FACTA UNIVERSITATIS
Series: **Mechanical Engineering** Vol. 7, N° 1, 2009, pp. 101 - 118

UTILIZING RFID FOR SMART PARKING APPLICATIONS

UDC 65.011.56

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Abstract. *In this study, a solution has been provided for the problems encountered in parking-lot management systems via RFID technology. RFID readers, RFID labels, computers, barriers and software are used as for the main components of the RFID technology. The software has been handled for the management, controlling, transaction reporting and operation tasks for parking lots located on various parts of the city. Check-ins and check-outs of the parking-lots will be under control with RFID readers, labels and barriers. It will be possible to see unmanned, secure, automated parking-lots functioning with RFID technology in the future. Check-ins and check-outs will be handled in a fast manner without having to stop the cars so that traffic jam problem will be avoided during these processes. Drivers will not have to stop at the circulation points and parking tickets will be out of usage during check-ins and check-outs. Vehicle owners will not have to make any payments at each check-out thus a faster traffic flow will be possible. Since there will not be any waiting during check-ins and check-outs the formation of emission gas as a result of such waiting will be avoided.*

Key Words: *RFID, Automation, Parking-Lot, Parking-lot Management*

1. INTRODUCTION

Radio Frequency Identification (RFID is a technology that helps to identify the animate or the inanimate through radio waves (Chen 2005). RFID is one of the most fundamental technologies enabling wireless data transmission (Dowla 2004). However, RFID is not a single, simple technology. It consists of tags, readers, computer networks, and systems including middleware, databases, and so forth.

There has been a considerable amount of reduction in transaction costs and decrease in stock shortage with the use of RFID technology in automation. Most of the RFID networks include a wide range of automation technologies. These technologies are RFID readers, RFID writers, RFID barcode scanners, RFID smart sensors and RFID controllers.

Received April 18, 2009

The use of RFID technology is expanding rapidly in numerous applications such as logistics, supply chain management, transportation, healthcare and aviation. Due to the variety of the current applications, typical RFID systems use application specific hardware and proprietary protocols (Tung and Jones 2008).

The integration of business systems with factory floor automation is a challenge with many aspects to consider. However, one bright spot is clearly visible: RFID information technology, which helps bridge the gap.

RFID is enabling companies to see further into the supply chain than ever before, providing more accurate real-time information and improvements in process efficiency.

1.1 The history of RFID

RFID is called a new technology, but it is actually older than barcodes. The first use of RFID technology goes back to World War II for airplane identification. In 1994, all rail cars in the United States used RFID for identification. Although it has been known for a long time, it has not been widely used in industry (Landt 2005). Because it was expensive and there was no standardization among the manufacturing companies, it took it a long time to be widely utilized.

1.2 Benefits of using RFID

RFID allows the wireless storage and automatic retrieval of data. It provides a significant improvement over not only conventional identification, tracking, and stocking of objects, but over the barcode system as well. RFID is expected to help boost supply chain efficiency, improve security, cut down on theft and counterfeiting, increase asset visibility, enhance inventory control, automate stock replenishment, etc (Landt 2005).

By the use of RFID technology, manually achieved workloads will be decreased considerably (Penttila et al. 2006). RFID technology is universal, useful and efficient (Zhang et al. 2005). RFID technology increases company efficiency and provides advantages on both company and client-wise (Higgins and Cairney 2006). RFID technology is much more secure (if cryptographic modules are involved) compared to other networks (Xiao et al. 2006). RFID labels play an important role as an inventory tracking technology (Goodrum et al. 2006).

RFID is becoming an important identification technology in applications such as inventory management, security access, personnel identification, factory automation, automotive toll debiting, and vehicle identification to name just a few (Ostojic et al. 2007).

1.3 Components of RFID technology

RFID technology is roughly composed of RFID tag and RFID tag reader. An RFID tag is composed of chip, power source and antenna. RFID reader/writer and application software can be added to them. The IC chip in the tag is used for data storage and logical operations, whereas the coiled antenna is used for communication between readers (Philips Semiconductor Technology). The tag is divided into active tag and passive tag according to the supply of electronic power. RFID reader or transceiver is a device that sends RF signal to the tag and receives the information from the tag, and then sends this information to the back office application. The reader may read data from the tag and write data to the tag. In general, reader is composed of a RF module, a control unit and a coupling element

to interrogate electronic tag via RF communication. The RFID reader device can communicate with multiple RFID tags simultaneously via radio frequency waves (Liu et all 2008).

1.4 RFID tag types

RFID tags can be divided into two, depending on their power source: Active tags, passive tags. Although they both fall under the "RFID" moniker and are often discussed interchangeably, Active RFID and Passive RFID are fundamentally different technologies. While both use radio frequency energy to communicate between a tag and a reader, the method of powering the tags is different. Active RFID uses an internal power source (Mccarth and Curran 2007) within the tag to continuously power the tag and its RF communication circuitry, whereas Passive RFID relies on RF energy transferred from the reader to the tag to power the tag (Want 2005). While this distinction may seem minor on the surface, its impact on the functionality of the system is significant. Passive RFID either reflects energy from the reader or absorbs and temporarily stores a very small amount of energy from the reader's signal to generate its own quick response. In either case, Passive RFID operation requires very strong signals from the reader, and the signal strength returned from the tag is constrained to very low levels by the limited energy. On the other hand, Active RFID allows very low-level signals to be received by the tag (because the reader does not need to power the tag), and the tag can generate high-level signals back to the reader, driven from its internal power source. Additionally, the Active RFID tag is continuously powered, whether in the reader field or not. These differences impact communication range, multi-tag collection capability, ability to add sensors and data logging, and many other functional parameters.

1.5 How does RFID system work?

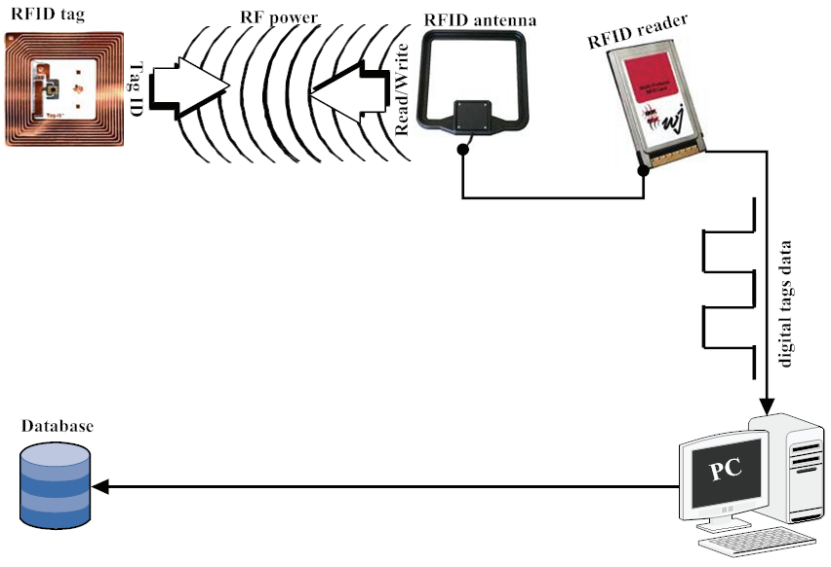

Fig. 1 RFID work scheme

RFID reader, one of the core components of RFID technology, sends signal around. Active tag senda its own identification signal around, whereas passive tag, getting the signal, uses it as power source and modulates incoming signal, after which resends it back to reader. Reader, after getting the modulated signal, demodulates it and transfers the data it extracts to the application program (Fig. 1). After this step, it is application program's responsibility to process tag data (Yan et all 2008).

1.6 RFID applications in the market

The market for RFID technology is growing rapidly, with significant opportunities to add value (Miles 2008).

There are many applications which depend on RFID technology in the market, especially in retail and health sector. One of these applications is developed in Taiwan to be used for patient registration and management in hospitals (Wang et all 2006). In this application, an RFID band, which is a bracelet like stripe, is given to the user to be used during the hospital processes.

In this stripe, according to the application infrastructure, there exists only RFID unique identifier, or sometimes owner's personal information. Retail applications of RFID are mainly used in shopping center automation. Radio frequency is a technology that supermarkets are already using in a number of places throughout the store. There are supermarkets where consumers walk into a store, select products whose packages are embedded with small radio frequency UPC codes, and exit the store without ever going through a checkout line or signing on the dotted line. By using RFID tags instead of those paper based or barcode labels, not only user satisfaction in fast total price calculation of objects bought without having each piece in shop-car read by infrared sensor reader or barcode reader, also reconciliation and dayclosing operations become easier. Besides, this infrastructure is also used for user tendency in shopping and had an effect on decreasing the thieveness (Chandramouli et all 2005). RFID based document management systems are another aspect of applications that depend on this technology. In those applications, a tag is glued on a document after matching and keeping the record of what document has what tag in an electronic format. In another way, tag is glued on the document after each tag encoded with the related data on paper based document. Whenever necessary, either reading the unique identity, or directly reading the related data, searched document can be found easily. Nowadays, this technology is also being used for separation of original and non-original products in markets. Each product, after being produced or just before sent to the market, is attached an RFID tag (Weinstein 2005). By using information in this tag, product properties or originality can be searched quickly (Bal 2007).

RFID has become very popular in many areas such as purchasing and distribution logistics, automation, manufacturing companies and even the wine industry where it is used as an anti-fraud system (Curty et all 2007).

1.7 RFID applications in the industry

RFID is used for hundreds, if not thousands, of applications such as preventing theft of automobiles and merchandise; collecting tolls without stopping; managing traffic; gaining entrance to buildings; automating parking; controlling access of vehicles to gated communities, corporate campuses and airports; dispensing goods; even providing ski lift access (Landt 2005).

Different uses of the RFID technology were reported recent years in the manufacturing industry (Budak et all 2007).

RFID technology can be applied in many different areas in the transportation domain––for example, electronic toll collection, electronic vehicle registration, automatic vehicle identification, fleet management, traffic management, and vehicle positioning. The technology can also be used in car parking, access control, and electronic fare collection (Banks et all 2007).

IBM has transformed chip production at it's Fishkill plant with semiconductor manufacturing system that leverages real-time information to automatically control the fabrication process, enabling employees to work more productively and be more responsive to customers' product status inquiries (IBM Fishkill semiconductor plant).

IBM has accomplished this using IBM Siview standard, a manufacturing execution system that the company integrated with its own wireless e-business technology. Siview standard leverages information from IBM DB2 Universal Database to automatically control each step of the fabrication process that need to be applied to every wafer containing chips, and supports data analysis tools that provide production-related statistics.

In the manual coding system, the identification sheets were manually updated at every stage in the production line. In the RFID-based system, however, updates are automatically written on the tag as the vehicle advances on the production line without the risk of operator error.

The application of RFID technology for tool tracking on construction job sites was discussed in (Goodrum et al 2006, Stankovski et al 2006).

The potential of RFID and mobile-computing technologies in improving the maintenance of facilities at Frankfurt Airport was presented in (Legner and Thiesse 2006). An interesting application of RFID technology in mines detection was reported in (Ruff and Hession-Kunz 2001).

1.8 RFID in the automotive industry

Electronic tracking and identification technology, which is the predecessor of RFID, has been in use in the automotive industry for around 20 years, but only to a limited extent. The major applications lie in vehicle identification and protection (Borysowich, 2004).

One of the rapidly budding applications of the use of RFID technology in the automotive industry is in vehicle immobilizers. Over the past few years, immobilizers have become very common in new cars, and over 40 percent of the new cars manufactured in North America come equipped with RFID-enabled immobilizers (RFID Update, 2006).

BMW and Vauxhall use RFID tags to enable accurate customization of customer orders (Brewer and Landers 1997). A read/write smart tag is programmed in the customer order. The tag is then attached to and travels with the car during production process. This tracking ensures that the car is manufactured with the correct color, model, interior, and any other option the customer specifies.

Ford Motor Company has successfully implemented an RFID-based Just-In-Time manufacturing model at its facility in Cuautitlan, Mexico (Johnson 2002).

The appeal of RFID technology in the automotive industry is the real time visibility and security protection that it offers the automobile itself, as well as the benefits in the assembly processes of automobiles. For example, General Motors, Volkswagen, and Johnson Controls are already employing RFID tags and readers in their assembly operations, whereas

TNT Logistics had deployed RFID technology to optimize the process of just-in-time parts sequencing to its automobile-manufacturing customers. Because of these emerging benefits offered by RFID, it has almost revolutionized the industry (Banks et all 2007).

TNT Logistics, the largest provider of third-party logistics services to the automotive industry, has launched an initiative to deploy RFID technology as part of its logistics solution offered to automotive manufacturers at the end of 2005 (Banks et all 2007). The initiative started at the Material Sequencing Center operated by TNT Logistics for Ford Motor Company to support their assembly plant in Dearborn, Michigan (Kiritsis, 2006).

Manufacturers are ambitious to find ways to boost the process security and data quality of material flow systems, optimize material planning, reduce error rates, employ labor efficiently, and accelerate transport processes. Siemens RFID solutions play a crucial role in addressing and eliminating these issues in the automotive industry (www.siemens.com).

1.9 Implementation of RFID technology in control center of a parking lot

During the last four decades numerous parking search models have been developed (Ker and Foster 1991, Saltzman 1997, Shoup 1999, Thompson and Richardson 1998, Arnott and Rowse 1999, Waterson et all 2001). Since parking plays an important role in the traffic system one of the problem concerning this area is parking revenue.

RFID technology is an automated vehicle identification system that is useful and requires no personnel. Vehicles are identified and parking-lot fees are collected automatically via this system (Pala and Inanc 2007). RFID system enables vehicles to check-in and check-out under fast, secure and convenient conditions. Most of the gate controlling systems includes barriers. The timing of the gates and additional sensors enables a one by one parking-lot circulation thus preventing multi check-ins or check-outs at a time (Glover and Bhatt 2006). RFID readers control check-in and check-out barriers. RFID is a technology that collects parking fees without having to stop vehicles (Anonymous 2005).

Since RFID technology is contactless identification technology a suggestion was given to use this technology in parking systems. Advantages of RFID technology in comparison to other technologies are:

- No need for physical contact between data carrier and the communication device
- Tags can be used repeatedly.
- Robust tags can withstand extreme conditions and temperature.
- Low maintenance costs.
- Tags available in a range of types, sizes and materials.
- Non-line-of-sight communication makes it possible to read and write tags in dirty conditions.
- RFID tags may be read by the RFID system at one time.
- Extremely low error rate.

It is the sole purpose of this study to utilize such an important technology with an application. In this study, via RFID technology, some solutions are provided for the problems encountered in parking lot management systems to the present and some important results have been gathered. In this study, the main components of RFID technology which are RFID readers, RFID labels, a barrier to control the gate and software have been utilized. The software aimed to handle the management, controlling, transaction reporting and operation tasks for parking lots located on various parts of the city.

As for the hardware requirements, by the utilization of RFID readers, barriers and labels, parking-lot check-in and check-out controls have been achieved. In that way, as an alternative to personnel-controlled traditional parking-lot operations, an unmanned, automated vehicle control and identification system has been developed.

Necessary precautions have been taken programmatically just in case of a parking-lot's running out of parking space problem during the process of this application. That way vehicles that are about to check-in will not be let in, thus, there will not be any time-loss to look for parking space.

Another problem is the application's disconnection to the central database during its operation. This is basically the result of the internet infrastructure breakdown. To avoid such a problem, necessary precautions were taken to run the database on both a local and a remote server simultaneously.

2. General Structure And Design Of The System

In this study, controlling of three parking-lot check-ins and check-outs has been achieved by using a central database system. The parking-lots are located on various parts of the city (Fig. 2).

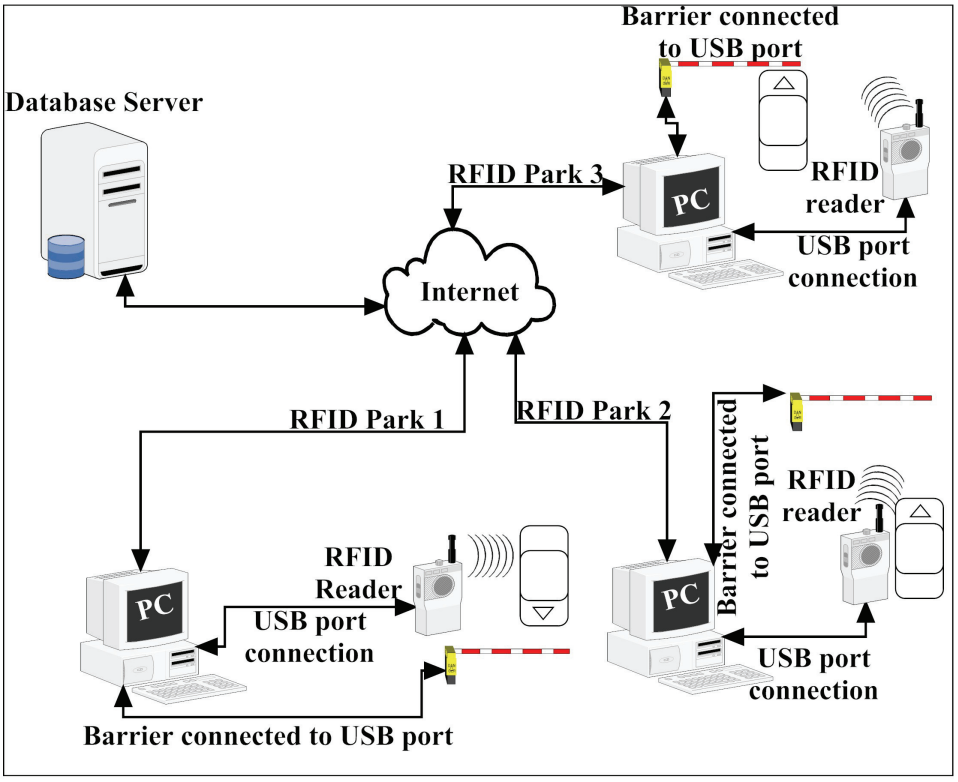

Fig. 2 Application scheme

The primary motive of choosing parking lots located on various locations is to show that this project has a city-wide working scale. The only physical connection with one lot to another is the intranet. Phone lines have been utilized for internet connection with four DSL modems to connect three parking lots and a central office.

The server containing database management system with current databases has been assigned static IPs at the central office. The same static IP assignment has been done to other three parking lots with DSL modems.

The server software which is Windows based and developed by dot net framework 2.0, has been installed on each computer at the parking lots.

The objective of the client software is to monitor and control RFID readers and barriers automatically. The vehicle data processed by RFID readers is transferred to the central server. Thus the server and client computers are in a synchronized state at all times.

While using hardware for the central management of the parking lots, software to control the hardware has been used as well. RFID readers, RFID antennas, RFID labels, Hubs (RJ45 to serial converters), cars, automatic barriers with RJ45 serial port connection, DSL modems, Cat5e Ethernet cables and laptop computers have been utilized for hardware requirements.

To store and manage the vehicle tracking data, a database management system has been used as software requirements. A visual programming language (Microsoft C# 2005) has been used for operating the parking-lots and to reach the collected data.

Table 1 RFID reader technical specifications (Siemens 2007)

Frequency range (adjustable)	865 … 868 MHz
Transmit power (adjustable in steps of 100 mW)	0.1 W to 2 W ERP
Tag read range (with 2x2 antennas, mounted opposite each other)	10 m(max.)
Tag read range (with 2 antennas, mounted side by side)	5 m(max.)
Number of antennas(configurable)	2 to 4
Impedance(nominal)	50 Ω
Standards	EPC Gen 1, EPC Gen 2, ISO-18000-6B, Mixed Mode Operation
Number of tags read per second	50 read actions/s
Data transmission rate for reading (EPC Gen 2)	160 Kbyte/s at 3 m
Interfaces	1 port:RS232 1 port :RS422 1 port: Ethernet RJ45 Digital in/out:3x24 V DC, each 0.5 A
Communications protocol	RS232, RS422, 802.3af Power over Ethernet
Antenna Type	Circular polarized
Temperature range	-25 … +75 0C
Dimensions L x B x H (in mm)	320 x 145 x 102

The utilized barrier gates were being controlled by using serial port. They opening/ closing time were 4-10 seconds. Barrier opening and closing time lengths could be adjusted by the software provided. Barriers were 2 m in length. They also included red and green light sockets. When the barrier was open green light was on while the red on meant it was closed.

The utilized RFID reader is a Siemens branded board operating with RJ45 Ethernet port at 865-868 MHZ. By using the above mentioned RFID reader, RFID labels were managed to be read from approximately 4 m distance (Table 1). In this study 6 Siemens Simatic RF660R readers were used.

The read data was a 96-bit identification data. The utilized RFID labels are considerably small with rectangle shapes. That way they could easily be plastered on the windshields of each cars (Table 2). RFID labels have been plastered on the right bottom side of the windshields of the vehicles from inside. In that way, the labels can be preserved from external damages and be kept in reading range.

The RFID labels on the vehicles approaching to the parking lot entrances with moderate speed have been read successfully and barriers opened for the authorized passages.

For each parking lot double RFID readers are used and for each reader, double Siemens RFID antennas were used. The antennas were connected to the reader side by side facing the passage road. The distance between antennas and the reader was 2m.

Table 2 RFID label technical specifications (Siemens 2007)

Frequency range (adjustable)	865 … 868 MHz
EPC Code	96 bits
Protocol	As per ISO 18000-6B
Typical read/write distance	0 … 4 m
Type of mounting	Adhesive on one side (self-adhesive labels)
Antenna size	20 x 88 mm
Antenna material	Copper
Operating temperature	-20 … +70 0C
Dimensions	101 x 152 mm (4" x 6")
Material	Paper

The computers used in this application were connected by the internet. A database titled as RFIDDATA was used to store data coming from the parking-lots in the city. In the database, as the main table, "VehicleInformation" and as a sub table "VehicleCirculationInfo" tables were created. The general information about a vehicle is stored on the main table and its circulation information is kept on the sub table. The main table consists of the fields such as vehicleID, number, type, and model. To monitor a vehicle's inner city parking-lot movements, its check-in and check-out attempts, the dates, the time, the parking-lot information and total parking fee, "VehicleCirculationInfo" table was used.

These two tables were prepared by a database management system and administered via the software developed.

The application software has been developed to use a new database each year in order to prevent database halts caused by possible massive registration data.

RFID reader was connected to the computer's RS-232 port by the Hubs (RJ45 to serial converters) to provide communication between the developed software and RFID reader. Another RJ45 Ethernet connection was established for the barrier as well. For each of the parking-lots, one computer, two barriers, four antennas, one DSL modems, one hubs and two RFID readers were utilized.

Each computer, through the RFID application, by utilizing intranet substructure has been connected to a computer running the central database. Insert and update privileges have been assigned for each parking lot computer that has successfully connected to the central database. Also though the network provided, data transfers among computers were also made possible.

Now, using RJ45 to serial converters, RFID readers and gate control mechanisms can be remotely monitored and controlled via Ethernet. The graphic depicts standard network-enabled RFID parking applications (Fig. 2). This network-enabled configuration opens up many possibilities for RFID-based access control systems. For example, a prepaid account can be linked to the car's RFID tag. The RFID reader authorizes the car for entry, logs entry time, and transmits that data back to the server, then the gate mechanism is activated and the car enters. A similar exit point is configured, and when the car leaves the RFID reader logs exit time, releases the gate mechanism, and transmits the exit data back to the server. The customer's account is then debited for the time (s)he spent in the parking lot. The advantages of this type of system include not only easy access for the customer, but the elimination of staffing at entry and exit points.

2.1 Communications protocols

Protocols are the definition and grammar of the language used by interrogators and tags to communicate with each other. The interrogator and tag must use the same protocol to communicate. The interrogator may have multi-protocol capability, but uses only one protocol at a time (Brown et all 2007). The protocols define air interface – that is, how a tag and interrogator communicate using electro-magnetic waves. This includes frequency of operation, emission power level, data rate, signal modulation, encoding of data bits, data structure, command structure, and anti-collision algorithm. In this study ISO 18000-6B protocol was used by the tag and interrogator pair. ISO 18000 was first published in 2004 and has been in direct conflict with the EPC Gen2 specifications developed in parallel (Roussors 2008).

2.2 How does the system work?

The system starts working as soon as RFID labels are acquired from RFID centers. Label selling centers are located on certain areas of the city which vehicle owners could easily reach. Upon the purchase of RFID labels, a lot of information concerning the vehicle is recorded to VehicleInformation table of RFIDDATA database. In that way, every one of RFID-enabled vehicles will easily be identified and their check-ins and check-outs to the determined parking lots will be monitored. In this project the RFID labels were distributed by the central server office.

When an RFID-labeled vehicle attempts to check-in to a parking-lot, the system queries if the vehicle is registered to the database or not. If it is a registered vehicle and it has not checked out of an unauthorized RFID-enabled parking-lot, the system will allow

its entrance. Upon the entrance, the vehicles identification information, entrance date and time and current parking-lot title are recorded in the VehicleCirculationInfo table of the database. The check-in information carries great importance since it will be compared to the check-out information of the vehicle. If a vehicle has made an unauthorized check-out of a parking-lot, the vehicle will not be able to check-in to any of the RFID-enabled parking-lots. The only solution for the vehicle to check-in is for the owner to pay the fine to the fine office. Upon receiving the approval, the barrier lifts up and initiates the check-in process (Fig. 3).

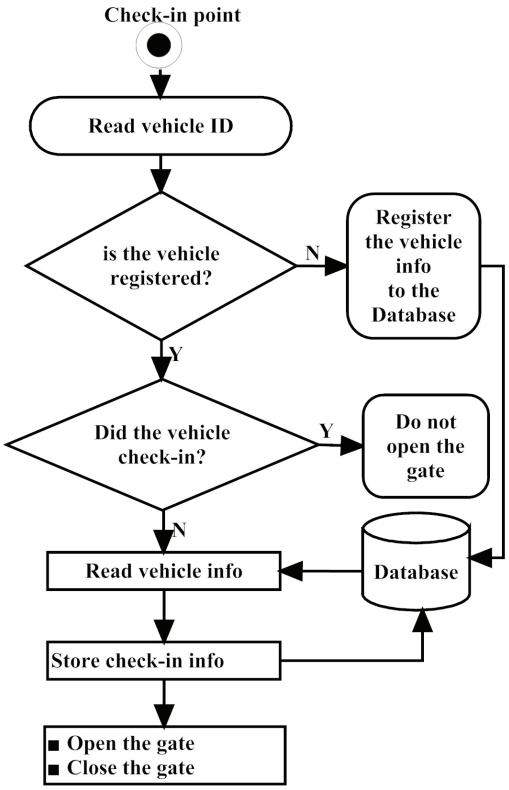

Fig.3 Parking-lot check-in process

When a vehicle drives into the exit area of the parking-lot to check-out, its identification information is queried on the database. If the vehicle is registered to the system and it has not made an unauthorized entry to the parking-lot the check-out process is initiated. The vehicle's check-out date and time is taken into consideration. The check-out date and time total are subtracted from check-in date and time total. The calculated time is converted into minutes thus the elapsed time in the parking-lot is determined. Upon the check-out, the check-in information of a vehicle is found and updated with check-out information. The check-out information means check-out date, time, the elapsed parking time, and the total fee.

Moreover, the total fee of the elapsed parking time is updated with the previous related info on the database. If the vehicle has made an unauthorized entry to the parking lot the system does not allow its check-out. In that case, a fine should be paid to check-out again. The check-out process is initiated by lifting off the barrier (Fig. 4).

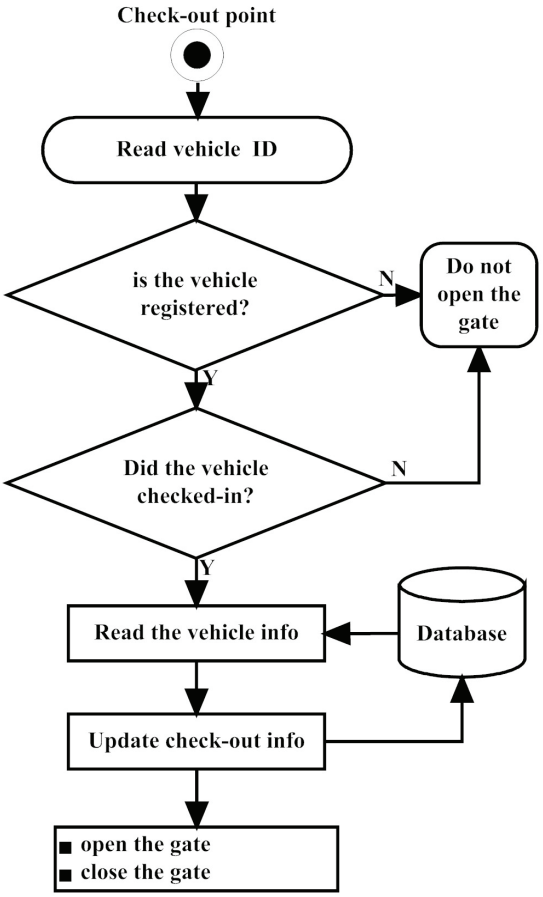

Fig. 4 Parking-lot check-out process

2.3 Payment system

Receiving money and paying the parking fees will be done though internet. At the end of each month, the total fees for each of the parking-lot member drivers will be calculated. Then these fees could be drawn from their bank accounts and transferred to the parking-lots' accounts automatically, issuing an invoice for each transaction (Fig. 5).

For payment processes, the tables titled as vehicleDepts, vehiclePayments and parkOwners have been used in the database. On vehicleDepts table, a vehicle's date-based payment data for various parking lots, on vehiclePayments table, a vehicle's monthly payment data, and on parkOwners table, monthly payment and credit data is kept.

All the payment and billing information can easily be monitored from internet as well. In that way, all the parking lots in a city will be operating on a fixed parking fee. This will more likely please vehicle owners.

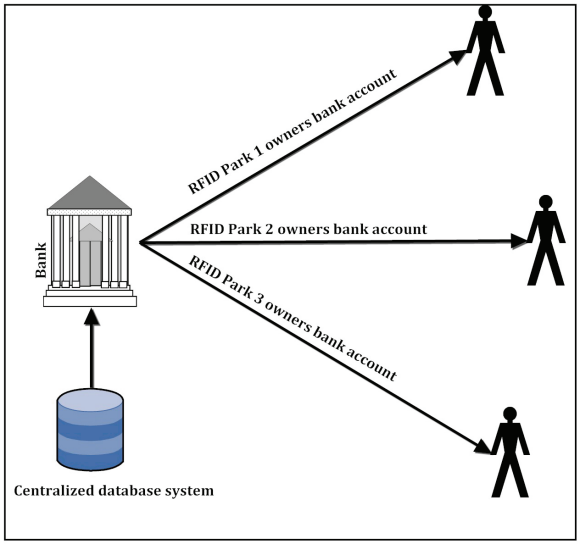

Fig. 5 Payment system

2.4 Testing process for the RFID-controlled parking lot

Two vehicles were used for the testing process. An RFID label was plastered on the windshields of each cars. Testing process began right after saving identification information of the cars to the system.

During the testing stage of the parking lot system the following criteria were taken into consideration:

A single vehicle's check-in and check-out processes were completed. Identification of the vehicle during check-ins and check-outs was successfully achieved at the distance of 2 to 4 m from the barrier. Then the barrier was automatically activated for the passage of the car in or out of the parking lot.

Simultaneous check-in and check-outs were successfully performed. The system could control two barriers at the same time.

One of the vehicles made an unauthorized entry to the parking lot. Upon its check-out stage, the barrier did not open. Only after the vehicle's fine has been paid up then the gate was open for the check-out.

One of the vehicles made an authorized entry to the parking lot but its check-out was unauthorized. Since the car's check-out process failed, and it was considered to be still parked on the parking lot, other parking-lot systems did not allow the check-in for the vehicle but only after the due fine payment.

Upon a regular check-in procedure, when the barrier was still open, another vehicle following right after it did also made a successful authorized check-in. The barrier continued working smoothly.

3. Discussion And Results

In this application, a vehicle's identification information is searched on the central database first, if a vehicle does not have any previous records registered to the database, the initial entry level information of a vehicle is stored in the database. If a vehicle has a previous record stored on the system, there will not be any secondary information entries thus duplicate entries will be avoided.

3.1 Discussion

Under normal circumstances, if a vehicle checks-in to a parking-lot without RFID notification, that vehicle will not be able to check-out afterwards. In that way, unauthorized entries will be avoided.

If a checked-in vehicle does not get checked-out, it will not be able to check-in to any of the parking lots in the city. Only the administrator of the central database could bring a solution to this problem.

Vehicle owners can access to the database to find out about their parking-lot fees anytime anywhere. By using the web interface designed, it will be possible to monitor a vehicle's total fee at once or in detailed listing (Fig. 6).

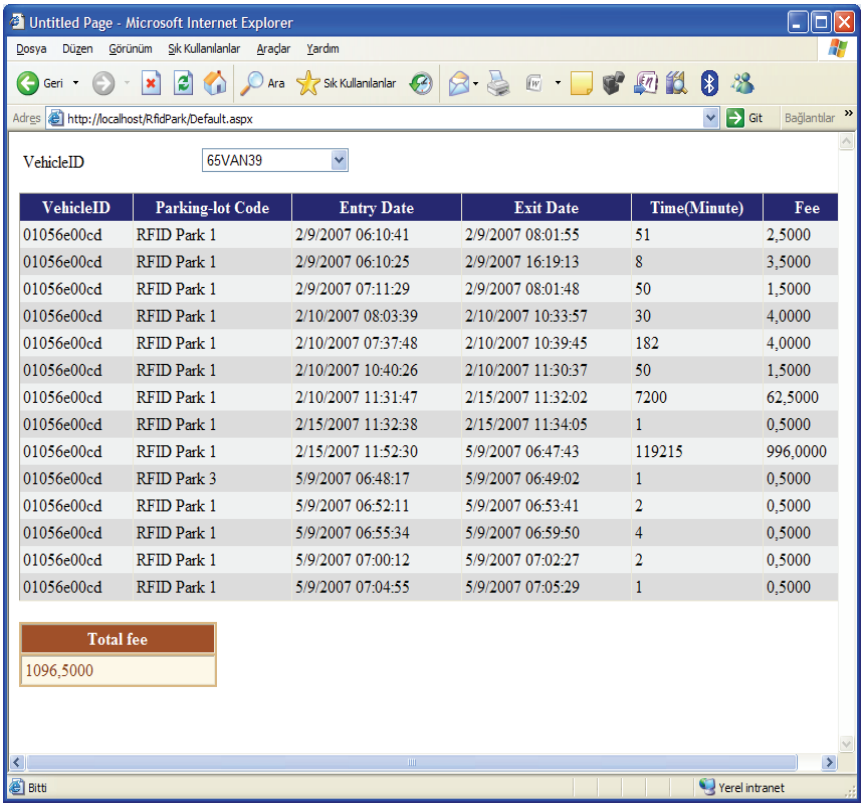

Fig. 6 Accessing vehicle information panel through the web interface.

Identification information of the registered vehicles within the coverage area of an RFID reader will constantly be read. If in this process, a vehicle's information is recorded into the database there will be duplicate entries and this will cause problems within the system. To avoid this problem, reading task is done when the vehicles gets out of the range of the RFID reader.

If two vehicles enter a parking-lot side by side, being within the range of the RFID reader, the system will not read their identification information and process it. To avoid such problems, parking-lot entrances should be designed to enable passage for one vehicle at a time.

Spot lights directly connected to the RFID reader located at the entrances of parking-lots to notify drivers about the availability of parking space in the lot will provide great convenience. For instance, if the parking-lot is full, spot lights flash red and otherwise they flash green. The color of the flash lights changes in accordance with the capacity status of the parking lots. In that way, there will not be any waste of time looking for park space. Also, it will not be an obstacle for the vehicles trying to check-out.

Internet disconnection during the processes will shut down the connection to the central database as well. In such cases, a local database system will be enabled. Once the internet connection is restored, the system will switch back to the remote database again.

Once the internet connection is restored, the modifications made on the local database will be transferred to the central database.

3.2 Results

Thanks to the system's easy installation and operation, automated data gathering and reporting will be possible. With a centralized management system, both the unity and security of the gathered data will be possible.

By a centralized database system, remote access and administration of the system will also be possible. Over the internet, administrators will be able to view identification and debt information of any vehicle and monitor the efficiency and functionality of RFID-enabled parking-lots. Thus, vehicle accumulations on various places will be avoided and new precautions will be taken according to the demands.

Via such a system, personnel costs will be cut off. As in the case of ATM machines, realization of unmanned, completely automated parking-lots will be possible in the future.

Without having to stop vehicles, check-ins and check-outs will be possible. In that way, there will not be any traffic jam problems. As in the traditional parking lot systems, drivers will not have to take and process parking tickets during check-ins and check-outs. Moreover, there will not be any ticket-jamming problems either.

Vehicle owners will not have to make payments upon every check-out. This will provide a smooth traffic flow within the parking-lot thus preventing the emission gas formation.

With this system an automated income reporting and a centralized vehicle monitoring will be possible. A pre-determined price-range will both relieve the city traffic and provide security for vehicles.

Instead of parking vehicles on streets and putting them into risk, drivers will be able to leave their vehicles to these parking-lots with contentment.

4. CONCLUSION

In this project, it is proven that by utilizing RFID readers and RFID labels with a centralized database system, all the parking-lots in a city could be operated in an economical and fast way.

This prototype will provide for automation of the operation and controlling ability for all of the parking-lots in a city by using standardized devices.

Compared with traditional barcode identification technology, RFID possesses characteristics; such as reading multiple tags once, reading/writing many times, and so on.

Implementation of the RFID technology, in an existing parking lot access control system, has given benefits to all interest parts (the Parking Operator, parking place users and parking collectors).

People using parking place are spending much less time waiting in line to buy the tickets for the on-street parking and much less time waiting at the entry and exit barriers of a parking lot or garage.

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UPOTREBA RFID-A ZA PRIMENE SMART PARKINGA

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U ovoj studiji je dato rešenje za probleme sa kojima se srećemo u sistemima upravljanja parkiralištima putem RFID tehnologije. RFID čitači, RFID oznake, kompjuteri, barijere i softveri se koriste kao glavne komponente RFID tehnologije. Softverom se rukovodi u cilju upravljanja, kontrole, izveštavanja o transakcijama i operacionim zadacima za parking prostore locirane u različitim delovima grada. Prijavljivanje i odjavljivanje sa parkirališta se nalazi pod kontrolom RFID čitača, oznaka i barijera. Tako će biti moguće obezbediti da parkiralište u budućnosti funkcioniše sa RFID tehnologijom, bez osoblja ali sigurno i automatizovano. Prijavljivanja i odjavljivanja će biti ubrzana bez potrebe da se kola zaustavljaju pa će se i time izbeći saobraćajne gužve tokom ovih procesa. Vozači neće morati da se zaustavljaju na kružnim tačkama a neće biti potrebe ni za izdavanjem kartica tokom prijavljivanja i odjavljivanja. Vlasnici vozila neće morati da plaćaju na punktu za odjavljivanje tako da će saobraćak biti brži. Pošto neće biti čekanja tokom prijavljivanja i odjavljivanja biće izbegnuto emitovanje gasova do koga dolazi tokom čekanja.

Ključne reči: *RFID, Automatizacija, Parkiralište, Upravljanje parkiralištem*