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(54) **ONBOARD-BASED ELECTRONIC INTERLOCKING SYSTEM AND METHOD THEREFOR FOR INTER-TRAIN CONNECTION-BASED AUTONOMOUS TRAIN CONTROL SYSTEM**

BORDBASIERTES ELEKTRONISCHES VERRIEGELUNGSSYSTEM UND VERFAHREN DAFÜR FÜR EIN AUTONOMES ZUGSTEUERUNGSSYSTEM BASIEREND AUF ZWISCHENZUGSVERBINDUNG

SYSTÈME DE VERROUILLAGE ÉLECTRONIQUE EMBARQUÉ ET PROCÉDÉ ASSOCIÉ DESTINÉS À UN SYSTÈME DE COMMANDE DE TRAIN AUTONOME BASÉ SUR UNE CONNEXION ENTRE TRAINS

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(73) Proprietor: **Korea Railroad Research Institute**
Uiwang-si, Gyeonggi-do 16105 (KR)

(72) Inventors:
• **OH, Seh-Chan**
Suwon-si
Gyeonggi-do 16311 (KR)
• **KIM, Joo-Uk**
Bucheon-si
Gyeonggi-do 14778 (KR)
• **KIM, Kyung-Hee**
Gunpo-si
Gyeonggi-do 15821 (KR)

• **KIM, Min-Soo**
Gunpo-si
Gyeonggi-do 15886 (KR)

(74) Representative: **Petraz, Gilberto Luigi et al**
GLP S.r.l.
Viale Europa Unita, 171
33100 Udine (IT)

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Description

Technical Field

[0001] The present invention relates to a train-centric electronic interlocking system and method for an autonomous train control system based on connection between trains.

Background Art

[0002] Generally, a railroad vehicle is large-scale transportation machine that transports large amounts of freight or many passengers, and a railroad vehicle is equipped with various types of train control systems having various degrees of complexity so that the vehicle can be safely driven along a track.

[0003] Here, train control systems utilize complicated system configurations where various types of supervisions and controls are possible to take charge of safe operation of the train. For safe operation of two trains, it is extremely important to secure a safe distance between preceding and following trains and a safe speed, and an example thereof is proposed in Korean Patent No. 10-1449742 that relates to a device for controlling a distance between trains. In a conventional wayside-centric wireless communications-based train control system, it is impossible to directly transmit and receive control information between a following train and a preceding train, and thus proximate driving with a preceding train is impossible.

[0004] Therefore, a device for measuring a position and a speed of a preceding train in real time is provided in a train, and an onboard system is configured to calculate a safe distance between trains by using movement authority received from a wayside system and speed and position values of the preceding train measured in the train, whereby it is proposed that train distance control between the preceding train and the following train is automatically performed in a range where the proximate driving is possible without human intervention.

[0005] Among such conventional wireless communications-based train control systems, a wayside-centric wireless communications-based train control system such as a communications-based train control (CBTC) system performs wayside-centric distance control based on control information between an onboard system and a wayside system.

[0006] Document EP 1 695 890 A1 describes a signaling system for ensuring the protection of a train, comprising an interlocking device.

[0007] However, all trains of the control area at the wayside are controlled depending on centralized control systems such as a wayside automatic train protection (ATP), a wayside electronic interlocking system (EIS), etc., and thus when more than the predetermined number of trains are deployed, there is a limit to the processing capacity. Therefore, it is required to establish more fac-

ilities depending on a predetermined section or the processing capacity. For example, document EP-A-1695890 discloses signaling system, train with control apparatus and point protection apparatus.

[0008] In order to solve such problems, it is required that a new autonomous train control system based on communication connection between trains performs safe train operation through control information interchange between trains without wayside facilities such as wayside ATP, EIS, etc.

Disclosure

Technical Problem

[0009] Accordingly, the present invention has been made keeping in mind the above problems occurring in the related art, and an object of the present invention is to provide a train-centric electronic interlocking system and method for an autonomous train control system based on connection between trains, the train-centric electronic interlocking system and method reducing system installation and maintenance costs by reducing wayside EIS facilities.

[0010] Particularly, an object of the present invention is to provide a train-centric electronic interlocking system and method for an autonomous train control system based on connection between trains, the train-centric electronic interlocking system and method simplifying a control path by enhancing flexibility and scalability of the system based on an onboard EIS.

Technical Solution

[0011] In order to accomplish the above object, the present invention provides:

a train-centric electronic interlocking system for an autonomous train control system based on connection between trains, the train-centric electronic interlocking system including: a control automatic train supervision (ATS) configured to perform a path command according to a unique schedule of a train; an onboard electronic interlocking system (EIS) configured to control a path of the train according to the command of the control ATS, and identifying integrity of the control; a point machine (PM) configured to switch a track of a switching area; and an object controller (OC) configured to control the PM according to a command of the onboard EIS, and providing state information of the PM to the onboard EIS. The state information of the point machine managed by the onboard electronic interlocking system includes a unique ID of the point machine, the switching area, a nominal or reverse state, a lock or unlock state of the point machine, and a key value for accessing the point machine. The object controller is configured to change the state of the point machine to the lock state while generating a unique key value and providing the unique key value to the onboard electronic interlocking system.

[0012] Here, the OC may identify the state information of the PM and may provide the state information to the onboard EIS, the state information including a nominal or reverse state, a lock or unlock state, a fault or normal state of the PM.

[0013] In addition, the PM may have the switching area to which a fouling point is applied, and the onboard EIS may receive an operation state of the PM from the OC to identify the operation state, and may provide the path as much as the switching area of the secured PM to an onboard automatic train protection (ATP).

[0014] In addition, the present invention provides: a train-centric electronic interlocking method for an autonomous train control system based on connection between trains, the train-centric electronic interlocking method including: receiving, by an onboard electronic interlocking system (EIS) of a train at step 1, state information of a point machine (PM) list of multiple PMs composing a path based on a path command of a control automatic train supervision (ATS) from an object controller (OC) of a PM to identify the state information of the point machines of said list; identifying, by the onboard EIS at step 2, whether a particular PM in said list is in an unlock or lock state, and requesting a change of the state of the particular PM to the lock state, from the OC connected to the particular PM when determining the particular PM is in the unlock state; receiving, by the onboard EIS at step 3, a unique key value required for accessing the particular PM from the OC, the unique key value being generated while changing the state of the particular PM to the lock state; and transmitting, by the onboard EIS at step 4, an unlock command to the OC connected with the particular PM by using the key value received from the OC, whereby the particular PM is unlocked.

[0015] Here, the step 1 may include: transmitting, by the onboard EIS of the train at step 1_1, a state request message requesting the state information of the particular PM to all OCs of a route; and receiving, by the onboard EIS at step 1_2, the state information of the particular PM from the OC of the particular PM.

[0016] In addition, at the step 1, the onboard EIS of the train may receive supervised state information of the PMs from all OCs that are individually connected with the PMs.

[0017] Furthermore, before the step 1, the method may include receiving, by the onboard EIS at step 5, the path command from the control ATS according to a unique schedule of the train, and storing IDs of all PMs of a route and switching areas of the PMs.

[0018] Also, the state information of the PM managed by the onboard EIS may include a unique ID of the PM, a switching area, a nominal or reverse state, a lock or unlock state of the PM, and a key value for accessing the PM.

[0019] Furthermore, at the step 2, the path of the train may be postponed until all PMs in the PM list requested by the onboard EIS are in the unlock state.

[0020] In addition, the step 4 may include: continuously receiving, by the onboard EIS at step 4_1, the position

of the train and an occupied section of the track from an onboard automatic train protection (ATP), and when a rear end portion of the train moves out of a PM area, commanding the OC of the PM to unlock the PM; and receiving, by the onboard EIS at step 4_2, state information after changing the state of the PM to the unlock state, from the OC that received the unlock command for the PM.

[0021] Furthermore, at the step 4, when the onboard EIS receives the forced unlock command for the locked PM from the OC of the PM in the lock state or from a control center while the train exists in a switching area, the onboard EIS may transmit unlock impossibility information to the control center or the OC.

[0022] In addition, at the step 4, when a current braking distance of the train received from an automatic train protection (ATP) exists in a non-switching area of the particular PM, the forced unlock command for the particular PM may be transmitted from a control center to the OC connected with the particular PM and to the onboard EIS; and the onboard EIS having the key of the particular PM may identify whether the particular PM can be unlocked, and may return the key to the OC of the particular PM, whereby the particular PM is unlocked.

Advantageous Effects

[0023] As described above, according to the present invention, a system for the autonomous train control system based on connection between trains is simplified based on the onboard EIS without requiring wayside EIS facilities, whereby installation and maintenance costs of the system can be reduced.

[0024] In addition, according to the present invention, it is possible to enhance flexibility and scalability of a system based on the onboard EIS. That is, the present invention can provide onboard facilities that were used as wayside facilities in a conventional wayside-centric wireless communications-based train driving safety system, whereby a control path can be simplified and can flexibly reply to operational change.

Description of Drawings

[0025]

FIG. 1 is a block diagram showing an autonomous train control system based on connection between trains for the present invention.

FIG. 2 is a configuration diagram showing a train-centric electronic interlocking system for an autonomous train control system based on connection between trains according for an embodiment of the present invention.

FIG. 3 is a configuration diagram showing a train-centric electronic interlocking system for an autonomous train control system based on connection between trains for another embodiment of the present

invention.

FIG. 4 is a view showing an example of a switching area of an object controller (OC) and a point machine (PM) for the present invention.

FIG. 5 is a view for explaining a process of transmitting and receiving information between components of a train-centric electronic interlocking system for the present invention.

FIGS. 6a and 6b are views for explaining processes of requesting and responding to state information of a PM by an onboard electronic interlocking system (EIS) for the present invention.

FIG. 7 is a view for explaining a process of periodically reporting state information of a PM to an onboard EIS for the present invention.

FIG. 8 is a view for explaining a switching area of a PM for the present invention.

FIG. 9 is a view for explaining a lock process of a PM through an OC for the present invention.

FIG. 10 is a view for explaining an unlock process of a PM through an OC of the present invention.

FIG. 11 is a view for explaining an example of separation of a track section managed by an onboard EIS for the present invention.

FIG. 12 is a view for explaining an example of train path configurations for the present invention.

FIGS. 13 and 14 are views for explaining a process of determining whether approach (stick) locking is performed by an onboard EIS for the present invention.

FIG. 15 is a view for explaining a situation where movement authority (MA) is shortened by reducing a path due to forced unlock by an operator for the present invention.

Best Mode

[0026] Hereinafter, features of a train-centric electronic interlocking system and method for an autonomous train control system based on connection between trains according to the present invention will be understood through a detailed description of the embodiment of the present invention with reference to the accompanying drawings.

[0027] First, referring to FIG. 1, a train control system based on connection between trains is broadly composed of wayside facilities and onboard equipment.

[0028] Here, the wayside facilities are composed of a control automatic train supervision (ATS) 1, a wayside data communication network, a precision stop marker (PSM) 2, and a trackside beacon 3 such as TAG/Balise. Onboard facilities are composed of an onboard wireless communication device 4, a PSM sensor 5, a beacon reader and antenna 6, the onboard equipment 7 such as onboard automatic train protection (ATP)/onboard automatic train operation (ATO)/onboard electronic interlocking system (EIS), etc., and a traction/braking system 8 of a train as a sub-system.

[0029] In the meantime, there are no wayside control facilities in the present invention, and thus a platform screen door (PSD) 9, a point machine (PM) 10, and an onboard ATP of the adjacent train transmit and receive control information therebetween through a wireless communication network. The onboard equipment 7 such as onboard ATP/ATO, etc. interfaces with the traction/braking system 8 of a train to control acceleration and deceleration of the train so as to secure a safe distance.

[0030] In such a train control system based on connection between trains, the onboard equipment 7 calculates a track occupied section of a train and movement authority of a train by itself, and provides them to an adjacent train (following train). In addition, it is possible to provide real-time information such as acceleration and deceleration control information, etc. including train characteristics.

[0031] Hereinafter, configurations of the train-centric electronic interlocking system for the autonomous train control system based on connection between trains according to the present invention will be described.

[0032] Here, in the electronic interlocking system of the train control system based on connection between trains, as shown in FIG. 2, an object controller (OC) 20 performs wireless communication with the control ATS 1 and an onboard EIS 30. Alternatively, as shown in FIG. 3, when it is easy to connect the point machine (PM) (track switch) 10 to a trackside wireless communication network base station 15, the OC 20 performs wired communication with the control ATS 1 and the onboard EIS 30 through the trackside wireless communication network base station 15.

[0033] More specifically, in a case of FIG. 2, the OC 20 autonomously has wireless facilities, and thus the OC transmits and receives control information to and from the control ATS 1 and the onboard EIS 30 through wireless communication. In contrast, in a case of FIG. 3, the OC 20 is connected to the trackside wireless communication facilities through a cable, and thus control information is transmitted and received through wireless communication between the onboard EIS 30 and the trackside wireless communication base station 15.

[0034] Such electronic interlocking system includes: the control ATS 1 performing a path command according to a unique schedule of a train; the onboard EIS 30 controlling the path of the train according to the command of the control ATS, and identifying integrity of the control; the PM 10 switching the track; and the OC 20 controlling the PM 10 according to a command of the onboard EIS 30, and providing state information of the PM 10 to the onboard EIS 30.

[0035] Here, the OC 20 is connected with at least one PM 10, and identifies state information of the PM such as a nominal or reverse state, a lock or unlock state, a fault or normal state, etc. of the PM, and provides the state information of the PM to the onboard EIS 30 or the control ATS 1.

[0036] In the concept of Mutex, lock or unlock means that in order to control a particular PM 10 by the onboard EIS 30 through the OC 20, lock or unlock is performed on the resource (here, the PM) so as to prevent the particular PM 10 from being dublicately controlled by an onboard EIS 30 of another train.

[0037] Here, as shown in FIG. 4, all PMs 10 at the trackside have a switching area 10a to which a fouling point is applied. Here, for example, in a case of twin PMs such as PM 21A and PM 21B, and a reverse state, the switching area is meaningful. Through this, the onboard EIS 30 of a train commands the OC 20 to lock and operate the PM 10. In addition, the onboard EIS 30 receives an operation state of the PM 10 from the OC 20 to identify the operation state, and provides the path as much as the switching area 10a of the secured PM 10 to the onboard ATP 32.

[0038] A process of transmitting and receiving information between components of each part of the train-centric electronic interlocking system is shown in FIG. 5. According to this, the onboard EIS 30 receives a position, a travel direction of a train T, train route section occupancy information, and movement authority from the onboard ATP 32. In addition, the onboard EIS 30 receives a braking distance based on a current position and a current speed of the train in order to decide a lock condition. In addition, the onboard EIS 30 provides the end of the safe path to the onboard ATP 32. Also, the onboard EIS 30 identifies a state of a PM 10 and commands control of the PM 10 through the OC 20. Furthermore, the OC 20 receives real-time state information of the PM 10 and provides the information to the onboard EIS 30.

[0039] Hereinafter, an operation process of the train-centric electronic interlocking system for the autonomous train control system based on connection between trains according to the present invention will be described with reference to FIGS. 6 to 15.

[0040] First, a communication method between the onboard EIS 30 and the OC 20 will be described with reference to FIGS. 6 and 7.

[0041] An onboard EIS 30 of every train T running on the route and wayside OCs 20 are respectively registered at single and multicast addresses. The onboard EIS 30 transmits and receives control information to and from the OC 20 through the communication addresses.

[0042] Here, there are two methods of identifying the state of the PM 10 by the onboard EIS 30 as shown in FIGS. 6 to 7. The first method is receiving state information of the PM 10 from the OC 20 in response to a request of the onboard EIS 30, and the second method is periodically reporting supervised state information of the PM 10 by each OC 20, to the onboard EIS 30.

[0043] First, FIG. 6 is a view for explaining request and response of the onboard EIS 30.

[0044] According to this, assuming that K trains T and N PMs 10 exist on the route, for example, as shown in FIG. 6a, when an onboard EIS 30 of train #1, which is a particular train, requests state information of a particular

PM 10, a state request message is transmitted to all OCs 20.

[0045] In the meantime, as shown in FIG. 6b, in response to the state request message, the onboard EIS 30 receives the state information from a particular OC 20 connected with the particular PM 10 among all OCs. Here, all trains running on the route receive the state information of the particular PM 10. However, an onboard EIS 30 that does not request the state information of the particular PM 10 among multiple onboard EISs 30 ignores the state information of the PM regardless of the reception.

[0046] That is, when an onboard EIS 30 of a particular train requests state information of a particular PM 10, a state request message is transmitted to all OCs 20, and the state information is received from a particular OC 20 connected to the particular PM 10 among all OCs.

[0047] In addition, FIG. 7 shows a case where all PMs on the route periodically provide state information of themselves to all trains. According to this, assuming that K trains T and N PMs 10 exist on the route, an onboard EIS 30 of a particular train does not request state information of a particular PM 10. All OCs 20 periodically transmit supervised state information of the PMs 10 individually connected therewith, to onboard EIS 30s of all trains running on the route.

[0048] Hereinafter, a process of storing state information of a PM by an onboard EIS will be described with reference to FIG. 8.

[0049] The onboard EIS 30 stores IDs of all PMs 10 on the route and switching areas 10a of all PMs 10. Alternatively, an OC corresponding to a PM may be configured to provide a switching area of the PM.

[0050] Here, the switching area 10a of the PM 10 is indicated as a distance from the trackside beacon 3 such as trackside TAG/Balise. That is, as shown in FIG. 8, the switching area 10a may be indicated by using distances x and y from a random reference TAG. Therefore, the start point of the switching area may be indicated as a point spaced apart from TG_K that is an ID of the reference TAG by distance y, and the end point of the switching area may be indicated as a point spaced apart from TG_K by distance x.

[0051] In the meantime, state information of a PM 10 managed by the onboard EIS 30 may be composed of as follows: a unique ID of the PM 10, a switching area, a nominal or reverse state, a lock or unlock state of the PM 10, a key value for accessing the PM, and an ID of the PM 10 in a case of twins.

[0052] Here, in the state information of the PM 10 managed by the onboard EIS 30, only when the nominal or reverse state and the lock or unlock state of the PM 10 are received through the OC 20, the values thereof may be set.

[0053] Such state information of the PM 10 is composed as "<PM_ID, [TG_K + y, TG_K + x], Nominal/Reverse, Lock/Unlock, Key, Twin PM_ID>."

[0054] Next, lock and unlock processes of a single PM

will be described with reference to FIGS. 9 and 10.

[0055] First, a method of locking an unlocked PM 10 by an onboard EIS 30 of a train through the OC 20 to secure the unlocked PM for its own resources is as follows.

[0056] Referring to FIG. 9, the onboard EIS 30 identifies whether a particular PM 10 is in an unlock state. When the particular PM 10 is identified as in the unlock state, the onboard EIS requests a change of the state of the particular PM 10 to a lock state, from an OC 20 connected to the particular PM 10. Accordingly, the OC 20 changes the state of the particular PM 10 to the lock state while generating a unique key value and providing the unique key value to the onboard EIS 30.

[0057] The OC 20 receives state information from the PM 10 and identifies whether the PM is in a lock state, and generates a unique key value and provides the unique key value to the onboard EIS 30.

[0058] Here, when the PM 10 is in an unlock state and whenever the onboard EIS 30 has a lock request for the PM 10, the OC 20 always generates a new key value and provides the key value to the onboard EIS 30.

[0059] In addition, the key value generated by the OC 20 should be long enough so as to prevent the onboard EIS 30 from being operated by an existing value and to prevent several OCs 20 from generating duplicate values.

[0060] When several PMs exist within the path rather than a single PM, the onboard EIS 30 of a train postpones configuration of the path until all PMs that exist within the path received from the ATS 1 are secured. That is, only when all PMs are secured, a key value is obtained.

[0061] In the meantime, referring to FIG. 10, in order to unlock the PM 10 secured by the onboard EIS 30, the onboard EIS 30 transmits an unlock command to the OC 20 by using a key value received from the OC 20. Accordingly, the OC 20 enables the PM 10 to be unlock only by a command of an onboard EIS 30 that locked the PM 10.

[0062] In the locking of the PM, the path is postponed until all PMs received from an ATS path command are secured. In contrast, in the unlock state, whenever a train moves out of a PM area, each PM is unlocked in order.

[0063] Such locking and unlocking of the PM 10 may be performed by manual handling of an operator of a control center besides the onboard EIS 30. The operator may identify the state of the PM 10 to be handled, through an operation monitor. When the PM 10 is in the unlock state by another train, a lock or unlock process is performed in the same manner as the case of the onboard EIS 30.

[0064] In addition, separation of a track section will be described with reference to FIG. 11.

[0065] In the train-centric electronic interlocking system according to the present invention, track sections are separated into a switching area and a non-switching area that is not the switching area. Path information provided to the onboard ATP 32 by the onboard EIS 30 man-

ages only the switching area of the PM 10. That is, as shown in FIG. 11, in a case of all track sections except for the switching area 10a (non-switching area), the onboard EIS 30 provides a path to the onboard ATP 32 without any conditions.

[0066] Next, train path configurations and provisions, and unlocking will be described with reference to FIG. 12.

[0067] The path provided by the onboard EIS 30 to the onboard ATP 32 is configured based on a schedule command of the control ATS 1. Here, when a path to be provided includes a switching area 10a, the onboard EIS 30 should identify a list of PMs 10 composing the path and a condition of each PM 10.

[0068] Here, in order to secure the PM list, the onboard EIS 30 receives the state by using the multicast address of the OC 20. In FIG. 12, the onboard EIS 30 of a train provided the path before a switching area corresponding to PM 21A and PM 21B, to the onboard ATP 32, and thus movement authority of the train may be extended to the X point as maximum.

[0069] For example, a train A receives the schedule command of the control ATS 1, and intends to enter a station in the direction of the red arrow. The control ATS 1 commands the onboard EIS 30 of the train A for a path related to the red arrow. Based on the path command of the control ATS 1, the onboard EIS 30 of the train A requests state information of PM list <21A, 21B, 23, 25> composing the path or receives a periodical report on the PM state from the OC 20.

[0070] Here, for example, when all PMs 10 in the PM list namely, all states of <21A, 21B, 23, 25> are the unlock state (resource not occupied by another train), the onboard EIS 30 of the train A locks the PM list (the train A performs locking before performing unlocking so as to prevent the PM list from being occupied by another train), and next, a PM control command is transmitted to each OC 20 by using a control key value received from each PM and a multicast communication address.

[0071] That is, <21A-nominal, 21B-nominal, 23-reverse, 25-nominal> command is transmitted. PM 21A and PM 21B are twin PMs, and thus when PM 21B is nominal, PM 21A is also nominal. The OC 20 of the PM 10 controls the PM 10 according to the command of the onboard EIS 30. The onboard EIS 30 of the train A receives state information of the PM from the OC 20 with respect to the control command, and identifies that the control of the PM is faultlessly performed.

[0072] Here, when any PM in the requested PM list is not in the unlock state, the onboard EIS 30 of the train A postpones the path of the train until all PMs in the requested list are in the unlock state. That is, the train A is unable to receive a path after the X point.

[0073] In the meantime, when providing the path of the train, the onboard EIS 30 identifies that the control of the PM 10 is faultlessly performed, and next, provides the path including switching areas of the PM list to the onboard ATP of the train. In FIG. 12, when the end of the path to be provided to the train A is the Y point, the on-

board EIS 30 secured switching areas required to move from the X point to the Y point, namely, all switching areas of PM 21A & 21B, PM 23, and PM 25, whereby the end of the path that is safe to the Y point may be provided to the onboard ATP. Accordingly, the onboard ATP allows the onboard ATO (or the driver) to move the train to the Y point.

[0074] In addition, when unlocking the path of the train, the onboard EIS 30 continuously receives the position of the train and an occupied section of the track from the onboard ATP 32. Therefore, whenever the rear end portion of the train moves out of the PM area while the train travels to the Y point, the onboard EIS 30 commands the OC 20 to unlock the PM 10 in order. Accordingly, the OC 20 that received the unlock command of the PM 10 unlocks the PM 10, and next, transmits the state information to the onboard EIS 30.

[0075] Hereinafter, a process of performing lock logic will be described with reference to FIGS. 13 to 15.

[0076] First, detector locking means that when the train exists in the switching area of the track, namely, when the occupied section of the train exists in the switching area, the PM 10 is locked to be prevented from being arbitrarily switched. In a normal situation, the OC 20 does not allow another train to access, and thus when the train T exists in the switching area 10a of the PM 10, unlocking is not performed.

[0077] When the operator uses the OC 20 to unlock a PM 10 that is already locked by an onboard EIS 30 of a particular train T, the information of the command is transmitted to all OCs 20 on the route and onboard EISs 30 of all trains.

[0078] That is, the ID of the PM 10 and the unlock command for the PM 10 that the operator requires to unlock are transmitted to all onboard EISs 30 through the multicast communication address. The onboard EIS 30 occupying the PM 10 continuously receives the position of the train and the occupied section of the track from the onboard ATP 32. The onboard EIS 30 exists in the switching area 10a of the PM 10, and thus the onboard EIS 30 transmits unlock impossibility information to the control center or the OC 20 for the cognition of the operator. Otherwise, namely, when a train does not exist in the switching area of the PM and there is enough distance not to enter the switching area by a current train being stopping, a control key of the PM is returned to the OC 20 and the state of the PM is changed to the unlock state. Next, the control ATS has a right to control the PM by obtaining the key returned to the OC 20.

[0079] Next, approach (stick) locking means that when the train T enters the switching area 10a, the PM handling the switching area 10a is locked to be prevented from being arbitrarily switched. In the train-centric electronic interlocking system, the onboard EIS 30, from the ATP 32, may receive real-time position and occupancy information of the train, a current braking distance, and movement authority. In addition, movement authority of the ATP 32 and a limit speed may be set to stop the train T

in front of an unauthorized PM 10 without fail.

[0080] When the operator forces to implement unlocking while the train T normally approaches to the switching area, information is transmitted to all OCs 20 on the route and the onboard EIS 30 of the train. Based on the ID of the PM 10, the onboard EIS 30 of the train having the key identifies whether the current braking distance of the train reaches the switching area 10a (namely, whether derailment may occur when the train brakes now), whereby whether the command is applied is decided.

[0081] FIG. 13 is a view showing a case where it is impossible for the operator to force to implement unlocking when determining whether approach (stick) locking is performed. When the train approaches the switching area and the operator intends to unlock the PM 10 through the OC 20, the request of the operator is transmitted to the onboard EIS 30 occupying the PM 10. However, the current braking distance of the train T reaches the switching area 10a, and thus the onboard EIS 30 may refuse the command of the operator.

[0082] FIG. 14 is a view showing a case where it is possible for the operator to force to implement unlocking when determining whether approach (stick) locking is performed. When the current braking distance of the train received from the ATP 32 exists outside of the switching area 10a, the onboard EIS 30 accepts the request of the operator, and unlocks the PM 10. In response to the unlock, movement authority of the train is shortened as shown in FIG. 15, and the train T stops outside of the switching area 10a.

[0083] Next, in the train-centric electronic interlocking system, the path of the train T means a list of PMs in series. Path locking means that start and end PMs composing the path of the train should not be unlocked until the train requests unlock while passing. As shown in FIG. 11, rather than the switching section, a general track section (non-switching area) may exist between the PMs of the list.

[0084] When the operator forces the particular PM 10 to be unlocked after the path for the train T is configured, the request of the operator is transmitted to the onboard EIS 30 occupying the resource of the particular PM 10. An unlock request is decided in the same manner as the case of the approach (stick) locking.

[0085] Although exemplary embodiments of the present invention have been described for illustrative purposes, the invention is defined by the features of the independent claims.

Industrial Applicability

[0086] The present invention relates to a train-centric electronic interlocking system and method for an autonomous train control system based on connection between trains.

Claims

1. A train-centric electronic interlocking method for an autonomous train control system based on connection between trains, the train-centric electronic interlocking method comprising:

receiving, by an onboard electronic interlocking system (30) of a train at step 1, state information of a point machine (10) list of multiple point machines (10) composing a path based on a path command of a control automatic train supervision (1) from an object controller (20) of a point machine (10) to identify the state information of the point machines (10) of said list;
 identifying, by the onboard electronic interlocking system (30) at step 2, whether a particular point machine (10) in said list is in an unlock or lock state, and requesting a change of the state of the particular point machine (10) to the lock state, from the object controller (20) connected to the particular point machine (10) when determining the particular point machine (10) is in the unlock state;

characterised by

receiving, by the onboard electronic interlocking system (30) at step 3, a unique key value required for accessing the particular point machine (10) from the object controller (20), the unique key value being generated while changing the state of the particular point machine (10) to the lock state; and
 transmitting, by the onboard electronic interlocking system (30) at step 4, an unlock command to the object controller (20) connected with the particular point machine (10) by using the key value received from the object controller (20), whereby the particular point machine (10) is unlocked.

2. The train-centric electronic interlocking method of claim 1, wherein the step 1 comprises:

transmitting, by the onboard electronic interlocking system (30) of the train at step 1_1, a state request message requesting the state information of the particular point machine (10) to all object controllers (20) of a route; and
 receiving, by the onboard electronic interlocking system (30) at step 1_2, the state information of the particular point machine (10) from the object controller (20) of the particular point machine (10).

3. The train-centric electronic interlocking method of claim 1, wherein at the step 1, the onboard electronic interlocking system (30) of the train receives supervised state information of the point machines (10)

from all object controllers (20) that are individually connected with the point machines (10).

4. The train-centric electronic interlocking method of claim 1, further comprising, before the step 1: receiving, by the onboard electronic interlocking system (30) at step 5, the path command from the control automatic train supervision (1) according to a unique schedule of the train, and storing IDs of all point machines (10) of a route and switching areas of the point machines (10).

5. The train-centric electronic interlocking method of claim 1, wherein the state information of the point machine (10) managed by the onboard electronic interlocking system (30) includes a unique ID of the point machine (10), a switching area, a nominal or reverse state, a lock or unlock state of the point machine (10), and a key value for accessing the point machine (10).

6. The train-centric electronic interlocking method of claim 1, wherein at the step 2, the path of the train is postponed until all point machines (10) in the point machine (10) list requested by the onboard electronic interlocking system (30) are in the unlock state.

7. The train-centric electronic interlocking method of claim 1, wherein the step 4 comprises:

continuously receiving, by the onboard electronic interlocking system (30) at step 4_1, the position of the train and an occupied section of the track from an onboard automatic train protection (32), and when a rear end portion of the train moves out of a point machine (10) area, commanding the object controller (20) of the point machine (10) to unlock the point machine (10); and

receiving, by the onboard electronic interlocking system (30) at step 4_2, state information after changing the state of the point machine (10) to the unlock state, from the object controller (20) that received the unlock command for the point machine (10).

8. The train-centric electronic interlocking method of claim 1, wherein at the step 4, when the onboard electronic interlocking system (30) receives the forced unlock command for the locked point machine (10) from the object controller (20) of the point machine (10) in the lock state or from a control center while the train exists in a switching area, the onboard electronic interlocking system (30) transmits unlock impossibility information to the control center or the object controller (20).

9. The train-centric electronic interlocking method of

claim 1, wherein at the step 4,

when a current braking distance of the train received from an automatic train protection (32) exists in a non-switching area of the particular point machine (10), the onboard electronic interlocking system (30) transmits the forced unlock command for the particular point machine (10) from a control center to the object controller (20) connected with the particular point machine (10) and to the onboard electronic interlocking system (30); and the onboard electronic interlocking system (30) having the key of the particular point machine (10) identifies whether the particular point machine (10) can be unlocked, and returns the key to the object controller (20) of the particular point machine (10), whereby the particular point machine (10) is unlocked.

10. A train-centric electronic interlocking system for an autonomous train control system based on connection between trains, the train-centric electronic interlocking system being suitable for carrying out a train-centric electronic interlocking method according to any preceding claims and comprising:

a control automatic train supervision (1) configured to perform a path command according to a unique schedule of a train;
an onboard electronic interlocking system (30) configured to control a path of the train according to the command of the control automatic train supervision (1), and identifying integrity of the control;
a point machine (10) configured to switch a track of a switching area; and
an object controller (20) configured to control the point machine (10) according to a command of the onboard electronic interlocking system (30), and providing state information of the point machine (10) to the onboard electronic interlocking system (30),
wherein the state information of the point machine (10) managed by the onboard electronic interlocking system (30) includes a unique ID of the point machine (10), the switching area, a nominal or reverse state, a lock or unlock state of the point machine (10), and a key value for accessing the point machine (10), and
wherein the object controller (20) is configured to change the state of the point machine (10) to the lock state while generating a unique key value and providing the unique key value to the onboard electronic interlocking system (30).

11. The train-centric electronic interlocking system of claim 10, wherein the object controller (20) is con-

figured to identify the state information of the point machine (10) and to provide the state information to the onboard electronic interlocking system (30), the state information including a nominal or reverse state, a lock or unlock state, a fault or normal state of the point machine (10).

12. The train-centric electronic interlocking system of claim 10, wherein the point machine (10) has the switching area to which a fouling point is applied, and

the onboard electronic interlocking system (30) is configured to receive an operation state of the point machine (10) from the object controller (20) to identify the operation state, and to provide the path as much as the switching area of the secured point machine (10) to an onboard automatic train protection (32).

Patentansprüche

1. Zugzentrisches-Elektronisches-Stellwerk-Verfahren für ein autonomes Zugsteuerungssystem basierend auf einer Verbindung zwischen Zügen, wobei das Zugzentrische-Elektronische-Stellwerk-Verfahren aufweist:

Empfangen, durch ein bordseitiges elektronisches Stellwerkssystem (30) eines Zuges in einem Schritt 1, von Zustandsinformationen einer Weichenantriebs (10)-Liste mehrerer Weichenantriebe (10), die eine Strecke bilden, basierend auf einem Streckenbefehl einer Automatischer-Zug-Steuerungsüberwachung (1) von einer Objektsteuereinrichtung (20) eines Weichenantriebs (10), um die Zustandsinformationen der Weichenantriebe (10) der Liste zu identifizieren, Identifizieren, durch das bordseitige elektronische Stellwerk-System (30) in einem Schritt 2, ob sich ein bestimmter Weichenantrieb (10) in der Liste in einem Entriegelungs- oder Verriegelungszustand befindet, und Anfordern einer Änderung des Zustands des bestimmten Weichenantriebs (10) in den Verriegelungszustand von der mit dem bestimmten Weichenantrieb (10) verbundenen Objektsteuereinrichtung (20), wenn festgestellt wird, dass sich der bestimmte Weichenantrieb (10) in dem Entriegelungszustand befindet,

gekennzeichnet durch

Empfangen eines eindeutigen Schlüsselwerts, der für den Zugriff auf den bestimmten Weichenantrieb (10) erforderlich ist, von der Objektsteuereinrichtung (20) durch das bordseitige elektronische Stellwerk-System (30) in einem Schritt 3, wobei der eindeutige Schlüsselwert erzeugt wird, während der Zustand des bestimmten

- Weichenantriebs (10) in den Verriegelungszustand geändert wird; und
Übertragen eines Entriegelungsbefehls durch das bordseitige elektronische Stellwerk-System (30) in einem Schritt 4 an die mit dem bestimmten Weichenantrieb (10) verbundene Objektsteuereinrichtung (20) unter Verwendung des von der Objektsteuereinrichtung (20) empfangenen Schlüsselwerts, wodurch der bestimmte Weichenantrieb (10) entriegelt wird.
2. Zugzentrisches-Elektronisches-Stellwerk-Verfahren nach Anspruch 1, wobei der Schritt 1 aufweist:
- Senden einer Zustandsanfragenachricht durch das bordseitige elektronische Stellwerk-System (30) des Zuges in einem Schritt 1_1, die die Zustandsinformationen des bestimmten Weichenantriebs (10) anfragt, an alle Objektsteuereinrichtungen (20) einer Route; und
Empfangen, durch das bordseitige elektronische Stellwerk-System (30) in einem Schritt 1_2, der Zustandsinformationen des bestimmten Weichenantriebs (10) von der Objektsteuereinrichtung (20) des bestimmten Weichenantriebs (10).
3. Zugzentrisches-Elektronisches-Stellwerk-Verfahren nach Anspruch 1, wobei das bordseitige elektronische Stellwerk-System (30) des Zuges im Schritt 1 Überwacher-Zustand-Informationen der Weichenantriebe (10) von allen Objektsteuereinrichtungen (20) empfängt, die einzeln mit den Weichenantrieben (10) verbunden sind.
4. Zugzentrisches-Elektronisches-Stellwerk-Verfahren nach Anspruch 1, das ferner vor dem Schritt 1 aufweist:
Empfangen des Streckenbefehls durch das bordseitige elektronische Stellwerk-System (30) in einem Schritt 5 von der Automatischer-Zug-Steuerungsüberwachung (1) gemäß einem eindeutigen Fahrplan des Zuges und Speichern der IDs aller Weichenantriebe (10) einer Route und der Schaltbereiche der Weichenantriebe (10).
5. Zugzentrisches-Elektronisches-Stellwerk-Verfahren nach Anspruch 1, wobei die Zustandsinformationen des vom bordseitigen elektronischen Stellwerk-System (30) verwalteten Weichenantriebs (10) eine eindeutige ID des Weichenantriebs (10), einen Schaltbereich, einen nominellen oder inversen Zustand, einen Verriegelungs- oder Entriegelungszustand des Weichenantriebs (10) und einen Schlüsselwert für den Zugriff auf den Weichenantrieb (10) aufweisen.
6. Zugzentrisches-Elektronisches-Stellwerk-Verfahren nach Anspruch 1, wobei im Schritt 2 die Zugfahrt so lange verschoben wird, bis sich alle Weichenantriebe (10) in der vom bordseitigen elektronischen Stellwerk-System (30) angeforderten Weichenantrieb (10)-Liste im Entriegelungszustand befinden.
7. Zugzentrisches-Elektronisches-Stellwerk-Verfahren nach Anspruch 1, wobei der Schritt 4 aufweist:
- kontinuierliches Empfangen der Position des Zuges und eines belegten Abschnitts des Gleises von einer bordseitigen automatischen Zugsicherung (32) durch das bordseitige elektronische Stellwerk-System (30) in einem Schritt 4_1 und, wenn sich ein hinterer Endabschnitt des Zuges aus dem Bereich eines Weichenantriebs (10) herausbewegt, Anweisen der Objektsteuereinrichtung (20) des Weichenantriebs (10), den Weichenantrieb (10) zu entriegeln; und
Empfangen, durch das bordseitige elektronische Stellwerk-System (30) in einem Schritt 4_2, von Zustandsinformationen, nachdem der Zustand des Weichenantriebs (10) in den Entriegelungszustand geändert wurde, von der Objektsteuereinrichtung (20), die den Entriegelungsbefehl für den Weichenantrieb (10) empfangen hat.
8. Zugzentrisches-Elektronisches-Stellwerk-Verfahren nach Anspruch 1, wobei im Schritt 4, wenn das bordseitige elektronische Stellwerk-System (30) den Zwangsentriegelungsbefehl für den verriegelten Weichenantrieb (10) von der Objektsteuereinrichtung (20) des Weichenantriebs (10) im Verriegelungszustand oder von einer Steuerzentrale empfängt, während sich der Zug in einem Schaltbereich befindet, das bordseitige elektronische Stellwerk-System (30) Informationen über die Unmöglichkeit der Entriegelung an die Steuerzentrale oder die Objektsteuereinrichtung (20) überträgt.
9. Zugzentrisches-Elektronisches-Stellwerk-Verfahren nach Anspruch 1, wobei im Schritt 4, wenn ein von einer automatischen Zugsicherung (32) empfangener aktueller Bremsweg des Zuges in einem Nichtschaltbereich des bestimmten Weichenantriebs (10) liegt, das bordseitige elektronische Stellwerk-System (30) den Zwangsentriegelungsbefehl für den bestimmten Weichenantrieb (10) von einer Steuerzentrale an die mit dem bestimmten Weichenantrieb (10) verbundene Objektsteuereinrichtung (20) und an das bordseitige elektronische Stellwerk-System (30) überträgt; und
das bordseitige elektronische Stellwerk-System (30), das den Schlüssel des bestimmten Weichenantriebs (10) aufweist, identifiziert, ob der bestimmte Weichenantrieb (10) entriegelt werden kann, und gibt den Schlüssel an die Objektsteuereinrichtung

(20) des bestimmten Weichenantriebs (10) zurück, wodurch der bestimmte Weichenantrieb (10) entriegelt wird.

10. Zugzentrisches elektronisches Stellwerk-System für ein autonomes Zugsteuerungssystem basierend auf einer Verbindung zwischen Zügen, wobei das zugzentrische elektronische Stellwerk-System geeignet ist, ein Zugzentrisches-Elektronisches-Stellwerk-Verfahren nach einem der vorhergehenden Ansprüche auszuführen, und aufweist:

eine Automatischer-Zug-Steuerungsüberwachung (1), die so konfiguriert ist, dass sie einen Streckenbefehl gemäß einem eindeutigen Fahrplan eines Zuges ausführt;
ein bordseitiges elektronisches Stellwerk-System (30), das so konfiguriert ist, dass es eine Strecke des Zuges gemäß dem Befehl der Automatischer-Zug-Steuerungsüberwachung (1) steuert und die Integrität der Steuerung identifiziert,
einen Weichenantrieb (10), der so konfiguriert ist, dass er ein Gleis eines Schaltbereichs schaltet; und
eine Objektsteuereinrichtung (20), die so konfiguriert ist, dass sie den Weichenantrieb (10) gemäß einem Befehl des bordseitigen elektronischen Stellwerk-Systems (30) steuert und Zustandsinformationen des Weichenantriebs (10) an das bordseitige elektronische Stellwerk-System (30) liefert,
wobei die Zustandsinformationen des Weichenantriebs (10), welcher von dem bordseitigen elektronischen Stellwerk-System (30) verwaltet wird, aufweisen: eine eindeutige ID des Weichenantriebs (10), den Schaltbereich, einen nominellen oder inversen Zustand, einen Verriegelungs- oder Entriegelungszustand des Weichenantriebs (10) und einen Schlüsselwert für einen Zugriff auf den Weichenantrieb (10), und wobei die Objektsteuereinrichtung (20) dazu eingerichtet ist, den Zustand des Weichenantriebs (10) in den Verriegelungszustand zu ändern, während ein eindeutiger Schlüsselwert erzeugt wird und der eindeutige Schlüsselwert dem bordseitigen elektronischen Stellwerk-System (30) bereitgestellt wird.

11. Zugzentrisches elektronisches Stellwerk-System nach Anspruch 10, wobei die Objektsteuereinrichtung (20) so konfiguriert ist, dass sie die Zustandsinformationen des Weichenantriebs (10) identifiziert und die Zustandsinformationen dem bordseitigen elektronischen Stellwerk-System (30) bereitstellt, wobei die Zustandsinformationen einen nominellen oder inversen Zustand, einen Verriegelungs- oder Entriegelungszustand, einen Fehler- oder Normal-

zustand des Weichenantriebs (10) aufweisen.

12. Zugzentrisches elektronisches Stellwerk-System nach Anspruch 10, wobei der Weichenantrieb (10) den Schaltbereich aufweist, an dem ein Grenzzeichen angebracht ist, und

das bordseitige elektronische Stellwerk-System (30) so konfiguriert ist, dass es einen Betriebszustand des Weichenantriebs (10) von der Objektsteuereinrichtung (20) empfängt, um den Betriebszustand zu identifizieren, und die Strecke bis zum Schaltbereich des gesicherten Weichenantriebs (10) einer bordseitigen automatischen Zugsicherung (32) bereitstellt.

Revendications

1. Procédé de verrouillage électronique centré sur le train pour un système de commande de train autonome basé sur une connexion entre trains, le procédé de verrouillage électronique centré sur le train comprenant :

recevoir, par un système de verrouillage électronique embarqué (30) d'un train à l'étape 1, des informations d'état d'une liste de machines d'aiguillage (10) de multiples machines d'aiguillage (10) composant un trajet basé sur une commande de trajet d'une supervision automatique de train de commande (1) à partir d'un contrôleur d'objets (20) d'une machine d'aiguillage (10) pour identifier les informations d'état des machines d'aiguillage (10) de ladite liste ;

identifier, par le système de verrouillage électronique embarqué (30) à l'étape 2, si une machine d'aiguillage particulière (10) dans ladite liste est dans un état déverrouillé ou verrouillé, et demander un changement de l'état de la machine d'aiguillage particulière (10) à l'état verrouillé, à partir du contrôleur d'objets (20) connecté à la machine d'aiguillage particulière (10) lors de la détermination que la machine d'aiguillage particulière (10) est dans l'état déverrouillé ;

caractérisé par la réception, par le système de verrouillage électronique embarqué (30) à l'étape 3, d'une valeur de clé unique requise pour accéder à la machine d'aiguillage particulière (10) à partir du contrôleur d'objets (20), la valeur de clé unique étant générée tout en changeant l'état de la machine d'aiguillage particulière (10) à l'état verrouillé ; et

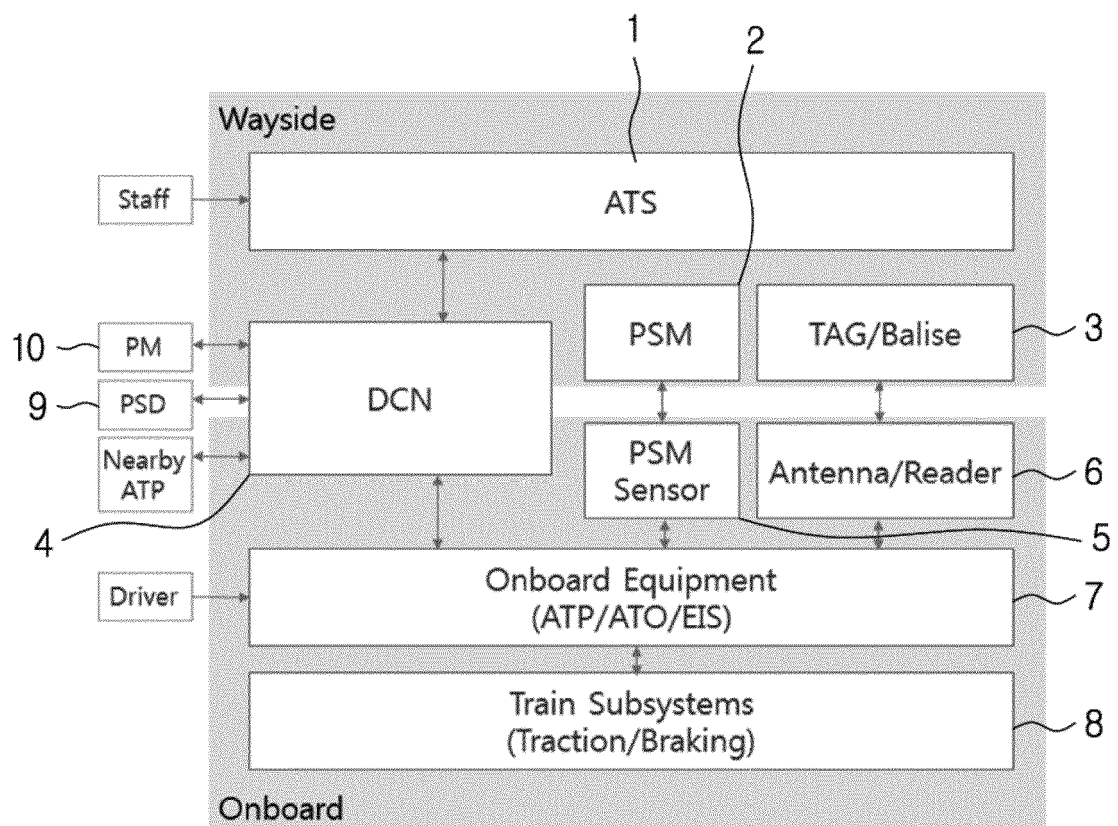
transmettre, par le système de verrouillage électronique embarqué (30) à l'étape 4, une commande de déverrouillage au contrôleur d'objets

- (20) connecté à la machine d'aiguillage particulière (10) en utilisant la valeur de clé reçue du contrôleur d'objets (20), moyennant quoi la machine d'aiguillage particulière (10) est déverrouillée.
2. Procédé de verrouillage électronique centré sur le train selon la revendication 1, dans lequel l'étape 1 comprend :
- transmettre, par le système de verrouillage électronique embarqué (30) du train à l'étape 1_1, un message de demande d'état demandant les informations d'état de la machine d'aiguillage particulière (10) à tous les contrôleurs d'objets (20) d'un itinéraire ; et
- recevoir, par le système de verrouillage électronique embarqué (30) à l'étape 1_2, les informations d'état de la machine d'aiguillage particulière (10) du contrôleur d'objets (20) de la machine d'aiguillage particulière (10).
3. Procédé de verrouillage électronique centré sur le train selon la revendication 1, dans lequel à l'étape 1, le système de verrouillage électronique embarqué (30) du train reçoit des informations d'état supervisées des machines d'aiguillage (10) de tous les contrôleurs d'objets (20) qui sont individuellement connectés aux machines d'aiguillage (10).
4. Procédé de verrouillage électronique centré sur le train selon la revendication 1, comprenant en outre, avant l'étape 1 :
- recevoir, par le système de verrouillage électronique embarqué (30) à l'étape 5, de la commande de trajet provenant de la supervision automatique de train de commande (1) selon un horaire unique du train, et stocker des identifiants de toutes les machines d'aiguillage (10) d'un itinéraire et des zones de commutation des machines d'aiguillage (10).
5. Procédé de verrouillage électronique centré sur le train selon la revendication 1, dans lequel les informations d'état de la machine d'aiguillage (10) gérées par le système de verrouillage électronique embarqué (30) comprennent un identifiant unique de la machine d'aiguillage (10), une zone de commutation, un état nominal ou inversé, un état de verrouillage ou de déverrouillage de la machine d'aiguillage (10), et une valeur de clé pour accéder à la machine d'aiguillage (10).
6. Procédé de verrouillage électronique centré sur le train selon la revendication 1, dans lequel à l'étape 2, le trajet du train est reporté jusqu'à ce que toutes les machines d'aiguillage (10) dans la liste des machines d'aiguillage (10) demandées par le système de verrouillage électronique embarqué (30) soient
- dans l'état déverrouillé.
7. Procédé de verrouillage électronique centré sur le train selon la revendication 1, dans lequel l'étape 4 comprend :
- recevoir en continu, par le système de verrouillage électronique embarqué (30) à l'étape 4_1, la position du train et une section occupée de la voie à partir d'une protection de train automatique embarquée (32), et lorsqu'une partie d'extrémité arrière du train sort d'une zone de machine d'aiguillage (10), commander le contrôleur d'objets (20) de la machine d'aiguillage (10) pour déverrouiller la machine d'aiguillage (10) ; et
- recevoir, par le système de verrouillage électronique embarqué (30) à l'étape 4_2, des informations d'état après avoir changé l'état de la machine d'aiguillage (10) à l'état de déverrouillage, à partir du contrôleur d'objets (20) qui a reçu la commande de déverrouillage pour la machine d'aiguillage (10).
8. Procédé de verrouillage électronique centré sur le train selon la revendication 1, dans lequel à l'étape 4, lorsque le système de verrouillage électronique embarqué (30) reçoit la commande de déverrouillage forcé pour la machine d'aiguillage verrouillée (10) du contrôleur d'objets (20) de la machine d'aiguillage (10) dans l'état verrouillé ou d'un centre de commande alors que le train subsiste dans une zone de commutation, le système de verrouillage électronique embarqué (30) transmet des informations d'impossibilité de déverrouillage au centre de commande ou au contrôleur d'objets (20).
9. Procédé de verrouillage électronique centré sur le train selon la revendication 1, dans lequel à l'étape 4,
- lorsqu'une distance de freinage actuelle du train reçue d'une protection de train automatique (32) subsiste dans une zone de non commutation de la machine d'aiguillage particulière (10), le système de verrouillage électronique embarqué (30) transmet la commande de déverrouillage forcé pour la machine d'aiguillage particulière (10) à partir d'un centre de commande au contrôleur d'objets (20) connecté à la machine d'aiguillage particulière (10) et au système de verrouillage électronique embarqué (30) ; et
- le système de verrouillage électronique embarqué (30) ayant la clé de la machine d'aiguillage particulière (10) identifie si la machine d'aiguillage particulière (10) peut être déverrouillée, et renvoie la clé au contrôleur d'objets (20) de la machine d'aiguillage particulière (10), moyennant quoi la machine d'aiguillage particulière (10) est déverrouillée.

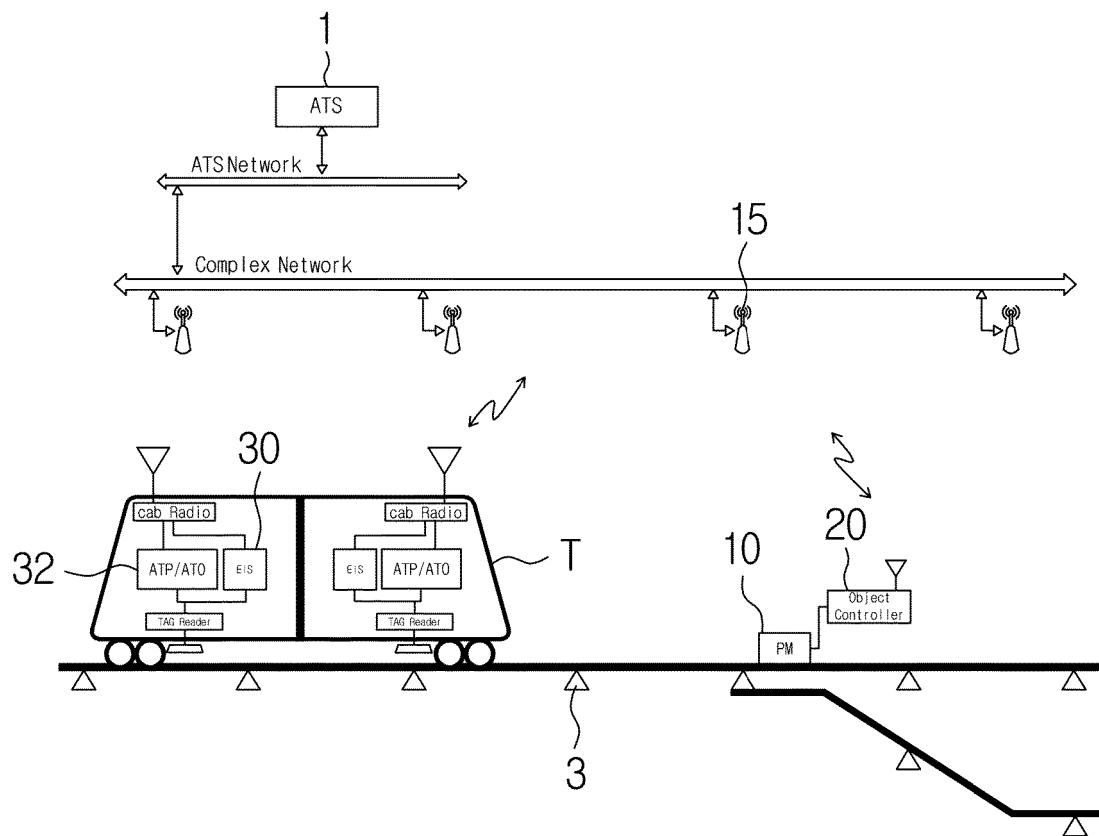
10. Système de verrouillage électronique centré sur le train pour un système de commande de train autonome basé sur une connexion entre trains, le système de verrouillage électronique centré sur le train étant approprié pour mettre en oeuvre un procédé de verrouillage électronique centré sur le train selon l'une quelconque des revendications précédentes et comprenant :
- une supervision automatique de train de commande (1) configurée pour exécuter une commande de trajet selon un horaire unique d'un train ;
 - un système de verrouillage électronique embarqué (30) configuré pour contrôler un trajet du train en fonction de la commande de la supervision automatique de train de commande (1), et identifier l'intégrité de la commande ;
 - une machine d'aiguillage (10) configurée pour commuter une voie d'une zone de commutation ; et
 - un contrôleur d'objets (20) configuré pour commander la machine d'aiguillage (10) selon une commande du système de verrouillage électronique embarqué (30), et fournir des informations d'état de la machine d'aiguillage (10) au système de verrouillage électronique embarqué (30), dans lequel les informations d'état de la machine d'aiguillage (10) gérées par le système de verrouillage électronique embarqué (30) comprennent un identifiant unique de la machine d'aiguillage (10), la zone de commutation, un état nominal ou inversé, un état de verrouillage ou de déverrouillage de la machine d'aiguillage (10), et une valeur de clé pour accéder à la machine d'aiguillage (10), et
 - dans lequel le contrôleur d'objets (20) est configuré pour changer l'état de la machine d'aiguillage (10) à l'état verrouillé tout en générant une valeur de clé unique et en fournissant la valeur de clé unique au système de verrouillage électronique embarqué (30).
11. Système de verrouillage électronique centré sur le train selon la revendication 10, dans lequel le contrôleur d'objets (20) est configuré pour identifier les informations d'état de la machine d'aiguillage (10) et pour fournir les informations d'état au système de verrouillage électronique embarqué (30), les informations d'état comprenant un état nominal ou inversé, un état de verrouillage ou de déverrouillage, un état de défaut ou normal de la machine d'aiguillage (10).
12. Système de verrouillage électronique centré sur le train selon la revendication 10, dans lequel la machine d'aiguillage (10) a la zone de commutation à laquelle un point d'engorgement est appliqué, et

le système de verrouillage électronique embarqué (30) est configuré pour recevoir un état de fonctionnement de la machine d'aiguillage (10) à partir du contrôleur d'objets (20) pour identifier l'état de fonctionnement, et pour fournir le trajet autant que la zone de commutation de la machine d'aiguillage sécurisée (10) vers une protection de train automatique embarquée (32).

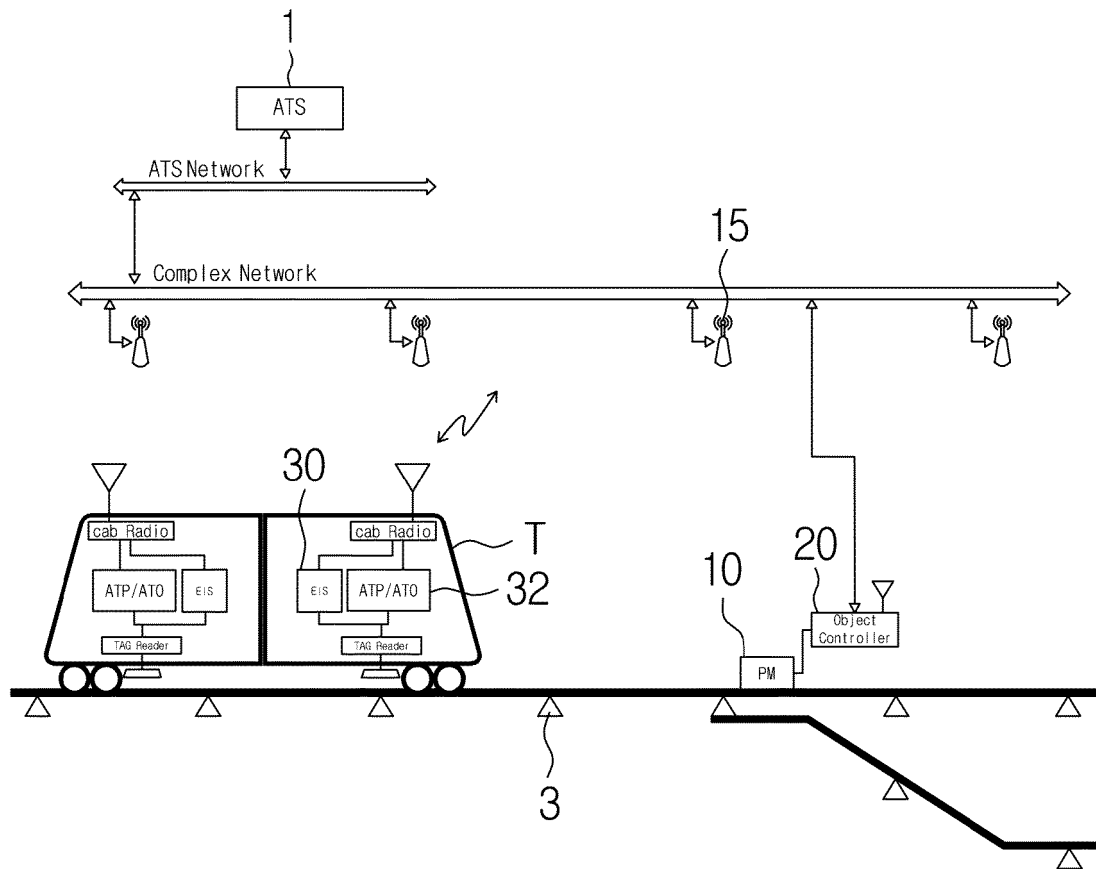
[Figure 1]



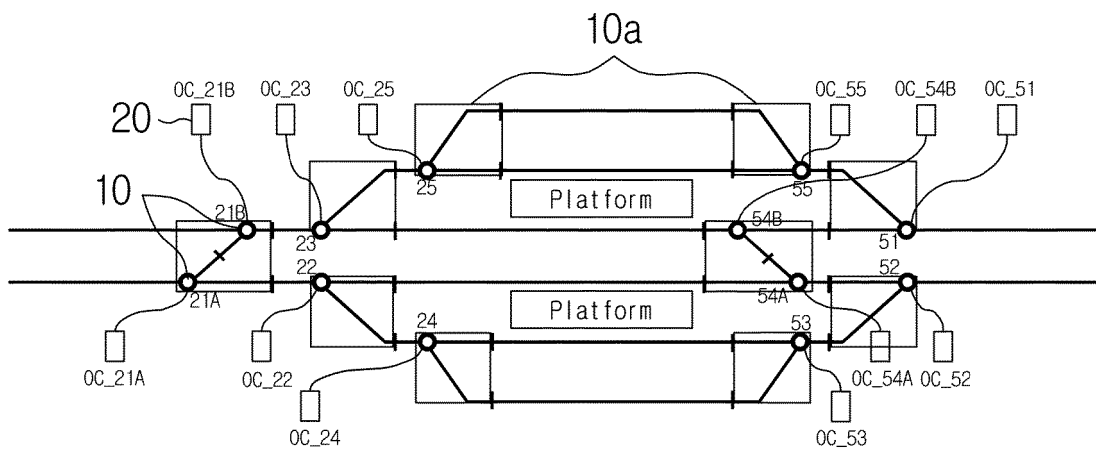
[Figure 2]



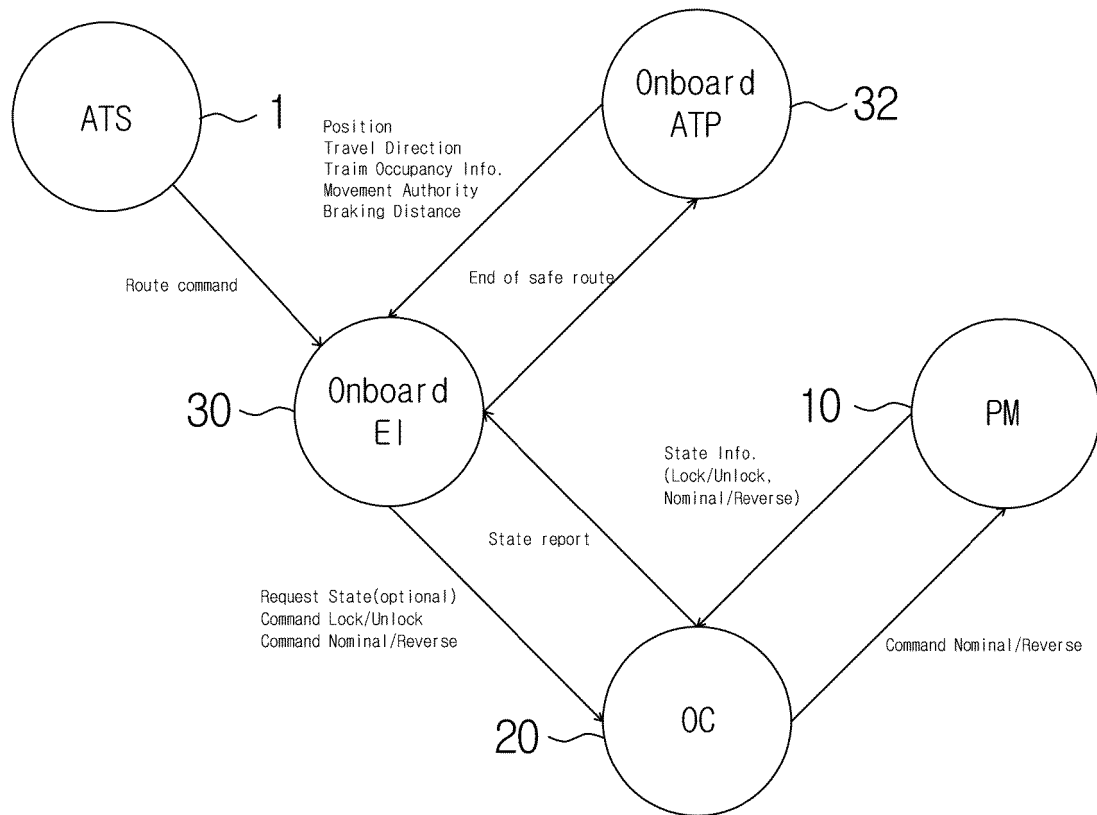
[Figure 3]



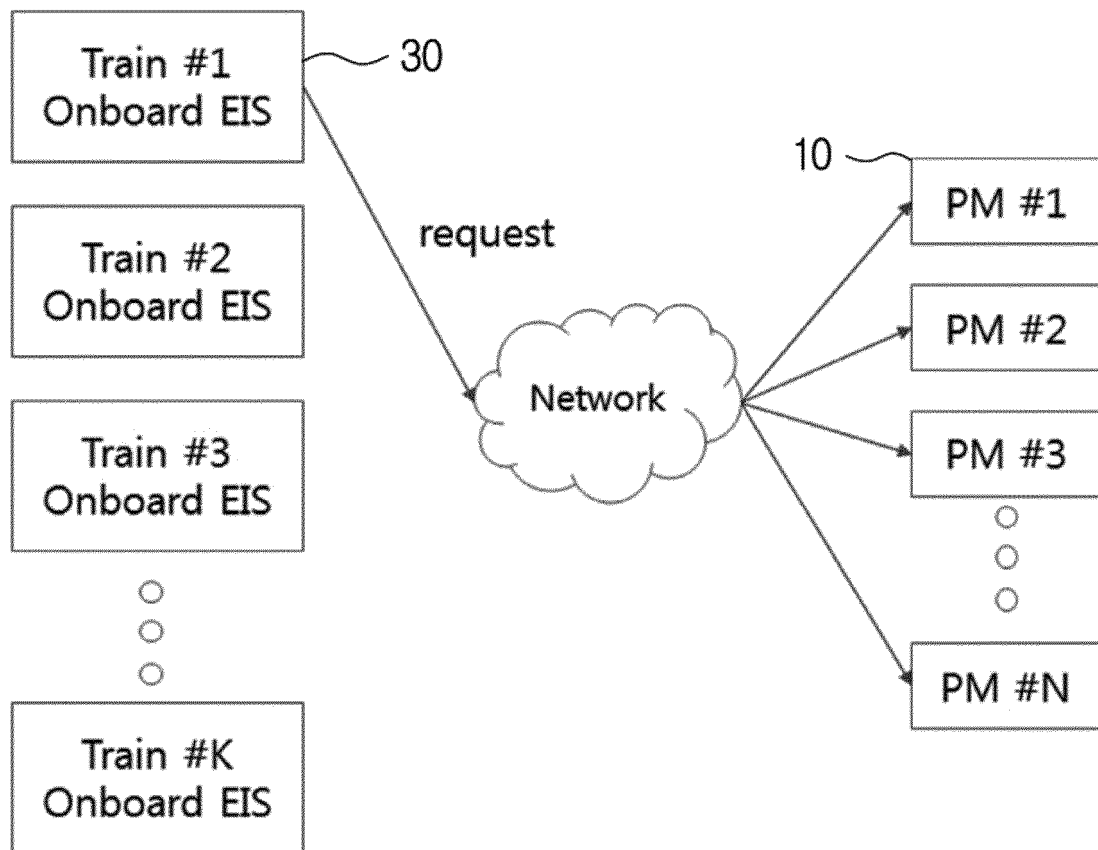
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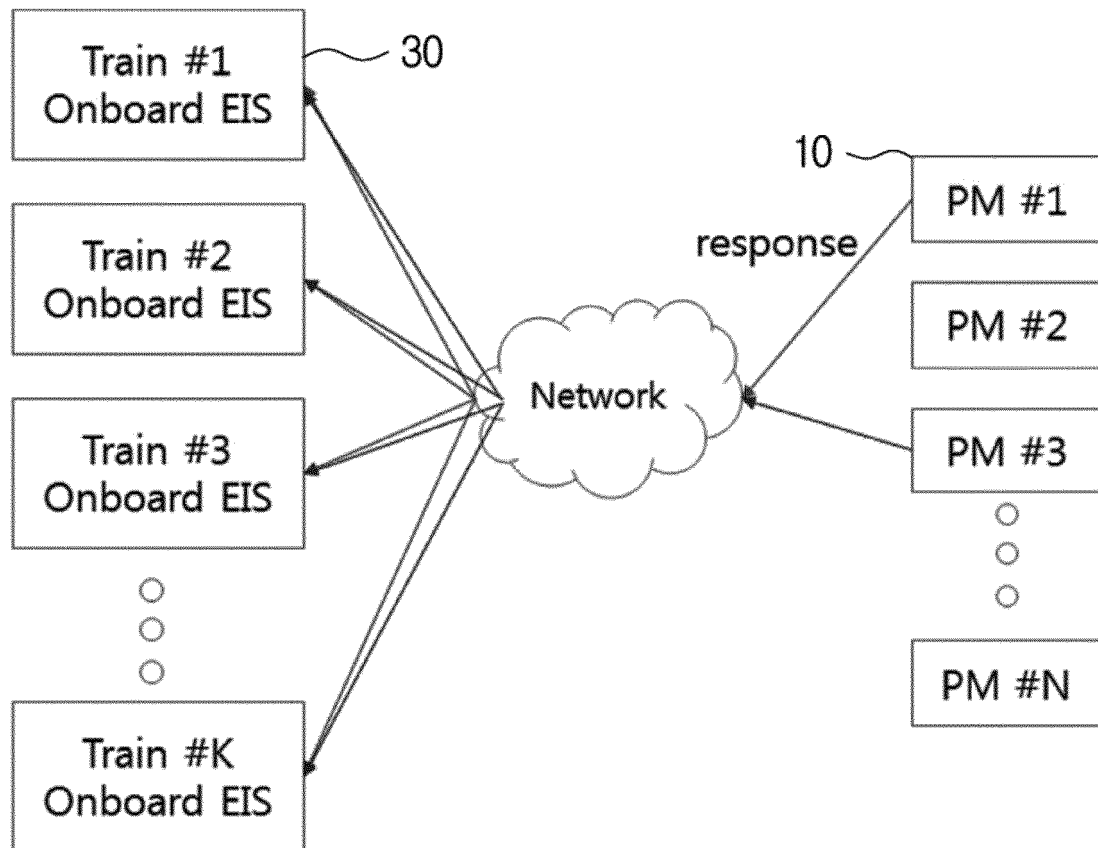
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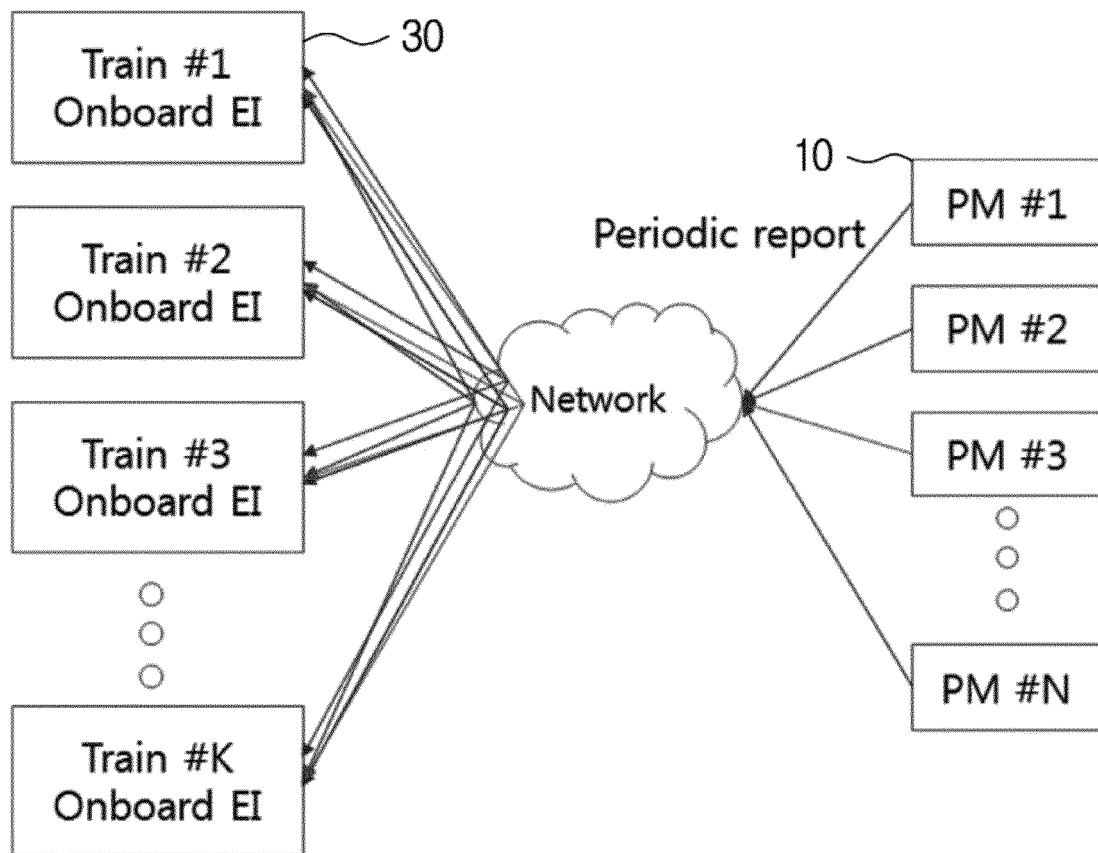
[Figure 6a]



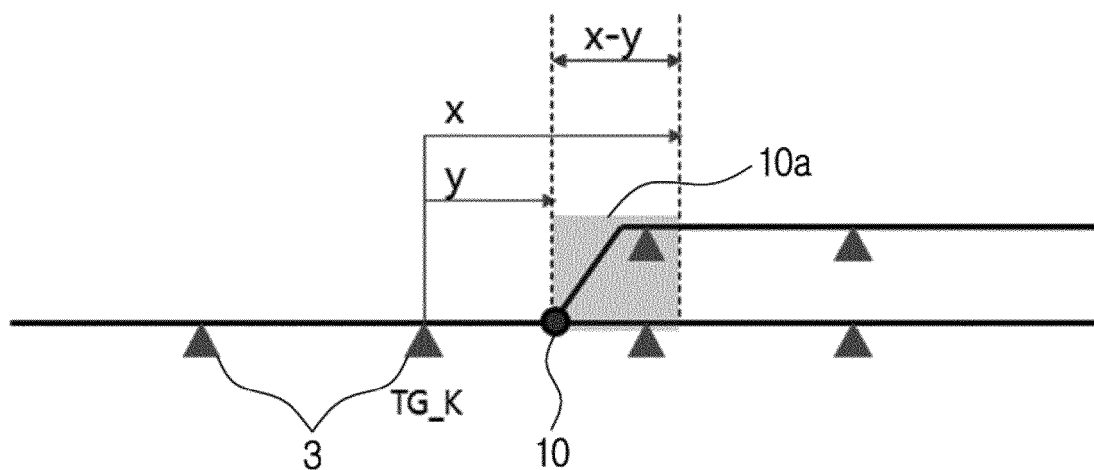
[Figure 6b]



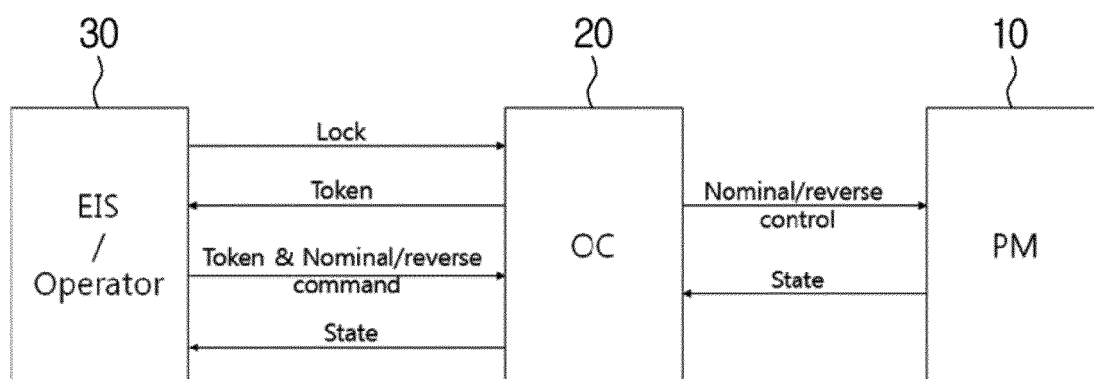
[Figure 7]



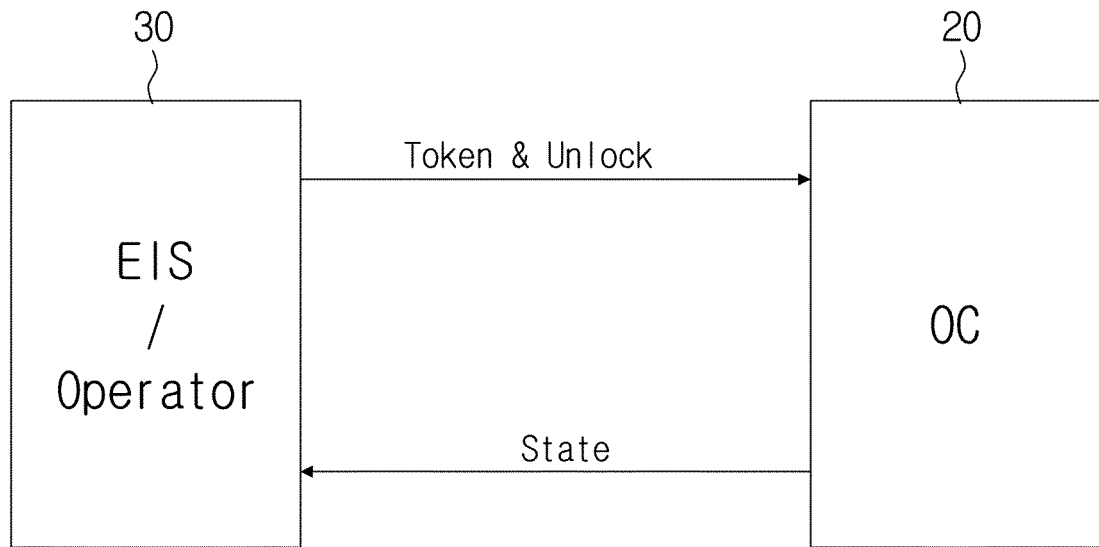
[Figure 8]



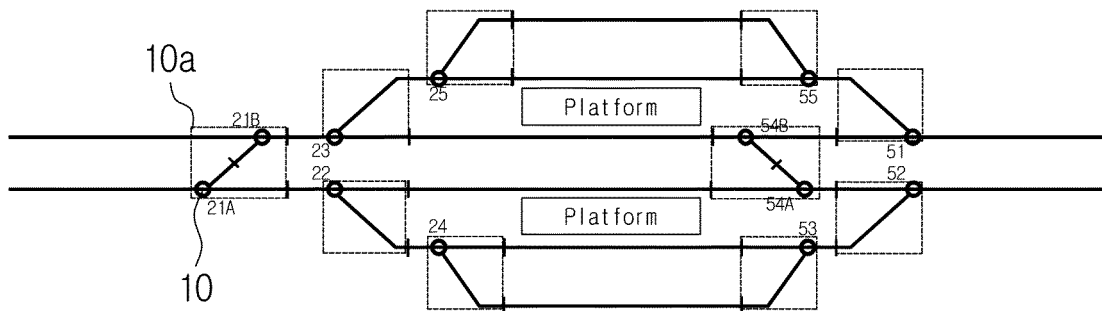
[Figure 9]



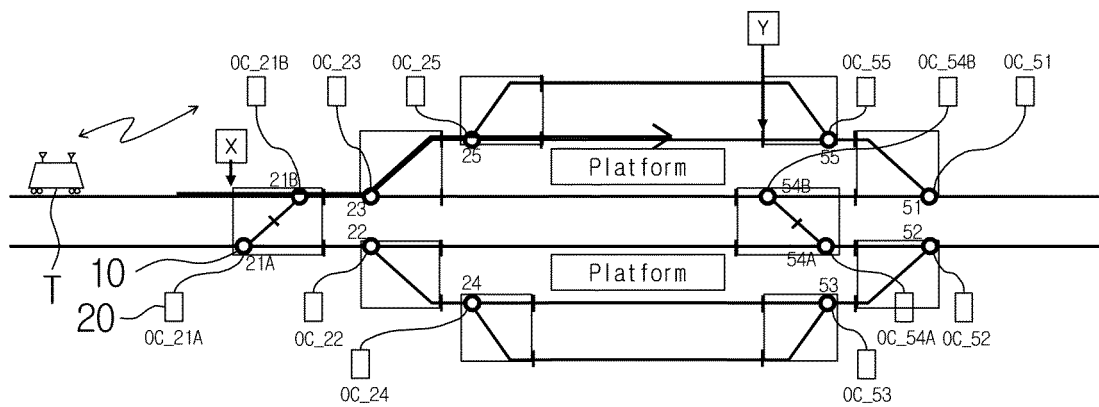
[Figure 10]



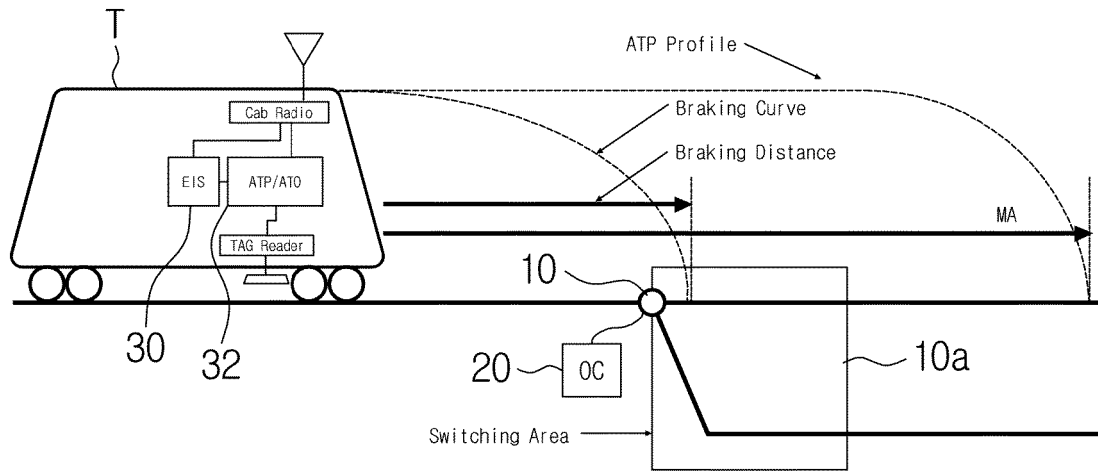
[Figure 11]



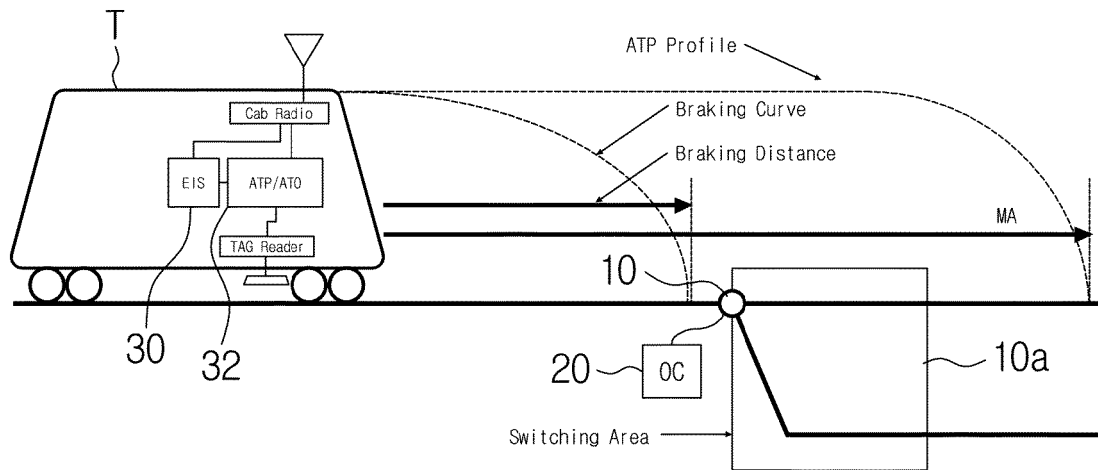
[Figure 12]



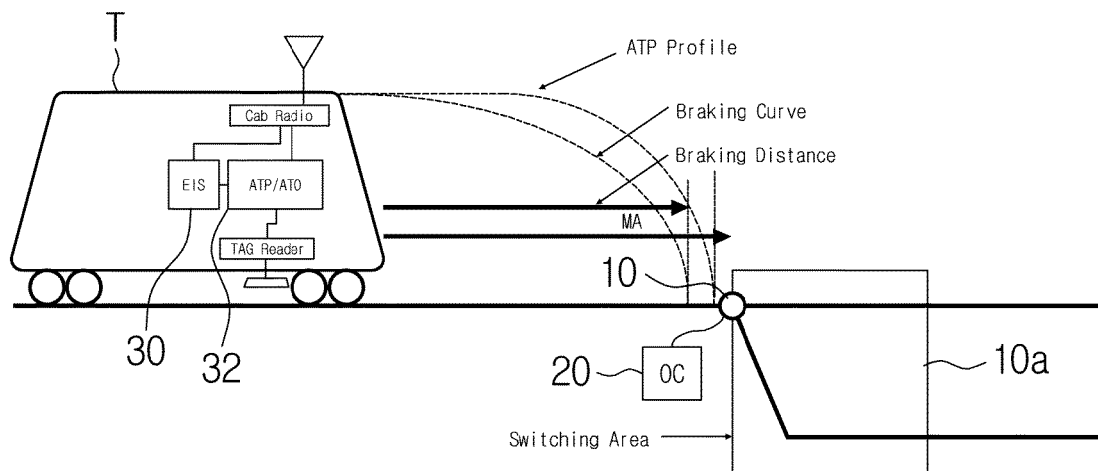
[Figure 13]



[Figure 14]



[Figure 15]



REFERENCES CITED IN THE DESCRIPTION

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