

The Impact of the Optimization Strategy of the Public Transportation System on Sustainable Urban Development

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Abstract: As urbanization accelerates and awareness of environmental conservation rises, the optimization and modernization of public transportation systems, crucial to urban infrastructure, encounter novel challenges and prospects. While public transportation has evolved in the past few years, the city still grapples with issues of inefficiency and poor passenger contentment, hindering its sustainable growth. In this context, there's an immediate need to investigate the ways in which creative optimization strategies can enhance the efficiency of public transit systems and aid in building cities that are both environmentally sustainable and conserve resources. Based on the above, this paper focus on the optimization strategy of the public transportation system and its impact on sustainable urban development. Firstly, the analysis focuses on the current status and challenges of public transportation systems, examining how these relate internally to objectives of sustainable development. Secondly, the leading strategies and technical frameworks for optimizing public transportation systems are presented from theoretical and technical aspects, especially the application value of big data analysis, intelligent scheduling systems, and energy-saving and emission-reduction technology. In addition, the researchers constructed a model to analyze the positive effects of optimization strategies on urban traffic flow, system efficiency, and environmental quality. They verified the actual effectiveness of these strategies through case analysis. To sum up, the research highlights the vital importance of effective and eco-friendly public transportation in lessening city traffic jams, enhancing the living standards of inhabitants, and curtailing carbon emissions. Furthermore, it offers practical experience and strategic advice for other cities.

Keywords: Public transportation system, optimization strategy, sustainable urban development, big data analysis, intelligent scheduling.

1. Introduction

With the acceleration of urbanization, the city's public transport network is increasingly accommodating the rising need for transportation. Nonetheless, the public transportation network has revealed numerous operational and managerial issues, such as bottlenecks in capacity, subpar service quality, and escalated environmental deterioration. Such issues impact not just the everyday journey of residents but also impede the city's ability to develop sustainably. Consequently, there is a critical need to investigate and apply efficient optimization strategies [1].

This study concentrates on enhancing and innovating public transport systems, guided by the general knowledge of current challenges faced by the system. The primary objectives are to enhance efficiency and promote environmental friendliness, proposing optimization strategies based on big data analysis and intelligent scheduling systems. With comprehensive use of modern information technology, this paper designs a refined management model for untimely response to passenger demand and uneven service coverage. In addition, technology for assessing environmental impacts is included to enhance the system efficiency and achieve eco-friendly advancement in public transportation.

In this paper, it applies the method of systematic analysis, in which the relevant documents were sorted to explore the impact of bus system optimization strategy on urban sustainable development. Through empirical analysis, it aims to improve the efficiency of public transportation systems, reduce its environmental impact and provide the scientific basis and technical support for promoting sustainable optimization of urban public transportation systems. The research is of great significance in promoting the intelligent and green transformation of urban traffic planning and management in the future.

2. Research Background of Sustainable Urban Development Based on the Public Transportation System

2.1. Analysis of the Status Quo and Challenges of Public Transportation Systems

Public transportation systems keep pace with modern urbanization processes [2]. It reflects the concept of sustainable development, emphasizes an advanced philosophy of environmental friendly in urban planning, and reflects the active global search for environmentally friendly and low-carbon modes of transportation since the end of the 20th century. However, it is difficult to obtain a unified and comprehensive measurement system by using specific quantitative indicators or efficiency standards to define the optimization of public transportation systems and evaluate the nature of implementation effects. Due to enormous differences in socio-economic contexts, infrastructure conditions, and public mobility needs in different cities, the challenges facing public transportation systems are diverse and complex, including, but not limited to, insufficient investment capital, uneven service quality, slow application of new technology, and diversification of passenger preferences. Therefore, an in-depth analysis of the current situation of public transportation systems and their challenges is crucial for promoting sustainable urban development.

2.2. The Relationship between Sustainable Urban Development Goals and Public Transport

Sustainable city is a necessary standard to measure the quality of urban development and a concrete expression of the ideal state of the city in the future. Considering environmental protection and economic development, scholars have discussed the definitions of sustainable cities from resource utilization and social justice perspectives. Some scholars believe sustainable cities represent ecological balance or the harmonious coexistence of human well-being and nature. Because the public transportation system has certain public nature and service, it belongs to the science of social service for the purpose of improving living quality. The history of public transport can even be traced back to the Industrial Revolution, and its main activities are related to improving transport efficiency and convenience. At the same time, the advantages of high efficiency and accessibility of public transportation have promoted the environmental sustainability and social inclusiveness of sustainable cities. By optimizing the public transport network, improving the quality of public transport services has become an essential responsibility for achieving sustainable urban development. At the end of the 20th century, the main contribution of the theory of sustainable development is to integrate the development concept of the three dimensions of environment, economy, and society. Therefore, the

concept of public transportation initially focused on environmental impact measurement based on reducing carbon footprint and improving energy efficiency.

2.3. A Comparative Study of Public Transport Optimization Strategies at Home and Abroad

Optimization strategy for public transportation is an essential means to promote the sustainable development of urban transport, and it is a practical exploration to improve travel efficiency and service quality [3]. Both developed and developing countries have demonstrated various ways of optimizing public transport from the perspective of technological innovation and policy guidance. It was noted that the success of optimization strategy lies in striking a balance between efficiency and equity and is an effective mechanism for promoting green travel. Because the optimization strategy of public transportation improves the function of the city, it is a comprehensive research field to improve the vitality of the city. The practice of public transportation system improvement has spanned a long time. From early route planning to the current intelligent scheduling, it covers many aspects, such as infrastructure upgrading and service time extension [4]. Furthermore, the innovativeness and adaptability of the strategy are closely related to the city's specific needs and socio-economic context. Through international comparison and analysis, finding best practices has become vital in improving global public transport. Since the end of the 20th century, the main contribution of integrated transportation planning has been the emphasis on the coordination and integration of multi-mode transportation systems. Therefore, the study of public transport optimization strategies initially focused on efficiency and environmental impact assessment based on technological progress and policy innovation.

3. Research Foundation and Key Technologies of Public Transportation System Based on Optimization Strategy

3.1. An Overview of the Theoretical Basis of Public Transportation System

Unlike transportation engineering, the theory of the public transportation system pays more attention to the relationship between public transportation service and urban spatial structure, which is more systematic and comprehensive. Although some scholars question whether local traffic improvement measures may not be directly related to the improvement of the overall traffic efficiency of the city, most scholars advocate that the public transportation system can be comprehensively and reasonably evaluated through comprehensive traffic planning. Daganzo et al. proposed the "Public Transport Performance Assessment" classic model with three elements: supply-demand balance, network efficiency, and environmental impact [5]. The model has become a typical tool for measuring the performance of the public transportation system, resulting in the development of "Transit-Oriented Development (TOD)". It suggests that TOD is oriented and integrated and is a co-evolution model of urban form and transportation system. Only when public transportation becomes the main artery of urban development can urban space expand in an efficient and orderly way. Therefore, optimizing the public transportation system is seen as the result of coordinating urban planning and transportation policies. Some scholars have summarized the optimization strategy of the public transportation system as "top-down" and "bottom-up" models, namely the macro-control model based on policy guidance and the micro-adjustment model based on demand feedback. The former focuses on top-level design and long-term planning, while the latter focuses on passenger needs and instant feedback, which is also known as people-oriented. Although the optimization of public transport system encounters various challenges and failures in practice, from the perspective of sustainable development, it can save energy, reduce emissions, and alleviate traffic congestion effectively. Subsequently, the concept of "public transport priority" has gradually become a common understanding in urban transport research and practice.

3.2. The Technical Framework and Methodology of Optimization Strategy

The core of the optimization strategy for the public transportation system focuses on improving service efficiency and passenger contentment. Data-driven optimization is the application of big data thinking in public traffic management. In order to make up for the limitations of previous empirical decision-making, it has entered the research field as a new strategic framework-intelligent public transport optimization system. The basic concepts of this framework are as follows: First, the public transportation system should ensure efficient allocation of resources. Second, data support standards for service quality output should be set. Third, professionals use data analysis, artificial intelligence, and other technologies to capture passenger needs. Fourth, simulation and machine learning are used to predict system performance and potential improvements [6]. The optimization framework of intelligent public transport restructures traditional planning and operating modes, emphasizes system flexibility and responsiveness, and improves service accessibility, economic rationality, environmental friendliness, and passenger experience integrity. It not only promotes the deep integration of technology and management practice but also provides an innovative way to realize the sustainable development of urban transportation.

3.3. Key Technologies: Big Data Analysis and Intelligent Scheduling System

Big data analysis and intelligent scheduling systems are the core technical support for optimization strategies for public transportation, which reflect the in-depth application of data value in traffic management. Massive data processing and model algorithms directly reflect the change in passenger demand and the real-time operation of the traffic network. Development elements in this field, such as data collection, storage, processing, and algorithmic model optimization, are gradually improving and maturing. At the same time, data privacy protection and system security evaluation system have gradually become the focus. However, from the perspective of practical application, the implementation of intelligent scheduling in some cities is still in the stage of preliminary exploration or local optimization. There is a gap between the logical framework of network-wide collaborative optimization and the generation mechanism of efficient dynamic response. It has led to many issues, such as uneven resource allocation, slow response, and poor passenger experience. To solve these, it is essential to better integrate cross-domain technologies to further promote intelligent scheduling in a more efficient way.

3.4. Environmental Impact Assessment and Energy Saving and Emission Reduction Technology

From the perspective of sustainable development, environmental impact assessment is the basis of green transportation planning and the core embodiment of energy conservation and emission reduction targets. Therefore, for technological innovation and development, the transportation sector has focused on reducing the carbon footprint and improving energy efficiency as the leading generation logic [7]. Green transportation is the primary goal of updating urban transportation systems and is a crucial challenge to achieving environmental friendliness. At the present stage, the traffic control department strengthens pollution control from the source control perspective. There are three primary forms. The first one is to promote new energy vehicles. The transition to clean energy vehicles is achieved by issuing vehicle purchase and use policies. The second is to establish a pollution emission standard system. Managers achieve standardized control of pollutant emissions by formulating strict exhaust emission and energy efficiency standards and disclosing monitoring data to the public. The third is the internal process of reengineering the public transportation system. In recent years, digital means have been used to improve operational efficiency and energy usage in

managing electric buses and bike sharing. However, compared with the international advanced level, the efficiency of environmental protection in China's transportation sector still needs improvement.

4. Modeling and Application of Sustainable Urban Development Based on Optimization Strategies for Public Transportation

4.1. Model Construction of the Impact of Optimization Strategies on Urban Traffic Flow

Unlike traditional transportation planning, the optimization strategy based on public transportation has the attribute of sustainable development. The evaluation standard of environmental impact and social and economic benefits of optimization strategy aims to improve the quality of urban life. The development of public transport reflects the efficient use of resources and environmental friendliness. In the multi-objective decision-making framework of urban traffic management, accurately predicting traffic demand, optimizing route layout, balancing capacity allocation, and promoting passengers' convenient travel are the core values and the highest criteria for the development of public transportation. Nowadays, the diversity of city scale and the differences in traffic demand lead to complex traffic congestion. Despite significant technological advances, the overall planning of transportation systems could be better, and public transportation systems also need more effective feedback and coordination mechanisms. Therefore, they are "short planks" that improve the efficiency of public transport and slow down the sustainable development process of the city [8].

4.2. Analysis of Public Transportation System Efficiency Improvement and Passenger Satisfaction

From the perspective of passenger experience, the traditional service mode often cannot accurately meet the individual needs of passengers. People's satisfaction evaluation is the primary assessment of the public transportation system's service quality. However, the current evaluation system needs more detailed information on passenger behavior characteristics and a dynamic feedback mechanism, and the root of this problem may lie in the low ability of data acquisition and analysis. In modern traffic research, passenger satisfaction is often called "comprehensive perception of travel efficiency and comfort". Passenger's evaluation of service quality directly reflects the public transportation system's effectiveness and service personnel's affinity. However, satisfaction surveys mainly provide feedback on explicit information, such as waiting times and crowding levels, and there is little solid data on passenger psychology and expectations. In general, it is difficult to directly capture or accurately measure people's subjective emotions. In a word, asymmetric information and imperfect evaluation systems directly lead to the matching obstacle between the improvement direction of the public transportation system and the real needs of passengers.

4.3. Research on the Improvement of Urban Environmental Quality through Green Public Transportation

From the environmental sustainability perspective, high carbon emissions and resource consumption have long constrained the ability of cities to develop in a much greener manner. In the 21st century, people are committed to green public transport, which is environmentally friendly, efficient and intelligent, and reshapes the urban traffic pattern through new energy and information technology. However, the disadvantages of traditional transportation system structure have restricted the improvement of the environmental quality. The popularity and acceptance of green mobility systems are low due to the fact that the use of public transportation is not common and the travel habits of passengers. Under the premise of pursuing low-carbon and environmental protection, the development of green public transport is regarded as a direct way to improve the quality of the urban

environment. In addition, the actual effect of a strategy based on replacing new energy vehicles on environmental improvement needs to be further evaluated. At the same time, economic costs and difficulties in infrastructure construction have led to the need for long-term and stable financial support and maintenance for green transportation projects in many cities. Therefore, they cannot achieve the expected environmental improvement goals in developing public transportation. In conclusion, promoting green public transport is not only a technical problem but also faces complex problems such as financial security, public participation, and policy formulation.

4.4. Case Analysis: Public Transport Optimization Practice and Effect Evaluation in Typical Cities

In China, it is hard for cities to escape developing countries' "latecomer advantage" and "route dependence" in public transportation optimization. In the mechanism of public transportation reform, case study is a standardized and practical evaluation method, which plays the role of a bridge in the combination of theory and practice. It makes case study analysis not only about academics, but also about practice. Therefore, "problem-oriented" case studies have become the key to understanding and promoting public transport optimization. The practices in typical cities are generally localized development paths that have been gradually formed upon international experience with much trial, error and adjustment. Regardless of strategy formulation or evaluation, case analysis is related to the actual effectiveness of the public transportation system and the passenger experience. Urban public transportation systems should be committed to technological innovation and service upgrading to meet the requirements of rapid urbanization. Nevertheless, as the diversity of individual needs increases, this also brings about a dilemma: how to balance the contradiction between universal services and personalized needs. In summary, there is room for improvement in the efficiency, environmental protection, and passenger satisfaction of the public transportation system, and its optimization strategy and evaluation system need to be improved, which is an important task for future urban traffic research and management.

5. Conclusion

This paper proposes novel and comprehensive optimization strategies based on the problems faced by public transportation systems and sustainable urban development. First, the author reconstructs the theoretical framework of the public transportation system and uses big data to analyze the model's passenger flow and supply and demand information. After optimizing and adjusting the layout of the transportation network, the intelligent scheduling algorithm is used to allocate bus lines and shifts dynamically. In addition, the environmental impact assessment model is constructed according to the actual operation data. Energy-saving and emission-reduction technology is applied to complete the quantitative analysis of traffic carbon emissions. The theoretical analysis, simulation experiments, and case studies confirm that the comprehensive optimization strategy can significantly improve the efficiency of the public transportation system and increase passenger satisfaction. At the same time, it provides a practical way to effectively promote improving urban environmental quality and realize green and sustainable urban transportation development.

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