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SERVICE QUALITY IMPROVEMENT STRATEGIES FOR RAIL TRANSIT STATIONS BASED ON PASSENGER EXPERIENCE

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Abstract: With the rapid expansion of urban rail transit, station service quality has become an important issue for improving overall operational efficiency and passenger travel experience. This study focuses on the service quality issues of rail transit stations during peak hours, analyzing factors such as passenger flow congestion, inadequate facility capacity, delayed information dissemination, and security management. Through both quantitative and qualitative analysis, the study identifies weak points in station services and proposes multi-dimensional improvement strategies, including passenger flow diversion, facility optimization, introduction of intelligent devices, and upgrades to the information release system. The research results indicate that implementing these optimization measures can significantly improve station throughput efficiency, reduce passenger waiting times, and enhance the overall passenger travel experience. Furthermore, this study provides valuable experience for other urban rail transit stations and contributes to the sustainable development of rail transit systems.
Keywords: Urban rail transit; Service quality; Passenger flow management; Facility optimization; Information release; Peak hours

1 INTRODUCTION

1.1 Research Background

With the acceleration of urbanization and the increasing demand for transportation in densely populated areas, rail transit has become a core component of the public transportation system in many cities[1-4]. Rail transit offers advantages of efficiency, environmental friendliness, and convenience, and especially in large cities, it has become a vital tool for alleviating traffic congestion and reducing carbon emissions. However, with the rapid expansion of rail transit, the service quality of stations has increasingly revealed issues that need to be addressed, especially during peak hours when the operational capacity of stations faces significant pressure. Entrance and exit points, transfer corridors, and security check areas often become bottlenecks during peak periods, as facility capacity and passage efficiency are insufficient to meet the growing passenger demand[5-7].

Improving station service quality not only affects passengers' travel experience but also has a profound impact on the overall operational efficiency and safety of the rail transit system. During peak hours, the high passenger volume causes station facilities to become overloaded, leading to phenomena such as long queues and delays, which negatively affect overall operational efficiency and passenger satisfaction. Therefore, optimizing the service quality of rail transit stations, especially during peak hours, has become an important issue in the field of transportation management[8-10].

1.2 Research Objectives and Significance

The primary goal of this study is to analyze the service quality issues faced by rail transit stations during peak hours and propose practical improvement strategies. By studying the operational status of a specific rail transit station, this research identifies the weak points in the current services and provides targeted optimization proposals aimed at improving the station's passenger flow management capabilities, facility passage efficiency, and overall information release and security management. The specific objectives include:

1. In-depth analysis of the current service situation at the station, identifying the main problems during peak hours;
2. Proposing multi-dimensional optimization strategies, including passenger flow diversion, facility optimization, and information management;
3. Evaluating and verifying the feasibility and effectiveness of these strategies in improving station service quality.

This study not only provides concrete optimization suggestions for a specific station but also offers practical experience for rail transit systems in other cities, particularly in balancing passenger flow with facility capacity during peak hours. The results of this research contribute to improving the operational efficiency of urban rail transit and enhancing passengers' travel experience, providing theoretical support and practical guidance for the sustainable development of rail transit systems.

1.3 Research Methodology

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This study combines both quantitative and qualitative analytical methods to systematically investigate the service quality of rail transit stations. By collecting historical passenger flow data, facility usage information, and passenger feedback, the study identifies the current issues in service quality. Based on existing research findings both domestically and internationally, a series of targeted optimization strategies are designed to improve station operational efficiency and passenger satisfaction.

Data analysis includes detailed examination of various service indicators, such as passenger flow, facility passage capacity, and queue waiting times, to reveal the key factors affecting service quality. By establishing simulation models, the study evaluates the effects of different optimization plans on improving station service quality. Furthermore, passenger feedback is gathered through surveys and interviews to further understand passengers' evaluations of station services and refine strategies based on their feedback.

Finally, through data validation and the evaluation of actual operational effects, this study will determine the feasibility and implementation effectiveness of the proposed optimization strategies, ensuring that the solutions achieve significant results in practical application.

2 ANALYSIS OF STATION SERVICE STATUS

2.1 Station Overview

The rail transit station analyzed in this study, located at a critical transportation hub, is situated at the intersection of several important lines. The station is equipped with multiple entrances and exits, security check devices, automatic ticket vending machines, entry and exit gates, escalators, and other facilities. The daily passenger flow is approximately 80,000, and during peak hours, the station's entry and exit flow increases significantly, reaching 12,000 to 15,000 passengers. The station's facilities are relatively well-equipped, but with the increase in passenger volume, some facilities fail to meet demand during peak times, leading to congestion and passenger delays.

The station's location plays an important role as a transportation hub and is connected to multiple bus lines, making it a crucial interchange point for passengers traveling to and from the city center. However, as passenger volume continues to increase, the passage capacity of existing facilities gradually reveals its limitations. Particularly during peak hours, some key facilities (such as entrance and exit points, transfer corridors, and security check devices) fail to cope effectively with the surge in passenger flow. To address this situation, it is necessary to analyze the station's passenger flow characteristics and facility operational efficiency to provide data support and theoretical basis for subsequent optimization strategies.

2.2 Passenger Flow Characteristics Analysis

The passenger flow characteristics of the station show significant temporal fluctuations, especially during peak hours, when the sharp increase in passenger flow puts tremendous pressure on station facilities. By analyzing the station's entry and exit passenger flow data, it is found that passenger flow varies greatly at different times, with peak hour flow primarily concentrated at critical locations such as entry and exit points, transfer corridors, and security check areas. These areas experience particularly severe congestion.

From the daily passenger flow distribution, the station's passenger flow is relatively stable, but during the morning peak (7:00–9:00) and evening peak (17:00–19:00), passenger flow reaches its maximum. Especially at the entry points and transfer areas, passenger delays are significant, leading to decreased travel efficiency. The passenger flow issues during peak hours can be categorized into the following aspects:

1. Entry and Exit Points: During peak hours, congestion at the entry and exit points is particularly severe, as the passenger flow at these points increases sharply, causing long queues, increased waiting times, and impacting the efficiency of passenger transfers and flow.
2. Transfer Areas: Transfer corridors are one of the most critical areas of the station. Especially during peak hours, passengers tend to concentrate in limited corridors, leading to long queues and congestion.
3. Security Check Devices: During peak periods, the number and processing capacity of the station's security check devices are insufficient to meet the surge in passenger flow, resulting in long waiting times at security checks, which further impacts overall passage speed.

Table 1 Distribution of Passenger Flow at the Station (By Time Period)

Time Period	Average Inflow (Passengers)	Average Outflow (Passengers)
Morning Peak (7:00-9:00)	12,000	13,500
Evening Peak (17:00-19:00)	14,500	15,000
Weekend (12:00-14:00)	16,000	14,500
Holiday (10:00-12:00)	18,000	17,000

As shown in Table 1, the analysis of passenger flow data across different time periods reveals a significant increase in passenger volume during morning and evening peak hours. Notably, there is greater fluctuation in passenger flow during holidays and weekends, placing higher demands on the station's facility configuration and operational management.

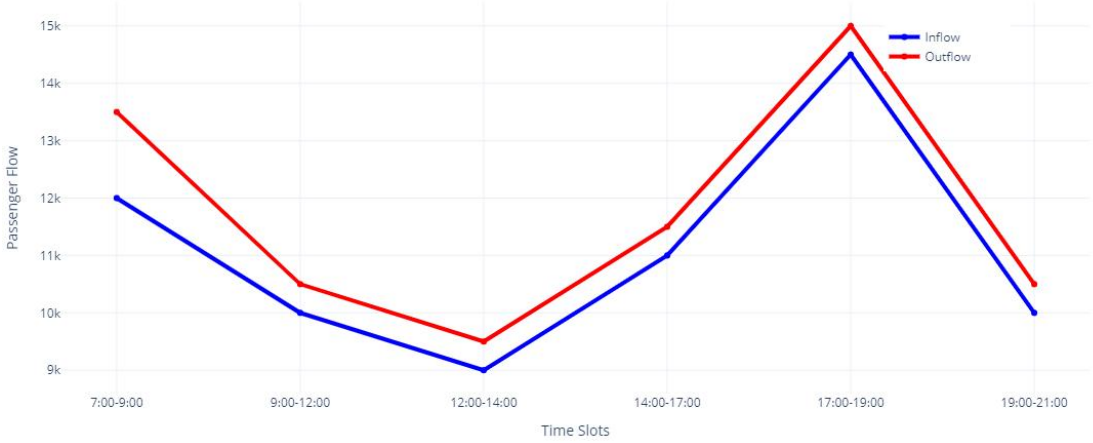

Figure 1 Fluctuation of Passenger Flow and Distribution of Congested Areas at the Station

The figure 1 shows the fluctuation of passenger flow at the station during different time periods, highlighting the congestion at key areas such as the entrance, transfer area, and security check during peak hours. It is clearly visible that the passenger flow pressure at the entry and transfer corridors is most prominent, especially during peak hours.

2.3 Service Quality Issues

Through an in-depth analysis of the station's current status, we identified several key issues affecting service quality during peak hours:

1. Passenger Flow Congestion: The station's main entry and exit points, transfer corridors, and security check areas face tremendous passenger flow pressure during peak hours. Due to the station's facilities not being adequately designed to handle peak hour demands, congestion often occurs at these areas, leading to severe passenger delays and queuing, which further impacts overall passage efficiency.
2. Insufficient Facility Capacity: The number of facilities such as automatic ticket vending machines, security devices, and entry/exit gates are insufficient during peak hours, unable to meet the surge in passenger demand. Particularly in the security check and ticketing areas, the limited capacity of these facilities restricts the quick flow of passengers, causing long waiting times and negatively affecting passenger experience.
3. Delayed Information Release: The station's real-time information release system fails to provide passengers with necessary information in a timely manner, especially during peak times and emergencies. Passengers are unable to obtain critical data such as train schedules or transfer information. The failure to update information promptly causes passenger anxiety and unnecessary waiting, further reducing travel efficiency.
4. Security Management Issues: During peak hours, the station's security checks face immense pressure. Due to limited numbers of security devices and insufficient staffing, the efficiency of security checks is low, leading to long waiting times for passengers. Particularly during busy periods, the security check process fails to operate efficiently, exacerbating passenger delays.

Table 2 Summary of Service Quality Issues at the Station

Service Issue	Influencing Factor	Impact Result
Passenger Flow Congestion	Insufficient facility capacity, unreasonable passageway setup	Passenger delays during peak hours, overall passage efficiency decreases
Insufficient Facility Capacity	Inadequate number of devices, unreasonable facility layout	Long waiting times for security checks and ticketing, affecting passenger experience
Delayed Information Release	Incomplete real-time information release system	Passengers cannot obtain timely train information, affecting travel efficiency
Security Management Issues	Insufficient staffing, inefficient security check processes	Extended security check times, potentially affecting station safety

As shown in Table 2, the main issues affecting station service quality are identified, along with detailed explanations of their influencing factors and consequences. Through in-depth analysis of these problems, the critical aspects in need of urgent improvement within station services have been clearly defined.

By analyzing the station's current service status, we have clearly identified the main issues affecting service quality during peak hours, including passenger flow congestion, insufficient facility capacity, delayed information release, and security management. The concentration of passenger flow has led to facility overload, especially in critical areas such as transfer corridors and security check points, resulting in passenger delays and queuing, which affects overall operational efficiency. These issues not only reduce the passenger travel experience but also increase the operational pressure on the station.

To effectively address these problems, this study will propose optimization strategies based on the identified issues, aiming to improve service quality at the station during peak hours, optimize facility configuration and passage capacity, enhance passengers' travel experience, and provide references for future rail transit stations.

3 SERVICE QUALITY IMPROVEMENT STRATEGIES

Based on the analysis of the station's current service status, the service quality during peak hours is influenced by multiple factors, particularly in areas such as passenger flow management, facility capacity, information release, and security management. To solve these problems and improve the station's service quality, this study proposes the following series of optimization strategies. These strategies aim to improve the station's operational efficiency, enhance passengers' travel experience, and provide references and insights for other similar stations.

3.1 Optimizing Passenger Flow Organization

Optimizing passenger flow organization is the primary strategy for improving station service quality. Especially during peak hours, proper passenger flow guidance and diversion can effectively alleviate congestion at the station and enhance overall passage efficiency. Specific optimization measures include:

Setting Up Diverting Channels: During peak hours, additional temporary channels should be set up to divert passenger flow from the main entry and exit points to alternate routes, avoiding excessive congestion in certain areas. Adding extra channels at entry points and transfer areas can effectively alleviate passenger flow pressure.

Optimizing Transfer Corridor Design: As transfer corridors are key parts of the station, they must handle a large passenger flow during peak hours. Increasing the number of transfer corridors, widening their width, and reasonably setting passenger flow direction can effectively reduce queuing times during transfers and relieve congestion in transfer areas.

Increasing Staff for Guidance: During peak hours, increasing the number of staff, especially in high-traffic areas such as entry points, transfer corridors, and security check areas, is essential. Staff can guide and direct passengers on-site to help them flow smoothly, ensure orderly passage, and reduce waiting times.

Figure 2 Diagram of Passenger Flow Diversion Plan

The figure 2 shows a plan for alleviating passenger flow pressure at the station during peak hours by setting up diversion channels and optimizing the design of transfer corridors. Through this approach, the station can effectively divert passenger flow for entry, exit, and transfers, reducing congestion.

3.2 Enhancing Facility Passage Capacity

Improving the passage capacity of station facilities is key to solving congestion problems during peak hours. By increasing facility capacity and introducing intelligent systems, the station's passenger flow handling capability can be significantly enhanced. Specific optimization measures include:

Increasing Security Check Devices and Ticket Machines: The current number and passage capacity of security check devices and automatic ticket vending machines are insufficient during peak hours. Adding more security channels, automatic ticket machines, and manual ticket windows can maintain high passage efficiency during passenger surges and reduce waiting times.

Introducing Intelligent Security Check Devices: Introducing intelligent security check devices such as facial recognition and QR code scanning can improve security check passage capacity, reduce bottlenecks in manual security checks, and enhance overall security check efficiency.

Improving Vertical Transportation Capacity: During peak hours, vertical transportation (such as escalators and stairs) often becomes a bottleneck for passenger flow. Installing additional escalators and optimizing their operation times (e.g., increasing the number of escalators in operation during peak hours) can significantly improve the efficiency of passengers moving up and down between levels.

Table 3 Comparison of Facility Optimization Before and After

Facility Type	Passage Capacity Before Optimization (Passengers/Hour)	Passage Capacity After Optimization (Passengers/Hour)
Entry Gates	12,000	18,000
Security Check Devices	2,500	4,500
Ticket Vending Machines	1,800	3,000
Escalators	5,000	8,000

As shown in Table 3, measures such as increasing the number of facilities and introducing intelligent security check equipment can significantly improve the passage capacity of various station facilities. Especially during peak hours, the enhancement of facility capacity will effectively reduce passenger waiting times and delays.

3.3 Security Management and Emergency Response

Security management during peak hours not only affects passengers' travel experience but also directly impacts the station's safety and operational efficiency. To ensure that the station's security management can efficiently cope with the pressures during peak hours, the following strategies are proposed:

Increasing Security Personnel: During peak hours, the number of security personnel should be increased, especially in key areas of the station such as entry points and transfer corridors. By adding more security staff, the efficiency of security checks can be effectively improved, reducing passenger waiting times.

Intelligent Security Check Systems: Introducing intelligent security devices, such as facial recognition and smart metal detectors, can enhance security check efficiency and reduce passenger queuing times. These devices will allow the station to improve security processing capacity without significantly increasing labor costs.

Establishing an Emergency Response Mechanism: To address emergencies during peak hours (such as equipment malfunctions or accidents), the station should develop a comprehensive emergency response plan. Through simulation drills and emergency exercises, the emergency handling capabilities of security and other staff can be improved, ensuring that the station can respond quickly and effectively to emergencies.

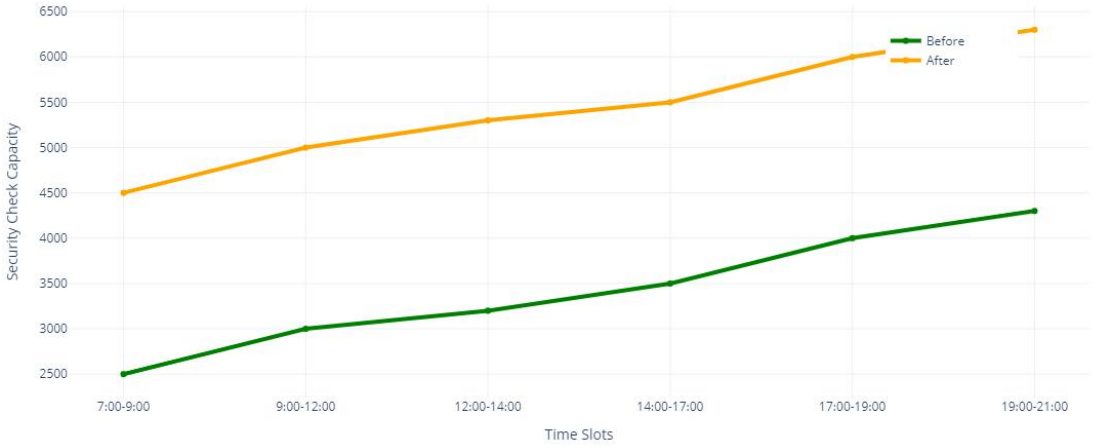

Figure 3 Comparison of Security Check and Emergency Response Optimization Before and After

The figure 3 shows the comparison of the security check and emergency response systems before and after optimization. Increasing security check devices and personnel will effectively improve security check efficiency, reduce waiting times during peak hours, and enhance the station's emergency response capabilities.

3.4 Enhancing Information Release and Passenger Guidance

Optimizing the information release system is crucial to improving passengers' travel experience. The station should strengthen the information release system to ensure that passengers can access accurate travel information at any time, thus improving overall travel efficiency. Specific optimization measures include:

Real-Time Information Release: Install additional electronic displays in the station to promptly update key information such as train schedules, passenger flow data, and equipment malfunctions. By providing real-time information, passengers can adjust their travel plans according to the situation, reducing unnecessary waiting times.

Mobile Application Support: Develop a dedicated station app that provides real-time train schedules, passenger flow monitoring, travel route planning, and other functions to help passengers obtain all the necessary information before their trip.

On-Site Guidance Personnel: Increase the number of staff at congested areas and key locations within the station to provide on-site guidance, helping passengers quickly find the appropriate passageways and routes, and reducing delays and waiting times.

Table 4 Comparison of Information Release Optimization Before and After

Information Release Method	Release Frequency Before Optimization	Release Frequency After Optimization	Optimization Effect
Electronic Displays	Updated once per hour	Updated every 10 minutes	Improved information accuracy and timeliness
Mobile Application Update Frequency	Updated once per day	Real-time updates	Enhanced passengers' ability to plan their travel
On-Site Guidance Personnel Configuration	1 person per area during peak hours	3 people per area during peak hours	Improved passenger experience in congested areas

As shown in Table 4, the optimization of the information release system will significantly enhance passengers' access to travel information, reduce their anxiety, and help them plan their trips more efficiently.

The service quality improvement strategies proposed above focus on the key issues faced by the station during peak hours. These strategies include optimizing passenger flow organization, enhancing facility passage capacity, strengthening security management and emergency response, and improving the information release system. The implementation of these strategies will effectively alleviate congestion during peak hours, enhance passengers' travel efficiency, and subsequently improve the overall operational efficiency and passenger satisfaction of the station. As these optimization measures are implemented, the station's service quality will be significantly improved, providing strong support for the sustainable development of the urban rail transit system.

4 CONCLUSION

This study takes a specific urban rail transit station as a case study. Through an in-depth analysis of the station's service status during peak hours, the study identifies key issues affecting service quality, including passenger flow congestion, insufficient facility capacity, delayed information release, and security management. In response to these issues, this study proposes a series of feasible service quality improvement strategies, including optimizing passenger flow organization, increasing facility capacity, introducing intelligent equipment, and improving security management and information release systems.

The research results indicate that the station's service quality during peak hours can be significantly improved through multi-dimensional strategic optimization. Firstly, by rationally diverting passenger flow and optimizing transfer corridors, congestion at entry points and transfer areas can be effectively alleviated. Secondly, increasing the number of facilities, especially security check devices and automatic ticket vending machines, will enhance the station's passage capacity during peak hours and reduce passenger waiting times. Thirdly, the introduction of intelligent security check devices significantly optimizes the security check process and improves overall operational efficiency. Furthermore, upgrading the information release system and establishing an emergency response mechanism also effectively reduce unnecessary waiting and anxiety for passengers, improving travel efficiency.

In conclusion, the optimization strategies proposed in this study not only solve the bottleneck issues at the station during peak hours but also enhance passengers' travel experience, further improving the station's operational efficiency and the overall service quality of the urban rail transit system. These measures will lead to significant improvements in the station's service quality in the near future, providing references and insights for other urban rail transit stations.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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