WHIOCE PUBLISHING PTE. LTD.
PROVIDING FIRST-CLASS SCIENTIFIC INFORMATION FOR TOP SCHOLARS

2025 Volume 1, Issue 1
Science Progress and Humanity

Study on the Automatic Fare Collection System in Rail Transit Supported by Cloud Platforms

Ruifu Zhang*, Zhongliao Wang, Linyao Chen
Zhejiang Happiness Rail Transit Operation Management Co., Ltd., Wenzhou 325000, China

***Corresponding author:** Ruifu Zhang, zcc@wzu.edu.cn

Abstract: With the continuous advancement of urban modernization, the rail transit system has undergone constant upgrades and innovations, significantly enhancing urban transportation capacity and addressing issues such as traffic congestion [1]. Regarding ticketing systems, the transition from manual ticketing to automated modes has been achieved, integrating ticketing, fare collection, and billing into a unified automated system. Against the backdrop of advancing information technology, the automatic fare collection (AFC) system in rail transit is expected to be further enhanced and promoted with the integration of cloud platforms, thereby increasing its application value. This paper conducts an in-depth study of the rail transit AFC system supported by cloud platforms, aiming to provide a reference for related research and to facilitate a deeper understanding of its principles [2].

Keywords: Cloud platform; Rail transit; Automated ticketing systems

Online publication: March 6, 2025

1. Introduction

The automatic fare collection (AFC) system serves as the foundation for ticketing management in urban rail transit. Leveraging modern technologies such as communication networks and database management, the ticketing and validation processes in rail transit have been transformed into automated and intelligent operations. The AFC system has replaced manual ticketing and fare collection with automated processes, significantly improving ticketing management efficiency and enhancing the passenger experience.

As urban modernization progresses, cloud platforms and cloud computing technologies have emerged as critical components of the AFC system, further expanding its service capabilities [3]. In this context, exploring the implementation and optimization of rail transit AFC systems supported by cloud platforms is of great practical significance, offering insights into enhancing operational efficiency and passenger satisfaction.

2. AFC system and cloud security mechanism

2.1. The existing problems of the traditional AFC system and the advantages brought by the cloud platform

Traditionally, the AFC system was composed of five subsystems: the first layer of the sorting system, the second layer of the line central computer system, the third layer of the station-level server system, the fourth layer of the ticket sales terminal equipment, and the fifth layer of the ticket card. Together, these five layers constituted the structure of the traditional AFC system [4]. However, in practice, several issues have been identified within this traditional structure. These include limited reliability and availability, such as the vulnerability of the third layer to single-point failures. Additionally, as the scale of the AFC system expands, operational management becomes increasingly complex, and the costs of operation and maintenance rise significantly. Furthermore, the growing number of passengers has led to a rapid increase in data volume, placing higher demands on the system's data processing capacity. Thus, in the context of rapid socio-economic development, the rail transit AFC system requires continuous upgrades to support the city's dynamic growth [5].

The introduction of cloud platforms has brought significant changes to the structure of the AFC system, particularly in its hierarchical organization. The traditional five-layer structure has been transformed into a three-layer system, where the first and second layers of the original hierarchy are replaced by the cloud platform. This new architecture consists of a cloud computing center, a ticket management terminal, and station terminal equipment, better aligning with the operational and management needs of modern rail transit [6].

In terms of functional enhancements, the AFC system integrated with a cloud platform offers advanced capabilities, including big data mining, analysis, storage, and management, in addition to its original functionalities. From an operational perspective, it enables the management of initial business processes, operational day switching, and operation mode adjustments. In the realm of ticket management, it encompasses tasks such as ticket card procurement, production, circulation, and recycling. Regarding big data management, the system facilitates mining, forecasting, and storage, along with the analysis of historical data to extract valuable insights. For instance, by analyzing passenger flow through big data, the system provides reliable information to support decision-making in the operation and management of the rail transit system.

2.2. Implementation of cloud security mechanisms

2.2.1. Software security mechanism

The system incorporates a robust security mechanism using software-based protection to prevent malicious data breaches, operational errors, and other potential threats [7]. For instance, to safeguard against malicious damage, the cloud platform automatically stores transaction data, including inbound and outbound records, within the system. When data volumes are large, the platform employs predefined rules to partition the data, storing it in separate locations to enhance security. In preventing operational errors, the system verifies the executor's password and authority for every action. This process effectively minimizes the likelihood of misoperations and strengthens system reliability.

2.2.2. Network security mechanism

Network security is fundamental to ensuring the overall security of AFC systems. With cloud platform support, network security focuses on preventing unauthorized access, data theft, and tampering. The network security architecture of the AFC system is divided into three domains: the node security domain, the cloud platform security domain, and the border security domain. Firewalls are strategically implemented between these domains by isolating ports, thereby improving the system's security and resilience against cyber threats [8].

2.2.3. Data security mechanism

The data security mechanism encompasses two critical aspects: data transmission and data storage.

In the context of data transmission, it is essential to ensure the complete and tamper-free transfer of data between parties. Data encryption technology serves as a vital safeguard during this process. Plaintext data is converted into highly secure ciphertext for transmission, and upon receipt, the original data is retrieved through verification and decryption. Effective key management is crucial in this process, requiring encryption and decryption keys to be both symmetric and unique.

For data storage security, the cloud platform leverages data backup techniques to secure system-generated data. This approach ensures that the stored data remains protected against potential threats, providing a reliable safety net for long-term system functionality [9].

3. The cloud payment model based on cloud platform

3.1. Passenger level

Passengers can download the corresponding mobile application to purchase tickets in advance before boarding the train, completing the ticket purchase process through online self-service. This approach effectively reduces the pressure on on-site manual ticket sales while also saving passengers' travel time. Additionally, passengers can purchase tickets online via the official website platform, further eliminating the need for manual ticket sales and enhancing travel convenience [10].

3.2. System management level

Supported by the cloud payment platform, the frequency of ticket purchases made through on-site ticketing equipment has decreased significantly. This reduction effectively lowers the maintenance and management costs of the equipment in the long term, significantly reduces the reliance on human resources in the rail transit system, and enhances the efficiency of station ticket sales and inspection processes. Moreover, the use of cloud payment channels has effectively controlled business card printing costs, streamlining system maintenance and ensuring the system's security and stability [11].

3.3. Urban rail transit operation level

The cloud payment model based on the cloud platform has played a crucial role in enhancing the operation of urban rail transit by making the management model more diverse and user-friendly, thereby providing passengers with a richer travel experience. For instance, in current operations, big data processing systems within cloud payment platforms are utilized to create passenger point accounts. Ride points are accumulated based on passenger cloud payment data and stored in user accounts. In the future, passengers may use these points to directly offset fares or participate in various exchange activities. This approach enables rail transit operations to retain customers through diversified management methods and promotes the development of urban rail transit.

4. AFC construction and operation management suggestions supported by the platform

4.1. Suggestions on AFC construction on the cloud platform

4.1.1. Define the scope of responsibilities of all parties involved

In constructing and managing the AFC system in conjunction with the cloud platform, the project team and relevant personnel must oversee this process, including the comprehensive service provider and the supply company. It is essential to clearly define the professional responsibilities of all parties to facilitate the orderly construction and operation of the rail transit AFC system. For instance, the construction unit is responsible for the technical and construction management of the entire project, which constitutes a crucial link in the AFC system's construction and operation [12]. From a technical management perspective, the construction unit must perform post-design improvements and modifications based on the project's planning, preliminary design, and construction drawing design to meet user requirements. Regarding construction management, strict adherence to the company's management system is required to enhance site management, improve work quality, and review and confirm the organizational design of the project. For the integration of service providers, equipment supply units, and supervision units, it is also necessary to clarify their respective responsibilities and tasks according to their specific functions.

4.1.2. Strengthen organizational structure and personnel allocation

A robust organizational structure and appropriate personnel allocation are critical to ensuring the construction and normal operation of the AFC system under cloud payment. This involves the coordination of equipment supplier projects, integration service projects, and supervision projects. Taking the organizational structure and personnel allocation of the integrated service project as an example, the structure typically includes the project leader, planning engineer, quality engineer, document manager, and professional engineer, each with clearly defined job responsibilities [13]. For instance, the project leader must sign the relevant cooperative service contract with the integrated service provider, coordinate the project construction unit, and manage tenderer resources. This role is crucial for the successful implementation and management of the entire project. Therefore, personnel allocation must include project management professionals with leadership and coordination abilities to ensure the effective execution of the integrated service contract. Similarly, the quality engineer is responsible for overseeing project quality, implementing the quality assurance system, and managing and supervising the quality of sub-suppliers. In summary, strengthening the organizational structure and personnel allocation is an essential safeguard for the construction and operation management of the AFC system supported by the platform.

4.1.3. Strengthen schedule management

In constructing the cloud platform AFC system, a detailed project schedule should be developed to enhance progress management. During the formulation process, the construction department of the rail transit ticket sales and inspection system must consider organizational, cost, and technical factors and prepare appropriate response plans. For instance, regarding organizational factors, whether in the construction phase of the automatic ticket selling and checking system or its operational phase after completion, human resources remain the most critical element. Effective management of the engineering team significantly impacts the project's overall progress. To address this, it is essential to introduce individuals with strong technical expertise and comprehensive abilities, allowing for the optimal utilization of human resources and efficient management of engineering personnel. This approach can save both time and labor costs while improving project implementation efficiency.

Cost factors also play a vital role throughout the project's lifecycle. Failure to control costs during the construction and operational phases can lead to financial mismanagement, resulting in a shortage of funds in later stages, thereby hindering project construction and operation. Consequently, during the preliminary design stage of the automatic fare collection system, cost management must include defining management pricing, execution costs, and budgets before equipment bidding. To prevent excessive project costs and potential fund shortages, stringent financial controls must be implemented to ensure the smooth construction and operation of the AFC system [14].

4.1.4. Quality assurance and related management of system equipment

In the design phase, all drawings and product data must adhere to clear quality standards, including specifications for components, materials, and detailed assembly processes. Manufacturers are expected to take full responsibility, accept revision proposals, and provide updated design drawings when necessary. The responsible personnel should possess sufficient experience and expertise, a thorough understanding of project site requirements, and the ability to guide related tasks effectively.

During the procurement phase, the equipment integrator must implement effective management measures to ensure that purchased materials meet the project's requirements and comply with relevant standards. In the trial operation phase, the integrator must verify that the automatic ticket sale and inspection system equipment is compatible with other systems and conduct thorough trial operation tests. This phase involves testing each component of the automatic inspection and ticketing system according to specific regulations and recording the results. Various methods should be employed to assess the system's control capabilities, ensuring that its performance aligns with contractual requirements.

4.2. Relevant suggestions for AFC operation on the cloud platform

4.2.1. Improve the "soft and hard" environment of the AFC system

The primary objective of enhancing the soft and hard environment of the AFC system is to improve its risk prevention capabilities, create a conducive environment for the adoption of the cloud platform, and further emphasize the advantages of the cloud-based AFC system. For instance, regarding the reliability of data transmission, anti-virus software and a Unix operating system with a higher security factor can be employed. Additionally, the key systems used in the data transmission process must ensure that all devices comply with legal standards. The key version should be stored in the card, corresponding to the secure access module (SAM) card, and used to calculate the authentication code.

From a management perspective, both the AFC system equipment operators in rail transit and the personnel responsible for maintaining the AFC system must use operational passwords. These passwords help manage and maintain different permission levels and control the activation or deactivation of specific functions.

4.2.2. Strengthen the training and education of employees

In the construction and operation of the rail transit AFC system, human resources play a critical role. Therefore, in enhancing the AFC system based on the cloud platform, the rail transit system must focus on employee training to ensure that personnel can effectively operate this advanced automation system, which has significant technical and operational implications.

For instance, during the promotion and implementation of the cloud-based AFC system, the transportation and rail operation departments should integrate employee training into their plans. System suppliers should be required to provide specialized training for rail transit employees, ensuring that the workforce acquires the necessary knowledge and skills to operate and maintain the system effectively. Additionally, a structured business training program should be established to ensure that, after the system's deployment, employees can independently, safely, and efficiently handle all operational and maintenance tasks [15].

Furthermore, training should not only cover professional knowledge and operational skills but also emphasize safety awareness among operation and maintenance personnel. Pre-employment training programs should incorporate safety-related content, helping staff identify potential hazards and instill a "safety-first" mindset across the organization.

4.2.3. Establish a sound emergency handling mechanism

A comprehensive emergency management mechanism enables the rail transit system to handle emergencies accurately and promptly, effectively preventing errors and minimizing the impact of accidents. For example, the AFC system under the cloud platform is not immune to hardware failures or other risk-related incidents. In such cases, emergency plans can be formulated based on the measures outlined for rail transit accident management to address potential risks.

For instance, if all entry gates malfunction and passengers enter the station with valid tickets but without recorded entry, the system can activate a "no entry inspection" mode at stations along the line. Each station should designate specific exits for this mode based on passenger flow to maintain the normal operation of the transit system.

To ensure the effective implementation of emergency plans, popularization and training measures must be undertaken. Employees should participate in risk management drills and receive comprehensive training to enhance their emergency response capabilities. Furthermore, to prevent potential faults from disrupting urban rail transit operations, staff must regularly inspect the AFC system for risks and hidden dangers, promptly identifying and resolving issues.

5. Conclusion

In summary, leveraging the cloud platform to further enhance the operational capacity of the rail transit AFC system represents the future direction of AFC development. In practical applications, its advantages effectively address the shortcomings of traditional AFC systems, resulting in a more streamlined automation process. Additionally, it provides passengers with diversified travel services while improving the standardization and intelligence of the urban rail transit AFC system.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Wang N, 2023, Design and Implementation of Automatic Ticket Sale and Inspection System of Rail Transit Based on Cloud Platform. Wireless Internet Technology, 20(11): 70–72.

[2] Nie H, Ma Y, 2022, Automatic Ticketing System of Urban Rail Transit Based on Hybrid Cloud Platform. Urban Rail Transit Research, 25(8): 166–169.

[3] Shenzhen Realbom Intellitech Co., Ltd., 2024, The Solution of Palmar Vein Recognition Industrial Computer Helps the Intelligent Upgrade of Automatic Ticket Selling and Checking System of Rail Transit. Automation Panorama, 41(11): 30–32.

[4] Chen X, Pan Z, 2024, Research on Network Security Technology of Automated Ticketing System Based on Urban Rail Cloud. Industrial Information Security, 2024(5): 82–88.

[5] Zhang C, 2024, Curriculum Ideological and Political Design Based on "Maintenance of Automatic Ticket Selling and Checking System of Urban Rail Transit". Times Automobile, 2024(19): 64–66.

[6] Yuan S, 2024, Application of Internet of Things Technology in Automatic Ticket Sale and Inspection System of Urban Rail Transit. Intelligent Buildings and Smart City, 2024(8): 176–178.

[7] Li J, Cai J, Fan H, et al., 2024, Architecture Design and Implementation of Intelligent Operation and Maintenance System for Automatic Ticket Sales of Urban Rail Transit Driven by Data and Model. Urban Rail Transit Research, 27(6): 202–206.

[8] Miao S, Li S, 2024, Research of Metro Automatic Fare Collection System Equipment Intelligence Operations. People's Bus, 2024(8): 88–90.

[9] Yang Y, 2024, Equipment Fault Analysis and Maintenance Countermeasures of Automatic Ticket Selling and Checking System in Subway. Equipment Maintenance Technology, 2024(1): 32–35.

[10] Huang L, Liu H, Wang M, et al., 2019, Analysis of Drug Use Rules of Injury-Related Diseases Prescription in "Traumatology Dacheng" Based on Cloud Platform of Ancient and Modern Medical Records. Chinese Folk Therapy, 32(24): 3–6.

[11] Wang X, Zhang W, 2024, Application of SaaS Cloud Platform in Informatization Construction of Higher Vocational Colleges. Journal of Qingdao Ocean Crew Vocational College, 45(4): 30–34.

[12] Zhao X, Chen X, Chen S, et al., 2024, Laboratory Design Based on Cloud Platform/Internet of Things (IoT). China Port Science and Technology, 6(12): 4–9.

[13] Du T, Cheng C, Zhang Q, et al., 2024, Overloaded Railway Intelligent Application Scheme Based on Cloud Platform Research. Journal of Railway Freight, 2024(12): 64–70 + 80.

[14] Xiao Y, 2025, Research on Automatic Monitoring System of Rail Transit Construction Behavior Based on Video AI Technology. Automation Technology and Application, Online ahead of print. http://kns.cnki.net/kcms/detail/23.1474.TP.20241230.1429.181.html

[15] Li X, Yan Z, Ma J, et al., 2024, Station Under the Perspective of Urban Rail Transit Intelligent Flood Control Integration Design. Journal of Transportation Engineering, 24(12): 55–60.

Publisher's note

Whioce Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.