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(54) INTERCONNECTION AND INTERCOMMUNICATION METHOD AND SYSTEM FOR VIRTUAL FORMATION TRAIN CONTROL SYSTEM OF HEAVY-HAUL RAILWAY

(57) The present invention discloses an interconnection and intercommunication method and system for a virtual marshalling train control system in a heavy haul railway. The method includes: determining a switching area for switching ground equipment between an existing line and a virtual marshalling line; switching a ground equipment control right when a train runs to within a range of the switching area; and after switching of the ground equipment control right is completed, sending, by the ground equipment in the virtual marshalling line, a marshalling command to on-board equipment of the train, and virtually marshalling, by the on-board equipment, the train corresponding to the on-board equipment and a front train in a formation based on the marshalling command. According to the present invention, the switching between different signal systems can be implemented, and the efficiency of train operation can be improved.

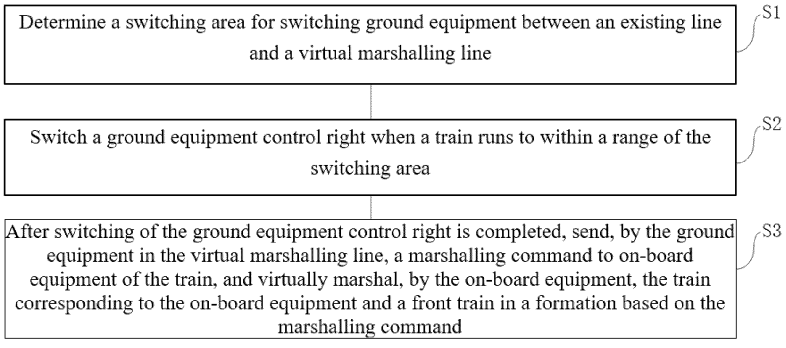

FIG. 1

EP 4 484 247 A1

Description

FIELD OF TECHNOLOGY

[0001] The present invention relates to the technical field of railway transportation, in particular to an interconnection and intercommunication method and system for a virtual marshalling train control system in a heavy haul railway, a storage medium, and an electronic device.

BACKGROUND

[0002] Since the development of heavy haul railway technology in China is limited by existing line station yard lengths of 850 m and 1,050 m, the transport capacity cannot be increased by increasing the number of train formations. On the basis of maximizing the utilization of existing infrastructures, the constraint of a current signal block system regarding a front train as static is broken. On the premise of safety, two or more adjacent trains are virtually marshalled to form a "whole train set" to complete train operation control and transport organization, which can significantly shorten the safety protection distance between the trains in the train set, and reduce the tracking interval of the trains, thus improving the transport capacity of lines.

[0003] At present, the research on virtual marshalling of trains has been carried out in the field of road traffic and rail transit at home and abroad, and the field real train verification has been carried out in the field of urban rail transit, but in the field of railway transportation, especially in the field of heavy haul railways, there is no precedent for the application of virtual marshalling technology and the interconnection and intercommunication between virtual line systems and existing line systems.

SUMMARY

[0004] The present invention aims to solve one of the technical problems in related technologies at least to a certain extent. In view of this, a first objective of the present invention is to provide an interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway, which can implement the switching between different signal systems and improve the efficiency of train operation.

[0005] A second objective of the present invention is to provide an interconnection and intercommunication system for a virtual marshalling train control system in a heavy haul railway.

[0006] A third objective of the present invention is to provide a computer-readable storage medium.

[0007] A fourth objective of the present invention is to provide an electronic device.

[0008] To achieve the above obj ective, the present invention is implemented by the following technical solution:

An interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway includes:

determining a switching area for switching ground equipment between an existing line and a virtual marshalling line;

switching a ground equipment control right when a train runs to within a range of the switching area; and

after switching of the ground equipment control right is completed, sending, by the ground equipment in the virtual marshalling line, a marshalling command to on-board equipment of the train, and virtually marshalling, by the on-board equipment, the train corresponding to the on-board equipment and a front train in a formation based on the marshalling command.

[0009] Optionally, the step of determining a switching area for switching ground equipment between an existing line and a virtual marshalling line includes:

arranging a ground equipment switching balise group in an overlapped co-management area of the virtual marshalling line and the existing line, and setting an area where the ground equipment switching balise group is located as the switching area for switching the ground equipment.

[0010] Optionally, when the train runs to within the range of the switching area, the ground equipment control right is handed over and switched by the on-board equipment of the train.

[0011] Optionally, the step of handing over and switching the ground equipment control right by the on-board equipment of the train includes:

when the train runs to the switching area, sending, by radio block center equipment in the existing line, a ground equipment switching command to the on-board equipment of the train;

receiving, by the on-board equipment, the ground equipment switching command, sending a communication session establishment request instruction to resource management equipment in the virtual marshalling line, and establishing, by the resource management equipment, a communication session with the on-board equipment after receiving the communication session establishment request instruction; and

when the train runs to completely pass through the switching area, performing interaction on ground equipment control right switching information by the established communication session.

[0012] Optionally, after the ground equipment control right is handed over and switched, the method further

includes:

terminating, by the on-board equipment, a communication connection with the radio block center equipment, and performing interaction on train operation safety data with the resource management equipment through the communication session, to complete the switching of the ground equipment.

[0013] Optionally, the method further includes:

when the train runs to a jurisdictional boundary of an existing management system corresponding to the existing line, causing the radio block center equipment to start to perform interaction on the ground equipment switching information with the resource management equipment.

[0014] Optionally, after the switching of the ground equipment is completed, the method further includes:

sending, by the resource management equipment, line resource information; and

receiving, by the on-board equipment, the line resource information, and monitoring an operating condition of the train based on the line resource information.

[0015] Optionally, after the switching of the ground equipment is completed, and before the resource management equipment sends the marshalling command to the on-board equipment, the method further includes:

obtaining, by the resource management equipment, a train marshalling plan, checking a train operation line condition based on the train marshalling plan, and sending the marshalling command to the on-board equipment after checking that the train operation line condition meets a train marshalling condition.

[0016] Optionally, before the on-board equipment virtually marshals the train corresponding to the on-board equipment and the front train in the formation based on the marshalling command, the method further includes:

determining, by the on-board equipment, whether the train meets a marshalling condition based on the marshalling command, and virtually marshalling the train and the front train in the formation when the train meets the marshalling condition.

[0017] Optionally, the step of virtually marshalling, by the on-board equipment, the train corresponding to the on-board equipment and the front train in the formation based on the marshalling command includes:

if the on-board equipment is on-board equipment in a first one of a train set to be marshalled, determining, by the on-board equipment, that the train meets a formation establishment condition, and informing trains in the formation to prepare for marshalling;

establishing, by the on-board equipment, train-train communication between the train and the front train in the formation, and performing interaction on train operation information through the train-train communication; and

calculating, by the on-board equipment, a relative position-based end of movement authority based on operation information of the train and operation information of the front train, and virtually marshalling the train and the front train.

[0018] Optionally, the on-board equipment completes virtual marshalling of the train and the front train in a manner that a tracking distance between the train and the front train is shortened and reaches a preset value.

[0019] Optionally, the operation information includes speed, acceleration and real-time position information of the train.

[0020] Optionally, the on-board equipment for determining whether the train meets the marshalling condition based on the marshalling command is on-board equipment in a first one of a train set to be marshalled.

[0021] To achieve the above objective, a second aspect of the present invention provides an interconnection and intercommunication system for a virtual marshalling train control system in a heavy haul railway, including:

a determination module configured to determine a switching area for switching ground equipment between an existing line and a virtual marshalling line;

a switching module connected to the determination module and configured to switch a ground equipment control right when a train runs to within a range of the switching area; and

a marshalling module connected to the switching module and configured to receive a marshalling command after switching of the ground equipment control right is completed, and virtually marshal the train and a front train in a formation based on the marshalling command.

[0022] To achieve the above objective, a third aspect of the present invention provides a computer-readable storage medium having a computer program stored thereon, where when the computer program is executed by a processor, the above interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway is implemented.

[0023] To achieve the above objective, a fourth aspect of the present invention provides an electronic device, including a processor and a memory, where the memory has a computer program stored thereon, and when the computer program is executed by the processor, the above interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway is implemented.

[0024] The present invention has at least the following technical effects:

1. According to the present invention, the switching area is arranged between the existing line and the virtual marshalling line, the switching of the ground equipment information is completed when the train runs to within the range of the switching area, the marshalling command is sent based on the train marshalling plan after the switching of the ground equipment information, and the virtual marshalling of the trains is completed through the marshalling command, such that the interconnection and intercommunication between an existing line train control system and a virtual marshalling train control system can be effectively implemented, the transport capacity of a freight railway in cross-line operation can be improved, the train set can run in a virtual marshalling mode of shortening the tracking distance between the trains, and the overall operation efficiency of a train operation system can be improved.

2. According to the present invention, after the virtual marshalling train control system is used in the heavy haul railway, the interconnection and intercommunication with the existing train control system can be implemented by sharing common line ground equipment resources and existing train on-board equipment, such that the construction and operation costs of the train operation system can be effectively reduced on the whole.

3. According to the present invention, the interconnection and intercommunication between the virtual marshalling train control system and the existing line train control system can be implemented without stop, seamless switching between the virtual marshalling train control system and the existing train control system can be implemented, the availability of the virtual marshalling train control system can be enhanced, and the popularization and application of the virtual marshalling train control system are facilitated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

FIG. 1 is a flowchart of an interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway provided by an embodiment of the present invention;

FIG. 2 is a schematic arrangement diagram of a ground equipment switching balise provided by an embodiment of the present invention;

FIG. 3 is a working principle diagram of an interconnection and intercommunication system for a virtual marshalling train control system in a heavy haul railway provided by an embodiment of the present invention;

FIG. 4 is a schematic diagram of an interconnection and intercommunication application scenario for a virtual marshalling train control system in a heavy haul railway provided by a first embodiment of the present invention;

FIG. 5 is a schematic diagram of an interconnection and intercommunication interface connection for a virtual marshalling train control system in a heavy haul railway provided by an embodiment of the present invention;

FIG. 6 and FIG. 7 are schematic diagrams of an interconnection and intercommunication application scenario for a virtual marshalling train control system in a heavy haul railway provided by an embodiment of the present invention;

FIG. 8 is a schematic diagram of an overall information flow for a virtual marshalling train control system in a heavy haul railway provided by an embodiment of the present invention; and

FIG. 9 is a structure block diagram of an interconnection and intercommunication system for a virtual marshalling train control system in a heavy haul railway provided by an embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0026] The present invention is further described in detail below with reference to the drawings and specific embodiments. The advantages and features of the present invention are clearer according to description and claims below. It should be noted that the drawings in a very simplified form and with an imprecise scale are only used to conveniently and clearly assist in describing the embodiments of the present invention.

[0027] To solve the technical problems in the background, the present invention provides a method capable of implementing resource sharing in common line areas, saving costs, and improving the efficiency of train operation, that is, a method for interconnection and intercommunication between a virtual marshalling train control system and an existing line train control system in a heavy haul railway. According to the present invention, on the basis of compatibility with existing signal systems in the heavy haul railway, in order to ensure the interconnection and intercommunication between operating lines using virtual marshalling and existing lines, the switching between ground equipment in different signal systems and between ground equipment and on-board equipment can be completed by designing switching areas and switching times of the systems, and based on marshalling plans and marshalling commands issued

by a dispatch center, such that the switching between the different signal systems can be dynamically implemented.

[0028] The interconnection and intercommunication method and system for a virtual marshalling train control system in a heavy haul railway in this embodiment are described below with reference to the drawings.

[0029] FIG. 1 is a flowchart of an interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway provided by an embodiment of the present invention. As shown in FIG. 1, the method includes steps below.

[0030] In step S 1, a switching area for switching ground equipment between an existing line and a virtual marshalling line is determined.

[0031] The step of determining a switching area for switching ground equipment between an existing line and a virtual marshalling line includes:

arranging a ground equipment switching balise group in an overlapped co-management area of the virtual marshalling line and the existing line, and setting an area where the ground equipment switching balise group is located as the switching area for switching the ground equipment.

[0032] Specifically, as shown in FIG. 2, the ground equipment switching balise group can be arranged on an outer side of a station exit in the overlapped co-management area of the virtual marshalling line and the existing line, which serves as a switching area for switching communication between on-board equipment and the ground equipment, where the existing line is a line where an existing line station 1, an interconnection and intercommunication common line station, an existing line station 3, and an existing line station 4 are located, and the virtual marshalling line is a line where the interconnection and intercommunication common line station, a virtual marshalling station 2 and a virtual marshalling station 3 are located.

[0033] In this embodiment, on the premise that the on-board equipment in a virtual marshalling train control system maintains communication with the ground equipment in an existing line train control system, a train pulls out of a station in a train operation mode of the existing line train control system, and then the handover and switching between the on-board equipment and the existing ground equipment or the ground equipment in the virtual marshalling line is completed in the switching area.

[0034] The virtual marshalling train control system includes the on-board equipment and the ground equipment, while the existing line train control system mainly includes the on-board equipment and the corresponding ground equipment. As shown in FIG. 3, the on-board equipment mainly includes an on-board automatic train protection (ATP) host and automatic train operation (ATO) host, a radio communication station, a balise receiving antenna, a Beidou satellite receiver, a speed sensor, a driver machine interface (DMI), an end of train (EOT), etc. The ground equipment in the existing line train control system mainly includes a centralized traffic control (CTC) system in the existing system, a CTC station extension in the existing system, interlocking equipment in the existing system, and a radio block center in the existing system. The ground equipment in the virtual marshalling train control system includes virtual marshalling CTC equipment, a virtual marshalling resource management update (RMU) system, object controller equipment, and a virtual marshalling CTC station extension.

[0035] In step S2, a ground equipment control right is switched when a train runs to within a range of the switching area.

[0036] Specifically, before the train runs to within the range of the switching area, when the train runs to a jurisdictional boundary of an existing management system corresponding to the existing line, radio block center equipment starts to perform interaction on ground equipment switching information with resource management equipment.

[0037] As shown in FIG. 4, when a first train in a train set pulls out of an exit of the interconnection and intercommunication common line station in an existing mode and an end of movement authority of the train reaches the jurisdictional boundary of the existing system, step ① is performed, that is, the radio block center in the existing system starts to perform interaction on the ground equipment switching information with RMU equipment in the virtual marshalling system, namely the above virtual marshalling RMU system.

[0038] Further, when the train runs to within the range of the switching area, the ground equipment control right can be handed over and switched by the on-board equipment of the train.

[0039] In this embodiment, a set of on-board equipment may be used to adapt to the ground equipment in the virtual marshalling line and the ground equipment in the existing line separately. FIG. 5 is a schematic diagram of an interface relationship between existing line equipment and virtual marshalling system equipment provided by an embodiment of the present invention. As shown in FIG. 5, the on-board equipment interacts with the ground equipment in the two systems simultaneously in the switching area, and the ground equipment in the two systems can complete relevant information interaction by the on-board equipment and complete the handover and switching of the ground equipment control right.

[0040] The step of handing over and switching the ground equipment control right by the on-board equipment of the train includes:

[0041] when the train runs to the switching area, sending, by radio block center equipment in the existing line, a ground equipment switching command to the on-board equipment of the train; receiving, by the on-board equipment, the ground equipment switching command, sending a communication session establishment request instruction to resource management equipment in the virtual marshalling line, and establishing, by the resource

management equipment, a communication session with the on-board equipment after receiving the communication session establishment request instruction; and when the train runs to completely pass through the switching area, performing interaction on ground equipment control right switching information by the established communication session.

[0042] After the ground equipment control right is handed over and switched, the method further includes: terminating, by the on-board equipment, a communication connection with the radio block center equipment, and performing interaction on train operation safety data with the resource management equipment through the communication session, to complete the switching of the ground equipment.

[0043] Specifically, as shown in FIG. 4, when the first train runs to the ground equipment switching balise group, step ② is performed, that is, the radio block center in the existing system sends the ground equipment switching command to the on-board equipment, and then step (3) is performed, that is, on-board equipment of the first train calls the RMU equipment in the virtual marshalling system and establishes the communication session, so as to perform interaction on the ground equipment control right switching information through the established communication session. As shown in FIG. 6, when the first train completely passes through the ground equipment switching balise group, step (4) is performed, that is, the ground equipment in the two systems performs interaction on the control right switching information. Further, step (5) is performed, that is, the on-board equipment of the first train terminates the communication connection with the radio block center in the existing system, maintains the connection with the RMU equipment in the virtual marshalling system, and performs interaction on the train operation safety data, to complete the switching of the ground equipment. After the on-board equipment of the first train completes the switching of the ground equipment, the switching of ground equipment control rights of all trains in the train set and the interaction of the train operation safety data are completed in sequence according to steps ①-⑤.

[0044] After the switching of the ground equipment is completed, the method further includes: sending, by the resource management equipment, line resource information; and receiving, by the on-board equipment, the line resource information, and monitoring an operating condition of the train based on the line resource information.

[0045] Specifically, after all the trains in the whole train set pull out of the interconnection and intercommunication common line station in the existing mode, the train set completes the switching of the ground equipment in the switching area, the trains monitor the safe operation thereof based on the line resource information provided by the RMU equipment in the virtual marshalling system, and then the train set runs in a virtual marshalling mode based on a marshalling plan.

[0046] In step S3, after the ground equipment control right is switched, the ground equipment in the virtual marshalling line sends a marshalling command to on-board equipment of the train, and the on-board equipment virtually marshals the train corresponding to the on-board equipment and a train in a formation based on the marshalling command.

[0047] After the switching of the ground equipment is completed, and before the resource management equipment, namely the ground equipment in the virtual marshalling line sends the marshalling command to the on-board equipment, the method further includes: obtaining, by the resource management equipment, a train marshalling plan, checking a train operation line condition based on the train marshalling plan, and sending the marshalling command to the on-board equipment after checking that the train operation line condition meets a train marshalling condition.

[0048] Specifically, as shown in FIG. 7, step ⑥ can be further performed, that is, the virtual marshalling CTC equipment issues the train marshalling plan to the RMU equipment in the virtual marshalling system, and the RMU equipment in the virtual marshalling system checks the train operation line condition based on the train marshalling plan; and step ⑦ is performed, that is, the virtual marshalling command is sent to the train set.

[0049] Before the on-board equipment virtually marshals the train corresponding to the on-board equipment and the front train in the formation based on the marshalling command, the method further includes: determining, by the on-board equipment, whether the train meets a marshalling condition based on the marshalling command, and virtually marshalling the train and the front train in the formation when the train meets the marshalling condition. According to the marshalling command, on-board equipment in a first one of a train set to be marshalled runs forward at a maximum speed based on the line condition and the train condition.

[0050] In this embodiment, after all the on-board equipment in the whole train set with the virtual marshalling train control system completes switching of communication with the ground equipment, the first train running in the whole train set can check a virtual formation establishment condition based on the marshalling plan and the marshalling command issued by the ground equipment in the virtual marshalling train control system, and prepares to switch to the virtual marshalling mode.

[0051] In one embodiment of the present invention, the step of virtually marshalling, by the on-board equipment, the train corresponding to the on-board equipment and the front train in the formation based on the marshalling command includes: if the on-board equipment is on-board equipment in a first one of a train set to be marshalled, determining, by the on-board equipment, that the train meets a formation establishment condition, and informing trains in the formation to prepare for marshalling; establishing, by the on-board equipment, train-train communication between the train and the front train in the

formation, and performing interaction on train operation information through the train-train communication; and calculating, by the on-board equipment, a relative position-based end of movement authority based on operation information of the train and operation information of the front train, and virtually marshalling the train and the front train in the formation. The on-board equipment completes virtual marshalling of the train and the front train in a manner that a tracking distance between the train and the front train is shortened and reaches a preset value. In this embodiment, the operation information includes speed, acceleration and real-time position information of the train.

[0052] Specifically, as shown in FIG. 7, after the first train running in the train set checks that the marshalling condition is met based on the marshalling command, the trains in the train set can establish the train-train communication connection therebetween and perform interaction on the train operation information, such as the speed, acceleration and real-time position information of the train, through the established train-train communication, and step ⑧ is performed, that is, the train and the front train in the formation are virtually marshalled based on the current operation information of the train and the current operation information of the front train. The specific train can track the front train in the virtual marshalling mode to gradually shorten the tracking distance from the front train. When front and rear trains keep a stable running interval and run in coordination with a virtual formation, dynamic marshalling of interconnection and intercommunication sections can be implemented.

[0053] In this embodiment, the trains in the whole train set perform interaction on the operation information through the train-train communication, and after a mode conversion condition is met, the train set runs in the virtual marshalling mode, such that the train set can dynamically complete the conversion of a virtual marshalling coordinated operation mode in the interconnection and intercommunication sections. It should be noted that the virtual marshalling train control system in this embodiment has a function of cross-line operation from the existing line to the virtual marshalling line, and also has a function of cross-line operation from the virtual marshalling line to the existing line. Thus, the virtual marshalling train control system in this embodiment can complete the switching of the ground equipment under the condition that the train does not stop in a switching section, and complete the virtual marshalling of the train set, thereby implementing the switching between different signal systems, and improving the efficiency of train operation.

[0054] As a specific example, as shown in FIG. 8, the CTC system can send a train plan to the radio block center in the existing system and the virtual marshalling RMU system, namely a resource management center in the virtual marshalling system. When the first train in the train set runs to the ground equipment switching balise group, the radio block center in the existing system and the virtual marshalling RMU system complete the switching of the ground equipment based on the train plan and by the on-board equipment; after completing the switching of the ground equipment, the on-board equipment terminates the communication with the ground equipment in the existing train control system; the ground equipment in the virtual marshalling train control system issues the marshalling command to on-board equipment CC1 and on-board equipment CC2 in the whole train set in a timely manner based on the marshalling plan issued by the CTC system; and the on-board equipment CC1 and the on-board equipment CC2 establish the communication between the trains based on the marshalling command and complete dynamic marshalling.

[0055] FIG. 9 is a structure block diagram of an interconnection and intercommunication system for a virtual marshalling train control system in a heavy haul railway provided by an embodiment of the present invention. As shown in FIG. 9, the interconnection and intercommunication system 10 for a virtual marshalling train control system in a heavy haul railway includes a determination module 11, a switching module 12, and a marshalling module 13. The determination module 11 is configured to determine a switching area for switching ground equipment between an existing line and a virtual marshalling line; the switching module 12 is connected to the determination module 11 and configured to switch a ground equipment control right when a train runs to within a range of the switching area; and the marshalling module 13 is connected to the switching module 12 and configured to receive a marshalling command after switching of the ground equipment control right is completed, and virtually marshal the train and a front train in a formation based on the marshalling command.

[0056] Specifically, an overlapped co-management area of the virtual marshalling line and the existing line can be first determined by the determination module 11, and a ground equipment switching balise group is arranged in the overlapped co-management area, to determine the switching area for switching the ground equipment between the existing line and the virtual marshalling line. When a train in a train set runs to the switching area, the determination module 11 sends out a determination instruction that the train runs to the switching area. After receiving the determination instruction, the switching module 12 confirms that the train runs to the switching area, then switches the ground equipment control right by the on-board equipment, and sends out a ground equipment switching completion instruction. After receiving the ground equipment switching completion instruction, the marshalling module 13 confirms that the switching of the ground equipment control right is completed, receives a marshalling command sent by a virtual marshalling RMU system based on a marshalling plan issued by virtual marshalling CTC equipment, and then performs virtual marshalling on the corresponding train and the front train in the formation based on the marshalling command, such that the train set can dyna-

mically complete the conversion of a virtual marshalling coordinated operation mode in interconnection and intercommunication sections.

[0057] It should be noted that, for a specific embodiment of the interconnection and intercommunication system for a virtual marshalling train control system in a heavy haul railway in this embodiment, reference may be made to the specific embodiment of the interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway. In order to avoid redundancy, it will not be repeated herein.

[0058] Further, the present invention provides a computer-readable storage medium having a computer program stored thereon, where when the computer program is executed by a processor, the above interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway is implemented.

[0059] Further, the present invention provides an electronic device, including a processor and a memory, where the memory has a computer program stored thereon, and when the computer program is executed by the processor, the above interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway is implemented.

[0060] In summary, according to the present invention, on the basis of compatibility with existing signal systems in the heavy haul railway, in order to ensure the interconnection and intercommunication between operating lines using virtual marshalling and existing lines, the switching between ground equipment in different signal systems and between ground equipment and on-board equipment can be completed by designing switching areas and switching times of the systems, and based on marshalling plans and marshalling commands issued by a dispatch center, such that the switching between the different signal systems can be dynamically implemented, the transport capacity of a freight railway in cross-line operation can be improved, the train set can run in a virtual marshalling mode of shortening the operating distance between the trains, and the overall operation efficiency of a train operation system can be improved; moreover, according to the present invention, after the virtual marshalling train control system is used in the heavy haul railway, the interconnection and intercommunication with the existing train control system can be implemented by sharing common line ground equipment resources and existing train on-board equipment, such that the construction and operation costs of the train operation system can be effectively reduced on the whole; and according to the present invention, the interconnection and intercommunication between the virtual marshalling train control system and the existing line train control system can be implemented without stop, seamless switching between the virtual marshalling train control system and the existing train control system can be implemented, the availability of the virtual marshalling train control system can be enhanced, and the popularization and application of the virtual marshalling train control system are facilitated.

[0061] While the content of the present invention has been described in detail with the above preferred embodiment, it should be recognized that the above description should not be considered as a limitation to the present invention. Various modifications and alternatives to the present invention will become apparent to those skilled in the art upon reading the above content. Therefore, the scope of protection of the present invention should be limited by the appended claims.

Claims

1. An interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway, comprising:

   determining a switching area for switching ground equipment between an existing line and a virtual marshalling line;
   switching a ground equipment control right when a train runs to within a range of the switching area; and
   after switching of the ground equipment control right is completed, sending, by the ground equipment in the virtual marshalling line, a marshalling command to on-board equipment of the train, and virtually marshalling, by the on-board equipment, the train corresponding to the on-board equipment and a front train in a formation based on the marshalling command.

2. The interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to claim 1, wherein the step of determining a switching area for switching ground equipment between an existing line and a virtual marshalling line comprises:
   arranging a ground equipment switching balise group in an overlapped co-management area of the virtual marshalling line and the existing line, and setting an area where the ground equipment switching balise group is located as the switching area for switching the ground equipment.

3. The interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to claim 2, wherein when the train runs to within the range of the switching area, the ground equipment control right is handed over and switched by the on-board equipment of the train.

4. The interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to claim 3, wherein the

step of handing over and switching the ground equipment control right by the on-board equipment of the train comprises:

when the train runs to the switching area, sending, by radio block center equipment in the existing line, a ground equipment switching command to the on-board equipment of the train;
receiving, by the on-board equipment, the ground equipment switching command, sending a communication session establishment request instruction to resource management equipment in the virtual marshalling line, and establishing, by the resource management equipment, a communication session with the on-board equipment after receiving the communication session establishment request instruction; and
when the train runs to completely pass through the switching area, performing interaction on ground equipment control right switching information by the established communication session.

5. The interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to claim 4, wherein after the ground equipment control right is handed over and switched, the method further comprises:
terminating, by the on-board equipment, a communication connection with the radio block center equipment, and performing interaction on train operation safety data with the resource management equipment through the communication session, to complete the switching of the ground equipment.

6. The interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to claim 5, further comprising:
when the train runs to a jurisdictional boundary of an existing management system corresponding to the existing line, causing the radio block center equipment to start to perform interaction on the ground equipment switching information with the resource management equipment.

7. The interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to claim 6, wherein after the switching of the ground equipment is completed, the method further comprises:

sending, by the resource management equipment, line resource information; and
receiving, by the on-board equipment, the line resource information, and monitoring an operating condition of the train based on the line resource information.

8. The interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to claim 7, wherein after the switching of the ground equipment is completed, and before the resource management equipment sends the marshalling command to the on-board equipment, the method further comprises:
obtaining, by the resource management equipment, a train marshalling plan, checking a train operation line condition based on the train marshalling plan, and sending the marshalling command to the on-board equipment after checking that the train operation line condition meets a train marshalling condition.

9. The interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to claim 8, wherein before the on-board equipment virtually marshals the train corresponding to the on-board equipment and the front train in the formation based on the marshalling command, the method further comprises:
determining, by the on-board equipment, whether the train meets a marshalling condition based on the marshalling command, and virtually marshalling the train and the front train in the formation when the train meets the marshalling condition.

10. The interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to claim 9, wherein the step of virtually marshalling, by the on-board equipment, the train corresponding to the on-board equipment and the front train in the formation based on the marshalling command comprises:

if the on-board equipment is on-board equipment in a first one of a train set to be marshalled, determining, by the on-board equipment, that the train meets a formation establishment condition, and informing trains in the formation to prepare for marshalling;
establishing, by the on-board equipment, train-train communication between the train and the front train in the formation, and performing interaction on train operation information through the train-train communication; and
calculating, by the on-board equipment, a relative position-based end of movement authority based on operation information of the train and operation information of the front train, and virtually marshalling the train and the front train.

11. The interconnection and intercommunication method for a virtual marshalling train control system in a

heavy haul railway according to claim 10, wherein the on-board equipment completes virtual marshalling of the train and the front train in a manner that a tracking distance between the train and the front train is shortened and reaches a preset value.

12. The interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to claim 10, wherein the train operation information comprises speed, acceleration and real-time position information of the train.

13. The interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to claim 9, wherein the on-board equipment for determining whether the train meets the marshalling condition based on the marshalling command is on-board equipment in a first one of a train set to be marshalled.

14. An interconnection and intercommunication system for a virtual marshalling train control system in a heavy haul railway, comprising:

a determination module configured to determine a switching area for switching ground equipment between an existing line and a virtual marshalling line;
a switching module connected to the determination module and configured to switch a ground equipment control right when a train runs to within a range of the switching area; and
a marshalling module connected to the switching module and configured to receive a marshalling command after switching of the ground equipment control right is completed, and virtually marshal the train and a front train in a formation based on the marshalling command.

15. A computer-readable storage medium having a computer program stored thereon, wherein when the computer program is executed by a processor, the interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to any one of claims 1 to 13 is implemented.

16. An electronic device, comprising a processor and a memory, wherein the memory has a computer program stored thereon, and when the computer program is executed by the processor, the interconnection and intercommunication method for a virtual marshalling train control system in a heavy haul railway according to any one of claims 1 to 13 is implemented.

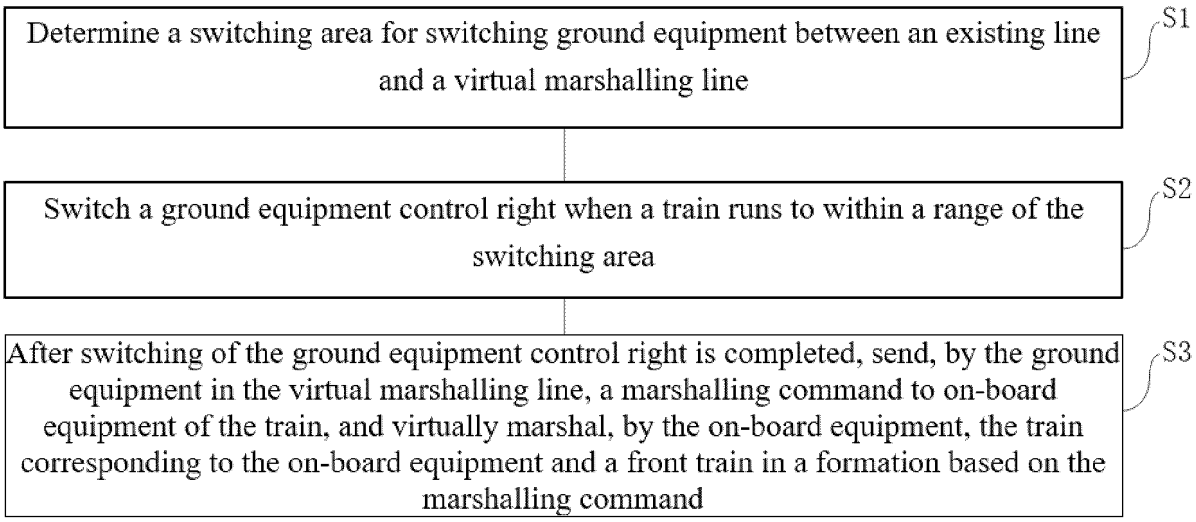
Determine a switching area for switching ground equipment between an existing line and a virtual marshalling line
S1
Switch a ground equipment control right when a train runs to within a range of the switching area
S2
After switching of the ground equipment control right is completed, send, by the ground equipment in the virtual marshalling line, a marshalling command to on-board equipment of the train, and virtually marshal, by the on-board equipment, the train corresponding to the on-board equipment and a front train in a formation based on the marshalling command
S3

FIG. 1

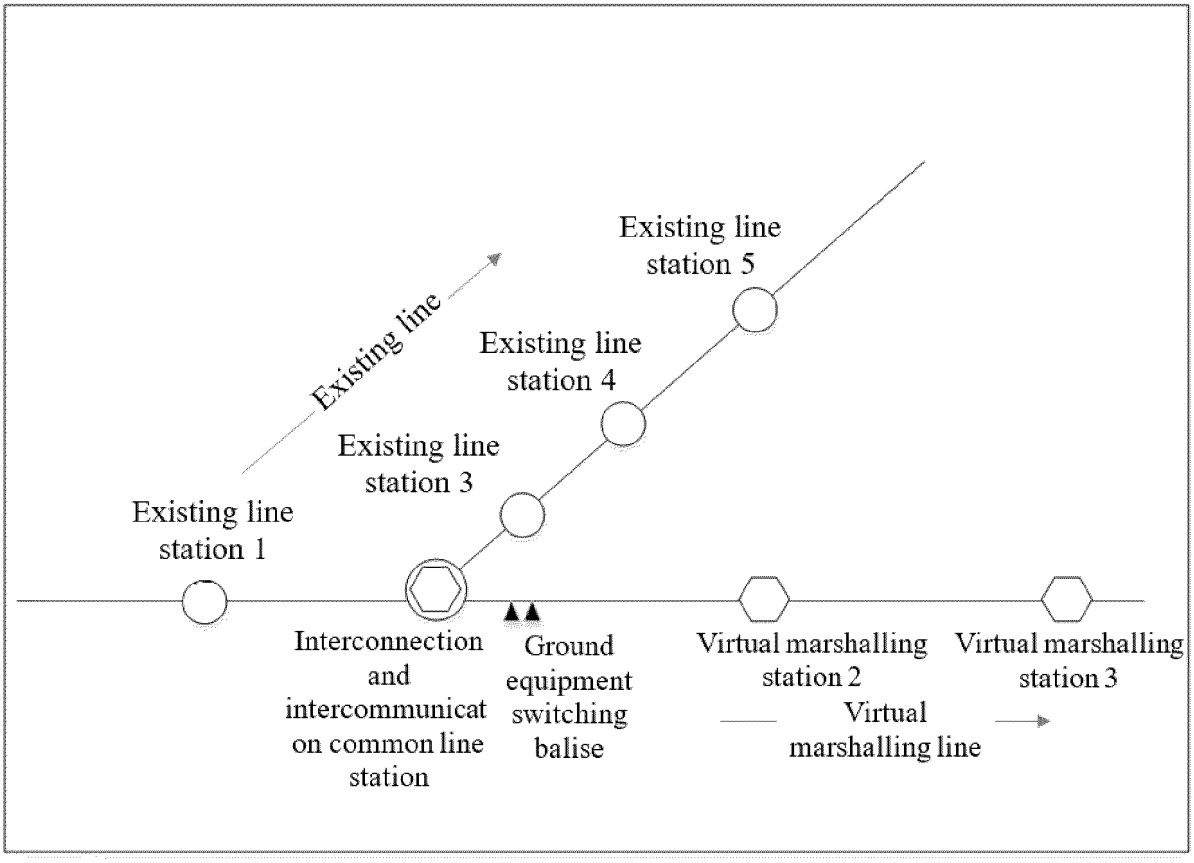
Existing line
Existing line station 1
Existing line station 3
Existing line station 4
Existing line station 5
Interconnection and intercommunicat on common line station
Ground equipment switching balise
Virtual marshalling station 2
Virtual marshalling station 3
Virtual marshalling line

FIG. 2

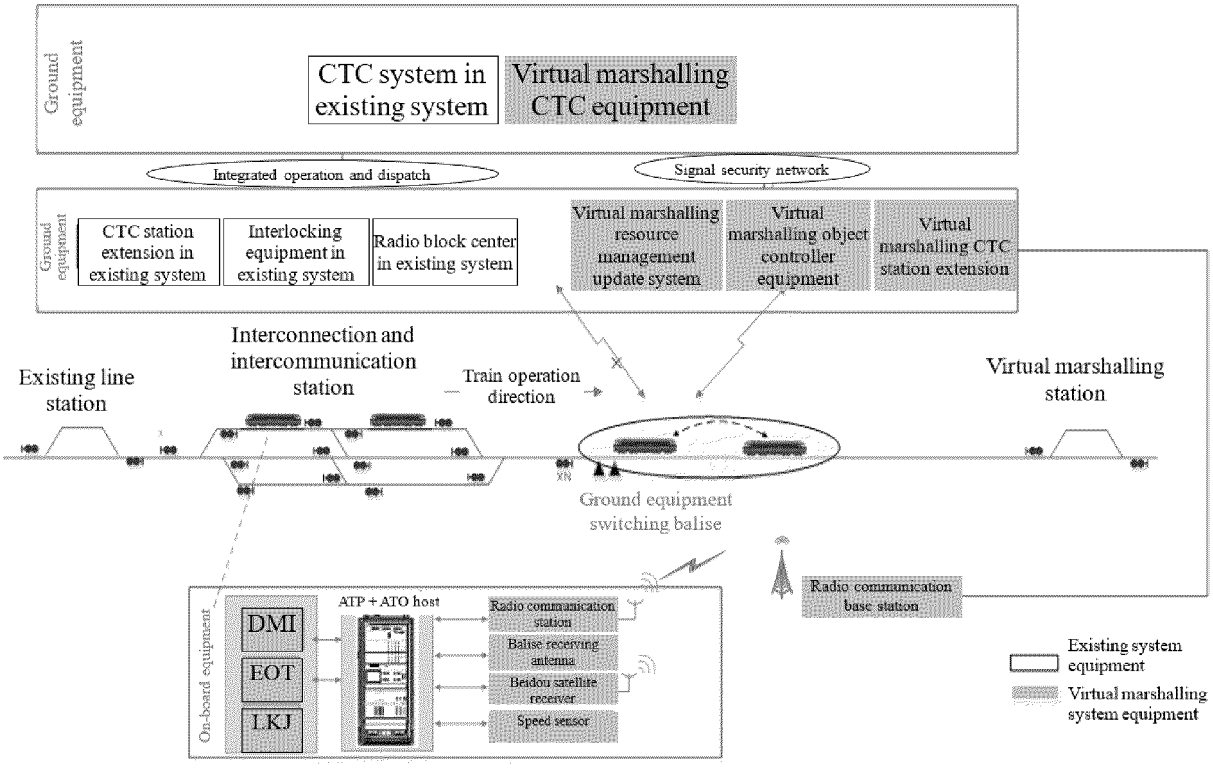
Ground equipment
CTC system in existing system
Virtual marshalling CTC equipment
Integrated operation and dispatch
Signal security network
Ground equipment
CTC station extension in existing system
Interlocking equipment in existing system
Radio block center in existing system
Virtual marshalling resource management update system
Virtual marshalling object controller equipment
Virtual marshalling CTC station extension
Existing line station
Interconnection and intercommunication station
Train operation direction
Virtual marshalling station
XN
Ground equipment switching balise
Radio communication base station
On-board equipment
DMI
EOT
LKJ
ATP + ATO host
Radio communication station
Balise receiving antenna
Beidou satellite receiver
Speed sensor
Existing system equipment
Virtual marshalling system equipment

FIG. 3

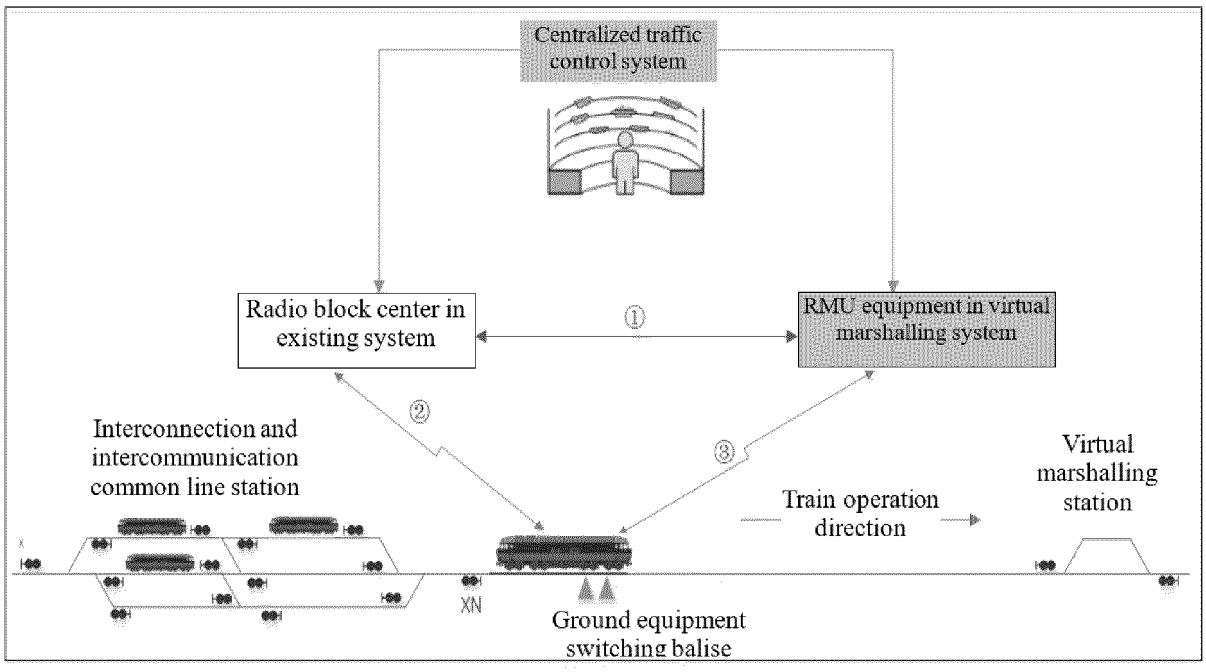
Centralized traffic control system
Radio block center in existing system
①
RMU equipment in virtual marshalling system
②
③
Interconnection and intercommunication common line station
Train operation direction
Virtual marshalling station
XN
Ground equipment switching balise

FIG. 4

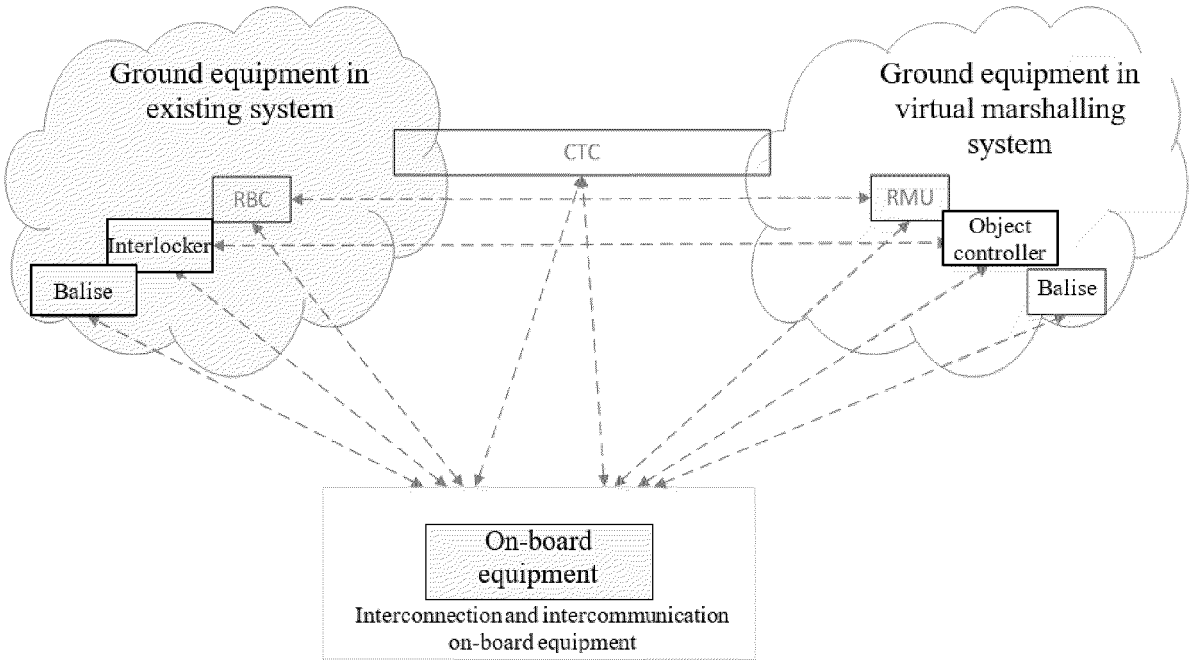
Ground equipment in existing system
CTC
Ground equipment in virtual marshalling system
RBC
RMU
Interlocker
Object controller
Balise
Balise
On-board equipment
Interconnection and intercommunication on-board equipment

FIG. 5

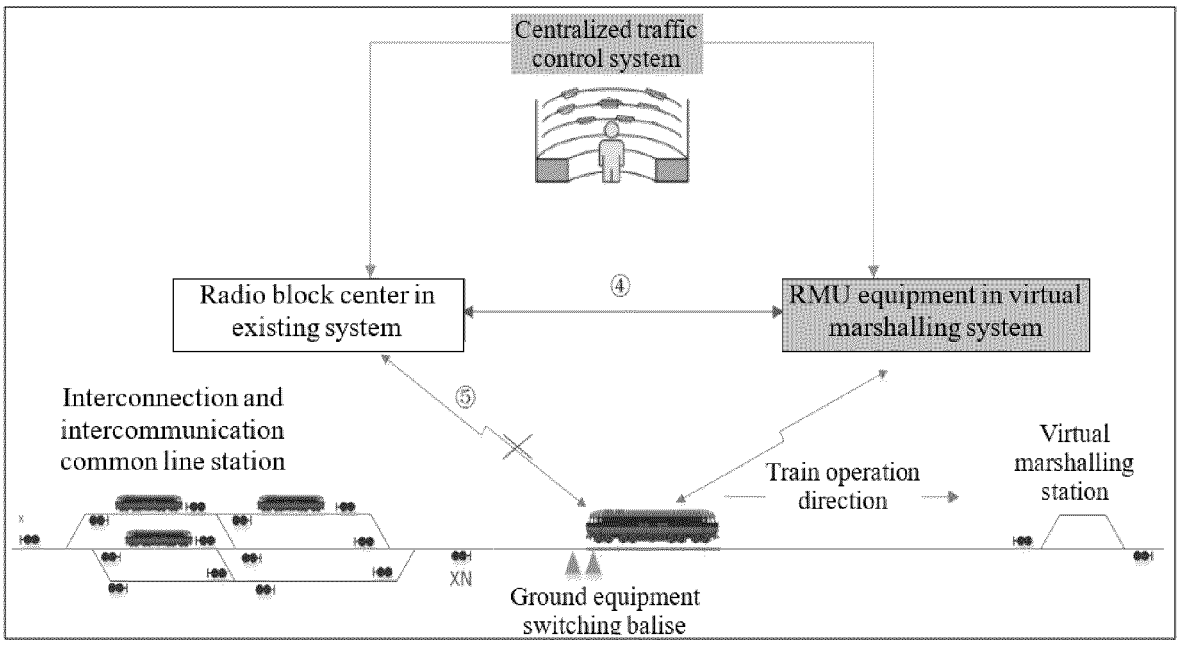
Centralized traffic control system
Radio block center in existing system
④
RMU equipment in virtual marshalling system
⑤
Interconnection and intercommunication common line station
Train operation direction
Virtual marshalling station
XN
Ground equipment switching balise

FIG. 6

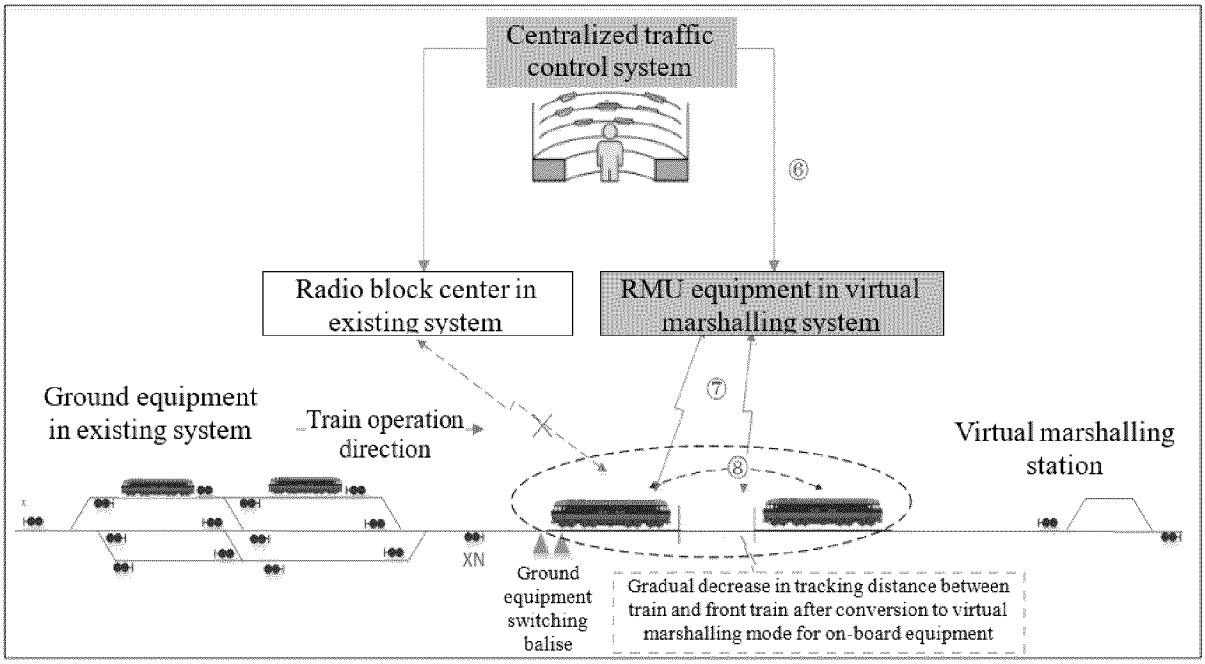
Centralized traffic control system
⑥
Radio block center in existing system
RMU equipment in virtual marshalling system
⑦
Ground equipment in existing system
Train operation direction
⑧
Virtual marshalling station
XN
Ground equipment switching balise
Gradual decrease in tracking distance between train and front train after conversion to virtual marshalling mode for on-board equipment

FIG. 7

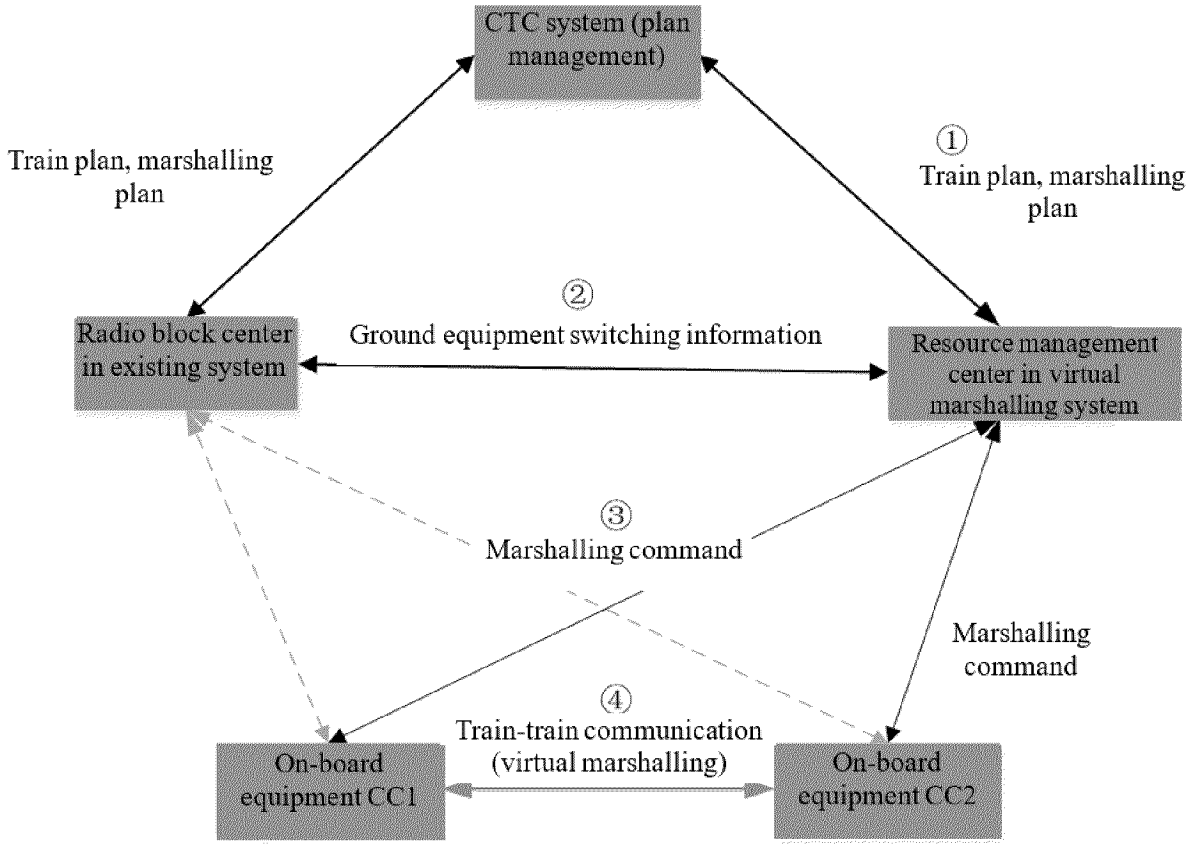
CTC system (plan management)
Train plan, marshalling plan
①
Train plan, marshalling plan
②
Radio block center in existing system
Ground equipment switching information
Resource management center in virtual marshalling system
③
Marshalling command
Marshalling command
④
Train-train communication (virtual marshalling)
On-board equipment CC1
On-board equipment CC2

FIG. 8

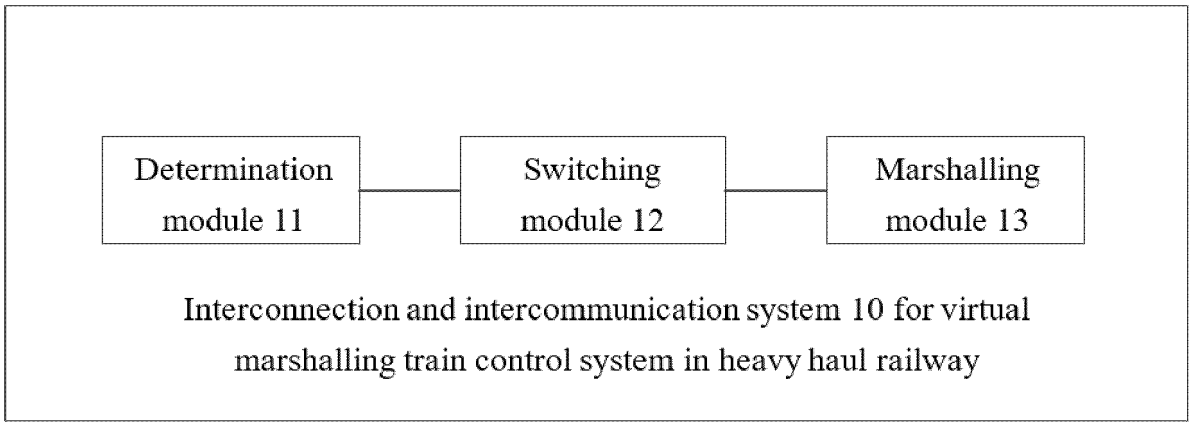
Determination module 11
Switching module 12
Marshalling module 13
Interconnection and intercommunication system 10 for virtual marshalling train control system in heavy haul railway

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/131343

A. CLASSIFICATION OF SUBJECT MATTER

B61L15/00(2006.01)i;B61L23/14(2006.01)i;B61L1/00(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)

CNKI, CJFD, WPABSC, CNTXT, ENTXTC, VEN: 列车, 编组, 虚拟编组, 车车通信, 协同, 切换, 交接, 边界, 交界, 前车, 应答器, train, consist, virtual consist, car communication, cooperation, handover, boundary, front car, transponder

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 113911181 A (TONGJI UNIVERSITY) 11 January 2022 (2022-01-11) description, paragraphs [0067]-[0104], and figures 1-8	1-16
A	CN 107685749 A (SIGNAL & COMMUNICATION RESEARCH INSTITUTE OF CHINA ACADEMY OF RAILWAY SCIENCES et al.) 13 February 2018 (2018-02-13) entire document	1-16
A	CN 112519836 A (TRAFFIC CONTROL TECHNOLOGY CO., LTD.) 19 March 2021 (2021-03-19) entire document	1-16
A	CN 113247051 A (BEIJING NATIONAL RAILWAY RESEARCH & DESIGN INSTITUTE OF SIGNAL & COMMUNICATION LTD.) 13 August 2021 (2021-08-13) entire document	1-16
A	JP 2002279579 A (TOSHIBA K. K.) 27 September 2002 (2002-09-27) 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
"D" document cited by the applicant in the international application
"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
24 March 2023	**04 April 2023**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/131343

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 113911181 A	11 January 2022	None	
CN 107685749 A	13 February 2018	None	
CN 112519836 A	19 March 2021	None	
CN 113247051 A	13 August 2021	None	
JP 2002279579 A	27 September 2002	None	

Form PCT/ISA/210 (patent family annex) (July 2022)