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(71) Applicant: **ALSTOM Transport Technologies**
93400 Saint-Ouen-sur Seine (FR)

(72) Inventors:
- **GANESAN, Muniandi**
  626001 Virudhunagar (IN)
- **BENNI, Jijo**
  670308 Kannur (IN)
- **GURUSAMY, Palanikumar**
  625001 Madurai (IN)

(74) Representative: **Lavoix**
2, place d'Estienne d'Orves
75441 Paris Cedex 09 (FR)

(54) SYSTEM AND A METHOD FOR MANAGING TRAFFIC OF A RAILWAY LINE

(57) A system (100) and method (300) for managing traffic of a railway line (200) comprising a plurality of stations (A, B) having platforms (202, 203) associated with platform tracks (204, 205, 206, 207), wherein a centralized control center (1), a plurality of on-board control systems (10), and a plurality of trackside control systems (30) distributed along the railway line (200), are in mutual operative communication. Each trackside control systems (30) is located in and controls traffic within a respective zone (200A, 200B) of the line (200) which includes a station zone.

Each railway vehicle (208) transiting in a line zone is routed by the correspond trackside control system (30) to a selected stopping position (204-1, 204-2, 205-1, 205-2, 206-1, 206-2, 207-1, 207-2) provided along a platform track of the station zone. Multiple railway vehicles can occupy, at a same time, corresponding selected stopping positions provided along the same platform track of the station zone. After on/off boarding passengers, railway vehicles are commanded to depart from the occupied stopping position according to a desired operation time schedule.

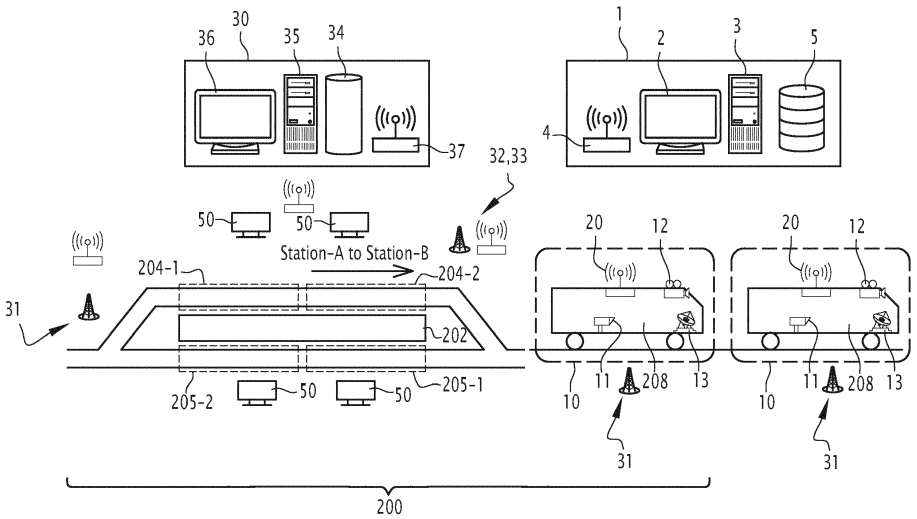

FIG.2

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Description

[0001] The present invention concerns a system and a method for managing traffic of a railway line, offering in particular an increased capability as regard to the total number of passengers that can be transported during time service.

[0002] The system and method according to the present invention are particularly suitable to be used in urban or metro rail lines, and they will be described hereinafter by making specific reference to such applications, without intending in any way to limit their possible application to other type of railway networks.

[0003] As known, urban rail transit systems have become more and more popular and have been implemented worldwide in an increasing number of cities.

[0004] One downside of the growing success of these means of transportation resides in the fact that several existing rail transit systems have become overcrowded and authorities are recurrently called to face the pressing need of increasing the overall transportation capability of such systems.

[0005] Some solutions, typically adopted to cope with this issue, foresee the expansion of existing networks by adding new lines.

[0006] These solutions, even if bringing some considerable benefits, are not fully satisfying for various reasons, for example they imply heavy investments and a rather long time for execution, they are not always applicable due to lack of space available or to technical or environmental constrains, and the like.

[0007] Further, taking into consideration the ever increasing population, at least in certain urban areas, the initial benefits of such solutions, are usually considerably reduced year after year.

[0008] Other solutions are instead focused on the operation side, namely they are aimed at improving productivity and efficiency of operations of existing lines.

[0009] For example, attempts have been made in order to control as much as possible the headway of railway vehicles, thus trying to increase the frequency of convoys per line and correspondingly the overall number of passengers that can be transported.

[0010] Clearly, by increasing the number of railway vehicles circulating on the same line, these solutions imply additional concerns about safety of operations, and heavily impact on the complexity of the overall infrastructure and related management of the rail system, and in particular on the communication and coordination among the various convoys, the creation of conflict-free timetables, et cetera....

[0011] One example of such type of solutions is disclosed in CA 2 761 014 A1, describing a railway vehicle control system based on short headway communications.

[0012] According to this solution, a local communication link is established between two or more successive railway vehicles transiting in the railway network, so that a single virtual railway vehicle is created and is managed and controlled by a central control unit.

[0013] In this way, the headway between railway vehicles can be modified, i.e. reduced, and the frequency of railway vehicles can be increased.

[0014] Although such solutions can provide some beneficial results, there is still substantial room and desire for further improvements.

[0015] Therefore, it is a main aim of the present invention to provide a system and a method for managing traffic of a railway line, offering substantial improvements over known solutions, in particular as regard to the capability of passengers that can be transported during service.

[0016] Within the scope of this aim, an object of the present invention is to provide a system and a method for managing traffic of a railway line, where the headway between railway vehicles can be substantially shortened compared to the average actual ones, while respecting the highest standards of safety.

[0017] Yet a further object of the present invention is to provide a system and a method for managing traffic of a railway line, which is highly reliable, easy to realize and at competitive costs.

[0018] This aim, these objects and others which will become apparent hereinafter are achieved by a system traffic management system for a railway line comprising a plurality of stations, each of said stations having one or more platforms associated with corresponding one or more platform tracks, the system being characterized in that it comprises:

- a centralized control center for the railway line;
- a plurality of on-board control systems suitable to be installed each on-board of an associated railway vehicle and being arranged, in operation, to be in communication at least with said centralized control center;
- a plurality of trackside control systems which are distributed along the railway line and are suitable to be in operative communication with said centralized control center and with said on-board control systems, each of said trackside control systems being suitable to control traffic within a respective assigned zone of the railway line, the assigned zone including at least a corresponding station zone associated with one of said plurality of stations, wherein each trackside control system is arranged to route railway vehicles, transiting in the respective station zone, each to a selected stopping position provided along a platform track of the corresponding station for on/off boarding passengers, wherein two or more of said railway vehicles transiting in the respective station zone can be routed, by the corresponding trackside control system, to occupy, at a same time, corresponding two or more selected stopping positions provided along the same platform track of the corresponding station, and to command, thereafter, departure of each stopped railway vehicle from the cor-

responding stopping position according to a desired railway vehicle operation time schedule.

[0019] The above mentioned aim and objects of the present invention are also achieved by a method for managing traffic of a railway line, characterized in that it comprises the following steps:

- providing, in whatever order, a centralized control center for the railway line, a plurality of on-board control systems suitable to be installed each on-board of an associated railway vehicle and a plurality of trackside control systems which are distributed along the railway line, said centralized control center and said plurality of on-board control systems and of trackside control systems being suitable, in operation, to be in mutual operative communication, wherein each of said trackside control systems being suitable to control traffic within a respective assigned zone of the railway line, the assigned zone including at least a corresponding station zone associated with one of said plurality of stations, each of said station zones having one or more platforms associated with corresponding one or more platform tracks;
- routing railway vehicles transiting in the respective station zone each to a selected stopping position along a platform track of the corresponding station for on/off boarding passengers, wherein two or more of said railway vehicles can be routed to occupy, at the same time, corresponding two or more selected stopping positions along the same platform track of the corresponding station;
- commanding, after on/off boarding passengers, departure of each stopped railway vehicle from the corresponding stopping position according to a desired railway vehicle operation time schedule.

[0020] Further characteristics and advantages will become apparent from the description of some preferred but not exclusive exemplary embodiments of a system and a method according to the present disclosure, illustrated only by way of non-limitative examples with the accompanying drawings, wherein:

Figure 1 is a block diagram schematically representing a system for traffic management of a railway line according to the invention;
Figure 2 is a view showing graphically the system of figure 1 applied to a railway line;
Figure 3 is a schematic plan view showing in greater details two platforms and related platform tracks of a line station;
Figure 4 is a schematic view showing two adjacent zones of a railway line.
Figure 5 is a flow chart illustrating a method for traffic management of a railway line according to the invention;
Figure 6 is a block diagram schematically representing an on-board railway vehicle control system according to an embodiment of the invention;
Figure 7 illustrates a sequence of railway vehicles operating according to an embodiment of the system and method according to the present invention;
Figures 8 and 9 are diagrams illustrating a mapping of railway vehicles executed at two adjacent stations by corresponding trackside control systems used in a system in accordance with the present invention.

[0021] It should be noted that in the detailed description that follows, identical or similar components, either from a structural and/or functional point of view, have the same reference numerals, regardless of whether they are shown in different embodiments of the present disclosure; it should also be noted that in order to clearly and concisely describe the present disclosure, the drawings may not necessarily be to scale and certain features of the disclosure may be shown in somewhat schematic form.

[0022] In figure 1 there is schematically illustrated an exemplary traffic management system for a railway line 200, according to the present invention, indicated by the overall reference number 100.

[0023] The railway line 200 can be for example an urban rail system, e.g. a subway, and comprises a plurality of line stations.

[0024] On figure 2 the railway line is represented only partially. More especially figure 2 represents only one line station A, also called station A, and a railway track linking the station A to another station.

[0025] The railway line comprises, for example, five line stations A, B, C, D, E, as schematically represented in the diagram of figures 8 and 9.

[0026] Clearly, the number and type of line stations can vary according to the specific applications.

[0027] Each station A, B, C, D, E, has one or more platforms, preferably at least two platforms 202, 203, as illustrated in the exemplary embodiment of figure 3, where each platform 202, 203 is associated with corresponding one or more tracks, also called platform tracks 204, 205, 206, 207, where railway vehicles, also called line railway vehicles 208, can stop for on/off boarding passengers.

[0028] Preferably, each platform 202, 203, is associated with two corresponding platform tracks 204 and 205, and 206 and 207, respectively, as illustrated in figure 3.

[0029] Preferably two subsequent stations are linked one to the other by a line rail track comprising advantageously a first railway track devised for the operations of railway vehicles moving in one direction along the railway line 200 and a second railway track devised for the operations of railway vehicles moving in the opposite direction along the railway line 200.

[0030] In this way, for each line rail track 240 linking two stations, there are in each station two platform tracks 204, 205, each at a corresponding side of the platform 202, devised for the operations of railway vehicles mov-

ing in one direction along the railway line 200, and two other platform tracks 206, 207, each at a corresponding side of the platform 203, devised for the operations of railway vehicles moving in the opposite direction along the railway line 200.

[0031] Switching points 250 allow routing railway vehicles 208, approaching or leaving the platforms 202, 203, from the line rail track 240 and notably from the corresponding first or second railway track to the relevant platform tracks 204, 205, 206, 207, and vice versa.

[0032] As illustrated in figures 1 and 2, the system 100 comprises a centralized control center, indicated by the reference number 1, for the railway line 200.

[0033] The centralized control center 1 is basically devoted to supervise and monitor the overall railway line 200, at a high control level and according to solutions readily available to those skilled in the art and therefore herein not described in details.

[0034] For example, the centralized control center 1 can be located in a central control room and can usually comprise an assembly of HW and SW components, such as one or more workstations and related control displays 2, elaboration units 3, et cetera, and is suitable to output commands issued by operators, for instance SOS alerts, Temporary Speed Restriction (TSR) limits, and the like, via a communication device 4.

[0035] In one embodiment of the system 100 according to the invention, the centralized control center 1 comprises a central database, indicated in figure 2 by the reference number 5, which stores data related to railway vehicles 208 suitable to operate on the railway line 200.

[0036] In particular, the central database 5 stores data related to the calibration of various sensors positioned on board of railway vehicles 208, which sensors are usually calibrated for specific parameters of each railway vehicle, either constructive or functional ones, and impact the operations and control of the railway vehicles on the railway line 200.

[0037] For example, a railway vehicle odometer is calibrated in view of the wheel diameter of such railway vehicle.

[0038] The central database 5 can also store other data indicative of operational parameters or characteristic of railway vehicles 208, for example the braking curve of each railway vehicle, and trackside related parameters as well.

[0039] The stored data are updated periodically by the railway vehicles 208 operating along the railway line 200, in order to take into account any change occurred in the previously stored parameter values.

[0040] During service operations, and for the scope that will appear more evident from the following description, based on request from a railway vehicle 208 moving along the railway line 200, the centralized control center 1 provides to the requesting railway vehicle pre-stored data for at least one of a railway vehicle 208 immediately preceding and a railway vehicle 208 immediately trailing the requesting railway vehicle along the railway line 200.

[0041] Preferably, pre-stored data for both the preceding and trailing railway vehicles 208 are supplied to the requesting railway vehicle 208.

[0042] For example, such data can be provided when the requesting railway vehicle 208 is stopped at any line station A, B, C, D, E, and preferably comprises sensor calibration parameters and braking curve of the railway vehicle 208 immediately preceding and the railway vehicle 208 immediately trailing the requesting railway vehicle 208.

[0043] As indicated in figures 1 and 2, the system 100 according to the invention comprises a plurality of on-board railway vehicle control systems 10, wherein each on-board railway vehicle control system 10 is suitable to be installed on-board of an associated railway vehicle 208, and is arranged, in operation, to be in communication with the centralized control center 1 and with a plurality of trackside control systems 30 which are also part of the whole system 100.

[0044] The track side control systems 30 are distributed along the railway line 200, and are also suitable to be in operative communication with the centralized control center 1 as well.

[0045] More in details, each trackside control system 30 is preferably located in and is suitable to control traffic within a respective assigned zone 200A, or 200B, et cetera, of the railway line 200, where each assigned zone includes at least a corresponding zone station A, or B, et cetera, which is located within the assigned zone.

[0046] Advantageously, in the system 100 according to the present invention, each trackside control system 30 is arranged to route railway vehicles 208 transiting in the respective assigned zone 200A, or 200B, or else, each to a selected stopping position along a platform track 204, 205, 206, 207 of the corresponding zone station A, B, et cetera, for on/off boarding passengers.

[0047] In the exemplary embodiment of figures 2-4, there are illustrated four stopping positions per each platform, namely stopping positions 204-1, 204-2, 205-1, 205-2, 206-1, 206-2, 207-1, 207-2.

[0048] In particular, each trackside control system 30 is arranged to route two or more railway vehicles 208 entering into the same zone station, e.g. station A, to occupy, at the same time, corresponding two or more selected stopping positions along the same platform track, e.g. two railway vehicles 208 can occupy, at the same time, stopping positions 204-1, 204-2, respectively.

[0049] Further, each trackside control system 30 is arranged to command, after on/off boarding is completed for a railway vehicle 208, the departure of each stopped railway vehicle from the occupied stopping position according to a desired railway vehicle operation time schedule.

[0050] According to an embodiment of the system 100, each trackside control system 30 is arranged to command departure of each stopped railway vehicle 208 from the occupied stopping position of a platform track 204, or 205; or 206, or 207, e. g. from stopping position 204-2

of platform 202, after a prefixed time interval T_d is elapsed from the instant of commanding, by the same trackside control system 30, departure from the same platform 202 of a preceding railway vehicle 208 moving in the same direction along the railway line 200 and which occupied a different stopping position, e.g. stopping position 204-1.

[0051] According to a further embodiment of the system 100, each trackside control system 30 is arranged to command departure of each stopped railway vehicle 208 from the occupied stopping position of a platform track 204, or 205; or 206, or 207, e. g. stopping position 204-2 of platform 202 of the corresponding zone station A, after a prefixed constant time interval T_d is elapsed from the instant of commanding, by the same trackside control system 30, departure from the same platform 202 of a preceding railway vehicle moving in the same direction along the railway line 200 and which occupied a different stopping position, e.g. stopping position 204-1.

[0052] According to an embodiment, the trackside control systems 30 are conceived so that the entire railway line 200 is divided in zones assigned to and controlled by at least one trackside control system 30, wherein each assigned zone comprises, in addition to a corresponding zone station, two inter-stations sections which are at the two sides of and in continuity with the subject zone station.

[0053] For example, as schematically illustrated in figure 4 for zones 200A and 200B, in addition to the respective zone station A and B, each assigned zone 200A, 200B includes a first inter-stations section 210A, 210B, respectively, and a second inter-stations section 220A, 220B, respectively.

[0054] The same applies likewise for all other zones and related line stations C, D, E, et cetera....

[0055] Preferably, for each line zone 200A, 200B, there are assigned two trackside control systems 30 of which, a first trackside control system 30 is responsible for controlling the traffic of railway vehicles 208 moving, within the assigned zone, in a first direction, e.g. from zone station A to zone station B and so on, while the second trackside control system 30 is responsible for controlling traffic of railway vehicles 208, within the same line zone, moving in the opposite direction, namely from station B to station A and proceeding further.

[0056] Hence, with reference to the example illustrated in figure 4, the part of the line zone 200B assigned to the corresponding first trackside control system 30 includes the upward inter-stations section 210B for railway vehicles moving from station A towards station B, the station B itself, and in particular its platform 202 and related platform tracks 204, 205 allocated to railway vehicles going towards station C, and the downward inter-stations section 220B for railway vehicles leaving the station B and moving towards the following line zone C.

[0057] For railway vehicles 208 moving in the opposite direction, e.g. from station C to station B, the part of the line zone 200B assigned to the corresponding second trackside control system 30 includes the second inter-stations section, e.g. the section 220B, constituting in this case the upward section for railway vehicles proceeding from station C towards station B, the station B itself, and the first section 210B, constituting in this case the downward section for railway vehicles 208 leaving station B and moving towards the following line zone 200A.

[0058] The same applies for all other line zones and related zone stations proceeding further along the railway line 200 in one direction or the other.

[0059] According to an embodiment, and as illustrated in the example of figure 4, two adjacent zones of the railway line 200 have a common overlapping area 260 where control of a transiting railway vehicle 208 is passed from a track control system 30 assigned to and controlling traffic within a first zone, e.g. zone 200A, to another track control system 30 assigned to and controlling traffic within a second adjacent zone, e.g. zone 200B, immediately following the previous zone, with reference to the direction of movement of the railway vehicle 208.

[0060] According to an embodiment of the system 100, among the plurality of trackside control systems 30 distributed alone the railway line 200, trackside control systems which are located in and control traffic within adjacent respective assigned zones, e.g. zones 200A and 200B, are in mutual communication and are arranged to cooperatively and coordinately control railway vehicles 208 transiting in the respective assigned zones so that each control system 30 commands, for each stopped railway vehicle 208, in the assigned zone station, e.g. zone station B, departure from the occupied stopping position at the corresponding platform, after a prefixed constant time interval T_t is elapsed from the instant of having commanded departure of the same railway vehicle 208 from the occupied stopping position at the platform of the adjacent preceding zone station, e.g. zone station A, by the corresponding adjacent trackside control system 30.

[0061] More in details, each trackside control system 30 comprises a plurality of devices, comprising hardware and/or software parts, which are suitably configured, mutually positioned and coordinated in order to properly perform the required functions the trackside control systems 30 are devised for.

[0062] In particular, each trackside control system 30 comprises one or more railway vehicle position localizers 31 arranged to interact with the on-board railway vehicle control system 10 of a railway vehicle 208 transiting in an inter-stations section, so that to localize the actual position of such transiting railway vehicle within the corresponding line zone, e.g. 200A, 200B, et cetera.

[0063] According to one embodiment, with reference to the direction of a railway vehicle 208 along the railway line, at least one railway vehicle position localizer 31 is for example placed, for each assigned zone, within the corresponding inter-stations section immediately upward the respective zone station.

[0064] Hence, for railway vehicles 208 moving from the zone 200A to the following zone 200B, the correspondingly assigned trackside control device 30 com-

prises at least a railway vehicle position localizer 31 located within the upward inter-stations section 210B, e.g. on a side wall of the line track 240.

[0065] Likewise, for railway vehicles 208 moving in the opposite direction, e.g. from zone C to following zone B, the correspondingly assigned trackside control device 30 comprises at least one railway vehicle position localizer 31 located within the upward inter-stations section 220B, e.g. on a side wall of the line track 240.

[0066] For example, the position localizers 31 can be constituted by laser projectors, operatively associated to suitable communication devices.

[0067] Further, each trackside control system 30 comprises a plurality of devices 32, 33, 34, 35 which are for example positioned at the corresponding assigned zone station and are arranged:

- to virtually segment each of the platform tracks 204, 205, 206, 207 associated to a platform 202, 203 of the corresponding zone station A, or B, or C, or else, in a plurality of virtual and uniquely identified platform blocks forming the previously indicated selected stopping positions, e.g. virtual platform blocks 204-1, 204-2, 205-1, 205-2, 206-1, 206-2, 207-1, 207-2; and
- to cooperatively interact with the on-board railway vehicle control system 10 of a railway vehicle 208 under stopping so that to stop such railway vehicle 208 at a selected virtual platform block among those available.

[0068] In particular, the plurality of devices of each trackside control system 30 comprises service stopping identifiers, indicated in figure 2 by the reference number 32, which are programmed each with a unique indicator of and assigned to a corresponding virtual platform block 204-1, 204-2, 205-1, 205-2, 206-1, 206-2, 207-1, 207-2.

[0069] In one embodiment, the plurality of devices of each trackside control system 30 comprises also virtual platform block indicators, indicated in figures 2 and by the reference number 33, which are operatively linked each with a respective service stopping identifier 32 and are suitable to interact with the on-board railway vehicle control system 10 of a railway vehicle 208 under stopping so that to stop it at a selected virtual platform block of a corresponding platform track 204, or 205, or 206, or 207.

[0070] The virtual platform block indicators 33 are for example positioned on a side of the associated platform track 204, 205, 206, 207, and are constituted for instance by laser projectors.

[0071] As schematically illustrated in figure 2, each trackside control system 30 comprises:

- a database server 34 which stores data indicative of the position of each railway vehicle position localizer 31 and of each virtual platform block indicator 33 and associated identifier 32 located in the respective assigned zone, and a list of predefined railway vehicle patterns along the railway line 200 within the assigned zone; and
- a data processing device 35 which is arranged to select, based on information received from an associated railway vehicle position localizer 31 indicating the actual position of a railway vehicle 208 transiting in the inter-stations upward section of the respective assigned zone, a railway vehicle pattern from the stored list and to send the selected railway vehicle pattern to the on-board railway vehicle control system 10 of the localized railway vehicle 208 for routing such railway vehicle 208 to a selected virtual platform block of the corresponding zone station.

[0072] In the exemplary embodiment illustrated, each trackside control system comprises one or more workstation 36 for line operators, and a communication device 37 for communication with the on-board railway vehicle control system 10, the centralized control center 1, and adjacent trackside control system 30.

[0073] In one embodiment, each trackside control system 30 can comprise one or more displays, represented in figure 2 by the reference number 50, adapted to display, for passengers on a platform, information indicative of on/off boarding times or availability related to railway vehicles 208 at, or approaching, or leaving the various platform blocks of a platform track, based on signals output from the respective data processing device 35.

[0074] In the exemplary embodiment illustrated, there is provided a display 50 associated to each virtual platform block and exhibiting information related to it.

[0075] For example, if a railway vehicle occupies a virtual block platform and boarding is allowed, the associated display 50 can appear as "green", if a railway vehicle occupies a virtual block platform but boarding is not allowed or if a virtual block platform is empty and no railway vehicles 208 are approaching, the associated display 50 can appear as "red", if a virtual block platform is empty but a railway vehicle 208 is approaching for stopping, the associated display 50 can appear "yellow".

[0076] Clearly, other types and/or forms of information can be exhibited to passengers, for example text messages.

[0077] As schematically illustrated in figures 2 and 6, each on-board railway vehicle control system 10 comprises a plurality of different devices, comprising hardware and/or software parts, which are installed on board of the associated railway vehicle 208 and are arranged to perform the required functions the on-board railway vehicle control systems 10 are devised for.

[0078] In particular, each on-board railway vehicle control system 10 comprises one or more sensors 11 cooperatively interacting with corresponding position localizers 31 so that to localize the position of the associated railway vehicle 208 along the railway line 200, and cooperatively interacting with the virtual block identifiers 32 and the virtual block indicators 33 for stopping the associated railway vehicle 208 at a virtual platform block selected by the elaboration device 34 of the trackside con-

trol system 30 assigned to the corresponding zone station.

[0079] In the exemplary embodiment illustrated, the one or more sensors 11 comprise for instance at least one camera 11 which is positioned on a side of each railway vehicle 208.

[0080] Preferably a camera 11 is placed at each side of every railway vehicle 208.

[0081] Each side camera 11 interacts with a position localizer 31, e.g. it reads a pattern from a laser projectors 31, to localize the position of a railway vehicle 208 at an inter-stations section, and correspondingly with the virtual platform block identifiers 32 and indicators 33, e.g. by reading a pattern from the laser projectors 33, to stop a railway vehicle 208 precisely in a selected virtual black platform, as per instructions received from the relevant trackside control system 30.

[0082] In particular, without these instructions issued by the responsible trackside control system 30, the railway vehicle would not be allowed to proceed, and in case of violation, an emergency procedure will be started immediately.

[0083] According to an embodiment, each on-board railway vehicle control system 10 comprises a front camera 12, and one or more range sensors 13 which are mounted for instance on the front head of a railway vehicle 208 in order to accurately stop a railway vehicle 208 behind a preceding one without collision.

[0084] Further, each on-board railway vehicle control system 10 comprises at least one communication device 20 for communicating with the centralized control center 1, with the trackside control systems 30 and with the on-board railway vehicle control systems 10 of other railway vehicles.

[0085] The various communication devices 4, 37, 20 et cetera, allows to realize a communication system among the various parts of the system 100.

[0086] For example, components and parts of the trackside control systems 30 can communicate among them through short-range wireless track-to-track communication links, for example via Wi-Fi, the mutual communication among the various trackside control system 30, with the on-board railway vehicle control systems 10 and the centralized control center 1 can occur through long range wireless communication links, such as for example 4G/GSM technology,

[0087] Further, in the exemplary embodiment illustrated, each on-board railway vehicle control system 10 comprises an odometer 14 and an accelerometer 15 for measuring the speed and acceleration of a railway vehicle 208, respectively.

[0088] In this way, it is possible to communicate corresponding data suitable to allow controlling, and in case adjusting, in a coordinated way, the mutual position of adjacent railway vehicles 208 along the railway line 200.

[0089] To this end, according to an embodiment, each on-board railway vehicle control system 10 comprises an inter-railway vehicle telemetry device 16 which is arranged to exchange data indicative of the movement of the own associated railway vehicle, i.e. the railway vehicle on which the subject control system 10 is installed, with the inter-railway vehicle telemetry device 16 of at least one of, preferably both, a first railway vehicle immediately preceding and a second railway vehicle immediately trailing the own associated railway vehicle 208, in the same direction along the railway line 200.

[0090] Each on-board railway vehicle control system 10 comprises a data processing unit 17 which is adapted to process data received, via the associated inter railway vehicle telemetry device 16, from the other on-board control systems 10 of the immediately preceding railway vehicle 208 and/or of the immediately trailing railway vehicle 208, and to adjust dynamically the movement of the associated own railway vehicle in response to the data received.

[0091] For example, the inter-railway vehicle telemetry device 16 sends raw sensors data of the own railway vehicle 208 and received from the associated own sensors, at high sampling time to the telemetry device 16 of one or more other nearby railway vehicles 208.

[0092] The transmission can occur, for example, while the transmitting railway vehicle 208 is moving along the railway line 200, while it can be interrupted when the railway vehicle is at a platform of a station.

[0093] While sending the raw sensor data, some header information are added, for example the identification number of the transmitting railway vehicle, the identification of the type of sensors providing data, e.g. odometer, accelerometer, side cameras, the actual mode of operation of the railway vehicle, for instance traction, braking, service, emergency, cruising, coasting.

[0094] The data processing device 17 receives and processes raw sensor data arriving at high sampling time in order to extract data indicative of the actual status of the transmitting railway vehicle, such as the distance, speed, acceleration.

[0095] Data processed are sent to a navigation and authority control unit 18 of the on board control system 10 which has the decision-making capability to decide, as quickly as possible, moving end of authority of the railway vehicle 208 based on the processed data received from the preceding and/or trailing railway vehicle and guidance trajectory is generated on-board of each railway vehicle dynamically based on inter-railway vehicle raw elaboration of the sensors data.

[0096] In particular, based on the calculated distance of separation between two successive railway vehicles, the speed profile of a railway vehicle can be adjusted dynamically.

[0097] In this case, the driving algorithm module of a railway vehicle 208, indicated in figure 6 by the reference number 19, helps to drive a railway vehicle 208 as per commands received from the authority control unit 18, for example commanding traction/braking systems.

[0098] For instance, if the distance of separation between the reference railway vehicle 208 and a preceding

railway vehicle 208 is longer than service braking distance, the reference railway vehicle 208 can follow the minimum of the permanent or temporary speed restriction.

[0099] If the distance of separation between the reference railway vehicle 208 and a preceding railway vehicle 208 is close to service braking distance of the reference railway vehicle 208, the speed of the reference railway vehicle 208 should match with the speed of the preceding railway vehicle and be effectively less than the minimum of permanent or temporary speed restriction.

[0100] If the preceding railway vehicle applies emergency brakes, the reference railway vehicle should apply emergency brake automatically.

[0101] This control action helps to prevent the collision of a reference railway vehicle 208 with a preceding railway vehicle 208 quickly decelerating.

[0102] Other and various operative situations and related adjustments are possible as those skilled in the art would easily appreciate.

[0103] The on-board authority control unit 18 of a railway vehicle 208 further sends Automatic Railway vehicle Protection with the necessary details in case the railway vehicle needs to trigger Emergency Brakes.

[0104] An on-board display informs the driver of the status, alerts, warning, errors, and also displays front camera and range sensor data along with speed, acceleration, virtual platform block number, running status at inter-stations sections, et cetera....

[0105] A method for managing traffic of a railway line 200, according to the invention, will be now described with reference to figure 5.

[0106] In particular, the method, indicated by the overall reference number 300, comprises at least the following steps:

- 301: providing, in whatever order, a centralized control center 1 for the railway line 200, a plurality of on-board railway vehicle control systems 10 suitable to be installed each on-board of an associated railway vehicle 208, and a plurality of trackside control systems 30 which are distributed along the railway line 200, said centralized control center 1 and said plurality of on-board railway vehicle control systems 10 and of trackside control systems 30 being suitable, in operation, to be in mutual operative communication, wherein each of said trackside control systems 30 is located in and controls traffic within a respective assigned zone 200A, 200B, et cetera of the railway line 200 inclusive of at least a corresponding zone station A, B, et cetera, each of said zone stations having one or more platforms 202, 203 associated with corresponding one or more platform tracks 204, 205, 206, 207;
- 305: routing railway vehicles 208 transiting in the respective assigned zone each to a selected stopping position 204-1, 204-2, 205-1, 205-2, 206-1, 206-2, 207-1, 207-2 along a platform track of the corresponding zone station for on/off boarding passengers, wherein two or more railway vehicles can be routed to occupy, at the same time, corresponding two or more selected stopping positions along the same platform track of the corresponding zone station;
- 310: commanding, after on/off boarding passengers, departure of each stopped railway vehicle 208 from the occupied stopping position according to a desired railway vehicle operation time schedule.

[0107] In one embodiment, the step 310 of commanding comprises commanding departure of each stopped railway vehicle 208 from the occupied stopping position of a platform track associated to a platform of the corresponding zone station, after a prefixed time interval T_d is elapsed from the instant of commanding departure from the same platform 202, 203 of a preceding railway vehicle 208 moving in the same direction along the railway line 200.

[0108] In a further embodiment of the method 300, the step 310 of commanding comprises commanding departure of each stopped railway vehicle from the occupied stopping position of a platform track associated to a platform of the corresponding zone station, after a prefixed constant time interval T_d is elapsed from the instant of having commanded departure from the same platform 202, 203 of a preceding railway vehicle 208 moving in the same direction along the railway line 200.

[0109] In practice, during operations, at the beginning of a line service, e. g. a railway vehicle leaving a depot, the on-board control system 10 of a railway vehicle 208 communicates with the centralized control center 1 and receives from it the identification number of the trackside control system 30 assigned to the nearest zone and responsible for controlling traffic along the direction of the railway vehicle, e.g. the first zone 200A with its zone station A.

[0110] Then, the on-board control system 10, starts communicating with the nearest trackside control system 30 requesting the server 34 for data indicative of the position of each railway vehicle position localizer 31 and of each virtual platform identifiers 32 and associated indicators 33 of such nearest trackside control system 30.

[0111] By processing the received data and cooperating with the relevant position localizer 31, the position of the railway vehicle 208 is localized and is communicated to the trackside control system 30, requesting instructions to move forward.

[0112] Meanwhile, the control system 30 contacts the centralized control center 1 to check whether a desired railway vehicle operation time schedule can be applied, or a modified one has to be used, for any reason.

[0113] If the desired schedule can be used, a clock of headway between successive railway vehicles is created.

[0114] Based on the data received about the position of the subject railway vehicle 208, the data processing

unit 35 selects a pattern from the list of patterns stored in the server 34 and sent it to the localized railway vehicle 208, in practice authorizing it to proceed further.

[0115] Since each railway vehicle 208 can proceed within the control zone based only upon the authorization of the associated trackside control system 30, the related trackside control system 30 has the full control over occupancy of virtual block positions at the associated station.

[0116] In particular, data transmitted to each requesting railway vehicle contains also the identification number of the virtual platform block allocated based on the occupancy of railway vehicles at the relevant platform.

[0117] Hence, a railway vehicle 208 enters the platform and occupies the allocated virtual platform block precisely, also thanks to the interaction between its side camera 11 and the corresponding virtual platform indicator 33.

[0118] If there is already another railway vehicle 208 stopped ahead at the same platform track, its front camera 12 and range sensor 13 helps stopping precisely without collision.

[0119] After the phase of off/on boarding passengers is completed, the trackside control system 30 commands the railway vehicle 208 to depart according to the desired railway vehicle operation schedule.

[0120] In case of SOS alerts issued by the centralized control center 1, the trackside control system 30 blocks the further movement of the railway vehicle 208 from the station.

[0121] The trackside control system 30 continues to monitor the railway vehicle 208 in its control zone i.e. in the downward inter-station section, so that to command SOS alerts if required.

[0122] Once a railway vehicle 208 is in an inter-stations section, it starts also receiving and processing inter-railway vehicle raw sensor data from other on-board control systems 10.

[0123] Each railway vehicle 208 processes all its sensor data and inter-railway vehicle data received from other railway vehicles 208 to decide on moving end of authority point.

[0124] The railway vehicle driving algorithm module 19 drives the railway vehicle to closely follow the navigation command from the navigation and authority control unit 18, in order to be in line with the desired railway vehicle operation schedule and in relation with the preceding and trailing railway vehicles.

[0125] When the railway vehicle 208 reaches the overlapping zone 260 between the zone assigned to the actual trackside control system 30, e.g. zone 200A, and the adjacent zone assigned to the following trackside control system 30, e.g. zone 200B, the following trackside control system 30 takes control and starts monitoring the railway vehicle 208 entering into the respective upward inter-stations section, e.g. inter-stations section 210B.

[0126] The above described phases for the first zone are routinely repeated for the second zone and any other following one.

[0127] In particular, and according to a very flexible schedule, the prefixed constant time interval can be the same for the whole series of railway vehicles 208 transiting from a station and also the same for all successive stations along the railway line 200.

[0128] It is possible to have a constant time interval for all railway vehicles moving in one direction and another prefixed constant time interval for railway vehicles moving in the opposite direction, or preferably the prefixed constant time interval can be the same for both directions.

[0129] Preferably, in all cases, the time interval between departure of a railway vehicle 208 and departure of the trailing railway vehicle 208 is less than one minute, e. g. more preferably thirty seconds.

[0130] Likewise, the various components of the whole system 100 are arranged and mutually cooperate, so that, under normal operating conditions, i.e. without any emergency situation, unexpected disruptions or failure of any part, the distance between each railway vehicle and the preceding or following one is the same, preferably constant and less than one minute, more preferably reduced to thirty seconds as well.

[0131] An exemplary way of how traffic of a railway line 200 can be managed by the system 100 and method 300 according to the present invention will be now described with reference to figure 7 where there is illustrated only one platform 202, with two corresponding platform tracks 204, 205 for railway vehicles moving from station A to station B.

[0132] For the sake of illustration, in figure 7, the various railway vehicles 208 are indicated as train 1, train 2, train 3 et cetera, according to the sequence of arrival and departure.

[0133] In the exemplary embodiment illustrated, each platform track is segmented in two virtual platform blocks, namely virtual platform blocks 204-1 and 204-2 for platform track 204, and virtual platform blocks 205-1 and 205-2 for platform track 205.

[0134] Railway vehicles always fill and vacate the same side of the track first i.e. the first-in-first-out principle is preferably applied by the relevant trackside control system 30, and the railway vehicles from the same platform track will depart first in sequence until emptying the entire platform track.

[0135] This paves the way for the occupancy of incoming railway vehicles of the other platform track, hence basically, one side of the platform on-board passengers and another side of the platform keeps transporting the passenger.

[0136] At station A, e.g. a terminus station, and at service time t=0, i.e. going to start the first trip of the day, four railway vehicles, namely train 1, train 2, train 3, and train 4 can occupy the four virtual platform blocks as shown in the top part of Figure 7.

[0137] Train 1 starts moving from platform 202, in particular from virtual platform block 204-1 of platform track 204 towards the following station B.

[0138] Since platform track 202 is still occupied by train

2, and platform track 205 is occupied by trains 3 and 4, no other railway vehicles can enter station A yet.

[0139] Proceeding down in the illustration of figure 7, at time t=30 sec, train 1 vacates its previously occupied virtual block 204-1 and train 2 is commanded to depart.

[0140] At time t=60 sec, train 2 has vacated its previously occupied virtual platform block 204-2 leaving the platform 202 and a train 5 is routed to and occupies the virtual platform block 204-1 at time t=90 sec.

[0141] Since platform track 204 is still occupied with train 4 at virtual platform block 205.2, a new train 6 cannot proceed towards platform track 205, and it is routed to occupy virtual platform block 204-2. Train 1 reaches station B in a prefixed time e.g. t=80 seconds, train 2 approaches station B and train is in inter-stations section.

[0142] In the example illustrated it is assumed that all inter-stations distances are substantially equal, e.g. 1.5 km.

[0143] If the distance between two stations is longer, then a higher number of railway vehicles can transit at that inter-station at the same time.

[0144] The same sequence of railway vehicle movements repeats further for all the railway vehicles as shown in the inferior part of figure 7.

[0145] According to the example illustrated, at steady state, two railway vehicles are always accessible to passengers at any instant of time for boarding and other two railway vehicles are always in an inter-stations section.

[0146] In order to achieve a desired headway between railway vehicles, e.g. a desired sub-minute headway, each trackside control system 30 associated to a station maintains an own headway clock of railway vehicles.

[0147] As illustrated in figures 8-9, each railway vehicle, e.g. train 1 in figure 8, and train 2 in figure 9, is allocated at rising edge of the clock, e.g. points R in figures 8-9, which is equivalent to a timetable at station, and each railway vehicle is mapped at the time interval of headway at each station.

[0148] For each station, each railway vehicle leaves at the desired frequency, e.g. 30 sec.

[0149] Each railway vehicle reaches the following destination in a desired time, e.g. 80 seconds, using also the own on-board railway vehicle driving algorithm.

[0150] A substantially constant dwell time for on/off boarding, e.g. 40 sec, can be maintained, as shown in figures 8-9.

[0151] Hence, it is evident from the foregoing description that the system 100 and method 300 according to the present invention allow to achieve the intended aim and objects since they allow increasing the overall capability of passengers to be transported.

[0152] Indeed, the efficiency of the overall railway line is improved since railway vehicles are controlled and move according to a shortened headway, which, as described, can be reduced under a minute, and preferably be fixed even at about 30 seconds.

[0153] In this way, the frequency of railway vehicles per unit of time service is increased and two or more railway vehicles can stay along a platform track at the same time, thus resulting in an overall increased frequency of service.

[0154] Further, deviations from a desired operation schedule can be identified and corrected in real time, and if necessary the schedule can be adjusted as a whole for all railway vehicles, or only for some railway vehicles with reference to others.

[0155] In case of abnormalities, a desired operation time schedule can be quickly recovered or suitably adjusted.

[0156] These results are achieved according to a solution very flexible that can be applied in building new lines or by intervening on existing ones with modification that are anyhow less expensive and cumbersome than building a new traditional line.

[0157] The method 300 and system 100 thus conceived are susceptible of modifications and variations, all of which are within the scope of the inventive concept as defined in particular by the appended claims; for example, the number of platform, platforms tracks and related virtual platform blocks can be any suitable in relation to the specific application, as those skilled in the art would appreciate.

[0158] All the details may furthermore be replaced with technically equivalent elements.

Claims

1. A traffic management system (100) for a railway line (200) comprising a plurality of stations (A, B), each of said stations having one or more platforms (202, 203) associated with corresponding one or more platform tracks (204, 205, 206, 207), the system (100) being **characterized in that** it comprises:

   - a centralized control center (1) for the railway line (200);
   - a plurality of on-board control systems (10) suitable to be installed each on-board of an associated railway vehicle (208) and being arranged, in operation, to be in communication at least with said centralized control center (1);
   - a plurality of trackside control systems (30) which are distributed along the railway line (200) and are suitable to be in operative communication with said centralized control center (1) and with said on-board control systems (10), each of said trackside control systems (30) being suitable to control traffic within a respective assigned zone (200A, 200B) of the railway line (200), the assigned zone including at least a corresponding station zone associated with one of said plurality of stations (A, B), wherein each trackside control system (30) is arranged to route railway vehicles (208), transiting in the respective station zone, each to a selected stop-

ping position (204-1, 204-2, 205-1, 205-2, 206-1, 206-2, 207-1, 207-2) provided along a platform track of the corresponding station for on/off boarding passengers, wherein two or more of said railway vehicles transiting in the respective station zone can be routed, by the corresponding trackside control system (30), to occupy, at a same time, corresponding two or more selected stopping positions provided along the same platform track of the corresponding station, and to command, thereafter, departure of each stopped railway vehicle from the corresponding stopping position according to a desired railway vehicle operation time schedule.

2. A traffic management system (100) for a railway line (200), as claimed in claim 1, wherein each of said trackside control systems (30) is arranged to command departure of each railway vehicle stopped at a corresponding stopping position of a platform track associated to a platform of the corresponding station zone, after a first prefixed time interval (T_d) is elapsed from the instant of commanding departure from the same platform (202, 203) of a preceding railway vehicle moving in the same direction along the railway line (200).

3. A traffic management system (100) for a railway line (200), as claimed in claim 2, wherein the first prefixed time interval (T_d) is constant.

4. A traffic management system (100) for a railway line (200), as claimed in one of claims 1 or 2, wherein trackside control systems (30), among said plurality of trackside control systems (30), which are located in and are suitable to control traffic within respective adjacent assigned zones (200A, 200B) of the railway line (200), are configured to be in mutual communication and are arranged to cooperatively control railway vehicles transiting in the respective adjacent assigned zones so that each control system (30) commands, for each railway vehicle stopped in the assigned station zone, departure from a corresponding stopping position after a second prefixed constant time interval (T_t) is elapsed from the instant of commanding departure of the same railway vehicle from a preceding adjacent station zone by a preceding adjacent trackside control system (30).

5. A traffic management system (100) for a railway line (200), as claimed in one of claims 1 or 2, wherein, for each zone of said railway line (200), there are assigned a first trackside control system (30) and a second trackside control system (30) which are suitable to control traffic, within the assigned zone, of railway vehicles moving along a first direction and a second opposite direction of said railway line (200), respectively.

6. A traffic management system (100) for a railway line (200), as claimed in claim 1, wherein each of said trackside control systems (30) is arranged to control an assigned zone (200A, 200B), the assigned zone including the station zone, a first inter-stations section (210A, 210B) of the railway line (200) immediately upward the corresponding station zone and a second inter-stations section (220A, 220B) of the railway line (200) immediately downward the corresponding station zone of the assigned zone, and wherein each trackside control system (30) comprises one or more railway vehicle position localizers (31), at least one railway vehicle position localizer (31) being placed, for each assigned zone, within said first inter-stations section (210A, 210B), and being arranged to interact with the on-board control system (10) of a railway vehicle transiting in the related inter-stations section for localizing the actual position of said transiting railway vehicle.

7. A traffic management system (100) for a railway line (200), as claimed in claim 1, wherein each trackside control system (30) further comprises a plurality of devices (32, 33, 34, 35) which are positioned at the corresponding assigned station zone and are arranged to virtually segment each of the platform tracks (204, 205, 206, 207) associated to a platform (202, 203) of the corresponding station zone in a plurality of virtual and uniquely identified platform blocks forming said selected stopping positions (204-1, 204-2, 205-1, 205-2, 206-1, 206-2, 207-1,207-2), and to cooperatively interact with the on-board control system (10) of a railway vehicle under stopping so that to stop it at a selected virtual platform block.

8. A traffic management system (100) for a railway line (200), as claimed in claim 7, wherein said plurality of devices of each trackside control system (30) comprises service stopping identifiers (32) which are each programmed with a unique indicator of and assigned to a corresponding virtual platform block, and a plurality of virtual platform block indicators (33) each operatively linked with a respective service stopping identifier (32) and suitable to interact with the on-board control system (10) of a railway vehicle under stopping in order to stop it at the selected virtual platform block of a platform track.

9. A traffic management system (100) for a railway line (200), as claimed in claims 6 and 8, wherein each trackside control system (30) further comprises:

- a server (34) storing data indicative of the position of each railway vehicle position localizer (31) and of each service stopping identifiers (32) and associated virtual platform block indicator (33) located in the respective assigned zone,

and a list of predefined railway vehicle patterns along the railway line (200); and
- a data processing device (35) arranged to select, based on information received from a railway vehicle position localizer (31) indicating the actual position of a railway vehicle transiting in the inter-stations upward section of the respective assigned zone, a railway vehicle pattern from said list, and to send the selected railway vehicle pattern to the localized railway vehicle for routing it to a selected virtual platform block of the corresponding station zone.

10. A traffic management system (100) for a railway line (200), as claimed in claims 6 and 8, wherein each on-board control system (10) comprises one or more first sensors (11) cooperatively interacting with corresponding railway vehicle position localizers (31) so that to localize the position of the associated railway vehicle (208) along the railway line, and cooperatively interacting with said virtual block identifiers (32) and said virtual block indicators (33) for stopping the associated railway vehicle (208) at a virtual platform block selected by the trackside control system (30) assigned to the corresponding station zone.

11. A traffic management system (100) for a railway line (200), as claimed in one of claims 1 or 2, wherein each on-board control system (10) comprises an inter railway vehicle telemetry device (16) arranged for exchanging data indicative of the movement of the associated railway vehicle, with the inter railway vehicle telemetry devices of the on-board control systems (10) of at least one of a first railway vehicle (208) immediately preceding and of a second railway vehicle immediately trailing the associated railway vehicle (208), along the railway line, respectively, and wherein each on-board control system (10) further comprises a data processing unit (17) adapted to process data received from the on-board control systems (10) of at least one of said first preceding railway vehicle and second trailing railway vehicle, and to adjust dynamically movement of the associated railway vehicle in response to the data received.

12. A traffic management system (100) for a railway line (200), as claimed in one of claims 1 or 2, wherein said centralized control center comprises a central database (5) storing data related to on-board sensors calibration parameters of each railway vehicle operating along the railway line (200), and wherein, based on a request from a railway vehicle operating along the railway line, said centralized control center provides to the requesting railway vehicle data related to the on-board sensor calibration parameters for at least one of a railway vehicle immediately preceding and a railway vehicle immediately trailing the requesting railway vehicle.

13. A method (300) for managing traffic of a railway line (200), **characterized in that** it comprises the following steps:

- (301): providing, in whatever order, a centralized control center (1) for the railway line (200), a plurality of on-board control systems (10) suitable to be installed each on-board of an associated railway vehicle (208) and a plurality of trackside control systems (30) which are distributed along the railway line (200), said centralized control center (1) and said plurality of on-board control systems (10) and of trackside control systems (30) being suitable, in operation, to be in mutual operative communication, wherein each of said trackside control systems (30) being suitable to control traffic within a respective assigned zone (200A, 200B) of the railway line (200), the assigned zone including at least a corresponding station zone (A, B) associated with one of said plurality of stations (A, B), each of said station zones having one or more platforms (202, 203) associated with corresponding one or more platform tracks (204, 205, 206, 207);
- (305): routing railway vehicles (208) transiting in the respective station zone each to a selected stopping position (204-1, 204-2, 205-1, 205-2, 206-1, 206-2, 207-1, 207-2) along a platform track of the corresponding station for on/off boarding passengers, wherein two or more of said railway vehicles can be routed to occupy, at the same time, corresponding two or more selected stopping positions along the same platform track of the corresponding station;
- (310): commanding, after on/off boarding passengers, departure of each stopped railway vehicle from the corresponding stopping position according to a desired railway vehicle operation time schedule.

14. A method (300) for managing traffic of a railway line (200), as claimed in claim 13, wherein said step (310) of commanding comprises commanding departure of each railway vehicle stopped from a corresponding stopping position of a platform track associated to a platform of the corresponding station zone, after a first prefixed time interval (T_d) is elapsed from the instant of commanding departure from the same platform (202, 203) of a preceding railway vehicle moving in the same direction along the railway line (200).

15. A method (300) for managing traffic of a railway line (200), as claimed in claim 14, wherein said step (310) of commanding comprises commanding departure of each railway vehicle stopped at a corresponding stopping position of a platform track associated to a platform of the corresponding station zone after a first prefixed constant time interval (T_d) is elapsed

from the instant of commanding departure from the same platform (202, 203) of a preceding railway vehicle moving in the same direction along the railway line (200).

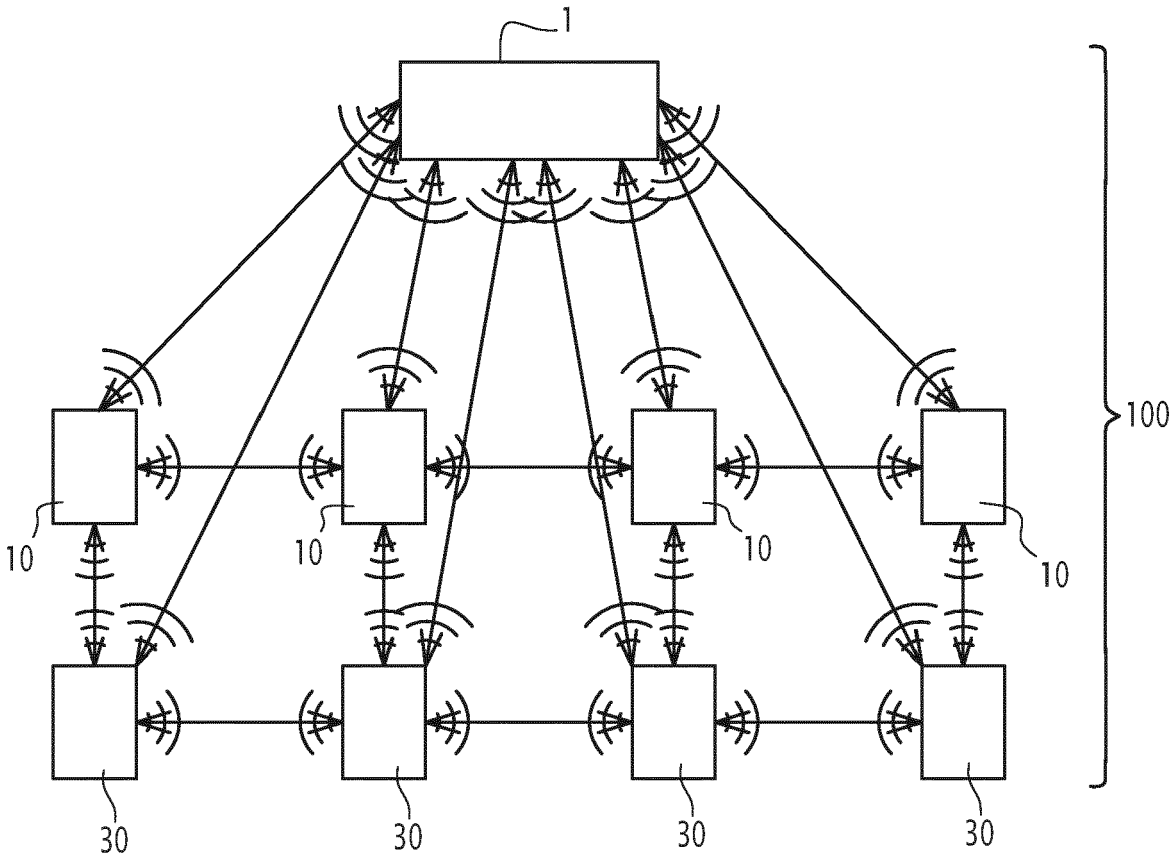

FIG.1

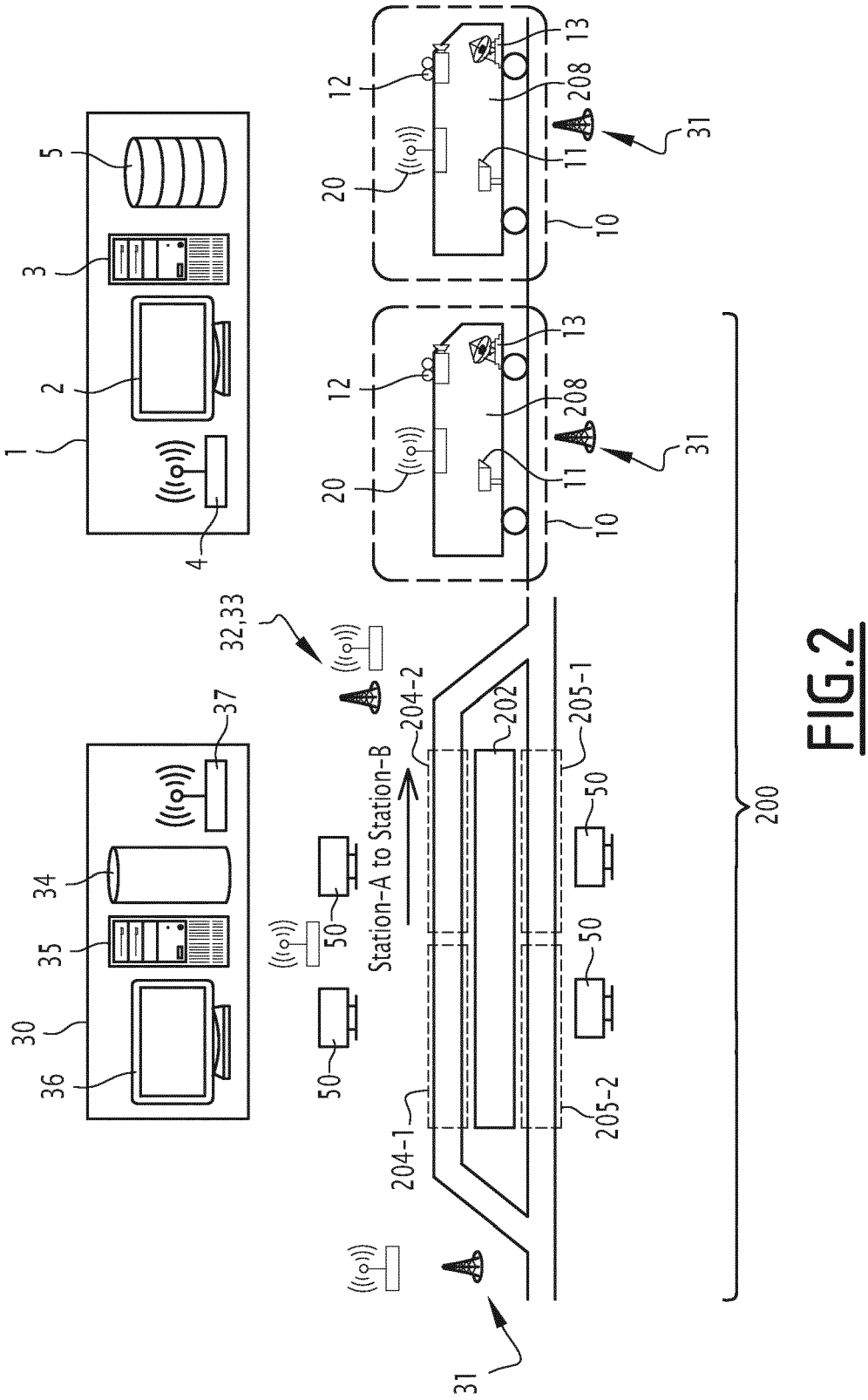
1
2
3
4
5
10
11
12
13
20
30
31
32,33
34
35
36
37
50
200
202
204-1
204-2
205-1
205-2
208
Station-A to Station-B

FIG.2

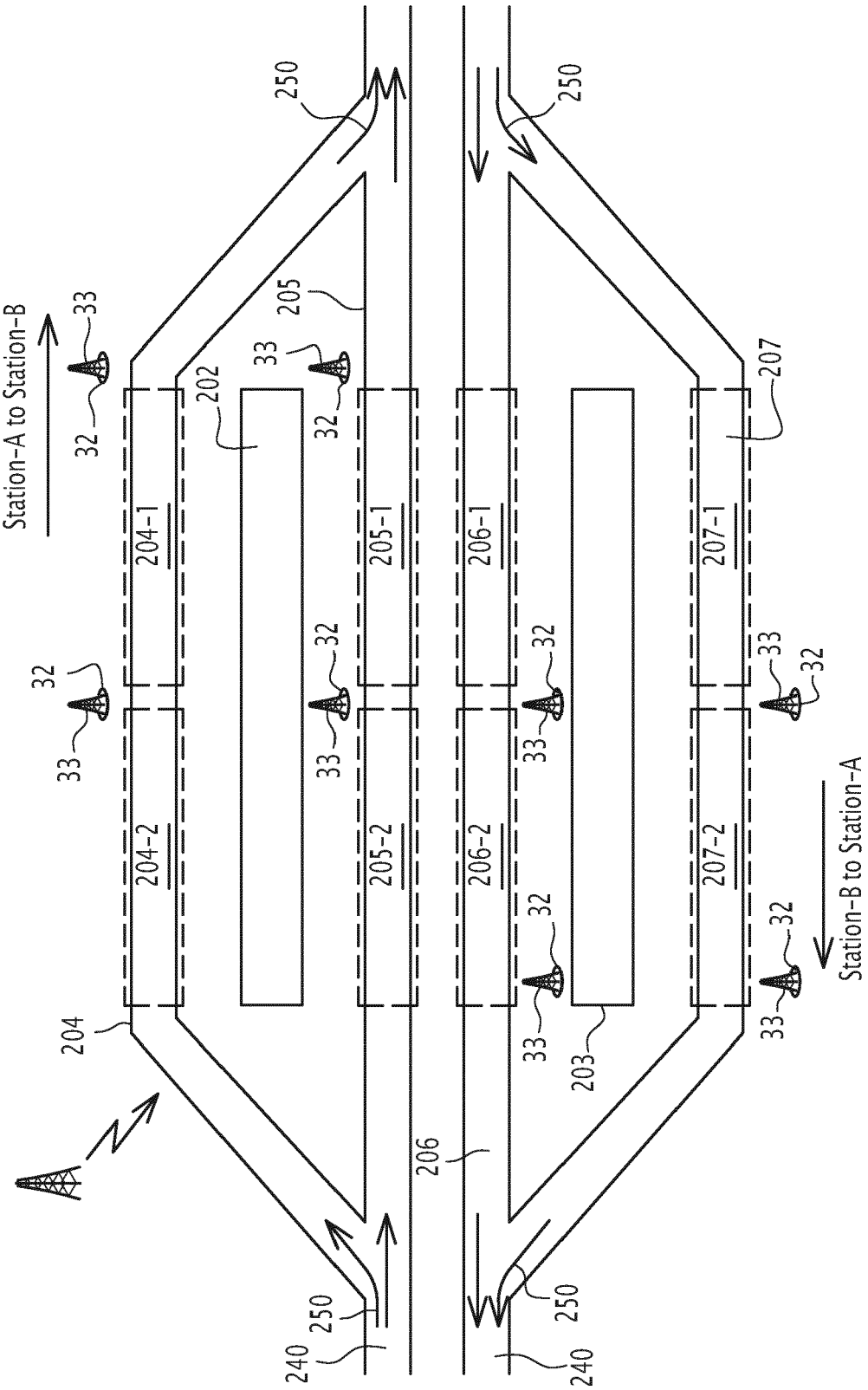
Station-A to Station-B
Station-B to Station-A
204
204-1
204-2
205
205-1
205-2
206
206-1
206-2
207
207-1
207-2
202
203
240
250
32
33

FIG.3

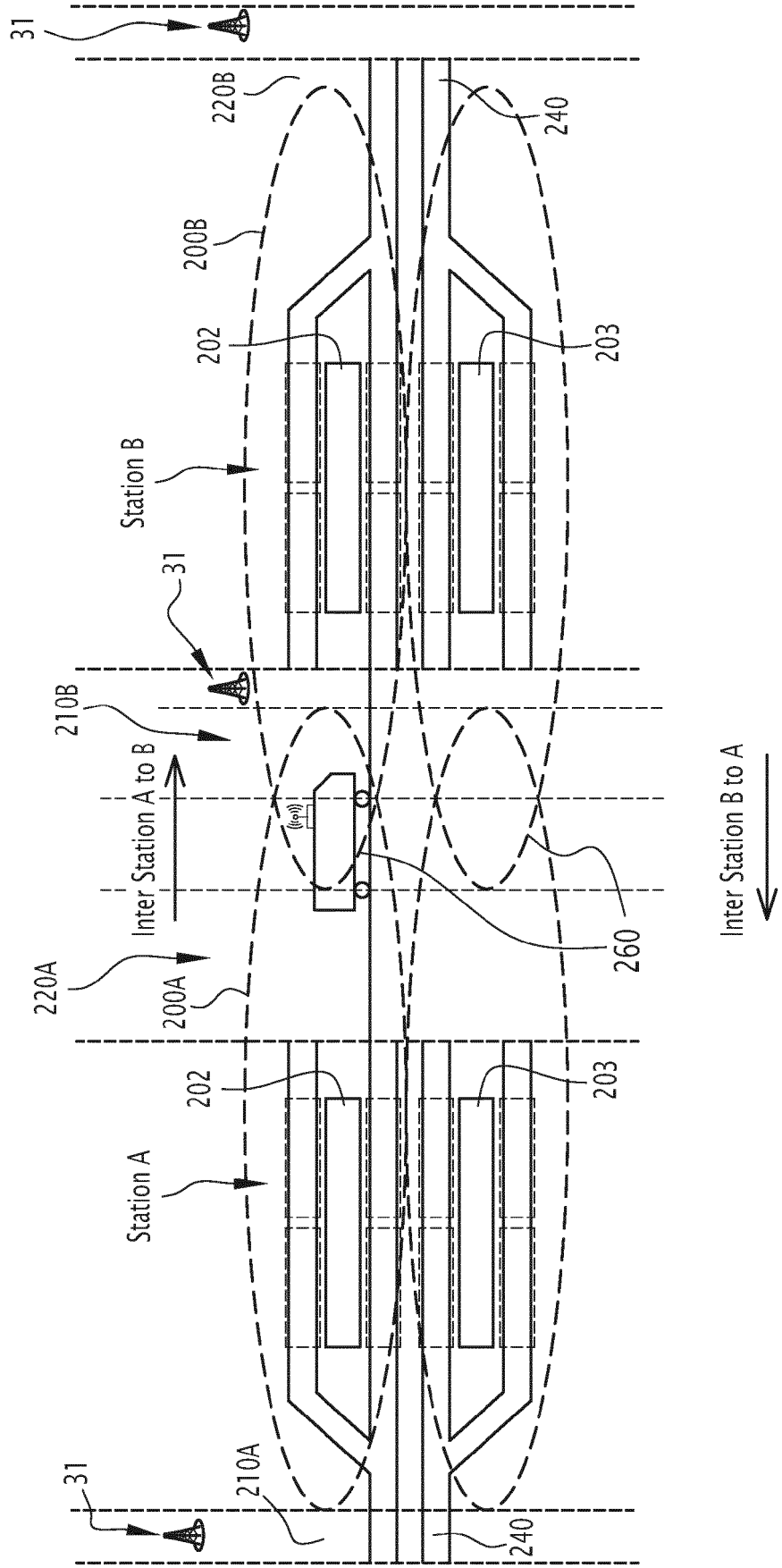
31
220B
240
200B
202
203
Station B
31
210B
Inter Station A to B
220A
200A
260
Inter Station B to A
202
203
Station A
31
210A
240

FIG.4

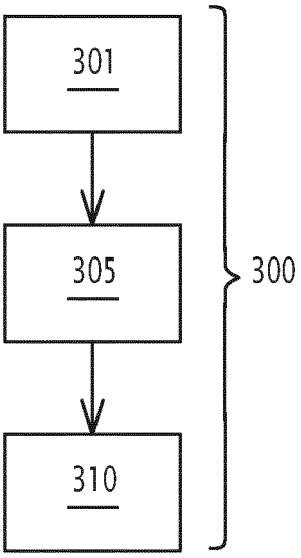

FIG.5

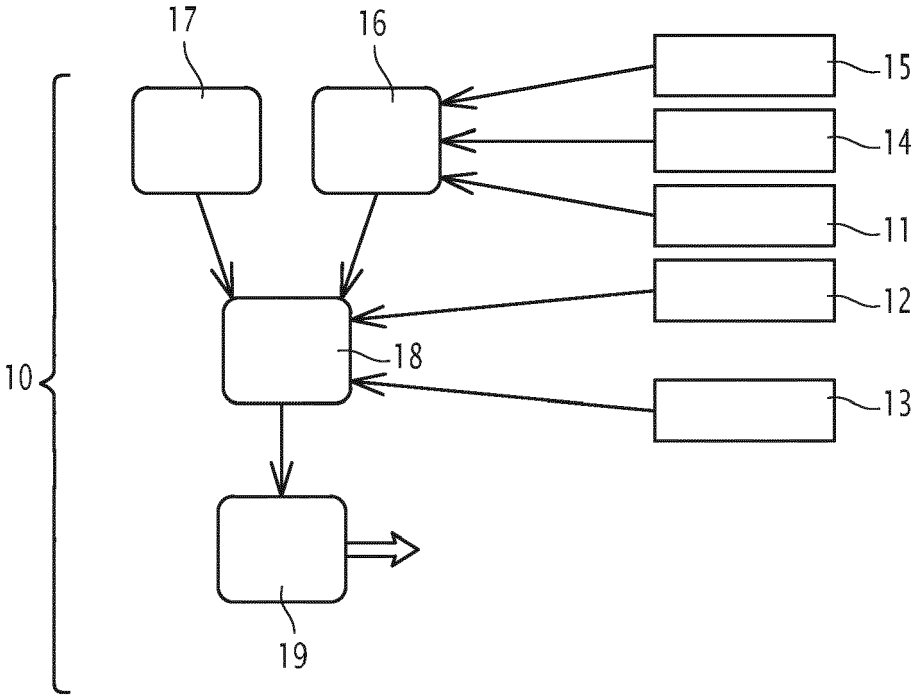

FIG.6

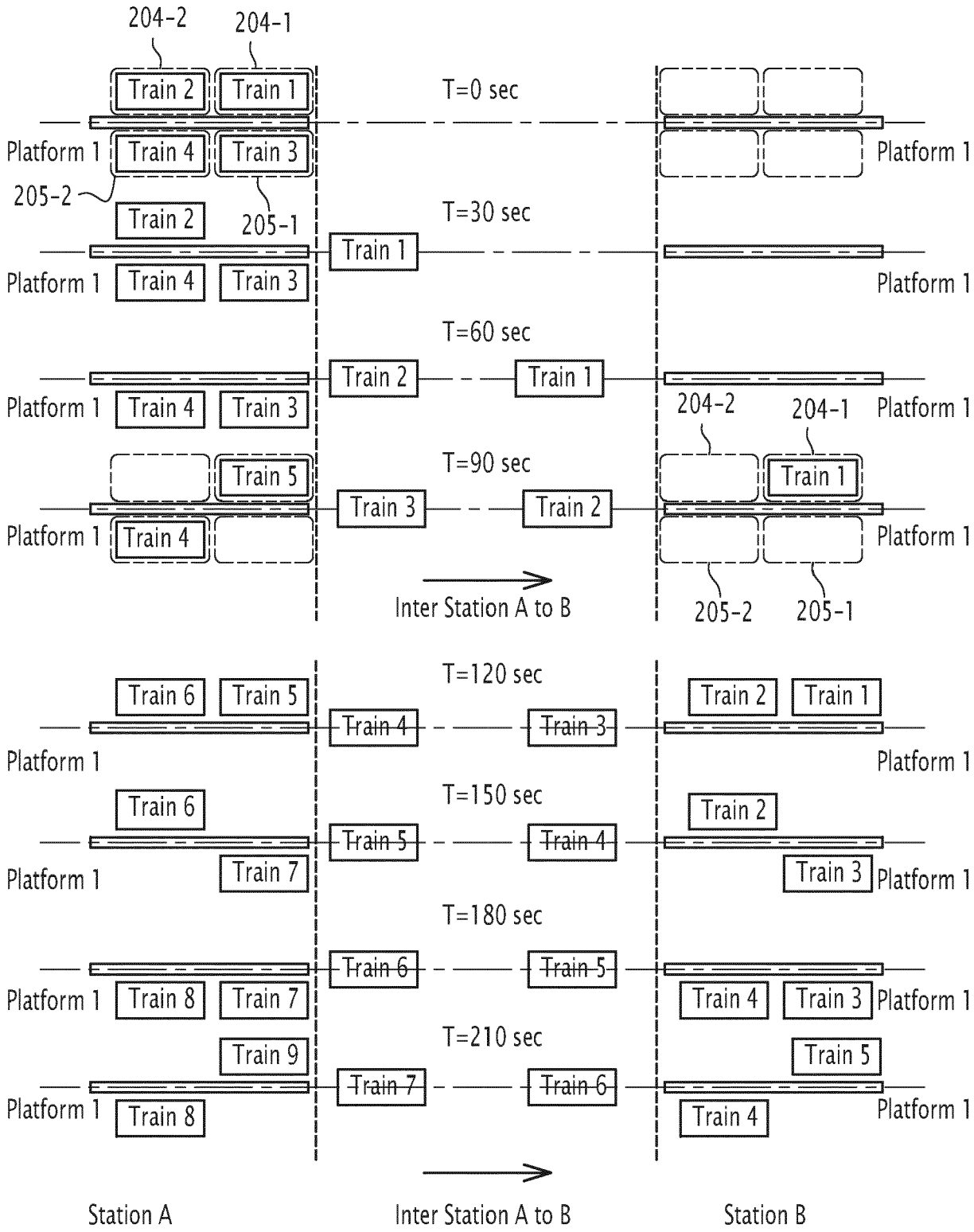
204-2
204-1
Train 2
Train 1
T=0 sec
Platform 1
Train 4
Train 3
Platform 1
205-2
205-1
Train 2
T=30 sec
Train 1
Platform 1
Train 4
Train 3
Platform 1
T=60 sec
Train 2
Train 1
Platform 1
Train 4
Train 3
204-2
204-1
Platform 1
T=90 sec
Train 5
Train 1
Train 3
Train 2
Platform 1
Train 4
Platform 1
Inter Station A to B
205-2
205-1
T=120 sec
Train 6
Train 5
Train 4
Train 3
Train 2
Train 1
Platform 1
Platform 1
T=150 sec
Train 6
Train 5
Train 4
Train 2
Platform 1
Train 7
Train 3
Platform 1
T=180 sec
Train 6
Train 5
Platform 1
Train 8
Train 7
Train 4
Train 3
Platform 1
T=210 sec
Train 9
Train 5
Train 7
Train 6
Platform 1
Train 8
Train 4
Platform 1
Station A
Inter Station A to B
Station B

FIG.7

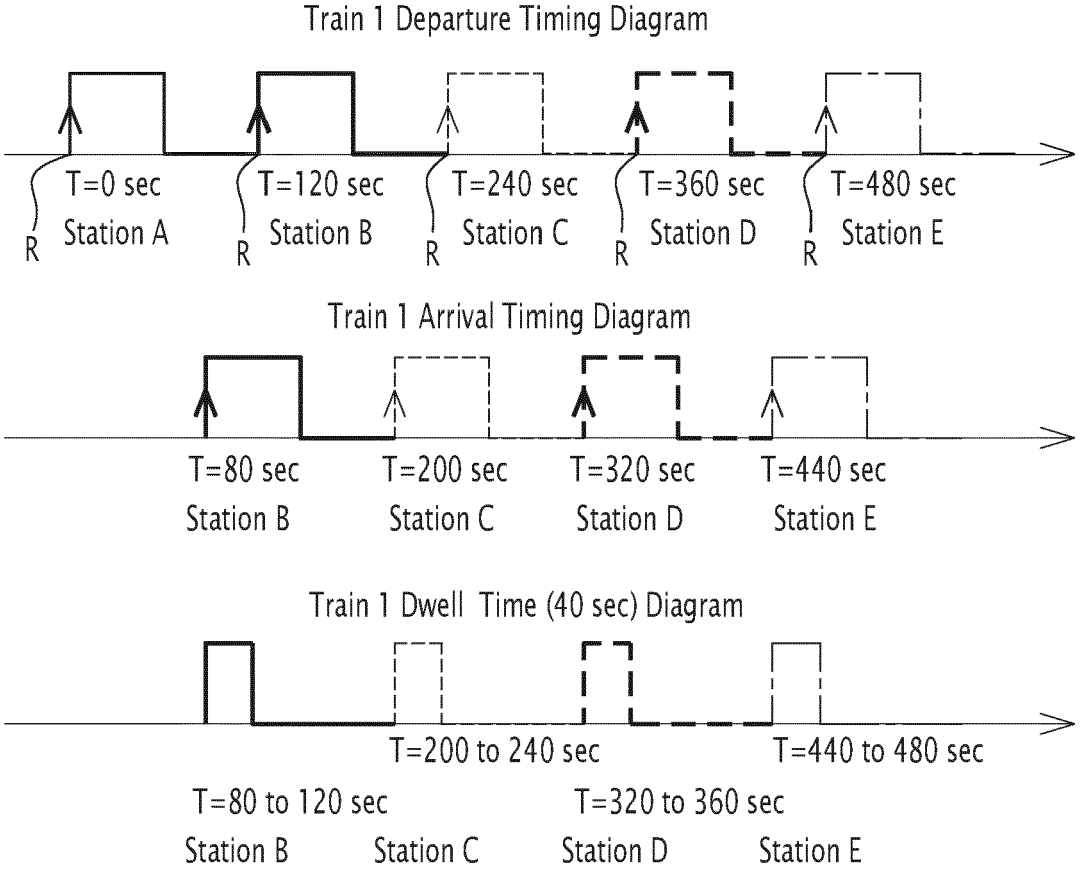
Train 1 Departure Timing Diagram
T=0 sec
Station A
T=120 sec
Station B
T=240 sec
Station C
T=360 sec
Station D
T=480 sec
Station E
R
Train 1 Arrival Timing Diagram
T=80 sec
Station B
T=200 sec
Station C
T=320 sec
Station D
T=440 sec
Station E
Train 1 Dwell Time (40 sec) Diagram
T=200 to 240 sec
T=440 to 480 sec
T=80 to 120 sec
Station B
Station C
T=320 to 360 sec
Station D
Station E

FIG.8

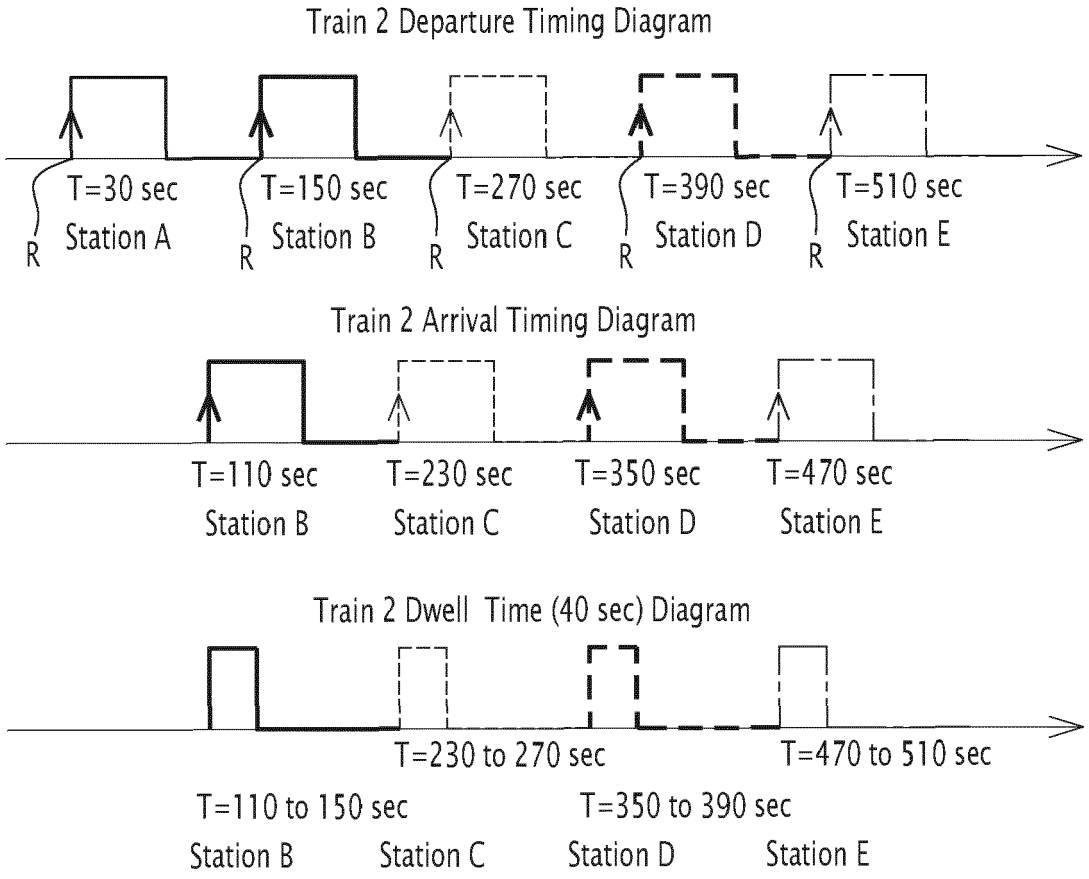
Train 2 Departure Timing Diagram
T=30 sec
Station A
T=150 sec
Station B
T=270 sec
Station C
T=390 sec
Station D
T=510 sec
Station E
R
R
R
R
R
Train 2 Arrival Timing Diagram
T=110 sec
Station B
T=230 sec
Station C
T=350 sec
Station D
T=470 sec
Station E
Train 2 Dwell Time (40 sec) Diagram
T=230 to 270 sec
T=470 to 510 sec
T=110 to 150 sec
T=350 to 390 sec
Station B
Station C
Station D
Station E

FIG.9

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 15 3876

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y A	WO 94/26571 A1 (HUGHES AIRCRAFT CO [US]) 24 November 1994 (1994-11-24) * figures 1 - 3; page 1, line 17 - page 2, line 5; page 8, line 26 - page 9, line 5; and page 9, lines 6 - 21 * -----	1-10, 13-15 11 12	INV. B61L15/00 B61L27/00 B61L25/02
A	DE 195 35 856 A1 (SIEMENS AG [DE]) 20 March 1997 (1997-03-20) * figure 1, column 2, lines 57 - 62 * -----	1-15	
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Place of search	Date of completion of the search	Examiner
Munich	6 July 2020	Plützer, Stefan

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