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Application of Internet of Things Technology in Automatic Ticket Sale and Inspection System

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Abstract

With the continuous development of society and the continuous progress of economy, Internet of Things technology has also been widely used in various urban rail transit systems. Its application in the automatic ticket sale and check system has greatly improved the efficiency of the automatic ticket sale and check system, while the development of Internet of Things technology has been further promoted. Based on this, this paper takes this as the main research content to carry out analysis and discussion, and provides a lot of reference suggestions for the application of Internet of Things technology in automatic ticket sales and inspection system, and also looks forward to its future development.

Keywords

Internet of Things technology; Automatic ticket sale and check; System application

Introduction

With the continuous development of my country's market economy and the continuous improvement of residents' living standards, urban traffic congestion has gradually become an important factor in urban development. The construction of urban rail transit has, to some extent, solved this problem. As an important component of urban rail transit, the automatic fare collection system integrates various high technologies, realizing a unified system encompassing ticketing, fare collection, billing, and statistics, greatly improving the efficiency and service level of rail transit. Furthermore, the application of Internet of Things (IoT) technology in the automatic fare collection system has effectively helped it achieve further development. Based on this, this paper further analyzes and discusses this aspect.

1. The Concept and Development of Internet of Things (IoT) Technology

The concept of the Internet of Things (IoT) was proposed in 1999 and has undergone several stages of development. Each stage has greatly promoted the development of IoT. Specifically, the first stage of IoT effectively connects information sensing devices to the Internet through radio frequency identification (RFID) technology, enabling intelligent identification and management. The second stage is the process of connecting everything, that is, achieving connection and communication between people and things, and between things themselves, through connections of time, location, and people. The third stage is the effective application of IoT in various urban life scenarios. The long-term development of IoT technology is achieved through its effective application in various urban life scenarios. In general, there is no single definition of the IoT system; different layer definitions are based on different industry perspectives, leading to significant differences in the choice of definition. The IoT architecture also has a sense layer, network layer, and application layer. The choice of different layers and application standards vary, resulting in different types of businesses and services that can be supported (Bai, 2019).

Note: The article was originally published in *Journal of Electrical Engineering and Automation*, and this is an authorized translation of it.

2. The Basic Status of My Country's Automatic Fare Collection System

With the continuous development of society and the increasing number of construction projects in China, urban transportation construction has reached a new level. The subway plays a crucial role in modern urban transportation, greatly contributing to solving population flow problems. The application of automatic fare collection systems (AFCS) can not only effectively improve work efficiency but also alleviate the workload of staff. However, the current state of China's AFCS reveals numerous problems in its operation. For example, frequent switching on and off can prevent the main control unit from operating normally. Such frequent occurrences not only accelerate the aging of related equipment but also reduce the efficiency of the AFCS and increase maintenance costs. Therefore, the current state of China's AFCS remains concerning (Bi et al., 2017).

3. Automated Ticketing System Based on Internet of Things Technology

The research on the application of automated fare collection systems based on Internet of Things (IoT) technology mainly includes three aspects: the perception layer, the network layer, and the platform layer. The application concepts used for different layers differ, specifically including the following parts:

3.1 Perception Layer

The terminal equipment of an automated fare collection system based on Internet of Things (IoT) technology mainly includes mobile ticket vending machines and automatic ticket gates. The key systems used in these terminal technologies are sensors, chipsets, and operating systems. IoT data processing algorithms not only enable dynamic monitoring of automated fare collection data within the station but also allow for effective analysis, ensuring that the selected equipment meets the system's requirements for low energy consumption and high performance. It is worth noting that an automated fare collection system based on IoT technology should also meet certain reliability and interoperability requirements to ensure that the software across different equipment components achieves a consistent organizational structure. Applying IoT technology at the perception layer enables status monitoring and data collection of related systems, thereby facilitating effective communication and transmission between station terminals and upper-level systems (Liu et al., 2020).

3.2 Network Layer

The application of the Internet of Things (IoT) in automated fare collection systems primarily relies on IoT access technology. Effective IoT access technology not only further ensures the security, reliability, and maintainability of the automated fare collection system but also significantly improves its efficiency and performance. However, it is crucial to strictly adhere to the relevant network access protocols when introducing IoT access technology to ensure that the network-layer IoT technology achieves its intended application effect in the automated fare collection system.

3.3 Application Layer

The application of IoT-based automated fare collection systems is also reflected at the application layer. The main content of the application layer involves connecting different types of terminal devices through the platform terminal to achieve unified management and accelerate business development and innovation. Therefore, the main role of IoT technology at the application layer is to build a transparent communication channel between terminals and applications, effectively connecting the platform and applications. It is worth noting that the application platform provides unified control over different types of devices and analyzes different application behaviors. Furthermore, IoT technology also needs to undertake certain analytical functions during the construction of application channels.

4. Application Strategies of Internet of Things (IoT) Technology in Automated Ticketing Systems

4.1 Targeted Use of IoT Technology According to Different Levels

The concepts and methods used in applying IoT technology at different levels of an automated fare collection system (AFCS) differ. Therefore, IoT technology should be applied selectively based on the specific functions at each level. This ensures that the application of IoT technology effectively improves the overall efficiency of the AFCS, thereby providing passengers with a faster and more comfortable experience (Wu, Cheng, & Liang, 2016).

4.2 Continuously Improve the IoT Technology Application Capabilities and Levels of Staff Working with Automated Fare Collection Systems.

The role of relevant personnel is crucial in the effective application of IoT technology in automated fare collection systems. Therefore, improving the IoT technology application skills of these personnel is essential to achieving the desired results. To achieve this, the following aspects should be addressed: First, establish a high-standard talent selection system to attract more outstanding individuals to the work of integrating IoT technology into automated fare collection systems, thus building a sufficient talent pool. Second, regularly conduct exchanges and training on relevant technical content to ensure that the work level and capabilities of relevant personnel remain at a high level, enabling them to effectively integrate IoT technology into automated fare collection systems. Continuously improving the work capabilities of relevant personnel through these two aspects is the foundation and guarantee for the effective integration of automated fare collection systems and IoT technology (Wu, Xia, & Li, 2018).

5. Specific Application Scenarios of Internet of Things (IoT) Technology in Automated Fare Collection Systems

5.1 Intelligent Ticketing

The application of IoT technology has made automated ticket vending machines more intelligent. By embedding various sensors and processing chips, these machines can perceive their surroundings in real time, such as passenger flow, temperature, and humidity, and automatically adjust their operating status based on this data. For example, they can automatically open more ticket windows during peak hours and enter energy-saving mode during off-peak hours. Simultaneously, IoT technology supports real-time data interaction between the ticket vending machines and the back-end system, enabling dynamic adjustments to fare strategies based on big data analysis results, achieving intelligent pricing. Furthermore, IoT-based ticketing systems can achieve cross-platform ticketing. Passengers can purchase tickets not only at the station using the vending machines but also through mobile apps, websites, and other channels. The system automatically synchronizes data, avoiding duplicate ticket sales. This greatly improves the convenience and efficiency of ticket purchasing (Yuan & Li, 2017).

5.2 Intelligent Ticket Checking

In the ticket checking process, the application of IoT technology is mainly reflected in the following aspects: First, intelligent facial recognition technology. By installing high-definition cameras and facial recognition algorithms on the ticket gates, the system can enable entry by facial recognition. Passengers only need to stand in front of the gate for a few seconds, and the system can automatically complete identity verification and ticket checking, greatly improving ticket checking efficiency. Second, intelligent anomaly detection. IoT sensors can monitor the operating status of the gates in real time. If abnormalities such as ticket jams or gate malfunctions occur, the system will immediately sound an alarm and automatically activate the emergency plan to minimize the impact on normal passage. Third, intelligent passenger flow statistics. By installing infrared sensors, pressure sensors, etc., in the ticket checking channels, the system can accurately count the passenger flow entering and exiting the station, providing data support for line operation. Combined with big data analysis, it can also predict future passenger flow trends, providing a basis for decision-making on capacity allocation.

5.3 Intelligent Operation and Maintenance

also plays a crucial role in the operation and maintenance management of automated fare collection systems: First, it enables equipment health monitoring. By installing various sensors on the fare collection equipment, the operating status of the equipment can be monitored in real time, including parameters such as temperature, vibration, and noise. Once an anomaly is detected, the system automatically alarms, allowing maintenance personnel to intervene promptly and prevent the impact of equipment failure. Second, it facilitates predictive maintenance. Based on the massive amounts of operational data collected by the IoT and combined with artificial intelligence algorithms, the system can analyze the equipment's lifespan and failure patterns, predicting potential problems in advance, thereby enabling preventative maintenance and reducing equipment failure rates. Third, it enables remote diagnostics and repair. When equipment malfunctions, maintenance personnel can remotely connect to view the equipment status and perform preliminary diagnostics. For some simple problems, repairs can even be completed remotely, greatly improving maintenance efficiency.

5.4 Intelligent Security

The Internet of Things (IoT) also provides more intelligent security solutions for automated fare collection systems: First, intelligent video surveillance. By deploying high-definition cameras in key areas and combining them with artificial intelligence algorithms, the system can automatically identify suspicious individuals and abnormal behaviors, providing timely warnings of potential security threats. Second, intelligent smoke and fire detection. By deploying smoke sensors, temperature sensors, and other sensors, the system can issue alarms in the early stages of a fire, buying valuable time for timely evacuation. Third, intelligent emergency command. When an emergency occurs, the IoT system can quickly collect on-site information, providing decision support to the command center and assisting in the development of emergency plans.

6. Challenges and Prospects of Applying Internet of Things (IoT) Technology in Automated Fare Collection Systems

6.1 Challenges Faced

While the Internet of Things (IoT) technology holds great promise for automated fare collection systems, several challenges remain in its practical implementation. First, there's the issue of data security. IoT systems involve vast amounts of passenger personal information and transaction data, making the security of data transmission and storage a critical concern. Multiple security measures, including encrypted transmission and access control, are necessary. Second, there's the issue of system stability. IoT systems involve numerous terminal devices and complex network architectures, making stable operation, especially reliability during peak passenger flow periods, a significant technical challenge. Third, there's the issue of standardization. Currently, the application of IoT technology in rail transit lacks unified standards, often leading to incompatibility and interoperability between systems from different manufacturers and cities. Finally, there's the cost issue. Full-scale application of IoT technology requires large-scale upgrades to existing systems, resulting in substantial upfront investment. Balancing investment and returns is a challenge for operators.

6.2 Future Outlook

Despite these challenges, the application of IoT technology in automated fare collection systems still has vast potential: First, the maturity of 5G technology will provide faster and more stable network support for IoT, potentially solving current network bandwidth and latency issues. Second, the development of artificial intelligence technology will enable IoT systems to possess stronger self-learning and decision-making capabilities, allowing them to more intelligently handle various complex scenarios. Third, the application of blockchain technology is expected to provide IoT systems with more secure and reliable data management solutions. Finally, with continuous technological advancements and expanded application scale, the cost of IoT solutions will gradually decrease, facilitating wider adoption and application.

7. Conclusion

In summary, as a crucial component of urban rail transit, the automatic fare collection system (AFCS) integrates multiple high technologies, realizing a unified system encompassing ticketing, fare collection, billing, payment, and statistics, significantly improving the efficiency and service level of rail transit. The application of IoT technology in AFCS has further facilitated its development. However, effectively applying IoT technology to AFCS requires tailored strategies based on specific application scenarios. For example, the network layer design of IoT technology should primarily consider network access protocols. Platform layer applications mainly involve logical functions such as connection management, equipment management, application support, and data analysis. The application layer primarily encompasses revenue analysis, passenger flow statistics, and intelligent maintenance. Providing different application strategies for different scenarios not only enhances the integration of IoT technology with the rail transit system but also lays a solid foundation for creating a comfortable, intelligent, and convenient travel experience for passengers.

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