(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 406 814 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
31.07.2024 Bulletin 2024/31

(21) Application number: **22903121.6**

(22) Date of filing: **09.11.2022**

(51) International Patent Classification (IPC):
B61L 27/10 *(2022.01)*

(52) Cooperative Patent Classification (CPC):
B61L 27/10

(86) International application number:
PCT/CN2022/130874

(87) International publication number:
WO 2023/103698 (15.06.2023 Gazette 2023/24)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **08.12.2021 CN 202111490452**

(71) Applicant: **Casco Signal Ltd.**
Shanghai 200072 (CN)

(72) Inventors:
- **LIU, Fengbo**
Shanghai 200072 (CN)
- **CAI, Jingpeng**
Shanghai 200072 (CN)
- **ZHOU, Tingliang**
Shanghai 200072 (CN)
- **QIAN, Jiang**
Shanghai 200072 (CN)
- **YAN, Honghui**
Shanghai 200072 (CN)

(74) Representative: **Yang, Shu**
Withers & Rogers LLP
2 London Bridge
London SE1 9RA (GB)

(54) **METHOD FOR COMPILING MULTI-DEPOT COORDINATED URBAN RAIL TRANSIT DEPARTING/GARAGING OPERATION LINES**

(57) Disclosed is a method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots, including the steps: S 1, screening out, based on the mainline path, a feasible outbound and inbound path set corresponding to switch tracks in each depot that can be connected to the mainline path; S2, identifying, based on a connection mode of an outbound and inbound path and the mainline path, outbound and inbound districts to be compiled in a feasible outbound and inbound path and assigning a time scale to the outbound and inbound districts as a feasible outbound and inbound operation line set; S3, matching a feasible outbound and inbound operation line of a corresponding time period, service route and direction for each originating event and terminating event of the mainline to be connected to the outbound and inbound operation line; and S4, according to a constraint on depot parking capacities, generating arrival and departure events of a corresponding feasible outbound and inbound operation line, and checking and resolving any time conflicts between the arrival and departure events of the feasible outbound and inbound operation line and those in mainline operation line; and determining the ultimately matched train outbound and inbound depots, outbound and inbound paths and arrival and departure events in the outbound and inbound operation line based on outbound and inbound interval constraint of the depot.

EP 4 406 814 A1

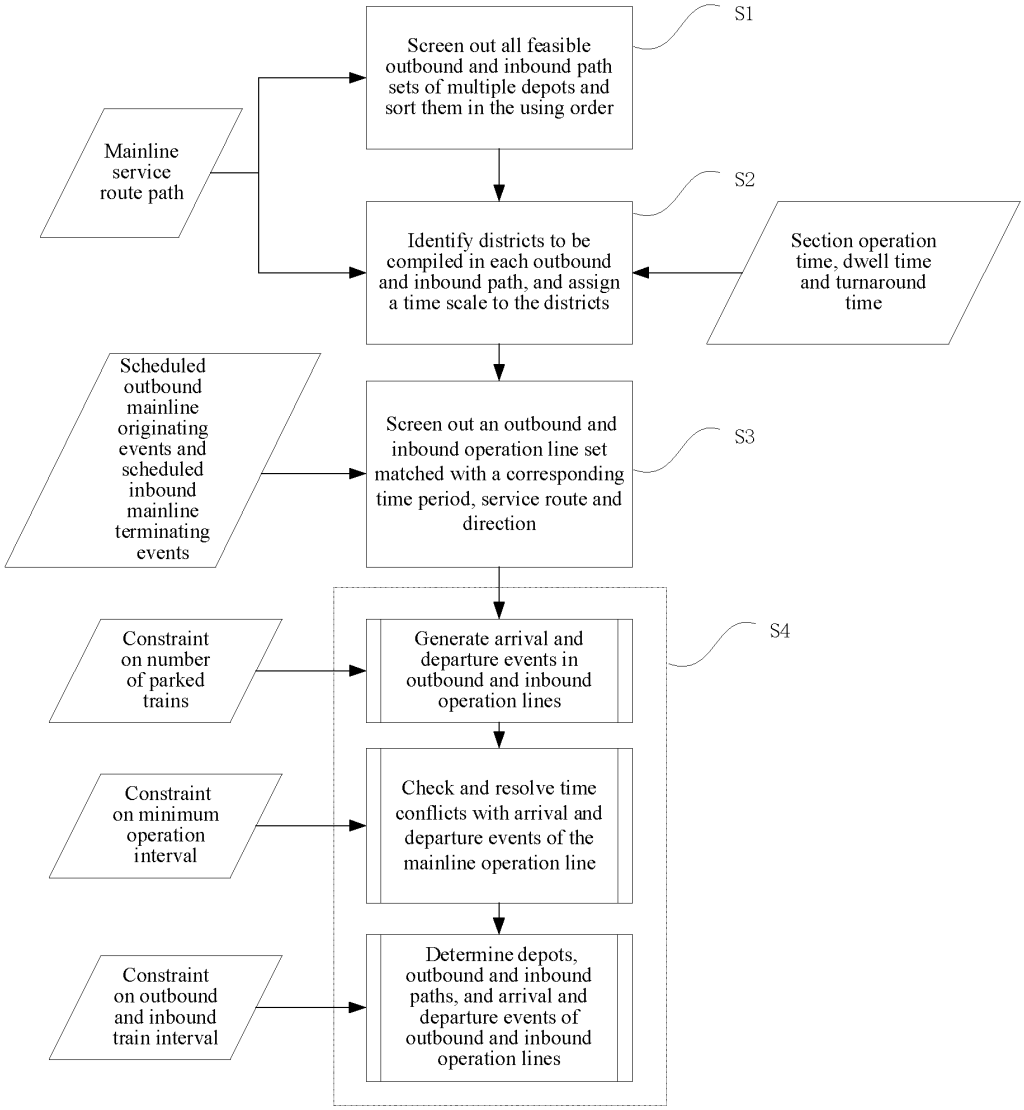
S1
Screen out all feasible outbound and inbound path sets of multiple depots and sort them in the using order
Mainline service route path
S2
Identify districts to be compiled in each outbound and inbound path, and assign a time scale to the districts
Section operation time, dwell time and turnaround time
Scheduled outbound mainline originating events and scheduled inbound mainline terminating events
Screen out an outbound and inbound operation line set matched with a corresponding time period, service route and direction
S3
S4
Constraint on number of parked trains
Generate arrival and departure events in outbound and inbound operation lines
Constraint on minimum operation interval
Check and resolve time conflicts with arrival and departure events of the mainline operation line
Constraint on outbound and inbound train interval
Determine depots, outbound and inbound paths, and arrival and departure events of outbound and inbound operation lines

FIG. 1

Description

TECHNICAL FIELD

[0001] The present invention relates to the field of rail transit operation scheduling, in particular to a method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots.

BACKGROUND

[0002] Transition districts are provided between urban rail transit mainlines and train depots or stabling yards (short for depot), named switch tracks. A train operation diagram is composed of a plurality of operation lines specifying train operation paths and operation timetables. A complete train operation diagram shows operation times of a train between line sections (including switch tracks) and a time sequence of the train arriving at, departing from or passing through stations. An operation line that connects turnaround tracks at an originating station and a terminating station in a mainline is named a mainline operation line. An operation line that connects a switch track and a mainline station is named an outbound or an inbound operation line, which is compiled generally after completing the compilation of the mainline operation line. The outbound and inbound operation lines are compiled by not only reasonably connecting the mainline operation lines but also satisfying constraints on parking capacities in the depots, continuous departure intervals, continuous return intervals, earliest departure times, latest return times, etc.

[0003] In order to meet passenger flow demands, domestic urban rail transit operation intervals get smaller, the number of on-line trains gets larger, and service routes get more varied. As a result, outbound and inbound operation lines that need to be scheduled get more complicated, including outbound and inbound statuses of rolling stock in all service routes before the start of the operation, after the end of the operation and between adjacent time periods. Additionally, there are two or more depots corresponding to multiple groups of switch tracks on most of the lines. The problems such as comprehensive utilization of the plurality of switch tracks, and optimal matching between rolling stocks, mainlines and the switch tracks, as well as coordination of outbound and inbound trains on the switch tracks of the same depot in different directions get more complicated.

[0004] Currently, the research field has focused on models for optimization of outbound paths without load on the rolling stock before the start of the operation, but not considered the inbound issue after the end of the operation and the outbound and inbound issues between adjacent time periods. At the same time, since commonly-used diagramming tools for operation management practices are designed without considering constraints on depots and capacities thereof, a diagram maker compiles outbound and inbound operation lines, constraints of multiple depots, multi-path outbound and inbound management, irregular connections and conflict resolution mainly through manual calculations, consuming a lot of working time, which is a major factor that influences diagram compiling efficiency.

SUMMARY

[0005] The present invention aims to provide a method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots, by which outbound and inbound operation paths of all rolling stock and operation times can be synchronously generated while compiling a mainline operation diagram. It also satisfies the constraints of actual parking capacities in multiple depots and the demand for resolving parking conflicts.

[0006] To achieve the above goal, the present invention provides a method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots. Based on arrival and departure events of the mainline path and mainline operation line, this method supports the compilation of outbound and inbound operation lines for the multiple depots, each of which contains multiple switch tracks. The method comprises the following steps:

S1, screening out, based on the mainline path, a feasible outbound and inbound path set corresponding to switch tracks in each depot that can be connected to the mainline path;

S2, identifying, based on a connection mode of an outbound and inbound path and the mainline path, outbound and inbound districts to be compiled in a feasible outbound and inbound path and assigning a time scale to the outbound and inbound districts as a feasible outbound and inbound operation line set;

S3, matching a feasible outbound and inbound operation line of a corresponding time period, service route and direction for each originating event and terminating event of the mainline to be connected to the outbound and inbound operation line;

S4, according to a constraint on depot parking capacities, generating arrival and departure events of a corresponding feasible outbound and inbound operation line at each station in a district, and checking and resolving any time conflicts between the arrival and departure events in the feasible outbound and inbound operation line and those in mainline operation line; and determining the ultimately adopted train outbound and inbound depots, outbound and inbound paths and arrival and departure events in the outbound and inbound operation line matched with the originating event and terminating event of the

mainline based on outbound and inbound interval constraint of the depot.

[0007] Optionally, in Step S 1, screening out a feasible outbound and inbound path set corresponding to switch tracks in each depot that can be connected to the mainline path comprises: screening out a direct outbound path set and a direct inbound path set;

The direct outbound path set comprises all the paths starting from a switch track, passing through an originating station of the mainline path, and ending at either an originating turnaround track or a terminating turnaround track in the mainline path;

The direct inbound path set comprises all the paths starting from either an originating turnaround track or a terminating turnaround track in the mainline path, passing through the terminating station of the mainline path, and ending at a switch track;

Optionally, a direct outbound path comprises a forward direct outbound path and a reverse direct outbound path; and a direct inbound path comprises a forward direct inbound path and a reverse direct inbound path;

In the forward direct outbound path, a travel direction of a train outgoing to the originating station of the mainline path is the same as that of the train departing from the originating station of the mainline path later;

In the reverse direct outbound path, a travel direction of a train outgoing to the originating station of the mainline path is opposite to that of the train departing from the originating station of the mainline path later;

In the forward direct inbound path, a travel direction of a train arriving at the terminating station of the mainline path is the same as that of the train departing from the terminating station of the mainline path for inbound;

In the reverse direct inbound path, a travel direction of a train arriving at the terminating station of the mainline path is opposite to that of the train departing from the terminating station of the mainline path for inbound;

Optionally, in Step S1, screening out a feasible outbound and inbound path set corresponding to switch tracks in each depot that can be connected to the mainline path comprises: screening out an indirect outbound path set and an indirect inbound path set;

Paths starting from switch tracks and ending at turnaround tracks of transfer stations are taken as first outbound paths; paths starting from turnaround tracks of transfer stations and ending at originating turnaround tracks of the mainline path are taken as second outbound paths; and combinations of the first outbound paths and the second outbound paths form an indirect outbound path set;

Paths starting from terminating turnaround tracks of the mainline path and ending at turnaround tracks of transfer stations are taken as first inbound paths; paths starting from turnaround tracks of the transfer stations and ending at the switch tracks are second inbound paths; and combinations of the first inbound paths and the second inbound paths form an indirect inbound path set;

Wherein, the transfer station is any station on the mainline operation line that has front and back paths in opposite directions and connects the switch track with the originating station of the mainline path, or with the destination station of the mainline path;

Optionally, identifying outbound and inbound districts to be compiled in a feasible outbound and inbound path comprises:

For the forward direct outbound path, a district between a switch track and an originating station of the mainline path is an outbound district to be compiled;

For the forward direct inbound path, a district between a destination station of the mainline path and a switch track is an inbound district to be compiled.

[0008] Optionally, identifying outbound and inbound districts to be compiled in a feasible outbound and inbound path further comprises:

For the reverse direct outbound path, a district between a switch track and an originating station of the mainline path is an outbound district to be compiled;

For the reverse direct inbound path, a district between a destination station of the mainline path and the switch track is an inbound district to be compiled.

[0009] Optionally, identifying outbound and inbound districts to be compiled in a feasible outbound and inbound path further comprises:

For the indirect outbound path, a district between a switch track and a transfer station and a district between the transfer station and an originating station of the mainline path are outbound districts to be compiled;

For the indirect inbound path, a district between a destination station of the mainline path and a transfer station and a district between the transfer station and a switch track are inbound districts to be compiled.

[0010] Optionally, the time scales comprise train section operation time scales, station dwell time scales and turnaround time scales.

Optionally, a forward direct outbound operation line is connected to the mainline operation line through station dwell time at the mainline originating station;

A forward direct inbound operation line is connected to the mainline operation line through station dwell time at the mainline destination station;

A reverse direct outbound operation line and an indirect outbound operation line are connected to the mainline operation line through turnaround time at the mainline originating station;

A reverse direct inbound operation line and an indirect inbound operation line are connected to the mainline operation line through turnaround time at the mainline destination station;

Optionally, Step S4 comprises:

S41, selecting an outbound and inbound path from the outbound and inbound path set; generating departure events and arrival events on outbound and inbound operation lines corresponding to depots at each station within the district based on the sequence with which the depots are used; where the departure events and the arrival events of corresponding switch track satisfy a constraint on the total number of the trains parked at the depot, a constraint on the total number of the outbound trains at the depot, and a constraint on the number of the trains parked on the switch track;

S42, checking whether the departure and arrival events of the outbound and inbound operation line and the departure and arrival events on the mainline operation line satisfy a minimum operation interval; if yes, going to Step S43; otherwise, translating the corresponding outbound and inbound operation line along a time axis within a set turnaround time range; and if the minimum operation interval is still not satisfied, going back to Step S41, and otherwise, going to Step S43;

S43, determining whether the departure events and arrival events on switch tracks corresponding to depots satisfy continuous departure and return intervals in the depots; if yes, determining final train outbound and inbound depots, outbound and inbound paths and arrival and departure events of outbound and inbound operation lines matched with the originating and terminating events on the mainline, and otherwise, going back to Step S41.

[0011] Compared with the prior art, the present invention has the beneficial effects as follows:

1) The method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots in the present invention can automatically identify feasible outbound and inbound paths corresponding to the mainline path. Based on the connectivity between outbound and inbound paths and the mainline path, it automatically determines the actual outbound and inbound districts to be compiled, eliminating the need for manual searching and calculation one by one;

2) It allows for selecting depots and outbound and inbound operation lines, enabling coordinated outbound and inbound management in multiple depots, multiple paths, and multiple directions;

3) Based on the sequence of the paths and the constraints on the capacities of the depots, it adaptively determines optimal outbound and inbound paths and timings, ensuring that the number of departing trains is equal to the number of return trains in each depot throughout the day and satisfying the continuous departure interval, the continuous return interval and the minimum operation interval;

4) It can integrate and compile all the outbound and inbound operation lines on the mainline operation line before the start of the operation, after the end of the operation and between the adjacent time periods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

FIG. 1 is a flow diagram of a method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots according to the present invention;

FIG. 2A is a schematic diagram of direct outbound paths, direct inbound paths and corresponding outbound and inbound districts to be compiled according to the embodiment of the present invention;

FIG. 2B is a schematic diagram of indirect outbound paths, indirect inbound paths and corresponding out-

bound and inbound districts to be compiled according to the embodiment of the present invention;

FIG. 3 is a flow diagram of the compilation of outbound and inbound operation lines determined to be ultimately adopted according to the embodiment of the present invention;

FIG. 4 is a schematic diagram of operation lines, including mainline operation lines, outbound operation lines at the start of the operation and outbound operation lines between adj acent time periods, generated according to the embodiment of the present invention;

FIG. 5 is a schematic diagram of operation lines, including mainline operation lines, inbound operation lines after the end of the operation and inbound operation lines between adj acent time periods, generated according to the embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0013] Further description of the present invention in detail will be made below in combination with drawings and specific embodiments. The advantages and features of the present invention are clearer according to descriptions and claims below. It is to be noted that the drawings in a quite simplified form and an inaccurate ratio are merely used for describing objectives of the embodiments of the present invention conveniently and clearly in an assistant manner.

[0014] The present invention provides a method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots, by which outbound and inbound operation lines during various time periods throughout the day are uniformly compiled, based on a determined mainline operation diagram, by collaborating parking capacities of multiple depots and resolving conflicts in operation paths and timings of multiple trains.

[0015] The method of the present invention supports the compilation of outbound and inbound operation lines of multiple depots, each of which includes multiple switch tracks, on the basis of the mainline path and arrival and departure events on the mainline operation line. As shown in FIG. 1, the compilation method includes the steps:

S 1, screening out, based on the mainline path, a feasible outbound and inbound path set corresponding to switch tracks in each depot that can be connected to the mainline path;

in Step S1, screening out a feasible outbound and inbound path set corresponding to switch tracks in each depot that can be connected to the mainline path includes: screening out a direct outbound path set, a direct inbound path set, an indirect outbound path set and an indirect inbound path set.

[0016] The direct outbound path set includes all the direct outbound paths starting from a switch track, passing through an originating station of the mainline path and ending at an originating turnaround track of the mainline path or at a terminating turnaround track of the mainline path.

[0017] As shown in FIG. 2A, a direct outbound path includes a forward direct outbound path and a reverse direct outbound path.

[0018] In the forward direct outbound path, a travel direction of a train outgoing to the originating station of the mainline path is the same as that of the train departing from the originating station of the mainline path later. That is, the originating station of the mainline path does not have front and back paths in opposite directions. When a path in which the train arrives at a station is opposite to a path in which the train departs from the station, the station has the front and back paths in opposite directions.

[0019] In the reverse direct outbound path, a travel direction of a train outgoing to the originating station of the mainline path is opposite to that of the train departing from the originating station of the mainline path later. That is, the originating station of the mainline path has front and back paths in opposite directions.

[0020] In FIG. 2A, switch track I, switch track II and switch track III are all connected to the mainline operation line, providing parking service for the trains on the mainline operation line through corresponding depot I, depot II and depot III.

[0021] As shown in FIG. 2A, the direct inbound path set includes all the direct inbound paths starting from an originating turnaround track of the mainline path or a terminating turnaround track of the mainline path, passing through the terminating station of the mainline path and ending at a switch track. A direct inbound path includes a forward direct inbound path and a reverse direct outbound path.

[0022] In the forward direct inbound path, a travel direction of a train arriving at the terminating station of the mainline path is the same as a travel direction of the train departing from the terminating station of the mainline path for inbound.

[0023] In the reverse direct inbound path, a travel direction of a train arriving at the terminating station of the mainline path is opposite to a travel direction of the train departing from the terminating station of the mainline path for inbound.

[0024] In FIG. 2B, a transfer station is provided between the switch track II and the mainline destination station. The transfer station is any station on the mainline operation line that has front and back paths in opposite directions and connects the switch track with the originating station of the mainline path, or with the destination

station of the mainline path.

[0025] Paths starting from switch tracks and ending at turnaround tracks of the transfer stations are taken as first outbound paths; paths starting from the turnaround tracks of the transfer stations and ending at originating turnaround tracks of the mainline path are taken as second outbound paths; and combinations of the first outbound paths and the second outbound paths form an indirect outbound path set.

[0026] Paths starting from terminating turnaround tracks of the mainline path and ending at turnaround tracks of the transfer stations are taken as first inbound path; paths starting from turnaround tracks of the transfer stations and ending at switch tracks are taken as second inbound paths; and combinations of the first inbound paths and the second inbound paths form an indirect inbound path set. FIG. 2B shows an indirect outbound path and an indirect inbound path respectively.

[0027] S2, identifying, based on a connection mode of an outbound and inbound path and the mainline path, outbound and inbound districts to be compiled in a feasible outbound and inbound paths; and assigning a time scale to the outbound and inbound districts as a feasible outbound and inbound operation line set.

[0028] For the forward direct outbound path, a district between a switch track and an originating station of the mainline path is an outbound district to be compiled, namely a district on the forward direct outbound path (solid line) that does not coincide with the mainline operation line (dotted line) in FIG. 2A.

[0029] For the forward direct inbound path, a district between a destination station of the mainline path and a switch track is an inbound district to be compiled, namely a district on the forward direct inbound path (solid line) that does not coincide with the mainline operation line (dotted line) in FIG. 2A.

[0030] For the reverse direct outbound path, a district between a switch track and an originating station of the mainline path is an outbound district to be compiled, namely a solid-line district on the reverse direct outbound path in FIG. 2A.

[0031] For the reverse direct inbound path, a district between a destination station of the mainline path and a switch track is an inbound district to be compiled, namely a solid-line district on the reverse direct inbound path in FIG. 2A.

[0032] For the indirect outbound path, a district between a switch track and a transfer station and a district between the transfer station and an originating station of the mainline path are outbound districts to be compiled, namely solid-line districts on the indirect outbound path in FIG. 2B.

[0033] For the indirect inbound path, a district between a destination station of the mainline path and a transfer station and a district between the transfer station and a switch track are the inbound districts to be compiled.

S3, matching a feasible outbound and inbound operation line of a corresponding time period, service route and direction for each scheduled originating event and terminating event of the mainline to be connected to the outbound and inbound operation line;

the originating event of the mainline refers to a departure event at the originating station in the first task for each rolling stock scheduling in a mainline operation diagram, and the terminating event of the mainline refers to an arrival event at the terminating station in the last task for each rolling stock scheduling in the mainline operation diagram.

A forward direct outbound operation line is connected to the mainline operation line through station dwell time at the mainline originating station;

A forward direct inbound operation line is connected to the mainline operation line through station dwell time at the mainline destination station;

A reverse direct outbound operation line and an indirect outbound operation line are connected to the mainline operation line through turnaround time at the mainline originating station;

A reverse direct inbound operation line and an indirect inbound operation line are connected to the mainline operation line through turnaround time at the mainline destination station;

S4, according to a constraint on depot parking capacities, generating arrival and departure events of a corresponding feasible outbound and inbound operation line at each station in a district, and checking and resolving any time conflicts between the arrival and departure events in the feasible outbound and inbound operation line and those in mainline operation line; and determining the ultimately adopted train outbound and inbound depots, outbound and inbound paths and arrival and departure events in the outbound and inbound operation line matched with the originating event and terminating event of the mainline based on outbound and inbound interval constraint of the depot.

[0034] As shown in FIG. 3, Step S4 includes:

S41, selecting an outbound and inbound path from the outbound and inbound path set; generating departure events and arrival events on outbound and inbound operation lines corresponding to depots at each station within the district based on the sequence with which the depots are used; where the departure events and the arrival events of corresponding switch track satisfy a constraint on the total number of the trains parked at the depot, a constraint

on the total number of the outbound trains at the depot and a constraint on the number of the trains parked on the switch track;

S42, checking whether the departure and arrival events of the outbound and inbound operation line and the departure and arrival events on the mainline operation line satisfy a minimum operation interval; if yes, going to Step S43; otherwise, translating the corresponding outbound and inbound operation line along a time axis within a set turnaround time range; and if the minimum operation interval is still not satisfied, going back to Step S41, and otherwise, going to Step S43;

S43, determining whether the departure events and arrival events on switch tracks corresponding to depots satisfy continuous departure and return intervals in the depots; if yes, determining final train outbound and inbound depots, outbound and inbound paths and arrival and departure events of outbound and inbound operation lines matched with the originating and terminating events on the mainline, and otherwise, going back to Step S41.

[0035] As shown in FIG. 4 and FIG. 5, taking an urban rail transit line as an example, all-day outbound and inbound operation lines with coordination of multiple depots, namely lines starting from or ending at a switch track at a parking yard or a train depot, are automatically compiled based on a mainline operation diagram generated by existing diagram compilation software according to the aforementioned steps. Wherein the feasible outbound and inbound path sets are sorted in ascending order of no-load distances. FIG. 4 is a schematic diagram of operation lines, including mainline operation lines, outbound operation lines at the start of the operation and between adjacent time periods, and FIG. 5 is a schematic diagram of operation lines, including mainline operation lines, inbound operation lines after the end of the operation and between adj acent time periods.

[0036] The method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots in the present invention can automatically identify feasible outbound and inbound paths corresponding to the mainline path. Based on the connectivity between outbound and inbound paths and the mainline path, it automatically determines the actual outbound and inbound districts to be compiled, eliminating the need for manual searching and calculation one by one. The present invention can screen out depots and outbound and inbound operation lines for use and allows outbound and inbound management in multiple depots, multiple paths and multiple directions. Based on the sequence of the paths and the constraints on the capacities of the depots, it adaptively determines optimal outbound and inbound paths and timings, ensuring that the number of departing trains is equal to the number of return trains in each depot throughout the day and satisfying the continuous departure interval, the continuous return interval and the minimum operation interval. The present invention can integrate and compile all the outbound and inbound operation lines on the mainline operation line before the start of the operation, after the end of the operation and between the adjacent time periods.

[0037] It should be understood that in the above embodiments, the serial numbers of the above-mentioned steps do not mean the execution sequence, and the execution sequence of the steps should be determined by their functions and internal logics, and not constitute any limitation to the implementation process of the embodiments of the present invention.

[0038] While the contents of the present invention have been described in detail by the foregoing preferred embodiments, it should be understood that the aforementioned descriptions should not be considered as limitations to the present invention. Various modifications and alternatives to the present invention will become apparent to those skilled in the art upon reading the foregoing disclosure. Accordingly, the protection scope of the present invention should be defined by the appended claims.

Claims

1. A method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots, supporting the compilation of outbound and inbound operation lines of multiple depots, each of which comprises multiple switch tracks, on the basis of a mainline path and arrival and departure events of a mainline operation line. The method comprises the steps of:

   S1, screening out, based on the mainline path, a feasible outbound and inbound path set corresponding to switch tracks in each depot that can be connected to the mainline path;

   S2, identifying, based on a connection mode of an outbound and inbound path and the mainline path, outbound and inbound districts to be compiled in a feasible outbound and inbound path and assigning a time scale to the outbound and inbound districts as a feasible outbound and inbound operation line set;

   S3, matching a feasible outbound and inbound operation line of a corresponding time period, service route and direction for each originating event and terminating event of the mainline to be connected to the outbound and inbound operation line; and

   S4, according to a constraint on depot parking capacities, generating arrival and departure events of a corresponding feasible outbound and inbound operation line at each station in a

district, and checking and resolving any time conflicts between the arrival and departure events in the feasible outbound and inbound operation line and those in mainline operation line; and determining the ultimately adopted train outbound and inbound depots, outbound and inbound paths and arrival and departure events of the outbound and inbound operation line matched with the originating event and terminating event of the mainline based on outbound and inbound interval constraint of the depot.

2. The method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots according to claim 1, wherein in Step S1, screening out a feasible outbound and inbound path set corresponding to switch tracks in each depot that can be connected to the mainline path comprises: screening out a direct outbound path set and a direct inbound path set;

the direct outbound path set comprises all the paths starting from a switch track, passing through an originating station of the mainline path and ending at either an originating turnaround track or a terminating turnaround track in the mainline path;
the direct inbound path set comprises all the paths starting from either an originating turnaround track or a terminating turnaround track in the mainline path, passing through the terminating station of the mainline path, and ending at a switch track.

3. The method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots according to claim 2, wherein a direct outbound path comprises a forward direct outbound path and a reverse direct outbound path; and a direct inbound path comprises a forward direct inbound path and a reverse direct inbound path;

in the forward direct outbound path, a travel direction of a train outgoing to the originating station of the mainline path is the same as that of the train departing from the originating station of the mainline path later;
in the reverse direct outbound path, a travel direction of a train outgoing to the originating station of the mainline path is opposite to that of the train departing from the originating station of the mainline path later;
In the forward direct inbound path, a travel direction of a train arriving at the terminating station of the mainline path is the same as that of the train departing from the terminating station of the mainline path for inbound;
in the reverse direct inbound path, a travel direction of a train arriving at the terminating station of the mainline path is opposite to that of the train departing from the terminating station of the mainline path for inbound.

4. The method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots according to claim 1, wherein in Step S1, screening out a feasible outbound and inbound path set corresponding to switch tracks in each depot that can be connected to the mainline path comprises: screening out an indirect outbound path set and an indirect inbound path set;

path starting from switch tracks and ending at turnaround tracks of transfer stations are taken as first outbound paths; paths starting from turnaround tracks of transfer stations and ending at originating turnaround tracks of the mainline path are taken as second outbound paths; and combinations of the first outbound paths and the second outbound paths form an indirect outbound path set;
paths starting from terminating turnaround tracks of the mainline path and ending at turnaround tracks of transfer stations are taken as first inbound paths; paths starting from turnaround tracks of the transfer stations and ending at the switch tracks are second inbound paths; and combinations of the first inbound paths and the second inbound paths form an indirect inbound path set;
wherein the transfer station is any station on the mainline operation line that has front and back paths in opposite directions and connects the switch track with the originating station of the mainline path, or with the destination station of the mainline path.

5. The method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots according to claim 3, wherein identifying outbound and inbound districts to be compiled in a feasible outbound and inbound path comprises:

for the forward direct departing path, a district between a switch track and an originating station of the mainline path is an outbound district to be compiled;
for the forward direct inbound path, a district between a destination station of the mainline path and a switch track is an inbound district to be compiled.

6. The method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots according to claim 3, wherein identifying outbound and inbound districts to be compiled

in a feasible outbound and inbound path further comprises:

for the reverse direct outbound path, a district between a switch track and an originating station of the mainline path is an outbound district to be compiled;
for the reverse direct inbound path, a district between a destination station of the mainline path and the switch track is an inbound district to be compiled.

7. The method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots according to claim 4, wherein identifying outbound and inbound districts to be compiled in a feasible outbound and inbound path further comprises:

for the indirect outbound path, a district between a switch track and a transfer station and a district between the transfer station and an originating station of the mainline path are outbound districts to be compiled;
for the indirect inbound path, a district between a destination station of the mainline path and a transfer station and a district between the transfer station and a switch track are inbound districts to be compiled.

8. The method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots according to claim 1, wherein the time scales comprise train section operation time scales, station dwell time scales and turnaround time scales.

9. The method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots according to claim 1, wherein

a forward direct outbound operation line is connected to the mainline operation line through station dwell time at the mainline originating station;
a forward direct inbound operation line is connected to the mainline operation line through station dwell time at the mainline destination station;
a reverse direct outbound operation line and an indirect outbound operation line are connected to the mainline operation line through turnaround time at the mainline originating station; and
a reverse direct inbound operation line and an indirect inbound operation line are connected to the mainline operation line through turnaround time at the mainline destination station.

10. The method for compilation of urban rail transit outbound and inbound operation lines with coordination of multiple depots according to claim 1, wherein Step S4 comprises:

S41, selecting an outbound and inbound path from the outbound and inbound path set; generating departure events and arrival events on outbound and inbound operation lines corresponding to depots at each station within the district based on the sequence with which the depots are used; where the departure events and the arrival events of corresponding switch track satisfy a constraint on the total number of the trains parked at the depot, a constraint on the total number of the outbound trains at the depot, and a constraint on the number of the trains parked on the switch track;
S42, checking whether the departure and arrival events on the outbound and inbound operation line and the departure and arrival events of the mainline operation line satisfy a minimum operation interval; if yes, going to Step S43; otherwise, translating the corresponding outbound and inbound operation line along a time axis within a set turnaround time range; and if the minimum operation interval is still not satisfied, going back to Step S41, and otherwise, going to Step S43; and
S43, determining whether the departure events and arrival events on switch tracks corresponding to depots satisfy continuous departure and return intervals in the depots; if yes, determining final train outbound and inbound depots, outbound and inbound paths and arrival and departure events of outbound and inbound operation lines matched with the originating and terminating events on the mainline, and otherwise, going back to Step S41.

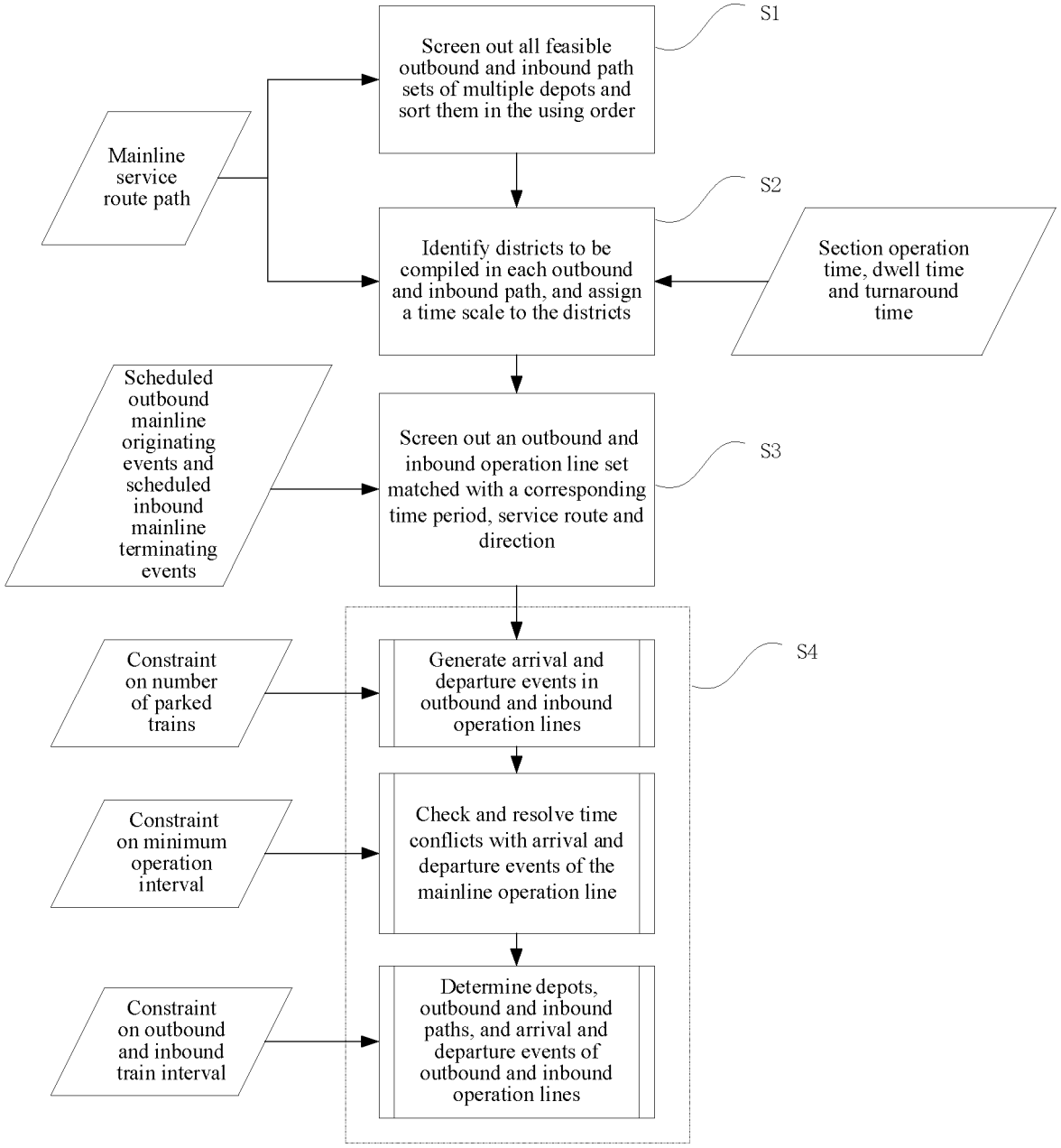
S1
Screen out all feasible outbound and inbound path sets of multiple depots and sort them in the using order
Mainline service route path
S2
Identify districts to be compiled in each outbound and inbound path, and assign a time scale to the districts
Section operation time, dwell time and turnaround time
Scheduled outbound mainline originating events and scheduled inbound mainline terminating events
Screen out an outbound and inbound operation line set matched with a corresponding time period, service route and direction
S3
S4
Constraint on number of parked trains
Generate arrival and departure events in outbound and inbound operation lines
Constraint on minimum operation interval
Check and resolve time conflicts with arrival and departure events of the mainline operation line
Constraint on outbound and inbound train interval
Determine depots, outbound and inbound paths, and arrival and departure events of outbound and inbound operation lines

FIG. 1

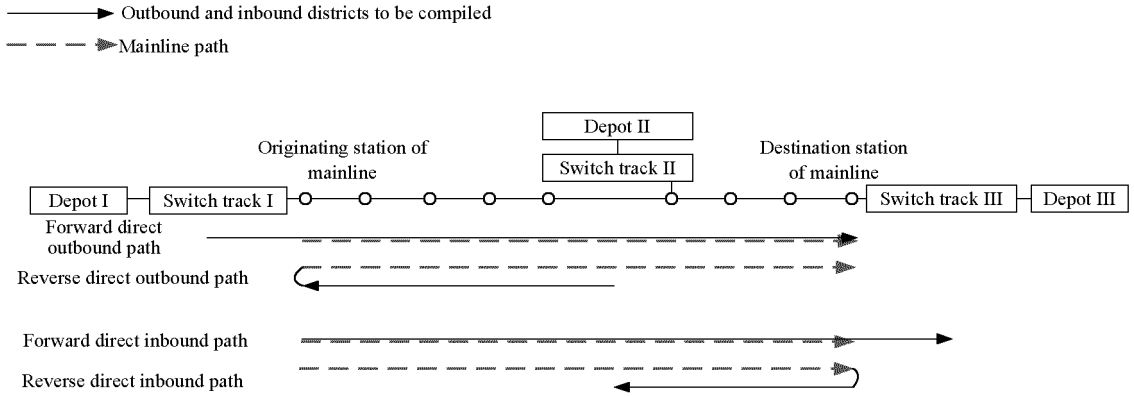
Outbound and inbound districts to be compiled
Mainline path
Depot II
Originating station of mainline
Switch track II
Destination station of mainline
Depot I
Switch track I
Switch track III
Depot III
Forward direct outbound path
Reverse direct outbound path
Forward direct inbound path
Reverse direct inbound path

FIG. 2A

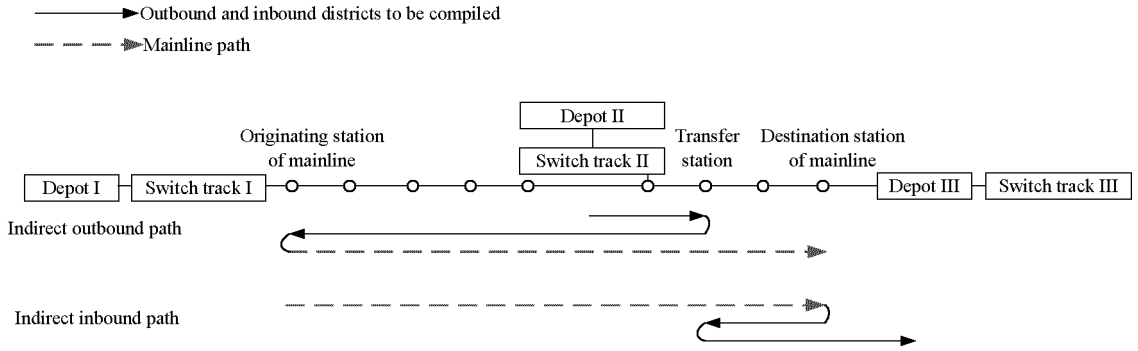
Outbound and inbound districts to be compiled
Mainline path
Depot II
Originating station of mainline
Switch track II
Transfer station
Destination station of mainline
Depot I
Switch track I
Depot III
Switch track III
Indirect outbound path
Indirect inbound path

FIG. 2B

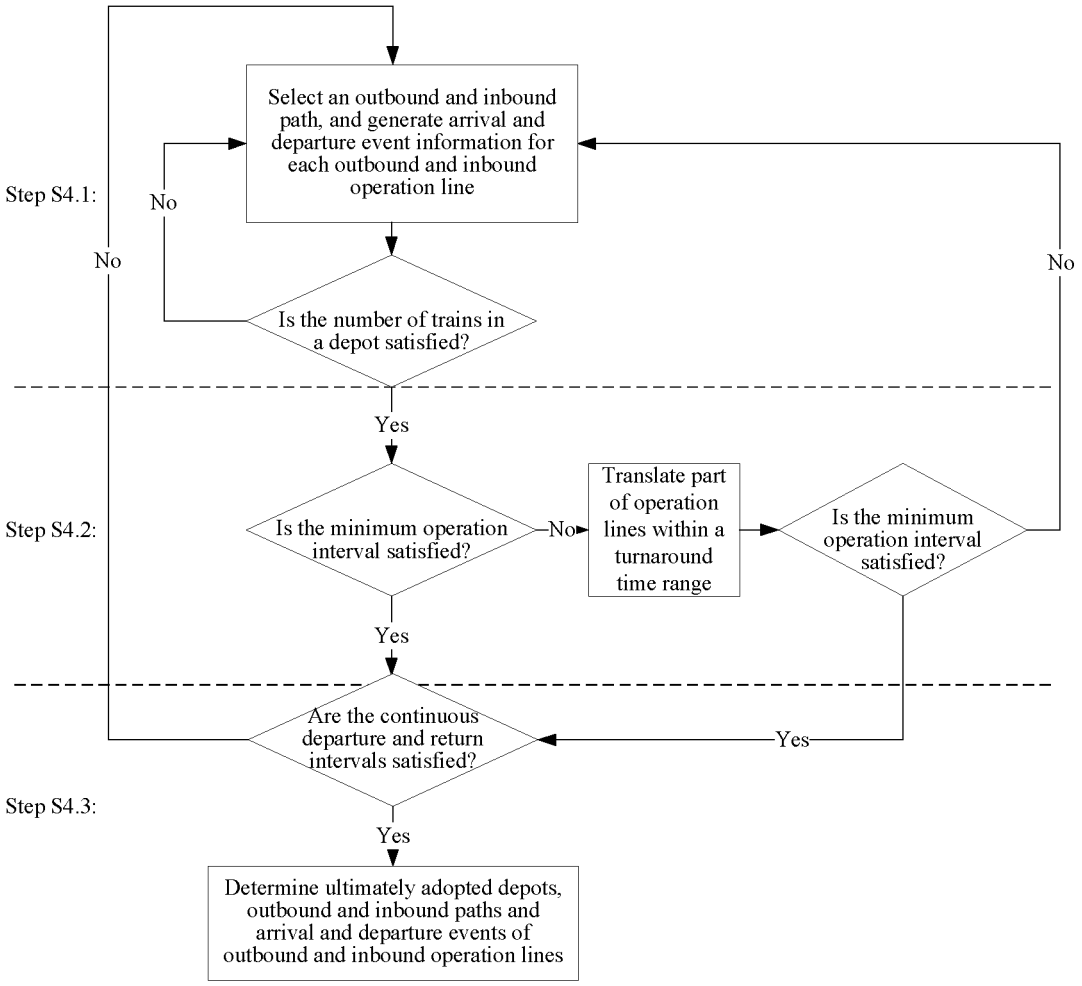
Step S4.1:
Select an outbound and inbound path, and generate arrival and departure event information for each outbound and inbound operation line
No
Is the number of trains in a depot satisfied?
No
Yes
Step S4.2:
Is the minimum operation interval satisfied?
No
Translate part of operation lines within a turnaround time range
Is the minimum operation interval satisfied?
No
Yes
Step S4.3:
Are the continuous departure and return intervals satisfied?
Yes
Yes
Determine ultimately adopted depots, outbound and inbound paths and arrival and departure events of outbound and inbound operation lines

FIG. 3

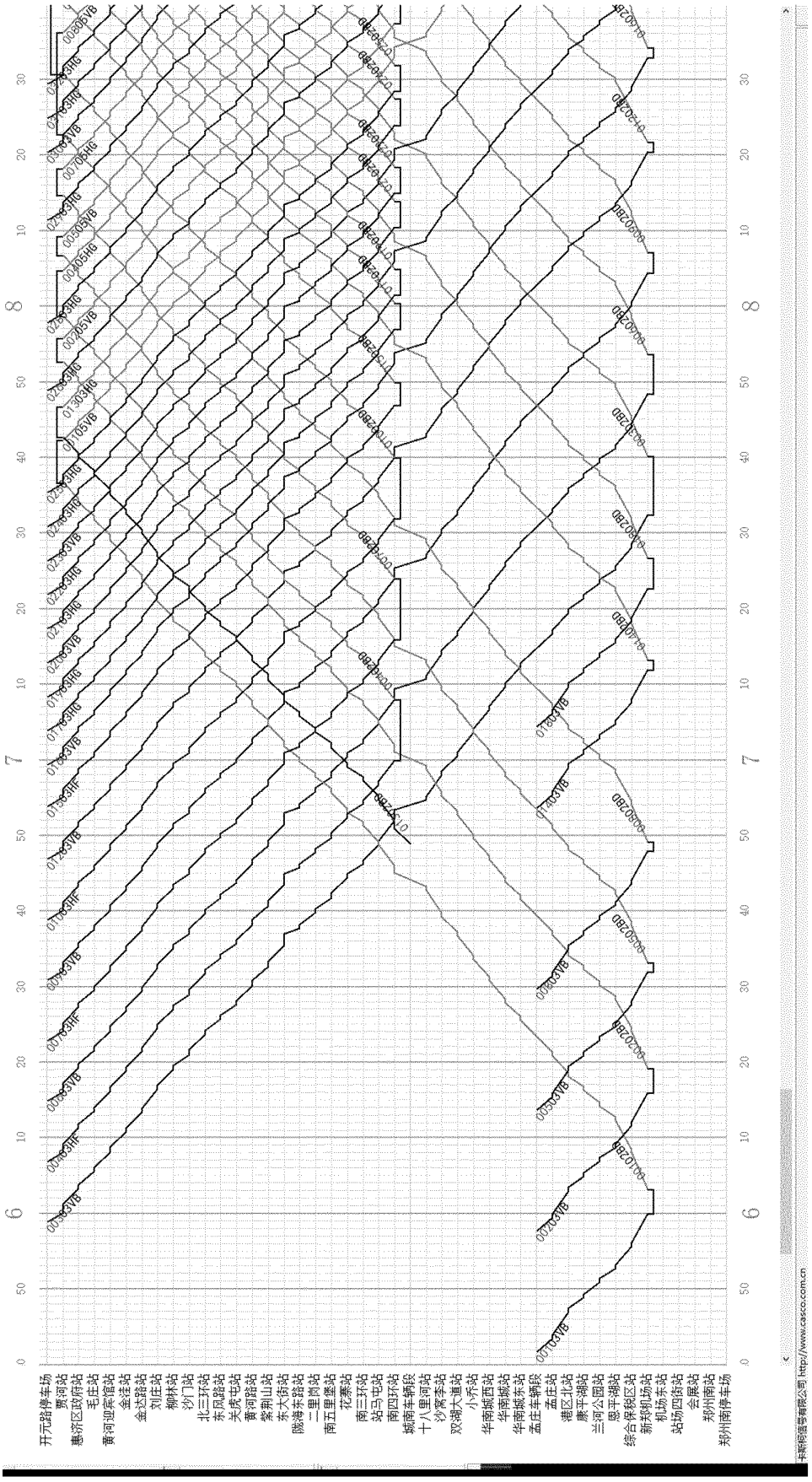
开元路停车场
贾河站
惠济区政府站
毛庄站
黄河迎宾馆站
金连站
金达路站
刘庄站
柳林站
沙门站
北三环站
东风路站
关虎屯站
黄河路站
紫荆山站
东大街站
陇海东路站
二里岗站
南五里堡站
花寨站
南三环站
站马屯站
南四环站
城南车辆段
十八里河站
沙窝李站
双湖大道站
小乔站
华南城西站
华南城站
华南城东站
孟庄车辆段
孟庄站
港区北站
廉平湖站
兰河公园站
恩平湖站
综合保税区站
新郑机场站
机场东站
站场四街站
会展站
郑州南站
郑州南停车场

FIG.4

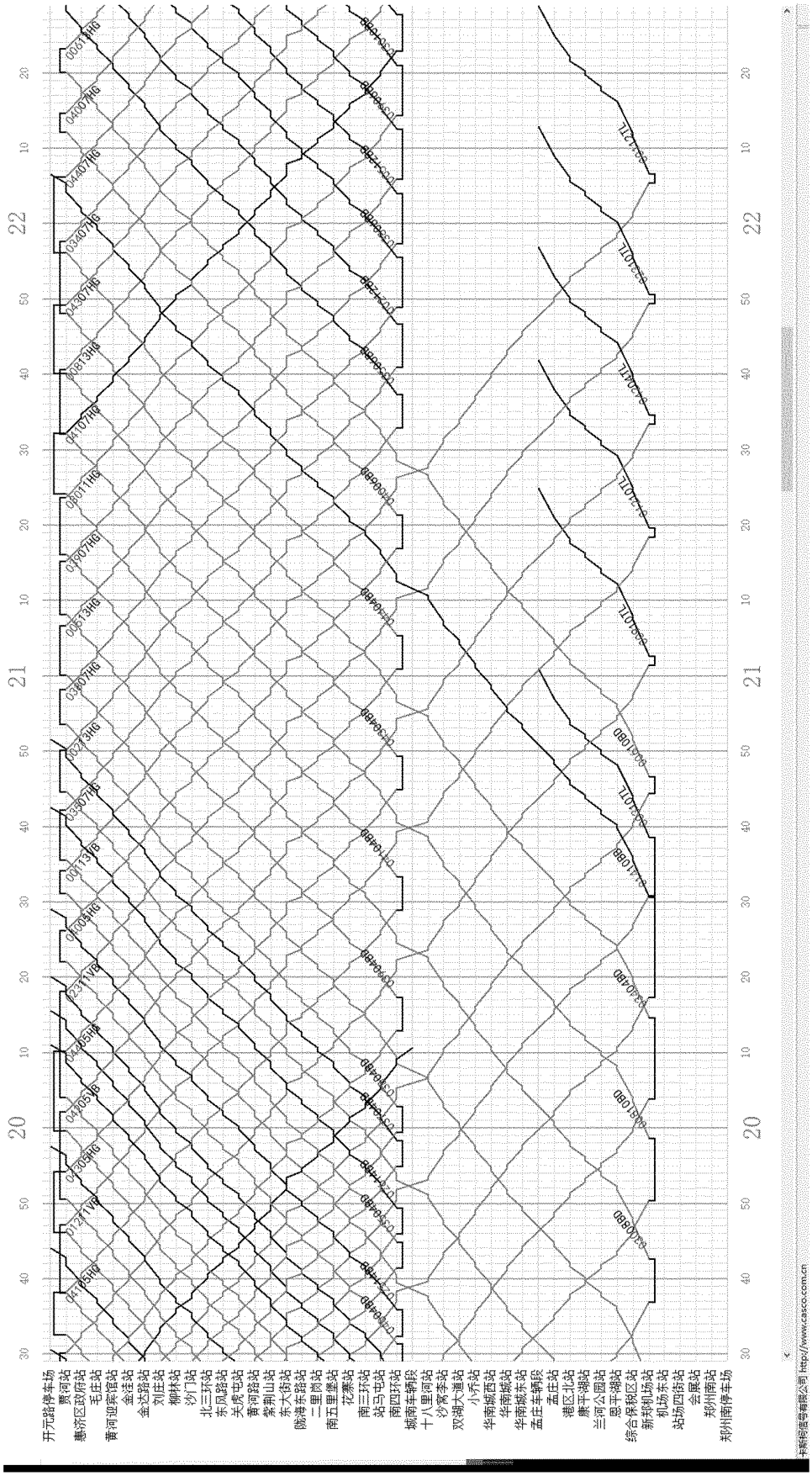
开元路停车场
惠河站
惠济区政府站
毛庄站
黄河迎宾馆站
金洼站
金达路站
刘庄站
柳林站
沙门站
北三环站
东风路站
关虎屯站
黄河路站
紫荆山站
东大街站
陈滩东路站
二里岗站
南五里堡站
花寨站
南三环站
站马屯站
南四环站
城南车辆段
十八里河站
沙窝李站
双湖大道站
小乔站
华南城西站
华南城站
华南城东站
孟庄车辆段
孟庄站
港区北站
康平湖站
兰河公园站
恩平湖站
综合保税区站
新郑机场站
机场东站
站场四街站
会展站
郑州南站
郑州南停车场
22
21
20

FIG.5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/130874

A. CLASSIFICATION OF SUBJECT MATTER

B61L 27/10(2022.01)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)

B61L

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

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

CNTXT, ENTXTC, CNKI: 轨道交通, 地铁, 出库, 入库, 场段, 车辆段, 停车场, 正线, 运行线, 编制; ENTXT, VEN: rail, railway, traffic, transportation, transit, metro, subway, garage, warehouse, depot, main track, running line, program, compile.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 113968264 A (CASCO SIGNAL LTD.) 25 January 2022 (2022-01-25) claims 1-10	1-10
A	CN 112373521 A (BEIJING URBAN CONSTRUCTION DESIGN & DEVELOPMENT GROUP CO., LTD.) 19 February 2021 (2021-02-19) description, paragraphs 34-202, and figures 1-11	1-10
A	CN 111353705 A (TRAFFIC CONTROL TECHNOLOGY CO., LTD.; CHENGDU RAIL TRANSIT GROUP CO., LTD.) 30 June 2020 (2020-06-30) description, paragraphs 47-144, and figures 1-2	1-10
A	JP 2001278052 A (KAWASAKI HEAVY INDUSTRIES LTD.) 10 October 2001 (2001-10-10) entire document	1-10
A	JP H06144230 A (TOSHIBA CORP.) 24 May 1994 (1994-05-24) entire document	1-10

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"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
27 January 2023	**10 February 2023**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/130874

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 113968264 A	25 January 2022	None	
CN 112373521 A	19 February 2021	None	
CN 111353705 A	30 June 2020	CN 111353705 B	06 April 2021
JP 2001278052 A	10 October 2001	None	
JP H06144230 A	24 May 1994	None	

Form PCT/ISA/210 (patent family annex) (July 2022)