# Elevator Group Control by Using Talented Algorithm

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**Abstract.** A simple and efficient control approach based on an operation strategy with a talented algorithm is presented for the elevator group control. In order to analyze the performance of the presented system, the control method was evaluated by considering different performance characteristics. The results of the method were compared with the results of the area weight algorithm. The results obtained from the simulations indicated that the presented approach exhibits high performance over the area weight algorithm with the minimum time consumption results.

## 1 Introduction

Elevator group control systems (EGCS) are control systems that manage to assign a service car of multiple elevators in a building in order to efficiently transport the passengers waiting in a hall. The main aim of the optimal elevator group control is to obtain the highest handling capacity, the shortest waiting and/or traveling time of passengers. The performance of the group control system is measured by several evaluation criteria such as the average waiting time of passengers, the percentage of passengers waiting more time of 60 sec and power consumption. Since the controller considers many different cases, the EGCS is a difficult and very complex control problem. In the EGCS, there are many uncertain factors such as number of passengers, hall calls, and car calls in any time. Furthermore, it must be possible for a skilled system operator to change the control strategy.

Some methods used to achieve the elevator group control have been presented in [1-8]. Kim et al. presented the design of a fuzzy elevator group control system based on the classification of the passenger traffic and system manager's requirements [1]. Ishikawa et al. proposed a group control system which addresses riding time and waiting time [2]. Tobita et al. employed a parameter tuning method for an elevator group control system using a genetic algorithm [3]. Another group control approach with floor attribute control method was presented by Fujino et al. [4]. Cho et al. described a control procedure with accurate estimation of hall call waiting times [5]. On the other hand, Ho and Fu defined a dynamic scheduling approach for the group control [6]. In [7], Gudwin et al. proposed a fuzzy group controller with linear context adaptation. Crites and Barto developed an elevator group control using multiple reinforcement learning agents [8].

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In this paper, a more simple and efficient control approach is presented for the elevator group control. The method is based on an operation strategy with a talented algorithm. In the operation strategy, the area weight algorithm is employed by the talented algorithm. The EGCS is introduced in the second section. The proposed control problem is defined in Section 3. In the Section 4, the operation approach and simulation results are presented and the results are discussed.

## 2 Elevator Group Control System (EGCS)

There are two types of calls in the elevator group control system (Fig.1). The hall call is given through buttons on the hall of the building, and the car call is given in the elevator by passengers. An EGCS has a pair of hall call buttons on each floor, one for up hall call and the other for down hall call. If a passenger presses a hall call button, an elevator is selected by the group control system for the passenger. The selected elevator moves to the floor where the hall call occurred.

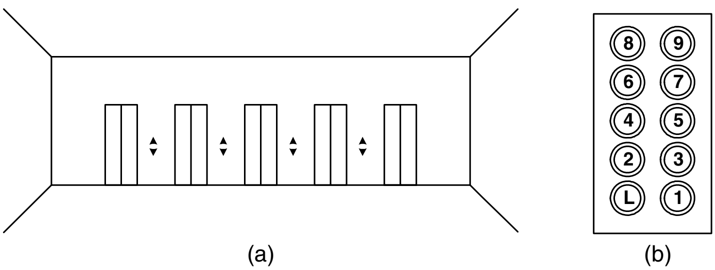


**Fig. 1.** (a) Hall call. (b) Car call.

Fig. 2 shows the structure of an EGCS. The EGCS consists of the passenger generation, group controller, elevator controller and monitoring units.

**(a) Passenger Generation:** In this module, there are some information about building configuration like number of floor and height of floors, number and capacity of cars, elevator configuration like door time and building traffic. Traffic model and profile is formed in this module. There are three kinds of passenger profile in the elevator systems. These are;

*i) The passengers calling upward:* These are the passengers going from the entrance hall to upwards. They make up-call.
*ii) The passengers calling downward: These are the passengers making calls from the upper halls to the entrance hall. They make down-call.*
*iii) The passengers calling to interfloor: These are the passengers making calls from the intermediate halls to the other intermediate halls. They make either up- or down-call.*

**(b) Group Controller:** In this module, hall and car information of calls are kept. The arrangement of the passengers is realized in this module by using the information about the cars. There are two task lists for hall calls and car calls that contain the

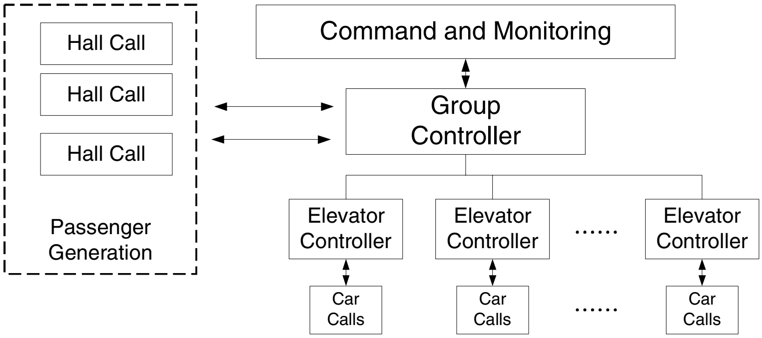


**Fig. 2.** Elevator group controller architecture

passengers getting on and already existing in the elevator, respectively. Stop and way information for the cars is determined by using this task list. When the car is charged for a given way, it does not give any response to requests in the reverse direction.

**(c) Elevator Controller:** In this module, the car will move after the current hall and target hall for car are compared. There is some information in this module such as the passengers in the car, target floor and the number of the passengers carried on a round trip.

**(d) Monitoring:** In this module, the data obtained from the evaluation criteria are computed and graphically reflected on the monitor.

The elevator group control system has to consider many factors about both the current and future states of the elevator system. In this step, we know the current data such as the position of each elevator and the hall call's and car call's allocation states, but do not know the information such as the number of passengers where a hall call happened. Furthermore, the information about the future hall calls and car calls are uncertain. Therefore, it is difficult to select an appropriate elevator when a call has happened. The selection of the elevator is made in order to minimize the average waiting time of passengers, the long wait probability and service time. This selection method of the appropriate elevator is called the hall call assignment method. In this method, an evaluation function is used to achieve the above multiple objectives. The function is evaluated for each elevator and the elevator with the smallest function value is selected. Let $\phi(\mathrm{k})$ be the evaluating function for the $\mathrm{k}^{\mathrm{th}}$ elevator, and then this function can be represented with the following formula [9]:

$$\phi(k) = T_{AVR} - \alpha T_{\alpha}(k), \qquad \mathrm{k}=1, 2, 3\ldots\ldots \mathrm{N} \qquad (1)$$

Here, $T_{AVR}(k)$ is the estimated arrival time of the $\mathrm{k}^{\mathrm{th}}$ elevator, which is the waiting time of the passenger when the $\mathrm{k}^{\mathrm{th}}$ elevator is assigned for the new call hall and N is the total number of elevators. $T_{AVR}(k)$ is calculated by the following formula:

$$T_{AVR}(k) = \sum_{stop} T_{stop}(k) + \sum_{drive} T_{drive}(k) \tag{2}$$

$$T_{stop}(k) = T_{speed\_down} + T_{get\_on/off}(k) + T_{speed\_up} \tag{3}$$

In the above formula, the path of the elevator is divided into stop and drive. Stop term means floors where hall calls and car calls are assigned, and drive term means floors where there are no calls near the floor. α and $T_\alpha(k)$ are described as the area weight and the area value, respectively. Area weight is a weighting factor for area value and it affects the performance of EGCS by the patterns of passenger traffic. The value of α also affects the possibility that the elevator close to the relevant floor can be selected. Therefore, α is an important parameter in the hall call assignment method.

The value of the $T_\alpha(k)$ is determined by the positions of assigned calls for each elevator. If an elevator is assigned to serve a call on a floor, the area of the elevator on the floor is defined. In general, the area is defined in the form of a triangle or a trapezoid as shown in Fig. 3(a). In Fig. 3(b), the trapezoidal area of elevator k on the floor n is given. The area value $T_\alpha(k)$ is defined for the floors where a call (hall and car) has happened. It can be seen that the $T_\alpha(k)$ = 1 for the floors n, n+1, n-1; $T_\alpha(k)$ = 0.5 for floors n+2, n-2; and $T_\alpha(k)$ = 0 for the others.

If a new hall call is generated on the floor where the k^th^ elevator is going to stop, the value of $\alpha T_\alpha(k)$ is subtracted from the evaluating function value of the k$^{th}$ elevator.

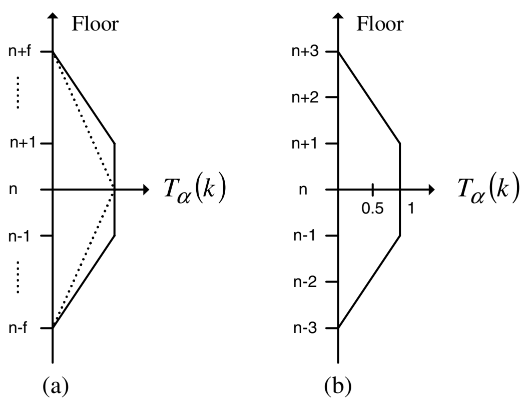


**Fig. 3.** Example of the area value

## 3 Proposed Talented Control Algorithm

Many evaluation criteria can be used to estimate the performance of the EGCS. In this paper, the following criteria are used;

i) Average waiting time (AWT) is the time until the service elevator arrives at the floor after a passenger presses a hall call button. AWT is the average of all waiting times in a unit time.
ii) Average journey time (AJT) is the total time a passenger spends within an elevator system first by waiting and then by riding inside a car. AJT is the average of all journey times in a unit time.
iii) Long waiting percent (LWP) is the percentage of the passengers who wait more then 60 sec in a unit time.

The flowchart of the general area weighting algorithm is given in Fig.4. In this flowchart, proposed talented control algorithm is also represented as the dotted area.

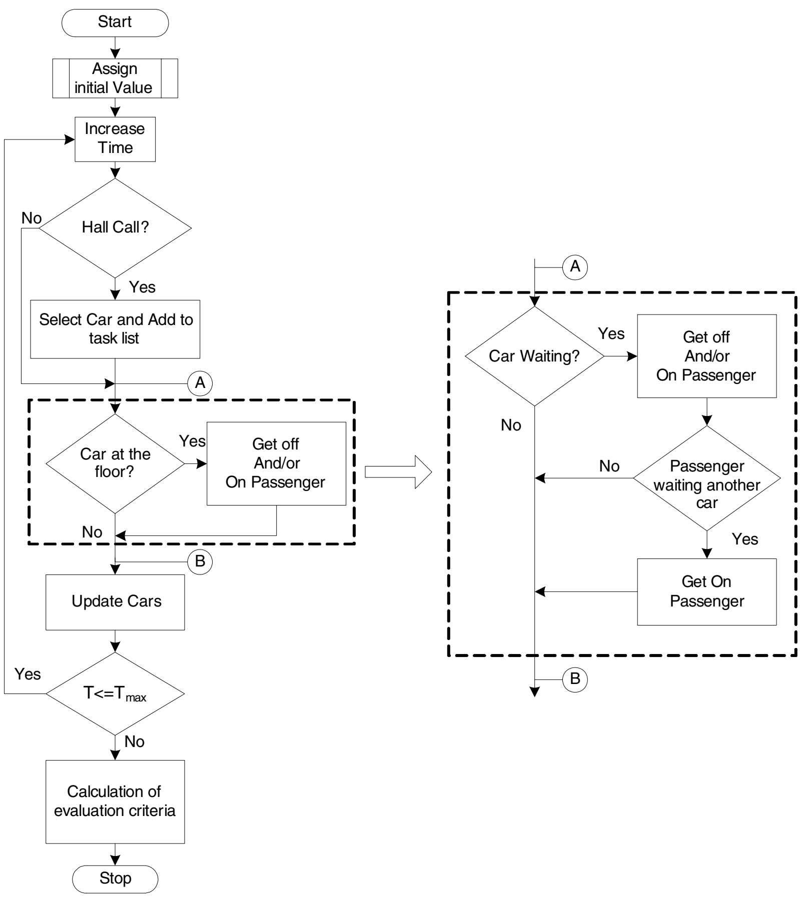


**Fig. 4.** Flowchart of simulation program

In the area weighting algorithm, firstly, the main parameters such as the number of floors, in the building, the number of elevator cars, speed and capacity of elevator cars, time that elevator car stops at floor to load/unload users are preserved by the program. The situation of the passengers is randomly generated. For the each elevator car, a task list is obtained, and this list is updated in the predetermined time intervals. The performance of the algorithm is computed by using the evaluation criteria at end of this process. The main feature of the proposed talented algorithm is with the task lists of the elevator cars. When a car stops at the any floor, its task list is compared with the task lists of other cars at different floors. If other cars have a task at this floor, these tasks are undertaken by this car at this floor. Thus, the time consumption is significantly decreased by the proposed algorithm.

## 4 Simulation Results

The conditions for simulation are given Table 1. As shown in this table, simulation time is selected as 60 min (1 hour, $T_{max}$). The number of floors and elevator cars used in the building are 16 and 6, respectively. In the simulation study, the person number of 50 to 200 is used for 5 minutes time interval and it is also assumed that the capacity of the each elevator is 20 people.

**Table 1.** Simulation conditions

| | |
|---|---|
| **Number of floors** | 16 floors |
| **Number of elevator / Capacity** | 6 cars / 20 persons |
| **Number of person** | 50 to 200 persons per 5 minutes |
| **Elevator speed** | 2 seconds per floor |
| **Stopping time** | 14 seconds |
| **Out traffic** | 1st to other floors : 25% |
| | Others to 1st floor : 50% |
| | Others to other floors : 25% |

**Table 2.** Average waiting time

| **Passenger (5min/men)** | **Average Waiting Time (sec) (AWT)** | | | | |
|---|---|---|---|---|---|
| | **Area Weight Algorithm [9]** | | | | **Proposed Talented** |
| | **α = 0** | **α = 15** | **α = 30** | **α = 40** | |
| **50** | 30,09 | 28,38 | 27,28 | 27,13 | 24,69 |
| **75** | 36,31 | 34,23 | 31,41 | 30,96 | 26,84 |
| **100** | 43,44 | 41,10 | 37,04 | 34,65 | 29,70 |
| **125** | 50,62 | 47,76 | 42,14 | 39,93 | 32,85 |
| **150** | 57,90 | 54,87 | 48,25 | 45,02 | 36,52 |
| **175** | 69,09 | 67,15 | 55,50 | 53,46 | 40,56 |
| **200** | 91,09 | 83,58 | 74,70 | 67,25 | 45,03 |

Tables 2-4 show the simulation results obtained for evaluation criteria given above. In these tables, the area weight algorithm and the proposed talented algorithm are compared for different performance indexes such as average waiting time (AWT), average journey time (AJT), long weighting percent (LWP). Since the value of α significantly affects the performance of area weight, the simulation results were repeated for different values of α (0, 15, 30 and 40).

**Table 3.** Average journey time

| Passenger (5min/men) | Average Journey Time (sec) (AJT) | | | | |
|---|---|---|---|---|---|
| | Area Weight Algorithm [9] | | | | Proposed Talented |
| | α = 0 | α = 15 | α = 30 | α = 40 | |
| **50** | 64,48 | 63,46 | 62,94 | 62,75 | 58,22 |
| **75** | 75,55 | 73,91 | 71,39 | 71,27 | 63,82 |
| **100** | 88,35 | 86,85 | 83,19 | 80,66 | 71,26 |
| **125** | 101,94 | 99,55 | 93,74 | 91,50 | 79,29 |
| **150** | 114,77 | 111,89 | 105,34 | 102,29 | 87,95 |
| **175** | 130,56 | 129,09 | 117,48 | 115,56 | 97,21 |
| **200** | 156,17 | 149,15 | 140,50 | 133,06 | 105,67 |

**Table 4.** Long waiting percent

| Passenger (5min/men) | Long Waiting Percent (%) (LWP) | | | | |
|---|---|---|---|---|---|
| | Area Weight Algorithm [9] | | | | Proposed Talented |
| | α = 0 | α = 15 | α = 30 | α = 40 | |
| **50** | 15,22 | 13,69 | 12,03 | 11,40 | 9,56 |
| **75** | 20,93 | 18,58 | 15,03 | 14,00 | 11,37 |
| **100** | 26,12 | 23,68 | 19,03 | 16,30 | 13,89 |
| **125** | 31,11 | 28,32 | 22,55 | 19,90 | 16,82 |
| **150** | 35,17 | 32,24 | 26,14 | 22,50 | 20,87 |
| **175** | 38,12 | 35,68 | 29,25 | 26,00 | 24,93 |
| **200** | 40,56 | 37,29 | 32,64 | 29,60 | 28,89 |

From these tables, the following conclusions can be drawn:

(1) The average waiting time for the passengers is the most crucial factor in the elevator group control. The waiting time occurred when the proposed control algorithm is used is quite shorter than that of the area weight algorithm (Table 2). As the number of passengers increases, it is seen that the waiting time significantly decreases when the results of both algorithms are compared. For example, when the number of passengers is 200 AWT of talented algorithm is 45.03 sec. For the same condition, AWT of area weight algorithm is 67.25 sec (α = 40).

(2) From Table 3, it can be clearly seen that the average journey time for the talented algorithm is also shorter than that of the area weight algorithm. For example, the difference between the average journey times of the talented algorithm and the area weight algorithm for 200 person is 50.50 sec and 27.39 sec for α = 0 and α = 40, respectively.

(3) As apparently seen from Table 4, the long waiting percent of the passengers for the elevator cars is considerably decreased in the proposed algorithm.

## 5 Conclusion

In this paper, a simple and efficient control approach based on a talented algorithm is presented for elevator group control system. When it is compared with the area weighting algorithm, it is verified that the proposed control algorithm is a very effective and reliable control method for any condition of the passenger. The presented algorithm is also capable to adopt for different process parameters such as the number of elevator car, capacities of the cars, floor numbers, different traffic situations, and it is a distinctive advantage of the algorithm.

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