1. Preface

The rapid expansion of urban areas and fast growth of motor vehicle ownership has increasingly led to parking difficulties, chaotic parking, and arbitrary fee collection in city centers. It is no longer feasible to rely solely on constructing traditional parking spaces to address the public parking issue. Imposing fees on parking vehicles and using different rates to adjust parking space turnover becomes a key component of the solution. Roadside parking management currently has a number of problems, such as arbitrary fee collection, inconvenient payment, poor regulation, and low intelligentization levels.

To turn roadside parking into an intelligent process, ZTE introduced an Internet of Things (IoT)-based intelligent roadside parking system by drawing on its years of experience in data mining and integrating technological advances of related fields.

ZTE’s intelligent roadside parking system boasts extensive service process management features. Parking monitoring, parking guidance, and management of defaulting vehicles allow customers to get real-time updates on the roadside parking situation in the city. Flexible charging standards management, numerous report analysis and statistical tools, and powerful data exchange capabilities make parking management more elastic. Convenient third-party payment drastically broadens payment options.

2. IoT-Based Intelligent Roadside Parking Solution

![Figure 1 ZTE's IoT Technology-Based Intelligent Roadside Parking Solution](image.png)
The system consists of four parts: the sensing layer, network layer, platform layer, and application layer.

The sensing layer includes IoT Detection Units (IDUs), IoT Access Gateways (IAGs), PDAs, and smartphones.

IDU: It is installed in each parking space to detect whether a vehicle has parked at or departed from the space. The IDU also uploads parking space occupation information to the IAG.

IAG: It collects parking space occupation information and transfers it to the operation & management platform.

PDA: It is used by on-site fee collection and regulation personnel as an inspection terminal. Its functions include collecting fees manually and taking photos as defaulting evidence.

Smartphone: The user starts the app or enters the WeChat official account, enters the parking space number and expected parking duration, and performs prepayment.

The network layer comprises various types of networks including communications networks and the Internet. The communications network enables two-way information exchanges between the IAGs, PDAs and smartphones on one end and the operation & management platform on the other. The Internet provides interfaces between the operation & management platform at one side and the communications network gateways and external systems at the other side. The IoT implements two-way information exchanges between the IDUs and IAGs.

The platform layer employs various cloud solutions such as cloud computing and cloud storage to establish a cloud-based operation support platform.

The IoT operation & management platform in the application layer consists of the parking system and the operation & management system. The operation & management platform performs three functions. The first function is to support processes of the intelligent roadside parking system, such as parking and fee collection. The second function is to use its statistical and analysis tools to help the operation & management departments get a full picture of the roadside parking situation and plan parking spaces. The third function is to conduct network management. For example, through the operation & management platform, related personnel can configure devices, obtain real-time device information such as the battery status and operating status of the IDU, manage patrol personnel, check the actually collected fees against the billing information in the system, query parking space status in real time, and produce statistics and make analysis of the turnover and utilization of parking spaces.

External systems are the systems that the intelligent roadside parking system can provide support to or obtain help from. The roadside parking system mainly has the following
interfaces for external systems: The interface with the traffic police system helps perform functions such as generating and processing tickets. The interface with the vehicle administration system helps perform functions such as annual inspection of users with records of parking violations. The interface with payment systems (such as China UnionPay, WeChat and Alipay) helps perform transaction clearing. The interface with the credit investigation system helps record intentional violations.

3. Solution Highlights

- Industry-leading technologies
  
  (a) The parking system features an architecture design that facilitates capacity expansion and interconnection with third-parties.
  
  (b) The IDU obtains parking space occupation information with a detection accuracy rate of at least 98 percent.
  
  (c) Data is transmitted through the IoT, thus easily achieving stable system access and reliable data transmission. Compared with the existing wireless technologies such as RF and ZigBee, transmission through the IoT boasts lower power consumption, a wider coverage area and a larger capacity.

- Easy use:
  
  (a) The parking system supports flexible parking guidance, including through Level-3 parking guidance displays and a smartphone app. The user can conveniently obtain parking space information and park the vehicle. With the parking system, the time needed by the user to find a parking space can be cut by around 43 percent.
  
  (b) The parking system supports diverse modes of fee collection. Parking fees can be paid by the user through the smartphone app, automatically deducted through an RFID tag, or manually collected by a collector. Consequently, user experience is improved and the workload of collection and patrol personnel is greatly reduced.

- Simple operation & maintenance:
  
  (a) The parking system uses an all-wireless architecture that supports remote maintenance, remote upgrading and easy management. Device installation is simple. A technician only needs around two hours of training to independently
carry out installation assignments. Installing 100 IDUs takes only two person days on average.

(b) The IDU has a small size that does not damage the pavement. It also features strong anti-interference capability, a dismountable structure, and a general-purpose, easy-to-purchase battery that lasts five years. When the battery level becomes lower than the preset threshold, the operation & management platform produces an alarm. The maintenance personnel then use a special tool to easily take out the inner container of the IDU and replace the battery. Replacing 100 batteries only takes an average of 0.5 person day.

- Efficient management: Using its industry-leading data mining technology, ZTE is able to integrate huge amounts of parking data to maximize the efficiency of the system.

(a) Based on the comprehensive parking information offered by the system, management departments can adopt measures including economic leverage to plan and manage parking resources in a unified manner and to coordinate the balance between roadside parking and dynamic traffic.

(b) Parking managers can use statistics generated by the system to find loopholes in parking management, thus boosting management efficiency and lowering operating costs.

4. Product Value

- Considerable economic benefits:

  Intelligent roadside parking brings substantial economic returns for the operation & management departments.

- Reduced labor costs:

  Diverse modes of fee collection reduce the human and material resources needed for parking management.

- Increased parking space utilization:

  Paring guidance allows management departments to make parking arrangements that improve parking space utilization and turnover and reduce the time taken by drivers to find parking spaces.
Improved traffic situation:

Imposing parking fees can drive many "zombie" and illegally parked vehicles out of the roadside. In areas where fees are required for roadside parking, average vehicle speeds increase significantly and the traffic situation improves noticeably. Statistics show that with parking fee collection, vehicle speeds increase by an average of 11.4 percent in all areas and by 8.8 to 14 percent in residential and business areas.

5. Successful Case

Intelligent roadside parking pilot in Nanjing, China

Parking is an important part of an urban transportation system. Parking difficulties are negatively affecting the urban and social development of Nanjing as well as the daily life of the city dwellers. Solving this problem is a priority of the municipal government.

Previously all the parking fee collection in the city center of Nanjing was manually managed, which resulted in issues including arbitrary fee collection, inconvenient payment, and poor regulation. By building and trialing the intelligent roadside parking system, Nanjing transformed its roadside parking fee collection model. The new model integrates collection, management, monitoring and service, making parking fee collection management more transparent and user-friendly.