

Research on the Expansion Application of Electronic Toll Collection System

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ABSTRACT

Electronic Toll Collection (ETC) system is an important part of modern intelligent transport system, which plays an important role in intelligent car parks and congestion charging. Electronic Toll Collection (ETC) system includes automatic vehicle identification system and electronic billing system. The automatic vehicle identification system includes three parts: automatic vehicle identification (AVI), automatic vehicle model identification (AVC) and inspection system (ES). The application of ETC in intelligent car parks and congestion charging also includes automatic vehicle identification system (automatic vehicle identification, automatic vehicle model identification and inspection system) and electronic billing system. In intelligent car parks, ETC technology achieves fast and accurate automatic toll payment by automatically identifying the ETC tags carried by vehicles, which greatly improves the efficiency of car parks and reduces the queuing and waiting time due to manual toll collection. In terms of congestion charging, ETC technology provides an effective means to implement congestion charge collection. By setting up ETC toll lanes in core urban areas or busy road sections, the system can automatically record the information of the vehicles passing through and carry out toll settlement, thus realising dynamic toll collection according to the degree of congestion and the frequency of vehicle use. This congestion charging strategy aims to regulate urban traffic flow through economic means, alleviate traffic congestion and promote the sustainable development of urban transport. Although China's theoretical research on congestion charging, has been relatively mature, but affected by a variety of factors, no city has yet to start the implementation of congestion charging, the lack of experience in practice. Singapore will not stop the car charging system (ETC) technology successfully applied to urban congestion charging and intelligent car parks, ETC system in intelligent car parks and congestion charging application, help to promote the development of urban transport to a more intelligent, green direction. China can learn from the successful experience of foreign countries and apply it to its own intelligent car parks and congestion charging. This paper introduces the basic principle of ETC, discusses the research progress of ETC in terms of technical characteristics, and analyses the application scenarios of ETC in intelligent car parks and congestion charging. By examining the opportunities offered by Electronic Toll Collection (ETC) systems in smart car parks and congestion pricing, this study aims to delve into the transformative impacts of Electronic Toll Collection (ETC) systems on intelligent mobility and contribute to the sustainable development of intelligent mobility.

KEYWORDS

Application Scenarios; Audit System; Automatic Vehicle Identification; Automatic Vehicle Identification System; Automatic Vehicle Model Identification; Congestion Charging; Intelligent Car Park; Electronic Billing System; Electronic Toll Collection System

1. INTRODUCTION

ETC electronic non-stop toll collection system has gradually developed from highway toll collection scenarios to urban car parks. Intelligent car parks achieve convenient services such as fast vehicle entry and exit, automatic toll payment and parking space finding by applying ETC technology.

First of all, when vehicles enter an intelligent car park, slow down and pay attention to the car park's signboards and signals. Car parks usually have obvious ETC payment signs and guidelines. When the vehicle passes through the ETC toll lanes, the sensors installed on the lanes will automatically recognise the vehicle information and deduct the tolls from the pre-stored fees. This process does not require human intervention and automatically completes the deduction and release, which greatly improves the efficiency of the car park.

Secondly, the intelligent car park also realises the automatic entry and recognition of vehicle information through the license plate recognition technology. After the vehicle is parked in place, the car park management system will record the vehicle's entry and exit time and parking time, and calculate the amount to be paid. When the vehicle owner leaves the car park, he only needs to confirm that the payment amount is correct and then complete the payment process. After the payment is completed, the vehicle can leave according to the instructions of the car park administrator, and there is usually a channel dedicated to the departure of ETC payment vehicles.

The application of intelligent car parks realises a seamless connection between car parks and car owners, providing car owners with more convenient and efficient parking services.

Traffic congestion charge is an economic tool that uses a price mechanism to reduce the density of car traffic on urban roads during peak hours. By charging a certain amount of money, drivers can be prompted to re-select the travelling time and travelling traffic road paths, from the time and space of these two dimensions to disperse the traffic demand, so as to improve the traffic speed of the traffic road. ETC technology in the application of congestion charging for the realization of this purpose provides an effective means.

Firstly, the congestion charging area will generally set clear boundaries and charging standards. When a vehicle enters the charging area, the ETC system will automatically recognise the vehicle information and deduct the corresponding congestion charge from the pre-stored fee. This process also eliminates the need for human intervention and enables automatic toll payment.

Secondly, the congestion charging rate can be dynamically adjusted according to time, location and congestion level. For example, during peak hours and in congested areas, the toll rates may be higher to further restrict traffic density. In contrast, during off-peak hours and in less congested areas, the toll rates may be relatively lower.

Through the application of ETC technology, congestion charging can be implemented more accurately and efficiently. Not only can manual intervention and errors be reduced and toll collection efficiency be improved, but real-time monitoring and adjustment of toll rates can also be realised to better achieve the goal of relieving urban traffic congestion.

The application of electronic non-stop charging system (ETC) in intelligent car parks and congestion charging provides a more efficient and convenient means for urban traffic management. Through the functions of automatic identification of vehicle information, automatic toll payment and real-time monitoring, it can not only improve the passage efficiency, reduce the waiting time and traffic congestion, but also achieve a more accurate and efficient toll management, making a positive contribution to the sustainable development of urban traffic.

The structure of this paper is as follows. The second part introduces the basic principle of ETC. The third part introduces the technical characteristics of ETC technology. The fourth part introduces the application of Electronic Toll Collection (ETC) system in intelligent car parks and congestion charging. Finally, conclusions are drawn in the fifth part.

2. BASIC PRINCIPLE OF ETC

ETC system mainly consists of three parts: vehicle electronic tag (OBU, On-Board Unit), toll station antenna (RSU, Roadside Unit) and data processing system.

On-Board Unit (OBU): It is an electronic device installed on the windscreen of the vehicle and usually contains a radio frequency identification (RFID) chip for storing vehicle information and account information. When the vehicle approaches the toll station, the OBU will communicate wirelessly with the RSU.

Toll Station Antenna (RSU): This is a communication device installed in the ETC lane of the toll station that uses microwave communication technology to communicate wirelessly with the OBU over short distances. The RSU is able to read the information in the OBU and send it to the data processing system.

Data processing system: this is a computer system located at the back end of the toll station, used to process ETC transaction data. Upon receiving the information sent by the RSU, the data processing system verifies the vehicle information and account information, calculates the tolls, and sends the results to the OBU to display to the driver for confirmation.

ETC use:

When the vehicles approaches the ETC toll passage, does not need to stop, the vehicle electronic label will automatically carries on the communication with the toll station antenna, completes the vehicles recognition and the expense calculation. The passage expense will automatically deduct from the pre-set account, does not need the cash transaction, the realisation fast, the convenient passage.

3. ETC TECHNOLOGY TECHNICAL CHARACTERISTIC

The technical characteristics of electronic toll collection system (ETC) are mainly reflected in the following aspects:

Quickness: This advanced technology of ETC system enables vehicles to pass through the toll station quickly and enjoy the convenience of quick passage.

Convenience: ETC system eliminates the trouble of cash payment, and all consumption data can be inquired through the network, which greatly facilitates vehicle and financial management. At the same time, ETC dedicated lanes can also eliminate the queuing and waiting time, which improves the passage efficiency.

Environmental protection: Since the vehicle does not need to stop to pay the fee, it can reduce the number of frequent stops and starts, which to a certain extent can reduce the wear and tear of the vehicle and tailpipe emissions, and make a certain contribution to environmental protection.

4. ETC TECHNOLOGY APPLICATION SCENE ANALYSIS

4.1. Application of ETC technology in intelligent car park management

The application operation of electronic non-stop toll collection system (ETC) technology in intelligent car park management mainly includes the following steps:

Slow down and drive into the car park: before entering the car park, the car owner needs to slow down and pay attention to the car park's signboards and signals. Generally speaking, the car park will have obvious ETC payment signs and guidelines.

Vehicle recognition: when the vehicle enters the electronic non-stop charging system (ETC) intelligent car park, the system through the microwave wireless communication between the car's

electronic label (OBU) and the charging station antenna (RSU), automatically recognises the car's vehicle information. At the same time, the automobile's licence plate recognition technology also carries on the licence plate calibration and the recognition, in order to improve the licence plate recognition rate and the accuracy rate.

Deduction Processing: Once the vehicle information is confirmed, the ETC system will automatically deduct the corresponding parking fees from the car owner's prepaid account. This process requires no human intervention and realises truly unattended automatic deduction.

Vehicle Parking in Place: According to the instructions of the car park manager, the owner will park the vehicle in the designated parking space. When parking, the owner needs to pay attention to the safety of the vehicle to avoid collision or scratching other vehicles.

Leaving the car park: When the car owner is ready to leave the car park, he/she only needs to drive to the exit lane according to the instructions of the car park manager. At this point, the ETC system will automatically recognise the vehicle information again and check the payment amount. If the payment amount is correct, the vehicle can leave the car park smoothly.

Electronic toll collection (electronic toll collection, ETC) technology has been used in a large number of intelligent transport systems in various countries around the world, mainly in the highway toll collection system. Electronic toll collection includes automatic vehicle identification system and electronic billing system. The automatic vehicle identification system includes three parts: automatic vehicle identification (AVI), automatic vehicle model identification (AVC) and inspection system (ES). The core of AVI system is the radio frequency automatic identification system, which consists of electronic markers, radio frequency devices and corresponding accessories. The radio frequency machine transmits the enquiry signal by the microwave frequency, if has the electronic label enters its signal area, the ID recognition code inside the label will be sent out, the communication machine receives this ID code to carry on the recognition after, so the code is confirmed the validity, the communication machine will send out the action order to the accessory facility, the computer records the relevant information and carries on the storage, the barricade machine lifts up or puts down automatically, realises the vehicle enters or drives out the car park when does not need to stop, the continuous The barriers are automatically lifted or lowered to achieve continuous operation without stopping when vehicles enter or exit the car park [1,2].

In order to realise the car park in the automobile in and out does not stop the situation automatic charge, needs in the vehicle installs the automobile recognition card (also called the electronic label), installs in the charge mouth the automobile automatic diagnosis system (AVI). The automobile intelligent recognition card, and the toll gate vehicles automatic diagnosis system (AVI) the radio transceiver between, through the microwave radio wave realisation automobile recognition and the data exchange, obtains through the automobile the type and belongs to the automobile vehicle owner and so on the data, and by the computer system from the electronic label the wallet allocates in the parking to need the expense and carries on automatically the storage to the electronic label and the backstage technological machine system, the system release the automobile Passes, thus realises does not stop the charge. AVC technology and the ES in the intelligence does not stop the charge (ETC) the car park charge management also is indispensable, is necessary the component part. the AVC technology guarantees the parking charge system work stability, prevents exchanges the automobile electron label and so on cheating phenomenon, avoids the car park due to to the automobile's type discernment mistake causes the loss. the ES can obtain the automobile's licence plate number by the automobile and reads out the automobile's information from the automobile electron label to make the comparison. ES can compare with the information of the car which is read out from the car electronic label by obtaining the licence plate number of the car, so as to prevent the occurrence of the event of fee evasion such as fraud. According to the Chinese present existing situation, in the highway does not stop the charge system, cannot immediately from the manual semi-automatic charge (MTC) the transformation to the full automatic does not stop the charge (ETC), therefore

needs to adopt the transitional policy and the strategy, namely the manual charge and does not stop the charge mixed mode: The toll station sets up one or two does not stop the charge the traffic lane, for has the electronic label the user to pass through directly; Does not have the electronic label the vehicle still to enter the manual charge The electronic label vehicle still enters the manual toll lane. Similarly, for does not stop the charge the intelligent car park management system, for the different user, also needs the different way. (1) the stored value card, the monthly card user (2) the temporary card user (3) the free card user. Charging is accomplished through the 3 subsystems of the intelligent car park management system of non-stop charging: Automatic Vehicle Identification (AVI), Automatic Vehicle Model Identification (AVC), and the Audit System (ES). The non-stop charging technology (ETC), applied to the car park intelligent management system, the car in and out of the car park does not need to stop, the driver does not need to carry out any manual operation, simplifies the vehicle entry and exit procedures, shortens the car in and out of the car park time, improves the efficiency of car parking management and car driving safety. It can be seen that the car park does not stop the charge as a future intelligent parking management programme, has a very good prospect of application. [1]

ETC intelligent parking is a mature technology, stable system, efficient operation, safe and reliable non-stop charging ETC technology applied to urban car park construction, operation and management. Aiming at the current situation of urban parking difficulties, by adopting the non-stop charging (ETC) technology and creating a smart parking city platform based on ETC technology, it will be able to effectively promote the construction of the city, enhance the reasonable distribution of the city's existing automobile car park resources, increase the use rate of the turnover of the automobile's car parking spaces, and facilitate the travel of the public with a car. In it can effectively promote the construction of urban traffic, improve the allocation of car parking space for urban traffic, increase the car parking space turnover utilisation rate of enterprises, and facilitate the daily life of people with cars. It is reported that the current 28 pilot cities have reported their initial implementation plan, led by the Ministry of Transport, organised relevant units and industry experts, to discuss and determine the guidance and implementation plan. ETC smart parking is rapidly into the daily life. [3]

4.2. Application of ETC technology in urban congestion charging

The application of electronic non-stop toll collection system (ETC) in urban congestion charging can follow the following steps:

System deployment: firstly, the city needs to deploy the ETC system, including the installation of ETC toll lanes and corresponding induction devices. These devices should be placed on major congested roadways or in the city centre so that all passing vehicles are automatically identified and charged.

The user registers and the equipment installment: The vehicle owner needs to carry on the registration in the related organisation, and installs the ETC vehicle equipment, including the electronic label and the fee deduction card and so on. These equipments should be installed in the vehicle's front windscreen, in order to ensure that the sensor can accurately identify the vehicle information.

Fee setting and deduction rules: cities need to set congestion fees and deduction rules. These rules can be dynamically adjusted according to congestion on different roads and at different times of the day. It also needs to set preferential policies, such as the difference in rates between peak and off-peak hours, to encourage vehicle owners to travel during off-peak hours.

Vehicles passing through ETC lanes: When a vehicle passes through an ETC toll lane, the sensors installed on the lane will automatically recognise the vehicle information and deduct the corresponding congestion charge from the pre-paid toll. This process requires no human intervention and can greatly improve the efficiency of passage.

Monitoring and management: The city needs to monitor the operation of the ETC system in real time, including vehicle passage and toll deduction. At the same time, it also needs to carry out regular maintenance and management of the system to ensure the stable operation of the system and the accuracy of the data.

Through the above steps, the ETC system can be effectively applied in urban congestion charging to improve the efficiency of passage, relieve traffic pressure, and reduce the additional costs incurred due to congestion. At the same time, the system can provide valuable data support for cities to help them better plan their transport and infrastructure development.

Congestion charging is one of the most important means of solving traffic congestion problems in large cities. At present, there are four technical solutions for urban congestion charging, including multi-lane free-flow system based on electronic non-stop toll collection (Electronic Toll Collection, ETC) technology, licence plate recognition system based on image and video collection technology, radio frequency identification (RFID) as the technical basis, and the system can also be used for traffic congestion charging. RFID) based toll collection system, and satellite positioning technology based toll collection system. By comparing the advantages and disadvantages of the various schemes, the results show that the multi-lane free-flow system based on ETC technology is mature and has been used for congestion charging in many countries around the globe, and it is a more suitable congestion charging technological scheme for cities in China. [4]

Congestion charging is one of the demand management measures to solve the traffic congestion, which mainly uses the price adjustment mechanism in economics to regulate and limit the traffic travelling demand. Global research on the theoretical model of congestion charging has been very mature, in Singapore, the United Kingdom and other countries, has implemented the congestion charging on urban roads, and achieved very good results. China's research on congestion charging mainly focuses on the policy, model and pricing of congestion charging, while the research on congestion charging technology mainly focuses on the summary of the existing technology in the world. The congestion charging scheme for mega-city roads is established on the basis of China's motorway ETC network charging system, which can make full use of the existing non-stop charging system (ETC) customer service system and automobile electronic tags (OBU), and can save the project construction cost. At the same time, the related non-stop charging technology, also in China highway can be applied for many years, the technical scheme is feasible. [5]

4.3. Integrated application of ETC technology in urban congestion charging and Intelligent car park management

Singapore is a small island-type country, has the reputation of a garden city, can be carried out on the road construction of land resources are relatively scarce. Based on the core concept of "people-centred and market-oriented", the local government has created a good experience of public transport services, and achieved sustainable and harmonious development of transport, economic and social, and ecological development. In the process of urbanisation, Singapore's car park charging mode has gone through a very long development process. Combined with the ERP system operation, ETC parking to the foreground, the city roads on the application of ERP electronic road pricing technology and car park scene, the integration of the highly intelligent car park entrances and exits to achieve a self-help unguarded non-stop channel, as well as electronic automatic deduction of non-cash transaction system; car park operations centre also introduced a centralized software services and systems management technology, can complete the The remote management and monitoring of the running condition of the car park can be completed by the enterprise, which provides a good quality parking platform to the car owners and customers, and at the same time improves the technical level of the enterprise's management and management, which effectively reduces the operating cost of the enterprise. At the same time, through the intelligent management system of the car park to improve, but also benefit all stages of corporate life. Although the urban traffic environment in China is very different from that

of Singapore, it is of great reference value for the construction of intelligent transport in China, especially the ETC network of motorways which is entering the urban traffic. [6]

5. SUMMARY

With the continuous progress of science and technology and the acceleration of urbanisation, the problems of traffic congestion and parking difficulties are becoming more and more prominent. In order to solve these problems, Electronic Toll Collection (ETC) system is widely used in intelligent car parks and has achieved remarkable results.

Although the theoretical research on congestion charging in China has been relatively mature, due to various factors, no city has yet started to implement congestion charging, and there is a lack of practical experience. No city in China has yet explicitly implemented congestion charging, but some large cities in China have implemented tolls on roads and bridges in urban areas in order to increase the capacity of urban roads and improve the environment for urban development, which is essentially a kind of road toll. China's domestic road tolls are mainly highway tolls and urban road, bridge and tunnel tolls.

In terms of intelligent car parks, the application of ETC technology brings great convenience to vehicle owners, as the ETC system can automatically identify vehicles and complete the toll collection process without the need for vehicle owners to stop and pay the toll. This not only saves vehicle owners' time, but also improves the efficiency of car parks and reduces traffic congestion caused by queuing. In addition, the application of ETC technology also helps car parks to achieve automated management, reducing manual intervention and improving management efficiency.

In the future, ETC technology will also play an important role in congestion charging. Through the ETC charging of roads in congested areas, it can effectively reduce the number of private cars entering the congested areas, thus alleviating the traffic congestion phenomenon. At the same time, by setting reasonable tolls, vehicle owners can also be guided to choose other non-congested routes, further dispersing traffic flow. This will not only help improve the urban traffic situation, but also help promote sustainable urban development.

However, it should be noted that although ETC technology plays an important role in intelligent car parks, there are still certain problems in its application. For example, some vehicle owners are concerned about the security of the ETC system, fearing that their personal information will be leaked or misused. In addition, the construction and maintenance costs of ETC systems are relatively high, and joint efforts by the government and the community are needed to promote their development.

The application of Electronic Toll Collection (ETC) systems in intelligent car parks and congestion charging has significant advantages and effectiveness. However, in order to give full play to its potential and solve the existing problems, it is necessary for the government, enterprises and vehicle owners to make joint efforts to strengthen technical research and development, improve policies and regulations, and enhance public awareness.

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