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(54) TRAFFIC SITUATION ESTIMATION SYSTEM AND TRAFFIC SITUATION ESTIMATION METHOD

(57) It is provided a traffic condition estimation system, comprising: a processor that executes a program; and a storage device that stores the program, wherein a plurality of base stations of a wireless communication system are installed in a boarding/deboarding facility for use of a transportation means, wherein the storage device stores connection information including connection start locations and connection termination locations between terminals possessed by users of the transportation means and any of the plurality of base stations, and wherein the processor is configured to: extract, from the connection information, terminals for which the connection start locations and the connection termination locations differ from each other; and multiply a number of said extracted terminals by a predetermined first coefficient to estimate a number of people waiting in the boarding/ deboarding facility for use of the transportation means.

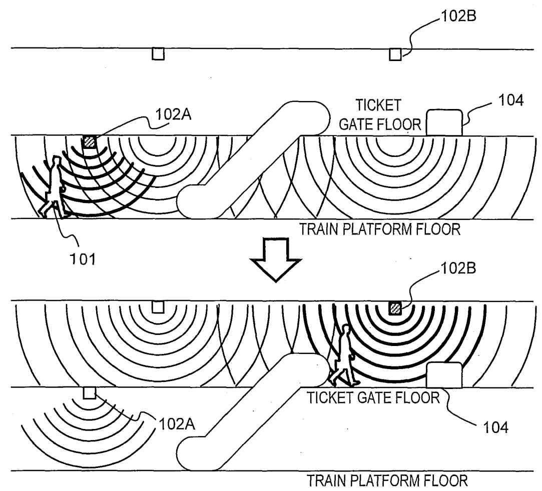

Fig. 2

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a system for estimating traffic conditions.

[0002] In order to provide passengers with a high quality transportation service, railway operators have been engaging in efforts to realize services in which operating conditions such as delays and congestion in trains and congestion in stations are transmitted in real time. Japanese railway companies have started providing services in the vicinity of Tokyo in which travel position information of trains acquired by a train operation management system and passenger number information measured by sensors installed in the trains are gathered, and information such as train delays and congestion is transmitted to the passengers.

[0003] Also, wireless base stations (such as public wireless LAN access points) are being installed in public transportation systems including in airports, stations, and trains, as well as in commercial establishments, particularly by railway companies and communications companies. In this environment, real-world testing is being conducted to measure with a high degree of accuracy the movements of people both indoors and outdoors using public wireless LANs and the like.

[0004] JP 2007-120953 A is an example of prior art of the present technical field. JP 2007-120953 A discloses a technique in which acceleration sensors provided in mobile terminals are used to determine whether a train has arrived at or departed from a station on the basis of detection results from an acceleration detection means and determination results of a communication area determination means.

SUMMARY OF THE INVENTION

[0005] As described above, a method for transmitting to passengers information acquired by a train operation management system requires a system in which sensors are installed in trains and measured data is gathered through wireless communication, which results in high installation and development costs. Also, it was difficult for many railway companies to deploy and operate such systems in a short time frame.

[0006] On the other hand, if high accuracy positioning is used, then the positions of passengers having mobile terminals in the station can be tracked, and thus, it can be determined whether a passenger has boarded a train, and the arrival/ departure time of the train can be measured in real time. However, in order to measure the arrival/departure time of the train, at least one passenger needs to be detected per train. Also, if the method disclosed in JP 2007-120953 A is used, the time at which the train has arrived at the station can be detected using acceleration data measured by mobile terminals possessed by individuals, but in order to detect the arrival/departure times of all trains and at all stations, there is a need to gather and analyze acceleration data measured by mobile terminals of many passengers. Therefore, in detecting the arrival/departure times of all trains using the method disclosed in JP 2007-120953 A, data must be gathered with those who possess mobile terminals having specialized applications and sensors being present in all trains.

[0007] An object of the present invention takes into consideration the above issues, and estimates the arrival/departure times of trains using information of connections to wireless base stations (such as public wireless LAN access points) disposed in the station, without needing to gather data from mobile terminals of passengers.

[0008] The representative one of inventions disclosed in this application is outlined as follows. There is provided a traffic condition estimation system, comprising: a processor that executes a program; and a storage device that stores the program. A plurality of base stations of a wireless communication system are installed in a boarding/ deboarding facility for use of a transportation means. The storage device stores connection information including connection start locations and connection termination locations between terminals possessed by users of the transportation means and any of the plurality of base stations. The processor is configured to: extract, from the connection information, terminals for which the connection start locations and the connection termination locations differ from each other; and multiply a number of said extracted terminals by a predetermined first coefficient to estimate a number of people waiting in the boarding/deboarding facility for use of the transportation means.

[0009] According to representative aspect of the present invention, the number of passengers in a transportation means (such as a train) can be estimated. Problems, configurations, and effects other than those described above are made clear from the following description of an embodiment of this invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 is a diagram illustrating an outline of a public wireless LAN in a system according to an embodiment of the present invention.

FIG. 2 is a diagram illustrating a relationship between a public wireless LAN in a system and movement within a station according to the embodiment of the present invention.

FIG. 3 is a diagram illustrating a structure of a record in which public wireless LAN connection information is stored according to the embodiment of the present invention.

FIG. 4A is a diagram illustrating a configuration of an entire system according to the embodiment of the present invention.

FIG. 4B is a diagram illustrating a configuration of a data server according to the embodiment of the present invention.

FIG. 4C is a diagram illustrating a configuration of a calculation server according to the embodiment of the present invention.

FIG. 5 is a diagram illustrating a data structure of master data according to the embodiment of the present invention.

FIG. 6 is a diagram illustrating a data structure of in-station movement data according to the embodiment of the present invention.

FIG. 7 is a flowchart of an in-station movement data generating process according to the embodiment of the present invention.

FIG. 8 is a diagram illustrating a method of estimating arrival/departure times of a train and a number of passengers in the train to the embodiment of the present invention.

FIG. 9 is a diagram illustrating a data structure of train time data according to the embodiment of the present invention.

FIG. 10 is a flowchart of a train arrival/departure times estimating process according to the embodiment of the present invention.

FIG. 11 is a flowchart of a train delay calculating process according to the embodiment of the present invention.

FIG. 12 is a diagram illustrating a data structure of ticket gate passage headcount data according to the embodiment of the present invention.

FIG. 13 is a diagram illustrating a data structure of a rebate coefficient table according to the embodiment of the present invention.

FIG. 14 is a flowchart of a rebate coefficient calculating process according to the embodiment of the present invention.

FIG. 15 is a diagram illustrating a data structure of train headcount data according to the embodiment of the present invention.

FIG. 16 is a flowchart of a train passenger headcount aggregating process according to the embodiment of the present invention.

FIG. 17 is a diagram illustrating a data structure of in-station waiting headcount data according to the embodiment of the present invention.

FIG. 18 is a flowchart of an in-station waiting headcount totaling process according to the embodiment of the present invention.

FIG. 19 is a diagram illustrating an example of a screen distributed by an information distribution server according to the embodiment of the present invention.

FIG. 20 is a diagram illustrating an example of a screen distributed by the information distribution server according to the embodiment of the present invention.

FIG. 21 is a diagram illustrating an example of a condition setting screen according to the embodiment of the present invention.

FIG. 22 is a flowchart of an information distribution process according to the embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0011] An embodiment of the present invention will be described with reference to FIGs. 1 to 22. In an embodiment of the present invention, the times at which trains arrive at or depart from stations and the number of passengers are estimated, but the present invention can be applied to any transportation means used by many people (such as buses and ferries). Furthermore, the present invention can be applied to taxi stands to estimate the degree of congestion of the taxi stand (that is, the number of people waiting to catch a taxi).

[0012] FIG. 1 is a diagram illustrating an outline of a public wireless LAN in a system according to an embodiment of the present invention.

[0013] A public wireless LAN is a service in which internet connection is provided through wireless LAN, and a user 101 connects to the internet through an access point 102 from a mobile terminal 103 such as a laptop computer, a smartphone, or a tablet computer. The signal range of one access point is typically in the range of tens of meters, and thus, in large spaces such as large-scale commercial establishments and stations, a plurality of access points are often installed.

[0014] In order to prevent interference when a mobile terminal can communicate with a plurality of access points 102, the wireless LAN access points 102 and the mobile terminals communicate using a common SSID to prevent interference and unnecessary communications, and the connection start time and connection termination time for each mobile terminal can be acquired by the access points 102. Also, there are public wireless LAN services in which the user would register a MAC address or the like, which is an identifier of the mobile terminal, in advance. Thus, the movement history of each mobile terminal can be analyzed from the wireless LAN connection data. Such settings and registration would typically require action by the owner of the mobile terminal who wishes to use the public wireless LAN.

[0015] FIG. 2 is a diagram illustrating a relationship between a public wireless LAN in a system and movement within the station according to the embodiment of the present invention.

[0016] In general, the public wireless LAN access points 102 in the station are installed near ticket gates and at platforms, and the general location of the mobile terminal can be estimated by the signal strength between each access point 102 and the mobile terminal. If the user 101 having a mobile phone connected to a public wireless LAN exits a train, for example, first the mobile terminal connects to an access point 102A installed at the platform level. When the user 101 moves towards a ticket gate 104 in order to leave the station, the mobile terminal switches connection to an access point 102B installed near the ticket gate. By tracking in this manner the access points 102 to which each mobile terminal is connected in time series order, it is possible to estimate movements of passengers in the station.

[0017] A plurality of access points may be installed in the same area (such as three access points at the track 1 platform).

[0018] FIG. 3 is a diagram illustrating a structure of a record in which public wireless LAN connection information 122 is stored according to the embodiment of the present invention.

[0019] The public wireless LAN connection information 122 includes information such as access point IDs 211, connection times 212, and connecting device IDs 213 representing the IDs of connected mobile devices, and is data of the devices connected at the time. The connection time 212 may store records at one second increments or several second increments. By retaining the connection time at narrow increments, it is possible to increase the estimation accuracy for the train arrival/departure times. The connecting device ID 213 can be uniquely identified in one day, and thus, anonymization may be performed by changing the ID assignment rules for each day. The public wireless LAN connection information 122 stores data included in a predetermined time window such as by stream data processing, and as time passes, new data is added and old time data is deleted.

[0020] FIG. 4A is a diagram illustrating the configuration according to the entire system of the embodiment of the present invention, FIG. 4B is a diagram illustrating the configuration of a data server 111, and FIG. 4C is a diagram illustrating the configuration of a calculation server 112.

[0021] In recent years, automatic ticket gates 104 are installed in many railway stations, and users 101 of the railway system are allowed to enter and exit the station as a result of the automatic ticket gates 104 reading a contactless IC card (or mobile terminal having a function of contactless IC card) or a magnetic ticket. The information read by the automatic ticket gate 104 is transmitted through a network 107 to a group of data management servers 108 managed by a railway operator, and is accumulated as ticket gate passage data. As previously described, connected device information is transmitted in real time to the group of data management servers 108 through the public wireless LAN access points 102 installed near the ticket gate or at the platforms. Also, in recent years, surveillance cameras 105 are installed near the ticket gates or at the platforms. The image data acquired by the surveillance cameras 105 can be viewed in real time through the network 107 at a command center or the like that manages railway operations.

[0022] A traffic condition estimation system 110 is constituted of the data server 111, the calculation server 112, and an information distribution server 113, and gathers, accumulates, and analyzes connection device information of the public wireless LAN access points 102 and ticket gate passage data. When describing the present embodiment, functions, configurations, and data processing techniques for wireless systems, ticket gates, and the like that are not directly relevant will not be described here.

[0023] The image data acquired by the surveillance cameras 105 and the ticket gate passage data is transmitted to the data server 111 through the network 107 whenever new data is acquired or at a predetermined time interval (such as once per hour or once per day). The traffic condition estimation system 110, which is constituted of a group of servers including the data server 111, the calculation server 112, and the information distribution server 113, can communicate with a computer 117 used by a railway operator 116 or a terminal 118 used by a passengers 115 through networks 107 and 114. In the present embodiment, the data server 111, the calculation server 112, and the information distribution server 113 constitute the group of servers, but the functions of this group of servers may be realized by one server or a plurality of servers.

[0024] As shown in FIG. 4B, the data server 111 is a computer primarily having a network interface, a processor, a memory, and a storage unit.

[0025] The processor executes programs stored in the memory. The memory includes ROM, which is a non-volatile memory element, and RAM; which is a volatile memory element. The ROM includes fixed programs (such as the BIOS). The RAM is a high speed and volatile memory element such as DRAM (dynamic random access memory), and temporarily stores programs to be executed by the processor and data used during execution of the programs.

[0026] The storage unit is constituted of a large capacity non-volatile storage device such as a magnetic storage device (HDD), a CD-ROM drive, or flash memory (SSD), for example, and stores programs to be executed by the processor and data to be used while executing the programs. In other words, the programs are read from the storage unit, loaded into the memory, and executed by the processor.

[0027] The data server 111 receives public wireless LAN connection information 122 and ticket gate passage headcount data 126 through the network 107 at a predetermined timing (predetermined update time interval) and stores the information in a data storage unit 121 (DB). Specifically, the storage unit has a data storage unit 121 (DB). The data storage unit 121 stores the public wireless LAN connection information 122, master data 123 indicating the configuration of the station, in-station movement data 124, train time data 125, ticket gate passage headcount data 126, train headcount data 127, in-station waiting headcount data 128, and the like. The master data 123 is inputted from an external source (such as the computer 117 used by the railway operator 116) every time there is a change and then updated. The in-station movement data 124, the train time data 125, the train headcount data 127, and the in-station waiting headcount data 128 are result data generated by the calculation server 112.

[0028] As shown in FIG. 4C, the calculation server 112 executes a process of estimating the arrival/departure times of trains using a data group accumulated in the data server 111. The calculation server 112 is a computer primarily having a network interface 130 (I/F(A)), a processor 131 (CPU), a memory 132, and a storage unit 133.

[0029] The network interface 130 is an interface for connecting to the networks 107 and 114. The processor 131 executes programs stored in the memory 132. The memory 132 includes ROM, which is a non-volatile memory element, and RAM, which is a volatile memory element. The ROM includes fixed programs (such as the BIOS). The RAM is a high speed and volatile memory element such as DRAM (dynamic random access memory), and temporarily stores programs to be executed by the processor 131 and data used during execution of the programs.

[0030] The storage unit 133 is constituted of a large capacity non-volatile storage device such as a magnetic storage device (HDD), a CD-ROM drive, or flash memory (SSD), for example, and stores programs to be executed by the processor 131 and data to be used while executing the programs. In other words, the programs are read from the storage unit 133, loaded into the memory 132, and executed by the processor 131. Specifically, the storage unit 133 includes a data storage unit 152 (DB) that stores programs such as an in-station movement data generating program 134, a train time estimating program 135, a train delay calculating program 136, a rebate coefficient calculating program 137, a train passenger headcount aggregating program 138, and a in-station waiting headcount totaling program 139, as well as data such as a rebate coefficient table 153, and also stores intermediate data generated during the calculation process. Alternatively, the data server 111 instead of the calculation server 112 may store the rebate coefficient table 153.

[0031] A plurality of recording devices may be provided, with programs and data being split among the plurality of recording devices.

[0032] When the programs are executed, data to be analyzed is acquired from the data server 111 and temporarily stored in the memory 132, and by reading from the memory 132 and executing the programs 134, 135, 136, 137, 138, and 139, the processor 131 realizes the respective functions thereof. These programs may be automatically executed at a predetermined time interval (such as every few seconds or every few minutes).

[0033] As shown in FIG. 4A, the information distribution server 113 is a computer primarily having a network interface 145 (I/F(B)), a processor 146 (CPU), a memory 147, and a storage unit 148.

[0034] The network interface 145 is an interface for connecting to the networks 107 and 114. The processor 146 executes programs stored in the memory 147. The memory 147 includes ROM, which is a non-volatile memory element, and RAM, which is a volatile memory element. The ROM includes fixed programs (such as the BIOS). The RAM is a high speed and volatile memory element such as DRAM (dynamic random access memory), and temporarily stores programs to be executed by the processor 146 and data used during execution of the programs.

[0035] The storage unit 148 is constituted of a large capacity non-volatile storage device such as a magnetic storage device (HDD), a CD-ROM drive, or flash memory (SSD), for example, and stores programs to be executed by the processor 131 and data to be used while executing the programs. In other words, the programs are read from the storage unit 148, loaded into the memory 147, and executed by the processor 146. Specifically, the storage unit 148 stores programs such as a condition acquiring program 141 and an information distribution program 142, and intermediate data generated during the process of calculation.

[0036] The information distribution server 113 is accessed through networks 114 and 151 by a terminal 120 used by a system operator 119, the computer 117 used by the railway operator 116, and the terminal 118 used by the passenger 115, and provides information. Information provided by the information distribution server 113 includes information for setting conditions pertaining to user verification and image display, results of estimating the number of people waiting at the station, and the like, for example, and is essentially provided whenever a computer or terminal accesses the information distribution server 113.

[0037] The system operator 119 who operates the traffic condition estimation system 110 uses the terminal 120 in order to confirm, through the network 151, the structure and state of data accumulated in the traffic condition estimation system 110, the state and calculation results of the calculation server 112, the search request state from users, and the like.

[0038] The servers 111, 112, and 113 may have an input interface and an output interface. The input interface is connected to a keyboard, a mouse, or the like and receives input from an operator. The output interface is connected to a display device, a printer, or the like and outputs execution results of the program in a format readable by an operator.

[0039] Programs executed by the processors 131 and 146 of the servers are provided to the servers 112 and 113 through removable media (such as CD-ROMs and flash memory) or through a network, and are stored in the non-volatile storage devices 133 and 148, which are non-transitory storage media. Thus, the servers 112 and 113 would have an interface for reading in data from removable media.

[0040] Each server 111, 112, and 113 is a computer system constituted of one physical computer or a plurality of logical or physical computers, and may be operated in individual threads on the same computer, or in virtual computers created in a plurality of physical computer resources.

[0041] FIG. 5 is a diagram illustrating a data structure of the master data 123 stored in the data server 111 according to the embodiment of the present invention.

[0042] The master data 123 includes information such as installation location information 170 indicating the installation locations of the access points 102, definition information 180 for movement patterns in the station, and a planned train timetable 190.

[0043] The installation location information 170 for the access points 102 is data indicating the locations at which the public wireless LAN access points 102 are installed, and includes access point IDs 171, installation station names 172, and details 173 of installation locations. In a case where the location of the access point 102 is changed, the system operator or railway operator updates the data by input from outside of the system.

[0044] In-station movement definition information 180 includes information such as station names 181, connection start locations 182, connection termination locations 183, and types 184, and is data classifying movements in the station by action type for every combination of connection start location and connection termination location to the public wireless LAN in the station. The type 184 can be classified into one of three types: boarding, exiting, and on-board. Also, in a case where a plurality of access points 102 are installed at a platform, the location on the platform of each mobile terminal can be estimated, and thus, information indicating the location on the platform of the mobile terminal may be included in addition to information of the type 184 indicating boarding or exiting from the train. In this manner, it is possible to perform detailed analysis such as which door on the train each mobile terminal entered or exited.

[0045] The planned train timetable 190 includes information such as station names 191, train IDs 192, train stopping locations 193, dates 194, arrival times 195, and departure times 196, and is data indicating the order in which trains arrive at or depart from each platform of each station. The railway operator determines operating schedules in advance in order to operate the trains, make arrangements for crews, and the like, and manages planned schedule information indicating the timing at which the trains operate. The planned train timetable 190 may record the planned schedule information as is or may extract only the necessary information and record that. Also, the planned train timetable 190 may be sequentially updated whenever the planned schedule is determined or updated, or by a batch process executed at predetermined times. The operating schedules sometimes are modified according to the day of week or season, and thus, the date 194 is used to determine which day operating schedule is to be used.

[0046] FIG. 6 is a diagram illustrating a data structure of the in-station movement data 124 stored in the data server 111 according to the embodiment of the present invention.

[0047] The in-station movement data 124 is generated from the public wireless LAN connection information 122. The in-station movement data 124 includes information such as connecting device IDs 231, station names 232, dates 233, connection start times 234, connection start locations 235, connection termination times 236, and connection termination locations 237, and is data indicating the time and place at which the mobile terminal started its connection to the access point in the station, and the time and place at which the connection was terminated. By referring to the in-station movement definition information 180 of the master data 123 using a combination of the station name 232, the connection start location 235, and the connection termination location 237 included in the in-station movement data 124, the action type of each mobile terminal in the station can be determined.

[0048] FIG. 7 is a flowchart of a process in which the in-station movement data generating program 134 generates the in-station movement data 124 according to the embodiment of the present invention.

[0049] First, all records included in the public wireless LAN connection information 122 in the data server 111 are reordered according to the connection time 212 and the connecting device ID 213 (step 301). The following process is repeated for all connecting device IDs using the reordered data (step 302).

[0050] When repeating in the step 302, first the value of the connection time 212 is referred to, and the data is split at portions with a gap of t minutes or longer (step 303). This is in order to split the communication record into the plurality of times during the day that a person used the public wireless LAN such as morning and night, and process the communication record correctly. The threshold of t minutes may be the time interval at which passengers generally use the station with this threshold being defined as being tens of minutes to a few hours, or public wireless LAN information may be used to determine an accurate time interval. In other words, one group including the connection start time and the connection termination time generated in step 302 is divided into a plurality of pairs of connection start times and connection termination times in step 302. This splitting may be performed by combining the connection start time with a connection termination time of another pair, and the connection termination time may be combined with a connection start time of another pair. Also, a determination may be made that the connection has lasted for a predetermined time from the connection start time and that the connection has lasted for a predetermined time before the connection termination time. In the latter case, even if connection data is lost, the connection time can be determined accurately.

[0051] The following process is repeated using the split data (step 304). During the repeat of step 304, the value of the connection time 212 is acquired from the first record, and stored as the connection start time (step 305). Furthermore, the value of the access point ID 211 is acquired from the first record, the installation location information 220 included in the master data 123 is referenced, and the station name and installation location are searched (step 306). Next, the value of the connection time 212 is acquired from the last record, and stored as the connection termination time (step 307). Furthermore, the value of the access point ID 211 is acquired from the last record, the installation location information 220 included in the master data 123 is referenced, and the station name and installation location are searched (step 308). In a case where a plurality of access points are installed in the same area (such as three access points at the track 1 platform), the installation locations of the plurality of access points are treated as the same in the process above.

[0052] Then, information including the connecting device ID, the acquired station name, the connection start time, the connection start location, the connection termination time, and the connection termination location are stored in the in-station movement data 124 (step 309). The date of the current time is stored in the date information.

[0053] FIG. 8 is a diagram illustrating a method of estimating the arrival/departure times of the train and the number of passengers in the train from the in-station movement data 124 according to the embodiment of the present invention.

[0054] The following three items are estimated using the in-station movement data 124 in the present embodiment:

A. Train arrival time;
B. Train departure time;
C. Number of people riding train.

[0055] Mobile terminals possessed by passengers on the train start connecting to an access point 102 installed in the station as the train arrives at the station. Thus, by creating a histogram with the number of devices that have started connecting to access points at the platform and analyzing the time series change, it is possible to detect the arrival time of the train as indicated by "A. Detect train arrival time". Similarly, by analyzing the time series change in the number of devices that have stopped connecting to access points at the platform, it is possible to detect the departure time of the train as indicated by "B. Detect train departure time".

[0056] Also, the mobile terminal possessed by the passenger on-board the train is connected to the public wireless LAN access point of the station while the train is stopped at the station. Thus, it can be inferred that devices where the connection start location and connection termination location of the in-station movement data 124 are at the same platform are possessed by passengers who are currently on-board the train. By aggregating the number of devices that satisfy this condition, it is possible to detect the number of people riding the train as indicated by "C. Detect number of people on-board the train".

[0057] As shown in FIG. 8, the histogram sometimes includes noise. By eliminating data in which the number of devices is less than a predetermined threshold, it is possible to filter out the noise. The threshold used for filtering may be a fixed value or a value that changes dynamically (such as the average value during a predetermined period prior to the current time). Also, noise may be filtered out by eliminating data in which the time period in which the data appears in the histogram is shorter than a predetermined time.

[0058] FIG. 9 is a diagram illustrating a data structure of the train time data 125 stored in the data server 111 according to the embodiment of the present invention.

[0059] The train time data 125 includes information such as station names 241, train IDs 242, in-station locations 243, dates 244, arrival times 245, and departure times 246, and is data indicating the arrival/departure times of each train. The train time data 125 stores results of estimating the arrival/departure information of the trains using the in-station movement data 124.

[0060] FIG. 10 is a flowchart of a process in which the train time estimating program 135 estimates the arrival/departure times of the train from the in-station movement data 124 according to the embodiment of the present invention. The train time estimating program 135 is executed at each station.

[0061] First, the station name 181 of the in-station movement definition information 180 included in the master data 123 is referenced, and all records including the station are extracted (step 401). Then, the following process is repeated for all extracted records (definition pattern) (step 402).

[0062] When repeating in the step 402, the connection start location 235 and the connection termination location 237 of the in-station movement data 124 are referenced, and all records corresponding to the definition pattern are extracted (step 403). The connection start time 234 and the connection termination time 236 of the extracted record are used to create a histogram of the number of records according to a predetermined time interval (step 404). As shown in FIG. 8, when estimating the arrival time of the train, a histogram is created using the connection start time 234, focusing on passengers who got off the train and onto the platform. When estimating the departure time of the train, a histogram is created using the connection termination time 236, focusing on passengers who have boarded the train and are moving away from the station. The time interval for creating the histogram is set in advance to a value from a few seconds to a few tens of seconds according to the station and the time period. In a station or time period where there are a large number of connected devices, for example, the arrival/departure times of the trains are detected with higher accuracy if a short time interval is used (every second, for example), but in stations or time periods with a small number of connected devices, aggregation may be performed with a longer time period (every few tens of seconds, for example).

[0063] Next, data is detected from the histogram and a train ID is assigned in the order of detection (step 405), and stored in the train time data 125 (step 406). The detection of data from the histogram may detect peaks, rises, or falls in the histogram. In a case where a peak is detected, for example, the arrival time of the train can be accurately estimated. In a case where a rise is detected, the departure time of the train can be accurately estimated.

[0064] In a case where the planned train timetable 190 can be used as the master data 123, the following may be performed: the original planned arrival/departure times 195 and planned departure time 196 are compared with the estimated time, and the train ID 192 closest to the arrival/departure times is detected and stored as the train ID 242 of the train time data 125. In a case where the gap between the train operation state and the plan is small on a given day, it is more useful to apply the planned train ID in order to analyze delays for each train.

[0065] FIG. 11 is a flowchart of a process in which the train delay calculating program 136 calculates the delay of trains calculates the delay of trains according to the embodiment of the present invention.

[0066] The train delay calculating program 136 uses the train time data 125 in order to calculate the delay of all trains operating on a given day. First, all records of a designated day are extracted from the train time data 125 (step 501), the records are rearranged with the station name 241, the train ID 242, and the in-station location 243 as keys (step 502), and the following process is repeated for all records (step 503).

[0067] When repeating in the step 503, in a case where the train ID is applied using the train time data 190 in the process of generating the train time data (125), the delay is calculated by simply comparing with the planned arrival time and departure time. Specifically, records including the corresponding train ID are extracted from the planned train timetable 190 (step 504), and the value ATplan for the train arrival time and the value DTplan for the train departure time are acquired (step 505). Also, the value AT for the train arrival time and the value DT for the train departure time are acquired from the train time data 125 (step 506). Lastly, ATplan is subtracted from AT to calculate the delay in the train arrival time and DTplan is subtracted from DT to calculate the delay in the train departure time (step 507).

[0068] By averaging over a predetermined period (for example, during the most recent month) the train delay calculated by the method above, it is possible to find out train delays that consistently occur, and to revise the train schedule and improve transit.

[0069] In a case where the train ID is applied to every station and in the order of arrival of the trains at each platform in the process of generating the train time data 125, a process may be performed in which records during a predetermined period in the past in which the combination of station name 241, train ID 242, and in-station location 243 are the same are extracted from the train time data 125, the average train arrival time is calculated and designated as ATplan and the average train departure time is calculated and designated as DTplan, and these values are compared with the train arrival time AT and the train departure time DT. By using the average value, it is possible to determine the delay in the train arrival time and the train departure time without the planned train timetable 190.

[0070] FIG. 12 is a diagram illustrating a data structure of the ticket gate passage headcount data 126 stored in the data server 111 according to the embodiment of the present invention.

[0071] The ticket gate passage headcount data 126 includes information such as station names 251, dates 252, time periods 253, types 254, and passage headcounts 255, and is data representing the number of passengers who have passed through the ticket gate of the station. The ticket gate passage headcount data 126 can be created by aggregating passage records and/or IC ticket data of the automatic ticket gate 104. Alternatively, people can be detected in the image captured by the surveillance camera 105 installed near the ticket gate using image analysis techniques or signal analysis techniques to aggregate the ticket gate passage headcount. The process of calculating the ticket gate passage headcount by image analysis or signal analysis may be executed in the data server 111 or processed outside of the system.

[0072] In a case where data cannot be acquired for each day, a statistical value determined from already stored ticket gate passage headcount data 126 (such as an average) may be used. The passage headcount may be recorded separately according to whether they are entering or exiting, or the total number of people entering and exiting may be recorded without separation.

[0073] The interval for the time period 253 is set in advance to anywhere from a few minutes to a few hours. The ticket gate passage headcount data 126 is needed in order to estimate the total number of passengers using the station. The reason is that some passengers do not use the public wireless LAN, or in some cases, one person has a plurality of mobile terminals, and thus, the number of connected devices attained from the public wireless LAN connection information 122 is not equal to the total number of passengers. In stations close to business districts and during commute times, the proportion of those having mobile terminals is thought to be higher, and thus, it is thought that there is some change depending on the station and time period in the ratio of the number of devices connected to the public wireless LAN and the total number of passengers.

[0074] FIG. 13 is a diagram illustrating a data structure of the rebate coefficient table 153 stored in the calculation server 112 according to the embodiment of the present invention.

[0075] The rebate coefficient table 153 includes information such as station names 261, time periods 262, and coefficients 263, and is data indicating the ratio of the number of devices connected to the public wireless LAN and the total number of passengers. The granularity of the time period 262 should match that of the time period 253 of the ticket gate passage headcount data 126. The rebate coefficient table 153 may record differing coefficients depending on day attributes such as whether the day is a weekday or weekend/holiday. The rebate coefficient table 153 may record differing coefficients depending on action types such as boarding, exiting, being onboard a train, or waiting at the station. Furthermore, the rebate coefficient table 153 may record differing coefficients depending on the location in the station. By subdividing the rebate coefficient table 153, it is possible to estimate the number of people more accurately.

[0076] FIG. 14 is a flowchart of a process in which the rebate coefficient calculating program 137 generates the rebate coefficient table 153 according to the embodiment of the present invention.

[0077] The rebate coefficient calculating program 137 need not be executed everyday, and may be executed at a predetermined timing (every few days or every few weeks). First, records of the corresponding period are extracted from the ticket gate passage headcount data 126 and the in-station movement data 124 (step 601). The corresponding period may be set as a given day or a plurality of days. However, it is preferable that data containing both ticket gate passage headcount data 126 and the in-station movement data 124 be used. The ticket gate passage headcount data 126 and the in-station movement data 124 of the same day could be used, but a statistical value (such as an average) of the ticket gate passage headcount data 126 and the in-station movement data 124 in which the attributes are of the same day may be used. Next, the following process is repeated for all stations (step 602).

[0078] When repeating in the step 602, the in-station movement data 124 is aggregated according to the granularity of the time period 253 of the ticket gate passage headcount data 126, and the number of connected devices N for each time period is determined (step 603). The time information used when aggregating may be the connection start time 234 or the connection termination time 236.

[0079] Then, the following process is repeated for all time periods (step 604). When repeating in the step 604, a record of the station and the time period is extracted from the ticket gate passage headcount data 126 and the passage headcount T is acquired (step 605). In a case where the ticket gate passage headcount data 126 is stored separately for entrance and exit, the total is calculated. Lastly, T/N is calculated and the calculated coefficient is stored in the rebate coefficient table 153 (step 606).

[0080] FIG. 15 is a diagram illustrating a data structure of the train headcount data 127 stored in the data server 111 according to the embodiment of the present invention.

[0081] The train headcount data 127 includes information such as station names 271, train IDs 272, in-station locations 273, dates 274, types 275, and headcounts 276, and is data indicating the number of passengers in each train, the number of people who have exited the train, the number of people currently riding the train, and the like. The type 275 is recorded as one of three types: boarding, exiting, and on-board.

[0082] FIG. 16 is a flowchart of a process in which the train passenger headcount aggregating program 138 generates the train headcount data 127 according to the embodiment of the present invention.

[0083] The train passenger headcount aggregating program 138 is executed at each day and each station determined on the basis of information inputted from outside, and generates the train headcount data 127 using the in-station movement data 124. First, records of the corresponding days and stations are extracted from the in-station movement data 124 (step 701). The following process is repeated for all extracted records (step 702).

[0084] When repeating in the step 702, the in-station movement definition information 180 is referenced with a combination of the station name 232 of the in-station movement data 124, the connection start location 235, and the connection termination location 237 as a key, and corresponding types 184 are extracted (step 703). Next, the train time data 125 is referenced and the train believed to have been ridden by a passenger having the connecting device is identified (step 704). Here, in a case where the type 184 is "boarding", the departure time 246 of the train time data 125 is referenced with focus on the connection termination location 237 and the connection termination time 236, and the ID of the train with the smallest difference between the connection termination time 236 and the departure time 246 (or with a difference less than or equal to a threshold) is acquired. Similarly, in a case where the type 184 is "exiting", the arrival time 245 of the train time data 125 is referenced with focus on the connection start location 235 and the connection start time 234, and the ID of the train with the smallest difference between the connection start time 234 and the arrival time 245 (or with a difference less than or equal to a threshold) is acquired. In a case where the type 184 is "on-board", the connection start time 234 is compared with the arrival time 245 of the train time data 125, and the train ID is acquired by a method such as determining whether the difference is within a predetermined threshold. In this case, the connection termination time 236 may be compared with the departure time 246 of the train time data 125.

[0085] The arrival time 245 or departure time 246 of the train ID acquired in step 704 is used to reference the rebate coefficient table 153, thereby acquiring the rebate coefficient (step 705). In a case where the rebate coefficient table 153 stores rebate coefficients separately according to whether the day is a weekday or weekend/holiday, the rebate coefficient is acquired in consideration of what day of the week the date is.

[0086] Then, a search is performed to determine whether a record of the corresponding station name, train

ID, date, and type is included in the record of the train headcount data 127. In a case where the record of the station name, train ID, date, and type is included in the corresponding train headcount data 127, a value equal to "rebate coefficient×1" is added to the passenger number data. In a case where the record of the station name, train ID, date, and type is not included in the corresponding train headcount data 127, a new record is created and a value equal to "rebate coefficient×1" is recorded as the number of passengers.

[0087] FIG. 17 is a diagram illustrating a data structure of the in-station waiting headcount data 128 stored in the data server 111 according to the embodiment of the present invention.

[0088] The in-station waiting headcount data 128 includes information such as station names 281, in-station locations 282, dates 283, time periods 284, and waiting headcounts 285, and is data indicating the station and the number of people waiting in the station. The interval for the time period 284 may be defined in advance as anywhere from a few minutes to a few hours. In a case where the in-station waiting headcount data 128 is generated at a narrow granularity such as a few seconds or a few minutes, it is possible to accumulate in greater detail short term changes in congestion in the station resulting from the arrival and departure of trains.

[0089] FIG. 18 is a flowchart of a process in which the in-station waiting headcount totaling program 139 generates the in-station waiting headcount data 128 according to the embodiment of the present invention.

[0090] Similar to the train passenger headcount aggregating program 138, the in-station waiting headcount totaling program 139 is executed at each day and each station determined on the basis of information inputted from outside, and generates the in-station waiting headcount data 128 using the in-station movement data 124.

[0091] First, records of the corresponding days and stations are extracted from the in-station movement data 124 (step 801). The following process is repeated for all extracted records (step 802).

[0092] When repeating in the step 802, the connection start location 235 and the connection termination location 237 of the in-station movement data 124 are acquired, and it is determined whether the connection start location 235 is the same as the connection termination location 237 (step 803). For records in which the connection start location 235 and the connection termination location 237 are the same, the records are considered to belong to a passenger currently on-board a train, and thus, the process is skipped in order not to count the passenger as someone waiting at the station (step 808).

[0093] In a case where the connection start location 235 and the connection termination location 237 differ from each other, the number of people waiting is added for both the connection start location and the connection termination location. First, the connection start time 234 is acquired and matched to the granularity of the time period of the in-station waiting headcount data 128, and the corresponding time period is determined (step 804). Then, a search is performed in the in-station waiting headcount data 128 to determine whether a record containing the station name, the connection start location, the date, and the time period is present. In a case where a corresponding record is present, the rebate coefficient table 153 is referenced and the value of the rebate coefficient is added. In a case where no corresponding record is present, a new record is added to the in-station waiting headcount data 128 (step 805).

[0094] Next, the connection termination time 236 is acquired and matched to the granularity of the time period of the in-station waiting headcount data 128, and the corresponding time period is determined (step 806). Then, a search is performed in the in-station waiting headcount data 128 to determine whether a record containing the station name, the connection termination location, the date, and the time period is present. In a case where a corresponding record is present, the rebate coefficient table 153 is referenced and the value of the rebate coefficient is added. In a case where no corresponding record is present, a new record is added to the in-station waiting headcount data 128 (step 807).

[0095] FIG. 19 is a diagram illustrating an example of a screen 1010 distributed by the information distribution server 113 according to the embodiment of the present invention.

[0096] The screen 1010 is distributed to the terminal 120 of the system operator 119 or the computer 117 of the railway operator 116, and displays information such as current train delays, train congestion, and station congestion, for example. Also, the screen 1010 includes a map display region 1011, a ranking display region 1012, and a graph display region 1013. The map display region 1011 displays on a map the number of people waiting at a station corresponding to the degree of congestion at the station, and the number of passengers in the train corresponding to the degree of congestion in the train. The ranking display region 1012 displays in ascending or descending order the number of people waiting at the station or the number of people on-board the train. The graph display region 1013 displays on a time series graph the number of people waiting in the station or the number of people riding the train from the first train of the day to the current time.

[0097] Also, in a case where the train delay or the number of people waiting at the station is anomalous to a degree that a predetermined condition is satisfied (such as greatly deviating from a past average value), a warning 1014 indicating an anomaly may be displayed to the user. Also, in a case of designating and displaying a certain date in the past, the data and time of the data displayed may be displayed on the screen. Information on the number of people waiting at the station and the number of people on the train can be conveyed in an easy to understand manner to the user by modifying display aspects (such as the size and color of the image) for stations and trains on the basis of a level differentiation definition set in advance.

[0098] Information on the number of people waiting at the station and the number of people on the train may be displayed as text. Furthermore, stations may be sorted in order of degree of congestion and displayed in tabular format during a certain time period or throughout the day. By displaying to the system operator or railway operator a screen that allows for a general overview, it is possible to attain information for improving service such as revisiting operation plans and drafting measures to alleviate congestion in the station. These screens can be operated using an input interface such as a mouse or keyboard, and one may zoom into/out of the map screen using a scroll wheel or the like, or select the station or train by clicking thereon and display detailed information such as the train ID and operation records.

[0099] FIG. 20 is a diagram illustrating an example of a screen 1020 distributed to the terminal 118 by the information distribution server 113 according to the embodiment of the present invention.

[0100] The screen 1020 is distributed to the terminal 118 of the passenger 115. A small screen indicated in a display of the mobile terminal 118 of the passenger 115 needs to be designed with consideration for small and low resolution. The screen 1020 includes an interface 1021 for selecting the line, the direction, and the station, and an information display region 1022 having a scroll function. Thus, the user can easily select the station or train for which to view information.

[0101] In conjunction with the GPS function of the terminal 118, information on the station closest to the current location of the user may be selected and displayed. The screen 1020 displays delays of trains scheduled to arrive at the station where the user is waiting as well as the degree of congestion at the station. In this manner, the user can determine whether to ride the next train or the train after the next.

[0102] FIG. 21 is a diagram illustrating an example of a screen 1110 for setting conditions for information to be distributed by the information distribution server 113 according to the embodiment of the present invention.

[0103] The condition-setting screen 1110 is to be displayed in the computer 117 of the railway operator 116, the terminal 118 of the passenger 115, or the terminal 120 of the system operator 119. In the condition-setting screen 1110, the station to be searched 1111, the date to be searched 1112, and the like are entered by direct input, by selecting an item on a drop down menu, or the like, and the execution button 1113 is pressed, thereby sending a request to the information distribution server 113. These display conditions can be set by the user through an input interface such as a mouse, a keyboard, or a touch panel.

[0104] In the condition-setting screen 1110 shown in FIG. 21, one train line, one station, and one date to be searched can be selected, but an interface may be adopted in which a plurality of options can be simultaneously selected. In a case where selecting a plurality of stations, an interface that operates in stages may be adopted such as by selecting the station after selecting the train line.

[0105] FIG. 22 is a flowchart of an information distribution process according to the embodiment of the present invention.

[0106] In a case where a request according to the search conditions inputted to the condition-setting screen 1110 is received, the information distribution server 113 executes an information distribution process. First, the conditions inputted in the search condition-setting screen 1100 are acquired from the received request (step 1200). Next, a record corresponding to the aggregated station and date is extracted from the train time data 125, the train headcount data 127, and the in-station waiting headcount data 128 according to the inputted search conditions (step 1201). Then, the extracted record is processed so as to fit the format of the time series graph or map screen, and distributed to the device that sent the request (step 1202).

[0107] The information distribution server 113 may create the screen to be distributed by combining a plurality of programs according to the characteristics of the device to which the information is being distributed or the content of the information being distributed. It is possible to use web server technology when distributing the screen, and the distributed information can be viewed by a web browser running on the device to which the information is being distributed, for example. A specialized application to be run on the device to which the information is being distributed may create the screen to be displayed using the data transmitted from the information distribution server 113.

[0108] As described above, according to the embodiment of the present invention, it is possible to estimate the time at which the train (transportation means) arrived at the station (boarding/deboarding means), and the time at which the train departed from the station. Also, it is possible to estimate the number of people boarding the train, the number of people exiting the train, and the number of people currently on-board the train. Furthermore, by accumulating the estimation values for the arrival/departure times of the train, the number of people on the train, and the number of people waiting at the station and calculating the average, it is possible to know whether train delays or congestion are worse than normal.

[0109] Specifically, the number of people waiting at the boarding/deboarding facility (a station, a terminal, or the like) to ride a transportation means (such as a train, a bus, a ferry, or a taxi) is estimated by extracting from the public wireless LAN connection information 122 the terminals where the connection start location and the connection termination location differ and multiplying the number of extracted terminals by the rebate coefficient, and thus, it is possible to know the degree of congestion at the station or the like without high equipment costs. Thus, in a case where the passenger has a plurality of options for stations, the passenger can select stations that are not as congested. Transportation operators can ensure safety by deploying personnel according to the degree of congestion at the station or the like or putting in place restrictions. Furthermore, by sending a large number of transportation means (buses, taxis, etc.) to congested stations, congestion can be eased in a short period of time.

[0110] Also, the number of people currently riding a transportation means is estimated by extracting from the public wireless LAN connection information 122 the terminals where the connection start location and the connection termination location are the same boarding/deboarding location and multiplying the number of extracted terminals by the rebate coefficient, and thus, it is possible to know the degree of congestion in the train or the like without high equipment costs. Passengers can select and ride less congested trains. Transportation operators can use this information as a basis for proposing measures to ease congestion (such as modifying the schedule).

[0111] In a case where the time from the connection start time to the connection termination time of the same terminal acquired from the public wireless LAN connection information 122 is greater than or equal to a predetermined time t, the time from the connection start time to the connection termination time is subdivided, and thus, it is possible to appropriately subdivide data on users who used one station a plurality of times, allowing for accurate estimation of the number of people.

[0112] Also, differing rebate coefficients are defined depending on the time period, and thus, it is possible to accurately estimate the number of people according to differing characteristics of users depending on the time period.

[0113] Also, connection data between the base station installed at the deboarding area and the terminal is acquired from the public wireless LAN connection information 122, and by performing a statistical process on the data, the time at which the number of terminals that have started connections is determined, and the determined time is considered to be the arrival time of the transportation means, and thus, it is possible to know the operation state (delays) of the train without high equipment costs. Passengers can know whether a train is delayed prior to going to the station. Transportation operators can use the daily arrival time data as a basis to improve the schedule.

[0114] Also, connection data between the base station installed at the boarding area and the terminal is acquired from the public wireless LAN connection information 122, and by performing a statistical process on the data, the time at which the number of terminals that have stopped connections is determined, and the determined time is considered to be the departure time of the transportation means, and thus, it is possible to know the operation state (delays) of the train without high equipment costs. Passengers can know whether a train is delayed prior to going to the station. Transportation operators can use the daily arrival time data as a basis to improve the schedule.

[0115] Also, when performing a statistical process on the connection data, at least one of the following is eliminated: data where the number of devices is less than a predetermined number per unit time, and data where the time period at which the data appears is shorter than a predetermined time. Thus, it is possible to accurately extract data resulting from the arrival/departure of the transportation means and prevent false detection of arrival/departure times.

[0116] Also, the average over a predetermined period of the estimated arrival time or departure time is calculated, and delays in the transportation means are estimated by the difference between the calculated average and the estimated arrival time and departure time, and thus, it is possible to know whether there is a delay even without a timetable.

[0117] Representative examples of the present invention other than what is recited in the claims are as follows.

(1) A traffic condition estimation system, comprising:

a processor that executes a program; and
a storage device that stores the program,
wherein a plurality of base stations of a wireless communication system are installed in a boarding/deboarding facility for use of a transportation means,
wherein at least one of the base stations is installed in a boarding/deboarding location for the transportation means, and
wherein the storage device stores connection information including connection start locations and connection termination locations between terminals possessed by users of the transportation means and any of the plurality of base stations, and
wherein the processor is configured to:

extract, from the connection information, terminals for which the connection start locations and the connection termination locations are the same boarding/deboarding location; and
multiply a number of said extracted terminals by a predetermined second coefficient to estimate a number of people currently onboard the transportation means.

(2) A traffic condition estimation system, comprising:

a processor that executes a program; and
a storage device that stores the program,
wherein base stations of a wireless communication system are installed in a deboarding location for a transportation means in a boarding/deboarding facility for use of the transporta-

tion means,
wherein the storage device stores connection information including connection start locations and connection start times between terminals possessed by users of the transportation means and any of the plurality of base stations, and
wherein the processor is configured to:

determine a time at which many terminals have started connections by performing a statistical process on the connection data, included in the connection information, between the terminal and the base station installed in deboarding location; and
estimate that the determined time is the arrival time of the transportation means.

(3) A traffic condition estimation system, comprising:

a processor that executes a program; and
a storage device that stores the program,
wherein base stations of a wireless communication system are installed in a boarding location for a transportation means in a boarding/deboarding facility for use of the transportation means,
wherein the storage device stores connection information including connection termination locations and connection termination times between terminals possessed by users of the transportation means and any of the plurality of base stations, and
wherein the processor is configured to:

determine a time at which many terminals have ended connections by performing a statistical process on the connection data, included in the connection information, between the terminal and the base station installed in the boarding location; and
estimate that the determined time is the departure time of the transportation means.

[0118] This invention is not limited to the above-described embodiments but includes various modifications. The above-described embodiments are explained in details for better understanding of this invention and are not limited to those including all the configurations described above. A part of the configuration of one embodiment may be replaced with that of another embodiment; the configuration of one embodiment may be incorporated to the configuration of another embodiment. A part of the configuration of each embodiment may be added, deleted, or replaced by that of a different configuration.

[0119] The above-described configurations, functions, processing modules, and processing means, for all or a part of them, may be implemented by hardware: for example, by designing an integrated circuit, and may be implemented by software, which means that a processor interprets and executes programs providing the functions.

[0120] The information of programs, tables, and files to implement the functions may be stored in a storage device such as a memory, a hard disk drive, or an SSD (a Solid State Drive), or a storage medium such as an IC card, or an SD card.

[0121] The drawings illustrate control lines and information lines as considered necessary for explanation but do not illustrate all control lines or information lines in the products. It can be considered that almost of all components are actually interconnected.

Claims

1. A traffic condition estimation system, comprising:

a processor that executes a program; and
a storage device that stores the program,
wherein a plurality of base stations of a wireless communication system are installed in a boarding/deboarding facility for use of a transportation means,
wherein the storage device stores connection information including connection start locations and connection termination locations between terminals possessed by users of the transportation means and any of the plurality of base stations, and
wherein the processor is configured to:

extract, from the connection information, terminals for which the connection start locations and the connection termination locations differ from each other; and
multiply a number of said extracted terminals by a predetermined first coefficient to estimate a number of people waiting in the boarding/deboarding facility for use of the transportation means.

2. The traffic condition estimation system according to claim 1,
wherein at least one of the base stations is installed in a boarding/deboarding location for the transportation means, and
wherein the processor is configured to:

extract, from the connection information, terminals for which the connection start locations and the connection termination locations are the same boarding/deboarding location; and
multiply a number of said extracted terminals by a predetermined second coefficient to estimate a number of people currently on-board the transportation means.

3. The traffic condition estimation system according to claim 1,
wherein the connection information includes a connection start time and a connection termination time between the terminals and the base stations, and
wherein the processor is configured to divide the time from the connection start time to the connection termination time in a case of determining that the time from the connection start time to the connection termination time is long by comparing a predetermined time with a time from the connection start time to the connection termination time of the same terminal which is acquired from the connection information.

4. The traffic condition estimation system according to claim 1,
wherein the storage device stores the first coefficient so as to be able to define differing coefficients depending on a time period.

5. The traffic condition estimation system according to claim 1,
wherein the connection information includes a connection start time between the terminals and the base stations, and
wherein at least one of the base stations is installed in a deboarding location for the transportation means, and
wherein the processor is configured to:

> determine a time at which many terminals have started connections by performing a statistical process on the connection data, included in the connection information, between the terminal and the base station installed in deboarding location; and
> estimate that the determined time is the arrival time of the transportation means.

6. The traffic condition estimation system according to claim 1,
wherein the connection information includes a connection termination time between the terminals and the base stations, and
wherein at least one of the base stations is installed in a boarding location for the transportation means, and
wherein the processor is configured to:

> determine a time at which many terminals have ended connections by performing a statistical process on the connection data, included in the connection information, between the terminal and the base station installed in the boarding location; and
> estimate that the determined time is the departure time of the transportation means.

7. The traffic condition estimation system according to claim 5,
wherein, when performing the statistical process on the connection data, the processor is configured to extract data generated by departure of the transportation means by eliminating at least one of the following: data where the number of terminals connected per unit time is less than a predetermined value, and data where a time period at which the data appears is shorter than a predetermined time.

8. The traffic condition estimation system according to claim 5,
wherein the processor
calculates an average of the estimated arrival time over a predetermined period, and
estimates delay of the transportation means according to a difference between the calculated average and the estimated arrival time.

9. A traffic condition estimation method to be executed by a computer,
wherein the computer has a processor that executes a program, and a storage device that stores the program,
wherein a plurality of base stations of a wireless communication system are installed in a boarding/ deboarding facility for use of a transportation means,
wherein the storage device stores connection information including connection start locations and connection termination locations between terminals possessed by users of the transportation means and any of the plurality of base stations, and
wherein the traffic condition estimation method comprises:

> a step of extracting, by the processor, from the connection information, terminals for which the connection start locations and the connection termination locations differ from each other; and
> a step of multiplying, by the processor, a number of said extracted terminals by a predetermined first coefficient to estimate a number of people waiting in the boarding/deboarding facility for use of the transportation means.

10. The traffic condition estimation method according to claim 9,
wherein at least one of the base stations is installed in a boarding/deboarding location for the transportation means, and
wherein the traffic condition estimation method further comprises:

> a step of extracting, by the processor, from the connection information, terminals for which the connection start locations and the connection termination locations are the same boarding/de-

boarding location; and
a step of multiplying, by the processor, a number of said extracted terminals by a predetermined second coefficient to estimate a number of people currently on-board the transportation means.

11. The traffic condition estimation method according to claim 9,
wherein the connection information includes a connection start time between the terminals and the base stations, and
wherein at least one of the base stations is installed in a deboarding location for the transportation means, and
wherein the traffic condition estimation method further comprises:

a step of determining, by the processor, a time at which many terminals have started connections by performing a statistical process on the connection data, included in the connection information, between the terminal and the base station installed in deboarding location; and
a step of estimating, by the processor, that the determined time is the arrival time of the transportation means.

12. The traffic condition estimation method according to claim 9,
wherein the connection information includes a connection termination time between the base stations and the terminals,
wherein at least one of the base stations is installed in a boarding location for the transportation means, and
wherein the traffic condition estimation method further comprises:

a step of determining, by the processor, a time at which many terminals have ended connections by performing a statistical process on the connection data, included in the connection information, between the terminal and the base station installed in the boarding location; and
a step of determining, by the processor, that the determined time is the departure time of the transportation means.

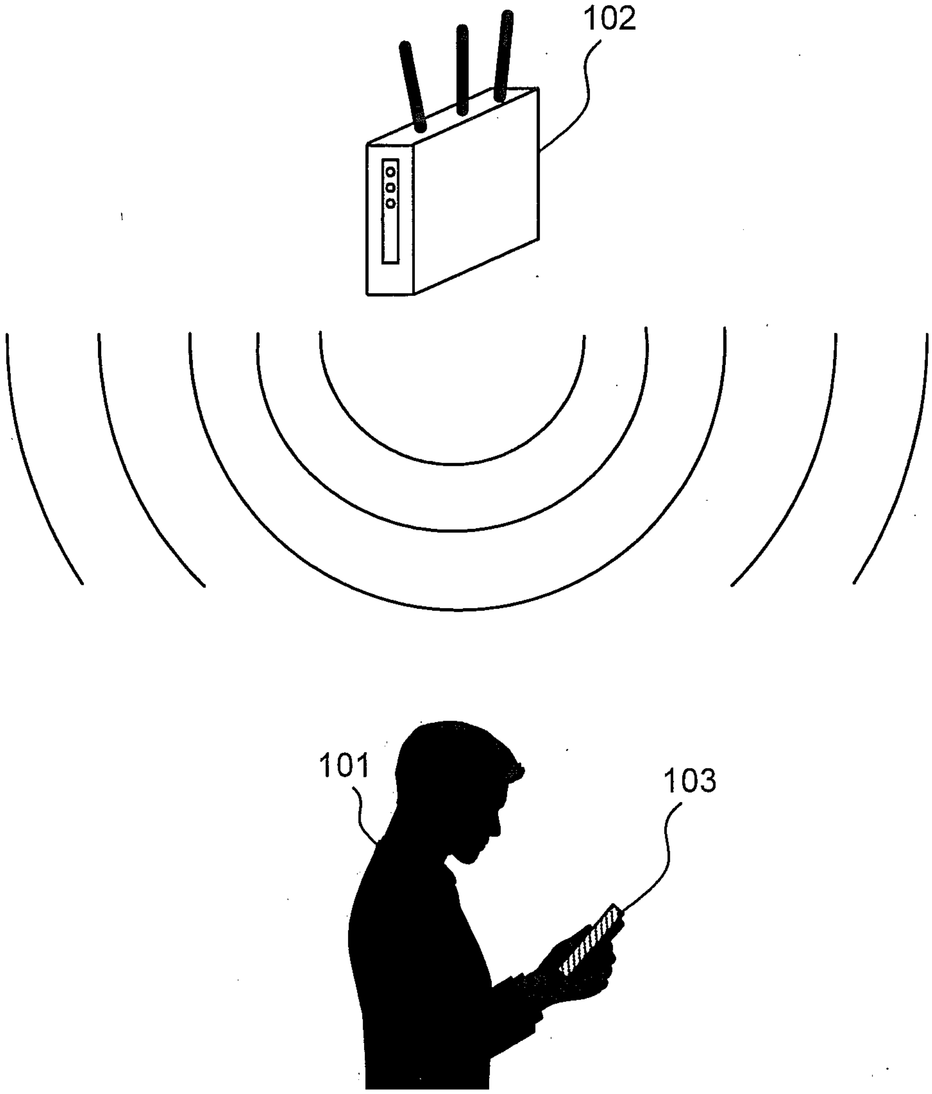

Fig. 1

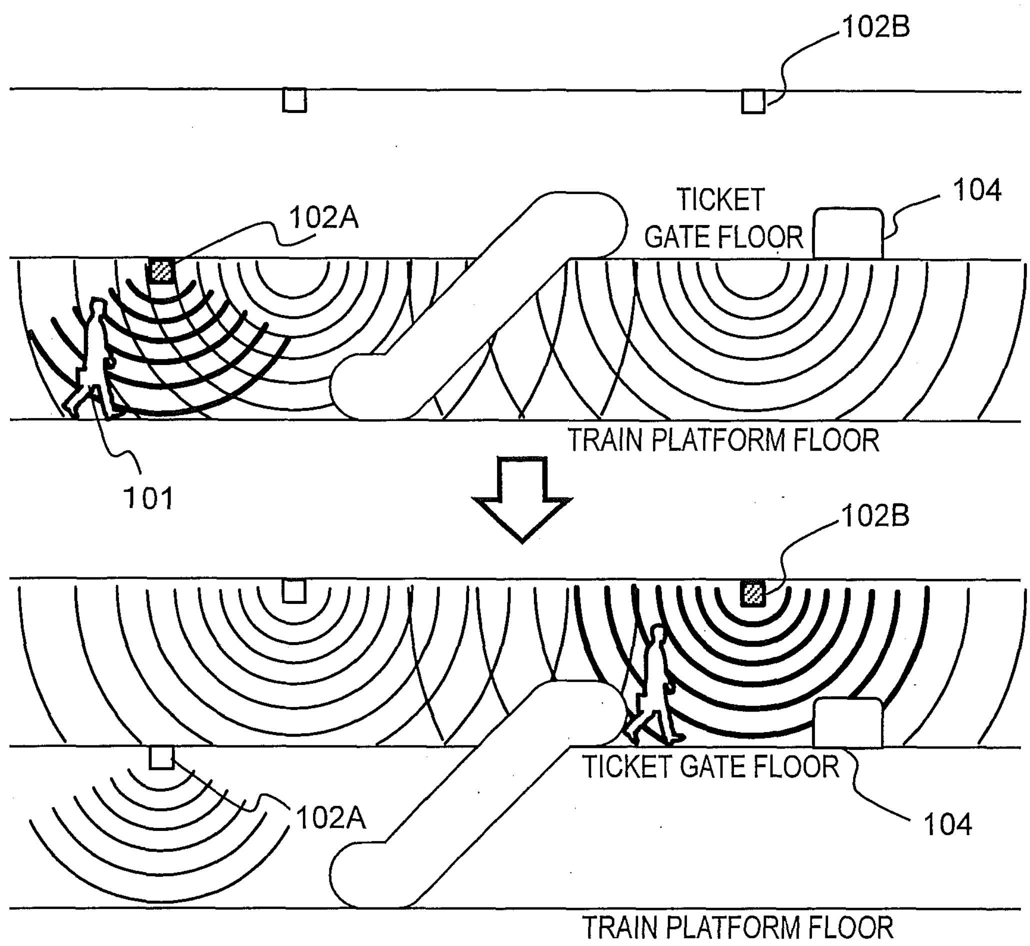

Fig. 2

211 212 213 122

ACCESS POINT ID	TIME	CONNECTING DEVICE ID	···
xxxxxxxxxxx1	08:00:00	00:00:00:00:00:00	···
xxxxxxxxxxx1	08:00:00	00:00:00:00:00:01	···
xxxxxxxxxxx2	08:00:00	00:00:00:00:00:02	···
xxxxxxxxxxx2	08:00:01	00:00:00:00:00:03	···
xxxxxxxxxxx3	08:00:01	00:00:00:00:00:04	···
···	···	···	···

PUBLIC WIRELESS LAN CONNECTION INFORMATION

Fig. 3

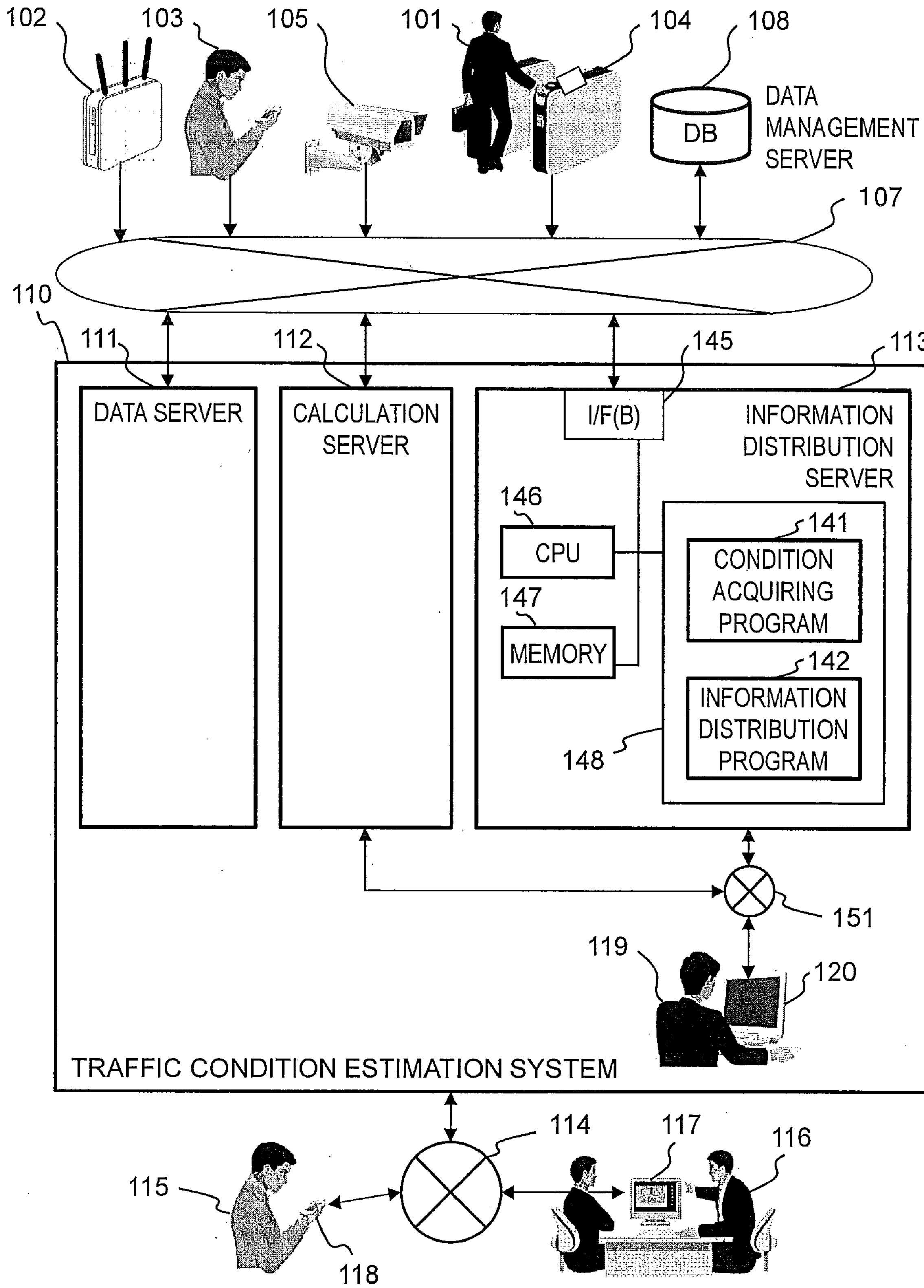
102
103
105
101
104
108
DB
DATA MANAGEMENT SERVER
107
110
111
112
145
113
DATA SERVER
CALCULATION SERVER
I/F(B)
INFORMATION DISTRIBUTION SERVER
146
CPU
141
CONDITION ACQUIRING PROGRAM
147
MEMORY
142
INFORMATION DISTRIBUTION PROGRAM
148
151
119
120
TRAFFIC CONDITION ESTIMATION SYSTEM
114
117
116
115
118

Fig. 4A

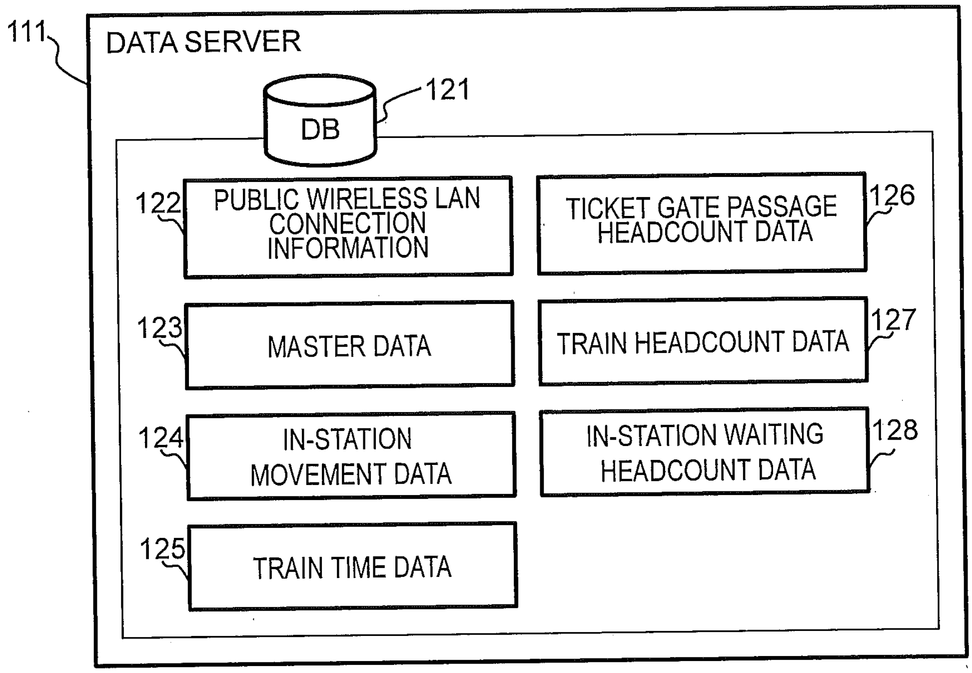
111
DATA SERVER
DB
121
122
PUBLIC WIRELESS LAN CONNECTION INFORMATION
TICKET GATE PASSAGE HEADCOUNT DATA
126
123
MASTER DATA
TRAIN HEADCOUNT DATA
127
124
IN-STATION MOVEMENT DATA
IN-STATION WAITING HEADCOUNT DATA
128
125
TRAIN TIME DATA

Fig. 4B

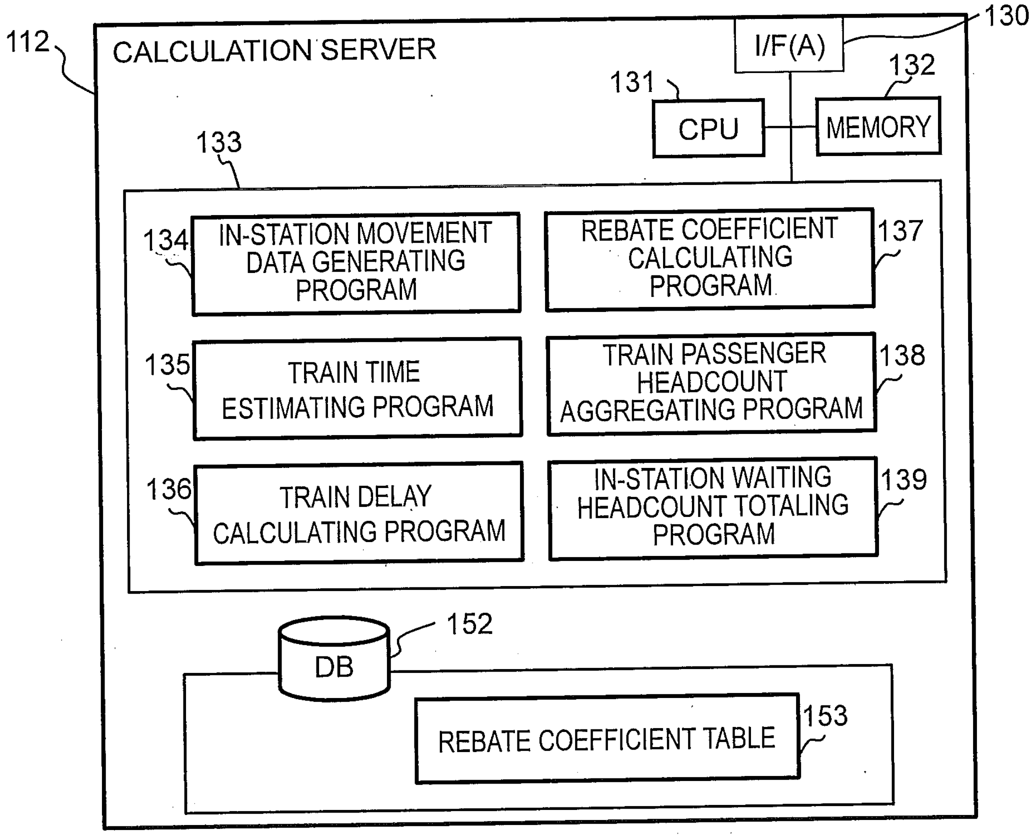
112
CALCULATION SERVER
I/F(A)
130
131
CPU
132
MEMORY
133
134
IN-STATION MOVEMENT DATA GENERATING PROGRAM
REBATE COEFFICIENT CALCULATING PROGRAM
137
135
TRAIN TIME ESTIMATING PROGRAM
TRAIN PASSENGER HEADCOUNT AGGREGATING PROGRAM
138
136
TRAIN DELAY CALCULATING PROGRAM
IN-STATION WAITING HEADCOUNT TOTALING PROGRAM
139
DB
152
REBATE COEFFICIENT TABLE
153

Fig. 4C

123

170 171 172 173

ACCESS POINT ID	INSTALLATION STATION NAME	INSTALLATION LOCATION DETAILS	···
xxxxxxxxxxx1	STATION A	TRACK 1 PLATFORM	···
xxxxxxxxxxx2	STATION A	TRACK 2 PLATFORM	···
xxxxxxxxxxx3	STATION A	TICKET GATE	···
xxxxxxxxxxx4	STATION B	TRACK 1 PLATFORM	···
xxxxxxxxxxx5	STATION B	TRACK 2 PLATFORM	···
···	···	···	···

INSTALLATION LOCATION INFORMATION

180 181 182 183 184

STATION NAME	CONNECTION START LOCATION	CONNECTION END LOCATION	TYPE	···
STATION A	TICKET GATE	TRACK 1 PLATFORM	BOARDING	···
STATION A	TICKET GATE	TRACK 2 PLATFORM	EXITING	···
STATION A	TRACK 1 PLATFORM	TRACK 1 PLATFORM	ON-BOARD	···
STATION A	TRACK 1 PLATFORM	TICKET GATE	降車	···
···	···	···	···	···

IN-STATION MOVEMENT DEFINITION INFORMATION

190 191 192 193 194 195 196

STATION NAME	TRAIN ID	TRAIN STOPPING LOCATION	DATE	ARRIVAL TIME	DEPARTURE TIME	···
STATION A	P001	TRACK 1 PLATFORM	2015/12/1	08:00:00	08:00:30	···
STATION A	P002	TRACK 1 PLATFORM	2015/12/1	08:01:40	08:02:00	···
STATION A	P011	TRACK 2 PLATFORM	2015/12/1	08:00:20	08:01:20	···
···	···	···	···	···	···	···

PLANNED TRAIN TIMETABLE

Fig. 5

124 231 232 233 234 235 236 237

CONNECTING DEVICE ID	STATION NAME	DATE	CONNECTION START TIME	CONNECTION START LOCATION	CONNECTION END TIME	CONNECTION END LOCATION	...
00:00:00:00:00:00	STATION A	2015/12/1	08:00:00	TICKET GATE	08:01:00	TRACK 1 PLATFORM	...
00:00:00:00:00:01	STATION A	2015/12/1	08:00:20	TRACK 2 PLATFORM	08:00:40	TRACK 2 PLATFORM	...
00:00:00:00:00:02	STATION B	2015/12/1	08:00:22	TRACK 1 PLATFORM	08:03:22	TICKET GATE	...
00:00:00:00:00:03	STATION B	2015/12/1	08:00:26	TICKET GATE	08:04:26	TRACK 1 PLATFORM	...
...	...	...	...	...	...	...	...

IN-STATION MOVEMENT DATA

Fig. 6

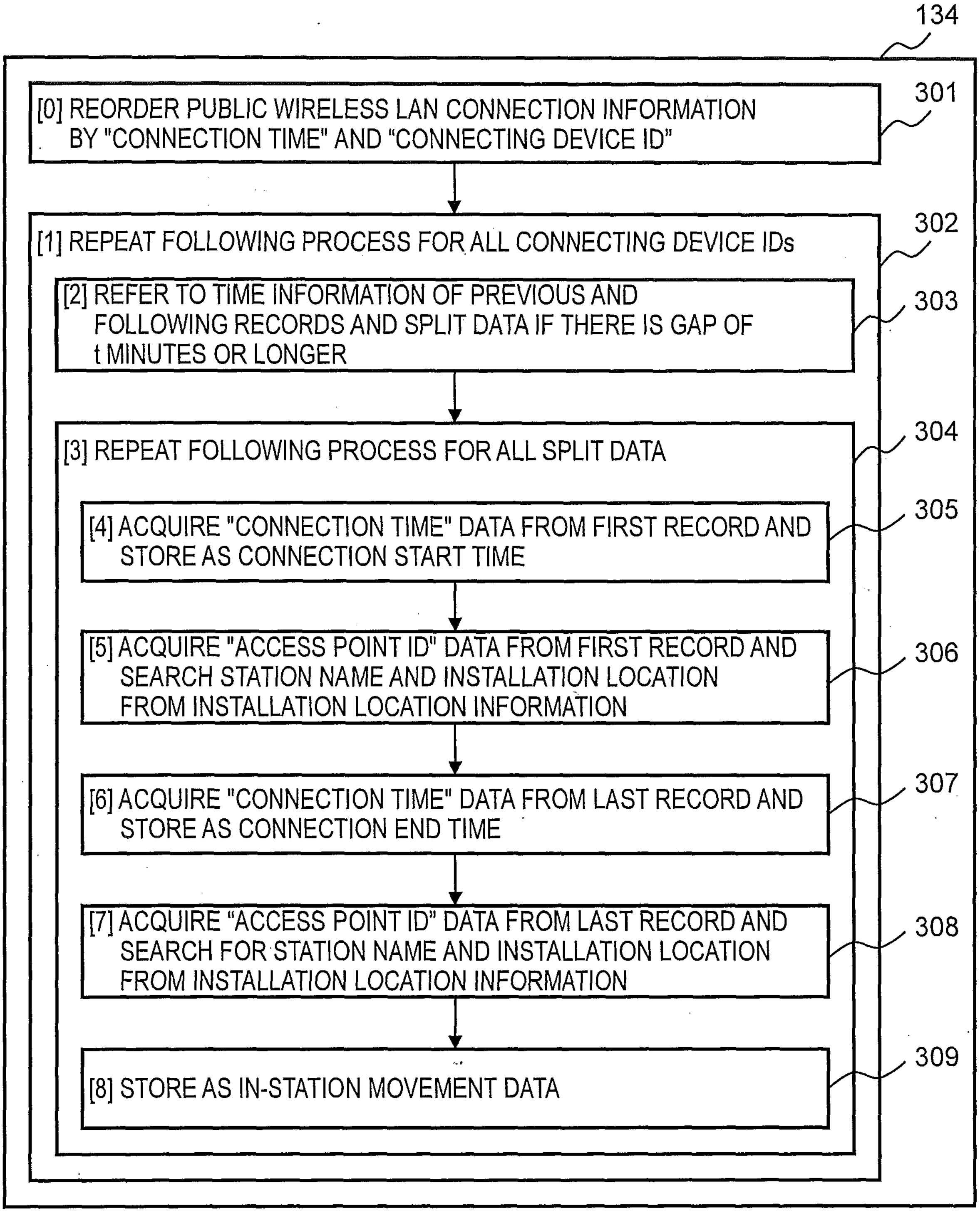
134
301
[0] REORDER PUBLIC WIRELESS LAN CONNECTION INFORMATION BY "CONNECTION TIME" AND "CONNECTING DEVICE ID"
302
[1] REPEAT FOLLOWING PROCESS FOR ALL CONNECTING DEVICE IDs
303
[2] REFER TO TIME INFORMATION OF PREVIOUS AND FOLLOWING RECORDS AND SPLIT DATA IF THERE IS GAP OF t MINUTES OR LONGER
304
[3] REPEAT FOLLOWING PROCESS FOR ALL SPLIT DATA
305
[4] ACQUIRE "CONNECTION TIME" DATA FROM FIRST RECORD AND STORE AS CONNECTION START TIME
306
[5] ACQUIRE "ACCESS POINT ID" DATA FROM FIRST RECORD AND SEARCH STATION NAME AND INSTALLATION LOCATION FROM INSTALLATION LOCATION INFORMATION
307
[6] ACQUIRE "CONNECTION TIME" DATA FROM LAST RECORD AND STORE AS CONNECTION END TIME
308
[7] ACQUIRE "ACCESS POINT ID" DATA FROM LAST RECORD AND SEARCH FOR STATION NAME AND INSTALLATION LOCATION FROM INSTALLATION LOCATION INFORMATION
309
[8] STORE AS IN-STATION MOVEMENT DATA

Fig. 7

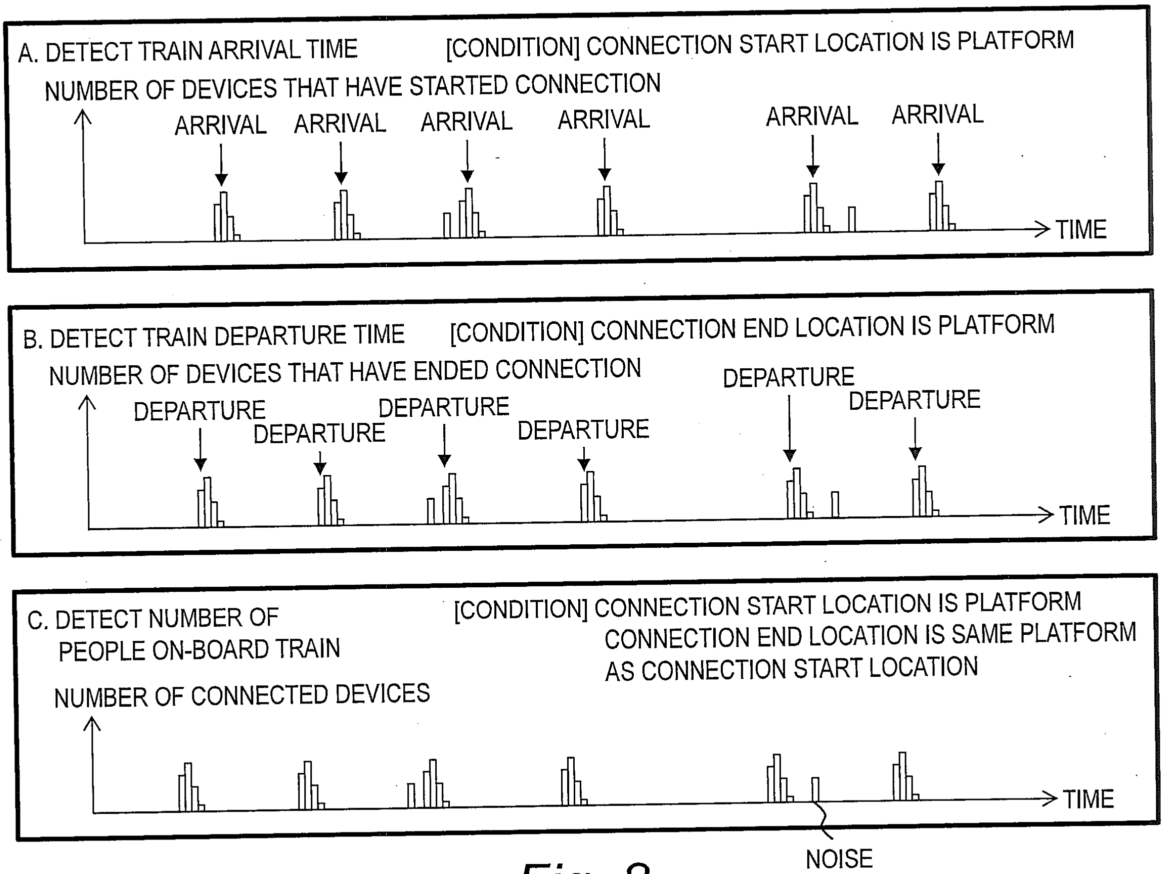
A. DETECT TRAIN ARRIVAL TIME
[CONDITION] CONNECTION START LOCATION IS PLATFORM
NUMBER OF DEVICES THAT HAVE STARTED CONNECTION
ARRIVAL
ARRIVAL
ARRIVAL
ARRIVAL
ARRIVAL
ARRIVAL
TIME
B. DETECT TRAIN DEPARTURE TIME
[CONDITION] CONNECTION END LOCATION IS PLATFORM
NUMBER OF DEVICES THAT HAVE ENDED CONNECTION
DEPARTURE
DEPARTURE
DEPARTURE
DEPARTURE
DEPARTURE
DEPARTURE
TIME
C. DETECT NUMBER OF PEOPLE ON-BOARD TRAIN
[CONDITION] CONNECTION START LOCATION IS PLATFORM
CONNECTION END LOCATION IS SAME PLATFORM AS CONNECTION START LOCATION
NUMBER OF CONNECTED DEVICES
TIME
NOISE

Fig. 8

125

STATION NAME (241)	TRAIN ID (242)	IN-STATION LOCATION (243)	DATE (244)	ARRIVAL TIME (245)	DEPARTURE TIME (246)	...
STATION A	001	TRACK 1 PLATFORM	2015/12/1	08:00:15	08:00:30	...
STATION A	002	TRACK 1 PLATFORM	2015/12/1	08:02:00	08:02:15	...
STATION A	011	TRACK 2 PLATFORM	2015/12/1	08:03:45	08:04:00	...
STATION A	012	TRACK 2 PLATFORM	2015/12/2	08:06:10	08:07:45	...
STATION A	013	TRACK 2 PLATFORM	2015/12/2	08:10:40	08:11:40	...
...	...	...	...	...	...	...

TRAIN TIME DATA

Fig. 9

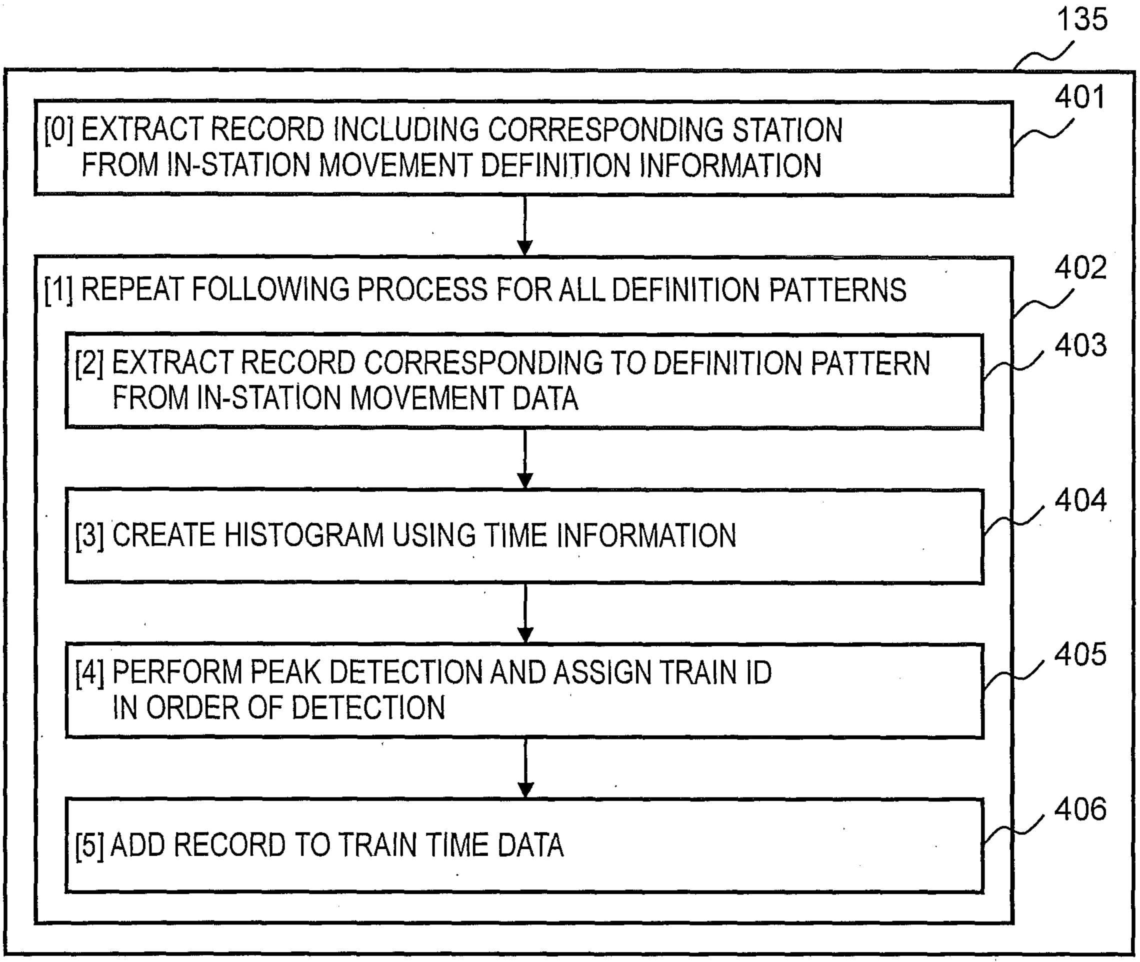
135
401
[0] EXTRACT RECORD INCLUDING CORRESPONDING STATION FROM IN-STATION MOVEMENT DEFINITION INFORMATION
402
[1] REPEAT FOLLOWING PROCESS FOR ALL DEFINITION PATTERNS
403
[2] EXTRACT RECORD CORRESPONDING TO DEFINITION PATTERN FROM IN-STATION MOVEMENT DATA
404
[3] CREATE HISTOGRAM USING TIME INFORMATION
405
[4] PERFORM PEAK DETECTION AND ASSIGN TRAIN ID IN ORDER OF DETECTION
406
[5] ADD RECORD TO TRAIN TIME DATA

Fig. 10

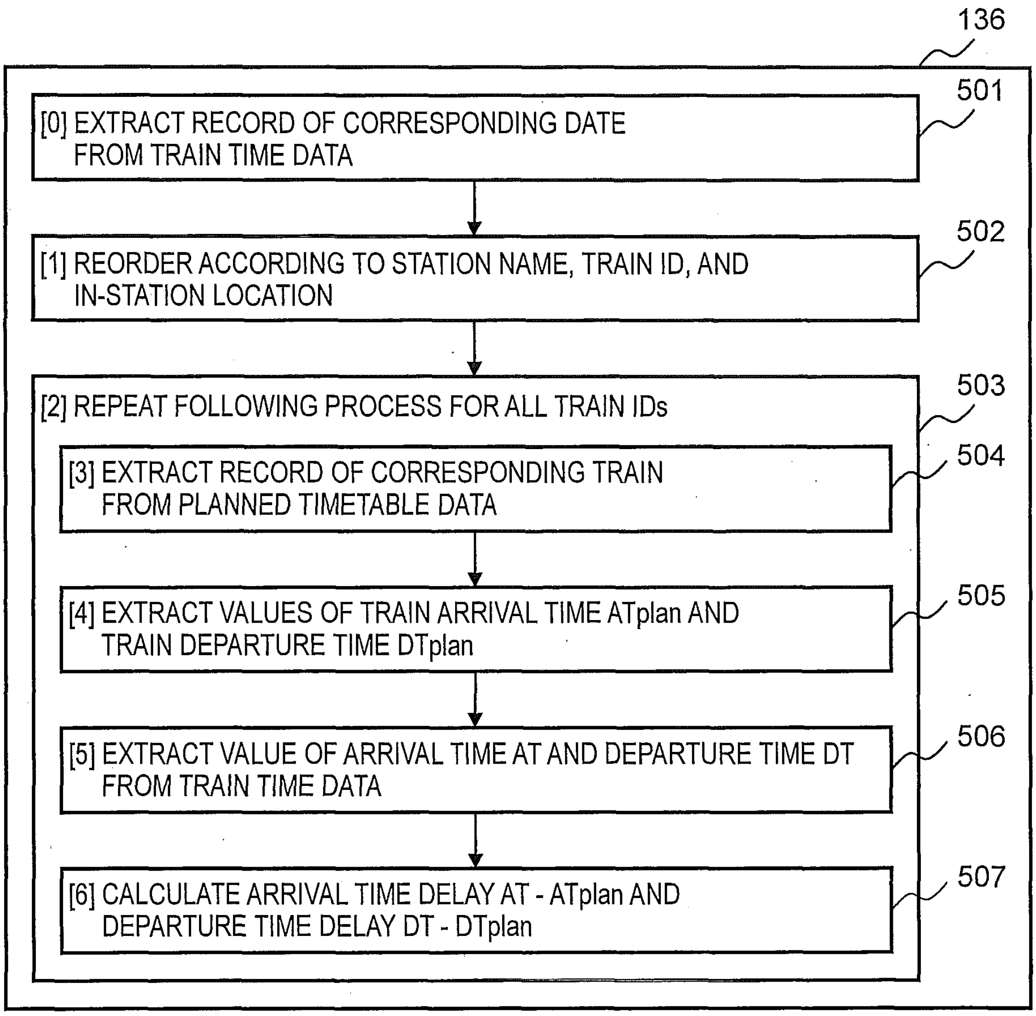

Fig. 11

126 251 252 253 254 255

STATION NAME	DATE	TIME PERIOD	TYPE	PASSAGE HEADCOUNT	···
STATION A	2015/12/1	08:00 – 09:00	ENTERING	318	···
STATION A	2015/12/1	08:00 – 09:00	EXITING	105	···
STATION A	2015/12/1	09:00 – 10:00	ENTERING	252	···
STATION A	2015/12/1	09:00 – 10:00	EXITING	174	···
STATION B	2015/12/1	10:00 – 11:00	ENTERING	89	···
···	···	···	···	···	···

Fig. 12

153 261 262 263

STATION NAME	TIME PERIOD	COEFFICIENT	...
STATION A	08:00 – 09:00	3.26	...
STATION A	09:00 – 10:00	4.45	...
STATION A	10:00 – 11:00	5.91	...
...	...	...	...

REBATE COEFFICIENT TABLE

Fig. 13

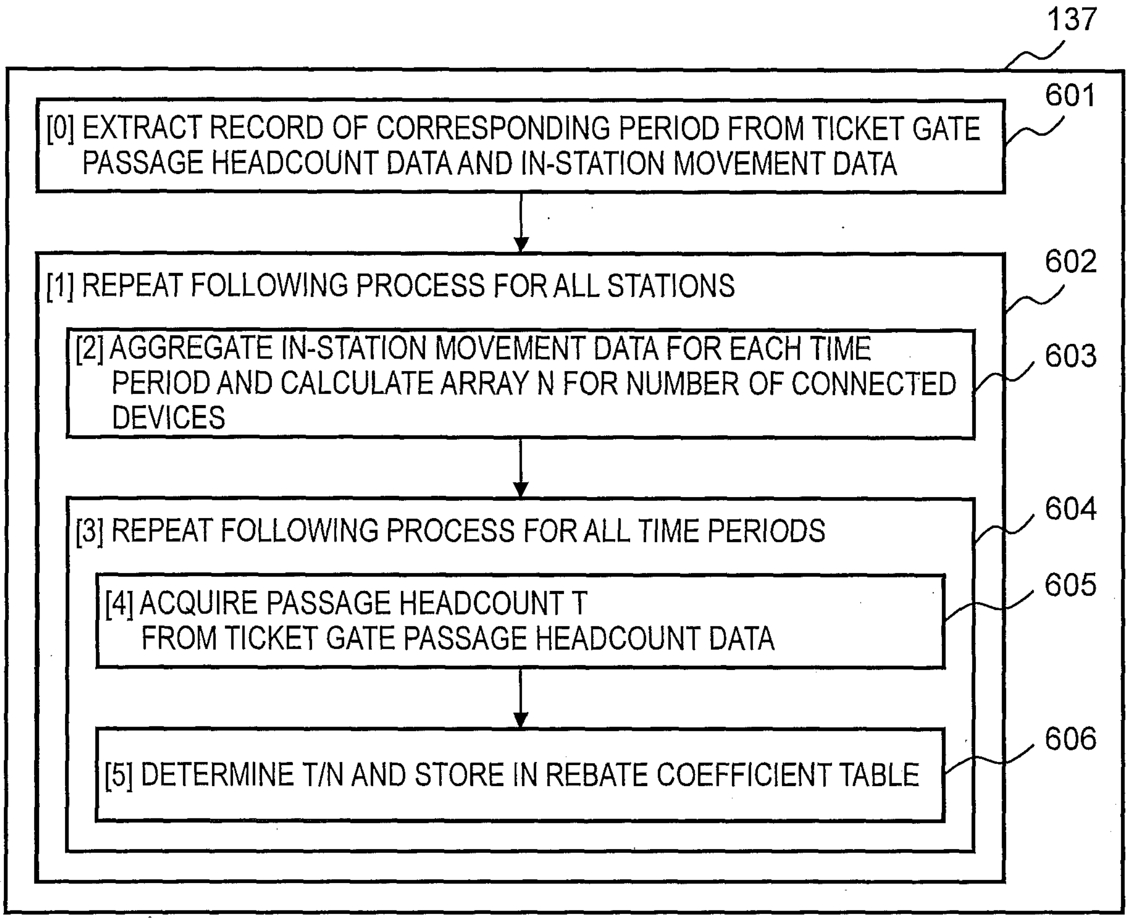

Fig. 14

127 271 272 273 274 275 276

STATION NAME	TRAIN ID	IN-STATION LOCATION	DATE	TYPE	HEADCOUNT	...
STATION A	001	TRACK 1 PLATFORM	2015/12/1	ON-BOARD	500	...
STATION A	001	TRACK 1 PLATFORM	2015/12/1	BOARDING	200	...
STATION A	001	TRACK 2 PLATFORM	2015/12/1	EXITING	300	...
STATION A	002	TRACK 2 PLATFORM	2015/12/2	ON-BOARD	600	...
STATION A	003	TRACK 2 PLATFORM	2015/12/2	BOARDING	300	...
...	...	...	...	...	...	...

TRAIN HEADCOUNT DATA

Fig. 15

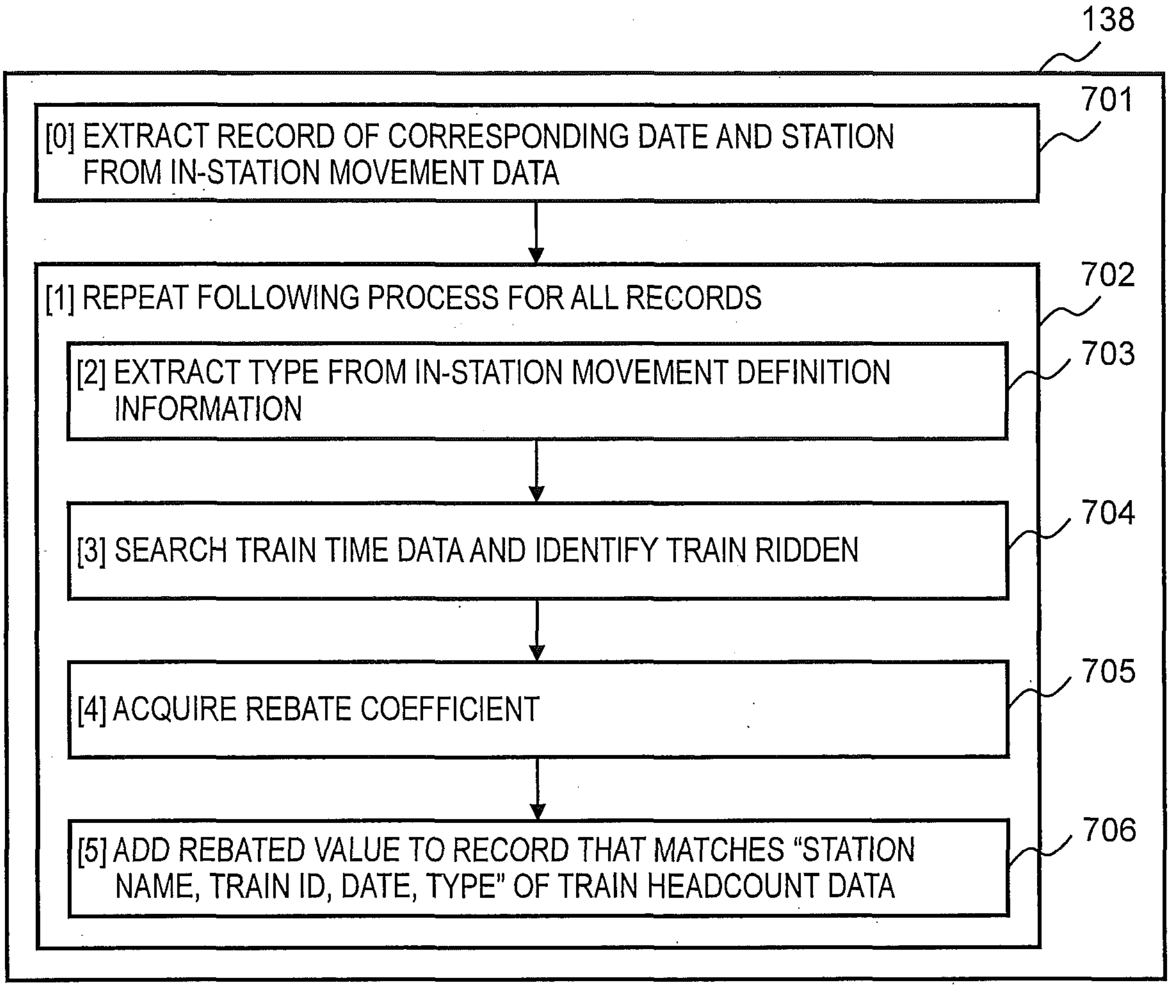
138
701
[0] EXTRACT RECORD OF CORRESPONDING DATE AND STATION FROM IN-STATION MOVEMENT DATA
702
[1] REPEAT FOLLOWING PROCESS FOR ALL RECORDS
703
[2] EXTRACT TYPE FROM IN-STATION MOVEMENT DEFINITION INFORMATION
704
[3] SEARCH TRAIN TIME DATA AND IDENTIFY TRAIN RIDDEN
705
[4] ACQUIRE REBATE COEFFICIENT
706
[5] ADD REBATED VALUE TO RECORD THAT MATCHES "STATION NAME, TRAIN ID, DATE, TYPE" OF TRAIN HEADCOUNT DATA

Fig. 16

128 281 282 283 284 285

STATION NAME	IN-STATION LOCATION	DATE	TIME PERIOD	WAITING HEADCOUNT	...
STATION A	TRACK 1 PLATFORM	2015/12/1	08:00 - 08:05	318	...
STATION A	TRACK 1 PLATFORM	2015/12/1	08:05 - 08:10	105	...
STATION A	TICKET GATE	2015/12/1	08:00 - 08:05	252	...
STATION A	TICKET GATE	2015/12/1	08:05 - 08:10	174	...
STATION A	TRACK 2 PLATFORM	2015/12/1	08:00 - 08:05	89	...
...	...	...	...	...	...

IN-STATION WAITING HEADCOUNT DATA

Fig. 17

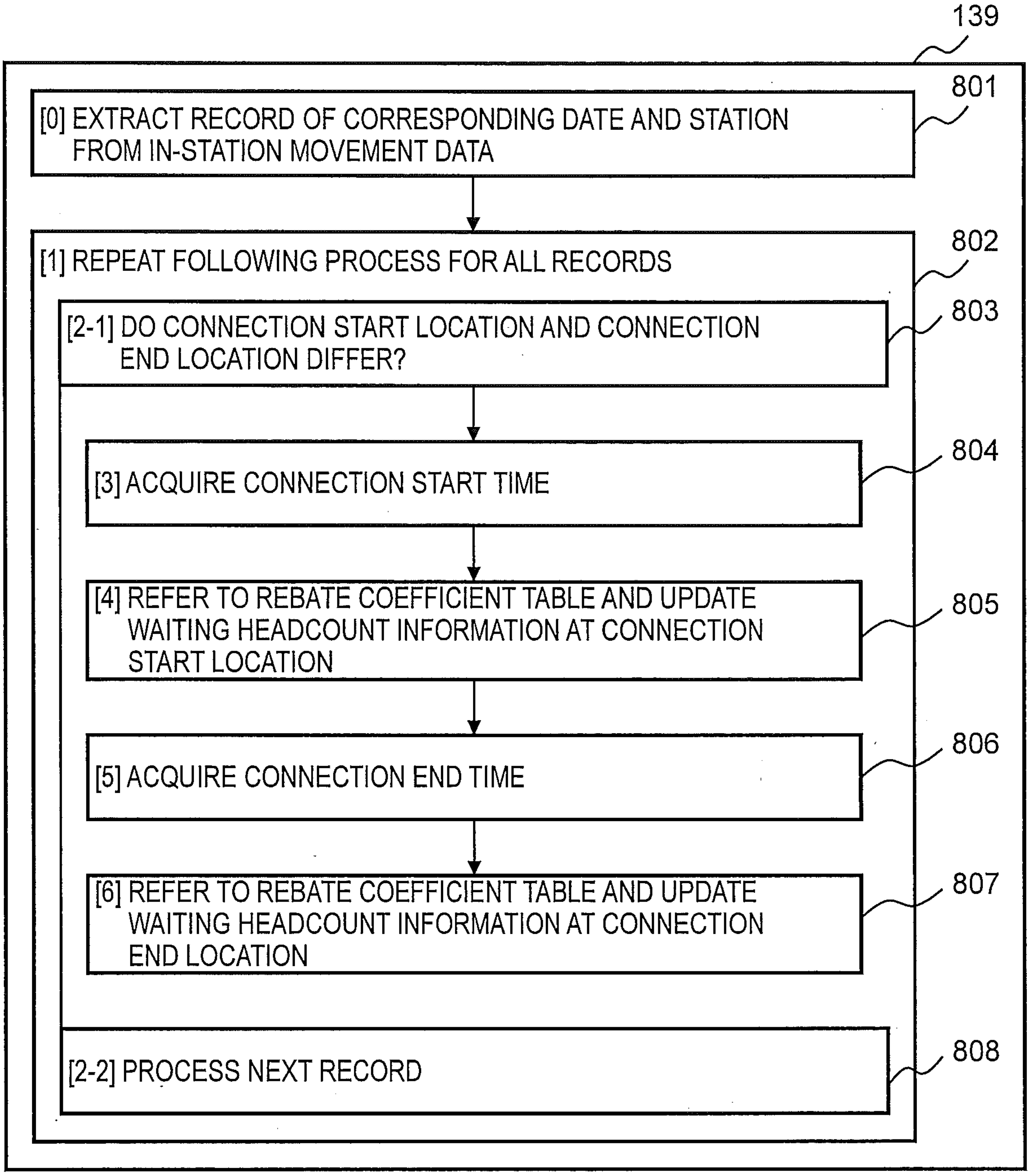
139
801
[0] EXTRACT RECORD OF CORRESPONDING DATE AND STATION FROM IN-STATION MOVEMENT DATA
802
[1] REPEAT FOLLOWING PROCESS FOR ALL RECORDS
803
[2-1] DO CONNECTION START LOCATION AND CONNECTION END LOCATION DIFFER?
804
[3] ACQUIRE CONNECTION START TIME
805
[4] REFER TO REBATE COEFFICIENT TABLE AND UPDATE WAITING HEADCOUNT INFORMATION AT CONNECTION START LOCATION
806
[5] ACQUIRE CONNECTION END TIME
807
[6] REFER TO REBATE COEFFICIENT TABLE AND UPDATE WAITING HEADCOUNT INFORMATION AT CONNECTION END LOCATION
808
[2-2] PROCESS NEXT RECORD

Fig. 18

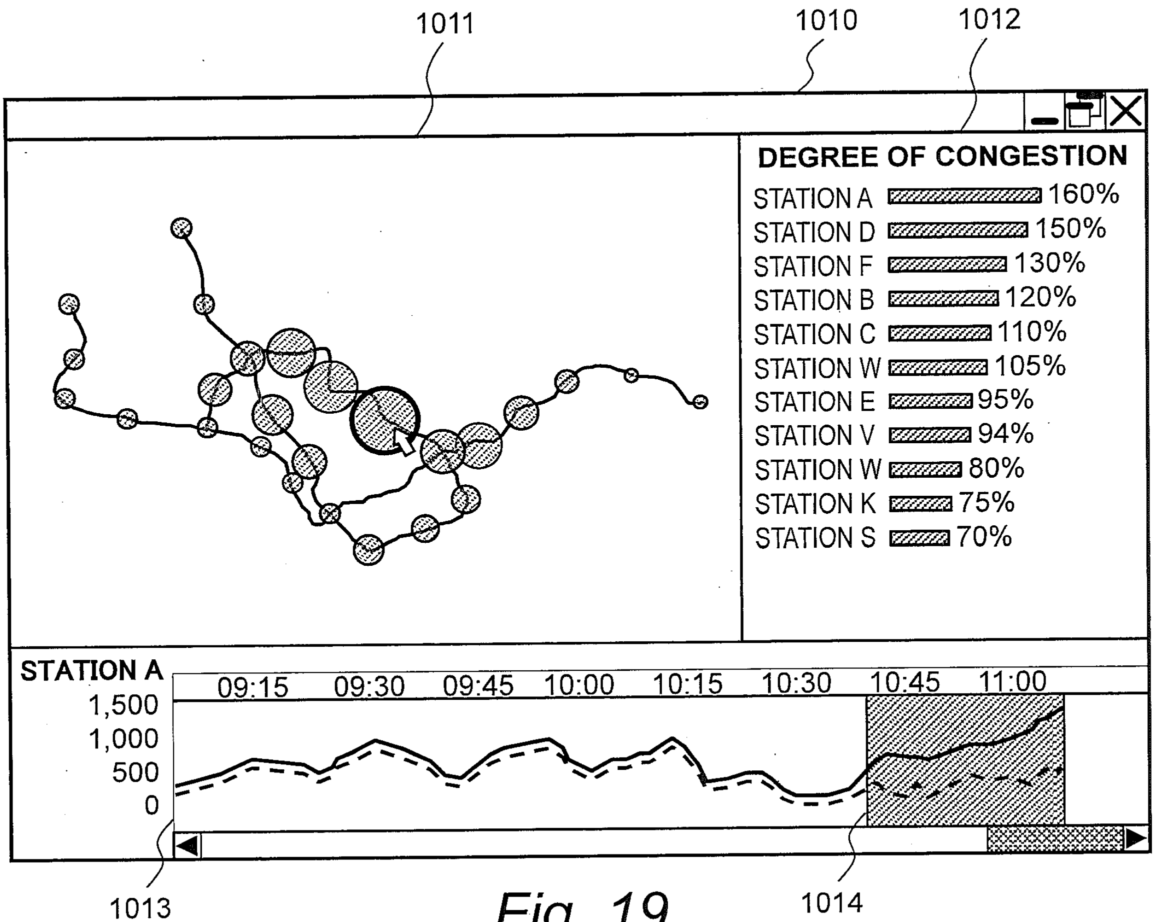
1011
1010
1012
DEGREE OF CONGESTION
STATION A 160%
STATION D 150%
STATION F 130%
STATION B 120%
STATION C 110%
STATION W 105%
STATION E 95%
STATION V 94%
STATION W 80%
STATION K 75%
STATION S 70%
STATION A
09:15 09:30 09:45 10:00 10:15 10:30 10:45 11:00
1,500
1,000
500
0
1013
1014

Fig. 19

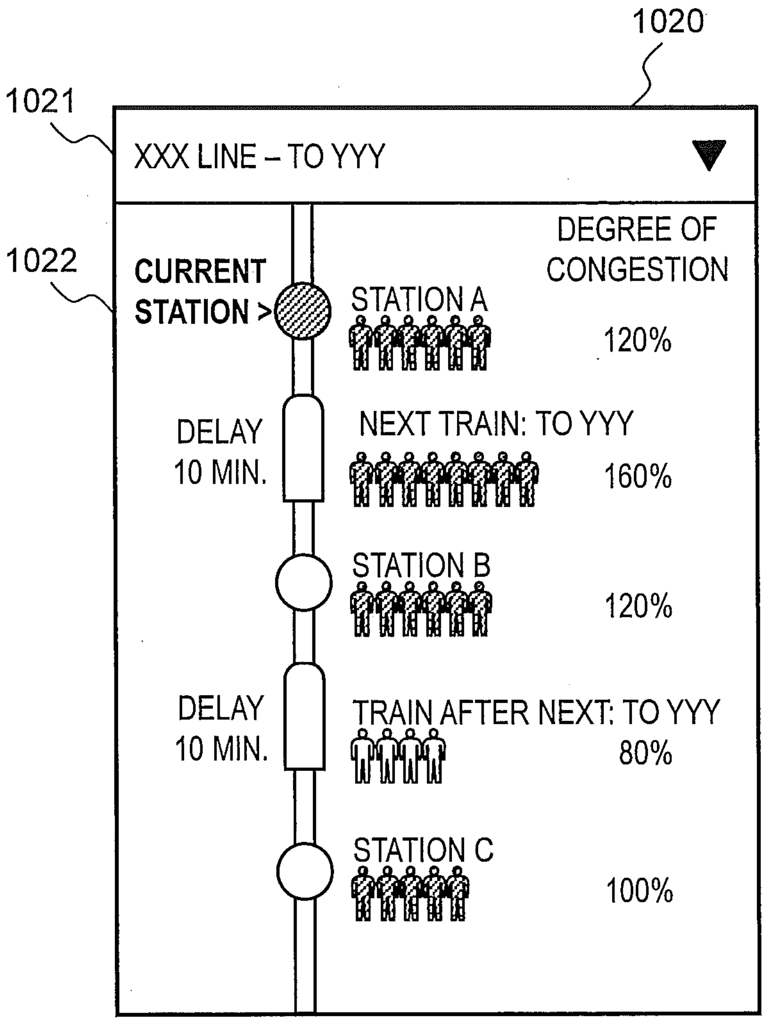
1020
1021
1022
XXX LINE – TO YYY
DEGREE OF CONGESTION
CURRENT STATION >
STATION A
120%
DELAY 10 MIN.
NEXT TRAIN: TO YYY
160%
STATION B
120%
DELAY 10 MIN.
TRAIN AFTER NEXT: TO YYY
80%
STATION C
100%

Fig. 20

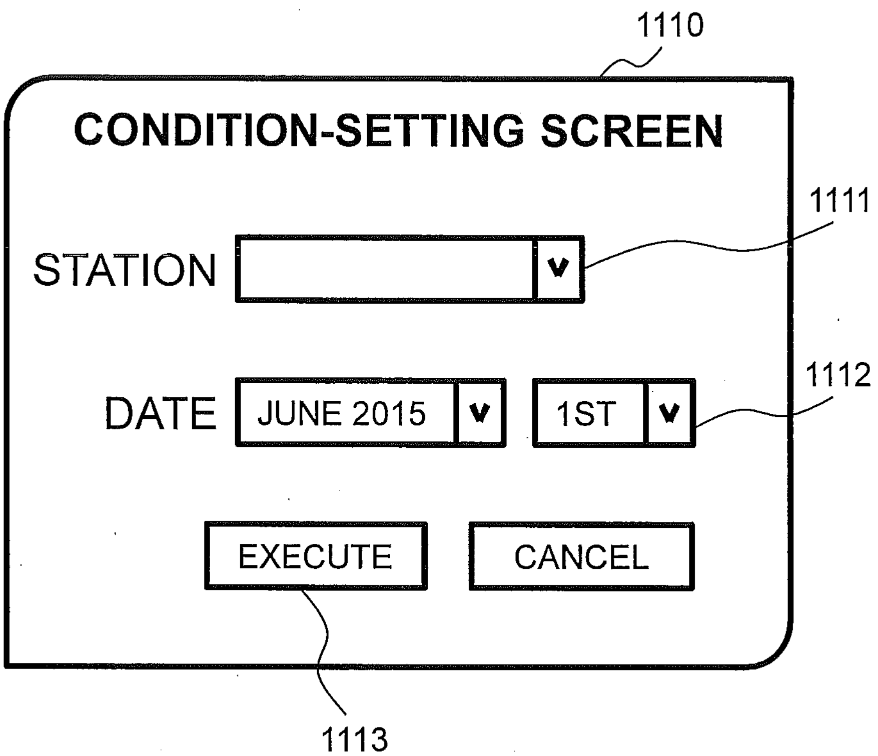
1110
CONDITION-SETTING SCREEN
1111
STATION
1112
DATE
JUNE 2015
1ST
EXECUTE
CANCEL
1113

Fig. 21

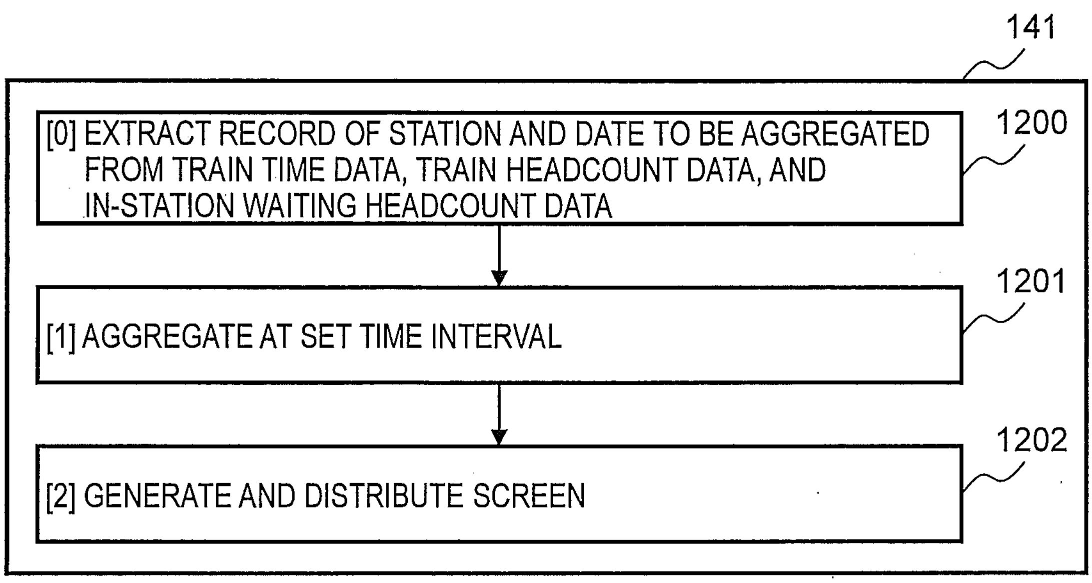
141
[0] EXTRACT RECORD OF STATION AND DATE TO BE AGGREGATED FROM TRAIN TIME DATA, TRAIN HEADCOUNT DATA, AND IN-STATION WAITING HEADCOUNT DATA
1200
[1] AGGREGATE AT SET TIME INTERVAL
1201
[2] GENERATE AND DISTRIBUTE SCREEN
1202

Fig. 22

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2016/056461

A. CLASSIFICATION OF SUBJECT MATTER
G08G1/01(2006.01)i, *B61L25/02*(2006.01)i, *G06Q50/30*(2012.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G08G1/01, B61L25/02, G06Q50/30

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2013-242822 A (Hitachi, Ltd.), 05 December 2013 (05.12.2013), paragraphs [0025] to [0033]; fig. 3, 6a (Family: none)	1-12
A	JP 2005-212641 A (Mitsubishi Electric Corp.), 11 August 2005 (11.08.2005), paragraphs [0008] to [0021]; fig. 1 to 2 (Family: none)	1-12
A	JP 2010-277190 A (Nippon Telegraph and Telephone Corp.), 09 December 2010 (09.12.2010), paragraphs [0026] to [0029], [0035], [0115] to [0122]; fig. 2 to 3 (Family: none)	1-12

☐ 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
06 May 2016 (06.05.16)	17 May 2016 (17.05.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2007120953 A **[0004] [0006]**