

[Name of Document] DESCRIPTION

[Title of Invention] ELEVATOR APPARATUS AND METHOD FOR
CONTROLLING ELEVATOR APPARATUS

[Technical Field]

[0001]

The present invention relates to an elevator apparatus and a method for controlling the elevator apparatus, and particularly relates to a group-management elevator apparatus that collectively manages a plurality of elevators and to a method for controlling the group-management elevator apparatus.

[Background Art]

[0002]

Relatively large buildings adopt systems in which a plurality of elevators are installed to increase the user transport capacity of elevators and in which an optimum elevator is selected for providing a service from among the plurality of elevators in response to a hall call registration. As the scale of a building increases, the number of elevators installed therein increases, and thus the plurality of elevators are appropriately managed by a group-management system so as to improve service, for example, to reduce the waiting time of a user (see, for example, PTLs 1 to 3).

[0003]

PTL 1 describes the following. "A target route indicating a target position of each elevator car at a time point within a predetermined future time is prepared for each elevator, and a predicted route corresponding to the target route is prepared by predicting the position of each elevator car. A hall call is assigned to an elevator car in such a manner that the predicted route approaches the target route. During the period when there is no assignment process, operation control other than assignment is performed, that is, the operation speed (car speed and acceleration) and the stop time (door open/close speed and opening time) of the elevators are adjusted."

[0004]

PTL 2 describes the following. "A target interval of each elevator is set, and a predicted interval of each elevator after the elapse of a predetermined period from the present time is calculated. The evaluation value of the predicted interval relative to the target interval of each elevator is calculated. On the basis of the evaluation value, assignment to a generated hall call is performed so that the predicted interval approaches the target interval."

[0005]

PTL 3 describes the following. "First evaluation for calculating a waiting time evaluation value of a hall call, second evaluation for calculating an evaluation value for a

time interval between elevators close to each other, and third evaluation for calculating an evaluation value for a journey time of each elevator are performed. An elevator to be assigned to a hall call is determined by using an overall evaluation value for evaluating, with a weight according to traffic demand, the evaluation values for the first evaluation, the second evaluation, and the third evaluation."

[Citation List]

[Patent Literature]

[0006]

[PTL 1] Japanese Unexamined Patent Application
Publication No. 2007-62927

[PTL 2] Japanese Unexamined Patent Application
Publication No. 2007-84184

[PTL 3] Japanese Unexamined Patent Application
Publication No. 2007-284164

[Summary of Invention]

[Technical Problem]

[0007]

In the related art described in PTL 1, a predicted route of each car along the time axis from the present time and a target route representing a target position are created, and the operation speed, the stop time, and the stop position of a waiting car are adjusted so that the

predicted route approaches the target route at a scheduled adjustment time point. However, in the related art described in PTL 1, although the equality of time intervals of cars is increased by predicting the operation routes of the individual cars and causing the operation routes at a predetermined future time point to be close to the target route or target intervals, the operation routes are highly dependent on prediction. Specifically, for example, an operation route is created by predicting the destination floor of a user on the basis of a past learning experience. That is, prediction from a learning experience, which is an uncertain element, is used to predict an operation route. Thus, the operation route is predicted with uncertainty, which causes variations in evaluation accuracy of the equality of intervals.

[0008]

In the related art described in PTL 2, a predicted route until a future interval estimation time after the elapse of a predetermined time is computed, and an interval evaluation value is calculated by using a deviation between a predicted interval and a target interval among individual cars at the interval estimation time. However, in the related art described in PTL 2, as in the related art described in PTL 1, prediction from a learning experience, which is an uncertain element, is used to predict an

operation route. Because the operation route is highly dependent on prediction, the evaluation accuracy of the equality of intervals varies.

[0009]

In the related art described in PTL 3, overall evaluation is performed by weighting the evaluation value of a weighting time at a hall call, the evaluation value for the time interval or distance interval between cars, and the evaluation value for a predicted value of one journey time. Furthermore, the stop time for exiting an elevator on a destination floor, input through a destination floor registration device, is newly reflected in an estimated arrival time. However, in the related art described in PTL 3, as in the related art described in PTL 1, prediction from a learning experience, which is an uncertain element, is used to predict an operation route. Because the operation route is highly dependent on prediction, the evaluation accuracy of the equality of intervals varies.

[0010]

An object of the present invention is to provide an elevator apparatus capable of suppressing variations in evaluation accuracy of the equality of intervals by predicting an operation route with higher reliability on the basis of elevator usage information registered by a user, and a method for controlling the elevator apparatus.

[Solution to Problem]

[0011]

To solve the above-described problems, the configuration described in the claims is adopted, for example.

The present application includes a plurality of solutions to the above-described problems, one of which is an elevator apparatus that assigns one of in-service units providing a service to each of users, on the basis of elevator usage information including at least an origin floor and a destination floor of the user, the elevator usage information being registered before entering an elevator. The elevator apparatus includes a route creation section that creates a future operation route that is fixed in reflection of the elevator usage information, an evaluation section that evaluates equality of time intervals of each of the in-service units in future on the basis of the future operation route, and a to-be-assigned unit determination section that assigns one of the in-service units providing a service to each of the users, on the basis of an evaluation result generated by the evaluation section.

[Advantageous Effects of Invention]

[0012]

According to the present invention, an operation route can be predicted with higher reliability on the basis of

elevator usage information including at least an origin floor and a destination floor of each user. Accordingly, variations in evaluation accuracy of the equality of time intervals at which in-service units are operated can be suppressed and stably equal time intervals can be realized. Thus, a long-wait ratio of an elevator for users can be decreased.

The problems, configurations, and advantages other than those described above will become apparent from the following description of an embodiment.

[Brief Description of Drawings]

[0013]

[Fig. 1] Fig. 1 is an example of a configuration diagram schematically illustrating the system configuration of a group-management elevator apparatus according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is an example of a flowchart illustrating a flow of a process of performing equality-of-intervals evaluation when an n-th unit is tentatively assigned in accordance with a fixed route according to Example 1.

[Fig. 3] Fig. 3 is an example of a diagram illustrating an exiting/entering times on individual floors table obtained through learning.

[Fig. 4] Fig. 4 is an example of a diagram illustrating an exiting/entering times on individual floors table based

on a registration status.

[Fig. 5] Fig. 5 is an example of a flowchart illustrating a flow of a process of performing equality-of-intervals evaluation in the case of tentatively assigning the n-th unit in accordance with a high-demand route according to Example 2.

[Fig. 6] Fig. 6 is an example of a diagram illustrating a number of users who exit/enter in each traffic flow on each floor table based on high-demand prediction.

[Fig. 7] Fig. 7 is an example of a flowchart illustrating a flow of a process of performing risk evaluation of the equality of intervals in the case of tentatively assigning the n-th unit in accordance with a high-demand route according to Example 3.

[Fig. 8] Fig. 8 is an example of an explanatory diagram illustrating the overview of a fixed route using reservation information according to Example 4.

[Fig. 9] Fig. 9 is an example of an explanatory diagram illustrating the overview of a high-demand route using reservation information according to Example 4.

[Fig. 10] Fig. 10 is an example of an explanatory diagram illustrating a high-demand floor table in each traffic flow according to Example 4.

[Fig. 11] Fig. 11 is an example of a diagram illustrating a display example of an estimated arrival time according to

Example 5.

[Fig. 12] Fig. 12 is an example of a diagram illustrating a display example of an estimated arrival route according to Example 5.

[Fig. 13] Fig. 13 is an example of a diagram illustrating a display example of an estimated arrival time at the time of registration according to Example 5.

[Fig. 14] Fig. 14 is an example of a diagram illustrating a display example of an estimated arrival time at the time of waiting according to Example 5.

[Description of Embodiments]

[0014]

Hereinafter, a mode for carrying out the present invention (hereinafter referred to as an "embodiment") will be described in detail with reference to the drawings. The present invention is not limited to the embodiment. Various numeric values and so forth according to the embodiment are merely examples, and various modification examples and application examples within the technical concept of the present invention are also included in the scope of the present invention.

[0015]

<Elevator Apparatus According to Embodiment of Invention>

An elevator apparatus according to an embodiment of the present invention is a group-management elevator apparatus

having a configuration of a group-management system that collectively manages a plurality of elevators.

[0016]

[System Configuration]

Fig. 1 is an example of a configuration diagram schematically illustrating the system configuration of a group-management elevator apparatus according to an embodiment of the present invention. As illustrated in Fig. 1, a group-management elevator apparatus 10 according to this embodiment has a system configuration including an elevator part 1, a group-management control part (group-management control device) 2, a hall call registration part (hall call registration device) 3, and an operation information display part (operation information display device) 4.

[0017]

(Elevator Part)

The elevator part 1 includes n (an integer of 2 or more) elevators 11_1, 11_2, ..., and 11_n and unit controllers 12_1, 12_2, ..., and 12_n that control the elevators 11_1, 11_2, ..., and 11_n, respectively. Hereinafter, the individual elevators 11_1, 11_2, ..., and 11_n of the elevator part 1 may be referred to as in-service units or simply units. The n elevators 11_1, 11_2, ..., and 11_n (the first unit 11_1, the second unit 11_2, ..., and

the n-th unit 11_n) are collectively managed under the control of the group-management control part 2, and a unit (elevator) for a user which is optimum from the viewpoint of waiting time and so forth is assigned via the unit controller 12_1, 12_2, ..., or 12_n.

[0018]

Each of the elevators 11_1, 11_2, ..., and 11_n of the elevator part 1 has a known configuration in which, for example, a car 111 and a counter weight 112 that are installed in a hoistway are connected to both ends of a main rope 113. In each of the elevators 11_1, 11_2, ..., and 11_n, the main rope 113 is wound around a sheave 114 and a pulley 115 of a hoisting machine (not illustrated).

[0019]

(Group-Management Control Part)

The group-management control part 2 includes a usage information acquisition section 20, a learning section 21, a high-demand information creation section 22, a fixed route/high-demand route creation section 23, a waiting time evaluation section 24, an interval evaluation section 25, a long-wait evaluation section 26, an overall evaluation section 27, a to-be-assigned unit determination section 28, and an operation information management section 29. The group-management control part 2 including these functional sections (20 to 29) collectively manages the n elevators

11_1, 11_2, ..., and 11_n so as to assign a unit (elevator) for a user which is optimum from the viewpoint of waiting time and so forth.

[0020]

The usage information acquisition section 20 acquires elevator usage information (described below) that is registered with the hall call registration part 3 by a user before entering an elevator, and provides the acquired elevator usage information to the leaning section 21 and the fixed route/high-demand route creation section 23.

[0021]

Here, the elevator usage information that is registered before entering an elevator is acquired from the hall call registration part 3, but the embodiment is not limited thereto. For example, the elevator usage information can be acquired via ID authentication at a security gate installed away from a hall, detection information generated by an arrival-at-building detector or arrival-at-hall detector such as a sensor installed in a building, or an information terminal carried by each user. In this case, the elevator usage information can be detected earlier than in the case of acquiring it from the hall call registration part 3, and thus the accuracy of various evaluations described below can be enhanced.

[0022]

The learning section 21 stores the elevator usage information provided from the usage information acquisition section 20 and operation information on each in-service unit provided from the operation information management section 29, calculates, for each traffic flow, the number of users going to each destination floor from each origin floor, and learns the calculation result as a traffic demand table in the origin destination (OD) format.

[0023]

Here, the traffic demand table in the OD format is data representing amounts of traffic on an origin floor and a destination floor (the number of users who exit/enter in a predetermined period), compiled into a two-dimensional matrix (that is, OD matrix) form of information on traffic flow of a building and stored in a database. In the OD matrix, the column direction denotes origin floor (an origin, that is, a starting point), whereas the row direction denotes destination floor (a destination, that is, a terminal point). Each element of the matrix represents the number of users who exit/enter in the predetermined period corresponding to the element. A method for creating the traffic demand table in the OD format will be described below.

[0024]

The high-demand information creation section 22 obtains

an average and standard deviation of amounts of traffic on the basis of the traffic demand table in the OD format held by the learning section 21. The high-demand information creation section 22 compares the obtained average and standard deviation of amounts of traffic with the traffic demand on each destination floor from each origin floor, and thereby judges a high-demand floor. The details of the high-demand floor will be described below.

[0025]

The fixed route/high-demand route creation section 23 receives elevator usage information from the usage information acquisition section 20, operation information on each in-service unit from the operation information management section 29, and high-demand information from the high-demand information creation section 22. The fixed route/high-demand route creation section 23 creates, as a future operation route of each in-service unit, a fixed route and a high-demand route on the basis of the elevator usage information, and the operation information and high-demand information on each in-service unit.

[0026]

The waiting time evaluation section 24 calculates and evaluates, for each in-service unit, a waiting time on each floor on the basis of the fixed route and high-demand route created by the fixed route/high-demand route creation

section 23. The interval evaluation section 25 evaluates the equality of time intervals of each in-service unit at a future predetermined interval estimation time point, on the basis of the fixed route and high-demand route. The long-wait evaluation section 26 calculates a long waiting time and the number of long-waiting users on each floor on the basis of the fixed route and high-demand route, and the waiting time of each user on each floor, and evaluates a long-wait load corresponding to the long waiting time and the number of long-waiting users.

[0027]

The overall evaluation section 27 performs overall evaluation to determine which in-service unit is optimum to be assigned from the viewpoint of waiting time and so forth, on the basis of the various evaluation values obtained from the waiting time evaluation section 24, the interval evaluation section 25, the long-wait evaluation section 26, and so forth. The to-be-assigned unit determination section 28 assigns an in-service unit having the best (highest) overall evaluation value generated by the overall evaluation section 27. The operation information management section 29 creates operation information on the basis of the unit to be assigned determined by the to-be-assigned unit determination section 28 and the elevator usage information and outputs the operation information to a mobile terminal or the

operation information display part 4 installed in a hall, a monitoring room, or the like.

[0028]

The above-described functional sections (20 to 29) of the group-management control part 2 can be implemented by software when a processor interprets and executes a program for implementing the individual functions. In this case, information including the program that implements the individual functions of the functional sections (20 to 29), a table, and a file can be recorded in a recording device such as a memory, a hard disk, or an SSD, or on a recording medium such as an IC card, an SD card, or a DVD. Furthermore, some or all of the individual functional sections (20 to 29) of the group-management control part 2 can be implemented by hardware, for example, by designing them on an integrated circuit.

[0029]

(Hall Call Registration Part/Operation Information Display Part)

The hall call registration part 3 includes an operation section including a numeric keypad and a display section and is installed in an elevator hall. With the hall call registration part 3, elevator usage information including at least the origin floor and destination floor of each user is registered through an operation by the user. For example,

if the user registers a fifth floor as a destination floor by using the hall call registration part 3 installed in a hall on a first floor, the first floor is registered as an origin floor and the fifth floor is registered as a destination floor.

[0030]

The elevator usage information may include a registration time, which is the time when a destination floor is input by the user. Preferably, the elevator usage information includes the number of users in addition to the origin floor and destination floor of the user in order to predict a future operation route more reliably. Here, the number of users can be grasped by, for example, causing each user to register elevator usage information once without fail, or installing an image capturing device in a hall and recognizing a user from an image capturing result obtained from the image capturing device. Furthermore, the elevator usage information may include information representing the width of an entrance/exit at the door of an elevator and a walking time of the user.

[0031]

The operation information display part 4 is a display part of a mobile terminal owned by a user of an elevator or a display device installed in a hall, a monitoring room, or the like. The operation information display part 4 presents

operation information to a user in response to output of the operation information, which is created on the basis of an assigned unit and elevator usage information, from the operation information management section 29. The details of the operation information presented to the user will be described below.

[0032]

As described above, the group-management elevator apparatus 10 according to this embodiment is an elevator apparatus that assigns one of in-service units providing a service to each of users before entering an elevator, on the basis of elevator usage information including at least an origin floor and a destination floor of the user. The group-management elevator apparatus 10 according to this embodiment creates a future operation route that is fixed in reflection of the elevator usage information registered by each user, and evaluates, on the basis of the operation route, the equality of time intervals of each in-service unit in the future at a predetermined interval estimation time point.

[0033]

That is, the group-management elevator apparatus 10 according to this embodiment predicts a future operation route with higher reliability on the basis of elevator usage information and evaluates the equality of time intervals in

the farther future (at the predetermined interval estimation time point). Accordingly, variations in evaluation accuracy of the equality of time intervals can be suppressed. In other words, evaluation accuracy of the equality of time intervals can be increased. As a result, stably equal time intervals can be realized and a long-wait ratio of an elevator for users can be decreased.

[0034]

The group-management elevator apparatus 10 according to this embodiment creates a high-demand route reflecting a high-demand floor in each traffic flow on the basis of past elevator usage information and uses the high-demand route as risk evaluation of the equality of time intervals for a user in the future. Accordingly, preparation can be made for a hall call and a destination floor call that are likely to occur in the future, and great correction of an operation route in the future can be reduced.

[0035]

(Method for Creating Traffic Demand Table)

Now, a description will be given of a method for creating the above-described traffic demand table in the OD format. In contrast to a traffic demand table that stores and learns the number of users who exit/enter by direction and floor, the traffic demand table in the OD format stores and learns the number of users who exit/enter by origin

floor and destination floor, which is associated with each traffic flow. Daily update is performed by using a weighted average of a traffic demand table for each traffic flow mode created by the day before the current day and a traffic demand table for each traffic flow mode created by the current day. To switch the traffic demand table, for example, traffic flows in the OD format collected at an interval of one minute are subjected to weighted average for the last one to ten minutes to hold a result, and the nearest learned traffic flow in the OD format is selected.

[0036]

(Method for Calculating High-Demand Floor Using Traffic Demand Table in OD Format)

Next, a description will be given of a method for calculating a high-demand floor using a traffic demand table in the OD format. A destination floor whose traffic demand is higher than in the other floors and an origin floor where the number of users going to the destination floor is larger than in the other floors are calculated as high-demand floors. A high-demand destination floor is a destination floor having a traffic demand higher than a total value of an average and standard deviation of amounts of traffic from one origin floor to individual destination floors. That is, the high-demand destination floor is calculated by using the following expression.

Traffic demand for destination floor > traffic amount
average $\mu + k \times$ traffic amount standard deviation ρ

Here, if a high-demand destination floor call is judged too strictly, imbalance in demand of each destination floor is not reflected, and thus a coefficient k is normally set to 1.

[0037]

Next, a description will be given of specific examples of a method for controlling the group-management elevator apparatus 10 according to this embodiment having the above-described configuration. In the following examples, it is assumed that the individual functional sections (20 to 29) of the group-management control part 2 are implemented by software and that the individual functions of the functional sections (20 to 29) are executed under the control of a central processing unit (CPU). Note that the control is not limited to that of the CPU.

[0038]

[Example 1]

Example 1 is an example of performing equality-of-intervals evaluation when the n -th unit is tentatively assigned in accordance with a fixed route. Here, a description will be given of equality-of-intervals evaluation when the n -th unit is tentatively assigned, but the same applies to the first to $n-1$ -th units.

[0039]

Fig. 2 is an example of a flowchart illustrating a flow of a process of performing equality-of-intervals evaluation when the n-th unit is tentatively assigned in accordance with a fixed route according to Example 1.

[0040]

First, the CPU calculates the stopping floors of individual in-service units on the basis of information on origin floor calls (hall calls) and destination floor calls that are currently registered (step S1). Subsequently, the CPU calculates the exiting/entering times on the individual stopping floors on the basis of an exiting/entering times on individual floors table (see Fig. 3) that is learned on the basis of the traffic demand table in the OD format, an exiting/entering times on individual floors table (see Fig. 4) that is calculated on the basis of information on origin floor calls and destination floor calls that are currently registered, the width of an entrance/exit at an elevator door, and walking times of users (step S2). Fig. 3 is an example of a diagram illustrating the exiting/entering times on individual floors table obtained through learning. Fig. 4 is an example of a diagram illustrating the exiting/entering times on individual floors table based on a registration status.

[0041]

The exiting/entering times on the individual stopping floors are calculated by weighting, for each traffic flow, the exiting/entering times learned from a past usage history (see Fig. 3) and the exiting/entering times based on the number of users who exit/enter, calculated from a current usage history (see Fig. 4). Accordingly, a difference in exiting/entering time between a currently unregistered floor and a currently registered floor increases to be value of higher reliability. Also, a value is set considering a risk for a floor that is not currently registered but normally has a long exiting/entering time, in other words, a floor that is used highly frequently.

[0042]

Furthermore, an exiting/entering time can be calculated by using the following expression, for example, in view of a coefficient based on the width of an entrance/exit at a door of an elevator (in-service unit).

Exiting/entering time = {exiting/entering time based on the number of users who exit/enter + ($\alpha \times$ learned exiting/entering time)} $\div 2$

Here, α represents a coefficient indicating the degree of dependence on prediction.

Exiting/entering time based on the number of users who exit/enter = {(the number of users who enter $\times$ average entering time per user) + (the number of users who exit $\times$

average exiting time per user)} × coefficient of width of entrance/exit at the door

As an average entering time or exiting time per user, a general value may be used, a learned value may be used, or a value obtained by detecting and averaging walking times of individual users may be used.

[0043]

Subsequently, the CPU creates fixed routes of the individual in-service units on the basis of the stopping floors of the individual in-service units and the exiting/entering times on the individual floors (step S3). The exiting/entering time on a floor that is not currently registered is included in a running route on a route. That is, the slope of a running route varies according to a floor. On a fixed route, a running time of each floor may become long to some extent due to the exiting/entering time on a floor that is not currently registered. However, the floors other than a frequently used floor have a value that does not affect the running time so much, and thus the fixed route does not significantly deviate from an actual route.

[0044]

Subsequently, the CPU determines the equality-of-intervals evaluation time points (predetermined interval estimation time points) of the individual in-service units (step S4). The time when the equality of intervals is

evaluated (evaluation time point) is the time (time point) when an in-service unit among all the in-service units arrives at a final reserved destination floor, which corresponds to the destination floor call in the farthest future, that is, which is a stopping floor farthest from the current point. In this way, as a result of evaluating the equality of time intervals in the farther future, the evaluation accuracy of the equality of intervals can be increased. Here, the time period from the present to the destination floor call in the farthest future may be divided at regular intervals, and the equality of intervals may be evaluated at each division point.

[0045]

The process from step S1 to step S4 may be performed in a constant cycle. In a period when there are no new users, the process may be performed when one in-service unit departs or arrives.

[0046]

Subsequently, the CPU checks whether or not there is a new user (step S5). If there are no new users (NO in S5), the CPU returns to step S1 and performs the process from step S1 to step S4 again. If there is a new user (YES in S5), the CPU tentatively assigns the floor where there is the new user, his/her destination floor, and the number of users to the n-th unit (step S6).

[0047]

Subsequently, the CPU adds the floor where there is the new user and his/her destination floor to the stopping floors of the n-th unit (step S7), and then modifies the exiting/entering times of the n-th unit on the floor where there is the new user and his/her destination floor (step S8). Subsequently, the CPU modifies the fixed route of the n-th unit (step S9) and then modifies the equality-of-intervals evaluation time (step S10).

[0048]

Subsequently, the CPU evaluates the equality of intervals of each in-service unit in the case of tentative assignment to the n-th unit, and sets the evaluation result as the interval evaluation value of the n-th unit (step S11). Here, a description is given of the n-th unit, but tentative assignment is performed on all the in-service units, and an equality-of-intervals evaluation value is set for each unit in a similar manner. Subsequently, the CPU calculates an overall evaluation value on the basis of various evaluation values of waiting time evaluation, long-wait evaluation, and so forth, and equality-of-intervals evaluation values (step S12), and then performs assignment to the in-service unit having the best evaluation (step S13).

[0049]

[Example 2]

Example 2 is a modification example of Example 1. Fig. 5 is an example of a flowchart illustrating a flow of a process of performing equality-of-intervals evaluation in the case of tentatively assigning the n-th unit in accordance with a high-demand route according to Example 2. The flowchart in Fig. 5 includes steps S14 to S19 in addition to the flowchart in Fig. 2. In the flowchart in Fig. 5, both the fixed route and high-demand route are expressed as fixed routes for convenience.

[0050]

First, the CPU judges whether or not there is a high-demand floor on the basis of the traffic demand table in the OD format (step S14). If there are no high-demand floors (NO in S14), the CPU calculates a fixed route in the process from step S1, as in the flowchart in Fig. 2. If there is a high-demand floor (YES in S14), the CPU judges whether or not a target in-service unit is a unit to stop at the high-demand floor (step S15).

[0051]

If the target in-service unit is a unit to stop at the high-demand floor (YES in S15), the CPU adds the high-demand origin floor and destination floor and a predicted number of users who exit/enter there to the stopping floors of the target in-service unit and the number of users who exit/enter there (step S16), and then the process proceeds

to step S1 and the CPU calculates a fixed route as in Example 1. As the predicted number of users who exit/enter, a difference value between the number of users who exit/enter in each traffic flow on each floor table in Fig. 6 based on high-demand prediction and the number of users who exit/enter on each floor based on a registration status illustrated in Fig. 4 is used. Fig. 6 is an example of a diagram illustrating the number of users who exit/enter in each traffic flow on each floor table based on high-demand prediction.

[0052]

If the target in-service unit is not a unit to stop at the high-demand floor (NO in S15), the CPU does not perform addition to the stopping floors and the number of users who exit/enter. Subsequently, the process proceeds to step S1 and the CPU calculates a fixed route as in Example 1.

[0053]

If the CPU judges in step S5 that there is a new user (YES in S5), the CPU judges whether or not there is a high-demand floor (step S17). If there are no high-demand floors (NO in S17), the process proceeds to step S6 where the CPU calculates a fixed route as in Example 1. If there is a high-demand floor (YES in S17), the CPU judges whether or not the floor where there is the new user is a high-demand floor (step S18).

[0054]

If the floor where there is the new user is a high-demand floor (YES in S18), the CPU adds the high-demand origin floor and destination floor and a predicted number of users who exit/enter there to the stopping floors of the target in-service unit and the number of users who exit/enter there (step S19). Subsequently, the process proceeds to step S6 and the CPU calculates a fixed route as in Example 1. If the floor where there is the new user is not a high-demand floor (NO in S18), the CPU does not perform addition to the high-demand stopping floors and the number of users who exit/enter of the target in-service unit. Subsequently, the process proceeds to step S6 and the CPU calculates a fixed route as in Example 1.

[0055]

[Example 3]

Example 3 is an example of performing risk evaluation of the equality of intervals in the case of tentatively assigning the n-th unit in accordance with a high-demand route. Fig. 7 is an example of a flowchart illustrating a flow of a process of performing risk evaluation of the equality of intervals in the case of tentatively assigning the n-th unit in accordance with a high-demand route according to Example 3.

[0056]

First, the CPU creates a fixed route (step S21). The process of creating the fixed route is performed in a manner similar to the process according to Example 1 (see Fig. 2). Subsequently, the CPU judges whether or not the n-th unit is a unit to stop at a high-demand floor (step S22). If the n-th unit is a unit to stop at a high-demand floor (YES in S22), the CPU adds the high-demand origin floor and destination floor and a predicted number of users who exit/enter there to the stopping floors and the number of users who exit/enter there (step S23). If the n-th unit is not a unit to stop at a high-demand floor (NO in S22), the CPU does not perform the addition.

[0057]

Subsequently, the CPU creates a high-demand route different from the fixed route (step S24) and then judges whether or not there is a new user (step S25). If there is a new user (YES in S25), the CPU tentatively assigns the floor where there is the new user and his/her destination floor to the n-th unit (step S26). If there are no new users (NO in S25), the process returns to step S21.

[0058]

Subsequently, the CPU modifies the fixed route of the n-th unit (step S27), modifies the equality-of-intervals evaluation time for the fixed route (step S28), and then evaluates the equality of intervals among the individual in-

service units in the case of tentative assignment to the n-th unit and determines the equality-of-intervals evaluation value for the fixed route of the n-th unit (step S29).

[0059]

Subsequently, the CPU judges whether or not the floor where there is the new user is a high-demand origin floor (step S30). If the floor where there is the new user is a high-demand origin floor (YES in S30), the CPU adds the high-demand origin floor and destination floor and a predicted number of users who exit/enter there to the stopping floors and the number of users who exit/enter there (step S31). If the floor where there is the new user is not a high-demand origin floor (NO in S30), the CPU does not perform the addition. Subsequently, the CPU tentatively assigns the floor where there is the new user, his/her destination floor, and the number of users to the n-th unit (step S32), and then modifies the high-demand route of the n-th unit (step S33).

[0060]

Subsequently, the CPU modifies the equality-of-intervals evaluation time for the high-demand route (step S34), evaluates the equality of intervals of each in-service unit in the case of tentative assignment to the n-th unit, and determines the equality-of-intervals evaluation value for the high-demand route of the n-th unit (step S35).

Subsequently, the CPU calculates the deviation between the fixed route and the high-demand route in the case of tentative assignment to the n-th unit and sets the calculation result as the risk evaluation value of the n-th unit (step S36).

[0061]

Subsequently, the CPU calculates an overall evaluation value on the basis of various evaluation values of waiting time evaluation, long-wait evaluation, and so forth, and an equality-of-intervals evaluation value for the high-demand route (step S37), and then performs assignment to the in-service unit having the best evaluation, that is, determines the unit to be assigned (step S38).

[0062]

[Example 4]

Example 4 is an example of a fixed route and high-demand route using reservation information. Fig. 8 is an example of an explanatory diagram illustrating the overview of a fixed route using reservation information according to Example 4. In Fig. 8, the dotted line represents a predicted route and the broken line represents a fixed route.

[0063]

Fig. 8 illustrates a state where three users going to the seventh floor, one user going to the eighth floor, and one user going to the ninth floor are waiting in a hall on

the fifth floor. In the example illustrated in Fig. 8, the stopping time is long on the fifth floor where five users enter and on the seventh floor where three users exit, whereas the stopping time is short on the eighth and ninth floors where only one user exit. Accordingly, the stopping times on the stopping floors that are not currently registered but that are grasped as reservation information can be reflected in the operation route with respect to the predicted route, and thus the accuracy of the position of the in-service unit at the interval evaluation time point is increased.

[0064]

Fig. 9 is an example of an explanatory diagram illustrating the overview of a high-demand route using reservation information according to Example 4. Fig. 10 is an example of an explanatory diagram illustrating a high-demand floor table in each traffic flow according to Example 4. In the example in Fig. 10, the seventh floor is detected as a high-demand destination floor, and the high-demand fifth and sixth floors associated with the high-demand destination floor are detected as high-demand origin floors.

[0065]

Fig. 9 illustrates a state where three users going to the seventh floor, one user going to the eighth floor, and one user going to the ninth floor are waiting in a hall on

the fifth floor. In the example in Fig. 9, the fifth floor is a high-demand origin floor and there are many users going to the seventh floor. Thus, there is a high possibility that the same in-service unit will be assigned to the hall on the sixth floor where there are many users going to the seventh floor, and thus the sixth floor is regarded as a high-demand origin floor and is included in the stopping floors on the high-demand route. Thus, the sixth floor can be considered in advance as a stopping floor of the in-service unit that is likely to be assigned in the future to a future user, and major modification of the future operation route can be reduced.

[0066]

[Example 5]

Example 5 is an example of presenting, to a user, an estimated arrival time and an estimated departure time, an estimated earliest arrival time and an estimated latest arrival time, and an operation route for estimated earliest arrival and an operation route for estimated latest arrival.

[0067]

The group-management elevator apparatus 10 according to this embodiment enables, with a fixed route, highly-accurate prediction of an arrival time and a departure time on each floor of each in-service unit, compared to the related art in which an operation route is highly dependent on

prediction. Furthermore, with the high-demand route, an arrival time and a departure time can be predicted with high probability in consideration of future users compared to the related art in which an operation route is highly dependent on prediction.

[0068]

The arrival time based on the fixed route is used as the estimated earliest arrival time and the arrival time based on the high-demand route is used as the estimated latest arrival time, and estimated arrival time information and estimated departure time information are displayed on a mobile terminal carried by a user or on the operation information display part 4 (see Fig. 1) installed in a hall, as illustrated in Fig. 11. Accordingly, the arrival time and departure time can be presented (disclosed) to the user in advance, the impatience of not knowing when the elevator will arrive or depart can be reduced, and service for users can be improved. Fig. 11 is an example of a diagram illustrating a display example of an estimated arrival time according to Example 5.

[0069]

Accordingly, a fixed route and high-demand route, instead of the arrival time and departure time, are displayed on a mobile terminal carried by a user or on the operation information display part 4 installed in a hall, as

illustrated in Fig. 12. Accordingly, a user is able to grasp the operation status of the unit for which an instruction to enter is provided. As a result, impatience can be further reduced and service for users can be further improved. Fig. 12 is an example of a diagram illustrating a display example of an estimated arrival route according to Example 5. In Fig. 12, a solid line represents the shortest route (fixed route) whereas a broken line represents the longest route (high-demand route). In Fig. 12, "a" represents an estimated earliest arrival time and "b" represents an estimated latest arrival time.

[0070]

Regarding the operation information, the amount of information can be reduced more by displaying only the information assigned to a corresponding floor on the operation information display part 4 on the corresponding floor. Accordingly, the time taken for a user to grasp the status can be shortened, and a factor that makes a user impatient, such as passage of another unit through the corresponding floor, can be eliminated.

[0071]

Fig. 13 is an example of a diagram illustrating a display example of an estimated arrival time at the time of registration according to Example 5. Fig. 14 is an example of a diagram illustrating a display example of an estimated

arrival time at the time of waiting according to Example 5. As illustrated in Figs. 13 and 14, as a result of displaying a departure time, an arrival time, and a route on the hall call registration part 3 (see Fig. 1) installed in a hall at the time of registration of a destination or using a waiting screen, the departure time, arrival time, and route can be presented to a user without installing an additional display device. At the time of registration of a destination, the arrival time and departure time of the unit for which an instruction to enter is provided are displayed. On the waiting screen, the arrival times and departure times of all the in-service units assigned to the floors installed with the screen are displayed.

[0072]

The present invention is not limited to the above-described examples and includes various modification examples. For example, the above examples have been described in detail in order to clearly explain the present invention and do not limit the invention to the example having all the configurations described above. One means of a configuration of a certain example can be replaced by a configuration of another example, and a configuration of a certain example can be added to a configuration of another example. Furthermore, regarding one means of a configuration of each example, another configuration can be

added, deleted, or replaced.

[Reference Signs List]

[0073]

- 1: elevator part
- 2: group-management control part
- 3: hall call registration part
- 4: operation information display part
- 10: group-management elevator apparatus
- 11_1, 11_2, ..., 11_n: elevator (in-service unit)
- 20: usage information acquisition section
- 21: learning section
- 22: high-demand information creation section
- 23: fixed route/high-demand route creation section
- 24: waiting time evaluation section
- 25: interval evaluation section
- 26: long-wait evaluation section
- 27: overall evaluation section
- 28: to-be-assigned unit determination section
- 29: operation information management section

CLAIMS

[Claim 1]

An elevator apparatus that assigns one of in-service units providing a service to each of users, on the basis of elevator usage information including at least an origin floor and a destination floor of the user, the elevator usage information being registered by the user before the user enters an elevator, the elevator apparatus comprising:

a route creation section that creates a future operation route that is fixed in reflection of the elevator usage information;

an evaluation section that evaluates equality of time intervals of each of the in-service units in future on the basis of the future operation route; and

a to-be-assigned unit determination section that assigns one of the in-service units providing a service to each of the users, on the basis of an evaluation result generated by the evaluation section.

[Claim 2]

The elevator apparatus according to Claim 1, wherein the elevator usage information includes the number of users on the origin floor and the destination floor.

[Claim 3]

The elevator apparatus according to Claim 2, further comprising:

a high-demand information creation section that creates,

for each traffic flow, high-demand information including a high-demand origin floor, a high-demand destination floor, and the number of users who exit/enter on each floor, on the basis of past elevator usage information, wherein

the route creation section creates a future high-demand route by using the high-demand information to determine an estimated stopping floor and an estimated number of users who exit/enter in future, and

the evaluation section evaluates, on the basis of the future high-demand route, equality of time intervals of each of the in-service units in future.

[Claim 4]

The elevator apparatus according to Claim 3, wherein the evaluation section performs risk evaluation on equality of time intervals for a future user, on the basis of the future operation route and the future high-demand route.

[Claim 5]

The elevator apparatus according to Claim 1, wherein the evaluation section evaluates equality of time intervals on arrival at a final reserved destination floor, which is a stopping floor farthest from a current point.

[Claim 6]

The elevator apparatus according to Claim 1, further comprising:

an operation information management section that calculates an estimated arrival time and an estimated departure time on the basis of the future operation route and that presents

the estimated arrival time and the estimated departure time to the user.

[Claim 7]

The elevator apparatus according to Claim 3, further comprising:

an operation information management section that calculates an estimated earliest arrival time and an estimated latest arrival time on the basis of the future operation route and the future high-demand route and that presents the estimated earliest arrival time and the estimated latest arrival time to the user.

[Claim 8]

The elevator apparatus according to Claim 7, wherein the operation information management section calculates an operation route for estimated earliest arrival and an operation route for estimated latest arrival on the basis of the future operation route and the future high-demand route, and presents the calculated operation routes to the user.

[Claim 9]

A method for controlling an elevator apparatus that assigns one of in-service units providing a service to each of users on the basis of elevator usage information including at least an origin floor and a destination floor of the user, the elevator usage information being registered by the user before the user enters an elevator, the method comprising:

creating a future operation route that is fixed in reflection of the elevator usage information;

evaluating equality of time intervals of each of the in-service units in future on the basis of the future operation route; and

assigning one of the in-service units providing a service to each of the users on the basis of an evaluation result generated through the evaluating.