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Intelligent Bus Scheduling and Route Optimization for Delhi Transport Corporation

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***Abstract* - Bus transport is the backbone of delhies as over two thirds of the population depends on it as a mode of transit. Here is a pressing need to identify the baseline situation and recognize the issues with services offered and take immediate measures for reforms in the system. This paper examines the key issues with the blue lines that consist of improper operation and driving habits due to incorrect set of incentives for the owners as well as the crew. The Issues with the public provider of the bus facility, Delhi Transport Corporation are also determined which is facing incurred losses of over 6000 crore. Over the years, traffic volumes on roads have increased considerably. Henceforth, traffic congestion continues to worsen producing longer commute times, increased energy consumption and air pollution, besides robbing people of a precious commodity their time. ITS has emerged as a worldwide solution to handle these problems. Like any other transportation system, building a good intelligent transportation system requires considerable planning and financial resources.**

Keywords: AITS, advanced traveller information systems, information technology, traffic engineering.

I. INTRODUCTION

Smart bus scheduling is transforming public transport by leveraging cutting-edge technologies like artificial intelligence, real-time data analysis, and machine learning to design responsive and adaptive transit systems. In contrast to conventional fixed timetables, this new method enables real-time route adjustments according to passenger demand, drastically reducing waiting times and fuel consumption while lowering operational expenses. The primary technologies responsible for this shift are GPS and real-time tracking to accurately track the location of vehicles and dynamic routing based on passenger pattern predictions and traffic stream analysis, machine learning-based predictive modeling of passenger patterns and traffic stream analysis, and IoT sensors for vehicle performance monitoring and counting passengers.

The advantages of smart bus scheduling are huge, resulting in less congestion via more intelligent routing, improved emissions through minimized routes, better access for wider urban audiences, and cost savings from data-driven decision-making. With cities on the rise, the adoption of smart bus scheduling is critical in creating sustainable, efficient, and customer-oriented public transit systems, eventually redefining urban mobility and making the city more livable and responsive to the needs of its population.

In a metropolis like Delhi, smooth daily commuting for depends on efficient public transport. This is where DTC, which is the heart of the bus network in this city, plays a crucial role. The present problems are overcrowding, very high demand, inefficient routes swelling population. Such issues require the implementation of sophisticated bus scheduling and route optimization approaches. Intelligent Bus Scheduling and Route Optimization use data analytics, machine learning, and real time traffic monitoring for optimized bus routes with reduce with reduced travel time and better punctuality

1.1 Delhi Transportation statistics visualization

The Delhi transportation info graphic offers a four-dimensional viewpoint to the city's urban transport industry, and it identifies five dimensions that make some pertinent observations. First, it deals with road space occupation, and it shows how 70% of road space is occupied by cars and how this share indicates an irrational allocation of infrastructure to personal transport and an extremely inefficient use of urban street corridors. According to passenger capacity, the comparison demonstrates how private cars can only take 1-2 passengers while buses can cater to more than 40, highlighting inefficiency in private car usage when it comes to space and resources.

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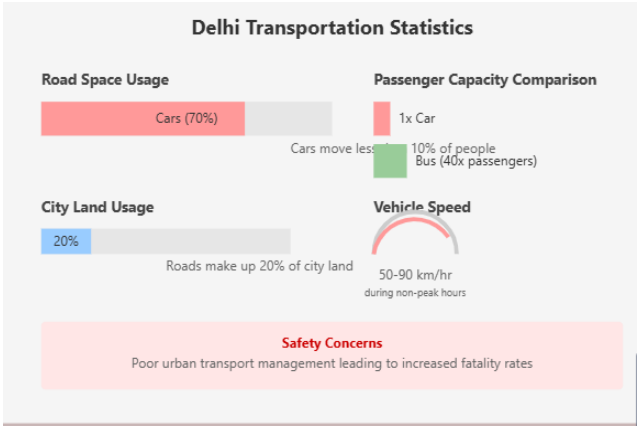

Fig. 1: Delhi Transportation statistics visualization

Delhi is at a crossroads in urban mobility. By adopting these integrated strategies, the city can shift its transport environment to one of sustainability, efficiency, and security for urban mobility.

1.2 Urban Transportation Analysis

The transport in cities analysis provides a holistic overview of how two primary modes—subways and buses—operate within a city, vividly illustrating urban mobility dynamics through graphs and key findings. The transport mode comparison indicates different performance and capacity levels, with gray bars for diverse transportation systems, blue bars for bus transportation, and red bars for subway transportation. Passenger flow analysis shows trends through time, with both modes increasing in a smooth climb in ridership, the blue line for buses and the red line for subway increasing at different rates. The key features of the analysis include temporal analysis, which examines the pattern of transportation pattern change, spatial distribution showing movement from one city zone to another, peak hour pattern determining the most congested periods of transportation, and predictive models predicting future transportation demand.

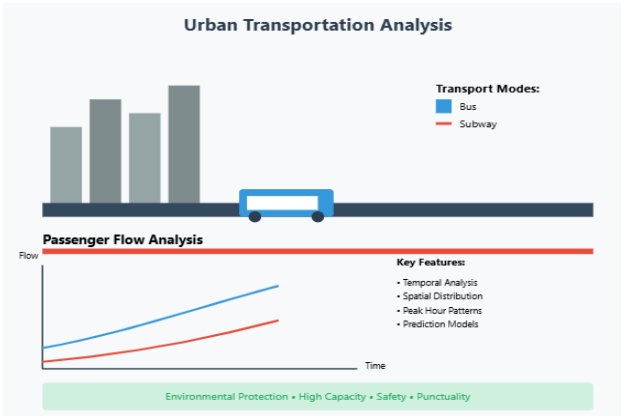

Fig. 2: Urban Transportation Analysis

II. METHODOLOGY

The method employed in the paper was identification of issues, data collection, interpretation of data for analyzing the given issues and finally suggesting solutions. We have been working on a realist basis because we belong to the stakeholders and kept the observations neat and measurable. We have used secondary data to form a strong theoretical framework to understand different dimensions.

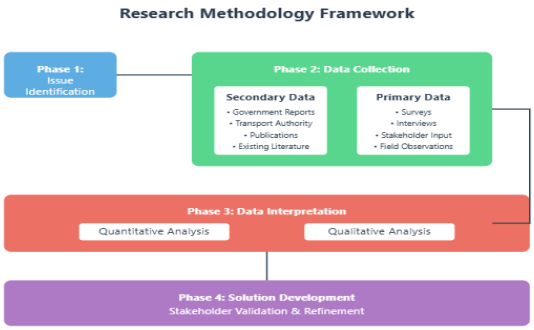

Fig. 3: Research methodology framework

2.1 Genetic Algorithm

Here, in this project, the Genetic Algorithm (GA) acts as the main optimization method for solving the problems of bus routing and scheduling. One of the major benefits of applying a GA here is that it can optimize bus assignments efficiently. The algorithm seeks to determine an optimal or near-optimal bus allocation to different routes, thereby minimizing the difference between the allocated buses and passengers' demand for any given route. Optimization allows for efficient operation of the transportation system and satisfies the passenger demands. GAs are also best at searching large and complex solution spaces. By emulating the mechanism of natural selection, the GA is able to effectively explore various combinations of bus allocations in order to identify good-quality solutions that would otherwise be difficult to discover through conventional optimization techniques.

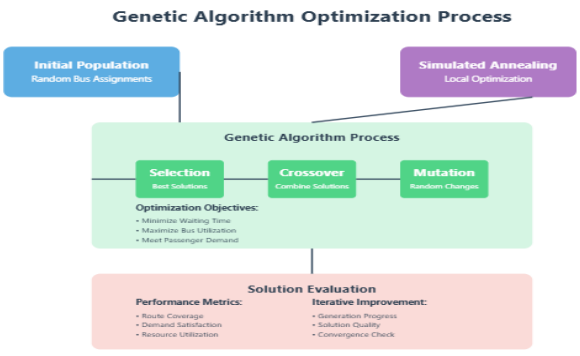

Fig. 4: Genetic algorithm process

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2.2 Simulated Annealing

Simulated annealing is implemented in bus scheduling optimization because of its ability to explore large solution spaces efficiently, allowing it to escape local optima. In a probabilistic manner simulated annealing creates feasible schedules by reducing operational costs and is apt for complex combinatorial problems like bus routing and scheduling.

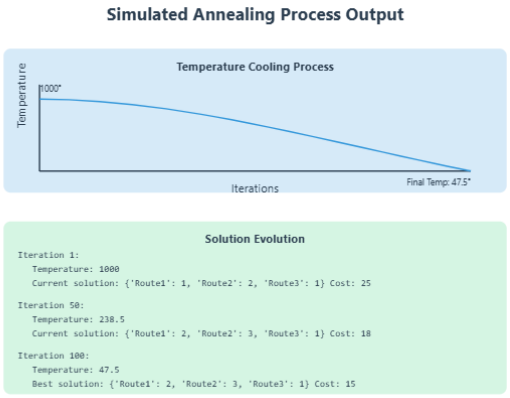

Fig. 5: Simulated Annealing

III. RESULTS AND DISCUSSIONS

Throughout the generations, the algorithm continuously improves the bus assignments. It tracks the best solution found in each generation, allowing it to report when a new, better solution is discovered.

IV. CONCLUSION

The application of an integrated Genetic Algorithm and Simulated Annealing technique to bus routing and scheduling has been an optimal method of solving the problem. With the capabilities of the two techniques, the algorithm effectively resolves the complexities involved in city transport and ends up assigning buses to routes in an ideal manner close to the actual passenger demand.

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