A Review of Elevator Dispatching Systems

Mohammed Kheshaim, Muhammad Latif, and Saikat Kundu

Abstract— **The real estate industry has been experiencing immense growth, evident from the growing number of tall buildings in cities and urban areas. In buildings, elevators play a vital role in carrying people to their destined floors. However, there is a need to improve the dispatching systems of these elevators that affect waiting and journey times of the users, as well as reliability and sustainability (economic and environmental) of the elevators systems. This paper reviews a number of widely used elevator dispatching systems and their underlying algorithms including Estimated Time to Dispatch (ETD), Destination Control System (DCS), and CompassPlus Destination System (CDS). A qualitative methodology was adopted for this study. From survey of literature, a number performance criterion for elevator systems was used to make a comparison amongst the elevator-dispatching systems. In addition, our study shows that a research into human behavioral aspect and (economic and environmental) sustainability are two other pertinent factors that should be considered whilst modelling dispatching systems for elevators.**

Index Terms— **Elevator, Elevator dispatching systems, Destination control, Destination dispatch, Human behavior, Sustainability, Energy efficiency, Smart Elevator**

I. Introduction

Over the past decade, the elevator industry has experienced tremendous growth as evidenced by the rapid proliferation of tall buildings in cities and urban areas across the globe. As a result of these developments, waiting times of the users of the elevators when accessing the upper floors of such buildings have become a concern, especially during heavy traffic periods. The amount of time it takes to access the top floors of the building using an elevator needs to be reduced as much as possible [1]. However, elevators can only perform two commands at any given time, meaning the collective up and collective down commands [1]. For these reasons, many of the recent developments in elevator systems have been focused on creating innovations in their dispatching systems [2]. The developments that have been made are mainly concerned with resolving the problems associated with elevator calling strategies and waiting times of the users during the busy periods.

II. Methodology of Study

The research reported in this paper adopted a qualitative research methodology based on a comprehensive analysis of the existing literature on elevator dispatching systems. The research relied on secondary data, which was gained from resources such as reviewed articles, journals and books.

The rest of the paper is organized as follows. Section 3 provides a brief review of the existing elevator dispatching systems and a table comparing among these dispatching systems followed by a succinct discussion on the results of comparison. Section 4 presents an overview of the importance of the human behaviour aspect for the elevator dispatching systems. Section 5 discusses the sustainability issues and highlights their importance for development of elevator dispatching systems. The key conclusions drawn from this study are presented in section 6.

III. Review of the Existing Elevator Dispatching Systems

In this section, summaries of some of the well-established elevator dispatching systems and their underlying algorithms are provided and a table of comparisons of the different dispatching system is presented.

A. *Estimated Time to Dispatch (ETD)*

Estimated Time to Dispatch (ETD) is one of the destination-based elevator dispatching algorithms widely used by the manufacturers such as ThyssenKrupp. Destination-based dispatching system (also called call allocation), asks the users to register their destination floors [3]. Depending upon the user response, the dispatching system allocate an appropriate elevator car to the user. EDS operates in three modes: (i) Destination dispatch, (ii) Conventional dispatching with up and down hall call buttons on other floors, and (iii) A combination of destination input on busy floors and conventional hall call buttons on other floors. As a result, with these three combinations ETD aims at ensuring individuals to reach their respective floors within the shortest time. Traditional elevators usually allocated elevator cars to individuals based on which elevator is closest to them. However, this at times could prove costly as these elevators would often become almost full, which could lead to people fighting to get their way into the elevators [4]. However, the ETD not only allocates elevators based on the proximity of the calls but also considers the number of people in the elevator car. Additionally, it also considers the number of stops the elevator is going to make before the last person exits. By taking such factors into consideration, the system is capable of calculating the amount of time it would take to transport an individual to the desired destination. For this reason, an individual is likely to be allocated to an elevator that would take as little time as possible to be taken to the chosen final destination [5].

Manuscript received April 4, 2016.
M. Kheshaim is a PhD researcher studying at the School of Engineering, Manchester Metropolitan University, Manchester, M1 5GD, UK (e-mail: Mohammed.kheshaim@hotmail.com).
M. Latif is an academic at the School of Engineering, Manchester Metropolitan University, Manchester, M1 5GD, UK (e-mail: M.Latif@mmu.ac.uk).
S. Kundu is an academic at the School of Engineering, Manchester Metropolitan University, Manchester, M1 5GD, UK (e-mail: S.Kundu@mmu.ac.uk).

B. *Destination Control System (DCS)*

The Destination Control System (DCS) groups users according to their registered destinations. It is extensively used by manufactures such as KONE and Schindler in their elevator systems [6]. DCS aims to provide increased efficiency for the users, reduced time taken for individuals moving from one floor to the other and increased security when using the elevators [7]. The DCS achieves this by incorporating artificial intelligence, travel forecasting, fuzzy logic and genetic optimization [8]. As such, through a combination of these elements, the DCS is capable of transporting people with ease. This is evident during peak hours, which could prove quite challenging for other dispatch systems and could thus affect the amount of time needed to traffic people [8]. The increase in the number of people leads to an increase in the number of calls made to the elevator car [9]. As a result, responding to all these calls could lead to malfunctions and increase the time of trafficking people from floor to floor. However, the DCS is able to forecast peak hours based on the integrated artificial intelligence. This is achieved by continuous monitoring of the traffic behaviour at all times. Consequently, during peak hours, the DCS is capable of adjusting itself to accommodate the increased traffic, thus reducing the amount of time taken to move people. The DCS also takes into account the disabled users, thereby ensuring that elevators are accessible and easy to use for everyone [10].

C. *Compass Plus Destination System (CDS)*

First developed by Otis, the CDS is an elevator dispatch system that has been developed to ensure that users enjoy the best trafficking experience they can get. This is achieved by coming up with a system that is easily understood by all the users. Additionally, CDS introduces the smart grouping concept, which is an improvement to the conventional dispatching systems and traditional dispatch systems [11]. Traditional dispatching systems allow individuals to choose the elevator car they would intend to board. However, this proved to be quite time consuming and led to crowding the lobbies. As a way of remedying the situation, conventional dispatching systems were developed [11]. The conventional dispatching systems group users based on their destinations, which floor they want to travel. Therefore, individuals having the same destination are assigned the same elevator car. This led to fewer stops being made and thereby reducing the time taken to reach the destination. Despite these improvements, the system still faces setbacks - the main setback being the overlapping of elevator cars [11]. This means that one or two elevator cars could end up serving the same floor at one particular time, which greatly affects the efficiency of the system. However, in response to this problem, CDS introduced a smart grouping of individuals and elevators. This system groups individuals based on their destination. Additionally, it also allocates elevators to specific floors. Thus, an elevator cannot access a floor it is not designated to access. As a result, this system eliminates the element of overlapping elevators and in return increases the efficiency of the system. For this reason, the time used to reach the destination is quite minimal compared to both, traditional and conventional dispatching systems [11].

TABLE I: A COMPARISON OF THE DIFFERENT DISPATCHING SYSTEM

System / Factors	Traditional System	Conventional System	ETD	DCS	CDS
Waiting time	8	6	6	7	7
Travelling time	4	5	7	7	8
Forecasting traffic	0	0	4	8	7
Grouping users	0	0	5	7	7
System reliability	5	5	7	6	6
Energy consumption	2	3	6	7	8
System factor Total	19	19	35	42	43

Ranking: 1 = very poor and 10 = excellent

D. *Discussion of table results*

Table I ranks each system on different factors. As starting with (1) to be a very poor service and following up to a (10) as an excellent service. The ranking system used is developed from observing each system thoroughly and evaluating each factor out of 10. For example; In the Traditional system, the system allocating elevator cars to individuals based on which elevator is closest to them, regards what direction the elevator is moving, as a result, the user will not wait long to enter the elevator car (Waiting time Factor = 8). However they could be in the elevator for a long period of time before arriving to their destination, due to the elevator stopping frequently (Travelling time Factor = 4). This also means a more energy will be consumed as there are more frequent stops to respond to each call immediately (Energy consumption Factor = 2). In addition, there could be more than one elevator serving the same floor at the same time. In responds to this the CDS has a smart grouping of individuals and elevators, as this concept group users based on their destination and allocates the elevator to a specific floor (Grouping users Factor = 7), Which means less stops leading to less use of energy. However, the CDS experiences overlapping at allocating elevator car with effects the reliability of the system (System reliability Factor = 6). On the other hand the forecasting feature in the DCS system may not be accurate in peak hours and effectively responsive in normal times (Forecasting traffic Factor = 8), with lowers the reliability of the system in peak hours (System reliability Factor = 6). From this comparison and analysis, the determination of what system is better than the other have no significant effects rather then what the stakeholders (users, owners and manufacturer/maintainer) expect from the system. This table is uncompleted primarily because future work is needed to review the role of distinct categories of stakeholders (users, owners and manufacturer/maintainer) of elevator systems who often have conflicting objectives and how it effects the systems factors.

ISBN: 978-988-14048-0-0
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

IV. The Human Behaviour Aspect

It is important to note that important factors in designing an elevator dispatch system are not solely confined to the size of the building but rather include several other factors. Human behaviour plays a major role in designing an elevator dispatch system [12]. These behaviours include gender differences, health conditions and social preferences among other factors, such as how our minds work and register even the sound when the call for an elevator has been made to when it arrives and how the colours on the control buttons of the elevator change [13]. When a call has been made our minds physiologically know that the elevator is on its way or when it has arrived [2]. Some current employed elevators use the following system on a floor to floor basis. For example when person A enters an elevator on floor 1 to go to floor 9 and person B enters on floor 2 to go to floor 3 frustration occurs for person A because he is standing in the elevator the longest. Or a passenger calls an elevator and can't enter for the reason that the elevator car is full, leading to a longer waiting time, which also causes frustration [14]. A solution is required to eliminate frustration for the elevator users, since elevators are essentially designed to meet the needs of the people [13]. Therefore, it goes without saying that a good elevator dispatch system should consider the preferences of the user. Additionally, elevator dispatch systems should also take into consideration that there may be individuals who board an elevator without pressing their destination at the point of entry. As a result, the dispatch system should be able to get such persons to their destination without needing to take them back to the lobbies to reinter their desire floor [14].

V. The Sustainability Aspect

Sustainability also plays a critical role in determining the manner in which an elevator dispatch system is to be designed. Sustainability in this sense refers to the life of the dispatch system, how often repairs should take place and the amount of energy or electricity needed to power it [5]. A good dispatch system should give the elevator a long lifespan. This is to say that, even after ten or fifteen years the dispatch system should be able to perform its tasks without much difficulty. In doing so then, its design has to be flexible enough to adapt itself to the changes in technology that may arise and incorporate them [15]. Additionally, a good dispatch system should be energy efficient, meaning that it should have the ability to consume less energy and at the same time meet its objectives. As a result of the growing concerns about protecting the environment a good dispatch system should be eco-friendly as well [15].

VI. Conclusion

In conclusion, the rise of tall buildings has led to the increase in demand for more sophisticated elevators, therefore elevator dispatch systems are being continuously improved and are forever changing. These improved systems aim to ensure that waiting durations are less and less and human behaviour is one of the major key factors which needs to be taken into consideration when it comes to restructuring elevator calling systems, as elevators can be one of the main annoyances in some one's experience with tall buildings. Additionally, the dispatch systems aim at eradicating crowds at peak traffic periods within buildings and at constantly developing new dispatch system that can overcome these problems. One way to achieve this is by grouping people based on their destinations. Assigning elevators to specific floors will also reduce crowds and avoid instances of overlapping elevators. Elevators should be developed in a manner that makes them energy efficient, with minimal repairs. To conclude, there are many opportunities and great potential in addressing the current issues that necessitate an ever smarter elevator system.

References

[1] Barney, G and Al-Sharif, L (2015), *Elevator Traffic Handbook: Theory and Practice*, Routledge, Abingdon-on-Thames. ISBN: 0415274761
[2] Al-Kodmany, K. (2015). *Tall Buildings and Elevators: A Review of Recent Technological Advances. Buildings*, 5(3), pp.1070-1104.
[3] Smith, R. and Peters, R. (2009). ETD Algorithm with Destination Dispatch and Booster Options, Peters Research Ltd. www.peters-research.com/index.php/support/articles-and-papers/42-etd-algorithm-with-destination-dispatch-and-booster-options)
[4] ThyssenKrupp Elevator (2016), Destination Dispatch, ThyssenKrupp Elevator, https://thyssenkruppelevator.com
[5] Parker, D & Antony, W (2013), *The Tall Building Reference Book*, Routledge, Abingdon-on-Thames. ISBN: 9781136258046
[6] Sorsa, J., Hakonen, H., and Siikonen, ML (2005). Elevator selection with destination control system. In: A. Lustig (ed), *Elevator Technology 15. The International Association of Elevator Engineers*
[7] Ruokokoski, M., Sorsa, J., Siikonen, M. and Ehtamo, H. (2016). Assignment formulation for the Elevator Dispatching Problem with destination control and its performance analysis. *European Journal of Operational Research*, 252(2), pp.397-406.
[8] Jamaludin, J., Rahim, N. and Hew, W. (2010). An Elevator Group Control System with a Self-Tuning Fuzzy Logic Group Controller. *Industrial Electronics, IEEE Transactions*, 57(12), pp.4188-4198.
[9] Wei, J and Zhao, G. (2013), Elevator group control with destination scheduling. *Natural Computation (ICNC) / Ninth International Conference*, pp. 1650-1654
[10] Strakosch, GR &Caporale, RS (2010), *the Vertical Transportation Handbook*, John Wiley & Sons, New Jersey, USA. ISBN: 9780470404133
[11] Otis Elevator Company (2016), Compass Plus: Destination Management System, Otis elevator Company, Farmington. http://www.otis.com/site/CompassPlusDestinationManagement.aspx
[12] Pauls, J., Gatfield, A. J., Juillet, E. (1991) Elevator Use for Egress: The Human-Factors Problems and Prospects. American Society of Mechanical Engineers; Council of American Building Officials and National Fire Protection Association. Elevators and Fire. 19, pp.63-75
[13] JM Kuusinen (2015). *People Flow in Buildings – Evacuation Experiments and Modelling of Elevator Passenger Traffic*. Aalto : Aalto University publication series. ISBN: 9789526061627
[14] Kuusinen, J.M., Sorsa, J., Siikonen, M.L. and Ehtamo, H., (2012). A study on the arrival process of lift passengers in a multi-storey office building. *Building services engineering research and technology*, 33(4), pp.437-449.
[15] De Almeida, A., Hirzel, S., Patrão, C., Fong, J. and Dütschke, E. (2012). Energy-efficient elevators and escalators in Europe: An analysis of energy efficiency potentials and policy measures. Energy and Buildings, 47, pp.151-158.