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(54) **TRAIN MOVEMENT AUTHORIZATION CONTROLLING METHOD**

(57) The present disclosure provides a method for performing mobile authorization control on a train, comprising: sending, by a radio blocking center (RBC), a conditional emergency stop (CEM) message to the train according to an occupancy situation of a block section, judging, by the train, whether or not a current position of the train passes a position of an emergency stop point based on the message, and determining whether or not to execute the CEM message. The present disclosure can avoid a situation that the train stops by emergency brake, in a case where the train has a higher running speed or a greater position report interval.

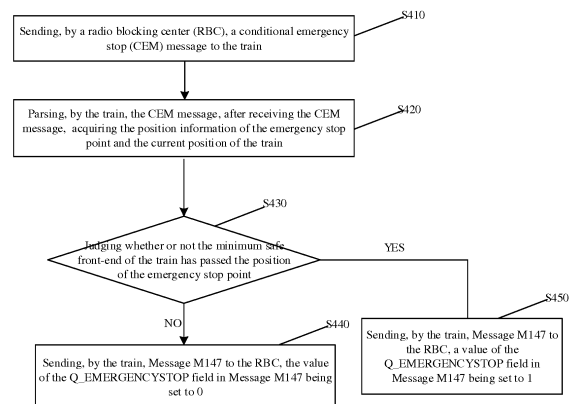


FIG. 4

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**Description**

**[0001]** The present application claims priority of Chinese Patent Application No. 201710983669.0 filed on October 20, 2017, the disclosure of which is incorporated herein by reference in its entirety as part of the present application.

TECHNICAL FIELD

**[0002]** The present disclosure relates to a technical field of train operation, and more particularly, to a method for performing movement authority control on a train.

BACKGROUND

**[0003]** When a train is running, a radio blocking center (RBC) sends movement authority including a plurality of block sections or routes to Train A according to a block section or route state on a line; FIG. 1 is a schematic diagram of the routes after RBC sending movement authority covering a plurality of block sections to the train. Here, the number of block sections or routes covered by movement authority includes 3 or more (including the block section or the route wherein the train is located).

**[0004]** If a block section or a route (with a case where the block section or the route where the train is located is separated by 1 or more block section or route as an example) within a movement authority range in front of the train is in an occupied state, at this time, movement authority sent by the RBC to the train is shortened to a starting point of the block section or the route occupied, FIG. 2 is a schematic diagram of the RBC sending Shortened Movement Authorization (SMA) to the train.

**[0005]** As shown in FIG. 2, the RBC sends shortened movement authorization to the train via Message 3 (movement authority); a message format of M3 is shown in Table 1 below;

Table 1 Message 3: movement authority

Section serial number	Variable/packet	Bits	Description	Value	Notes
1	NID_MESSAGE	8	Message identification number	3	
2	L_MESSAGE	10	Message length	Depends on packet content included	
3	T_TRAIN	32	Vehicle device clock	Depends on message sending time	
4	M_ACK	1	Determiner for confirming a request	1	After the message is received, confirmation must be returned
5	NID_LRBG	24	Identification number of the last relevant balise group	NID_LRBG in a latest train position report	
6	CTCS-Class 3 movement authority				Packet 15
7	Link Information		Optional		Packet 5
8	Slope curve		Optional		Packet 21
9	Static speed curve		Optional		Packet 27
10	Configuration parameters		Optional		Packet 3

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(continued)

Section serial number	Variable/packet	Bits	Description	Value	Notes
11	Class conversion commands		Optional		Packet 41
12	Setting temporary speed limit		Optional		Packet 65
13	Line condition		Optional		Packet 68
14	Guidance/ Setting of a shunting section		Optional		Packet 80

**[0006]** After receiving the SMA, the train shall take corresponding safety measures (for example, emergency brake), and return a confirmation message to the RBC; the confirmation message is Message 146 shown in Table 2 below.

Table 2 Message 146

Section serial number	Variable/packet	Bits	Description	Value	Notes
1	NID_MESSAGE	8	Message identification number	146	
2	L_MESSAGE	10	Message length	14	
3	T_TRAIN	32	Vehicle device clock	Depends on message sending time	
4	NID_ENGINE	24	CTCS identification number of a vehicle device	Depends on configuration parameters of the vehicle device	
5	T_TRAIN	32	Vehicle device clock	Depends on a timestamp of a message confirmed	Timestamp included in the message being confirmed

**[0007]** After receiving the confirmation message from the train, the RBC believes that the train has accepted the SMA, and that the train has taken appropriate safety measures (for example, emergency brake).

**[0008]** When the train receives the SMA, if the train's position has not passed the terminal point of the SMA, a measure of emergency brake is taken to ensure that the train stops before the terminal point of the SMA. When the train receives the SMA, if the train's position has passed the terminal point of the SMA, the train will turn into an overrun mode, and a measure of maximum service brake will be taken for stopping the train.

**[0009]** A disadvantage of the solution in the above-described prior art that the RBC sends the SMA scheme to the train is that: when running, the train sends a position report based on the balise to the RBC (Message M136), and the RBC locates a specific position of the train on the line according to the received position information. However, the train sends the position information to the RBC at preset intervals, which is once every few seconds in a case where radio connection between the train and the RBC is normal; while in a case where radio connection is delayed or interrupted, the RBC receives two pieces of position information at longer intervals. Therefore, the position information of the train received by the RBC is hopping; a distance for the train position to hop is proportional to a train's operation speed; that is to say, the higher the train's operation speed, the greater the distance for the train position to hop. The distance for the train position to hop is proportional to a position information sending interval, that is, the longer the sending interval, the greater the distance for the train position to hop.

**[0010]** FIG. 3 is a schematic diagram of relationship between the train position hop and occupancy; the train sends a position report to the RBC at "Position 1", and receives movement authority sent by the RBC. Thereafter, the train normally runs forward, sequentially occupies Sections N3->N5 and N5->N7, and sends a position report again to the RBC at "Position 2". A dotted line segment in FIG. 3 indicates the train's movement authority, and a solid line segment indicates the track section occupancy; it is assumed that a track section has a length of  $L_{\text{track}}$ , the train's running distance within the train position hop time is  $L_{\text{move}}$ , i.e., the train's running distance within the train position hop time is greater than the track section length.

**[0011]** The RBC sequentially receives occupancy information of the two sections, and according to Position 1 of the train, sequentially sends the SMA to the train; the SMA's stop points are N3 and N5, and at this time, the train needs to accept the SMA's stop points unconditionally. At this time, when the train has a higher operation speed, the train has passed the stop point of N5, which will cause the train to stop by emergency brake. A reason for the phenomenon is that: a case where the train has a higher operation speed or a greater position report interval is not taken into account. Therefore, application of the SMA strategy may cause a problem that availability is affected by brake for train stopping.

## SUMMARY

**[0012]** Embodiments of the present disclosure provide a method for performing mobile authorization control on a train, to implement effective movement -authority control of the train.

**[0013]** In order to achieve the above-described objective, the present disclosure uses technical solutions as follows: A method for performing movement authority control on a train, comprising:

Sending, by a radio blocking center (RBC), a conditional emergency stop (CEM) message to the train;  
 Acquiring, by the train, position information of an emergency stop point according to the CEM message, after receiving the CEM message, and acquiring a current position of the train through a positioning system;  
 Judging, by the train, whether or not the current position of the train has passed the position of the emergency stop point, and judging whether or not to execute the CEM message according to the judgement result.

**[0014]** Further, the sending, by a radio blocking center (RBC), a conditional emergency stop (CEM) message to the train, includes:

Sending, by the radio blocking center (RBC), the CEM message to the train, if the RBC determines that there is block section occupancy or abnormality occurring within a range of movement authority it sends to the train, the occupied or abnormal block section is not a block section adjacent to the block section where the train is located in a train operation direction.

**[0015]** Further, the CEM message includes a NID\_LRBG field, a D\_EMERGENCYSTOP field, and an M ACK field; a value of the NID\_LRBG field indicates an identification number of a last relevant balise group in a latest train position report, a value of the D\_EMERGENCYSTOP field indicates a distance value between the last relevant balise group (LRBG) and the emergency stop point in the latest train position report, and a value of the M ACK field is 0, which indicates that it is not necessary to return confirmation, after the message is received.

**[0016]** Further, the acquiring, by the train, position information of an emergency stop point according to the shortened movement authorization information included in the CEM message, after receiving the CEM message, includes:

Parsing, by the train, the CEM message, after receiving the CEM message, and querying pre-stored position planning information in the last relevant balise group (LRBG) according to an identification number of the last relevant balise group (LRBG) in the NID\_LRBG field in the CEM message, acquiring the position information of the last relevant balise group (LRBG), acquiring the distance value between the last relevant balise group (LRBG) and the emergency stop point according to the D\_EMERGENCYSTOP field, and adding the distance value to the position information of the last relevant balise group (LRBG), to obtain the position information of the emergency stop point.

**[0017]** Further, the judging, by the train, whether or not the current position of the train has passed the position of the emergency stop point, and judging whether or not to execute the CEM message according to the judgement result, includes:

Acquiring, by the train, the current position of the train through the positioning system, acquiring a minimum safe front-end position of the train according to the current position of the train, and judging whether or not a minimum safe front-end value of the train has passed the position of the emergency stop point, and if so, ignoring, by the train, the CEM message; otherwise, accepting, by the train, the CEM message, and stopping normally when a subsequent train runs to the position of the emergency stop point.

**[0018]** Further, the ignoring, by the train, the CEM message, includes:

Sending, by the train, Message M147 to the RBC, a value of the Q\_EMERGENCYSTOP field in Message M147 being set to 1, and the ignoring, by the train, the CEM message, which indicates that the occupancy is occupancy by the train itself; after receiving Message M147, continuing to control, by the RBC, the train according to movement authorization

before sending the CEM message.

**[0019]** Further, the accepting, by the train, the CEM message, and stopping normally when a subsequent train runs to the position of the emergency stop point, includes:

Sending, by the train, Message M147 to the RBC, the value of the Q\_EMERGENCYSTOP field in Message M147 being set to 0, accepting, by the train, the CEM, and stopping normally when a subsequent train runs to the position of the emergency stop point.

**[0020]** As can be seen from the technical solutions provided by the above-described embodiments of the present disclosure, after the train receives the CEM message, it is judged whether or not the current position of the train passes the position of the emergency stop point, and it is judged whether or not to execute the CEM message according to the judgement result, which may avoid a situation that the train stops by emergency brake, in a case where the train has a higher running speed or a greater position report interval.

**[0021]** Additional aspects and advantages of the present disclosure will be provided partially in description below, which will become apparent from the description below, or may be learned by practice of the present disclosure.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**[0022]** In order to clearly illustrate the technical solutions of the embodiments of the present disclosure, the drawings of the embodiments will be briefly described in the following; it is obvious that the described drawings are only related to some embodiments of the present disclosure, those of ordinary skill in the art can also obtain other drawings based on these drawings without any inventive work.

FIG. 1 is a schematic diagram of an RBC sending movement authority covering a plurality of block sections or routes to a train in the prior art;

FIG. 2 is a schematic diagram of the RBC sending shortened movement authorization to the train in the prior art;

FIG. 3 is a schematic diagram of relationship between train position hop and occupancy in the prior art;

FIG. 4 is a processing flow chart of a method for performing movement authority control on a train provided by an embodiment of the present disclosure.

**DETAILED DESCRIPTION**

**[0023]** Embodiments of the present disclosure are described in detail below, and examples of implementation modes are illustrated in the accompanying drawings, wherein same or similar reference signs denote same or similar elements, or elements having same or similar functions from beginning to end. The embodiments described below with reference to the accompanying drawings are exemplary, which are used for explaining the present disclosure only, and cannot be construed as limitation to the present disclosure.

**[0024]** In order to facilitate understanding of the embodiments of the present disclosure, several specific embodiments will be taken as example for further explanation and description below in conjunction with the accompanying drawings, and respective embodiments do not constitute limitation to the embodiments of the present disclosure.

**[0025]** A processing flow of a method for performing movement authority control on a train provided by an embodiment of the present disclosure is shown in FIG. 4, and comprises steps of:

Step S410: sending, by an RBC, a conditional emergency stop (CEM) message carrying shortened movement authorization information to the train.

**[0026]** When the RBC judges there is block section occupancy or abnormality occurring within a range of movement authority it sends to the train, and the occupied or abnormal block section is not a block section adjacent to the block section where the train is located in a train operation direction, i.e., not a next block section of the block section where the train is located in the train operation direction, but a second or subsequent block section of the block section in the train operation direction, then the RBC sends the CEM message with shortened movement authorization information to the train.

**[0027]** A format of the CEM message is shown in Table 3 below;

Table 3

Section serial number	Variable/packet	Bits	Description	Value	Notes
1	NID_MESSAGE	8	Message identification number	15	

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(continued)

Section serial number	Variable/packet	Bits	Description	Value	Notes
2	L_MESSAGE	10	Message length	13	
3	T_TRAIN	32	Vehicle device clock	Depends on message sending time	
4	M_ACK	1	Determiner for confirming a request	0	Not necessary to return confirmation, after the message is received
5	NID_LRBG	10+14	Identification number of the last relevant balise group	NID_LRBG in a latest train position report	
6	NID_EM	4	Emergency message identification number	1~15	Identification number of emergency stop message
7	Q_SCALE	2	Distance scale determiner	1 (1m)	
8	Q_DIR	2	Validity direction of data transmission	1 (Valid in a forward direction)	
9	D_EMERGENCYSTOP	15	Distance from LRBG to the emergency stop point		Distance from LRBG to the emergency stop point

**[0028]** A value of the NID\_LRBG field indicates an identification number of a last relevant balise group in a latest train position report, a value of the D\_EMERGENCYSTOP field indicates a distance value between a last relevant balise group (LRBG) and the emergency stop point in the latest train position report, and a value of the M ACK field is 0, which indicates that it is not necessary to return confirmation, after the message is received. A starting point of the block section occupied within the range of movement authority is just the emergency stop point.

**[0029]** Those skilled in the art should understand that the format type of the above-described CEM message is only an example; other format types of the CEM message existing or possibly appearing in the future, if applicable to the embodiments of the present disclosure, shall also be included in the protection scope of the present disclosure, and are hereby incorporated in a manner of reference.

**[0030]** Step S420: in a case where the train has a higher running speed or a greater position report interval, receiving, by the train, the CEM message, and judging whether or not to accept the CEM message according to its own position information, so as to avoid a case where the train stops by emergency brake.

**[0031]** After receiving the CEM message, the train parses the CEM message, queries pre-stored position planning information in the last relevant balise group (LRBG) according to the identification number of the last relevant balise group (LRBG) in the NID\_LRBG field in the CEM message, acquires the position information of the last relevant balise group (LRBG), acquires the distance value between the last relevant balise group (LRBG) and the emergency stop point according to the D\_EMERGENCYSTOP field, and adds the distance value to the position information of the last relevant balise group (LRBG), to obtain the position information of the emergency stop point.

**[0032]** Step S430: acquiring, by the train, the current position of the train through the positioning system, acquiring a minimum safe front-end position of the train according to the current position of the train, judging whether or not the minimum safe front-end of the train has passed the position of the emergency stop point, and if so, executing step S450; otherwise, executing step S440.

**[0033]** The minimum safe front-end of the train refers to an actual position calculated by the train according to speed and distance ranging devices or radar, and other devices, added by an under-reading error of a confidence range of a speed ranging point.

**[0034]** Step S440: sending, by the train, Message M147 to the RBC, when it is judged that the minimum safe front-end of the train has not passed the position of the emergency stop point, the value of the Q\_EMERGENCYSTOP field in Message M147 being set to 0, i.e., accepting, by the train, the CEM message, and stopping normally when a subsequent

train runs to the position of the emergency stop point.

**[0035]** After receiving the above-described Message M147, the RBC shortens movement authorization of the train to the emergency stop point of CEM.

**[0036]** A format of the above-described Message M147 is as follows:

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Section serial number	Variable/packet	Bits	Description	Value	Notes
1	NID_MESSAGE	8	Message identification number	147	
2	L_MESSAGE	10	Message length	Depends on packet content included	
3	T_TRAIN	32	Vehicle device clock	Depends on message sending time	
4	NID_ENGINE	24	CTCS identification number of a vehicle device	Depends on configuration parameters of the vehicle device	
5	NID_EM	4	Emergency message identification number	0~15	Identification number of emergency message confirmed
6	Q_EMERGENCYSTOP	2	Determiner of emergency stop confirmation	0 (conditional emergency stop accepted) 1 (conditional emergency stop ignored) 2 (unconditional emergency stop accepted) 3 (standby)	The determiner indicates whether or not the minimum safe front-end of the train has passed the position of the emergency stop point, when the emergency stop message is received.
7	Packet 0 or 1				

**[0037]** Those skilled in the art should understand that the format type of the above-described Message M147 is only an example; other format types of Message M147 existing or possibly appearing in the future, if applicable to the embodiments of the present disclosure, shall also be included in the protection scope of the present disclosure, and are hereby incorporated in a manner of reference.

**[0038]** Step S450: sending, by the train, Message M147 to the RBC, when it is judged that the minimum safe front-end of the train has passed the position of the emergency stop point, the value of the Q\_EMERGENCYSTOP field in Message M147 being set to 1, i.e., ignoring, by the train, the CEM message, which indicates that the occupancy is occupancy by the train itself.

**[0039]** After receiving Message M147, the RBC continues to control the train according to movement authorization before sending the CEM.

**[0040]** According to the above-described processing method according to the embodiment of the present disclosure, in a scenario as described in FIG. 3, the RBC sequentially receives occupancy information of two sections, and sequentially sends the CEM message to the train according to Position 1 of the train, the positions of the emergency stop point in the CEM message are respectively N3 and N5. After the train receives emergency, it is judged that the minimum safe front-end of the train has passed the position of the emergency stop point according to the current position of the train, so that the CEM message is ignored.

**[0041]** Summing up the above-described strategic response analysis, when Ltrack is less than Lmove, the CEM message may still be used for accomplishing judgement of train occupancy check; however, use of the SMA strategy will result in train emergency brake.

**[0042]** In summary, in the embodiments of the present disclosure, after the train receives the CEM message, it is

judged whether or not the current position of the train passes the position of the emergency stop point, and it is judged whether or not to execute the CEM message according to the judgement result, which may avoid a situation that the train stops by emergency brake, in a case where the train has a higher running speed or a greater position report interval.

**[0043]** Those skilled in the art can understand that, the accompanying drawings are merely schematic diagrams of an embodiment, and modules or flows in the accompanying drawings are not necessarily required to implement the present disclosure.

**[0044]** It can be known from the description of the above embodiments that, those skilled in the art can clearly understand that the present disclosure may be implemented by means of software plus a necessary universal hardware platform. Based on such understanding, the technical solutions of the present disclosure may essentially or a part thereof that contributes to the prior art may be embodied in a form of a software product, the computer software product may be stored in a storage medium, such as, ROM/RAM, a diskette, an optical disc and the like, including instructions for causing a computer device (which may be a personal computer, a server, or a network device, etc.) to execute the methods as described in various embodiments or portions of the embodiments of the present disclosure.

**[0045]** Respective embodiments in the present specification are described in a progressive manner, same or similar parts among the respective embodiments may be referred to each other; each embodiment focuses on difference from other embodiments. In particular, with respect to the device or system embodiment, since it is basically similar to the method embodiment, description thereof is relatively simple, and for the related parts, description of the parts of the method embodiment may be referred to. The device and system embodiments as described above are only schematic, wherein the units described as separate parts may or may not be physically separated, and the part displayed as a unit may or may not be a physical unit, i.e., it may be located in one place, or it may be distributed to a plurality of network units. According to actual needs, some or all of the modules may be selected to achieve the objective of the solution of this embodiment. Those ordinarily skilled in the art can understand and implement without inventive effort.

**[0046]** The above are only preferred embodiments of the present disclosure, but the scope of the present disclosure is not limited thereto, and any skilled in the art, within the technical scope disclosed by the embodiment of the present disclosure, can easily think of variations or replacements, which should be covered within the protection scope of the embodiment of the present disclosure. Therefore, the scope of the present disclosure should be the scope of the following claims.

## Claims

1. A method for performing mobile authorization control on a train, comprising:

sending, by a radio blocking center (RBC), a conditional emergency stop (CEM) message to the train;  
 acquiring, by the train, position information of an emergency stop point according to the CEM message, after receiving the CEM message, and acquiring a current position of the train through a positioning system;  
 judging, by the train, whether or not the current position of the train has passed the position of the emergency stop point, and judging whether or not to execute the CEM message according to the judgement result.

2. The method according to claim 1, wherein, the sending, by a radio blocking center (RBC), a conditional emergency stop (CEM) message to the train, includes:

sending, by the radio blocking center (RBC), the CEM message to the train, if the RBC determines that there is block section occupancy or abnormality occurring within a range of traffic permission it sends to the train, and the occupied or abnormal block section is not a block section adjacent to the block section where the train is located in a train operation direction.

3. The method according to any one of claims 1 to 2, wherein, the CEM message includes a NID\_LRBG field, a D\_EMERGENCYSTOP field and an M ACK field; a value of the NID\_LRBG field indicates an identification number of a last relevant balise group in a latest train position report, a value of the D\_EMERGENCYSTOP field indicates a distance value between the last relevant balise group (LRBG) and the emergency stop point in the latest train position report, and a value of the M ACK field is 0, which indicates that it is not necessary to return confirmation, after the message is received.

4. The method according to any one of claims 1 to 3, wherein, the acquiring, by the train, position information of an emergency stop point according to shorten mobile authorization information included in the CEM message, after receiving the CEM message, includes:

parsing, by the train, the CEM message, after receiving the CEM message, and querying pre-stored position planning information in the last relevant balise group (LRBG) according to an identification number of the last relevant balise

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group (LRBG) in the NID\_LRBG field in the CEM message, acquiring the position information of the last relevant balise group (LRBG), acquiring the distance value between the last relevant balise group (LRBG) and the emergency stop point according to the D\_EMERGENCYSTOP field, and adding the distance value to the position information of the last relevant balise group (LRBG), to obtain the position information of the emergency stop point.

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5. The method according to any one of claims 1 to 4, wherein, the judging, by the train, whether or not the current position of the train has passed the position of the emergency stop point, and judging whether or not to execute the CEM message according to the judgement result, includes:

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acquiring, by the train, the current position of the train through the positioning system, acquiring a minimum safe front-end position of the train according to the current position of the train, and judging whether or not a minimum safe front-end value of the train has passed the position of the emergency stop point, and if so, ignoring, by the train, the CEM message; otherwise, accepting, by the train, the CEM message, and stopping normally when a subsequent train runs to the position of the emergency stop point.

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6. The method according to any one of claims 1 to 5, wherein, the ignoring, by the train, the CEM message, includes: sending, by the train, Message M147 to the RBC, a value of the Q\_EMERGENCYSTOP field in Message M147 being set to 1, and the ignoring, by the train, the CEM message, which indicates that the occupancy is occupancy by the train itself; after receiving Message M147, continuing to control, by the RBC, the train according to mobile authorization before sending the CEM message.

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7. The method according to any one of claims 1 to 6, wherein, the accepting, by the train, the CEM message, and stopping normally when a subsequent train runs to the position of the emergency stop point, includes:

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sending, by the train, Message M147 to the RBC, the value of the Q\_EMERGENCYSTOP field in Message M147 being set to 0, accepting, by the train, the CEM message, and stopping normally when a subsequent train runs to the position of the emergency stop point.

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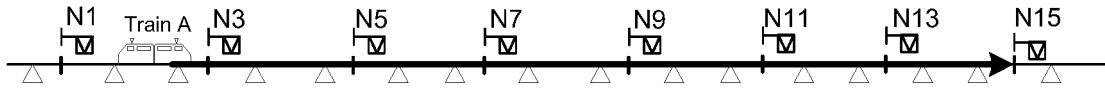


FIG. 1

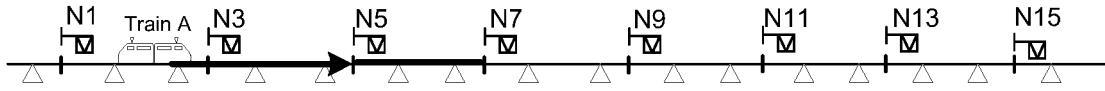


FIG. 2

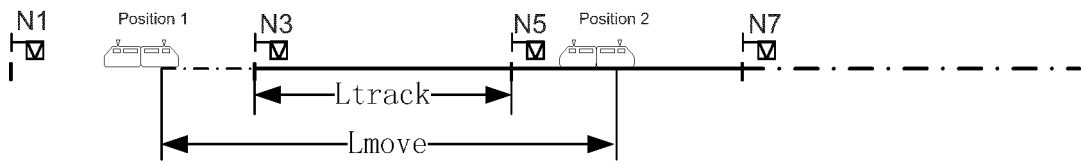


FIG. 3

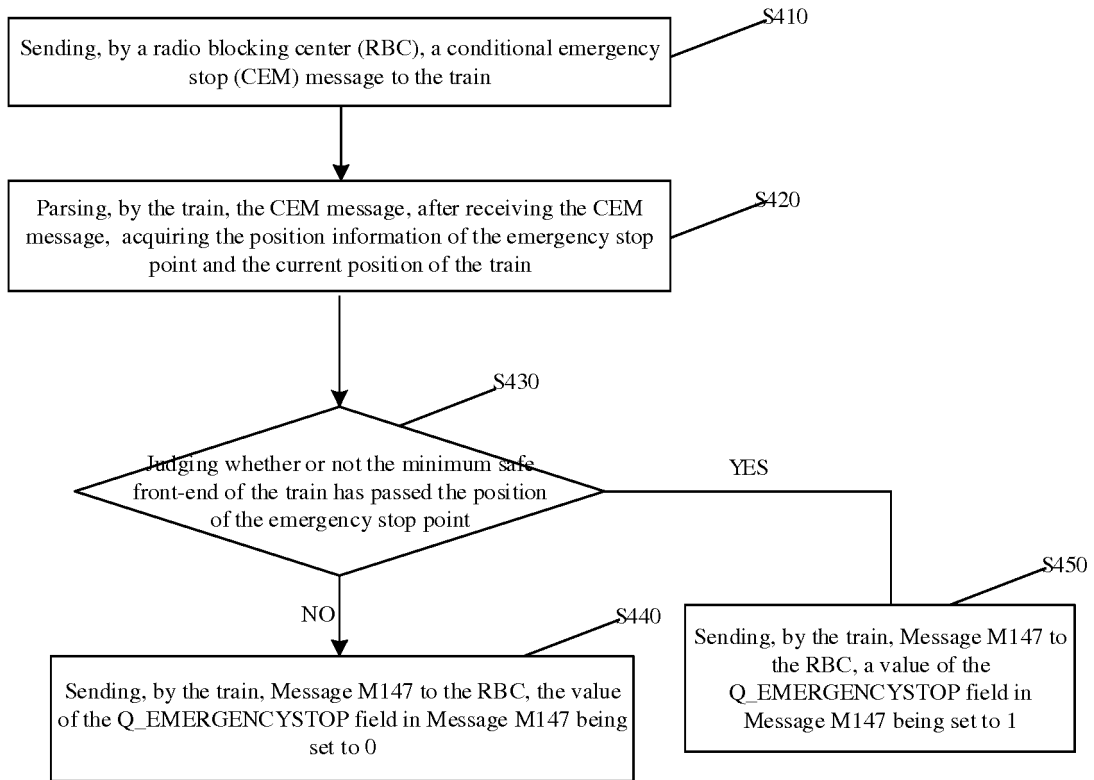


FIG. 4

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2018/085945

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**A. CLASSIFICATION OF SUBJECT MATTER**

B61L 27/00(2006.01)i; B61L 23/16(2006.01)i; B61L 25/02(2006.01)i

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

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**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

15

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

CNPAT, CNKI, EPODOC, WPI, IEEE: 缩短的移动授权, 有条件紧急停车, 无线闭塞中心, 相邻, 闭塞, 分区, 区间, SMA, CEM, RBC, neighbor, blocking, segment, section

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 107914739 A (BEIJING NATIONAL RAILWAY RESEARCH & DESIGN INSTITUTE OF SIGNAL & COMMUNICATION LTD.) 17 April 2018 (2018-04-17) claims 1-7	1-7
X	CN 102510823 A (HUAWEI TECHNOLOGIES CO., LTD.) 20 June 2012 (2012-06-20) description, paragraphs [0036]-[0075]	1-7
A	CN 102248958 A (BEIJING NATIONAL RAILWAY RESEARCH & DESIGN INSTITUTE OF SIGNAL & COMMUNICATION CO., LTD.) 23 November 2011 (2011-11-23) entire document	1-7
A	EP 3040250 A1 (LIU, JIAN) 06 July 2016 (2016-07-06) entire document	1-7

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

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Date of the actual completion of the international search

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**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- CN 201710983669 [0001]