

ELEVATOR-GROUP MANAGEMENT SYSTEM

FIELD

Embodiments described herein relate generally to an elevator-group management system which controls
5 operations of a plurality of cars.

BACKGROUND

In an elevator-group management system, if a hall call is newly made, an evaluation value of each of cars is calculated based on an evaluation function using
10 parameters such as a call or calls registered for each car (a hall call and a car call) and the position of each car. Then, of the cars, a car having the best evaluation value is determined as a to-be-applied car. The to-be-applied car is a car to be made to respond to
15 the hall call; i.e., a car to which the hall call is to be assigned.

As a method for making evaluations related to a hall call, a new method referred to as real-time scheduling (RTS) has been considered. RTS is a method
20 for predicting and evaluating an operation of each of cars in consideration of an influence of a presently assigned call upon a call which will be made and an influence of a call which will be made upon all calls which have already been assigned to cars, but for which
25 the cars have not yet arrived. By calculating evaluation values of the cars based on RTS, a more appropriate to-be-applied car can be selected.

However, in the above RTS, with respect to virtual assignment patterns for calls, an operation prediction
30 is repeated. Thus, computational complexity is very increased, and it therefore takes long time to select an optimal to-be-applied car.

In general, it is preferable that a to-be-applied car be selected within one second from the time a hall button is operated (i.e., a hall call is made). If an
35 operation based on an assignment algorithm is performed for long time, it adversely affects an operation of

another task. Therefore, in the case of using RTS, it is necessary to take an efficient processing procedure.

SUMMARY

According to one aspect, there is provided an
5 elevator-group management system which is provided with
a group management controller and a plurality of car
controllers, and controls a plurality of cars with the
car controllers under a control of the group management
controller, the group management controller comprising:
10 assignment request issuing means for issuing an
assignment request to the car controllers when a new
hall call is made, assigning an assignment request call
and virtual calls to each of the car controllers when
the assignment request is issued, the assignment
15 request call corresponding to the new hall call, the
virtual calls being assumed to be made and causing the
car controllers to execute respective parts of
assignment evaluation processing for assigning the new
hall call to any of the cars; evaluation result
20 acquiring means for acquiring evaluation results
obtained by the car controllers in accordance with the
assignment request; and assignment evaluating means for
finally determining to which of the cars the new hall
call is to be assigned by using an algorithm which
25 combines the evaluation results acquired from the car
controllers by the evaluation result acquiring means,
limits virtual assignment patterns to be evaluated to
likely ones and evaluates the likely virtual assignment
patterns, wherein the algorithm selects a node having a
30 smallest evaluation value as a base node for
development from the virtual assignment patterns by
comparing evaluation values among nodes corresponding

to the virtual assignment patterns, repeats a node development process of adding a virtual call not yet subjected to virtual assignment, generating a new node for each of the cars from the base node for
5 development, and removing the base node for development from nodes to be compared with each other, corrects each evaluation value on a presumption that a no-response time for a virtual call not yet subjected to virtual assignment is a predetermined time when the
10 nodes to be compared with each other differ from each other in the number of virtual assignments, and finally extracts a node having a smallest evaluation value by limiting the number of repetitions of the node development process, and the car controllers each
15 comprises: assignment request receiving means for receiving the assignment request along with the assignment request call and the virtual calls; virtual assignment pattern making means for making a plurality of virtual assignment patterns for an associated one of
20 the cars based on the assignment request call and the virtual calls received by the assignment request receiving means; operation prediction evaluating means for evaluating operation predictions of the virtual assignment patterns made by the virtual assignment
25 pattern making means to obtain evaluation values of the virtual assignment patterns; and evaluation result transmitting means for transmitting as evaluation results of the associated car, the evaluation values of the virtual assignment patterns obtained by the
30 operation prediction evaluating means to the group management controller.

There is also disclosed an elevator elevator-group management system which is provided with a group
35 management controller and a plurality of car controllers, and controls a plurality of cars with the car controllers under a control of the group management

controller, includes assignment request issuing means for issuing an assignment request to the car controllers when a new hall call is made, and causing the car controllers to execute respective parts of assignment evaluation processing for assigning the new hall call to any of the cars, evaluation result acquiring means for acquiring evaluation results obtained by the car controllers in accordance with the assignment request, and assignment evaluating means for making a comprehensive evaluation of the evaluation results acquired from the car controllers by the evaluation result acquiring means to finally determine to which of the cars the new hall call is to be assigned.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view showing virtual assignment patterns of an RTS;

FIG. 2 is a view showing a processing procedure in the case of applying an algorithm A to RTS;

FIG. 3 is a view showing virtual assignment patterns in the case of applying the algorithm A to RTS;

FIG. 4 is a view showing a procedure of a centralized control of RTS;

FIG. 5 is a view showing how processing according to the algorithm A applied to RTS is distributed to control boards for cars;

FIG. 6 is a view showing a procedure of a distributed control of RTS;

FIG. 7 is a view showing a procedure of a combination of the centralized control and the distributed control of RTS (with the algorithm A not applied);

5 FIG. 8 is a view showing an example of a determination by each of the control boards for cars with respect to how virtual assignment patterns (only for an associated car) are made;

10 FIG. 9 is a view showing the virtual assignment patterns for the associated car only;

FIG. 10 is a view showing an example of a determination by a common board with respect to how virtual assignment patterns for all the cars are made;

15 FIG. 11 is a view showing the virtual assignment patterns for all the cars;

FIG. 12 is a view showing some steps of a procedure of proceeding according to the algorithm A on a common board side in the combination of the centralized control and the distributed control of RTS (with the algorithm A applied);

20 FIG. 13 is a view showing other steps of the procedure of the processing according to the algorithm A on the common board side in the combination of the centralized control and the distributed control of RTS (with the algorithm A applied);

25 FIG. 14 is a view showing different other steps of the procedure of the processing according to the algorithm A on the common board side in the combination of the centralized control and the distributed control of RTS (with the algorithm A applied);

30 FIG. 15 is a view showing a configuration of an elevator-group management system according to an embodiment;

35 FIG. 16 is a block diagram showing a function configuration of a group management controller in the elevator-group management system according to the embodiment;

FIG. 17 is a block diagram showing a function configuration of car controllers in the elevator-group management system according to the embodiment; and

5 FIG. 18 is a flowchart showing processing of the group management controller and the car controllers in the elevator-group management system according to the embodiment.

DETAILED DESCRIPTION

10 Embodiments will be described hereinafter with reference to the accompanying drawings.

First of all, in order that the embodiments be easily understood, a real-time scheduling (RTS) and an algorithm A applied to as an assignment control method for elevators will be explained.

15 (RTS)

RTS is a method in which a virtual hall call (virtual call) approximately indicating a hall call which will be made is set, and an operation schedule is prepared also in consideration to a virtual response to the virtual call. In this case, it is necessary to predict an operation schedule (operation prediction), after determining which car should be virtually applied in response to not only a newly registered hall call (an assignment request call to be described later), but
20 a virtual call. Thus, if a large number of virtual calls are set, an enormous number of virtual assignment patterns are made.

If x virtual calls are set for c cars, the number of virtual assignment patterns is $c(x+1)$.

30 For example, in an elevator-group management system provided with 2 cars (cars A and B), if 2 virtual calls are set, the number of virtual assignment patterns is 8 as shown in FIG. 1. If the number of cars is increased or that of virtual calls is
35 increased, that of virtual assignment patterns is explosively increased. For example, if the number of cars is 12 and that of virtual calls is 3, that of

virtual assignment patterns is 20,736.

In such a manner, in RTS, evaluations are also made in consideration of virtual calls. Thus, if the number of cars is increased, it takes longer time to determine which car should be applied.

(Basis of assignment evaluation)

In RTS, with respect to each of virtual assignment patterns made regarding all calls, i.e., a call which has been assigned to a car, but for which the car has not yet arrived (which will be hereinafter referred to as an assigned call), a call which has not yet been assigned to any of cars (which will be hereinafter referred to as an assignment request call), and virtual calls, squares of no-response time predicted values are determined, and the sum of the squares is determined as an evaluation value of each virtual assignment pattern.

Supposing A assigned calls are present, and F virtual calls are present, evaluation values E of virtual assignment patterns are expressed by the following equation 1:

$$E = \sum_{i=1}^A (r_{ai}^2) + r_n^2 + \sum_{i=1}^F (r_{fi}^2) \quad (1)$$

where r_{ai} is a no-response time predicted value for each of the assigned calls, r_n is a no-response time predicted value for an assignment request call, and r_{fi} is a no-response time predicated value for each of the virtual calls.

A no-response time means time required from registration of a hall call to arrival of a to-be-applied car, and will be determined as follows:

With respect to an assigned call, a no-response time is determined by summing time required from registration of a hall call to present time and time expected to be required from the present time to arrival of a to-be-applied car (predicted required

time).

With respect to an assignment request call (a hall call made newly), the no-response time is time expected to be required from registration of the call to arrival of a car after the car is determined as a to-be-applied car for the call (predicted required time).

With respect to a virtual call, the no-response time is determined by subtracting time expected to be required from present time to registration of the virtual call, from time expected to be required from registration of the call to arrival of a to-be-applied car (predicted required time).

It should be noted that the smaller an RTS evaluation value, the better the virtual assignment pattern.

By the above method, RTS evaluation values of all virtual assignment patterns are determined. Then, of the virtual assignment patterns, a virtual assignment pattern having the smallest RTS evaluation value is extracted. Then, in the extracted virtual assignment pattern, an actual assignment output is supplied to a car to which the assignment request call is virtually assigned. This is a basic of RTS.

However, if the above method is simply applied, it requires long processing time. Therefore, in order to reduce computational complexity, the algorithm A is applied as explained as follows:

(Algorithm A)

The algorithm A is one of a plurality of algorithms for achieving RTS method. In the algorithm A, with respect to operation schedule, virtual assignment patterns to be evaluated are limited to likely ones, and the likely virtual assignment patterns are then evaluated, to thereby reduce the computational complexity. It should be noted that "A" of "algorithm A" is meaningless; that is, a specific one of the above algorithms is referred to as the algorithm A as a

matter of convenience.

FIG. 2 is a view showing a procedure of processing according to the algorithm A in the case where the algorithm A is applied to RTS. Also, an elevator-group management system having two cars (cars A and B) is shown by way of example.

An individual virtual assignment pattern will be referred to as a "node". If a call is added to a given node, it is virtually assigned to a car to make new nodes. This will be hereinafter referred to as "development" (making of new nodes). By providing an upper limit for the number of times development is carried out, calculation time is reduced. If a larger number of nodes are searched for, a better operation schedule is obtained, and thus an elevator-group management function is improved.

As shown in FIG. 2, in the case where the algorithm A is applied to an elevator-group management system having two cars (cars A and B), the processing procedure is taken as follows:

(1) For each of both an assignment request call (corresponding to "hall call to be actually assigned" in FIG. 2) and a virtual call (corresponding to "virtual hall call" in FIG. 2), an operation schedule in which virtual assignment is not made is determined. Suppose this operation schedule is a start node.

(2) With respect to the cases where an assignment request call is assigned to the car A and where it is assigned to the car B, operation schedules of the car A and the car B are determined. With respect to the determined operation schedules, RTS evaluation values are calculated. In those cases, a method of calculating the RTS evaluation values is slightly different from that of the above basic, and will be described in detail later.

(3) Of virtual assignment patterns evaluated in operation schedule, an evaluated virtual assignment

pattern having the smallest evaluation value is determined as a base node for development.

5 (4) A virtual call is further added to the base node for development, and virtually assigned to a car, to thereby make a virtual assignment pattern (node development). With respect to all cars to which the virtual call can be virtually assigned, descendant nodes are made.

10 In an example as shown in FIG. 2, "assignment pattern 1" is a base node for development. Also, in the base node for development, if a first virtual call is virtually assigned to the car A, a new assignment pattern is made as an "assignment pattern 3", and if the first virtual call is virtually assigned to the car
15 B, another new virtual assignment pattern is made as an "assignment pattern 4".

(5) The above steps (3) and (4) are repeated a predetermined number of times.

20 (6) When the step (5), i.e., repetition of the steps (3) and (4), ends, a node having the best (smallest) RTS evaluation value is extracted.

(7) In the extracted node, a car to which the assignment request call is virtually assigned is selected as a "to-be-applied car".

25 (Method of calculating an RTS evaluation value in the case where the algorithm A is applied)

In the processing according to the algorithm A, RTS evaluation values of virtual assignment patterns of nodes are compared with each other, a node having the
30 smallest RTS evaluation value is selected as a base node for development, and processing of node development is continued. At this time, there is a case where the nodes to be compared with each other differ from each other in the number of virtual
35 assignments to be evaluated in no-response time.

For example, referring to FIG. 2, in the start node, two virtual assignments are evaluated in

no-response time. In the assignment patterns 1 and 2, three virtual assignments are evaluated in no-response time, and in the assignment patterns 3 and 4, four virtual assignments are evaluated in no-response time.

5 The larger the number of virtual assignments evaluated in no-response time, the greater the RTS evaluation value. Thus, a node having the smallest number of virtual assignments is selected. In view of this point, it is set that a correction value is added
10 to RTS evaluation value on the presumption that the no-response time for a virtual call not yet subjected to virtual assignment is equal to an average no-response time.

 Supposing that A assigned calls are present, F
15 virtual calls are present, and G virtually assigned virtual calls are present, and RTS evaluation values E of virtual assignment patterns are expressed by the following equation 2:

20
$$E_a = \sum_{i=1}^A (r_{ai}^2) + r_n^2 + \sum_{i=1}^G (r_{fi}^2) + (F - G) \times P \quad (2)$$

 where r_{ai} is a no-response time predicted value for each of the assigned calls, r_n is a no-response time predicted value for an assignment request call, r_{fi} is
25 a no-response time predicated value for each of the virtual calls, and.

 It should be noted that P is an average penalty value, which is a square of an average no-response time, and (F-G) indicates the number of virtual calls
30 not subjected to virtual assignment in the above node. A value obtained by multiplying a value indicated by "(F-G)" by the average penalty value P is added to an RTS evaluation value, to thereby compensate for an evaluation value for a virtual call not evaluated.

35 In the procedure according to the algorithm A, virtual assignment patterns made and added by

performing virtual assignment during virtual assignment processing are also evaluated. If x virtual calls are set for c cars, the number of virtual assignment patterns is $(c(x+2) - 1) / (c-1)$.

5 For example, in an elevator-group management system provided with 2 cars (cars A and B), if 2 virtual calls are set, the number of virtual assignment patterns is 15 as shown in FIG. 3. This example includes virtual assignment patterns in which calls are
10 not subjected to virtual assignment. Thus, in the example, the number of patterns expected to be made is increased, as compared with the example as shown in FIG. 1.

 In RTS, as described above, the number of times
15 the steps (3) and (4) are repeated is limited to the predetermined number of times. Therefore, it is not expected that all virtual assignment patterns will be evaluated. However, only virtual assignment patterns expected to have good evaluation values are selected
20 and evaluated. Thus, a virtual assignment pattern having a value close to the best evaluation value can be determined for short time.

 The number of times as indicated in the above step
25 (5) (the number of times the steps (3) and (4) are repeated) is defined as "the number of times node development is performed". In the above step (4), a single call is virtually assigned to cars to make nodes. Thus, if node development is performed u times,
30 $u \times c + 1$ virtual assignment patterns are evaluated, where c is the number of cars. Also, the $u \times c + 1$ virtual assignment patterns includes a virtual assignment pattern of a base node for development, from which node development is performed.

 For example, if 3 virtual calls are set for 4
35 cars, when node development is performed 21 times, in the processing according to the algorithm A, 85 ones of 341 virtual assignment patterns can be evaluated. On

the other hand, in the example as shown in FIG. 1, 256 virtual assignment patterns are present. Therefore, if the algorithm A is applied, it can reduce the number of the patterns to be evaluated to approximately 1/3 of that in the case where the algorithm A is not applied.

(Application of RTS to the elevator-group management system)

The following explanation is given with respect to the case where RTS is applied to the elevator-group management system.

The elevator-group management system comprises a common board (group master) which exercises an entire group-management control, and control boards for respective cars. The common board and the control boards for the cars are connected to each other such that they can exchange information with each other. In the case where the elevator-group management system having such a structure is applied to RTS, (a) centralized control, (b) distributed control, (c) a combination of distributed control and centralized control with non-application of the algorithm A and (d) the combination of the distributed control and the centralized control with application of the algorithm A can be conceived as control processing of the elevator-group management system.

(a) Centralized control

The centralized control is a method in which information on the cars is collected in the group master, and the group master performs solely processing according to the algorithm A applied to RTS.

FIG. 4 is a view showing a procedure of centralized control of RTS. A common board 11 is a group master, and also connected to control boards 12a, 12b, . . . for the cars such that they can exchange information with each other.

(1) Data acquisition with common board

Before assignment processing, the common board

(group master) 11 acquires information on positions of the cars, whether calls are each registered or not and operation schedules regarding predicted arrival time of the cars at each of floors, etc., from the control boards 12a, 12b, . . . for the cars.

(2) Acquisition of evaluation results regarding expert rules, etc., by the common board

The common board 11 notifies the control boards 12a, 12b, . . . for the cars, of occurrence of an assignment request. The control boards 12a, 12b, . . . provide information necessary for evaluation processing of RTS, etc., to the common board 11.

The following are main items of the information: predicted arrival time of the cars at each of the floors in the case where an assignment request call is virtually assigned to the cars; and evaluation results regarding expert rules.

The expert rules are control objectives other than the predicted arrival time, and including, e.g., energy saving and avoidance of a crowded car.

(3) Processing according to algorithm A by the common board

The common board 11 solely performs the processing according to the algorithm A to evaluate operation schedules of the cars. Present operation schedules of the cars are acquired in the above procedure (1) if the assignment request call has not yet been virtually assigned to the cars, and are also acquired in the above procedure (2) in the case where the assignment request call has been assigned to the cars.

The algorithm A to be applied while assigning virtual calls to the cars is applied by the common board 11 solely. The processing according to the algorithm A includes a process for selecting a node to be developed subsequently. In this case, the node can be arbitrarily selected from nodes which have already been searched for. Therefore, the algorithm A can be

applied in the procedure explained with reference to FIG. 1.

(4) Determination of to-be-applied car by the common board

5 The common board 11 determines a to-be-applied car based on evaluation results regarding RTS and evaluation results regarding the expert rules. The evaluation results regarding the expert rules are acquired in the above procedure (1) from the control
10 boards 12a, 12b, . . . for the cars.

The above centralized control has the following advantages and disadvantages:

(Advantages)

15 Since all processes are executed by a single element, i.e., the common board, RTS can be simply applied to the common board.

The algorithm A can be applied as it is, and a node to be searched for subsequently can thus be selected with the highest accuracy.

20 It is possible to reduce processing loads on the control boards 12a, 12b, . . . for the cars.

(Disadvantages)

25 Since all the processes are executed by the common board 11 only, the load on a CPU in the common board 11 and the memory usage thereof are great. It cannot be expected that sufficient evaluations will be obtained with a single board.

30 If the common board 11 goes down, the processing according to the algorithm A cannot be easily performed by the control boards 12a, 12b, . . . for the cars.

(b) Distributed control

35 The distributed control is a method in which the processing according to the algorithm A applied to RTS is distributed to the control boards, and executed by the control boards. In an example as shown in FIG. 5, the processing based on the algorithm A is distributed to the control boards 12a-12c for cars A-C, and

executed by these control boards.

First, each of the control boards 12a-12c predicts an operation of an associated one of the cars with respect to the case where the assignment request call is virtually assigned to the associated car. At this time, each control board acquires from the other control boards, operation prediction data regarding the case where the assignment request call is not virtually assigned to cars associated with the other control boards.

In each of the control boards 12a-12c, a virtual assignment pattern in which "only the assignment request call is virtually assigned to the associated car" is determined as a starting point of processing according to the algorithm A which is to be executed by each control board. Furthermore, with respect to selection of a node to be selected subsequently based on the algorithm A, it is set that only a pattern deriving from the virtual assignment pattern in which "only the assignment request call is virtually assigned to the associated car" can be selected.

FIG. 6 is a view showing a procedure of the distributed control of RTS. As described above, the common board 11 is a group master, and connected to the control boards 12a, 12b, . . . for the cars such that they can exchange information with each other.

(1) Exchange operation schedules between the control boards for cars

Before assignment processing, the control boards 12a, 12b, . . . for the cars periodically exchange information on positions of the cars, whether calls are registered or not, and predicted arrival time of the cars at each of the floors, etc., with each other.

(2) Preparation of operation schedule regarding the case where each control board assigns an assignment request call to the associated car

When an assignment request call is made, each of

the control boards 12a, 12b, . . . prepares an operation schedule of the associated car in the following manner:

5 An operation schedule of the associated car is prepared regarding the case where the assignment request call is virtually assigned to the associated car. A predicted arrival time of the associated car regarding the case where the assignment request call is virtually assigned to the associated car can be
10 calculated by existing processing.

 An operation schedule of each of the other cars is prepared on the presumption that the assignment request call is not virtually assigned to the other cars. A predicated arrival time of each of the other
15 cars regarding the case where the assignment request call is not virtually assigned to the other cars is obtained in advance by information exchange in the above procedure (1).

 (3) Execution of processing according to the algorithm A by each control board with respect to the
20 case where virtual calls are set

 Each of the control boards 12a, 12b, . . . searches for the best virtual assignment pattern in accordance with the algorithm A only regarding the case
25 where virtual calls are set. An evaluation value calculated regarding the best virtual assignment pattern searched for is determined as an RTS evaluation value of the associated car. Furthermore, each control board makes an expert-rule evaluation. RTS evaluation
30 values and expert-rule evaluation values obtained by the control boards 12a, 12b, . . . are collected in the common board 11.

 (4) Determination of to-be-applied car by common board.

35 The common board 11 finally determines a car to which an assignment request call (a new hall call) is to be assigned, based on a combination of RTS

evaluation values and the expert-rule evaluation values.

The above distributed control has the following advantages and disadvantage:

5 (Advantages)

The control boards for the cars execute processing according to the algorithm A in parallel with each other, thus improving a processing efficiency.

10 Even if the common board cannot take part in assignment processing, it is easy to perform RTS.

(Disadvantage)

15 The common board also evaluates an operation schedule regarding the case where a virtual call is virtually assigned to a car other than the above associated car. Thus, each of the control boards needs to hold operation schedules of all the cars, and thus needs a large storage area.

(c) Combination of distributed control and centralized control (with algorithm A not applied)

20 A combination of the distributed control and the centralized control is a method in which each of the control boards evaluates operation schedules of all virtual assignment patterns for an associated car, and the common board evaluates operation schedules of all
25 virtual assignment patterns for all the cars. In this case, the algorithm A is not used.

30 In such a manner, the above methods (a) and (b) are considered on the premise that the algorithm A is applied. However, in order to reduce the operational complexity, another approach can be considered. To be
35 more specific, in the above methods (a) and (b), the number of virtual assignment patterns is large. This is because with respect to the entire group management system, the common board determines to which car each of calls should be virtually assigned.

If only one car is considered, with respect to an assignment request call or virtual calls, it suffices

to determine whether the assignment request call or the virtual calls should be assigned to the above car, not to which of all the cars the assignment request call or the virtual calls should be assigned. Therefore, in
5 this case, the number of virtual assignment patterns is $2^{(x+1)}$, not $c^{(x+1)}$.

In view of the above, an operation prediction regarding the case where virtual calls are set can be considered in the following two patterns, i.e., process
10 1 and process 2. The process 1 is a distributed process, and the process 2 is a centralized process.

To be more specific, in the process 1, each of the control boards makes virtual assignment patterns which are all conceivable on the presumption that an
15 assignment request call and virtual calls are assigned to the associated call only, and evaluates operation schedules of the virtual assignment patterns (operation prediction).

In the process 2, the common board calculates
20 evaluation values of all the assignment patterns made regarding all the cars in the group management system, on the basis of evaluation results obtained in the above process 1 regarding the cars.

FIG. 7 is a view showing a procedure of the combination of the centralized control and distributed control of RTS (with the algorithm A not applied). As
25 described above, the common board 11 is a group master, and connected to the control boards 12a, 12b, . . . for the cars such that they can exchange information with each other.
30

(1) Preparation of operation schedule by each of the control boards with respect to the case where an associated car is subjected to virtual assignment

If an assignment request is made, each of the
35 control boards 12a, 12b, . . . prepares an operation schedule regarding the case where it receives the assignment request. It should be noted that an

operation schedule prior to receipt of the assignment request is prepared in advance by each of the control boards 12a, 12b,

5 (2) Evaluation of all assignment patterns of associated car, by each control board

Each of the control boards 12a, 12b, . . . for the cars prepares all virtual assignment patterns indicating whether an assignment request call and virtual calls are assigned to an associated car or not, and evaluates operation schedules of the virtual assignment patterns.

FIG. 8 shows an example of a determination on how each control board assigns virtual calls to the associated car. If x virtual calls are set, the number of virtual assignment patterns is $2^{(x+1)}$ with respect to each control board.

An operation schedule not considering virtual calls has been prepared in the above procedure (1). Thus, in the above case, the virtual calls are added and virtually assigned to the associated car to make a new operation schedule, and the new operation schedule is evaluated. For example, as an example of virtual assignment patterns made only for the associated car, if 2 virtual calls are set, 8 virtual assignment patterns as shown in FIG. 9 are made. This number of virtual assignment patterns does not depend on the number of cars.

The control boards 12a, 12b, . . . transmit evaluation values of all the virtual assignment patterns obtained in the above method to the common board 11.

(3) Combination of evaluation results obtained regarding cars by common board, and evaluation of all virtual assignment patterns by common board

The common board 11 evaluates virtual assignment patterns regarding the entire system, based on the evaluation values transmitted from the control boards 12a, 12b,

FIG. 10 shows an example of a determination on how the common board assigns virtual calls to the cars. Those virtual assignment patterns are patterns indicating to which of the cars each of the calls is assigned, and the total number of the virtual assignment patterns is $c(x+1)$.

For example, in a group management system provided with 3 cars (cars A-C), if 2 virtual calls are set, the common board 11 evaluates 27 virtual assignment patterns as shown in FIG. 11. In this case, the common board 11 can easily calculate evaluation values of virtual assignment patterns based on evaluation results determined by the control boards 12a, 12b,

To be more specific, for example, regarding "combined pattern 8" as shown in FIG. 11, "independent patterns" as shown in FIG. 9 will be referred to. In this case, independent patterns 5, 2 and 3 are applied to the cars A, car B and C, respectively. As a result, evaluation values can be calculated without preparing operation schedules of the cars. That is, the evaluations of all the virtual assignment patterns can be made with reduced computational complexity.

(4) Final determination of to-be-applied car by common board

The common board 11 combines evaluation values of all the above virtual assignment patterns and expert-rule evaluation values to determine a car to which the assignment request call (new hall call) is to be assigned.

The above combination of the centralized control and the distributed control has the following advantages and disadvantages:

(Advantages)

A larger number of virtual assignment patterns can be evaluated than in the distributed control as described in the above item (b) (all conceivable virtual assignment patterns can be evaluated).

Since each of the control boards performs an operation prediction of the associated car only, it does not need a large storage area.

(Disadvantages)

5 Since processing regarding all virtual calls is executed, the computational complexity is geometrically increased in accordance with the number of the virtual calls. The number of times an operation prediction needs to be performed is 16 if 3 virtual calls are set,
10 and it is 32 if 4 virtual calls are set. In view of computational capabilities of the control boards, it can be considered hard to make evaluations in the case where 5 or more virtual calls are set.

15 It is necessary to add processing for combining virtual assignment patterns to the processing by the common board.

20 If the common board goes down, one of the control boards needs to execute both the centralized processing and the distributed processing, thus lowering a response of an assignment output.

(d) Combination of centralized processing and distributed processing (with algorithm A applied)

25 As described above, the method adopting the combination of the centralized processing and the distributed processing has great advantages. That is, the processing efficiency is high, and the storage area to be required is small. However, in the above method (c), the common board evaluates all the virtual assignment patterns, and the computational complexity
30 thus greatly varies in accordance with both the number of cars and that of virtual calls.

35 For example, in a group management system provided with 12 cars, if 3 virtual calls are set, it is necessary to determine evaluation values of 20,736 virtual assignment patterns. It is hard to determine such a large number of evaluation values for short time. Thus, the algorithm A is applied to the

evaluation processing by the common board.

First of all, sharing roles of the common board 11 and the control boards 12a, 12b, . . . will be explained with respect to all virtual assignment
5 patterns as shown in FIG. 11.

The common board 11 evaluates all combined patterns, selects a combined pattern having the best evaluation value from all the combined patterns, and determines a car (to-be-applied car) to which the
10 assignment request call is to be actually assigned. It should be noted that the "combined pattern" is a pattern indicating to which of the cars each of target calls is assigned. For example, the pattern indicates that a new hall call (an assignment request call)
15 determined as a target call is assigned to the car A, and a virtual call 1 determined as another target call is assigned to the car B.

A pattern indicating that the new call is assigned to the car A, the virtual call 1 is assigned to the car B, and a virtual call 2 is assigned to the car C is a
20 combined pattern 6 as shown in FIG. 11. With respect to the cars, the combined pattern 6 indicates the following state:

To the car A, the new call is assigned, but
25 neither the virtual call 1 nor the virtual call 2 is assigned.

To the car B, the virtual call 1 is assigned, but neither the new call nor the virtual call 2 is assigned.

30 To the car C, the virtual call 2 is assigned, but neither the new call nor the virtual call 1 is assigned.

If the above state is applied to a table as shown in FIG. 9, for the car A, an independent pattern 5 is
35 used, for the car B, an independent pattern 3 is used, and for the car C, an independent pattern 2 is used. It should be noted that the "independent pattern" is a

pattern indicating whether each of a new hall call and virtual calls is virtually assigned to an associated single car or not. For example, it indicates that the new call is virtually assigned to the associated car,
5 the virtual call 1 is not virtually assigned to the associated car,

That is, the evaluation value of the combined pattern 6 can be obtained by combining a value calculated with respect to the independent pattern 5
10 for the car A, that calculated with respect to the independent pattern 3 for the car B, and that calculated with respect to the independent pattern 2 for the car C. In such a manner, the combined pattern can be evaluated by combining the values of the
15 independent patterns for the cars.

Next, it will be explained how evaluations are made by the common board 11 by applying the algorithm A.

As described above, if the algorithm A is applied,
20 it is possible to limit virtual assignment patterns to be evaluated to likely ones, and evaluate the likely virtual assignment patterns only, as a result of which the computational complexity can be reduced, and a to-be-applied car can be determined for short time.

25 For example, in a group management system provided with 12 cars, if 3 virtual calls are set, the number of virtual assignment patterns (combined patterns), which are explained with reference to FIG. 11, are 20,736 as follows:

30 The number of cars to which a new hall call is virtually assigned is 12, and 12 virtual assignment patterns are thus made.

The number of cars to which a virtual call 1 is virtually assigned is 12, and 12 virtual assignment
35 patterns are thus made.

The number of cars to which a virtual call 2 is virtually assigned is 12, and 12 virtual assignment

patterns are thus made.

The number of cars to which a virtual call 3 is virtually assigned is 12, and 12 virtual assignment patterns are thus made.

5 Since the above four sets of "12 virtual assignment patterns" are independent of each other, the total number of all those virtual assignment patterns is 20,736 ($12 \times 12 \times 12 \times 12$).

10 In the above, a car to which each of all the calls is to be assigned is selected. This selection operation is made such that for example, a new hall call is assigned to the car A, a virtual call 1 is assigned to the car B, a virtual call 2 is assigned to the car C, and a virtual call 3 is assigned to the car
15 D.

In the case of applying the algorithm A, not all the virtual assignment patterns are evaluated. That is, results can be estimated without evaluating all the virtual assignment patterns.

20 To be more specific, in the processing according to the algorithm A, combined patterns indicating to which of the cars each of all the calls is assigned are not prepared from the beginning. At first, the processing starts from a state in which none of the new
25 and virtual calls is virtually assigned. Then, as occasion demands, calls are added and virtually assigned one by one, and evaluation is re-performed. Therefore, the combined patterns explained with reference to FIG. 11 are not the same as those obtained
30 by the processing according to the algorithm A. Combined patterns (search nodes) obtained by RTS include combined patterns in each of which it is not determined to which car a given call is assigned.

35 The above processing will be explained in detail with reference to FIGS. 12-14.

FIGS. 12-14 are views showing a procedure of the processing according to the algorithm A by the common

board. They show by way of example the case where 2 virtual calls are set in a group management system provided with 3 cars (cars A, B and C).

5 In the figures, "(Na)", "(Nb)", . . . "(Nm)" denote nodes for floors.

First, a node (Na) is prepared as a node in which operation schedules of all cars, to which none of a new hall call and virtual calls has been assigned, are made.

10 Next, nodes (Nb), (Nc) and (Nd) are prepared in accordance with to which of the cars the new call is assigned. Also, evaluation values of the operation schedules of the cars have been calculated by the method explained with reference to FIG. 9.

15 Each of the above nodes will be explained by referring to the node (Nb) by way of example.

Suppose the new call is assigned to the car A. At this time, the operation schedule of the car A is different from that of the node (Na). The operation
20 schedules of the cars B and C are the same as those of the node (Na).

Also, according to the algorithm A, it is possible to make evaluations based on results calculated with respect to independent patterns of the cars. This is
25 because the independent patterns include patterns prepared without virtual assignment of the new call and the virtual calls and patterns prepared with not all the new call and the virtual calls virtually assigned.

30 An operation schedule of the car A is evaluated based on an evaluation value of an independent pattern 5 of the car A.

An operation schedule of the car B is evaluated based on an evaluation value of an independent pattern 1 of the car B.

35 An operation schedule of the car C is evaluated based on an evaluation value of an independent pattern 1 of the car C.

An evaluation value of the node (Nb) is calculated by adding a value obtained by multiplying "average penalty value" by 2 to the sum of three evaluation values obtained by evaluating the operation schedules of the cars A-C in the above manner. In such a manner, the average penalty value is multiplied by 2. This is because in the node (Nb), the number of calls assigned is smaller by two than that in the case where two virtual calls are both assigned. That is, an evaluation value obtained in the case of assigning two calls, which are not present in the node (Nb), is made up by doubling an average valuation value obtained in the case of assigning one call (average penalty value). The evaluation value made up by adding double the average penalty value can be compared later with an evaluation value of a node in which the virtual calls are assigned to cars.

As the average penalty value, a value (e.g., the square of average no-response time) by which the evaluation value is expected to be increased in the case of assigning a single call is applied.

The above "evaluation value" will be explained in further detail.

The evaluation value of the independent pattern 5 of the car A is an evaluation value of an operation schedule of only the car A regarding the case where the new call is assigned to the car A, and neither the virtual call 1 nor the virtual call 2 is assigned to the car A. The above evaluation value is obtained by adding a predicted value of no-response time measured until the car A responds to the new call to the square of a predicted value of no-response time for a call assigned to the car A. It should be noted that the evaluation value has already been calculated as the evaluation value of "independent pattern 5" by the control board 12a for the car A.

The evaluation value of the independent pattern 1

of the car B is an evaluation value of an operation
schedule of the car B regarding the case where none of
the new call and the virtual calls 1 and 2 is assigned
to the car B. This evaluation value is the sum of the
5 squares of predicted values of no response time for
calls assigned to the car B.

The evaluation value of the independent pattern 1
of the car C is an evaluation value of an operation
schedule of the car C regarding the case where none of
10 the new call and the virtual calls 1 and 2 is assigned
to the car C. This evaluation value is the sum of the
squares of predicted values of no response time for
calls assigned to the car C.

As described above, the evaluation value of the
15 entire node (Nb) is a value calculated by adding a
value obtained by multiplying the average penalty value
by 2 to the sum of the squares of no-response time
regarding all calls assigned to the cars A-C.
Therefore, the evaluation value of an entire node can
20 be obtained by combining evaluation values of
independent patterns, which are indicated as shown in
FIG. 9, and the average penalty value.

With respect to the other nodes also, an
evaluation can be calculated in the same manner as
25 described above. The following is the points of the
calculation:

With respect to each of the nodes, it is checked
to which of the cars each of the calls is assigned.

Virtual assignments of the calls to the cars (as
30 shown in FIG. 11) is replaced with virtual
determinations on whether each of the calls is
virtually assigned to any of the cars (as shown in
FIG. 10); and

the evaluation values of independent patterns as
35 shown in FIG. 9 are combined with the average penalty
value to obtain an evaluation value of the above each
node.

After evaluations of nodes (Na), (Nb), (Nc) and (Nd) are completed, a process for selecting a node to be developed subsequently is executed as a main process included in the processing according to the algorithm

5 A. This process is a process for selecting a node having the best evaluation value (i.e., the smallest evaluation value) from among nodes which have already been evaluated, and preparing a subsequent node to be developed from the selected node, on the assumption

10 that a further call is virtually assigned to any of the cars.

It should be noted that once development is carried out from a base node for development, the base node will not be applied to another development. For

15 example, if the nodes (Na), (Nb), (Nc) and (Nd) have already been evaluated, the node (Na) will not be re-applied as a base node for development.

Of the nodes (Nb), (Nc) and (Nd), for example, if the evaluation value of the node (Nb) is the best, the

20 evaluation process proceeds to evaluations of the nodes (Ne), (Nf) and (Ng). In the nodes (Ne), (Nf) and (Ng), the virtual call 1 is assigned to the car A, the car B and the car C, respectively. Also, those nodes all hold virtual assignment of the new call to the car A,

25 which is that in node (Nb).

After evaluations of the nodes (Ne), (Nf) and (Ng) are completed, a node having the best evaluation value is selected from among nodes (Nc), (Nd), (Ne), (Nf) and (Ng), and determined as a base node for development.

30 In this case, the virtual call 1 is virtually assigned to neither the node (Nc) nor the node (Nd), and have already been assigned to the nodes (Ne), (Nf) and (Ng). Thus, the number of calls subjected to evaluation processing varies from one node to another. However,

35 when an evaluation value of each of nodes is calculated, the number of times the average penalty value is added is adjusted. Thus, the nodes can be

compared with each other.

For example, if the node (Nd) has the best evaluation value, nodes (Nh), (Ni) and (Nj) are developed. On the other hand, if the node (Nf) has the best evaluation value, nodes (Nk), (Nl) and (Nm) are developed.

However, restrictions are put on the number of times development is carried out. For example, if the number of times is 4, the following evaluations are made:

First time: evaluations of nodes (Nb), (Nc) and (Nd);
second time: evaluations of nodes (Ne), (Nf) and (Ng);
third time: evaluations of nodes (Nh), (Ni) and (Nj); and
fourth time: evaluations of nodes (Nk), (Nl) and (Nm)

If the fourth node development is completed, finally, a node having the best evaluation value is selected. As a result, for example, if the node (Nm) has the best evaluation value, the car A is selected as a to-be-applied car, since in the node (Nm), the new call is assigned to the car A.

In such a manner, in the combination of the centralized control and the distributed control, in the case where the group master executes the processing according to the algorithm A, the following advantages can be obtained:

(Advantages)

Processing for determining evaluation values of independent patterns includes no unnecessary process. That is, with respect to all operation predictions of the car B in the nodes (Nf), (Nk) and (Nm), the independent pattern 3 is applied. Also, in the node (Ni), in the operation prediction of the car B, the independent pattern 3 is applied.

In an example of the distributed control as shown in FIG. 5, in the nodes (Nf), (Nk) and (Nm), evaluations are made by the control board 12a for the car A, and in the node (Ni), an evaluation is made by the control board 12b for the car C. Thus, it is necessary that a prediction of the independent pattern 3 of the car B is made by both the control board 12a for the car A and the control board 12c for the car C. This is wasteful.

On the other hand, in the combination of the centralized control and the distributed control (with the algorithm A applied), an evaluation of the independent pattern 3 of the car B is made in a step of evaluating all the independent patterns in advance with the control board 12b for the car B (which corresponds to a step as shown in FIG. 9). Therefore, the common board 11, which executes the processing according to the algorithm A, has only to use calculated evaluation values of the independent patterns, and thus does not need to re-make evaluations, unlike the distributed control as shown in FIG. 5.

It should be noted that with respect to the above example, in order that the explanation thereof be simplified, it is given with respect to the case where 3 cars are provided, and node development is carried out 4 times. However, in the case where a larger number of cars are provided, and node development is carried out a larger number of times, the computational complexity can be greatly reduced by omitting wasteful overlaps between evaluations regarding the cars.

(Embodiments)

The elevator-group management system using the combination of the centralized control and distributed control (with the algorithm A applied) as described in the above item (d) will be explained.

FIG. 15 is a view showing a configuration of an elevator-group management system according to an

embodiment, and also management of a group of elevators. It should be noted that the term "elevator" described herein basically means "car".

5 The elevator-group management system according to the embodiment comprises a group management controller 21 and car controllers 22a, 22b, 22c, . . . connected to the group management controller 21. The group management controller 21 corresponds to the above common board (group master), and exercises centralized
10 control of operations of cars.

 The car controllers 22a, 22b, 22c, . . . correspond to the above control boards, and exercise centralized control of operations of the cars, respectively. The car controllers 22a, 22b, 22c, . . .
15 provided for the cars, respectively, and as described above, control the respective operations of the cars. To be more specific, the car controllers 22a, 22b, 22c, . . . controls opening and closing of doors of the cars, and also motors (hoisting machines) not shown
20 which are provided to move up and down the cars 23a, 23b, 23c,

 It should be noted that the group management controller 21 and the car controllers 22a, 22b, 22c, . . . comprise computers.

25 The cars 23a, 23b, 23c, . . . are moved up and down in elevator shafts by driving of the motors (hoisting machines). In the car 23a, destination floor buttons 24a for indicating a destination floor for a passenger are provided. Information on a destination
30 floor indicated by any of the destination floor buttons 24a is transmitted as a car call for the car A to the group management controller 21 through the car controller 22a.

 The same is true of the other cars, i.e., the cars
35 23b, 23c, Thus, in the cars 23b, 23c, . . . , destination floor buttons 24b, 24c, . . . are provided, respectively.

At elevator halls of floors, hall buttons 25a, 25b, 25c, . . . for registering hall calls are provided. The hall buttons 25a, 25b, 25c, . . . are connected to the group management controller 21 by a transmission cable not shown. The hall buttons 25a, 25b, 25c, . . . comprise up buttons and down buttons, to thereby enable a passenger to press an up button or a down button in accordance with his or her intended destination direction. At the lowest one of the floors, only up buttons are provided, and at the highest one of the floors, only down buttons are provided.

It should be noted that "hall call" corresponds to a signal indicating a call to be registered by operating any of the hall buttons 25a, 25b, 25c, . . . at each of the floors, and also indicating information on a registered floor and a destination direction. "Car call" corresponds to a signal indicating a call to be registered by operating any of the destination floor buttons 24a, 24b, 24c, . . . provided in the cars, and also indicating information on a destination floor.

In the embodiment, the group management controller 21 and the car controllers 22a, 22b, 22c, . . . have functions of achieving assignment controls by the method as described in the item (d), i.e., the combination of the centralized control and the distributed control (with application of the algorithm A).

FIG. 16 is a block diagram showing a function configuration of the group management controller 21 in the elevator-group management system.

The group management controller 21 comprises a call storage module 31, a call storage module 31, an assignment request issuing module 32, an evaluation result acquiring module 33, an assignment evaluating module 34 and an assignment outputting module 35 as modules for performing functions on a master side,

which correspond to the method as described in the above item (d).

5 The call storage module 31 stores a hall call registered by operating any of the hall buttons 25a, 25b, 25c, . . . at a given one of the floors. The hall call includes information on a registered floor and a destination floor.

10 The assignment request issuing module 32 issues an assignment request to the car controllers 22a, 22b, 22c, . . . when a new hall call is stored in the call storage module 31, to thereby cause the car controllers 22a, 22b, 22c, . . . to execute some of assignment estimation processing for assigning the new hall call to any of the cars 23a, 23b, 23c,

15 At this time, an assignment request call and a virtual call necessary for RTS are given to the car controllers 22a, 22b, 22c, The "assignment request call" is a hall call to be actually assigned, i.e., a new hall call. The "virtual call" is a hall
20 call assumed to be made at some point. Thus, the virtual call is made based on past operation result data, demands for operations of the cars at each floor, etc.

25 The evaluation result acquiring module 33 acquires evaluation results of the cars which are obtained by the car controllers 22a, 22b, 22c, . . . , respectively, in accordance with the assignment request.

30 The assignment evaluating module 34 makes a comprehensive evaluation of the evaluation results of the cars acquired by the evaluation result acquiring module 33 to finally determine a car to which the new hall call is to be assigned. To be more specific, first, the assignment evaluating module 34 combines the
35 evaluation results from the car controllers 22a, 22b, 22c, Then, it limits all virtual assignment patterns to likely ones to be evaluated, and evaluates

the likely virtual assignment patterns, as the processing according to the algorithm A. It thereby finally determines a car to which the new hall call is to be assigned.

5 The assignment outputting module 35 gives the car determined as a to-be-applied car by the assignment evaluating module 34 an assignment command to assign the new hall call to the car.

10 FIG. 17 is a block diagram showing a function configuration of the car controllers 22a, 22b, 22c, . . . in the elevator-group management system.

15 The car controllers 22a, 22b, 22c, . . . each comprises an assignment request receiving module 41, a virtual assignment pattern making module 42, an operation prediction evaluating module 43 and a the evaluation result transmitting module 44, as modules for performing functions on a slave side, which correspond to the method as described in the above item (d).

20 The assignment request receiving module 41 receives an assignment request issued by the assignment request issuing module 32 in the group management controller 21. At this time, the assignment request receiving module 41 receives an assignment request call and a virtual call, which are transmitted from the group management controller 21 at the time of issuing the assignment request.

25 The virtual assignment pattern making module 42 makes virtual assignment patterns based on the assignment request received by the assignment request receiving module 41. To be more specific, the virtual assignment pattern making module 42 in each car controller makes all virtual assignment patterns for an associated car based on the assignment request call and the virtual call.

30 The operation prediction evaluating module 43 prepares operation schedules (operation predictions) of

all the virtual assignment patterns made by the virtual assignment pattern making module 42, and then evaluates the operation schedules.

5 The evaluation result transmitting module 44 transmits evaluation values of the virtual assignment patterns which are obtained by the operation prediction evaluating module 43, as evaluation results of the above associated value, to the group management controller 21.

10 Next, an operation of the elevator-group management system according to the embodiment will be explained.

15 FIG. 18 is a flowchart of processing of the group management controller 21 and the car controllers 22a, 22b, 22c, . . . in the elevator-group management system. The left and right sides of the figure show a flow of the processing of the group management controller 21 and that of the car controllers 22a, 22b, 22c, . . . , respectively.

20 If a new hall call is registered by any of the hall buttons 25a, 25b, 25c, . . . at a given one of the floors (Yes in step A11), the group management controller 21 stores information on the hall call (a registered floor and a destination direction) in the call storage module 31, and then executes the following processing:

25

More specifically, first, the group management controller 21 causes the assignment request issuing module 32 to issue an assignment request. At this

30 time, the assignment request issuing module 32 prepares a virtual call list based on past operation result data and demands for operations of the cars at each of the floors (step A12). The assignment request issuing module 32 transmits along with the assignment request call (new hall call) a predetermined number of virtual

35 calls in the virtual call list to the car controllers 22a, 22b, 22c, . . . (step A13).

After receiving an assignment request through the assignment requesting receiving module 41 (step B1), the car controllers 22a, 22b, 22c, . . . execute the following processing. It should be noted that suppose
5 each of the control boards 12a, 12b, . . . for the cars prepares in advance an operation schedule (including information on an assigned call to which an associated car has not yet arrived, and the position of the car, etc.) to be prepared before receipt of the assignment
10 request.

First, each of the car controllers 22a, 22b, 22c, . . . makes virtual assignment patterns for an associated car, using the virtual assignment pattern making module 42 (step B12). To be more specific, the
15 virtual assignment pattern making module 42 prepares virtual assignment patterns each indicating whether each of the assignment request call and virtual calls is assigned to the associated car or not (see FIGS. 8 and 9). The prepared virtual assignment patterns are
20 all given to the operation prediction evaluating module 43.

The operation prediction evaluating module 43 prepares operation schedules (operation predictions) of the above virtual assignment patterns, and evaluates
25 the operation schedules (steps B13 and B14). To be more specific, as indicated in the above equation (1), with respect to each of the virtual assignment patterns, values of squares of no-response time predicted values are determined regarding all virtual
30 assignments of an associated call and the assignment request call and virtual assignments of virtual calls, and the sum of the determined values is calculated as an evaluation value of each virtual assignment pattern.

If evaluations values of all the virtual
35 assignment patterns are calculated (Yes in step B15), the evaluation result transmitting module 44 transmits the evaluation values as evaluation results regarding

the associated car to the group management controller 21 (step B16).

5 The car controllers 22a, 22b, 22c, . . . execute the above processing at the same time. The evaluation results obtained by each of the car controllers 22a, 22b, 22c, . . . (evaluation values of all the virtual assignment patterns made with respect to the associated car) are given to the group management controller 21.

10 The group management controller 21 receives the evaluation results for the cars through the evaluation result acquiring module 33 (step A14). Thereby, the group management controller 21 gives the evaluation results to the assignment evaluating module 34 to make the following assignment evaluation:

15 The assignment evaluating module 34 finally determines a car to which the assignment request call (new hall call) is to be assigned, based on the evaluation results for the cars. In this case, the assignment evaluating module 34 does not evaluate all
20 the virtual assignment patterns obtained as evaluation results for the cars, i.e., it limits all the virtual assignment patterns obtained as evaluation results for the cars to likely ones to be virtually evaluated, using the algorithm A, and evaluates the likely virtual
25 assignment patterns (step A15).

 To be more specific, as explained with reference to FIGS. 12-14, the assignment evaluating module 34 compares RTS evaluation values of virtual assignment patterns of nodes with each other, selects a node
30 having the smallest evaluation value as a base node for development, and continues processing for node development. The above RTS evaluation values are determined from a combination of the average penalty value and evaluation values for the cars which are
35 determined separately. After node development is performed a predetermined number of times, the assignment evaluating module 34 searches for a node

having the best evaluation value, and finally determines a car to which a new hall call is virtually assigned in the above node, as a to-be-applied car.

5 It should be noted that actually, in addition to RTS evaluation values, expert-rule evaluation values are also applied in order to optimally select a car; however, the expert-rule evaluation values are not necessarily required for the above selection of a car.

10 The assignment outputting module 35 issues to the car determined as the to-be-applied car by the assignment evaluating module 34 an assignment command to assign the hall call to the determined car (step A16). For example, if the car 23a to be controlled by the controller 22a for car A as shown in FIG. 15 is
15 determined as the to-be-applied car, the group management controller 21 issues an assignment command regarding the hall call to the controller 22a. In response to the assignment command, the controller 22a controls driving of the hoisting machine not shown to
20 cause the car 23a to move to a registered floor for the hall call.

In such a manner, according to the embodiment, in the group management system adopting RTS method, evaluation processing of virtual assignment patterns
25 for an assigned call and virtual calls are dividedly executed by controllers 22a, 22b, 22c, . . . , thus reducing a processing load on the group master (the group management controller 21).

30 Furthermore, each of the car controllers prepares and evaluates virtual assignment patterns for an associated car only, not those of all the cars. Thus, the car controllers are prevented from preparing or evaluating a virtual assignment pattern identical to a prepared and evaluated virtual assignment pattern. It
35 is therefore possible to eliminate waste, and efficiently obtain evaluation results.

On the other hand, the group master (group

management controller 21) can select an optimal one of the cars based on the evaluation results obtained with respect to the cars. In this case, processing time can be greatly reduced by limiting virtual assignment
5 patterns to be evaluated to likely ones according to the algorithm A, and evaluating the likely virtual assignment patterns only. Therefore, even if the number of cars provided is increased, in the shortest possible time, an optimal one of the cars can be
10 selected as a to-be-applied car, and be then made to respond to a call.

According to at least one of the above embodiments, it is possible to provide an elevator-group management system in which assignment
15 evaluation processing using RTS can be efficiently executed, and even if the number of cars provided is increased, an optimal one of the cars can be selected and be also made to respond to a call, as early as possible.

20 While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms;
25 furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their
30 modifications as would fall within the scope and spirit of the inventions.

WHAT IS CLAIMED IS:

1. An elevator-group management system which is provided with a group management controller and a plurality of car controllers, and controls a plurality of cars with the car controllers under a control of the group management controller, the group management controller comprising:
 - assignment request issuing means for issuing an assignment request to the car controllers when a new hall call is made assigning an assignment request call and virtual calls to each of the car controllers when the assignment request is issued, the assignment request call corresponding to the new hall call, the virtual calls being assumed to be made, and causing the car controllers to execute respective parts of assignment evaluation processing for assigning the new hall call to any of the cars;
 - evaluation result acquiring means for acquiring evaluation results obtained by the car controllers in accordance with the assignment request; and
 - assignment evaluating means for finally determining to which of the cars the new hall call is to be assigned by using an algorithm which combines the evaluation results acquired from the car controllers by the evaluation result acquiring means, limits virtual assignment patterns to be evaluated to likely ones and evaluates the likely virtual assignment patterns, wherein
 - the algorithm
 - selects a node having a smallest evaluation value as a base node for development from the virtual assignment patterns by comparing evaluation values

among nodes corresponding to the virtual assignment patterns,

5 repeats a node development process of adding a virtual call not yet subjected to virtual assignment, generating a new node for each of the cars from the base node for development, and removing the base node for development from nodes to be compared with each other,

10 corrects each evaluation value on a presumption that a no-response time for a virtual call not yet subjected to virtual assignment is a predetermined time when the nodes to be compared with each other differ from each other in the number of virtual assignments, and

15 finally extracts a node having a smallest evaluation value by limiting the number of repetitions of the node development process, and the car controllers each comprises:

20 assignment request receiving means for receiving the assignment request along with the assignment request call and the virtual calls;

25 virtual assignment pattern making means for making a plurality of virtual assignment patterns for an associated one of the cars based on the assignment request call and the virtual calls received by the assignment request receiving means;

30 operation prediction evaluating means for evaluating operation predictions of the virtual assignment patterns made by the virtual assignment pattern making means to obtain evaluation values of the virtual assignment patterns; and

35 evaluation result transmitting means for transmitting as evaluation results of the associated car, the evaluation values of the virtual assignment patterns obtained by the operation prediction evaluating means to the group management controller.