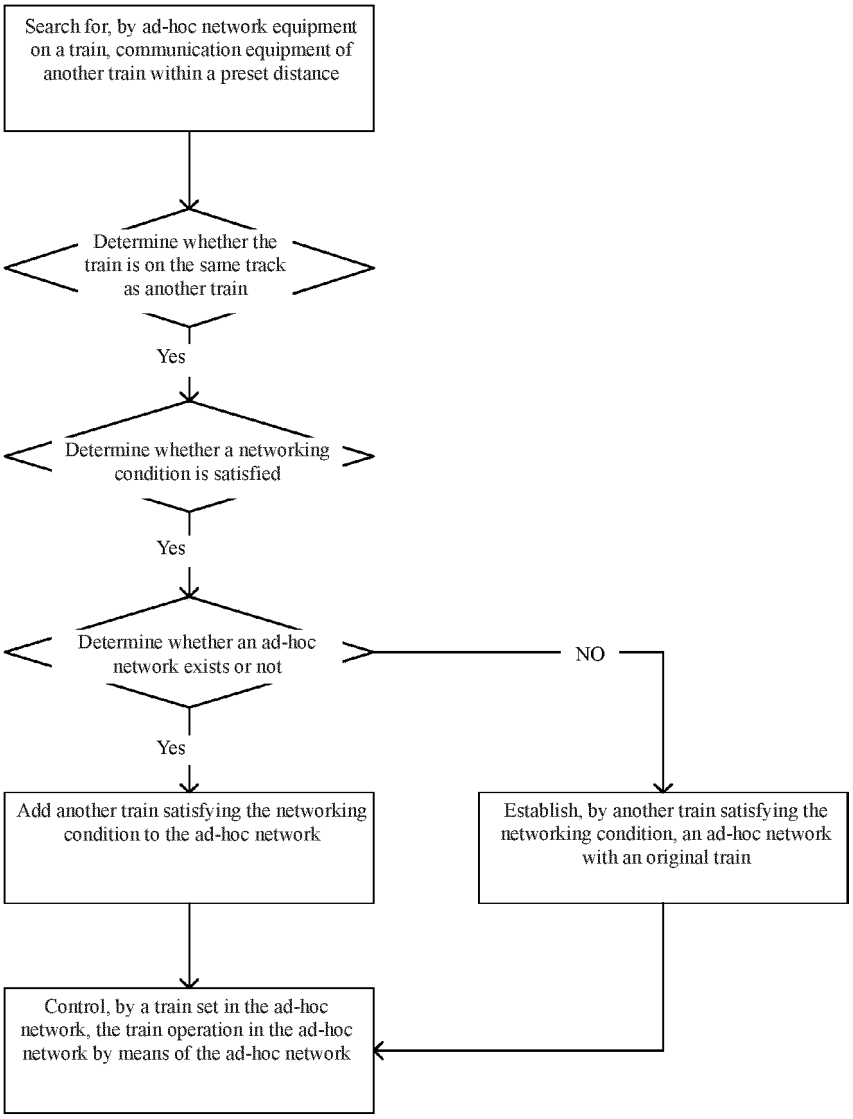
Search for, by ad-hoc network equipment on a train, communication equipment of another train within a preset distance
Determine whether the train is on the same track as another train
Yes
Determine whether a networking condition is satisfied
Yes
Determine whether an ad-hoc network exists or not
NO
Yes
Add another train satisfying the networking condition to the ad-hoc network
Establish, by another train satisfying the networking condition, an ad-hoc network with an original train
Control, by a train set in the ad-hoc network, the train operation in the ad-hoc network by means of the ad-hoc network

FIG. 1

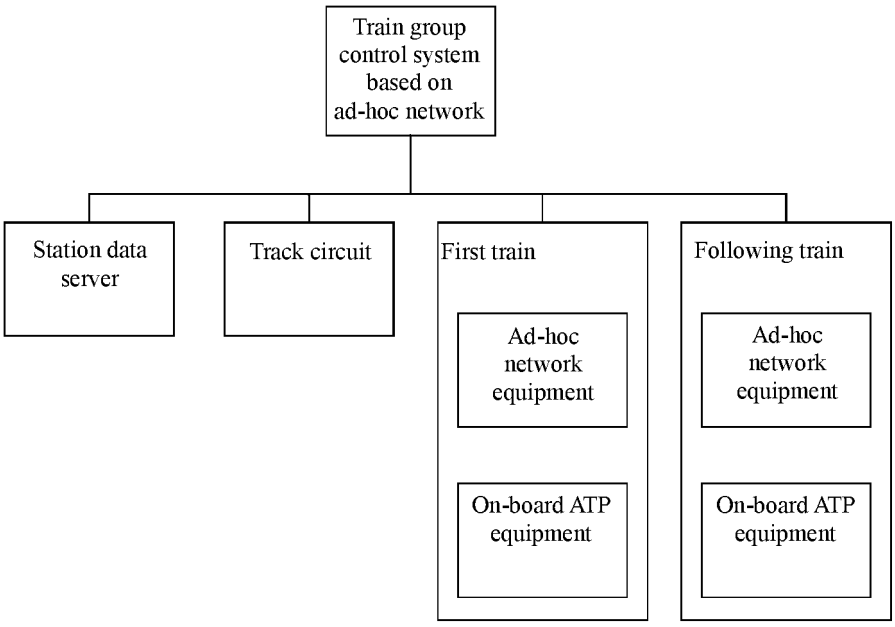
Train group control system based on ad-hoc network
Station data server
Track circuit
First train
Ad-hoc network equipment
On-board ATP equipment
Following train
Ad-hoc network equipment
On-board ATP equipment

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/105122

A. CLASSIFICATION OF SUBJECT MATTER

B61L 23/18(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; B61B

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)

SIPOABS; DWPICNABS; CNTXT: b61l27/+, train?, railway?, locomotive?, interval, distant, distance, flock+, gerd+, crowd+, group?, 列车, 火车, 货车, 机车, 自主, 组队, 群组, 编队, 距离, 跟随车, 控制, 间距, 组网, 自组, 编组

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 112009526 A (BEIJING NATIONAL RAILWAY RESEARCH & DESIGN INSTITUTE OF SIGNAL & COMMUNICATION LTD.) 01 December 2020 (2020-12-01) description, paragraphs 0008-0067, and figures 1-2	1-16
X	CN 111376950 A (TRAFFIC CONTROL TECHNOLOGY CO., LTD.) 07 July 2020 (2020-07-07) description, paragraphs 0037-0089	1-3, 9-11
Y	CN 111376950 A (TRAFFIC CONTROL TECHNOLOGY CO., LTD.) 07 July 2020 (2020-07-07) description, paragraphs 0037-0089	4-8, 12-16
Y	CN 111273675 A (SHAANXI TIEYING SPECIAL VEHICLE CO., LTD.) 12 June 2020 (2020-06-12) description, paragraphs 0003-0016	4-8, 12-16
A	CN 111516735 A (CHONGQING JIAOTONG UNIVERSITY) 11 August 2020 (2020-08-11) entire document	1-16
A	CN 108919799 A (TONGJI UNIVERSITY) 30 November 2018 (2018-11-30) entire document	1-16

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"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
28 September 2021	**11 October 2021**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** **China**	Authorized officer
Facsimile No. **(86-10)62019451**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/105122

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 110682943 A (CRRC INDUSTRY RESEARCH INSTITUTE CO., LTD.) 14 January 2020 (2020-01-14) entire document	1-16
A	CN 110962888 A (CENTRAL SOUTH UNIVERSITY) 07 April 2020 (2020-04-07) entire document	1-16
A	CN 104442933 A (LANZHOU JIAOTONG UNIVERSITY) 25 March 2015 (2015-03-25) entire document	1-16
A	CN 104583053 A (CO.EL.DA. SOFTWARE SRL) 29 April 2015 (2015-04-29) entire document	1-16
A	JP 2018107940 A (NIPPON SHARYO SEIZO K. K.) 05 July 2018 (2018-07-05) entire document	1-16

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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