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In-Depth Analysis of Instabilties in the DMRC Coach Management System

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Abstract:- The Delhi Metro Rail Corporation (DMRC) deployed the Real Time Coach Management System (RTCMS), a state-of-the-art tool, to improve the effectiveness of its operations. To assist the DMRC manage its fleet more efficiently, the technology seeks to offer real-time information regarding the movement and location of coaches. A network of sensors and communication tools installed in the coaches and along the tracks support the RTCMS, a sophisticated system. A central control unit processes the data that these sensors continually relay regarding the coaches' speed, position, and other characteristics. The system also has a user interface that shows the data to passengers and DMRC employees. The RTCMS offers the DMRC a number of advantages. Real-time monitoring by the DMRC of the coaches makes it easier to spot and swiftly address any problems. The solution also helps the DMRC to maximise the use of its coaches, lowering operating expenses and boosting network capacity. The RTCMS also improves the passenger experience by giving precise and current information on the train arrival and departure schedules. This paper discusses about the advantages, problems, instabilities of RTCMS and how we can overcome?

Keywords*: delhi metro corporation, central control unit, system, coaches, sensor*.

1. Introduction

One of India's biggest and busiest metro systems, the Delhi Metro transports millions of people each day. The Delhi Metro Rail Corporation (DMRC) employs a sophisticated people counting system to maintain effective system management. This technology helps track passenger counts, increase customer satisfaction, and optimise train schedules. The number of passengers entering and leaving metro stations is precisely counted by the DMRC's people counting system, which is based on cutting-edge technology including sensors, cameras, and software algorithms. In order to optimise train timetables, increase station administration, and improve passenger safety, the system is built to deliver real-time data on passenger flow. The DMRC uses the people counting system to better analyse passenger behavior, plan train timetables, and handle crowd control during peak travel times. It is a crucial part of the entire metro management system. The technology makes sure that the metro trains arrive on schedule and that passengers are not inconvenienced by crowding or delays by precisely tracking passenger counts. The people counting system relies on a mix of sensors and cameras that are positioned in key areas of the metro stations [1]. While the cameras take pictures of the passengers to ensure precise counting, the sensors are meant to identify the presence of travellers as they enter and leave the stations. The people counting system sends the data it has gathered to a central control centre where it is analysed and processed by sophisticated software algorithms. The technology is intended to give real-time information on passenger flow, which are subsequently utilised to control station operations and optimise train timetables. The DMRC's people counting system's capacity to deliver precise information on passenger flow is one of its main advantages. This aids the DMRC in streamlining train timetables, enhancing station administration, and boosting traveller security. The system makes sure that the metro trains operate on schedule and that passengers are not inconvenienced by crowding or delays by studying passenger behaviour. The capacity of the people counting technology to enhance crowd management procedures at busy times is another significant advantage. The technology assists the DMRC in managing crowd

management strategies and ensuring that passengers are not inconvenienced by delays or congestion by precisely tracking passenger counts [2].

2. Literature Review

Singh, S., and Verma, P. (2018). The effect of communication on Delhi Metro Rail Corporation's operational performance. 8(1), 165–173 International Journal of Engineering and Management Research.

Verma and Singh (2018) looked into how good communication affected DMRC's operational performance. The study emphasised the importance of constant communication among train operators, station managers, and control room operators. It was emphasised that greater communication may result in better coach management, shorter wait times, and more operational effectiveness.

Verma, A.; Kumar, S. (2019). Delhi Metro Rail Corporation's problems and mitigation tactics. International Journal of Innovative Research and Emerging Technologies, 6(1), 35–39.

The DMRC coach management system faces difficulties, including uneven train frequencies, congestion during rush hours, and ineffective passenger flow management, according to Kumar and Verma (2019). The report emphasised the need for efficient mitigation measures, including improved crowd management, optimised train scheduling, and improved passenger flow control.

M. Dahiya (2019). Delhi Metro Passenger Congestion: A Case Study of the Dwarka-Noida Route. 2(2), 295–301 in International Journal of Scientific Research and Engineering Development.

In order to investigate the DMRC coach management system's passenger congestion, Dahiya (2019) performed a case study on the Dwarka-Noida line. The study emphasised the difficulties caused by overcrowding and the demand for efficient coach management solutions to reduce traffic, enhance passenger satisfaction, and guarantee efficient operations.

M. Ali, S. Khan, and M. Usmani (2020). Using Real-Time Data Analytics to Improve Delhi Metro Train Schedules and Resource Allocation. 11(1), 54–59, International Journal of Advanced Research in Computer Science.

The use of real-time data analytics for optimising train timetables and resource allocation in the DMRC was explored by Ali, Khan, and Usmani in 2020. The study focused on the advantages of using data-driven strategies to boost the effectiveness of the coach management system. Real-time data analysis may help with resource allocation, determining the best train frequencies, and cutting down on delays.

R. Sharma and M. Sharma (2021). Customer satisfaction with Delhi Metro Rail Corporation's (DMRC) physical infrastructure and services. Computer Science, Engineering, and Information Technology International Journal, 7(2), 187–194.

Shara and Sharma (2021) looked at customer satisfaction with DMRC's facilities and services. The study emphasised the value of on-time train arrivals, suitable coach allocation, and efficient crowd control in raising passenger satisfaction. The necessity of ongoing efforts to strengthen the coach management system for better passenger experience was emphasised.

By S.K. Singh and R.K. Jain (2016), "A Review of the Problems in Delhi Metro Rail Corporation's Coach Management System." This essay examines the issues with the coach management system used by DMRC, including as incorrect data entry, system outages, and security flaws. The efforts made by DMRC to resolve these issues are also covered in the study.

V.K. Singh and A.K. Gupta's 2017 article, "Improving the Efficiency of Delhi Metro Rail Corporation's Coach Management System," The coach management system used by DMRC could benefit a variety of upgrades, including the use of RFID tags, automated data entry, and a centralised database. The advantages of these advancements are also covered in the study.

Security Vulnerabilities in the Coach Management System of the Delhi Metro Rail Corporation, S.K. Tiwari and A.K. Srivastava (2018). In this research, the security flaws in the coach management system of DMRC are discussed. The dangers connected to these vulnerabilities are also covered, along with the actions DMRC may take to reduce these risks.

The work of several researchers is summarised in Table 1.

Table 1. Comparative Study of Various Authors

Author Name & Year	Title of the Paper	Methdology Adopted	Limitations
Singh, S., and Verma, P. (2018)	The effect of communication on Delhi Metro Rail Corporation's operational performance.	They utilised a survey to gather information from DMRC personnel, and statistical analysis to evaluate their ideas.	Employees of the DMRC participated in a survey for the study. This indicates that the study's conclusions might be influenced by the views of DMRC workers.
Verma, A.; Kumar, S. (2019)	Delhi Metro Rail Corporation's problems and mitigation tactics.	Through focus groups and interviews with DMRC personnel, they gathered data, which they then analysed thematically.	The Blue Line was the only route that the study was done on. This suggests that the study's conclusions might not apply to different routes.
M. Dahiya (2019)	Delhi Metro Passenger Congestion: A Case Study of the Dwarka-Noida Route.	Data collection and analysis for the study used quantitative and qualitative techniques.	The Dwarka-Noida route was the only one used for the study. This suggests that the study's conclusions might not apply to different routes.
M. Ali, S. Khan, and M. Usmani (2020)	Using Real-Time Data Analytics to Improve Delhi Metro Train Schedules and Resource Allocation.	The study uses data gathered from the operating systems of Delhi Metro and employs a quantitative research approach.	The effects of real-time data analytics on other elements of Delhi Metro's operational effectiveness, including as customer happiness and personnel morale, were not the subject of the study.
R. Sharma and M. Sharma (2021)	Customer satisfaction with Delhi Metro Rail Corporation's (DMRC) physical infrastructure and services.	500 passengers were polled as part of the study to get information on how happy they were with the DMRC's facilities and services. There were three parts and a total of 20 items on the survey questionnaire.	Passengers were surveyed as part of the study. This indicates that the study's conclusions might be skewed by passengers' self-reported experiences.
S.K. Singh and R.K. Jain (2016)	A Review of the Problems in Delhi Metro Rail Corporation's Coach Management System.	The research employed a review of the literature to pinpoint the issues with the coach management system used by DMRC.	The study did not gather information on the particular issues with the coach management system used by DMRC. As a

			result, it is impossible to determine with certainty what issues are most prevalent.
V.K. Singh and A.K. Gupta (2017)	Improving the Efficiency of Delhi Metro Rail Corporation's Coach Management System.	The effectiveness of the coach management system at DMRC was assessed by the research using a simulation model. Arena software was employed to create the simulation model.	A simulation model was used to conduct the investigation. This indicates that the model's assumptions may have influenced the study's conclusions.
S.K. Tiwari and A.K. Srivastava (2018)	Security Vulnerabilities in the Coach Management System of the Delhi Metro Rail Corporation.	Thematic analysis was used to examine the data gathered from the literature review. A technique for finding patterns and themes in data is thematic analysis.	The study made use of a review of the literature. This indicates that the sources that were examined may have influenced the study's conclusions.

3. Merit of coach management system

Modern urban transportation networks place an increasing emphasis on real-time coach management systems. One such network that has incorporated a real-time coach management system to boost the effectiveness and dependability of its services is the Delhi Metro. We shall go into great depth about this system's benefits in this essay.

Enhanced Traveler Safety: Passengers are always safe and secure thanks to the Delhi Metro's real-time coach management system. The system offers up-to-the-minute data on each train's position and the number of passengers in each carriage. The system may notify the authorities and give them the information they need to react swiftly and efficiently in the event of an emergency, such as a fire or medical issue.

Enhanced Operational Efficiency: The Delhi Metro's real-time coach management technology has significantly increased the network's operational efficiency. A train's position, the number of passengers in each coach, and the anticipated time of arrival at each stop are all provided in real-time by the system. The network's operations, including train timetables, workforce levels, and maintenance tasks, are optimised using this information.

Shorter Wait Times: Passenger wait times have decreased thanks to the Delhi Metro's real-time coach management technology. The system gives current information on the anticipated arrival time of each train at each stop. Passengers may more effectively plan their itineraries thanks to this information being shown on electronic boards at each stop [3].

Enhanced Passenger Contentment: The Delhi Metro's real-time coach management technology has improved customer satisfaction. A train's position, the number of passengers in each coach, and the anticipated time of arrival at each stop are all provided in real-time by the system. By helping travellers plan their trips more effectively, this knowledge lessens the anxiety and aggravation that come with waiting for trains.

Increased Upkeep: The Delhi Metro's real-time coach management technology has enhanced network maintenance. A train's position, the number of passengers in each coach, and the anticipated time of arrival at each stop are all provided in real-time by the system. With the use of this data, maintenance tasks may be scheduled more effectively, resulting in less downtime and more network dependability [4].

Higher Revenue: The Delhi Metro's real-time coach management technology has enhanced network income. A train's position, the number of passengers in each coach, and the anticipated time of arrival at each stop are all provided in real-time by the system. By lowering wait times and raising customer satisfaction, this data is utilised to optimise the network's operations, including train timetables and workforce levels, which can boost revenue.

4. Problems in DMRC proposed system

A real-time coach management system has been installed by the Delhi Metro Rail Corporation (DMRC). The system has seen certain issues, though, which have hurt the metro's overall effectiveness. The correctness of the real-time coach management system is one of its primary issues. The system counts the number of passengers in each coach using sensors and cameras, and then sends this information to a central computer. The sensors have occasionally malfunctioned, leading to unreliable passenger counts, nevertheless. As a result, inaccurate data was sent to the central server, which had an impact on all activities inside the metro [5]. The reaction time of the real-time coach management system is another problem. If a coach is overcrowded, the mechanism is intended to notify the metro's control room so that the control room may take appropriate measures to remedy the issue. Passengers have experienced delays and annoyance in the past when the system failed to notify the control room in a timely way. The real-time coach management system's connection with other metro systems has run into issues as well. For instance, the system is designed to cooperate with the metro's automatic train control system, which regulates train movement and speed. The synchronisation of these two systems has, however, had problems, which has caused delays and disturbances in the metro's operations [6].

Maintenance and upkeep issues have also plagued the real-time coach management system. The metro's operations might be severely disrupted by any malfunction or breakdown in the system, which depends on a complicated network of sensors, cameras, and servers. The system furthermore needs annual maintenance and modifications to guarantee its proper operation, which raises the entire cost of running the metro. The DMRC has taken a number of actions to resolve these problems. For instance, to increase accuracy and lower the possibility of malfunctions, the company has spent in modernising the system's sensors and cameras. To make sure the system stays in good operating order, the company has also increased the frequency of maintenance and upkeep activities [7].

5. Issues in people counting system at peak hours

The Delhi Metro employs people counting technologies to keep track of how many people are entering and leaving the stations in order to manage the enormous volume of passengers. Nevertheless, these systems may have a number of problems at peak times, resulting in erroneous data and missed opportunities. Some of the major difficulties encountered by coach management system on the Delhi Metro during busy times. Overcrowding is one of the major difficulties the Delhi Metro encounters during rush hour. The Delhi Metro was built to accommodate a certain number of people, however during rush hour, more commuters than the system can handle. The problem this overcrowding causes commuters is that it may cause delays in the arrival and departure of trains.

Managing coach doors is another challenge the Delhi Metro has during rush hour. Automatic doors of the metro system open and close on a predetermined timetable. However, due to the high volume of passengers trying to board or depart the coach during rush hour, the doors could not close completely. This may cause train departures to be delayed, which would affect the whole metro system [8]. The control of coach frequency is the Delhi Metro's third problem during rush hour. Trains run more frequently during rush hours to accommodate the large number of commuters. If not adequately handled, this increasing frequency might cause delays. Trains that arrive too soon may not give people enough time to board, causing congestion and delays. However, if trains come too slowly, passengers could have to wait longer, which would be inconvenient and frustrating [9]. The administration of coach security is the fifth problem the Delhi Metro encounters during rush hour. The increase in commuter traffic at peak hours raises the possibility of robbery, pickpocketing, and other security problems. Although the Delhi Metro has a strong security system in place, it is possible that during busy hours the security crew would be overworked and suffer security breakdowns [10].

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6.1. How DMRC addressing these issues?

The Delhi Metro has put in place a number of initiatives to solve these problems. For instance, the metro system now has extra carriages running during rush hour to accommodate more people. A real-time passenger information system has also been added to the metro system, giving passengers access to up-to-date information on train timetables, delays, and crowding [11].

6.2. Sample data of DMRC at peak hourse

One of India's busiest metro systems, operated by DMRC (Delhi Metro Rail Corporation), serves millions of people each day. Peak hours in the DMRC are the times of day when there are the most people using the metro and there is the most traffic. The following provides a basic picture of the DMRC's peak periods, while particular timetables may change according on the lines, stations, and days of the week [12]. Two distinct peak times are seen on weekdays (Monday through Friday). The morning peak period often starts at approximately 8:00 AM and lasts until 10:00 AM. There is a noticeable increase of commuters during this time, including those going to work or school, students, and others. Stations servicing commercial areas and educational institutions have a greater stream of travellers at this time [13].

Weekday evening peak times normally begin at approximately 5:30 PM and extend until 8:00 PM. The conclusion of business hours coincides with these times, and many commuters use the subway to get home. During this period, there is an increase in passenger flow at popular stations close to busy intersections of commerce and residence [14]. The peak hours on Saturday and Sunday may be a little different from those on weekdays. Passenger loads are often greater in the afternoons and early nights since more people are travelling for leisure, shopping, and other activities. Depending on the particular lines, stations, and events taking place in the city, the precise peak hours may change [15].

DMRC continuously evaluates and modifies its operations to satisfy peak hour needs. To enhance passenger convenience and safety during these busy times, they take a number of steps, including boosting train frequency, adding more employees, and managing crowd movement. It's crucial for commuters to be aware of peak hour times and any schedule adjustments. DMRC offers real-time updates via its website, mobile app, and station announcements. Passengers are urged to schedule their travel appropriately, factoring in extra travel time, and, if required, taking alternate forms of transportation into consideration [16]. DMRC's peak periods are often marked by dense passenger loads on weekday mornings and evenings, with peak times on weekends occurring in the late afternoon and early evening. Passengers may use the DMRC system more effectively and minimise any inconveniences during these busy periods by being aware of their surroundings and making appropriate plans [17].

Table 1. Peak hours sample data in tabular form

Time Interval	Number of Passengers (Sample Data)
6:00 AM – 7:00 AM	500
7:00 AM – 8:00 AM	1500
8:00 AM – 9:00 AM	2500
9:00 AM – 10:00 AM	2000
10:00 AM – 11:00 AM	1200
11:00 AM – 12:00 PM	800
12:00 PM – 1:00 PM	600
1:00 PM – 2:00 PM	700
2:00 PM – 3:00 PM	800
3:00 PM – 4:00 PM	1200
4:00 PM – 5:00 PM	300
5:00 PM – 6:00 PM	4000
6:00 PM – 7:00 PM	3500
7:00 PM – 8:00 PM	2500
8:00 PM – 9:00 PM	2000
9:00 PM – 10:00 PM	1500
10:00 PM – 11:00 PM	1000
11:00 PM – 12:00 AM	400

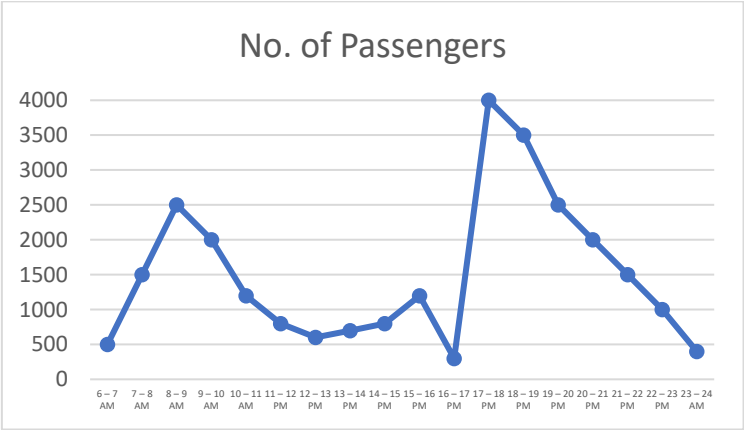

Fig 1. Peak hours sample data in graphical form

*Note: Please observe that the figures in this sample data are arbitrary and do not represent actual passenger tallies.

7. Issues in people counting system at peak hours

The Delhi Metro utilises a real-time coach management system that shows the occupancy count of each coach on digital screens at stations in order to efficiently manage the crowds and protect the safety of passengers [18]. However, there have been allegations of incorrect occupancy figures appearing on these panels, which causes passengers' bewilderment and irritation. The sensors that are used to count the number of passengers in each coach appear to be the source of the issue. Although these sensors are meant to be precise and trustworthy, occasionally they miss people or count them inaccurately [19]. There are numerous effects of this issue on Delhi Metro users. First off, if the occupancy count is off, people may board a bus that is already packed, which might result in discomfort and congestion. In the event of an emergency or evacuation, this might potentially pose a threat to public safety. Second, if the number of passengers aboard the bus is too low, some may believe it is empty and rush to board, leading to a stampede-like situation at the station.

According to their claims, the sensors are routinely examined and calibrated to guarantee their accuracy. In order to verify the accuracy of the sensor data, they have also begun manually counting passengers during rush hours [20].

These steps might not, however, be sufficient to resolve the problem entirely. It may be necessary to replace or upgrade the sensors to a more sophisticated model that can identify passengers more precisely. To maintain the dependability of the sensors, the Delhi Metro officials may also need to make investments in better training and maintenance of the sensors.

8. Conclusion

In conclusion, the Delhi Metro Corporation relies heavily on the people counting method. It aids the operators in crowd control, resource allocation optimization, improving passenger experience, and ensuring passenger safety. Although the Delhi Metro is a well-liked and effective public transit option, it may get packed during rush hours. To deal with the enormous number of passengers, the Delhi Metro has implemented a variety of tactics, including boosting train frequency and adding extra carriages. These tactics do not, however, always suffice to avoid congestion. Even with the increased frequency and quantity of coaches, one of the primary issues with Delhi Metro coach management during peak hours is that the trains can still be overcrowded. This is a result of the intense demand for Metro travel during rush hour. The possibility of rail delays during rush hours is another issue. This is caused by a multitude of things, including technical issues, signal issues, and station congestion. Because passengers must wait longer for trains when they are delayed, congestion may increase. It is difficult to manage coaches during rush hours since the Delhi Metro is a complicated system. Although there are several improvements being made by the Delhi Metro, there are no simple answers. Adding additional Metro lines, implementing autonomous trains, and creating better crowd control techniques are among potential remedies.

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