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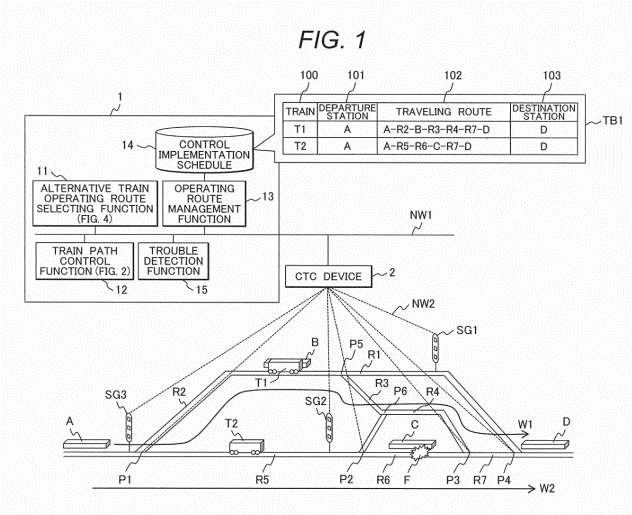
(54) METHOD FOR SELECTING ALTERNATE OPERATING ROUTE FOR TRAIN, AND SYSTEM THEREFOR

(57) The objective of the present invention is to minimize the sum of delay times of trains managed in a train operation management system and the number of operation cancellations of the trains when an operational trouble occurs. A method for selecting an alternative operating route for a train of the present invention includes the step of preparing beforehand all travelable routes from a current location to a destination place of trains, travel times to travel the travelable routes, trouble-caused delay times according to trouble types, and operational delay times for inter-train troubles. When an operational trouble of a train occurs, a sum of a travel time, a trouble-caused delay time, and an operational delay time is obtained for each of combinations of the travelable routes for all trains in operation, and a combination of the travelable routes for which the sum is smallest is extracted as an alternative operating route for the train.

FIG. 1



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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a method for selecting an alternative operating route for a train and a system therefor.

BACKGROUND OF THE INVENTION

[0002] In conventional train operation management, when an operational trouble occurs on a route from a current location to a destination station of a train (hereinafter referred to as an "operating route"), an alternative operating route may be selected depending on the type and operation of the train, and the train may be operated using the alternative operating route for an early arrival at the destination station.

[0003] The operating route of a train can be changed manually. Document 1 discloses a method in which the train itself proposes an operating route to realize the appropriate operation management.

DOCUMENTS ON RELATED ARTS

PATENT DOCUMENTS

[0004] Document 1: JP 2011-020578

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] Changing an operating route of a single train without considering other trains may cause an occupation of the same operating route or the same station by the train and other trains at the same time. In such a situation, the train which has changed the operating route may obstruct the operations of other trains to cause a delay arrival of other trains at their destinations.

[0006] The present invention has been made in view of the above problem. The objective of the present invention is to minimize the sum of delay times of trains managed in a train operation management system and the number of operation cancellations of the trains (hereinafter referred to as "operational risks") when an operational trouble occurs.

MEANS FOR SOLVING THE PROBLEM

[0007] To solve the above problem, a method for selecting an alternative operating route for a train includes the step of preparing beforehand all travelable routes from a current location to a destination place of trains, travel times to travel the travelable routes, trouble-caused delay times according to trouble types, and operational delay times for inter-train troubles. When an operational trouble of a train occurs, a sum of a travel time, a trouble-caused delay time, and an operational delay time is obtained for each of combinations of the travelable routes for all trains in operation, and a combination of the travelable routes for which the sum is smallest is extracted as an alternative operating route for the train.

ADVANTAGEOUS EFFECTS OF THE INVENTION

[0008] The method for selecting an alternative operating route for a train and the system therefor of the present invention can provide the optimum operating routes from the whole train operation in the system and also can provide an operation to fit the user's needs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Figure 1 is a schematic block diagram showing an overall configuration of a train operation management system;
Figure 2 is a block diagram of an alternative train operating route selecting function 11;
Figure 3 shows information stored in a travelable route information database 11E;
Figure 4 shows information stored in a train operation information database 11F; and
Figure 5 is a process flowchart for changing an operating route.

DESCRIPTION OF EMBODIMENTS

[0010] In the following, an embodiment of the present invention will be described with reference to drawings.

[0011] Figure 1 is a schematic block diagram showing an overall configuration of a train operation management system according to an embodiment of the present invention.

[0012] The train operation management system shown in figure 1 includes a railway network and a control system for controlling the railway network. The railway network includes, for example, stations (station A, station B, station C and station D), paths R (R1 to R7) switched by point switches P (P1 to P6), railway signals SG (SG1 to SG3), and trains T (T1 and T2).

[0013] The control system includes an automatic path controller 1, a CTC device 2, and networks NW1 and NW2, and configures train paths, controlling the signals SG and point switches P.

[0014] The automatic path controller 1 and the CTC device 2 are connected via the network NW1. The CTC device 2, the signals SG1 to SG3 and the point switches P1 to P6 are connected via the network NW2. The automatic path controller 1 can control the signals SG1 to SG3 and the point switches P1 to P6 via the network NW1, CTC device 2 and network NW2. The trains T1 and T2 run along the paths R1 to R7 following the direc-

tions given by the signals SG1 to SG3.

[0015] The automatic path controller 1, for configuring train paths, includes an alternative train operating route selecting function 11, a train path control function 12, an operating route management function 13, an implementation scheduling function 14 and a trouble detection function 15.

[0016] Of these functions, the control implementation scheduling function 14 stores a train via-point table TB1 and data required for train operation in a storage device. The train via-point table TB1 includes a departure station 101, paths to be followed 102 (hereinafter referred to as a "traveling route"), and a destination station 103 for each of the trains 100 to be controlled by the system.

[0017] In the case of the railway network in figure 1, the train via-point table TB1 stores operating schedules for two trains. Train T1 is scheduled to follow a route of travelling station A, path R2, station B, path R3, path R4, path R7, and station D in this order. Train T2 is scheduled to follow a route of travelling station A, path R5, path R6, station C, path R7, and station D in this order. In figure 1, these scheduled routes are denoted as W1 and W2. The control implementation scheduling function 14 is assumed to be inputted beforehand from an external device or an external medium before train control is started.

[0018] The operating route management function 13 manages additions, changes and references for the control implementation scheduling function 14.

[0019] The train path control function 12 reads the paths for each of the trains via the operating route management function 13, controls the field equipment such as the signals SG1 to SG3 and the point switches P1 to P6 via the CTC device 2, and enables each of the trains to be operated according to a control implementation schedule.

[0020] The trouble detection function 15 detects an intersystem operational trouble F based on a signal which is obtained from the CTC device 2 and indicates the field equipment condition. It is also able to detect an operational trouble based on information manually inputted from the automatic path controller or another device.

[0021] In the case shown in figure 1, the operational trouble F has occurred in the station C and accordingly the operation of trains to pass the station C has become impossible. This operational trouble is detected by the trouble detection function 15. Upon detection of the operational trouble, the trouble detection function 15 reports the occurrence and type of the operational trouble to the alternative train operating route selecting function 11.

[0022] Upon receiving the report on the operational trouble, the alternative train operating route selecting function 11 changes the traveling route stored in the control implementation scheduling function 14 via the operating route management function 13, based on the types of the operational trouble. Since the operational trouble F occurred in the station C makes it impossible to operate the train T2 to pass the station C, it is necessary to guide the train T2 to an alternative route leading to the station D.

[0023] A specific method of changing the traveling route will be described later. Although an example case of changing the traveling route will be described in the present embodiment, other data used in operating trains may be changed.

[0024] Based on the control implementation scheduling function 14 changed by the alternative train operating route selecting function 11, the train path control function 12 moves the trains T1 and T2 in accordance with the train via-point table TB1.

[0025] Figure 2 is a block diagram of the alternative train operating route selecting function 11. The alternative train operating route selecting function 11 shown in figure 2 includes an alternative train operating route searching function 11A, an operating route evaluation function 11B, an operating route selecting function 11C, an operating route changing function 11D, a travelable route information database 11E, and a train operation information database 11F.

[0026] The travelable route information database 11E includes a table which can store information on the traveling routes from the present location of each train to its destination station. Figure 3 shows an example of the information stored in the table.

[0027] The train operation information database 11F includes tables which can store the routes, train delay times caused by operational troubles, train delay times caused by inter-train operational troubles, and computation results of the alternative train operating route searching function 11A and the operating route evaluation function 11B. Figure 4 shows an example of the information stored in the table.

[0028] The alternative train operating route searching function 11A searches for routes leading to the destination (hereinafter referred to as "alternative operating routes") based on the current location of the train and the destination station in the implementation scheduling function 14, and stores the alternative operating routes in the train operation information database 11F.

[0029] The operating route evaluation function 11B computes operational risks for each of the alternative operating routes, which are stored in the train operation information database 11F, for each of the trains, and stores the computed operational risks in the train operation information database 11F.

[0030] Furthermore, the operating route selecting function 11C selects an operating route which minimizes the operational risks of the whole system based on the operational risks computed for each of the alternative operating routes for each of the trains. The operating route changing function 11D switches to the selected operating route via the operating route management function 13.

[0031] Figure 3 shows an example of information stored in the travelable route information database 11E. The travelable route information database 11E includes a route information table 11E-1 which stores the travelable route information in association with the route num-

bers 104. The travelable route information includes departure paths or stations from which the train departs (hereinafter referred to as "departure points") 105, arrival paths or stations at which the train arrives (hereinafter referred to as "arrival points") 106, and routes and stations by which the train passes (hereinafter referred to as "via points") 107. The via points 107 store the paths or stations travelable and available in operation from the departure points 105 to arrival points 106.

[0032] Detail of the travelable route information associated with the route number 104 in the route information table 11E-1 will be omitted. The route numbers 104 in the 1000s cover all routes from the station A as a departure point to the station D as an arrival point. The route numbers 104 in the 1100s cover all routes from the path R5 as a departure point to the station D as an arrival point. The route numbers 104 in the 1200s cover all routes from the station B as a departure point to the station D as an arrival point.

[0033] The travelable route information database 11E can be defined according to clients' operations and is inputted beforehand. The information to be stored in this table may be prepared by computation using a computer based on the connections between stations and between paths.

[0034] Figure 4 shows an example of information stored in the train operation information database 11F.

[0035] The train operation information database 11F includes a route travel time table 11F-1 for storing the travel times for the trains to travel each of the routes, a trouble-caused delay time table 11F-2 for storing the delay times of the trains caused according to the types of the operational troubles, an operational delay time table 11F-3 for storing average delay times caused by operational troubles between trains, an alternative operating route table 11F-4 for storing the alternative train operating routes, and an inter-train operational risk table 11F-5 for storing the operational risks according to combinations of the alternative train operating routes for each of the trains.

[0036] The route travel time table 11F-1, trouble-caused delay time table 11F-2, and operational delay time table 11F-3 are stored manually, but may be stored automatically based on the past data.

[0037] The alternative operating route table 11F-4 and the inter-train operational risk table 11F-5 store the computation results of the alternative operating route searching function 11A and the operating route evaluation function 11B. The computing methods will be described later.

[0038] These tables included in the train operation information database 11F will be described below.

[0039] The route travel time table 11F-1, which stores the travel times for the trains to travel each of the routes, stores travel times 108 for the trains to travel all the available routes stored in the travelable route information table 11E-1 in figure 3, associated with the route numbers 104. Therefore, information stored in the travelable route information table 11E-1 and the route travel time table 11F-1 can be retrieved as inter-related information. Much of information stored in the foregoing tables is associated with the route numbers 104 and can be used as inter-related information, though explanation of the detail is omitted.

[0040] The information stored in the route travel time table 11F-1 can be interpreted, considering the relationship between information associated by the route numbers 104. For example, it is known that, of the routes from the station A as the departure point to the station D as the arrival point, the route 1001 including via points R5, R6 and R7 requires a travel time of 60 minutes for a train to pass through the route 1001. It is also known that the route 1002 from the same departure point to the same arrival point as the route 1001 requires a travel time of 55 minutes.

[0041] The trouble-caused delay time table 11F-2, which stores the delay times of the trains caused according to the types of the operational troubles, stores the relationships between the trouble types 109 and the delay times 110. For example, when trouble type 109 is an equipment trouble, the delay time 110 including the time required for recovery before resumption of the train operation is 60 minutes, and when the trouble type is an accident, the delay time is 80 minutes.

[0042] The operational delay time table 11F-3, which stores average delay times caused by operational troubles between trains, stores the relationships between the inter-train trouble types 111 and the delay times 112. The operational delay time table 11F-3 stores, for example, an average delay time caused when plural trains use the same route in the same time period. In this case, the average delay time includes a sum of times to consult and determine an inter-train operation procedure for recovery.

[0043] The alternative operating route table 11F-4, which stores alternative train operating routes, stores the alternative operating routes for each of the trains. That is, the alternative operating route table 11F-4 stores the relationships between the trains 100 and the routes 104. In this case, the trains 100 in the operational delay time table 11F-3 correspond to the trains 100 in the train via-point table TB1 of the control implementation scheduling function, and the routes 104 correspond to the routes 104 in the travelable route information database 11E.

[0044] According to this table, in the case of the train T1, for example, the routes 1201 and 1202 stored as travelable route information can be used as alternative operating routes out of the routes 104 stored in the travelable route information table 11E-1 in figure 3. In the case of the train T2, the routes 1101, 1102, 1103 and 1104 stored as travelable route information can be used as alternative operating routes out of the routes stored in the travelable route information table 11E-1.

[0045] The inter-train operational risk table 11F-5, which stores the operational risks according to combinations of the alternative train operating routes for each of the trains, is constructed as follows. The inter-train op-

erational risk table 11F-5 basically includes information obtained from the corresponding columns of other tables. The reference characters for the table 11F-5 in figure 4 indicate the corresponding columns in other tables. However, note that the column indicated by the reference character 104T1 denotes the routes only for train T1 out of the routes stored in the column indicated by the route number 104 and the column indicated by the reference character 104T2 denotes the routes only for train T2 out of the routes stored in the column indicated by the route number 104.

[0046] To construct the inter-train operational risk table 11F-5, combinations of the alternative operating routes for each of the trains are determined. To do this, first, all the alternative operating routes (routes 1201 and 1202 in the present example) for train T1 stored in the alternative operating route table 11F-4 are entered, as base information, in the train route 104T1.

[0047] In case A based on the alternative operating route 1201 of the entered alternative operating routes, all the alternative operating routes usable by train T2 (routes 1101, 1102, 1103 and 1104 in the present example) are entered. In case B based on the alternative operating route 1202, all the alternative operating routes usable by train T2 (routes 1101, 1102, 1103 and 1104 in the present example) are entered.

[0048] The items laterally arranged in the inter-train operational risk table 11F-5 include travel time 108 and trouble-caused delay time 110 for the trains T1 and T2 (100). In addition, the operational delay time 112 and the total time 113 are included in the table 11F-5 according to the combinations between trains T1 and T2.

[0049] It is known from the inter-train operational risk table 11F-5 thus prepared that, for example, when the alternative operating route 1101 is selected for the train T2 in the case A based on the alternative operating route 1201 for the train T1, the travel time 108 and the trouble-caused delay time 110 for the train T1, the travel time 108 and the trouble-caused delay time 110 for the train T2, the operational delay time 112 according to the combination between the trains T1 and T2, and the total time 113 are 70 minutes, 60 minutes, 40 minutes, 60 minutes, 0 minute, and 230 minutes, respectively.

[0050] Similarly, when the alternative operating route 1102 is selected for the train T2 in the case A based on the alternative operating route 1201, the above time values are 70 minutes, 60 minutes, 45 minutes, 0 minute, 20 minutes and 195 minutes, respectively.

[0051] When the alternative operating route 1103 or 1104 is selected for the train T2 in the case A based on the alternative operating route 1201, the total time is 210 minutes. Therefore, it is known that the alternative operating route 1102 for the train T2 makes the total time shortest when the alternative operating route 1201 is used for the train T1.

[0052] In case B based on the alternative operating route 1202 for the train T1, the table can be interpreted similarly. In this case, the alternative operating route 1102 for the train T2 makes the total time shortest

[0053] In the table, though all the possible route combinations are entered with respect to the train T1, all the possible route combinations may be entered with respect to the train T2 alternatively.

[0054] Figure 5 is a detailed process flowchart performed by the alternative train operating route selecting function 11 to change an operating route inputted to the control implementation scheduling function 14.

[0055] In the process flowchart, first in step S1, the alternative operating route searching function 11A searches for alternative operating routes for all the trains managed in the train operation management system 1.

[0056] Alternative operating routes are routes (via points 107) whose departure point 105 is a station or path R the train currently passes through and whose arrival point 106 is a destination station stored in the control implementation scheduling function 14. All such alternative operating routes are extracted by searching the travelable route information database 11E.

[0057] For example, in a case where the train T1 stops at the illustrated location (the station B) and is scheduled to head for the station D in the railway network in figure 1 when an operational trouble F occurs, the alternative operating route for the train T1 is the route 1201 (B, R1), except for the initially scheduled route W1 (B, R3, R7), i.e. the route 1202 in the travelable route information database 11E. In this case, the routes 1201 and 1202 are extracted as alternative operating routes from the travelable route information database 11E.

[0058] In a case where the train T2 travels the illustrated location (path R5) and is scheduled to head for the station D in the railway network in figure 1 when an operational trouble F occurs, the alternative operating routes for the train T2 are the route 1102 (R5, R4, R7), route 1103 (R5, A, R2, B, R1) and route 1104 (R5, A, R2, B, R3, R4, R7), except for the initially scheduled route W2 (R5, R6, R7), i.e. the route 1101 in the travelable route information database 11E. In this case, the routes 1101, 1102, 1103 and 1104 are extracted as alternative operating routes from the travelable route information database 11E. The routes 1103 and 1104 are routes for the train to once return to the departure station and then change the route.

[0059] In step S1, the travelable route information database 11E is searched as described above, the extracted routes are set as the alternative operating routes for the respective trains, and the route numbers for the respective trains are entered along with the train numbers in the route 104 columns and the train 100 columns in the alternative operating route table 11F-4.

[0060] Next, in step S2, the operational risks are computed by the operating route evaluation function 11B based on the alternative operating route table 11F-4 storing the extracted alternative operating routes, the route travel time table 11F-1, the trouble-caused delay time table 11F-2, and the operational delay time table 11F-3.

[0061] The operational risks thus computed are en-

tered in the inter-train operational risk table 11F-5 that can be used in the manner as described in the foregoing. In the following, a procedure for producing the table and interpretation of the table will be described.

[0062] The operational risks are computed not for a single train but for all the combinations of the possible alternative operating routes between all the trains in the system.

[0063] This computation includes all the combinations, if a train (e.g. train T1) is assumed to use an alternative operating route (e.g. route 1201), between the alternative operating route for the train (train T1) and the alternative operating routes (e.g. routes 1101, 1102, 1103, and 1104) for other trains (e.g. train T2). This computation also includes all the combinations when the alternative operating route for the train (train T1) is changed to other (e.g. route 1202).

[0064] In the present embodiment, the operational risks are represented by the total travel time of all the trains in the system. In this case, the travel time required to pass the alternative operating route, the time required to pass the place of the trouble, and the time required to eliminate the inter-train operational trouble are computed for each of the trains in the system, and the computed values are totalized for all the trains in the system.

[0065] The inter-train operational risk table 11F-5 stores the total travel time of all the trains in the system as the total 113 which is a sum of the travel time 108 and the trouble-caused delay time 110 of the train T1 (100), the travel time 108 and the trouble-caused delay time 110 of the train T2 (100), and the operational delay time 112 according to the combination of the routes for the trains T1 and T2.

[0066] The travel time 108 for each of the trains traveling an alternative operating route is determined by searching for the travel time 108 based on the route number 104 of the alternative operating route in the route travel time table 11F-1.

[0067] The time required to pass an operational trouble location (trouble-caused delay time) 110 is determined by searching the trouble-caused delay time table 11F-2 based on the operational trouble type 109 (e.g. equipment failure or accident). In the example shown in figure 4, the trouble-caused delay time is estimated to be 60 minutes in the case of an equipment failure and 80 minutes in the case of an accident.

[0068] Lastly, the operational delay time 112 is determined. For this, the time required to eliminate the inter-train operational trouble is determined by searching for routes from the current location of the train as the departure point to the via points in the alternative operating routes as the arrival points from the travelable route information 11E, and by obtaining the time required to travel the routes from the route travel time table 11F-1 based on the route number. The time required to travel routes is also obtained for the via points in the alternative operating routes for other trains by the same computation method. In this way, the time required to reach each of the via points are determined. If two trains are to reach the same via point at the same time, the delay time according to the operational trouble is obtained by searching the operational delay time table 11F-4.

[0069] The respective computation results are recorded in the total travel time table 11F-5.

[0070] Next, in step S3, the operating route selecting function 11C selects an alternative operating route whose operational risks are smallest in the total travel time table 11F-5. When the operational risks are represented by the total travel time of all the trains in the system, a combination of the alternative operating routes with the smallest total travel time is selected.

[0071] In the example shown in figure 4, the total travel time is smallest with a combination of the train T1 using the route 1202 and the train T2 using the route 1102. This route combination leads the train T1 currently at the station B to travel the route W1 via R3, R4, R7, and D as initially planned, and leads the train T2 currently on the route R5 to travel the changed route via R4, R7, and D.

[0072] In step S4, the operating route changing function 11D changes the route for each of the trains stored in the train via-point table 14-1 via the operating route management function 13 so that the route changes to the selected combination of the alternative operating routes.

[0073] In this way, even when an operational trouble occurs, operating routes are automatically changed to operating routes that minimize the operational risks for the trains managed in the train operation management system.

[0074] Though operating routes are automatically changed in the present embodiment, operating routes may be changed after an inquiry to the user via an interface such as a display or a mouse.

EXPLANATION OF REFERENCE CHARACTERS

[0075]

1 ... automatic path controller
2 ... CTC device
NW1, NW2 ... networks
11 ... alternative train operating route selecting function
12 ... train path control function
13 ... operating route management function
14 ... control implementation schedule
15 ... trouble detection function
11A ... alternative operating route searching function
11B ... operating route evaluation function
11C ... operating route selecting function
11D ... operating route changing function
11E ... travelable route information
1E-1 ... route information table
11F ... train operation information
11F-1 ... route travel time table
11F-2 ... trouble-caused delay time table

11F-3 ... operational delay time table
11F-4 ... alternative operating route table
11F-5 ... inter-train operational risk table
TB1 ... train via-point table
TR1, TR2 ... trains to be controlled
SG1 to SG3 ... signals to be controlled
P1 to P6 ... point switches to be controlled
A to D ... stations
R1 to R7 ... paths
F ... operational trouble

Claims

1. A method for selecting an alternative operating route for a train, comprising the steps of:

preparing beforehand route data including travelable routes for trains and train operation data including operational risks associated with operational troubles;
searching for alternative operating routes for a current operating route for a train from the route data;
determining the operational risks based on the train operation data;
selecting an alternative operating route for the current operating route for the train based on the operational risks; and
changing the current operating route for the train to the selected alternative operating route for the train.

2. The method for selecting an alternative operating route for a train according to claim 1,
wherein the route data includes a departure place, a destination place, and at least one via point of the trains; and
wherein, in selecting the alternative operating route, a travelable route is obtained based on a current location and the destination place of the train from the route data.

3. The method for selecting an alternative operating route for a train according to claim 1,
wherein the train operation data includes values indicating the operational risks associated with the operational troubles for a single train and for a plurality of trains; and
wherein the operational risks are prepared for operational risks caused by changing a route for the train for combinations of the travelable routes for each of the trains.

4. The method for selecting an alternative operating route for a train according to claim 3,
wherein operational risks are obtained between trains in a train path by simulating future locations of the trains based on current locations of the trains, the route data, and the train operation data.

5. The method for selecting an alternative operating route for a train according to one of claims 3 and 4, wherein a route with a smallest operational risk is selected based on the operational risks determined for each of the combinations of the travelable routes.

6. The method for selecting an alternative operating route for a train according to claim 5,
wherein the selected alternative operating route is proposed to a user and, after an approval of the proposal by the user, train operation is changed to change the current operating route to the selected alternative operating route.

7. A method for selecting an alternative operating route for a train, comprising the step of:

preparing beforehand all travelable routes from a current location to a destination place of trains, travel times to travel the travelable routes, trouble-caused delay times according to trouble types, and operational delay times for inter-train troubles;
wherein, when an operational trouble of a train occurs, a sum of a travel time, a trouble-caused delay time, and an operational delay time is obtained for each of combinations of the travelable routes for all trains in operation, and a combination of the travelable routes for which the sum is smallest is extracted as an alternative operating route for the train.

8. A system for selecting an alternative operating route for a train, comprising:

route data including travelable routes for trains;
train operation data including operational risks associated with operational troubles;
a route searching function for searching for alternative operating routes for a current operating route for a train;
a risk computing function for computing operational risks;
a route selecting function for selecting an alternative operating route based on the operational risks; and
a route changing function for changing the operating route for the train.

9. The system for selecting an alternative operating route for a train according to claim 8,
wherein the route data includes a departure place, a destination place, and at least one via point of the trains; and
wherein the route searching function obtains a trave-

lable route based on a current location and the destination place of the train from the route data.

10. The system for selecting an alternative operating route for a train according to claim 8,
wherein the train operation data includes values indicating the operational risks associated with the operational troubles for a single train and for a plurality of trains; and
wherein the risk computing function computes the operational risks caused by changing a route for the train for combinations of the travelable routes for each of the trains.

11. The system for selecting an alternative operating route for a train according to claim 10,
wherein the risk computing function computes operational risks between trains in a train path by simulating future locations of the trains based on current train locations of the trains, the route data, and the train operation data.

12. The system for selecting an alternative operating route for a train according to one of claims 10 and 11,
wherein the route selecting function selects a route with a smallest operational risk based on operational risks computed for each of the combinations of the travelable routes.

13. The system for selecting an alternative operating route for a train according to claim 12,
wherein the route changing function proposes the selected alternative operating route to a user and, after an approval of the proposal by the user, changes train operation to change the current operating route to the selected alternative operating route.

14. A system for selecting an alternative operating route for a train, comprising:

a first storage unit for storing all travelable routes from a current location to a destination place of trains;
a second storage unit for storing travel times to travel the travelable routes, trouble-caused delay times according to trouble types, and operational delay times for inter-train troubles;
an operational trouble detection function for detecting occurrence of an operational trouble of a train;
a function for computing a sum of a travel time, a trouble-caused delay time, and an operational delay time for each of combinations of the travelable routes for all trains in operation when the operational trouble is detected;
a selection function for selecting a combination of the travelable routes for which the sum is smallest; and
a function for presenting the selected combination as an alternative operating route for the train.

FIG. 1

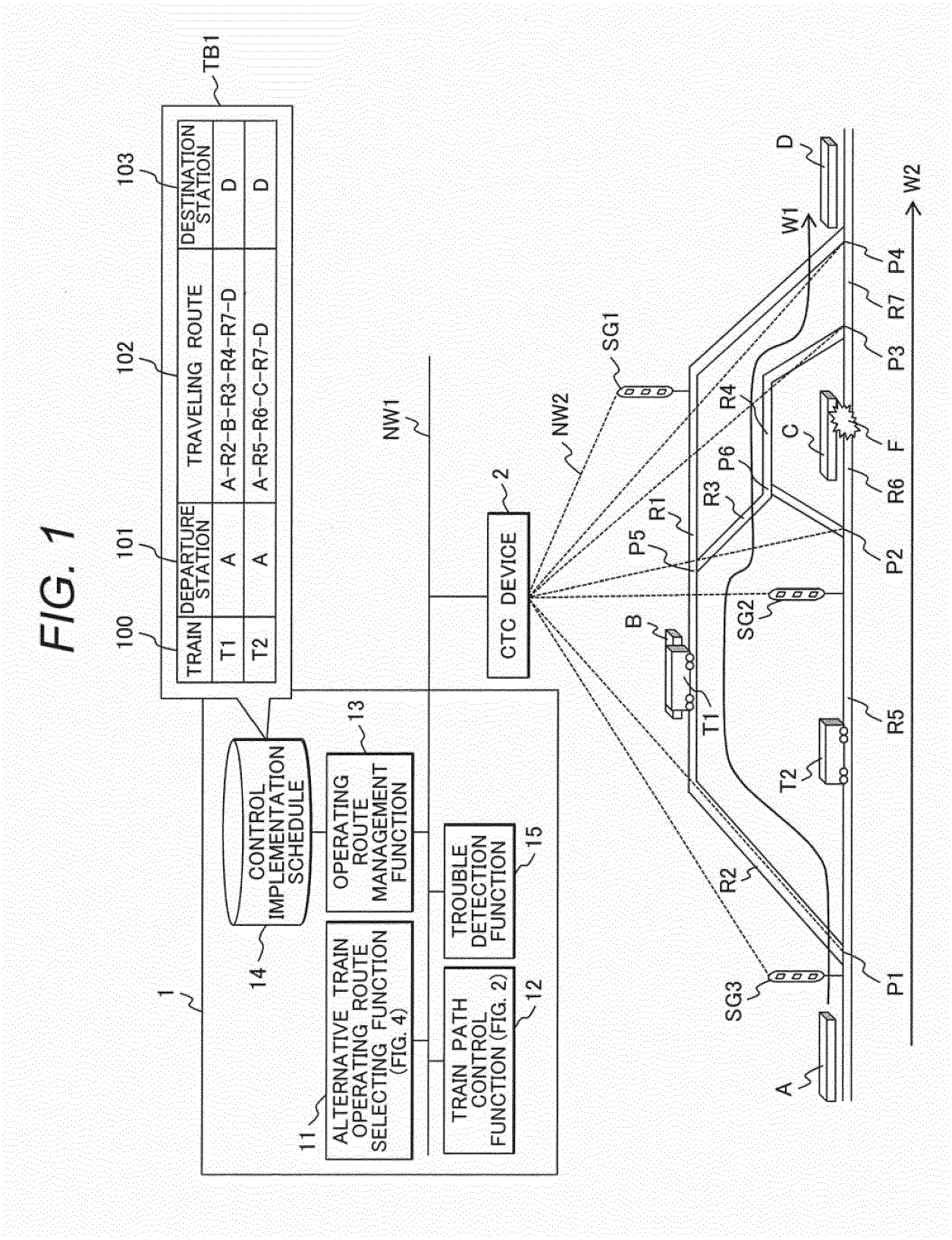

TB1
TRAIN
DEPARTURE STATION
TRAVELING ROUTE
DESTINATION STATION
T1
A
A-R2-B-R3-R4-R7-D
D
T2
A
A-R5-R6-C-R7-D
D
100
101
102
103
1
CONTROL IMPLEMENTATION SCHEDULE
14
OPERATING ROUTE MANAGEMENT FUNCTION
13
ALTERNATIVE TRAIN OPERATING ROUTE SELECTING FUNCTION (FIG. 4)
11
TROUBLE DETECTION FUNCTION
15
TRAIN PATH CONTROL FUNCTION (FIG. 2)
12
NW1
CTC DEVICE
2
NW2
SG1
SG2
SG3
A
B
C
D
T1
T2
R1
R2
R3
R4
R5
R6
R7
P1
P2
P3
P4
P5
P6
F
W1
W2

FIG. 2

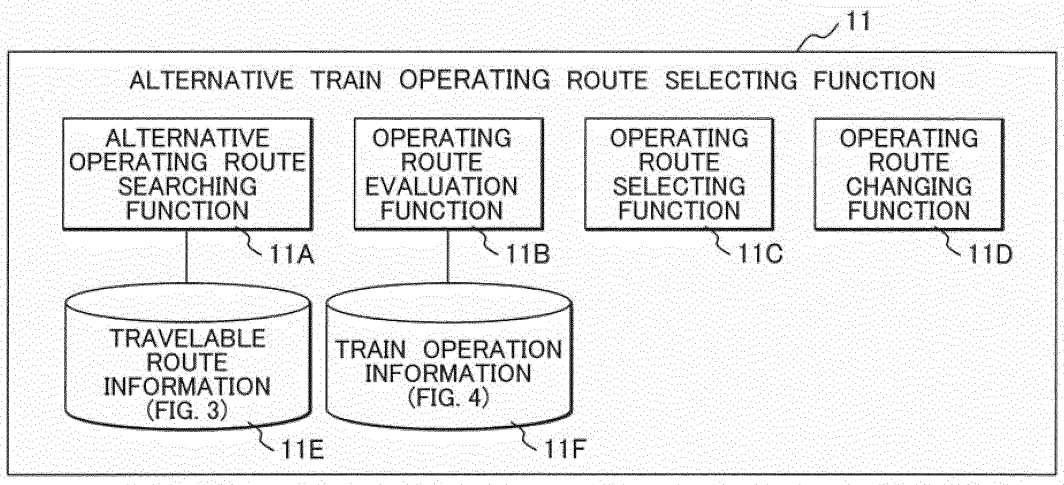


FIG. 3

TRAVELABLE ROUTE INFORMATION

11E

104 ROUTE NO.	105 DEPARTURE POINT	106 ARRIVAL POINT	107 VIA POINT
1001	A	D	R5-R6-R7
1002	A	D	R5-R4-R7
...	...	...	...
1101	R5	D	R6-R7
1102	R5	D	R4-R7
1103	R5	D	A-R2 -B-R1
1104	R5	D	A-R2-B -R3-R4-R7
...	...	...	...
1201	B	D	R1
1202	B	D	R3-R4-R7
...	...	...	...

11E-1

FIG. 4

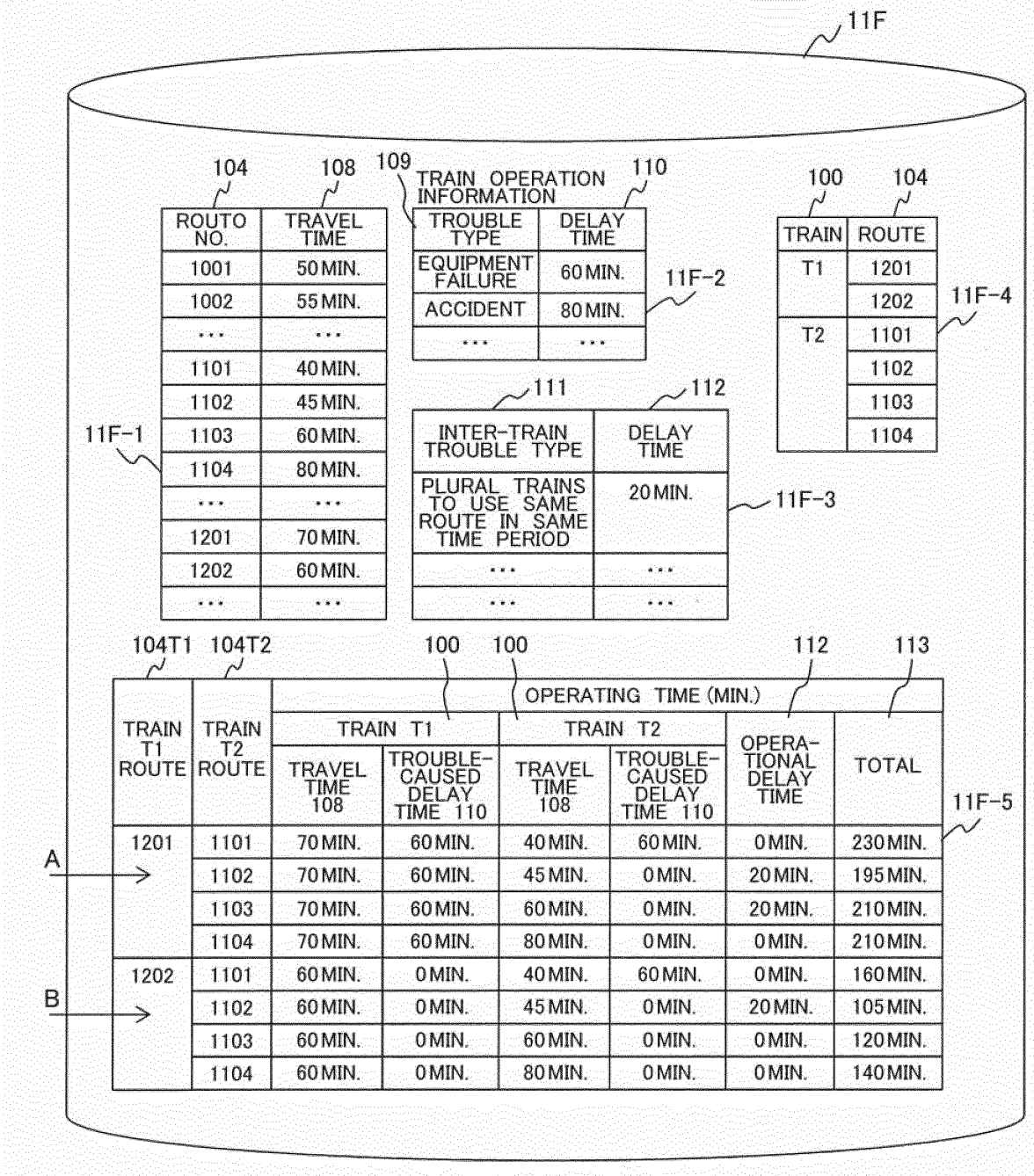
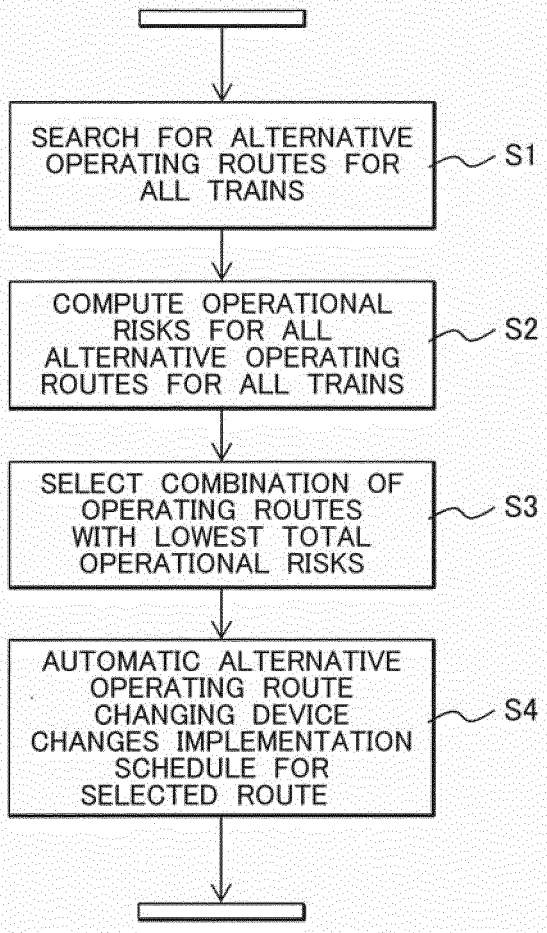

11F
104
108
ROUTO NO.
TRAVEL TIME
1001 50 MIN.
1002 55 MIN.
1101 40 MIN.
1102 45 MIN.
1103 60 MIN.
1104 80 MIN.
1201 70 MIN.
1202 60 MIN.
11F-1
109
TRAIN OPERATION INFORMATION
110
TROUBLE TYPE
DELAY TIME
EQUIPMENT FAILURE 60 MIN.
ACCIDENT 80 MIN.
11F-2
111
112
INTER-TRAIN TROUBLE TYPE
DELAY TIME
PLURAL TRAINS TO USE SAME ROUTE IN SAME TIME PERIOD 20 MIN.
11F-3
100
104
TRAIN
ROUTE
T1 1201
1202
T2 1101
1102
1103
1104
11F-4
104T1
104T2
100
100
112
113
TRAIN T1 ROUTE
TRAIN T2 ROUTE
OPERATING TIME (MIN.)
TRAIN T1
TRAIN T2
TRAVEL TIME 108
TROUBLE-CAUSED DELAY TIME 110
TRAVEL TIME 108
TROUBLE-CAUSED DELAY TIME 110
OPERATIONAL DELAY TIME
TOTAL
1201 1101 70 MIN. 60 MIN. 40 MIN. 60 MIN. 0 MIN. 230 MIN.
1102 70 MIN. 60 MIN. 45 MIN. 0 MIN. 20 MIN. 195 MIN.
1103 70 MIN. 60 MIN. 60 MIN. 0 MIN. 20 MIN. 210 MIN.
1104 70 MIN. 60 MIN. 80 MIN. 0 MIN. 0 MIN. 210 MIN.
1202 1101 60 MIN. 0 MIN. 40 MIN. 60 MIN. 0 MIN. 160 MIN.
1102 60 MIN. 0 MIN. 45 MIN. 0 MIN. 20 MIN. 105 MIN.
1103 60 MIN. 0 MIN. 60 MIN. 0 MIN. 0 MIN. 120 MIN.
1104 60 MIN. 0 MIN. 80 MIN. 0 MIN. 0 MIN. 140 MIN.
11F-5
A
B

FIG. 5


SEARCH FOR ALTERNATIVE OPERATING ROUTES FOR ALL TRAINS
S1
COMPUTE OPERATIONAL RISKS FOR ALL ALTERNATIVE OPERATING ROUTES FOR ALL TRAINS
S2
SELECT COMBINATION OF OPERATING ROUTES WITH LOWEST TOTAL OPERATIONAL RISKS
S3
AUTOMATIC ALTERNATIVE OPERATING ROUTE CHANGING DEVICE CHANGES IMPLEMENTATION SCHEDULE FOR SELECTED ROUTE
S4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/067885

A. CLASSIFICATION OF SUBJECT MATTER
B61L25/02(2006.01)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)
B61L25/02

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 1996-2012
Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

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.
Y A	JP 2011-20578 A (Railway Technical Research Institute), 03 February 2011 (03.02.2011), paragraphs [0012] to [0023] (Family: none)	1,2 3-14
Y A	JP 2011-31697 A (Hitachi, Ltd.), 17 February 2011 (17.02.2011), paragraphs [0119] to [0125] (Family: none)	1,2 3-14
A	JP 2010-228688 A (Hitachi, Ltd.), 14 October 2010 (14.10.2010), entire text; all drawings (Family: none)	1-14

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 September, 2012 (18.09.12)	02 October, 2012 (02.10.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

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Patent documents cited in the description

- JP 2011020578 A **[0004]**