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On Research IoT-based Intelligent Parking Management System and Its Design

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Abstract

With the rapid economic development and constant social advancement in our country, people's production and lifestyle are undergoing profound changes, consequently resulting in traffic jams and increasingly severe challenges on the limited parking resources. How to enhance the utilization of parking places has been an important problem influencing city image and the harmonious economic and social development. This paper introduces a Internet of Things (IoT)-based intelligent parking management system, innovatively proposes a non-source RFID card that utilizes label and sensor binding to actualize vehicle identification and to accomplish functions of vehicle entrance & exit authentication, automatic charging, and parking lot certification, eventually further enhancing the utilization, traffic efficiency and service level of parking places.

Keywords*: Internet of Things, RFID, non-source, sensor, intelligent parking*

1. Introduction

With rapid enhancement of urbanization level, people's production ways, Work condition, lifestyle and living standard are undergoing profound changes. Severe traffic jam is one of the major reasons for such changes. Construction and management of parking places is reinforced in a standardized and scientific manner. Intelligent management of parking places is the inevitable development direction since it can not only resolve the problems of undesirable city appearance and traffic jams, but also be a necessary condition for normal operation of intelligent buildings and residences. [1-3]Traditional parking place management usually features low efficiency and poor safety. Difficulties in parking have been a common problem in major cities all over the world. [4] Presently the problems faced by parking place management mainly include:

(1) Manually attended, severe delay and low traffic efficiency;
(2) Fixed parking spaces to be manually locked for enclosure;
(3) Unlocked fixed parking spaces occupied by other vehicles freely;
(4) Not familiar with the parking places, vehicle owners can not find their cars quickly;
(5) Every time there is a vehicle entering the main channel by mistake, the system fails and needs restart, making the management process chaotic.
(6) Gate opening lacks emergency-responding system. When a motorcade going through, the whole system needs to be powered off and then on after pass.
(7) RFID vehicle management system is no connected with the video system or the alarms.
(8) Other potential haphazards in management...

To avoid the defects in the present management mode, RFID and senor technology were applied to parking place management in order to effectively managing the parking

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resources, enhance the management level, and actualize automatic management featuring smooth traffic, simple procedures, fast speed and less manual work.

2. Internet of Things, RFID and Sensor

2.1. Internet of Things

Internet of things was formally proposed on World Summit on Information Society WSIS held in as early as in 2005. [5] Internet of Things is the Internet connecting things together, which can be understood as a network adding a variety of information sensor devices to the traditional Internet to actualize intelligent identification, positioning, tracking, monitoring and management of objects according to agreed protocols. It is an important component to the new-generation information technology. [6]

The present communication network mainly addresses the communication among people. Internet is for the man-man communication, while the future Internet of things focuses on the man-man, man-machine, man-object, and object-object communication and dialog. [7] Information technology development contributes to great improvement in man-man communication, information storage and processing, and reconstructs the methods and forms of human relation generation. Internet of Things actualized the integration of human society and physical system, and real-time read and control of man, machines, devices and infrastructures in the integrated network, sense information gathering to cloud computation-based data storage, process and integration platform, accordingly supports to better development of traffic intelligent management and control. Application innovation is the core of Internet of things, while innovation 2.0 centered by user experience is the soul of Internet of things. As the next new strategic industry with trillions RMB scale, Internet of things is entering a new stage of in-depth application and becoming the pilot area for constructing new social and economic development modes and building long-term national competitiveness. [8]

2.2. RFID

Radio Frequency Identification (abbr. as RFID), also known as electronic label, is a communication technology that can identify certain targets and read and write relevant data without establishing mechanical or optical contact with certain objects through identification system, also a non-contact auto-identification technology with the greatest potential and fastest developing speed that is widely applied to Internet of things. A set of typical RFID system consists of three parts: the reader, TAG and band-end software system. [9]

RFID can be divided into powered, non-powered and half-powered ones. Powered RFID labels are equipped with their own battery, accordingly featuring long Read and Write distance, large size and high price, manly applied to Smart Hospital, smart parking place, smart traffic etc, the main operating frequency including low-frequency 125 KHZ, high-frequency 13.56 MHZ, UHF 433 MHZ, UHF 915 MHZ; non-powered RFID labels are no equipped with batteries and acquire power from the reader emittor, featuring small size, low price and long life cycle, reading distance 10mm to 5 m, widely applied to public vehicle cards, diner cars and bank cards, work frequencies including low frequency 125 KHZ, high frequency 13.56 MHZ, UHF 433 MHZ, UHF 915 MHZ, a kind of close--distance identification; half powered RFID draws the advantages of the two forms, and displays the advantages of the microwave 2.45 G triggered by the low frequency 125KHZ.

2.3. Sensor

Transducer Sensor is a testing device that can sense the tested information and transform the the sensed information into electronic information or other necessary forms

so as to meet the requirements of information transformation, processing, storage, display, record and control *etc.*

Presently there are accelerometer, proximity sensor, temperature sensors, air-sensitive and wet-sensitive sensor, pressure-sensitive sensor, accelerometer, gyro, acceleration sensors, location and displacement sensors, and so on. Each sensor is an information source, and information acquired by different sensors varies in content and forms. Data acquired by sensors are real-time-based and are updated at a certain frequency.

Sensors feature at miniaturization, digitalization, intelligence, multi-function, Systematicness, Networked, and so on it has not only urged the traditional industry reform, but also contributes possible construction of new industry and thereby become the new economic growth points in 21st century.

3. Requirements, and Design Concepts

3.1. Requirements

RFID tags and sensors are regarded as the two most important interface terminals of IoT, it has been used in the traffic management [10-11].

When a vehicle entering a packing place, it goes through the admission induction coil, then induction signal generated, electronic tag information of the vehicle read by remote readers and transported to the server database and vehicle information displayed by the system software, the system will then identify the legitimacy and attribute of the access card. For authorized or registered vehicle, open the gate and give access, once authorized, he lock will be unlocked automatically. For non0authorized vehicle, the system will alarm and the securer can handle the vehicle manually for registration.

3.2. Design Concept

In system operation, electronic tag is installed inside the vehicle's front windshield, about 5-15 m from the remote reader. In order to prevent the vehicle plate being used by others legally, the tag features an anti-removing function: once installed, the tag can not be removed without legal authorization, or it will be invalid. Therefore, a new non-powered RFID card was used in the system design. The card is designed with a chip and antenna for data transmission and reception, air-proof and water-proof.

Relative to the present traditional parking system, the design though of the system presented in this paper is:

(1) Upgrade the existing Taoji non-vehicle electronic tag to Taoji vehicle tag, allow securer to identify the vehicle card by eye from the front of vehicles.

(2) Sense the card remotely, require no stop of vehicle or issuing cars, simplify the vehicle access procedures, safe and reliable.

(3) Forbid unauthorized vehicles from access to the parking places, control exclusive parking lots to prevent other vehicles from occupying the lots.

(4) After the vehicle packed, the parking lot information will be sent to the vehicle owners' mobile phone, allowing owners to find their vehicles quickly and enhance customer service quality.

(5) Reduce the parking place management staff to control the operation cost.

(6) Enhance the device performance, upgrade he reader and antenna products, optimize the antenna deployment position, through separation between readers and antenna and "double control" access control methods, offer technical guarantee and enhance identification rate.

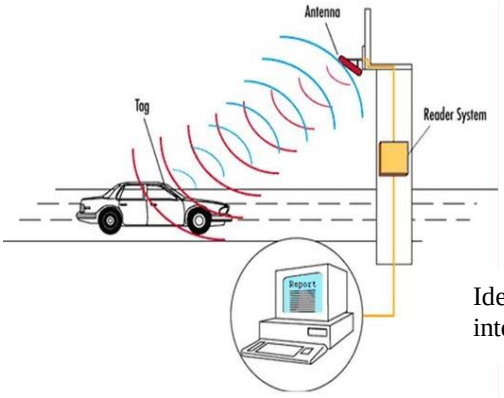
(7) optimize the coil deployment quantity and position, improve the vehicle passing process.

(8) Update he vehicle management software system, enhance software early warning hint, support two-stage life cycle vehicle management, support C/S mode of front/rear-

end management, support front-end stand-alone off-grid run, support gate manual intervention quick management, designed with temporary parking management module, equipped with driver management and authorization module, and interface mode with video system, as well as management module for exit system intervention.

4. System Design

4.1. System Structure



Identity intelligent decision, intelligent release

Figure 1. Basic Model of Parking Ramp Application

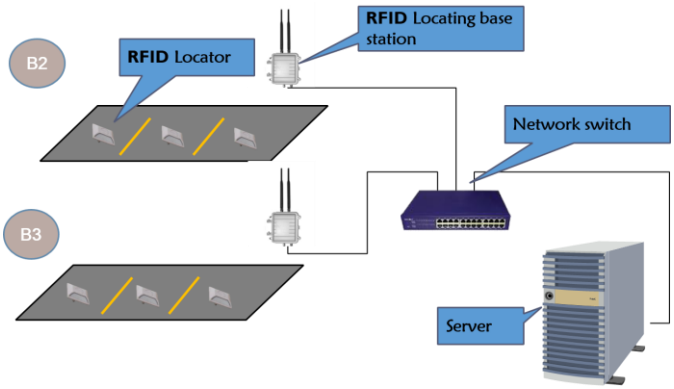


Figure 2. Basic Model of Parking Lot Application

To achieve instant automated management of parking places, each parking lot was installed with RFID locator, and equipped with corresponding RFID locating base station, all of which are networked with the server through network.

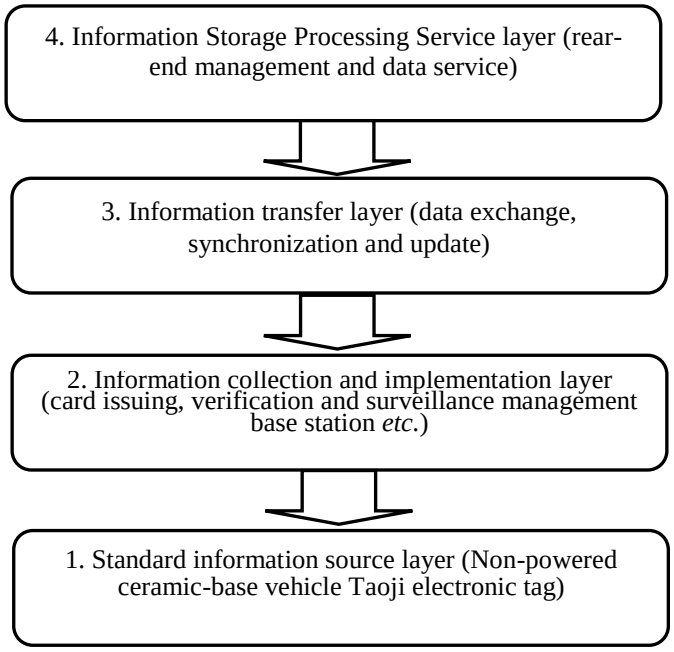


Figure 3. System Structure Diagram

The system consists of four layers: standard information layer, information collection and execution later, information transfer layer, information storage and processing layer.

4.2. Function Design

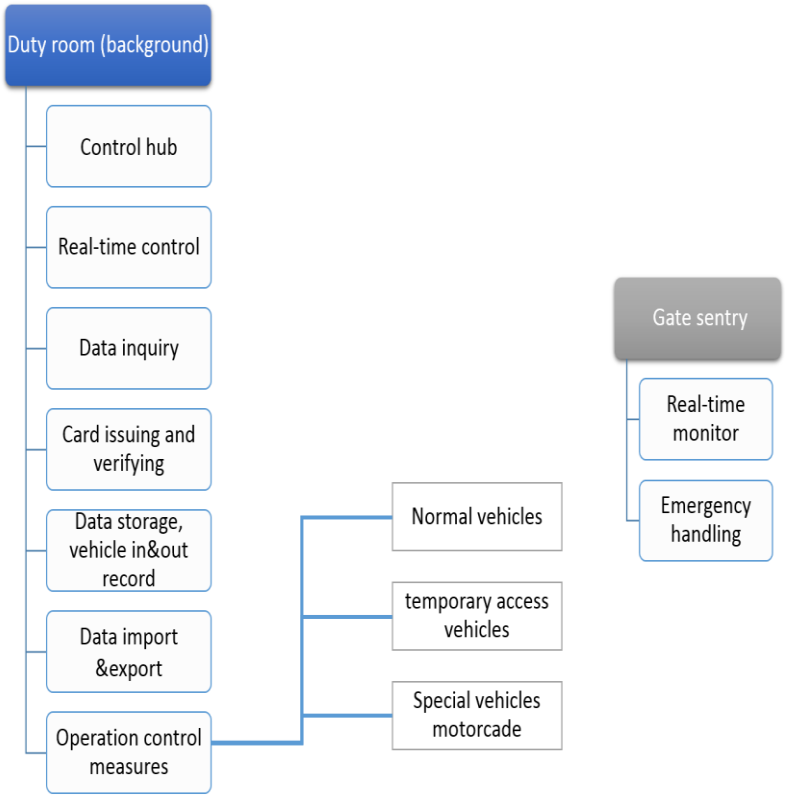


Figure 4. System Function Design Diagram

4.3. Key Subsystem

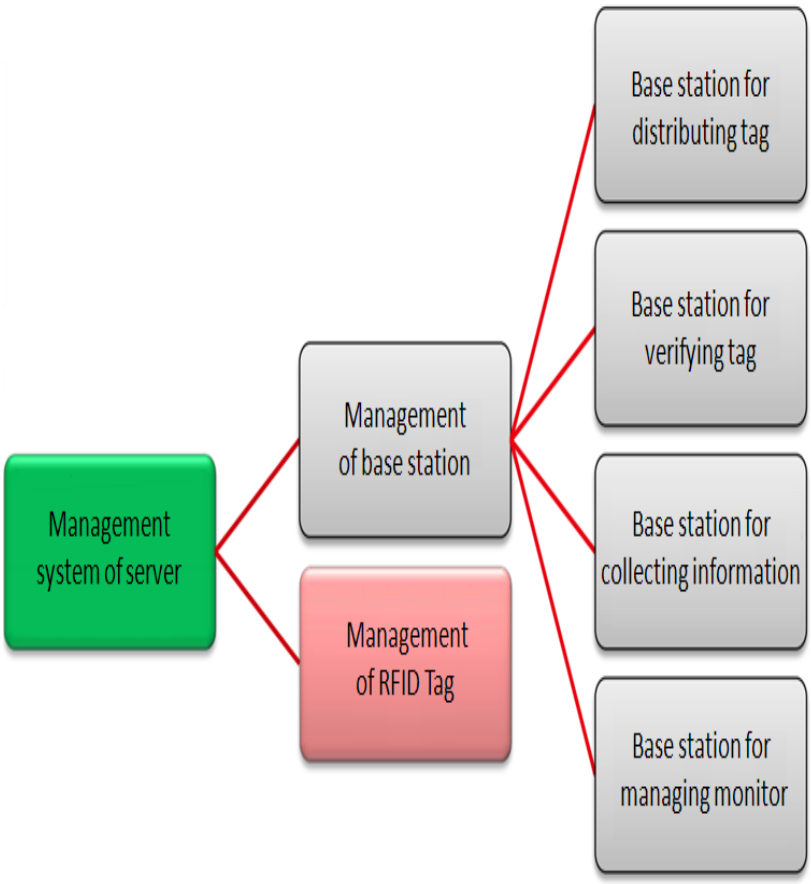


Figure 5. Key Sub-System Structure

The system consists of three key sub-systems: (1) Vehicle card and card management systems, (2) front-end base station system (including card issuing, installing and verifying base station, information collection base station, surveillance management base station): (3) rear-end management system; of these, the cards and card management system, the front-end base station system and card issuing, installing and verifying base station are for vehicle card issuing and management service; front-end base station system information collection base station, surveillance management base station are for management service offering toe vehicles entering RFID management and control lane; rear-end management system provides data summary, analysis, inquiry and statistical services.

4.4. Workflow

System management process is as follows:

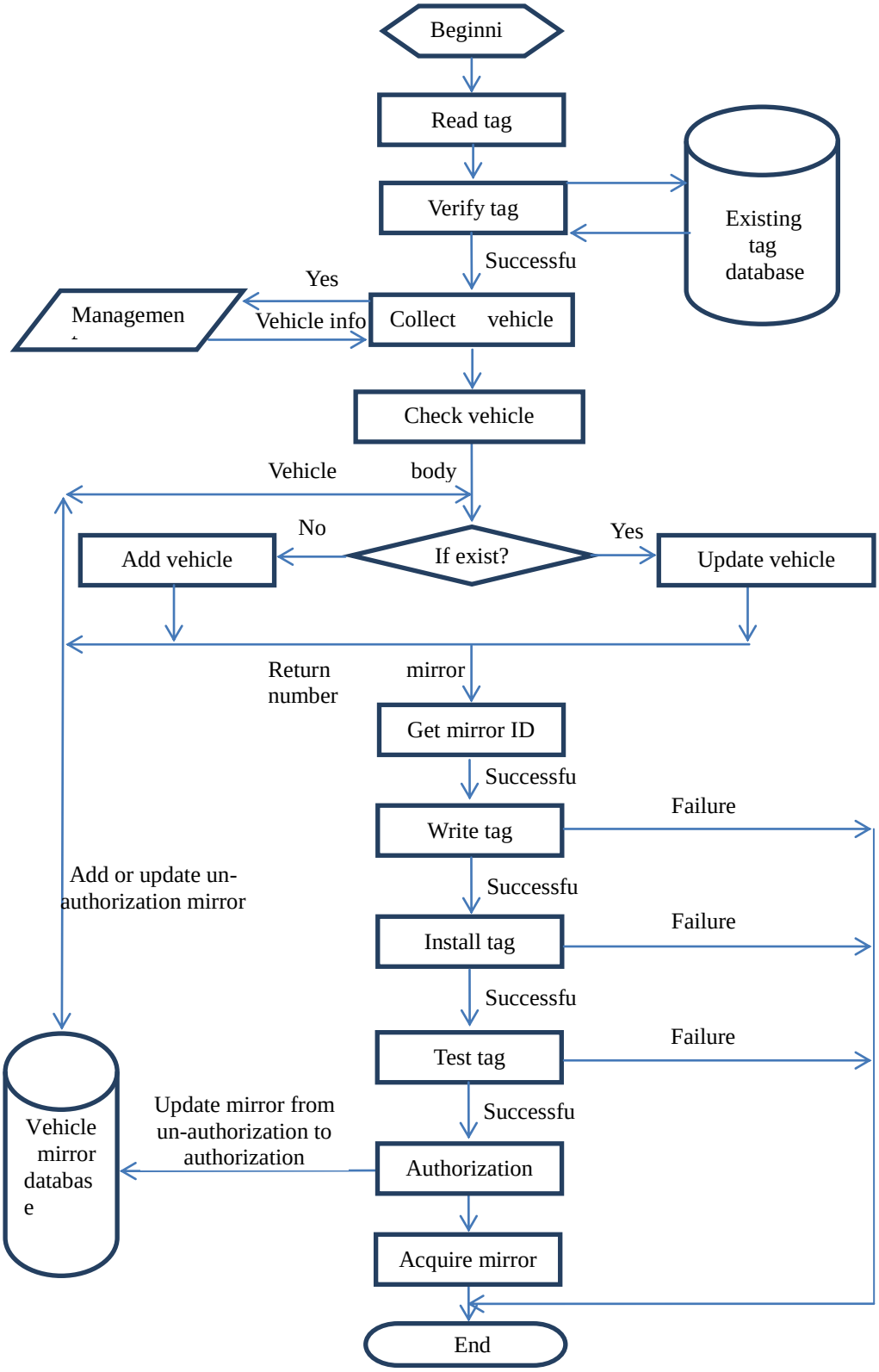


Figure 6. Generating Process of Vehicle Mirror

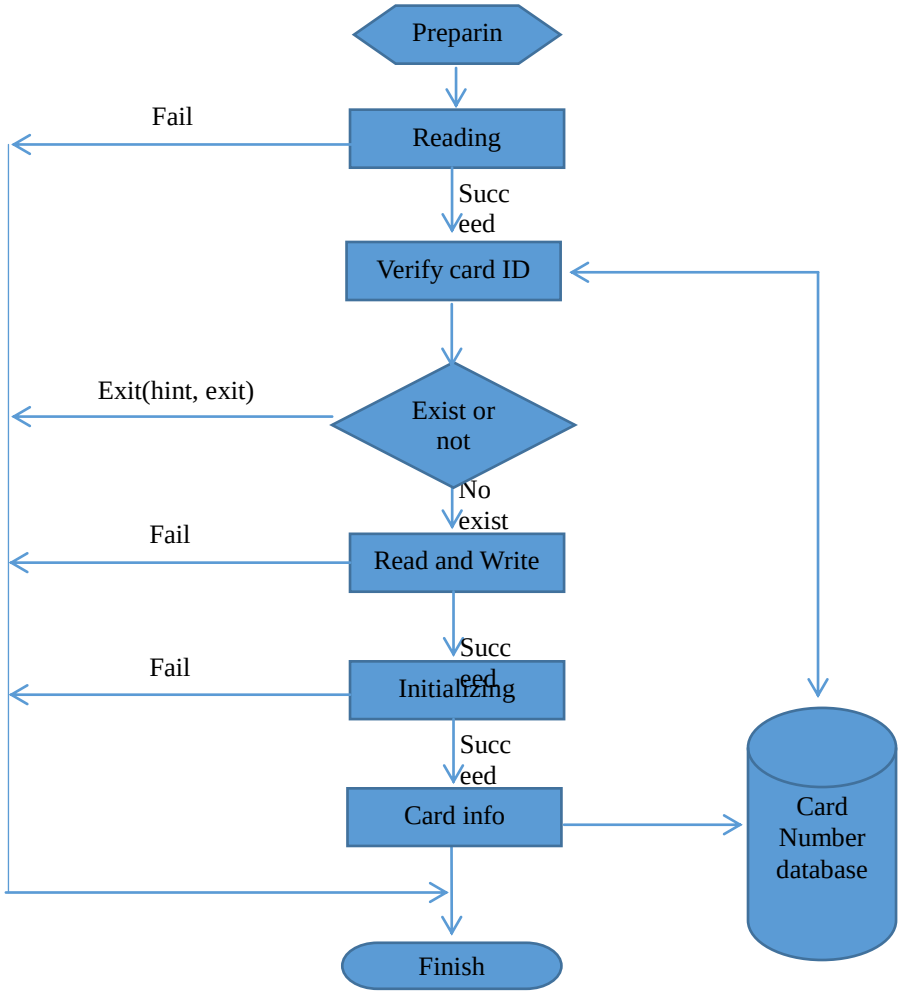


Figure 7. Card Writing Flow

4.5. Sub-Module Design

4.5.1. Vehicle Card: Vehicle card refers to the non-powered Taoji vehicle electronic tag installed onto the managed vehicles that is matched with he managed vehicles when it was input with the managed vehicle information and management fundamental information.

*Non-powered, Ceramic base;

* Unique ID;

* Unique corresponding (anti-removing design);

* Automotive Specific design (media matching, multi-path effect, cavity effect);

* Importance of installing and verifying cards

4.5.2. Card Management Sub-system: The card management system of the System is a key sub-system and an important foundation of the major system, offers "vehicle identity mirror data service" to all other sub-systems to support the normal operation and demonstrate its function in the system.

This part is mainly responsible for establishment of the mirror of vehicle/drive, and its core content is the card management system. Though speaking from the system position, this part belongs to operation center, the mirror of vehicle/drive is the core of "traffic Internet of things", featuring particularity and complexity, and the three elements of "identity. time & space and event" are changing with time at any time. Getting clear with the the identity information of the mirror is the most essential and fundamental.

Card (tag) is he carrier and media of vehicle/drive mirror, yet there is one thing to be cleared: in the system the final objects managed is mirror, but o card, or vehicles.

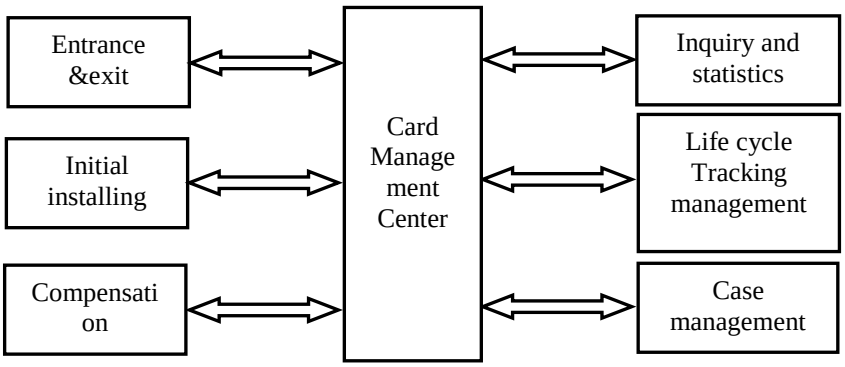


Figure 8. Schematic of Card Management System

4.5.3. Card Installing and Verifying Base Station: After the card installed and verified, as the only device establishing the corresponding relation between vehicle and card, it can be then used. It is designed with pass code device for base station operation and functions of "auto record of work process".

Card installing and verifying device is equipped with picture capturing and storage devices and can collect information of objects at the same step with RFID. The information collected can then be transported to "card management" on a real time base, while the "electronic mirror" of the identified objects can be generated in the rear-end database. Mirror information is the effective infor of the vehicle card at "system life cycle" and the symbol that the card is put into use.

Besides, card reading and writing by the card installing and verifying base station is he most strict limit index among all base station technical index in order to ensure the qualified vehicle cards can operate smoothly in all bas stations, meeting the needs of "smooth use for all station after qualified".

4.5.4. Design of Ramp System Operation Control Measures: Ramp system operation control measures refer to a series of management approaches ensuring normal operation of the whole system. To reach this goal, the access road to the community can be deified into temporary parking place, temporary card lane and RFID lane. In the process of using, the following situations may occur frequently, and the corresponding measures are proposed as follows;

4.5.5. Control Measures for Vehicles with Cards: When vehicles with cards enter RFID lanes for entrance, the driving speed should be limited with 20km/h to make sure releasing one vehicle by lifting the gate once. In other words, when vehicles go through the bumpers and enter the microwave area (indicated by the read dashed line), other vehicles should wait in front of the bumpers and then enter after the front vehicle passes the gate.

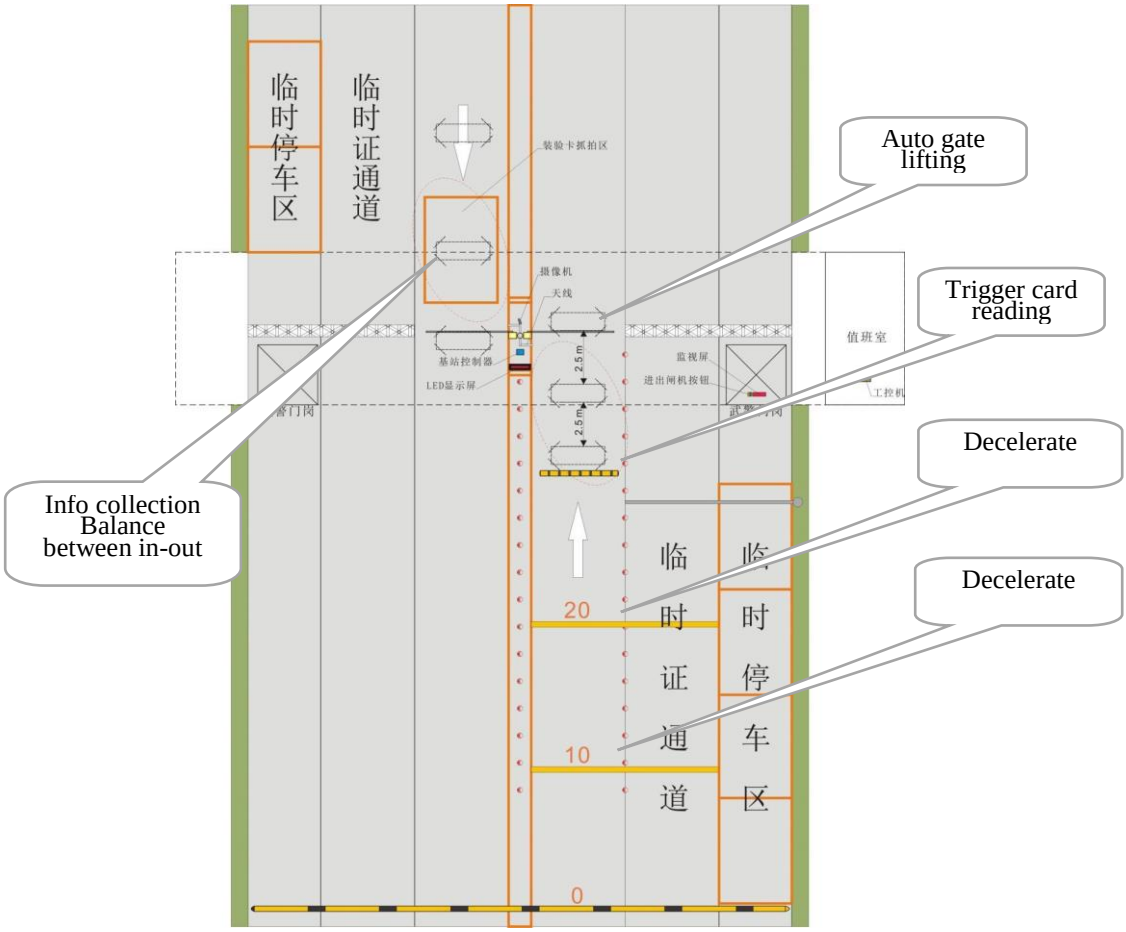


Figure 9. Schematic of Vehicle In and Out

4.5.6. Control Measures for Vehicles Without Cards: Vehicles without cards can be divided into two types: vehicles for temporary access and those entering by mistake, the corresponding control measures are:

(1) Control measures for vehicles for temporary access

There are two control plans regarding this:

Plan 1: Vehicles for temporary access can be parked as temporary parking places, and drivers come to the duty room to get a temporary card, and then drive the vehicle to the temporary lane, then enter RFID lane. After the securer checks the card, the vehicle can be released. Vehicles without cards are prohibited from entering or can get a temporary card by entering the temporary parking places.

Plan 2: After the temporary card issued, the vehicle may have access directly and enter from the temporary lane. That is, Vehicles for temporary access can be parked as temporary parking places, and drivers come to the duty room to get a temporary card, and then drive the vehicle to the temporary lane. After the securer checks the card, the vehicle can be released. Vehicles without cards are prohibited from entering or can get a temporary card by entering the temporary parking places. Vehicles without cards are prohibited from entering or can get a temporary card by entering the temporary parking places.

(2) Control measures for vehicles entering by mistake

When vehicles enter RFID lane by mistake, the staff need to guide the vehicle exit the lane and urge it to leave.

4.5.7. Wireless Parking Lot Sensor: When a vehicle packed at a lot, the locator activator will acquire the tag information that will be sent to READER and stored in the server, at the same time the parking info (time, location and fees) will be sent to the vehicle owner. Since the locator activator is matched with each parking lot, we can know where the parking lot is accurately.

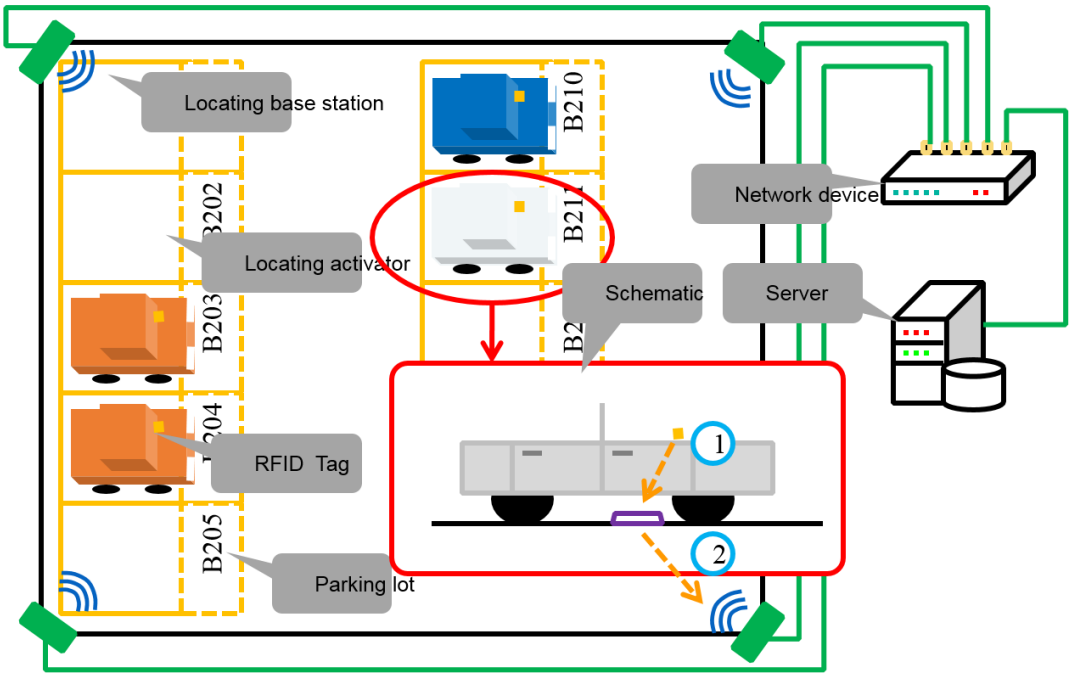


Figure 10. Wireless Parking Lot Sensor

4.5.8. Wireless Parking Lot Ground Lock: Each parking lot is installed with a wireless parking lot ground lock and once the vehicle recognizer received the vehicle information, it will judge if it is the owner of the lot. Once ID verified, the verification information will be sent to the lock. After information received, the parking lot lock will decelerate the pole to allow the vehicle to park here. When the vehicle is leaving, the ground vehicle sensor will sense it and deliver releasing information to the intelligent vehicle parking management system. The system will automatically mark it as available and lift the parking lock.

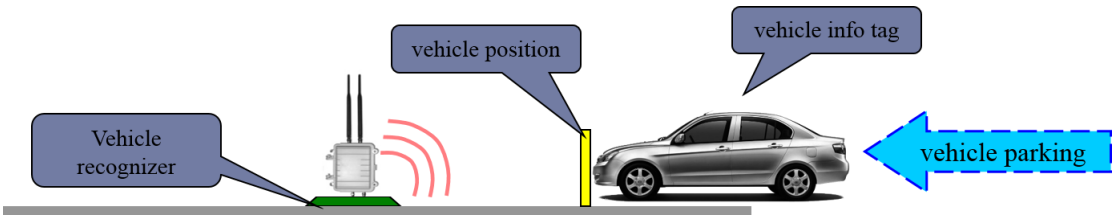


Figure 11. Schematic of Wireless Parking Lot Ground Lock

4.5.9. Background Management Software Design (Control Room): Background Management Center is the database built by SQL Sever, mainly used for management of card management database and data operation in all base stations. It is the core of the system functioning storage, inquiry and statistics of data as well as data consolidation and distribution. Background Management Center Server IS hosted in the control room.

Background Management Center will complete the following functions.

(1) Card issuance management;

(2) Base station vehicle in&out record management
(3) Date import & export management

4.5.10. Reserved System Function Design: Taking into account the post system improvement and expansion, the reserved system functions are as follows:

(1) Video capturing and interface are reserved at the exist monitoring management base station.

(2) Vehicle testing and LED screen display modules and interface are reserved at the Entrance information collection base station.

(3) temporary vehicle (temporary card) Management Module is reserved for the system.

(4) Driver and other authorization management modules are reserved

(5) Other RFID lane and its base station data interface are reserved.

5. Conclusion

This paper introduces a Internet of Things (IoT)-based intelligent parking management system which make full use of new generation information technology such as Internet of things and cloud computation to actualize modern, intelligent, high-efficient management of internal and external vehicle entrance & exit with advantages of convenience, speediness, accurate charging, confidentiality, sensitivity, long life cycle, flexibility and multiple functions *etc*. From a micro perspective, it will contribute to significant enhancement of service level by resolving the problems of vehicle in & out without parking, chaotic parking, and difficulties in finding the vehicle. From a macro perspective, it can achieve intelligent management of vehicles, effective use of urban parking resources and improvement of urban parking efficiency, lay a solid foundation for the construction and development of smart city in the future.

Acknowledgments

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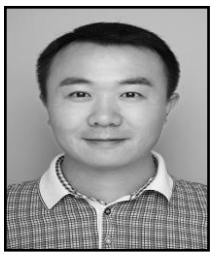

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