Achieving interoperability of parking system based on *RFID* technology

Miloš Ivanović*

*University of Belgrade, Faculty of Organizational Sciences, Belgrade, Serbia

**Qfree-Elcom d.o.o, Belgrade, Serbia

smajhel.m@gmail.com

***Abstract* — The subject of this paper is based on communication between two heterogeneous systems. It is necessary to ensure the parking system or unit that will accept data from other systems and thus to ensure efficient data exchange to work together, without altering the exchanged information. The goal of this research is to present concrete example of parking system using RFID technology and its interoperability which will increase productivity and efficiency of the entire system.**

I. INTRODUCTION

The research in this paper is directed towards the ability of communication between two heterogeneous systems. On one side there are the concepts of RFID (Radio Frequency identification) technology, which should solve the problem of simple use of parking system when entering or exiting the vehicle via radio waves. Thereby it will reduce the waiting time and operating costs of parking and increase productivity and efficiency complete parking system as well. When thinking of a complete parking system, it means that the application of these technologies must be applied from the standpoint of interoperability so that these technologies can be integrated into existing parking systems and , using them information can be exchanged that actually allow operation of the entire system.

On the other side, there are existing parking systems that work using the device for issuing paper cards and devices to control barriers at the entrances and exits to the parking area. These parking systems contain certain protocols and rules that they operate on. It is necessary to carry out interoperability of the two systems by the concept that these two systems are heterogeneous and that it is necessary to ensure the parking system or unit that will accept data from the other systems and thus to ensure effective data exchange and joint operation of the system, without changing the structure of the exchanged information. RFID technology is a technology that uses radio frequency to exchange information between the portable devices.

This system consists of the tag (transponder), which is actually a data bearer, and the antenna that communicates with tags. This system has no utility value unless a unit is provided between the antenna and the existing parking system that will manage and monitor the communication between the antenna and the tag, in order to use resources from this transaction in other parts of the parking system more efficiently. This research problem is worth studying because of the quality, accuracy, and achieving productivity at the lowest costs of this system. This system must operate completely, without any possible exceptions because it can cause big problems in exploitation and work, because this is a system that works in real time. One of the problems that can occur due to inadequate communication of software in the controller with the antenna, is that the controller, which is a mediator between the two systems, incorrectly processed data from the tag. Further research will explain in detail in what way the software in the controller communicates with other components of the system and allows its functionality.

Figure 1. Integration of RFID technology with existing parking system

The rest of paper is organized as follows. In the second chapter will discuss about the concepts of RFID technology to be applied in the functioning of the parking system, and their advantages. In the third chapter will discuss about the ways of solving the problem of interoperability RFID technology in existing parking system. In the fourth and the fifth chapter will be presented a concrete example of interoperable parking system based on RFID technology.

II. RFID TECHNOLOGY AND A PARKING SYSTEM

The application of RFID technology in the operation of parking systems, achieves a higher level of automation of all business processes and algorithms that make up the system. For example, in most cases, RFID in parking systems is used for automating the access control in closed or open parking spaces where the inputs and outputs are automatic barriers.

A vehicle, that has a transponder placed on the windshield in front of the driver, when approaching the entrance of the parking lot, has space where the RFID reader via radio waves reads data from the memory of the transponder and communicates with him dually. Then the software, that manages the reader, converts data from the transponder into useful system information that it stores, processes, shares with other systems and updates. After verification, system sends a signal to the automatic barrier to allow access to the vehicle in a parking space. Transponder has its own unique identification number that distinguishes it from all the other such devices, along with a valid data of the owner or of the vehicle.

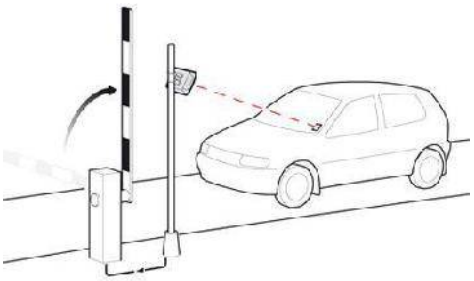

Figure 2. Identification of vehicle on the entrance/exit of parking lot

The advantages of using RFID technology in the parking system are:

1. Processing data from the transponder takes place without the influence of user, i.e. antenna reads data from the microchip in the transponder via radio waves.

2. There is a centralized software that manages the complete system and devices, and it collects, processes and exchanges data with other parts of the system, which makes this system interoperable.

3. Transponder is easy to use and by dimension it can be easily placed onto the inside of the vehicle.

4. Memory of transponders is large enough to be able to store all the necessary information about its holder.

5. Distance range in which the antenna detects the transponder is up to 10 meters, which is enough for a parking space.

6. The RFID system consists of components that can be easily installed in the field and do not require much space and cables to connect them to the network and power source.

7. Speed of reading data from the transponder is measured in milliseconds, which implies that communication is very quick and it saves user waiting time for the transaction.

8. The lifespan of a transponder is far greater than the barcode and can handle up to 100 000 transactions to its next replacement. That is, the user of a transponder can realize up to 100 000 entrance / exit of the parking space.

III. ACHIEVING INTEROPERABILITY OF RFID TECHNOLOGY WITH PARKING SYSTEM

The result of this research is a concrete example of parking system using RFID technology and how its interoperability increases the productivity and efficiency of the entire system by reducing the cost of investing in only the maintenance and operation of the entire system. The desired results of this research will be reached by applying the concept of interoperability between the two heterogeneous systems and the ways of exchanging data between them without altering the exchanged information and communication protocol.

European centre for interoperability stated that interoperability can be achieved using the following levels of interoperability [1]:

1. Technical interoperability

2. Syntax interoperability

3. Semantic interoperability

Using the above stated levels of interoperability , we will come to the unit system that will completely contain technical, syntactic and semantic interoperability and it will be operational for its safe and efficient exploitation. Interoperability is defined as a common set of processes, procedures and equipment adopted by more than one provider, to support and improve simple use for users and for data acquisition. In interoperable system, user can easily switch between heterogeneous parts of the system, and take data from them in order to integrate information suitable for achieving good results of the system. At the highest level of interoperability between heterogeneous system, boundaries are invisible to the user, in order that these background processes and procedures work together and provide the user with the transaction of system, data exchange, data warehousing and distributing data to other parts of the system.
RFID systems consist of transponders (tags), reader (antenna), programmed cell and various server software interfaces that enable interoperability with other systems. Over the management software interoperability of such a system is achieved, because this software is the main component in the management of RFID systems and exchanging information with other parts of the system. Many RFID systems have a server that collects information from the transponder in parking systems and maintains a complete database in one place.

Database as a first and important component of this parking system is the starting point in achieving interoperability. In fact, many parking systems are designed to store all transactions between the reader and transponder in a database, in order to monitor the history and create reports with the possibility to exchange such information with other systems.
To ensure interoperability, parking system needs to improve the capability and the technology used for storage, import and export data (in real time), to adopt standards and standardization for networking and data management, and to adopt the use of open source, so the user can enhance the functionality of the software.

Two possible ways in achieving interoperability in terms of data exchange between systems are [2]:

1. The exchange of data between systems via peer2peer technology is suitable for a small number of systems but manages to overcome the barriers between systems and enables them to communicate.

2. The database is the most up-to-date central component that allows you to interact with the systems, it is removable and standardized.

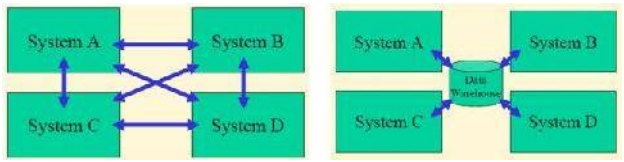

Figure 3. Achieving interoperability between heterogeneous systems

RFID interoperability refers to the ability to allow vehicles to identify the different needs and in different locations, using unique On-Board-Unit (transponder or tag) for each vehicle. In the transponder all the necessary information about its owner are found, in this case that is the vehicle. RFID interoperability obtains its role when the parking system expands to different locations, and when it is necessary that users can safely use any parking site that they have the privilege and that the data between the parking system can be viewed and processed.

Parking system that uses RFID technology as the holder of control and access to the vehicle parking area comprises three essential components that the user needs to have in order to participate in the system. Those are:

1. Bank account - to be able to pay the money for the use of parking spaces.

2. Transponder - a device used by a user identified at the entrance / exit of the parking lot.

3. Mobile phone - through which also more easily, via messages can provide funds in his account and he receives information timely on using transponders.

The above stated components of the system are the very interoperability of the system. Interoperability is the connection of these three components in a single unit which enables mutual cooperation and exchange of data and information, through appropriate software. It is a very significant technical, operational and administrative undertaking whose application is not to be taken lightly, but it is necessary to invest a lot of time and effort to implement and use in the best possible way.

Advantages of RFID interoperability achieved in the parking system are [2]:

1. Increase of loyalty and customer satisfaction.

2. Reduction of operating costs parking system, since they no longer use automatic billing for spent hours in the parking lot, where he spends far more, both the electricity and paper for printing bills.

3. Increase cooperation between the parking system.

4. Without interoperability, parking systems could function independently, without mutual cooperation that would lead users in an awkward position as it would have to communicate independently with any parking system.

5. Application of physical interoperability means that users can use their transponders for any parking system located in this community.

6. Back-office interoperability enables data exchange between the parking system on the status of transponders, the validity of transactions, payment status and account of the users.

IV. "LCC 550" PARKING SYSTEM

"LCC 550" parking system uses a universal controller, here in after referred to as the controller, which on one hand allows the integration of RFID technology in the entire system and on the other side, the same interoperability with other parts of the system. The controller in the parking system enables the exchange of data between heteregonous system, thus enabling the efficiency of the entire system, which leads to positive business results.

The controller is one of the currently available products on the market. Designed and developed to automatically connect to an existing parking systems, which makes it very efficient, because now there are largely on the market parking systems that operate successfully and the advantage of this controller is that it in a simple way of implementation allows achieving interoperability with RFID technology. The use of RFID technology, which was previously discussed, recently reached a high level of use in the systems of collection of parking and tolls.

This controller is called the universal as it can support the management of various applications, such as:

1. Parking systems,

2. Systems of access control,

3. Systems for automatic license plate recognition.

Figure 4. Universal parking controller "LCC 550", key for interoperability

The controller allows its interoperability with different producers parking systems currently on the market. So far, in practice it has been implemented with the following manufacturers of parking systems for the collection of use of parking spaces:

1. Skidata

2. Schiedt & Bachmann (S&B)

3. Parcare

Connection with other parking systems is realized via RS232 serial communication and via an ethernet Local Area Network. These modes of communication provide the basis for achieving interoperability with other parts of the parking system, because in this way they enable the exchange of data with the same through predefined communication protocols without changing the content and meaning of data exchanged.

The controller can be synchronized and implemented on all modern systems for the collection of parking services, including current and future systems that are installed in parking systems. It enables improvement of parking systems without replacing existing parts of the system, but to integrate with them and enhance the quality of results from the system. Also, the architecture of the system allows remote management of entire system from the so-called control center. The control center is mainly a large office with modern equipment to enable connections to other parking systems. It secures way of exchanging data for the purpose of processing, viewing and storage of data as well as the maintenance of the system to be functional and without exception in work.

The advantages of this system are:

1. The possibility of upgrading the system, depending on the additional requirements.

2. Management system from remote locations.

3. Processor, memory and communication system are stable and fast.

4. Controller is designed to work in real systems in different environments, temperatures and operating conditions.

5. Operating system of controller is based on the Linux platform.

6. Reduces operating costs of the parking system, as it automates all business processes for entry-exit of vehicles, payment of parking space usage and processing of data.

The objectives of the operation of this parking system can be multiple. First of all, users who decide to introduce this type of parking system, aware that it will speed up the processes of the system and create serving its customers, drivers, effectively. The advantage, that at the very beginning of the introduction of this system is achieved, is a reduction of operating costs and business automation.

The very architecture of the system allows data exchange not only with existing parts of the system, but also through the global Internet network, which creates a high level of efficiency of such a system. Complete system can be operated from a single control center, which is connected with the equipment via a wired or wireless Local Area Network, depending on the user's request.

This parking system removes vending machines for paying of spent hours in the parking lot, because in this system, all transactions between the driver and the parking system are carried out through practical transponders or tags. Transponder is located in the vehicle, mainly on the windshield, and it contains all the information about its owner such as name and surname, address, registration number, telephone number, account number, etc... The memory of the transponder allows the storage of sufficient data of the owner so that system can function normally, and most importantly that it can be improved in the future. The system is very dynamic and open for any additional customer requirements, making it flexible and interoperabile.

The main objective of this system justifies the subject of this work, and that it is interoperabile with other systems. Data exchange with other parts of the system is performed via serial communication and local network communication. This exchange of data is a key of interoperability, for this parking system has been developed to be easy and simple to integrate into existing communication protocols and comply with them. The goal of interoperability is data exchange between systems without disrupting and changing the content of the data to be exchanged in order to preserve the integrity of the system.

V. SYSTEM ARCHITECTURE

The components that make up this parking system and its operation efficient and flexible are the following:

1. Controller

2. Transporder (tag)

3. Antenna (RFID reader)

4. Control management center

5. Existing parking system

Figure 5., shows the architecture of "LCC 550" parking system, where we can see the role of the controller (in the middle), which is to maintain interoperability between system components. Namely, it enables the exchange of data between the RFID technology, existing parking systems and parking management center. In the current parking systems , there is a certain system that allows its operation, the aim of this controller is to integrate all parts of the system in one unit and that all have one common goal: to increase the efficiency and flexibility of the entire system while reducing operating costs and increasing profits.

Figure 5. “LCC 550” system architecture based on RFID technology

The transponder or tag is the main component of this system because it is the only system component with which the user has direct contact and therefore it is essential to be very reliable, of appropriate design and dimensions. Specifically, the design and functionality of this component is determined by the quality and cost of the entire system because users use it to communicate with parking systems using RFID technology.

Tag is the holder of all required information about the user and it is located in the interior of the vehicle. RFID reader communicates by using radio waves with transponder and exchange data with it.

The advantages of the transponder in relation to the other on marke are as follows:

1. New chassis design, size 60 x 40 x 19 mm,

2. Easily attached with a single carrier,

3. New and faster processor that with the antenna exchanges data with a reader,

4. Weighing about 30 grams,

5. Lifetime = 10 years,

6. Active transponder, which means it has its own power supply using battery.

Figure 6. Transponder (Tag)

RFID antenna „RSE 650“, is the version that this parking system has in use currently, representing the components of this system whose main function is the identification and communication with the transponder. This antenna is placed at the entrance / exit of the parking space and by detection of transponders, it reads data from it and forwards them to the controller for further processing and exchange with other parts of the system.

The antenna has been optimized and programmed to operate parking systems, toll collection and access control systems. It is designed to be able to operate in all weather conditions, the so-called internal and external use. Works by standard IP65, which defines the requirement that the product is water-impermeable, as this allows the antenna to operate in outdoor conditions. Range up to which it can communicate with the transponder is 6 to 8 meters, which is quite sufficient condition for a parking system, where it is a lot less distance, up to 4 meters.

Power antenna is less than 4 watts, which is 70% less than competitors use. This is a very important characteristic of this component, because it reduces the cost of the power resources a lot, that are not convenient source today. In standby mode, the antenna draws less than 1 watt.The antenna is in this mode, until it is activated, and the controller activates it at the time when the vehicle encounters an inductive loop which represents the trigger for starting a transaction between the antenna and transponder. So, the controller, that is the key for achieving interoperability in this system, reduces cost efficiency of the power source, which is the most expensive for the operation in the system, and it is current. An additional feature of the antenna is that its power supply can be from batteries and solar panels.

Speed of activated antenna after switching from the defunct regime, is 200 milliseconds, and it is ready for the transaction. Speed of activated antenna after standby mode is 10 milliseconds. This feature is very important and it justifies the possibility of putting the antenna in standby mode when there is no vehicle on the inductive loop, because many users will not wait for the transaction, i.e. speed of service is very efficient.

Dimensions of antenna are 170 x 310 x 40 mm with housing, weighing 1.1 kilograms, and with angle-adjustable mounting bracket to the din rail. Design and antenna is a recent standard that allows this antenna to participate in market competition.

Figure 7. RFID Antenna

Universal parking controller is the central and main component of the system that allows interoperability of parking system with RFID technology. On one side it communicates and exchanges data with an RFID antenna that is reader, it retrieves data from the transponder, processes them and prepares for exchange with other parts of the system. Other parts of the system are the existing parking systems and management center. After receiving and processing data from the transponder, controller packs them in a defined protocol to communicate with the existing parking system. The existing parking system is a very important part of the system with which the controller must achieve two-way communication, because the system is managed by barriers (gates) at the entrances and exits of parking spaces and also communicates with inductive loops that give us information about when to activate the RFID antenna to start the transaction. The structure of the controller, which can be seen in Figure 8., consists of the following hardware and software components:

1. Industrial PC on which to install the appropriate software for the management controller. The configuration of this component is very important because the quality and speed of these components is dictated by how

effectively and quickly operates the software that performs the processing and exchange of information with other parts of the system, of course without failure.

2. Power Switch, which in addition to enabling connection to the network controller parking system, powers RFID antenna.

3. On storage drive is installed the operating system Linux and the software required for the management controller, a memory space of up to 120 gigabytes, which is enough for many years of operation of this controller.

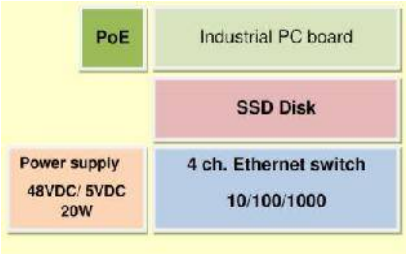

Figure 8. Structure of universal parking controller "LCC 550"

Controller communication with the RFID antenna is realized through Local Area Network (LAN), connecting the antenna in switcher controller which powers the antenna in addition to communication. The protocol used in communication is TCP client-server. The RFID antenna in software has running TCP client, through which it sends data from the transponder to the controller. The antenna is the client and in the controller there is a running server that listens to all clients on the network. This is done so that multiple antennas can be connected to one controller. The antenna after reading data from the transponder packes them into a single XML telegram and sends them to the controller. The controller takes XML telegram from antennas, processes and prepares a set of data that needs to be sent to the existing parking system so the transaction could be ended. Controller communication with the existing parking system is made via a serial RS232 communication, and through it forwards the telegram to the system as a series of bytes. Parking system takes the data and checks the identification number of transponder in the database and if the conditions for entry into the parking lot are completed, it sends a command to the barrier to open.

VI. CONCLUSION

Universal parking controller provides interoperability of parking system and RFID technology, through the levels of interoperability that fulfills completely. The levels of interoperability which the controller uses as an intermediary in the exchange of data between two heterogeneous systems are:

1. The technical interoperability refers to the level at which there are defined communications protocols for data exchange between systems, through which he established communication infrastructure for the exchange of bits and bytes. Controller sharing of bits and bytes is exercised in serial communication with the RFID antenna and the existing parking system.

2. Syntax interoperability refers to the ability of two or more systems to exchange data at its basis are defined data formats and communication protocols. Example for syntax interoperability is the XML standard. In the controller is a syntax interoperability contained in communication with the RFID antenna, where as the standard for data exchange uses defined data format XML.

3. Semantic interoperability ensures that the two systems are able to exchange information automatically, meaningfully and precisely, and also to mutually interpret the information exchanged in order to provide useful outputs or results that users expect. Controller automatically and without affecting the operator communicates with other parts of the system and over defined communication protocols realizes the transaction of the system and gives the effective output of the system which the user expects.

The benefit of this research is the implementation of solutions to the problem of interoperability in the parking system based on the use of RFID technology. The main components of RFID technology are RFID readers, RFID tags, computer units, barriers and software for managing the complete system. The software has been handled for the management, control and reporting of transactions for different parking spaces. Check-in/out of vehicles from the parking lot is exclusively controlled by RFID readers, RFID tags and barriers. This means that in the future the use of RFID technology can enable parking system that will fully operates unmanned, secure and automated. Check-vehicles will be accelerated without requiring that the vehicle stops to seize the card or pays service for using the parking lot and in order to reduce traffic congestion.

ACKNOWLEDGMENT

This project is supported and financed by the Norwegian company Q-free with headquarter in Trondheim. I would like, as the author of this system, to thank the company Q-free on the provided trust and support during the development of the system. This system is currently installed at dozens of parking lots in the cities of Spain and Chile.

REFERENCES

[1] Luras, M., Zelm, M., Archimede, B., Benaben, F. & Doumeingts, G., "Enterprise Interoperability", London: ISTE Ltd., 2015.

[2] Lierz, L., "Unified parking systems", unpublished.

[3] Cameron T. Howie, John C. Kunz, Kincho H. Law, "Software Interoperability", Stanford University, 1997.

[4] Rahul, M., Phatale, P., Kulkarni P.H, "RFID technology for parking", 2011.

[5] Pfleeger, S.L., i Atlee, J.M., "Softversko inženjerstvo", 3.izdanje. Beograd: CET., 2006.

[6] Ivanovic, M., "Achieving interoperability of parking system based on RFID technology", Belgrade: FON, Specialistic academic work, 2015.