(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 March 2019 (14.03.2019)

WIPO | PCT

(10) International Publication Number
WO 2019/050901 A1

(51) International Patent Classification:
B61L 27/00 (2006.01) *B61L 1/18* (2006.01)
B61L 15/00 (2006.01) *B61L 21/10* (2006.01)

(21) International Application Number:
PCT/US2018/049480

(22) International Filing Date:
05 September 2018 (05.09.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/554,667 06 September 2017 (06.09.2017) US

(71) Applicant: **WESTINGHOUSE AIR BRAKE TECHNOLOGIES CORPORATION** [US/US]; 1001 Air Brake Avenue, Wilmerding, Pennsylvania 15148 (US).

(72) Inventors: **DREASHER, Rebecca, W.**; 806 Bluegrass Drive, Longmont, Colorado 80503 (US). **GRIMM, Ann, K.**; 1535 Maplewood Drive NE, Cedar Rapids, Iowa 52402 (US). **KERNWEIN, Jeffrey, D.**; 2532 L. Avenue NW, Cedar Rapids, Iowa 52405 (US). **PRETORIUS, Francois**; 12999 Minerich Road, Paonia, Colorado 81428 (US).

(74) Agent: **BYRNE, Richard, L.** et al.; The Webb Law Firm, One Gateway Center, 420 Ft. Duquesne Blvd., Suite 1200, Pittsburgh, Pennsylvania 15222 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

WO 2019/050901 A1

(54) Title: SYSTEM FOR ENFORCING CONDITIONAL AUTHORITIES USING LOCOMOTIVE TO LOCOMOTIVE MONITORING

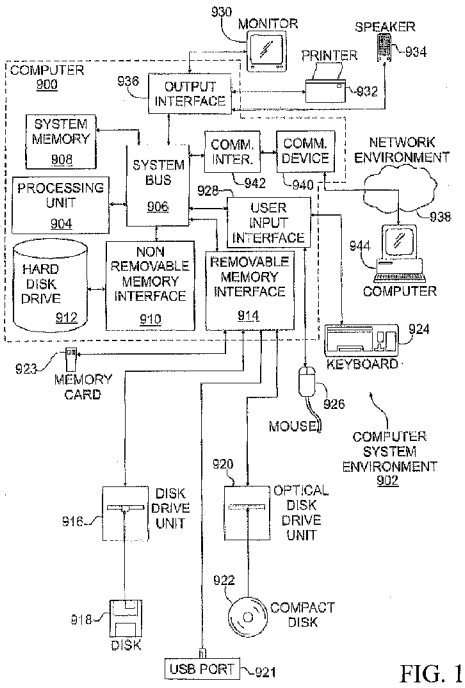

FIG. 1

(57) Abstract: A system for managing movement authorities in a positive train control system includes a first on-board system situated on a first train having one or more locomotives; a second on-board system situated on a second train having one or more locomotives; and a back office system remote from the first and second trains, wherein the first and second on-board systems are configured to receive a respective first and second movement authority from the back office system, wherein the second movement authority includes a condition that constrains the second movement authority by the first movement authority, wherein the second on-board system is configured to transmit to the first on-board system an inquiry relating to the condition, wherein the first on-board system is configured to transmit a report to the second on-board system in response to receipt of the inquiry when the condition is satisfied.

[Continued on next page]

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

SYSTEM FOR ENFORCING CONDITIONAL AUTHORITIES USING LOCOMOTIVE TO LOCOMOTIVE MONITORING

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to United States Provisional Application No. 62/554,667 filed September 6, 2017, the disclosure of which is incorporated in its entirety by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] Preferred and non-limiting embodiments are related to positive train control (PTC) systems and, in particular, to a system and method for managing movement authorities in a PTC system.

Description of Related Art

[0003] Previous generation train control systems support movement authorities with conditions through verbal procedures between crew and dispatcher. The crew is responsible for monitoring and complying with the conditions. Newer, PTC-compliant train control systems tolerate the issuance of movement authorities with conditions, but do not algorithmically enforce the fulfillment of conditions. To overcome this limitation, dispatching systems might implement authority stacking, where movement authorities with conditions are queued. The dispatching system monitors the movement of trains and issues queued authorities only after conditions are fulfilled.

[0004] In Dynamic Block operations, an office computer exclusively allocates one or more track blocks to each train. As a train progresses, vacated blocks are released and allocated to other trains. Since the minimum spacing of trains is a function of the size of blocks and speed of the release and allocation process, efficient use of the Dynamic Block method requires that a railroad be subdivided into small block sections and provide robust communications between on board computers and the office computer.

[0005] Railroads are not able to employ radio blocking on subdivisions where PTC is required because the current implementation of positive train control systems, such as I-ETMS® of Wabtec Corp., do not support enforcement of the authority limits that are released from a leading train to a following train without dispatching system supervision.

[0006] Additionally, the Federal Railroad Administration (FRA) is not satisfied with the current implementation of PTC systems with regard to conditional movement authority (e.g., a movement authority that includes an "in effect after arrival" or "do not foul limits ahead / in effect behind" condition). The on-board segment or computer prompts the crew of

the train holding the conditional authority to press a key to indicate the arrival of the train(s) identified in the authority. The opportunity for human error is higher than desired with the prior art.

SUMMARY OF THE INVENTION

[0007] Generally provided is a system and method for managing movement authorities in a positive train control (PTC) system that addresses or overcomes some or all of the deficiencies and drawbacks associated with existing methods and systems for transmitting enforceable instructions in PTC systems, including, but not limited to, I-ETMS® of Wabtec Corp.

[0008] Preferably, provided is a system for managing movement authorities in a positive train control (PTC) system, the system including (a) a first on-board system situated on a first train having one or more locomotives; (b) a second on-board system situated on a second train having one or more locomotives; and (c) a back office system remote from the first and second trains, wherein the first on-board system, the second on-board system, and the back office system are communicatively connected to each other via a network, wherein the first and second on-board systems are configured to receive a respective first and second movement authority from the back office system, wherein the second movement authority includes a condition that constrains the second movement authority by the first movement authority so that a movement of the second train is dependent on a movement of the first train, wherein the second on-board system is configured to directly transmit to the first on-board system an inquiry relating to the condition, wherein the first on-board system is configured to directly transmit a report to the second on-board system either: (i) in response to receipt of the inquiry when the condition is satisfied; or (ii) prior to when the condition is satisfied as determined by the second on-board system. It is to be understood that the first train/locomotive may evaluate a condition involving more than one train/locomotive.

[0009] Determination that the condition is satisfied may be based at least on the first movement authority and location data of the first train defined by (a) a head-end location of the train and a (b) a crew-confirmed point or an end-of-train location of the train. The second movement authority may include one or more of (a) an "In Effect After Arrival" condition; (b) "Do Not Foul Limits Ahead / In Effect Behind" condition; and (c) an identification of the one or more locomotives of the first train and direction of movement thereof. The second on-board system may be configured to display visual indicia corresponding to the report. The first and second movement authorities are received by the back office system from a

computer-aided dispatch. The back office system may determine that an overlap existing between the first and second movement authorities is valid before transmitting the first and second movement authorities to the respective first and second on-board systems. The back office system may transmit communication parameters to the first and second on-board systems to effect communication therebetween. The second on-board system may be configured to directly transmit to a plurality of other on-board systems respective inquiries relating to respective conditions associated with a plurality of movement authorities received by the second on-board system.

[0010] A method for managing movement authorities in a positive train control (PTC) system includes the steps of: (a) receiving at a first on-board system of a first train having one or more locomotives a first movement authority from a back office system; (b) receiving at a second on-board system of a second train having one or more locomotives a second movement authority from the back office system, wherein the second movement authority includes a condition that constrains the second movement authority by the first movement authority so that a movement of the second train is dependent on a movement of the first train, wherein the back office system is remote from the first and second trains, wherein the first on-board system, the second on-board system, and the back office system are communicatively connected to each other via a network; (c) transmitting from the second on-board system to the first on-board system an inquiry relating to the condition; and (d) transmitting from the first on-board system to the second on-board system a report in response to receipt of the inquiry either (i) when the condition is satisfied; or (ii) prior to when the condition is satisfied as determined by the second on-board system.

[0011] An on-board locomotive system used to receive movement authorities in a positive train control (PTC) system, the on-board locomotive system including one or more computers having computer readable mediums having stored thereon instructions which, when executed by one or more processors of the one or more computers, causes the system to perform the steps of: (a) receiving at the on-board locomotive system a movement authority from a back office system, wherein the movement authority includes a condition that constrains the movement authority by another movement authority received by another on-board locomotive system; (b) transmitting from the on-board locomotive system to the another on-board locomotive system an inquiry relating to the condition; and (c) receiving at the on-board locomotive system from the another on-board locomotive system a report in response to receipt of the inquiry either (i) when the condition is satisfied; or (ii) prior to when the condition is satisfied as determined by the second on-board system.

[0012] A computer readable medium having stored thereon instructions which, when executed by one or more processors of one or more computers, causes the one or more processors to execute steps of a method for receiving movement authorities by an on-board locomotive system in a positive train control (PTC) system, the method including the steps of: (a) receiving at the on-board locomotive system a movement authority from a back office system, wherein the movement authority includes a condition that constrains the movement authority by another movement authority received by another on-board locomotive system; (b) transmitting from the on-board locomotive system to the another on-board locomotive system an inquiry relating to the condition; and (c) receiving at the on-board locomotive system from the another on-board locomotive system a report in response to receipt of the inquiry either (i) when the condition is satisfied; or (ii) prior to when the condition is satisfied as determined by the second on-board system.

[0013] The present invention may be useful to facilitate increased train throughput in the absence of absolute signals. Communication between a dependent and constraining locomotives may be leveraged to inform a crew of a dependent locomotive of progress of constraining locomotives against the conditions and to inform a crew of a constraining locomotive of the existence of dependent locomotives. The present invention is intended to have minimal impact to a track data file. Train spacing may be minimized without increasing the number of track blocks defined in the track model. The present invention may reduce departure delays. Since conditional authorities may be delivered in advance of conditions being fulfilled, the crew can review a movement authority while waiting for the conditions to be met without causing departure delays. The present invention may reduce dependence on communication between a back office computer and on-board computers. The present invention may implement train clearance reports only when a dependent locomotive has requested reports. This approach essentially distributes the burden of release and allocation of track to on board computers. The present invention may be incrementally implemented in a PTC system without disrupting existing interoperable methods.

[0014] These and other features and characteristics of the present invention, as well as the methods of operation and functions of the related elements of structures and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following description and the appended claims, if any, with reference to the accompanying drawings, all of which form a part of this specification, wherein like reference numerals designate corresponding parts in the various figures. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description

only and are not intended as a definition of the limits of the invention. As used in the specification and the claims, if any, the singular form of "a", "an", and "the" include plural referents unless the context clearly dictates otherwise.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1 is a block diagram of a computer system according to principles of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0016] For purposes of the description hereinafter, the terms "end", "upper", "lower", "right", "left", "vertical", "horizontal", "top", "bottom", "lateral", "longitudinal" and derivatives thereof shall relate to the invention as it is oriented in the drawing figures. It is to be understood that the invention may assume various alternative variations and step sequences, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the drawings, and described in the following specification, are simply exemplary embodiments of the invention. Hence, specific dimensions and other physical and/or processing characteristics related to the embodiments disclosed herein are not to be considered as limiting.

[0017] As used herein, the terms "communication" and "communicate" refer to the receipt or transfer of one or more signals, messages, commands, or other type of data. For one unit or component to be in communication with another unit or component means that the one unit or component is able to directly or indirectly receive data from and/or transmit data to the other unit or component. This can refer to a direct or indirect connection that may be wired and/or wireless in nature. Additionally, two units or components may be in communication with each other even though the data transmitted may be modified, processed, routed, and the like, between the first and second unit or component. For example, a first unit may be in communication with a second unit even though the first unit passively receives data, and does not actively transmit data to the second unit. As another example, a first unit may be in communication with a second unit if an intermediary unit processes data from one unit and transmits processed data to the second unit. It will be appreciated that numerous other arrangements are possible.

[0018] Table 1 below defines various acronyms used in the description.

TABLE 1

Acronym	Definition
BOS	Back Office Server or Segment
CAD	Computer Aided Dispatch
FRA	Federal Railroad Administration
I-ETMS	Interoperable Electronic Train Management System
ITC	Interoperable Train Control
PTC	Positive Train Control

[0019] Table 2 below defines various terms used in the description.

TABLE 2

Term	Definition
Constraining Locomotive	Controlling locomotive of a train leading another train or meeting another train; the authority held by the constraining locomotive is not conditional upon movement of the train controlled by the dependent locomotive
Dependent Locomotive	Controlling locomotive of a train following another train or waiting for a meet with another train; the dependent locomotive's authority is conditional upon movement of the train controlled by the constraining locomotive
Do Not Foul Limits Ahead / In Effect Behind	A condition placed on a locomotive's movement authority indicating that the movement authority is not in effect until it is no longer occupied by one or more leading trains. Note that "do not foul limits ahead / in effect behind" is the terminology agreed upon by the ITC although railroads may use different terminology for this condition in their operations.
In Effect After Arrival	A condition placed on a locomotive's movement authority indicating that the movement authority is not in effect beyond an "at" milepost until one or more opposing trains have arrived. Note that "in effect after arrival" is the terminology agreed upon by the ITC although railroads may use different terminology for this condition in their operations.

[0020] The present invention is a system and method of train control where movement authorities with conditions are electronically issued by a back office system to on-board computers, where the conditions are monitored and resolved by means of direct communications among on-board computers, without relying upon incremental authority

being provided by a back office system. A conditional authority is a movement authority that is subject to one or more conditions that must be satisfied for the authority to be considered in effect. The condition may be fulfilled once (in effect after arrival) or must be perpetually met (do not foul limits ahead / in effect behind). A constraining locomotive is the controlling locomotive of a train leading another train or meeting another train. A dependent locomotive is a controlling locomotive of a train following another train or waiting for a meet with another train; the dependent locomotive's authority is conditional upon movement of the train controlled by the constraining locomotive.

[0021] The invention may include various components, such as an office computer, an on-board computer installed on a dependent locomotive, and an on-board computer installed on a constraining locomotive.

[0022] The office computer may perform one or more of the following functions: (1) accept movement authorities from an existing dispatching system; (2) validate that any overlap among issued movement authorities is explained by an acceptable rule or authority condition; (3) attach a code to each authority that represents all bulletins and restrictions that must be present on the on-board computer to which the authority is issued; (4) electronically transmit authorities to the appropriate on-board computer, and (5) provide communication parameters to facilitate direct communication between on-board computers.

[0023] The onboard computer installed on a dependent locomotive may perform one or more the following functions: (1) process a movement authority message that includes one or more conditions; (2) obtain communication parameters from a back office computer to allow direct communication with an onboard computer associated with a condition of a movement authority; (3) communicate with the onboard computer(s) associated with each condition of a movement authority; (4) monitor and update movement authority targets based on train clearance locations reported by the onboard computer associated with each movement authority condition; and (5) limit train movement to where movement authority conditions are met.

[0024] The on-board computer installed on a constraining locomotive may perform one or more of the following functions: (1) accepts requests from a plurality of on-board computers for train clearance reports; (2) selects train clearance track locations based on current movement authority, train head end location, and either crew-confirmed clearance points or a location calculated using a GPS-equipped end-of-train (EOT) device; and (3) reports track clearance location to all on-board computers that have requested reports.

[0025] A track database may identify dispatchable points that may be referenced by the on-board computers on both dependent and constraining locomotives. It is to be understood that the system may continue to rely on voice radio conversations between crews.

[0026] In one embodiment, issuing a movement authority to a constraining locomotive is set forth as follows. CAD (e.g., the dispatching system) specifies the full limits of the movement authority for the constraining locomotive and sends that movement authority to the BOS (e.g., back office computer). The BOS delivers the movement authority to the constraining locomotive as in the prior art. Any movement authority that constrains the movement authority of a dependent locomotive must be wholly unidirectional. CAD may determine that any bidirectional authority segment is issued separately from any movement authority that constrains the movement authority of a dependent locomotive. The movement authority issued to a constraining locomotive does not necessarily identify any dependent locomotive(s).

[0027] In one embodiment, issuing a movement authority to a dependent locomotive is set forth as follows. CAD sends a movement authority to the BOS for a dependent locomotive as in the current implementation. The movement authority contains the applicable condition, either "in effect after arrival" or "do not foul limits ahead / in effect behind", and identifies the constraining locomotive(s) and their direction of movement.

[0028] The BOS will detect an overlap of limits between the movement authorities of the constraining locomotive and dependent locomotive but will allow the overlap due to the presence of the "in effect after arrival" or "do not foul limits ahead / in effect behind" condition. Following successful transformation checking the BOS delivers the movement authority to the dependent locomotive's on-board segment.

[0029] The present invention, as discussed above, may be implemented on a variety of computing devices, servers, processing units, and systems, wherein these computing devices, servers, processing units, and systems include the appropriate processing mechanisms and computer-readable media for storing and executing computer-readable instructions, such as programming instructions, code, and the like. As shown in FIG. 1, computers 900, 944, in a computing system environment 902 are provided. This computing system environment 902 may include, but is not limited to, at least one computer 900 having certain components for appropriate operation, execution of code, and creation and communication of data. For example, the computer 900 includes a processing unit 904 (typically referred to as a central processing unit or CPU) that serves to execute computer-based instructions received in the appropriate data form and format. Further, this processing

unit 904 may be in the form of multiple processors executing code in series, in parallel, or in any other manner for appropriate implementation of the computer-based instructions.

[0030] In order to facilitate appropriate data communication and processing information between the various components of the computer 900, a system bus 906 is utilized. The system bus 906 may be any of several types of bus structures, including a memory bus or memory controller, a peripheral bus, or a local bus using any of a variety of bus architectures. In particular, the system bus 906 facilitates data and information communication between the various components (whether internal or external to the computer 900) through a variety of interfaces, as discussed hereinafter.

[0031] The computer 900 may include a variety of discrete computer-readable media components. For example, this computer-readable media may include any media that can be accessed by the computer 900, such as volatile media, non-volatile media, removable media, non-removable media, etc. As a further example, this computer-readable media may include computer storage media, such as media implemented in any method or technology for storage of information, such as computer-readable instructions, data structures, program modules, or other data, random access memory (RAM), read only memory (ROM), electrically erasable programmable read only memory (EEPROM), flash memory, or other memory technology, CD-ROM, digital versatile disks (DVDs), or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage, or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by the computer 900. Further, this computer-readable media may include communications media, such as computer-readable instructions, data structures, program modules, or other data in other transport mechanisms and include any information delivery media, wired media (such as a wired network and a direct-wired connection), and wireless media. Computer-readable media may include all machine-readable media with the possible exception of transitory, propagating signals. Of course, combinations of any of the above should also be included within the scope of computer-readable media.

[0032] The computer 900 further includes a system memory 908 with computer storage media in the form of volatile and non-volatile memory, such as ROM and RAM. A basic input/output system (BIOS) with appropriate computer-based routines assists in transferring information between components within the computer 900 and is normally stored in ROM. The RAM portion of the system memory 908 typically contains data and program modules that are immediately accessible to or presently being operated on by processing unit

904, *e.g.*, an operating system, application programming interfaces, application programs, program modules, program data and other instruction-based computer-readable codes.

[0033] With continued reference to FIG. 1, the computer 900 may also include other removable or non-removable, volatile or non-volatile computer storage media products. For example, the computer 900 may include a non-removable memory interface 910 that communicates with and controls a hard disk drive 912, *i.e.*, a non-removable, non-volatile magnetic medium; and a removable, non-volatile memory interface 914 that communicates with and controls a magnetic disk drive unit 916 (which reads from and writes to a removable, non-volatile magnetic disk 918), an optical disk drive unit 920 (which reads from and writes to a removable, non-volatile optical disk 922, such as a CD-ROM), a Universal Serial Bus (USB) port 921 for use in connection with a removable memory card, etc. However, it is envisioned that other removable or non-removable, volatile or non-volatile computer storage media can be used in the exemplary computing system environment 900, including, but not limited to, magnetic tape cassettes, DVDs, digital video tape, solid state RAM, solid state ROM, etc. These various removable or non-removable, volatile or non-volatile magnetic media are in communication with the processing unit 904 and other components of the computer 900 via the system bus 906. The drives and their associated computer storage media discussed above and illustrated in FIG. 1 provide storage of operating systems, computer-readable instructions, application programs, data structures, program modules, program data and other instruction-based computer-readable code for the computer 900 (whether duplicative or not of this information and data in the system memory 908).

[0034] A user may enter commands, information, and data into the computer 900 through certain attachable or operable input devices, such as a keyboard 924, a mouse 926, etc., via a user input interface 928. Of course, a variety of such input devices may be utilized, *e.g.*, a microphone, a trackball, a joystick, a touchpad, a touch-screen, a scanner, etc., including any arrangement that facilitates the input of data, and information to the computer 900 from an outside source. As discussed, these and other input devices are often connected to the processing unit 904 through the user input interface 928 coupled to the system bus 906, but may be connected by other interface and bus structures, such as a parallel port, game port, or a universal serial bus (USB). Still further, data and information can be presented or provided to a user in an intelligible form or format through certain output devices, such as a monitor 930 (to visually display this information and data in electronic form), a printer 932 (to physically display this information and data in print form), a speaker 934 (to audibly

present this information and data in audible form), etc. All of these devices are in communication with the computer 900 through an output interface 936 coupled to the system bus 906. It is envisioned that any such peripheral output devices be used to provide information and data to the user.

[0035] The computer 900 may operate in a network environment 938 through the use of a communications device 940, which is integral to the computer or remote therefrom. This communications device 940 is operable by and in communication to the other components of the computer 900 through a communications interface 942. Using such an arrangement, the computer 900 may connect with or otherwise communicate with one or more remote computers, such as a remote computer 944, which may be a personal computer, a server, a router, a network personal computer, a peer device, or other common network nodes, and typically includes many or all of the components described above in connection with the computer 900. Using appropriate communication devices 940, *e.g.*, a modem, a network interface or adapter, etc., the computer 900 may operate within and communication through a local area network (LAN) and a wide area network (WAN), but may also include other networks such as a virtual private network (VPN), an office network, an enterprise network, an intranet, the Internet, etc. It will be appreciated that the network connections shown are exemplary and other means of establishing a communications link between the computers 900, 944 may be used.

[0036] As used herein, the computer 900 includes or is operable to execute appropriate custom-designed or conventional software to perform and implement the processing steps of the method and system of the present invention, thereby, forming a specialized and particular computing system. Accordingly, the presently-invented method and system may include one or more computers 900 or similar computing devices having a computer-readable storage medium capable of storing computer-readable program code or instructions that cause the processing unit 904 to execute, configure or otherwise implement the methods, processes, and transformational data manipulations discussed hereinafter in connection with the present invention. Still further, the computer 900 may be in the form of a personal computer, a personal digital assistant, a portable computer, a laptop, a palmtop, a mobile device, a mobile telephone, a server, or any other type of computing device having the necessary processing hardware to appropriately process data to effectively implement the presently-invented computer-implemented method and system.

[0037] It will be apparent to one skilled in the relevant art(s) that the system may utilize databases physically located on one or more computers which may or may not be the

same as their respective servers. For example, programming software on computer 900 can control a database physically stored on a separate processor of the network or otherwise.

[0038] Although the invention has been described in detail for the purpose of illustration based on what is currently considered to be the most practical and preferred embodiments, it is to be understood that such detail is solely for that purpose and that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover modifications and equivalent arrangements that are within the spirit and scope of the appended claims, of any. For example, it is to be understood that the present invention contemplates that, to the extent possible, one or more features of any embodiment can be combined with one or more features of any other embodiment.

WHAT IS CLAIMED:

1. A system for managing movement authorities in a positive train control (PTC) system, the system comprising:

a first on-board system situated on a first train having one or more locomotives;

a second on-board system situated on a second train having one or more locomotives; and

a back office system remote from the first and second trains, wherein the first on-board system, the second on-board system, and the back office system are communicatively connected to each other via a network, wherein the first and second on-board systems are configured to receive a respective first and second movement authority from the back office system, wherein the second movement authority includes a condition that constrains the second movement authority by the first movement authority so that a movement of the second train is dependent on a movement of the first train, wherein the second on-board system is configured to directly transmit to the first on-board system an inquiry relating to the condition, wherein the first on-board system is configured to directly transmit a report to the second on-board system either:

(i) in response to receipt of the inquiry when the condition is satisfied; or

(ii) prior to when the condition is satisfied as determined by the second on-board system.

2. The system of claim 1, wherein determination that the condition is satisfied is based at least on the first movement authority and location data of the first train defined by (a) a head-end location of the train and a (b) a crew-confirmed point or an end-of-train location of the train.

3. The system of claim 1, wherein the second movement authority includes one or more of (a) an "In Effect After Arrival" condition; (b) "Do Not Foul Limits Ahead / In Effect Behind" condition; and (c) an identification of the one or more locomotives of the first train and direction of movement thereof.

4. The system of claim 1, wherein the second on-board system is configured to display visual indicia corresponding to the report.

5. The system of claim 1, wherein the first and second movement authorities are received by the back office system from a computer-aided dispatch.

6. The system of claim 1, wherein the back office system:

determines that an overlap existing between the first and second movement authorities is valid before transmitting the first and second movement authorities to the respective first and second on-board systems; and

transmits communication parameters to the first and second on-board systems to effect communication therebetween.

7. The system of claim 1, wherein the second on-board system is configured to directly transmit to a plurality of other on-board systems respective inquiries relating to respective conditions associated with a plurality of movement authorities received by the second on-board system.

8. A method for managing movement authorities in a positive train control (PTC) system, the method comprising the steps of:

receiving at a first on-board system of a first train having one or more locomotives a first movement authority from a back office system;

receiving at a second on-board system of a second train having one or more locomotives a second movement authority from the back office system, wherein the second movement authority includes a condition that constrains the second movement authority by the first movement authority so that a movement of the second train is dependent on a movement of the first train, wherein the back office system is remote from the first and second trains, wherein the first on-board system, the second on-board system, and the back office system are communicatively connected to each other via a network;

transmitting from the second on-board system to the first on-board system an inquiry relating to the condition; and

transmitting from the first on-board system to the second on-board system a report in response to receipt of the inquiry either:

(i) when the condition is satisfied; or

(ii) prior to when the condition is satisfied as determined by the second on-board system.

9. An on-board locomotive system used to receive movement authorities in a positive train control (PTC) system, the on-board locomotive system comprising one or more computers having computer readable mediums having stored thereon instructions which, when executed by one or more processors of the one or more computers, causes the system to perform the steps of:

receiving at the on-board locomotive system a movement authority from a back office system, wherein the movement authority includes a condition that constrains the movement authority by another movement authority received by another on-board locomotive system;

transmitting from the on-board locomotive system to the another on-board locomotive system an inquiry relating to the condition; and

receiving at the on-board locomotive system from the another on-board locomotive system a report in response to receipt of the inquiry either:

(i) when the condition is satisfied; or

(ii) prior to when the condition is satisfied as determined by the second on-board system.

10. A computer readable medium having stored thereon instructions which, when executed by one or more processors of one or more computers, causes the one or more processors to execute steps of a method for receiving movement authorities by an on-board locomotive system in a positive train control (PTC) system, the method comprising the steps of:

receiving at the on-board locomotive system a movement authority from a back office system, wherein the movement authority includes a condition that constrains the movement authority by another movement authority received by another on-board locomotive system;

transmitting from the on-board locomotive system to the another on-board locomotive system an inquiry relating to the condition; and

receiving at the on-board locomotive system from the another on-board locomotive system a report in response to receipt of the inquiry either:

(i) when the condition is satisfied; or

(ii) prior to when the condition is satisfied as determined by the second on-board system.

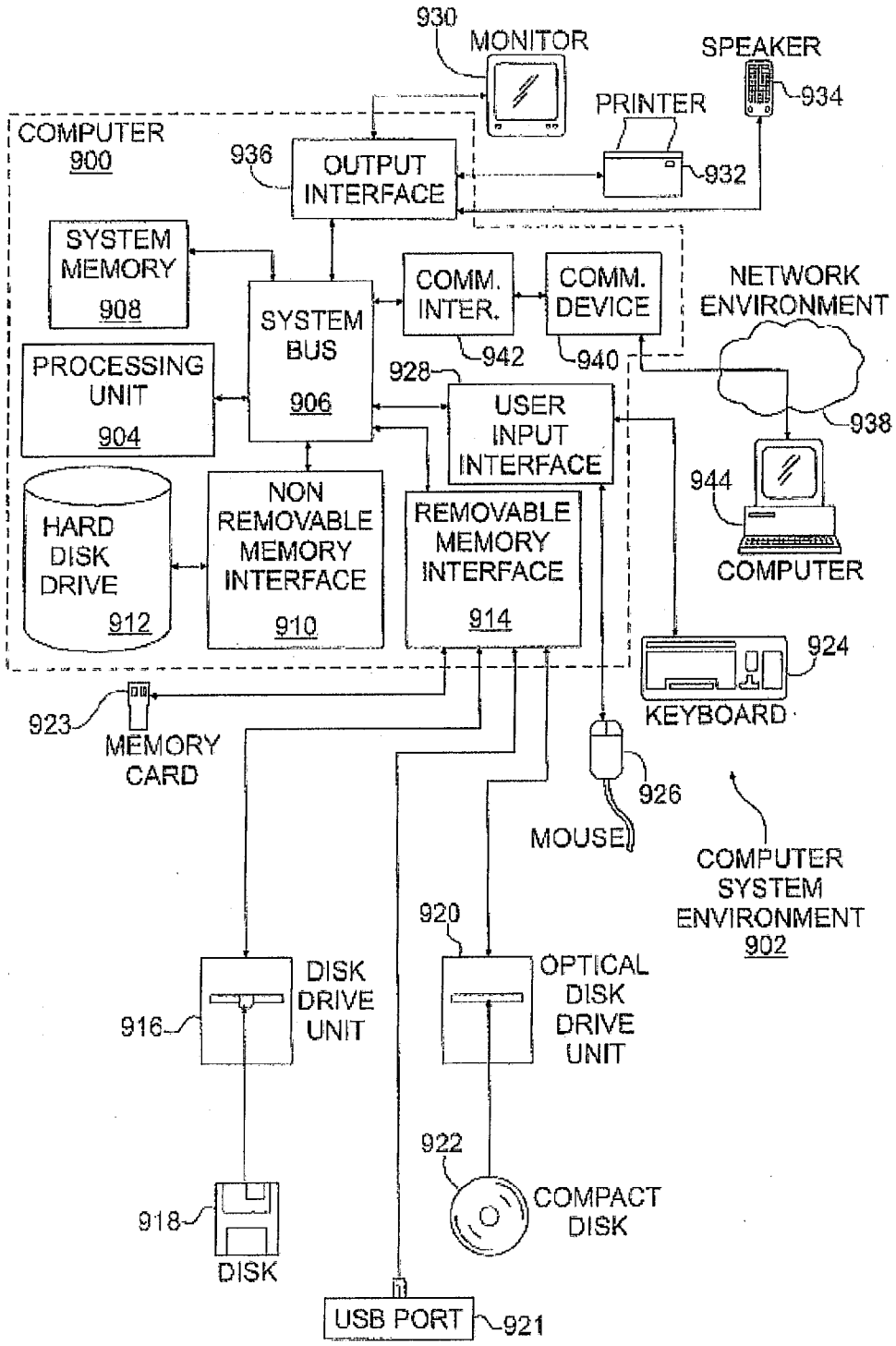
930
MONITOR
SPEAKER
934
PRINTER
COMPUTER
900
936
OUTPUT INTERFACE
932
SYSTEM MEMORY
908
SYSTEM BUS
906
COMM. INTER.
COMM. DEVICE
NETWORK ENVIRONMENT
942
940
928
PROCESSING UNIT
904
USER INPUT INTERFACE
938
944
HARD DISK DRIVE
912
NON REMOVABLE MEMORY INTERFACE
910
REMOVABLE MEMORY INTERFACE
914
COMPUTER
924
KEYBOARD
923
MEMORY CARD
926
MOUSE
COMPUTER SYSTEM ENVIRONMENT
902
920
DISK DRIVE UNIT
916
OPTICAL DISK DRIVE UNIT
922
COMPACT DISK
918
DISK
USB PORT
921

FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/049480

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B61L 27/00; B61L 15/00; B61L 1/18; B61L 21/10 (2018.01)

CPC - B61L 27/0038; B61L 15/0027; B61L 21/10; B61L 27/0077; B60L 15/40; B61L 15/0072 (2018.08)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

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

USPC - 701/19; 246/3; 246/219; 701/117 (keyword delimited)

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2015/0353110 A1 (WESTINGHOUSE AIR BRAKE TECHNOLOGIES CORPORATION) 10 December 2015 (10.12.2015) entire document	1-10
Y	US 2011/0172856 A1 (KULL) 14 July 2011 (14.07.2011) entire document	1-10
A	US 2009/0184212 A1 (ALLSHOUSE et al) 23 July 2009 (23.07.2009) entire document	1-10
A	US 2017/0113707 A1 (GHALY) 27 April 2017 (27.04.2017) entire document	1-10
A	US 2016/0046307 A1 (MITSUBISHI HEAVY INDUSTRIES, LTD.) 18 February 2016 (18.02.2016) entire document	1-10
A	US 2013/0334373 A1 (TRANSPORTATION TECHNOLOGY CENTER, INC.) 19 December 2013 (19.12.2013) entire document	1-10

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 October 2018	15 NOV 2018
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774