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Dynamic Dispatching of Elevators in Elevator Group Control System with Time-Based floor Preference

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Abstract*: *Elevator Group Control System (EGCS) has a significant role in the transportation system of buildings. This study presents an elevator group dynamic even and odd floor preference approach based on the real-time passenger traffic to overcome the difficulty of using elevators in the up peak and down-peak traffic mode. The proposed system framework divides building floors as even and odd based on the floor number, some lifts allocated for even numbered floors and some for odd floors. Even numbered lifts are responsible for serving calls of even floors, and odd number lifts are responsible for serving calls of odd floors. Proposed study uses time-based floor preference logic for dynamic allocation of elevators. The primary motive of the proposed research study is to reduce the passengers traveling time, average-waiting time and improve overall system performance in up-peak traffic and down-peak traffic conditions. The time-based floor preference logic used for dynamic allocation of elevators significantly minimizes the waiting time and traveling time of passengers.

Index Terms*: *Down-peak traffic, Dynamic dispatching, Elevator, EGCS, time-based floor preference, Up-peak traffic.

I. INTRODUCTION

Elevators are commonly used as vertical transportation systems equipped with tall buildings and skyscrapers. As fast and continuous development in the high-rise & intelligent buildings, the elevator as a vertical transport system has gained more and more popularity. Single-lifts often cannot meet the passengers' needs. To reduce the waiting time, the ride time and energy loss, there is a need to install an elevator group. For these reasons, the Elevator Group Control System (ECGS) introduced, which regards two or more elevators as an organic whole. In the EGCS, the key technology is the choice of an elevator dispatching strategy, which determines the pattern of traffic flow. Generally, the passenger traffic pattern includes up-peak traffic (huge traveling in the upward direction), down-peak traffic (huge traveling in the downward direction), inter-floor traffic and the idle traffic (very less up, down or interfloor traveling). The proposed system focuses on the dynamic scheduling of elevators in these traffic modes. The proposed system introduces a new concept for dynamic scheduling of lifts/elevators in an EGCS. In traditional EGCS, the elevators provide service to all floors. As elevators, involved servicing all floors the number of stops increased which results in more waiting time for passengers. To reduce this time, EGCS uses even and odd elevator concept where EGCS divides building floors as even floors and odd floors depending on the floor number. EGCS splits elevators as even floor lifts, to service even floors and odd floor lifts, to service odd floors, which in turn reduces the waiting time for passengers significantly. Suppose in the peak traffic time many passengers want to go on even floor; then they need to use even elevator only. By considering elevator capacity, not all request can serve at a time resulting in increased waiting time for passengers. In this situation, passengers cannot use odd lifts, even if odd lifts may idle. Either they need to wait for even lifts, or they can hire odd lift, reach to the next odd floor and climb to even floor. The proposed system introduces dynamic even and odd elevator scheduling algorithm, which uses time-based floor preference logic. In the peak traffic time, the elevator allocation is dynamic to the preferred floors. During normal traffic, elevators work within assigned floors.

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II. LITERATURE SURVEY

There are many algorithms to solve the up-peak traffic problem, for example, analytical method, search method, dynamic programming and so on. Dynamic programming approach based on the optimization theory proposed by Bellman solves the critical path, which does not need to search all the paths. The study of Yaowu Liu, Zhangyong Hu, Qiang SU and Jiazhen Huo [1] focuses on the optimal zoning strategy with inter-floor traffic condition for energy saving. The optimal zoning strategy for energy saving is designed using a genetic algorithm. Donghua Wang Baofeng Li [2] presents a study on the elevator group dynamic zoning system. The study focuses on the design of elevator service-quality model and elevator energy-loss model to optimize the elevator group zoning strategy. The research of Peter B. Luh, Qian-Chuan Zhao, and Sun, Jin [3] focuses on vertical transportation with advance traffic data. Discussed methods are CPU time-consuming. Jinglong Zhang, Qun Zong [4] proposes an optimization technique for less energy consumption in EGCS. The technique focuses on power usage only; not the perfect solution for waiting time reduction. The study of Li, Mao and Jianping Wu [5] uses Queue theory for car allocation. The study says that elevators move from the source floor to the destination floor within the zone only. The study of Suying, Tai, and Shao [6] used destination floor data for scheduling.

The study focused on a single input for both the lift call and selection of destination. The study considered only up-peak traffic. Zhonghua, Jianping, and Zongyuan [7] introduced a novel approach based on the artificial immune algorithm for elevator traffic. The study focuses on dynamic non-continuous zoning during peak traffic; to improve the real-time processing capability of various traffic demands. Therefore, Yu and Chan [8] introduced a concept that provides a solution to dynamic zoning. The study of Deying, GU, and Yan Dongmei [9] uses the fuzzy system to optimize the elevator control system in MATLAB. The study uses dynamic zoning with the help of the immune system. Fujino, Atsuya, et al. [10] uses control method depending on a floor attribute, which uses a combination of floor-based attribute and car-based attribute. If the preferential floor has given a car call, then the car with minimum waiting time is preferred, for less crowding priority the car with fewer passengers is preferred. In the floor-based, attribute control method, the selection logic changes according to the floor-attribute.Floor-based attribute evaluation method gives priority to the floors, which are preferable floors, and uses the control settings according to the assigned floor priority. Covington and Michael A [11] use MATLAB to create a simulation. The study focuses on the use of defeasible logic by using Prolog and then d-prolog. In a defeasible logic, new information may override earlier information/conclusions made. Like human beings, the automatic control systems are also dealing with several situations, which describes as a rule with specific exceptions. Defeasible logic is a system in which the set of conclusions can be shrink and grow for the enlarged premises. In this logic the rules have the form A: B: C. If A is true and B is assumed true without contradiction, then conclude C. Utgoff, Paul E., and Margaret E. Connell [12] uses the MV10 algorithm for dispatching of elevators.Srikumar R., Arvind U. Raghunathan and Daniel Nikovski [13] proposes a greedy algorithm and submodular function for elevator scheduling using matroid constraints. The algorithm assumes a single passenger per matroid. Wang Chuansheng, Chen Chunping [14] focuses on the shortest distance algorithm for elevator allocation in VC++ and SQL server database environment. However, the energy consumption constraints have not considered. Yine Zhang, Yun Yi, Jian Zhong [15] proposes the use of fuzzy BP neural network. In the fuzzy BP neural network, there are five layers available input layer, fuzzy layer, fuzzy condition layer, fuzzy judgments layer, and DeFuzzyfication layer. With the fuzzy BP Neural Network Theory, the service quality and performance of the elevator operation improves. However, fuzzy systems lead to memory fault errors. The study of Jun Wang, Airong Yu et al. [16] proposed a new simulation platform of an EGCS, implemented in C# using the fuzzy-neural network technology.Various passenger traffic pattern recognition based on the fuzzy neural network model of an elevator control system. The study of Jafferi Jamaluddin, Nasrudin Abd. Rahim at al. [17] introduces the self-tuning scheme for elevator scheduling which offers the self-tuning FLGC to self-tune and automatically initiates immediate corrective actions because of any changes in system conditions. The algorithm needs continuous tuning and periodic tuning. J. Fernandez, P. Cortes [18], gives the dynamic solution to the landing calls. The research focuses on the fuzzy logic algorithm to find the solution by considering the waiting time. The study does not consider traffic flow of passengers at a particular time. The study assumes only one call button is available on each floor. When a call comes from a specific floor, the EGCS allocates car to the floor by considering minimum waiting call. The study [19] propose even-odd elevator scheduling, where elevators used as even and odd elevators to service the even and odd floors. The study uses a fuzzy approach for scheduling of elevators [20]. Different studies identify and compare various algorithms. These algorithms include zoning based algorithms, genetic algorithms, artificial intelligence, and fuzzy based techniques. Fuzzy based algorithms need the use of fuzzy controllers that leads to memory related problems. To overcome such challenges, researchers introduced the combination of fuzzy algorithms and neural networks. With that solution, parallel operations execution are not able to process. ANN needs individual training and expert knowledge to operate the system.

III. PROPOSED SYSTEM

The proposed system works on the EGCS problem by optimizing the even and odd zones of elevators in different traffic patterns.

Figure 1 shows the structure of building with twenty floors and four elevators.

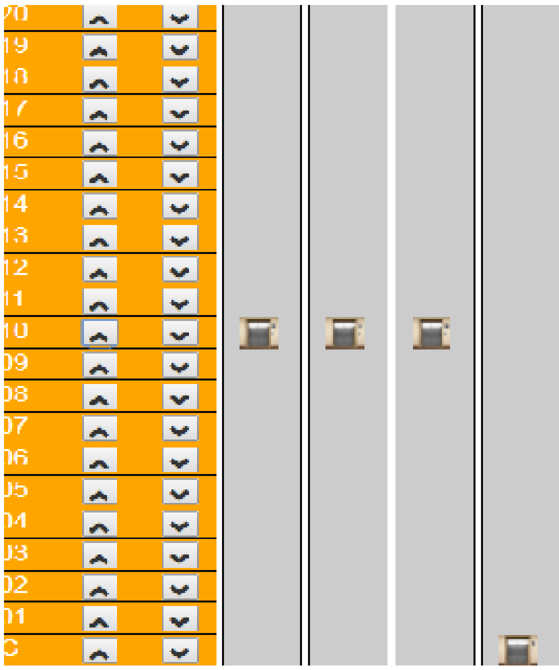

Fig.1 Proposed Building architecture

At each floor up and down buttons are considered. Passengers can call lift by pressing either up or down button. EGCS collects all calls, identifies calling floor number, determines time and priority of floor, identifies elevator, then allocates elevator to calling floor by using time-based floor preference logic. In traditional systems, the elevators provide services to all floors. As the elevator stops at each floor the waiting time and the journey time of passengers is more. If passengers want to go on the 10th floor, they can use any lift. Assuming 15 passengers in a lift intends to get out at each floor then lift stops at each floor.

Which in turn, results wastage of passengers time, increased waiting time and journey time.In an even-odd elevators system, even elevators stop at even floors and odd elevators stop at odd floor only. If an elevator is in motion and not available, then passengers need to wait for lift arrival, or they can take other elevators (even/odd depending on floor) and one-floor climb by stairs. When multiple calls come at a specific time from the specific floor, and the allotted elevator is in motion or not capable of satisfying all requested calls, then passengers need to wait although other elevators are available. The proposed system provides a solution to overcome this problem. A survey of the twenty-floor commercial building has the kinder garden school on the 10th floor, government office on the 5th floor, and remaining floors have commercial flats. EGCS receives a knowledge base of building design, which is helpful in the dynamic allocation of elevators to specific floors.

Simulation considers a building with twenty floors, a school on the tenth floor, the office on the fifth floor, and four elevators. The proposed system divides all twenty floors into two sections; even the floor section and odd floor section (ten floors in each section). In the morning time, all students want to go to the tenth floor. Multiple calls come from the ground floor, as they want to reach school on time. Students can use an elevator number two or four, as school is on the even floor. Considering elevator capacity as fifteen passengers, only thirty students can use the elevator at a time and remaining need to wait for the lift. At the same time, other elevators may idle or less traffic, but still, passengers cannot use these, as they are odd elevators and allocated to the odd floor only. Passengers need to either wait for the lift to come to the requested floor or use odd floor lift, go at the odd floor and then climb to the required destination, which in turn results in less system performance and passenger's satisfaction. The proposed system provides a solution to this situation by the time-based dynamic allocation of elevators.

In time-based dynamic allocation, in the morning when multiple calls are coming from the ground floor, EGCS allocates three lifts to school and one lift to service all floors.

Figure 2 shows the proposed system block diagram. In the proposed system, Elevator group control module passes the calling floor Id to the dynamic even/odd controller. The controller system directs the elevator to move from source floor to the destination floor. An elevator receives Id and transits to the directed floor.

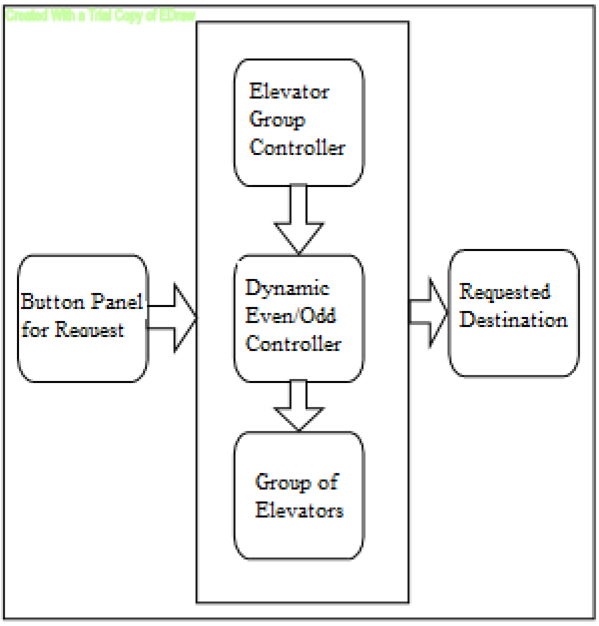

Fig. 2 General Block diagram of Proposed System

Figure 3 shows the proposed system Architecture with Even/Odd Elevators.

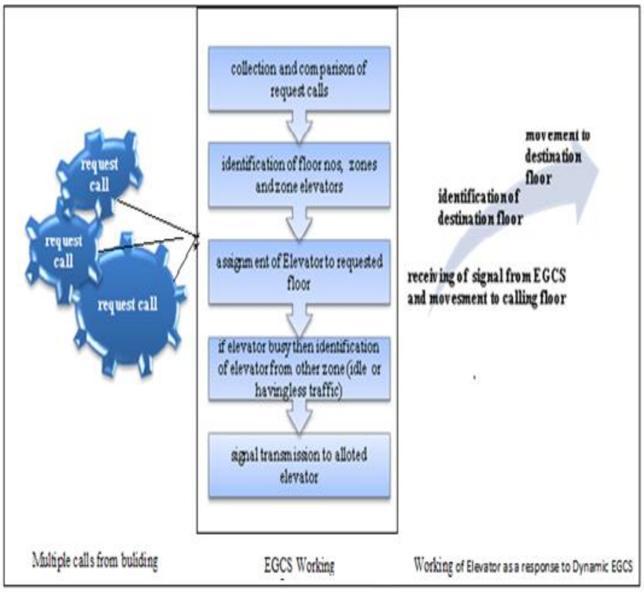

Fig.3 Proposed system Architecture with Even/Odd Elevator.

Figure 4 shows the time-based floor preference logic used by the system. When passengers give a call to an elevator, the signal passes to EGCS. EGCS collects different calls and identifies floor number from which calls are coming, records timings of incoming calls, number of calls and elevator positions. By using this information, the controller compares all calls and stores in buffer depending on whether it is up going call or down going call. If incoming calls are within a predefined time stamp (morning 9.00 to 9.15 am, and 10.00 to 10.15 am, evening 4.00 to 4.15 pm and 5.00 to 5.15 pm) then by using time-based floor preference logic, EGCS identifies elevators and allocates to calling floor.

If the time is not predefined, then EGCS allocates elevators by using even/odd elevators logic. Once the elevator receives a signal, it moves to the allocated floor.

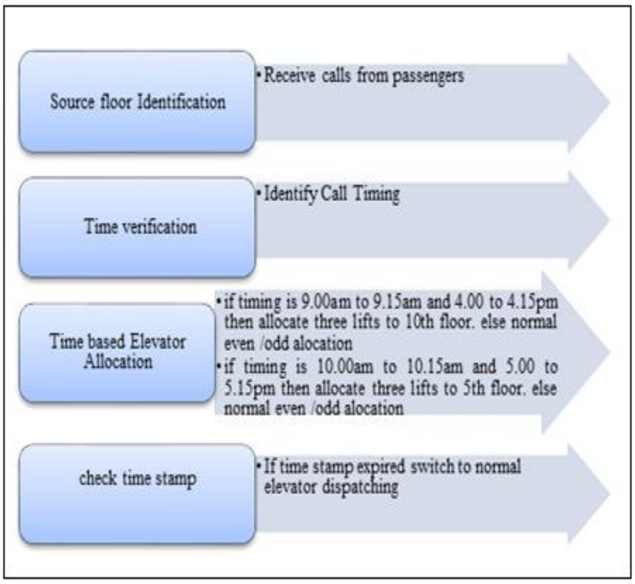

Fig.4 Time based Floor preference Logic

The relationship between elevator running time T and distance x can be T (x). Let 'x' be the running distance of the elevator, 'v_0', be the rated speed, 'a' be the rated acceleration and 'q' be the change of rate of acceleration. Ignoring changes of speed $T(x) = x/v\_0$. Without consideration of the changes of the acceleration and the initial velocity is zero, then the speed of elevator is $v = at$ ($v \leq v\_0$), the time for the elevator to reach the rated acceleration is $t1 = v\_0/a$.

Then the total running time is

$$T(x) = x/v\_0 + v\_0/a$$

Distance is the number of floors that the elevator must travel from the current position of the elevator to the floor where the new call occurred.

Waiting time: is the estimated time that the passengers must wait in the halls until the elevator arrives at the floor after the passenger presses a new call button. Below equation gives the estimated waiting time.

$$\text{Waiting Time (WT)} = \text{Floor no} \times DT + (\text{Travelled Distance}) \times Tt$$

Where,

DT = time required to open the lift door + time required to close the lift door.

Tt = Time required to transit between two adjacent floors.

Assume an even distribution of the up-peak traffic that is, the probability that the passengers move to each floor is equal. Therefore, the average journey time Wr equals the mean value of the longest average waiting time Wlr, and the shortest average waiting time Wsr.

$$Wr = (Wlr + Wsr)/2$$

IV. RESULTS

The proposed system consists of an elevator group controller, for building with twenty floors and four elevators working on twenty floors. All floors can be the source or destination floor and accordingly results are noted. To handle multiple requests at different floors, EGCS uses the time-based floor preference logic in even odd elevators.

A kinder garden school is on the 10th floor, and its timing is 10 am to 5 pm. In the morning time, many students want to reach school on time, and they give a call at ground floor. In the evening after school, they want to reach home and give a call at 10th floor. Assume all lifts position is on the 20th floor and there are calls from all intermediate floors (each floor from the ground to 10th floor and ground to 5th floor).

In regular lifts configuration as all lifts stop at all floor the waiting time and journey time is more. As compared to regular lifts configuration, the even/odd lifts configuration take fewer stops, resulting less waiting time and journey time. However, in the time-based configuration, from 10.00 am to 10.15 am three lifts positioned at ground floor, and assigned to the 10th floor only. Also, in evening time from 5.00 to 5.15 pm, three lifts positioned at 10th floor and assigned to ground floor only. This configuration reduces waiting time and journey time for students. Similarly, a government office located on the fifth floor and office timings are 9 am to 4 pm. In the time-based configuration in morning time during 9.00 to 9.15am three lifts positioned at ground floor and assigned to the fifth floor only. Also, during 4.00 to 4.15pm three lifts positioned on the fifth floor and assigned to ground floor only. This configuration reduces waiting time and journey time for passengers. Results have calculated with regular lifts, even/odd lifts and time based even/odd lifts configuration.

Table 1: Waiting and Journey time in traditional EGCS

Floor no	Waiting time	Journey time	Total time
0-5	0.42	0.52	0.94
0-10	0.42	1.28	1.70
5-0	0.36	0.52	0.88
10-0	0.25	1.28	1.53

Table 1 and figure 5 shows the waiting time and journey time required to reach the 5TH & 10TH floor in the morning period and to ground floor in the evening in the traditional EGCS where all lifts stop at all floors.

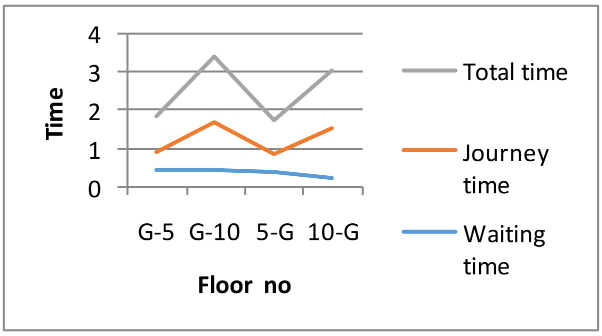

Fig 5. Waiting and Journey time in traditional EGCS

Table 2 and figure 6 shows the waiting time and journey time required to reach the 5th & 10th floor in the morning period and to ground floor in the evening in the Even/Odd EGCS where two lifts stop at even floors and two lifts stop at odd floors.

Table 2: Waiting and Journey time in Even/Odd EGCS

Floor no	Waiting time	Journey time	Total time
0-5	0.42	0.31	0.73
0-10	0.42	0.54	0.96
5-0	0.36	0.31	0.67
10-0	0.25	0.54	0.79

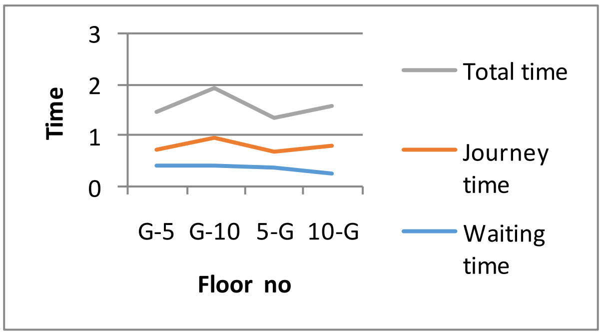

Fig 6. Waiting and Journey time in Even/Odd EGCS

Table 3 and figure 7, shows the waiting time and journey time required to reach 5th & 10th floor in the morning and to ground floor in the evening. The time-based floor preference Even/Odd EGCS, with three lifts positioned at ground floor in the morning and allocated to 10th & 5th floor only. In evening three lifts positioned at 5th & 10th floor and allocated to ground floor only. One lift is used to serve remaining calls. After the specified time the proposed system works as a regular even/odd system.

Table 3: Waiting and Journey time in Time-based floor preference Even/Odd EGCS

Floor no	Waiting time	Journey time	Total time
0-5	00	0.16	0.16
0-10	00	0.25	0.25
5-0	00	0.16	0.16
10-0	00	0.25	0.25

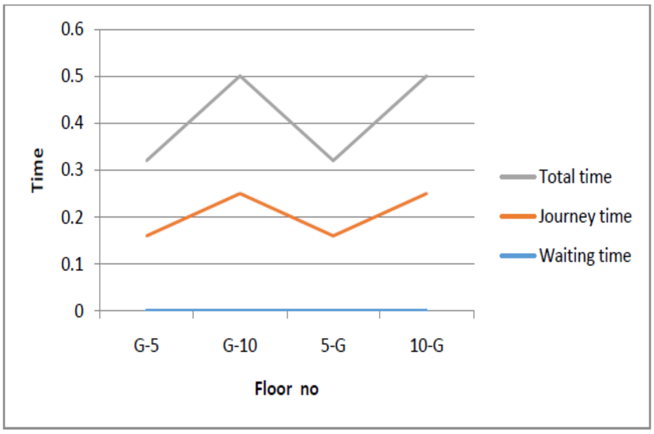

Fig 7. Waiting and Journey time in Time-based floor preference Even/Odd EGCS

From the above results, it has been clear that the proposed dynamic approach with time-based floor preference in even/odd elevators gives the best solution in all traffic patterns than conventional elevator system and even/odd elevator system. The proposed system gives minimum waiting time and traveling time as compared to other traditional systems.

V. CONCLUSION

The study shows that the dynamic approach with time-based floor preference in even/odd elevators improves an existing elevator system by reducing the average passenger waiting/traveling time. The primary mission of the group controller is to assign proper elevators according to the real-time floor demand and update their service zone. The successful implementation of dynamic approach relies on a good monitoring system that evaluates the real-time traffic demand of every floor. The proposed dynamic method gives the better solution in real time traffic demands. The simulation with twenty floors and four elevators in building handles multiple calls and allocate elevators in both static and dynamic mode. The proposed dynamic approach with time-based floor preference in even/odd elevators algorithm is feasible and practical to reduce passengers waiting and journey time.

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