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Design of an RFID Vehicle Authentication System: A Case Study for Al-Nahrain University Campus

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Abstract
Automatic Vehicle Identification (AVI) is an ongoing application that is becoming a necessity in almost in university campuses, schools, hospitals, etc. Its great advantage in university campuses lies in decreasing the wasted time and increasing the security throughout allowing only the authorized users to get access. The Radio Frequency Identification (RFID) Technology can be used in AVI to collect the vehicle information in real-time at the parking lots through receiving the vehicles ID from RFID readers. This paper proposes a design and implementation of a dedicated RFID based Vehicle Authentication System for Al-Nahrain University Campus (VASNUC) in Baghdad. The website was programmed to be used for displaying and registering the account of the user, sending and receiving emails, advertising and providing reports for the tracking process. The VASNUC is composed of installing of RFID readers in parking lots around the campus for gathering data and monitoring all entering and departing vehicles to organize the parking lots. The most prominent aspect of this system is the classification of user types according to a predefined hierarchy, where it will separate and grant the vehicle parking slot according to the status of the client.

Keywords: RFID, Tags and Readers, AVI, VAS

1. Introduction

The RFID is a generic term for technologies employing radio waves for identifying objects. The advance in the information society is expanding the use of RFID (Nambiar, 2009). The automatic vehicle tracking or identification facility delivers the flexibility, scalability, and responsiveness that today's organizations need. It provides accurate, up-to-minute information, high- speed communication, and powerful analysis features required to make better decisions faster. The major potential comes from the much acclaimed no line of sight and simultaneous reading properties of RFID (Mhatre,et al, 2013). Vehicles are identified and parking-lot validation is collected automatically using this system (Pala, 2007).

The suggested application in this paper is RFID based vehicle authentication system for Al-Nahrain University campus in Iraq to collect the vehicle information in real-time at the parking lots through receiving the vehicle IDs from RFID readers. This system will provide an automatic process for controlling and monitoring the parking lots in the university by using RFID readers, Client-Server PCs, barriers and network connection between them. The system installation and operation will allow automatic data to be gathered and important reporting will be available. By creating a central database, an administration and a remote access of the system will also be possible. Over the remote access (the internet), the administrators will be able to view tag IDs and information of users and their vehicles and monitor the effectiveness and functionality of RFID and parking lots. This unique identifier can be used to retrieve all the staff records from a centralized database to increases the security of data, as records can only be retrieved with an appropriate username and password combined with the specific vehicle tag number.

The rest of this paper is organized as follows. The basic components of an RFID system are reviewed in section two. In section three, RFID attendance system is discussed. VASNUC architecture and structure are introduced in sections three and four respectively. Design and typical preliminary simulation results are presented in section five. Finally, conclusions are given in section six.

2. System Components

A basic RFID system consists of an RFID reader that transmits and receives data through radio waves from the associated antennas. These functions contain reading/writing data and powering the tag as shown in Figure1 (El Khaddar, et al, 2011). The list of components is as follows:

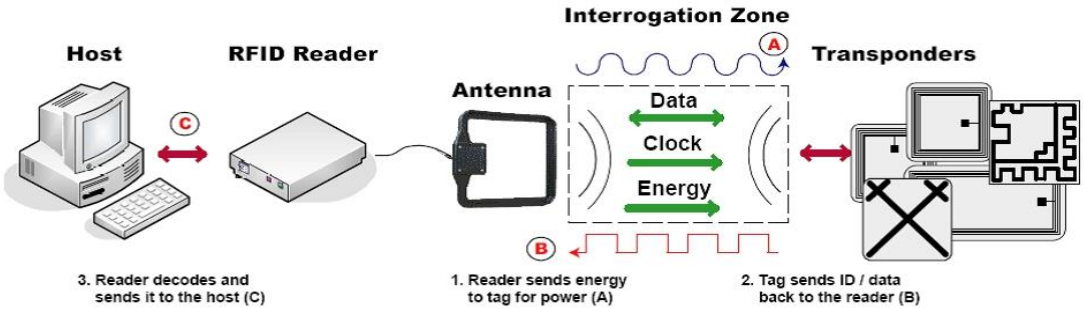

Figure 1. RFID system components **(Mehdia Ajana El Khaddar, 2011)**

2.1 Tags

Tags should be attached to all objects that are placed in an RFID system. A tag is normally composed of an antenna and integrated circuit board. Different types of tags which have different functionalities also have different sources for power or operate at different radio frequencies (Weis, 2007).

2.2 Reader

A reader is made of three major parts, the RF module, reading and writing modules and antenna. The basic function of the reader is reading or writing information from the electronic tags (Chonghua, 2010).

2.3 Antenna

Antenna is a device that transmits and receives the information between readers and tags. Through the chips of the antenna one can receive and transmit microwave signals, such as information of vehicle (Chonghua, 2010).

2.4 Middleware

An RFID middleware is the software subsystem which sits between the RFID hardware and the RFID applications (Anirudh, 2008). Middleware hides the complexity and implementation details of the RF subsystem from the analytical systems. This allows the developers and users of the analytical systems to focus on the business implications of RFID data rather than the intricacies of wireless communication (Karygiannis, et al, 2007).

2.5 Database

All RFID systems require a smart database for storing all data received from readers in real-time. My Structured Query Language (MySQL) was selected to build the VASNUC database, as it is robust, compatible with Microsoft Visual Basic 2012 and Visual Basic support special Application Programming Interface (API) command to communicate with it (Bell, 2007).

3. System Architecture

This section defines the architecture of the system. The main objective is to automate the whole system of getting the information of vehicles using RFID. The first step in the VASNUC system is to attach RFID tag to all vehicles that can be identified by RFID readers. This system is designed and implemented to deal with all vehicles entering the university campus. The only data stored in a tag only being the tag ID and without any other details of the vehicle so as to keep the person privacy of the vehicle owners. The VASNUC is composed of installing of one RFID reader antenna and one IR sensor and one servo motor in each parking lot in the university, as depicted in Figure 2.

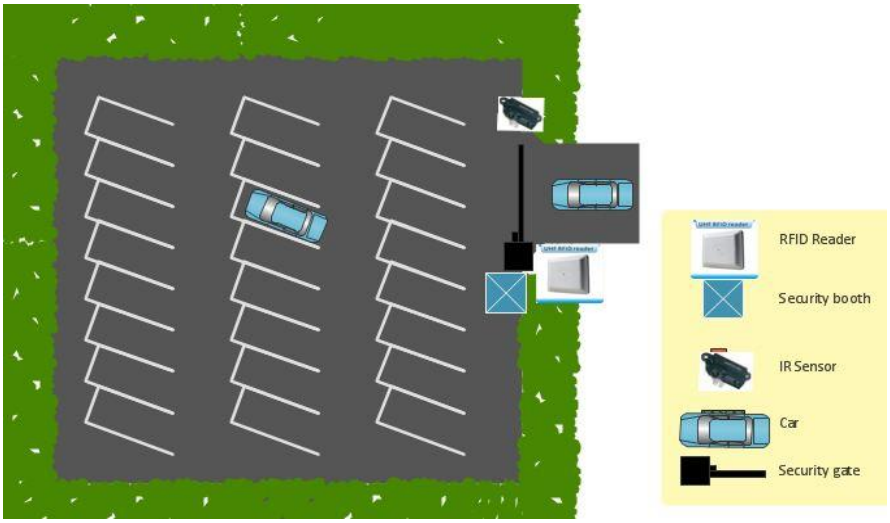

Figure 2. Architecture of parking in VASNUC

The system under investigation in Al-Nahrain university campus comprises eight parking areas for different defined users (Faculty Members, Employee, Students and Visitors), and two central gates for entering and leaving the campus; namely the main gate and middle gate as shown in the map of Figure 3 adapted from the Google Earth map (Google Earth, 2015). All these parks and gates are connected by a local area network (LAN), and the central server will be responsible for recording the information of all vehicles and then providing them to online parking website.

Figure 3. Parking Area Locations in the University Campus

Once a driver wants to enter the university from main gate, he or she will have to pass through the field generated by the reader's antenna installed at the gate. After a successful reading, the client PC to which the RFID reader is connected establishes a connection with an RFID server in order to send the vehicle ID to a central server. If this ID is authenticated and valid the central server will send a request

to the client PC to open barrier of the gate. In the park table in the database the field of status changes its value from 0 to 1 which means that the registered vehicle is now present within the university campus as shown in Figure 4.

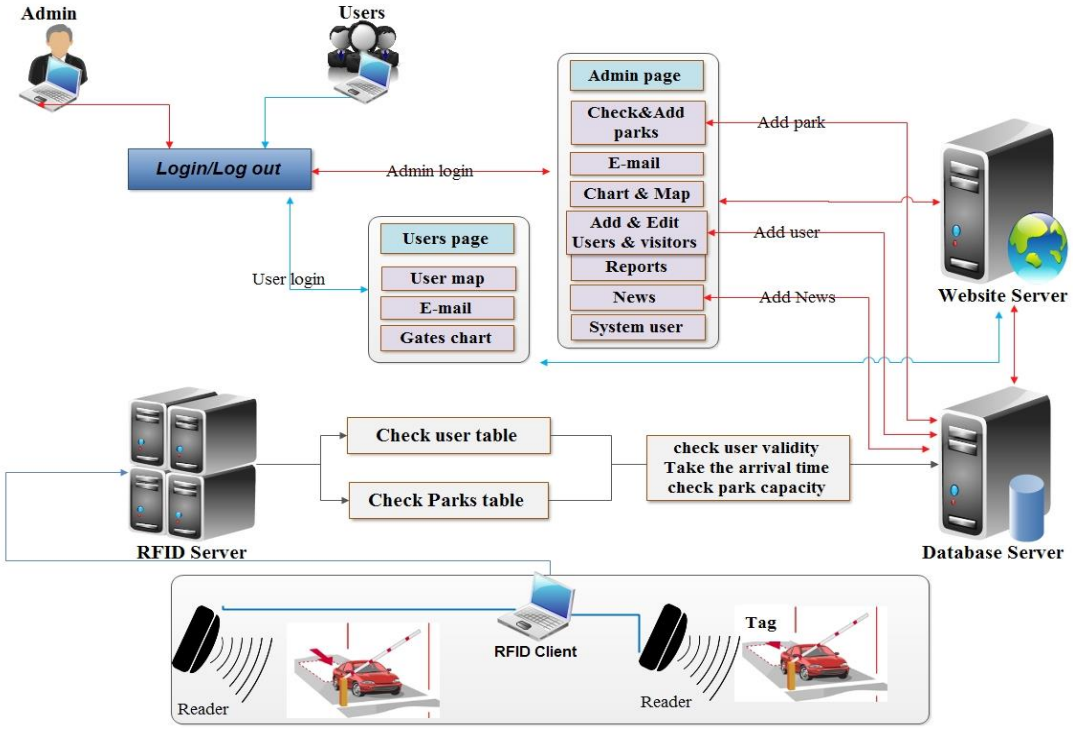

Figure 4. The Proposed System Architecture

The DB server keeps all records related to the registered client parks designated to different users (Faculty Member, Employee, Students, and Visitors) and the capacity of each of these parks. It is used to store all the essential records of vehicles in the campus, such as the vehicle identification number, the parking lots, the date/time and the ID of the reader which records the readings. The web services server provides some web methods that can be used by external applications like the front-end which is available from the Internet. To fetch these data, this server queries the DB-Server to get all records, parks information, vehicles information records and other related information. This system tracks all vehicles within the university campus. It can also monitor the locations of vehicles and the capacity of each park. The tracking and monitoring are done by RFID readers and tags. The system website will register and display any details in the database and generate daily reporting for all process in university campus. In the proposed VASNUC, each RFID reader and the Arduino controller communicate with a client PC via RS232 cable. The servo motor and IR sensor are connected to Arduino, while the clients PCs are connected to central server by UTP cable.

4. The System Structure

The VASNUC project is divided into two parts: software and hardware. The software part is implemented using (Microsoft Visual Basic 2012 program) that works on (Microsoft .NET Framework 4.0) environment and the large database system is designed by (MySQL Database Server version: 5.5.24). The web site is programmed using (PHP scripting language ver. 5.3.13, CSS and HTML), while the web server uses Apache web server ver. 2.2.22, Wamp Server Version 2.2 program and MySQL connector 5.2.7.msi to connect the client to the MySQL Database Server. The hardware part of VASNUC consists of RFID readers and tags, Arduino UNO as a microcontroller, servo motor with IR sensor to open or close the barrier, client PC, central server PC, USB to Serial Convertor to interface with the RFID reader, and PL-2303 Win 7 USB drivers to work with RFID.

4.1 Software Part

The RFID reader module is emulated using VB.net client and server sockets. It is important to understand that this virtual environment allows using the real protocol of the RFID tag and reader. A socket is one

endpoint which establishes communication between two programs that are running on the same machine or over a network. Sockets are used to represent the connectivity between client and server. A socket is exposed on the network as a port at an IP address. To use a socket we must program a server that creates the socket, associating it (or binding it) with a port. The socket will then wait for incoming requests. When the client connects to a port and the server accepts the connection then the server creates a new temporary port that is used for the actual send/receive communication with the server during the transaction as shown in Figure 5 (Gauld, 2015). This frees the original port for more incoming connection requests.

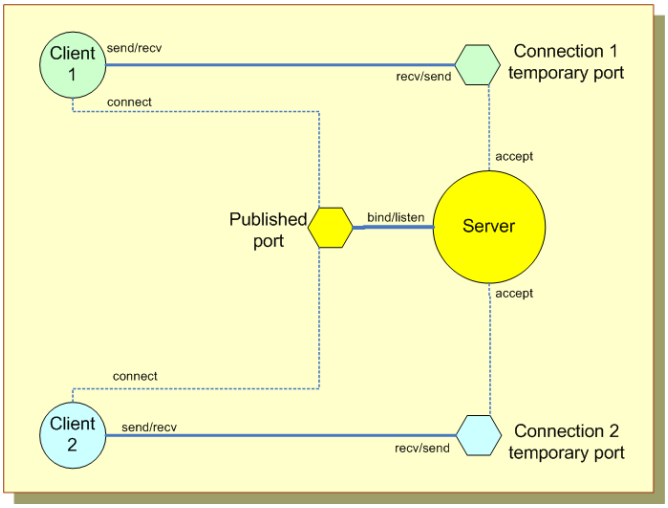

Figure 5. Client and Server Socket Ports

This system was implemented using real ELA816 RFID card readers to connect all parking lots and main gate at the same time, these RFID readers are successfully connected to client PC which is connected to the main server and all entry/leave records are done successfully in these parking lots separately using client-server sockets with different port number for each parking lot as shown in Figure 6.

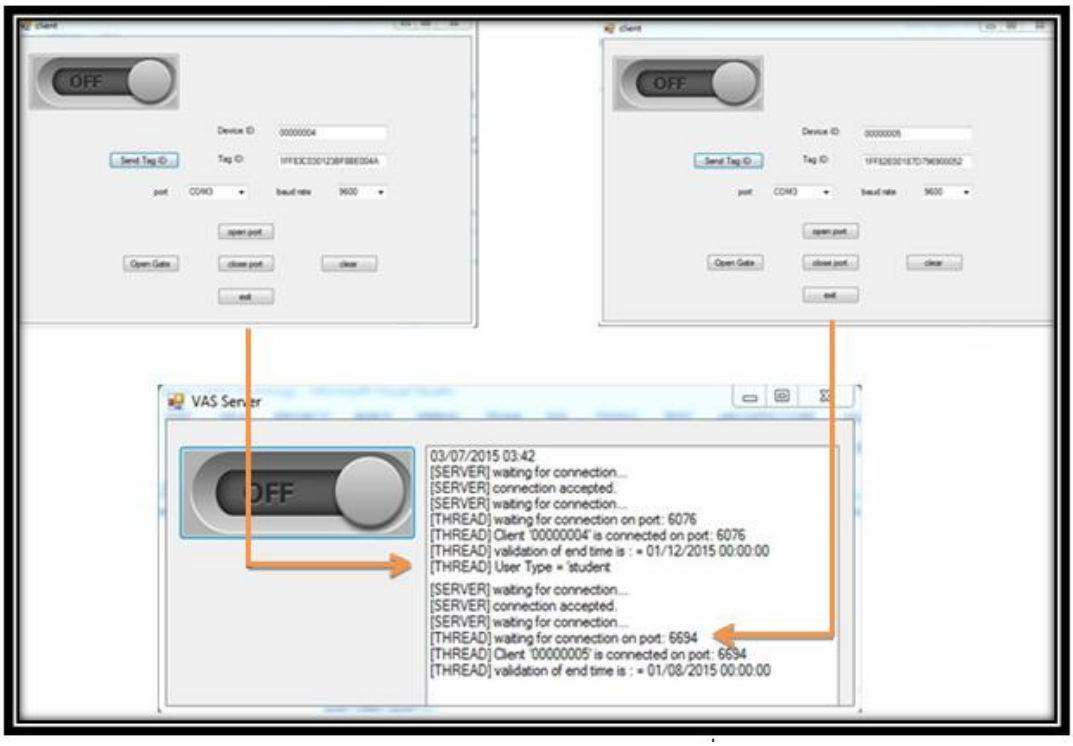

Figure 6. Multi-client Connection with the Server

4.2 Hardware Part

The RFID reader used in this system is the ELA816 card reader, which is a small range reader (typically 5-15 cm reading range). This reader operates at a frequency of 125 kHz. The ELA816 card reader is designed to provide access control. It is connected to an access controller, which is positioned at main gate or at specific parking lot to allow access for authorized vehicles only. The system contains Arduino UNO to control the barrier and IR sensor that is connected with client PC. Once the RFID tag passes over the card reader, the reader will handle all the RF and digital functionality required in communicating with the RFID tag. Then, the ELA816 card reader will pass the tag number to the host computer. If the vehicle is authorized the barrier is open and the vehicle is allowed access. The communication among the host, the reader and the Arduino is over a serial cable (RS- 232). Figure7 shows the implemented connection between the RFID reader and the host computer using serial port through RS-232, while Figure 8 shows the connection between Arduino UNO and barrier with host computer.

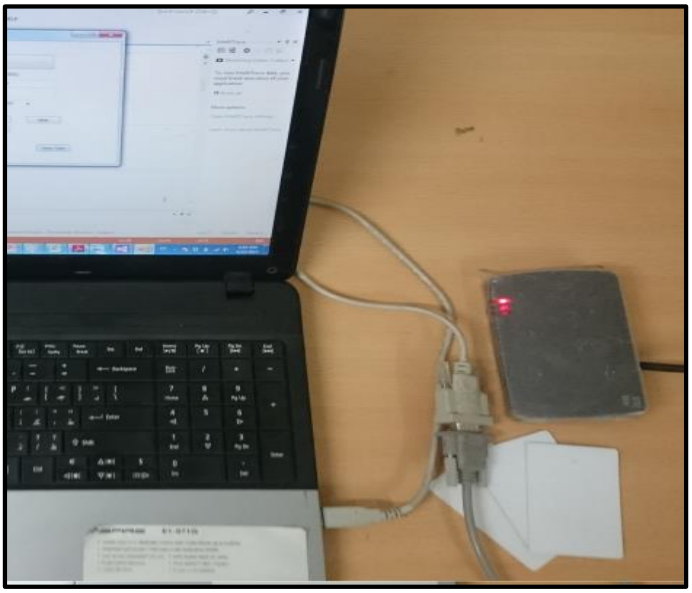

Figure 7. Communication between the RFID Reader and PC

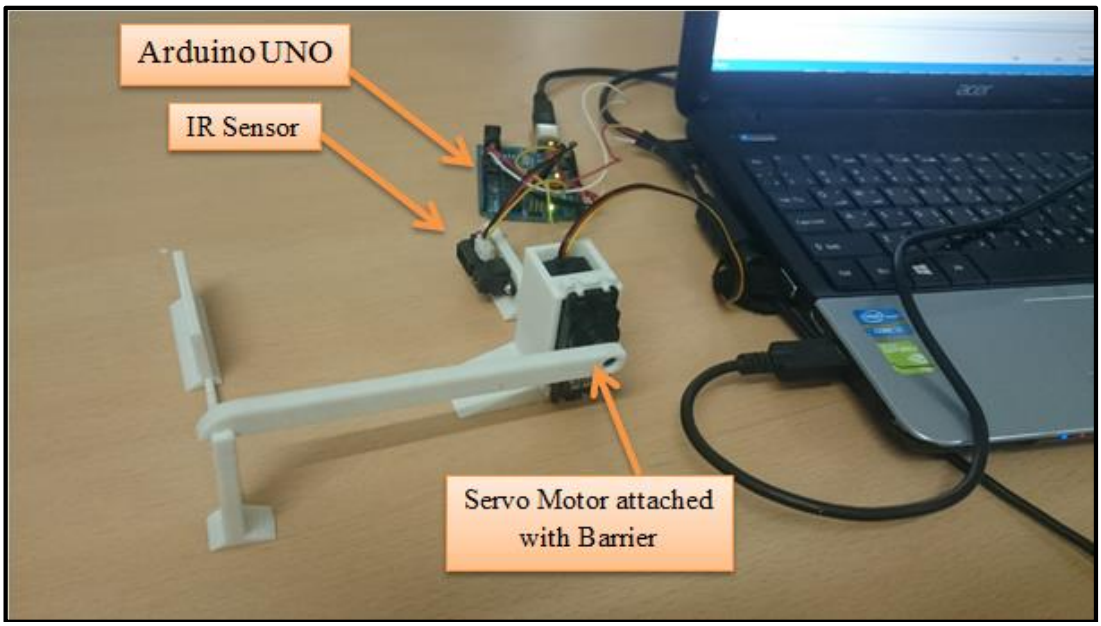

Figure 8. Arduino Connected IR Sensor and Servo Motor with the Client PC

The primary function of the client side application is to communicate with the RFID reader and Arduino UNO with barrier from one side and with the server from the other side. The flow chart of Figure 9 illustrates the interfacing procedure of the system.

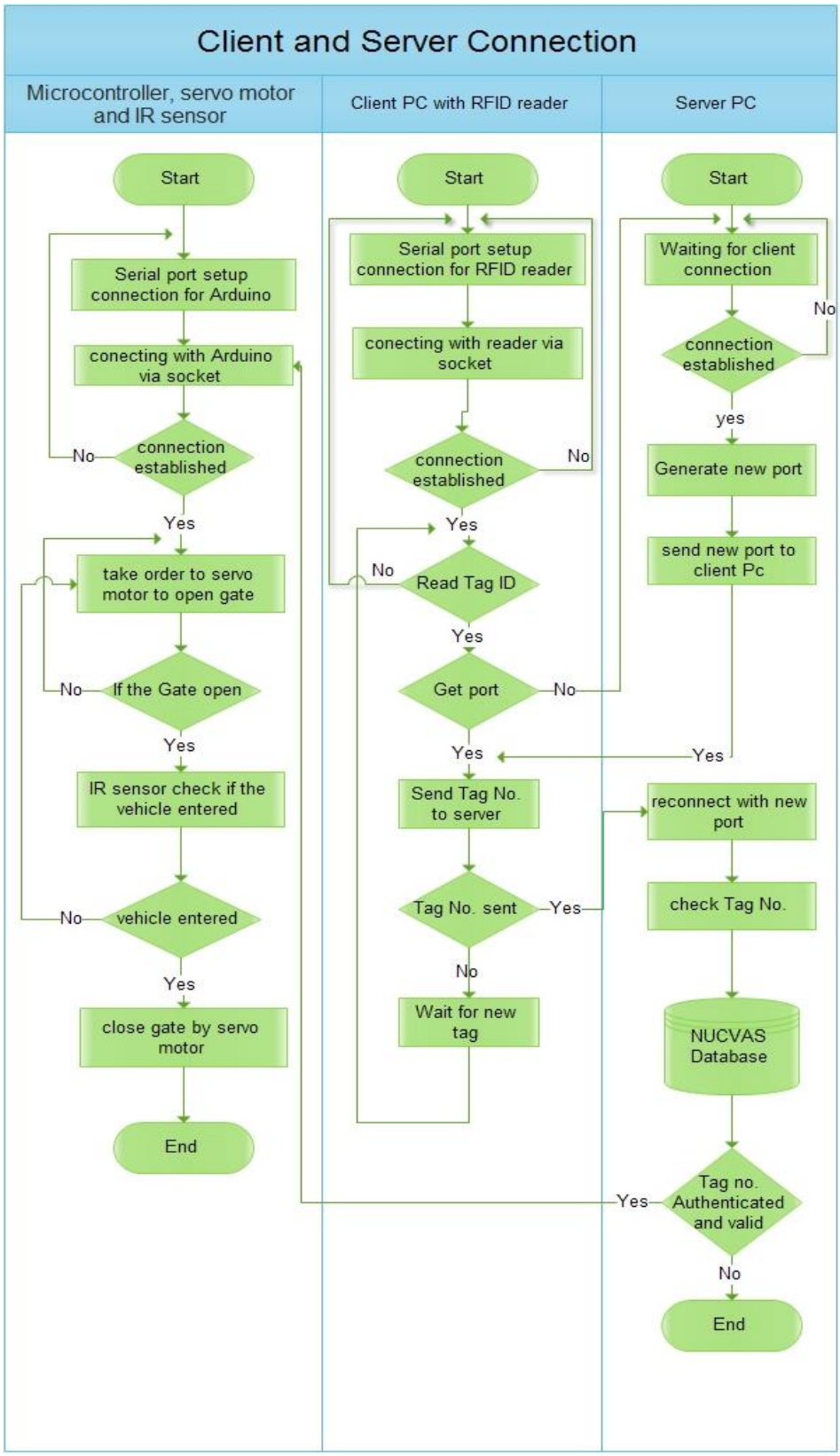

Figure 9. The interfacing with the System Requirements

5. System Implementation

The main function of the VASNUC is checking the entrance of authenticated vehicle and tracking it within the university campus. When the park is full the VASNUC does not open the barrier of the park. This system contains eight parking lots and each of them is used for specific users in the university. In the case of access to the university from main gate the main program will be executed according to RFID location which is installed in the main gate and the gates, parks and user tables are used to check the availability of vehicles in that park and gate. The main program steps are explained in the flow chart of Figure 10.

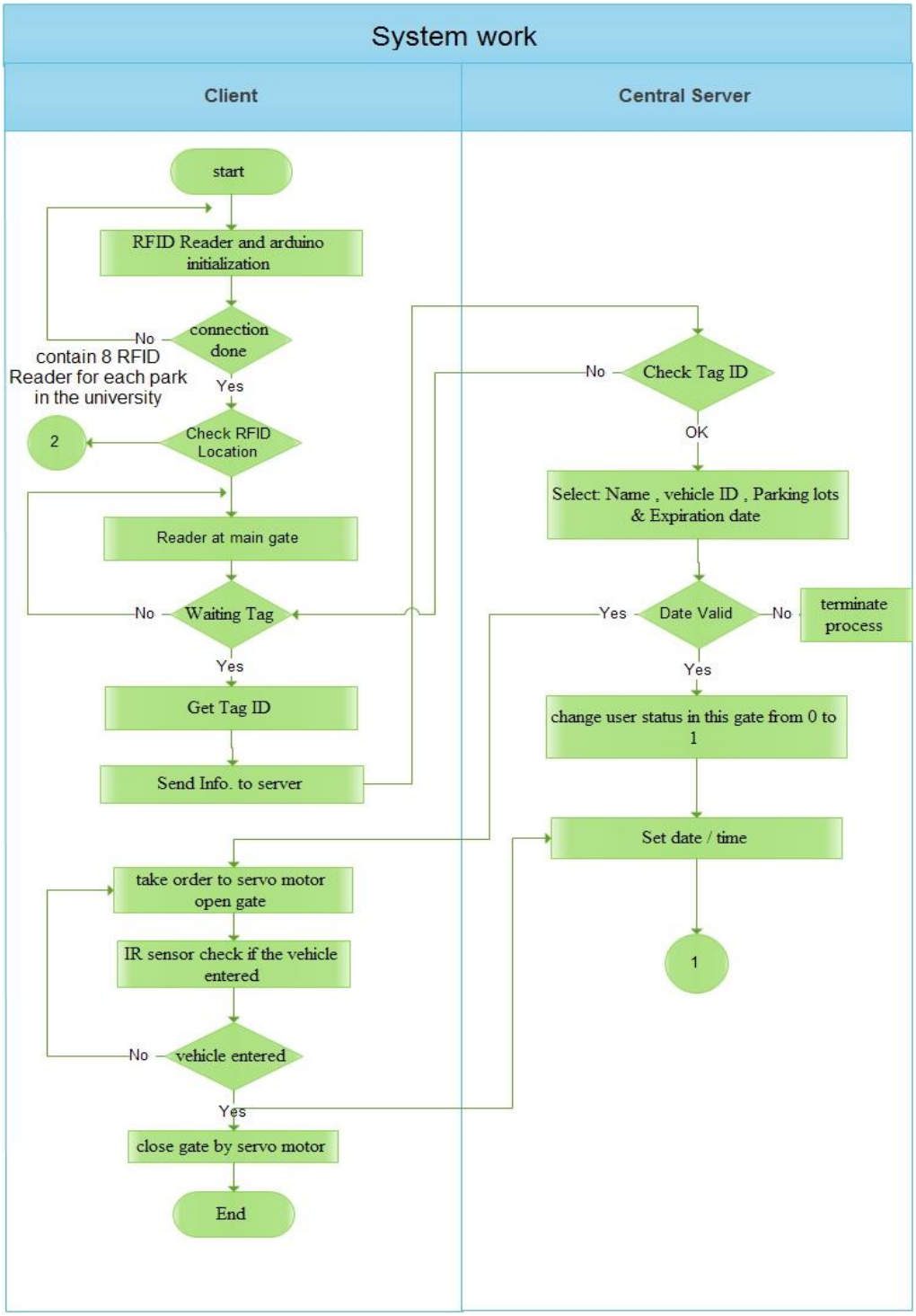

Figure 10. System Flow Chart

5.1 System Hierarchy

The system consists mainly of two major categories according to the uses of the system and can be notified as administrator level and user level. Each one of these levels requires a separate login form to access these facilities. This website was built to serve the user and to simplify the registration process and get approval to enter the user vehicle to the university parking lots, since it contains all information required by students, employees, faculty members, administrators and visitors as shown in Figure 11.

Figure 11. VASNUC Home Page

Administrators who are predefined in the database will be at the top of system hierarchy so they can access all users of university and check the entrance, departure and tracking of the users. They can also add, edit and update users and visitors information.

5.2 Preliminary Simulation Results

In this section the main website tabs will be discussed. The results show that the system works successfully in such an efficient manner that it can connect with readers and collect information in real time. Figure 12 shows the administrator main page.

Figure 12. The Administrator Main Page

This page consists of nine parts (System users tab, Users tab, Visitors tab, Reports tab, E-mail tab, Parks tab, News tab, Gate chart and final one is Gate map). Figure 13 shows an example of tracking a user in certain date that can be done by inserting his/her name, the tag ID and the duration, then press search to get all tracking information of that user.

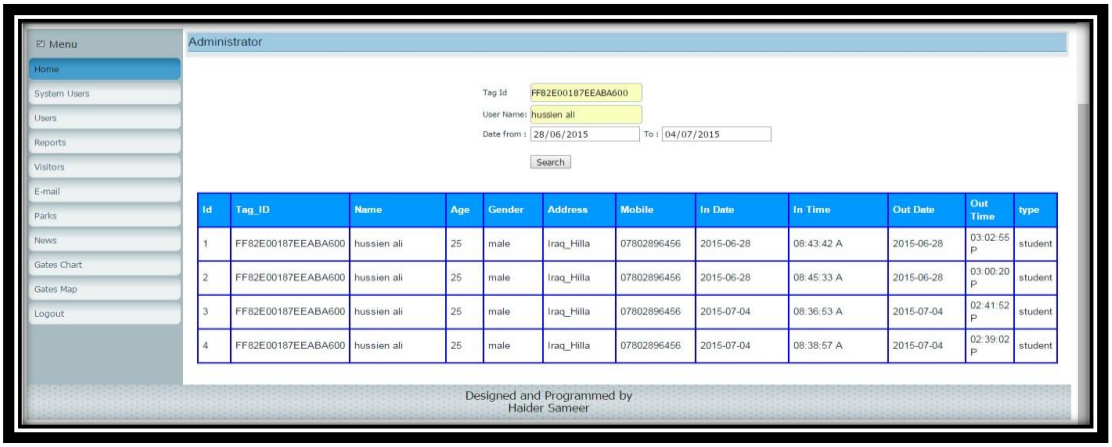

Figure 13. A User Report

Figure 14 shows an example of checking all the information concerning the daily access of users to and from the registered eight parking lost in the university campus.

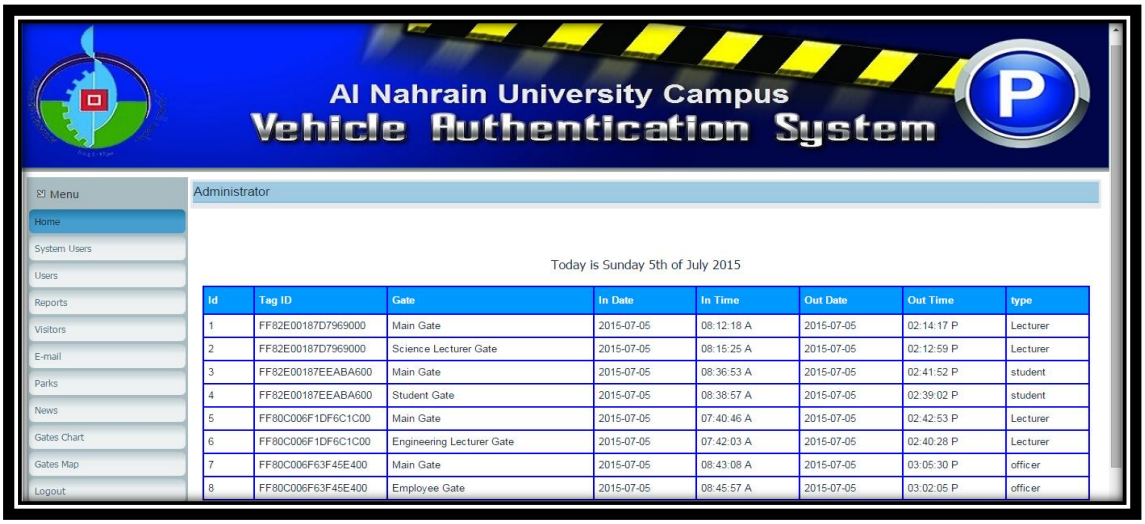

Figure 14. A Typical Daily Report

Figure 15 shows an example of Email facilities if the administrator decides to send any instructions or warnings.

Figure 15. Administrator Email Page

Figure 16 shows an example of checking the gates charts tab that displays all parks and their capacity at a specific time. From this facility one can find out the total number of vehicles in all and in each park in the university.

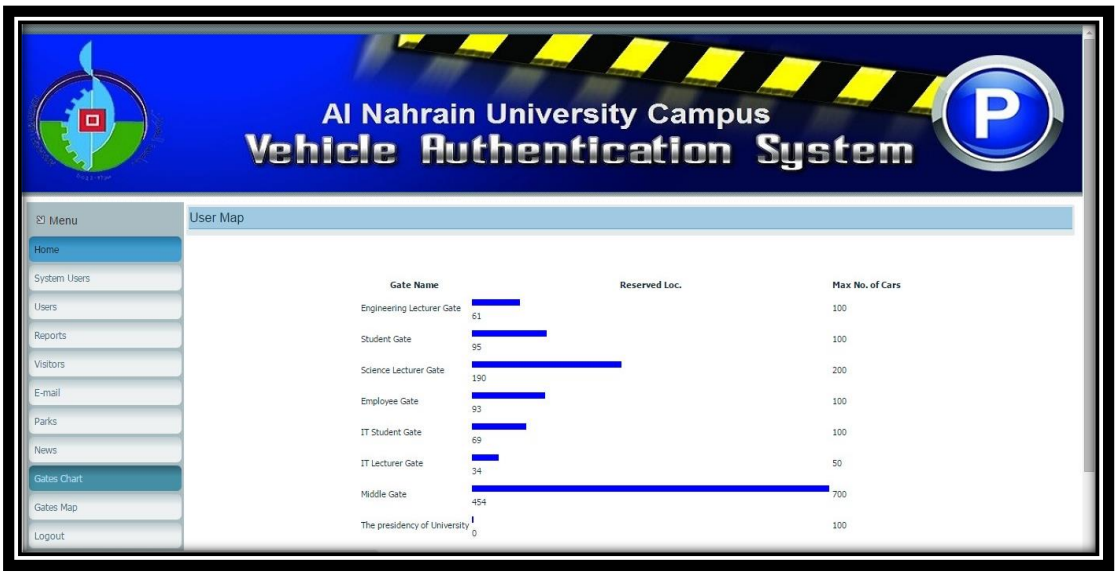

Figure 16. Gates Chart

Figure 17 shows an example to check the parking map that contains the locations of vehicles on the engineering faculty member parking lot of total capacity of 100 vehicles.

Figure 17. Parking Map

6. Conclusion

The presented system successfully merges the RFID readers and their tags with central database, such that all the parking lots in the university can work in fast and efficient manner. The RFID tag provides a secure and robust method for holding the vehicle identify. The web-based database allows for the centralization of all vehicles and owners records. This increases the security of data, as records can only be retrieved with an appropriate username and password, combined with the vehicle tag number. The proposed VASAUC website represents an attempt to fill part of Al-Nahrain university parking lots needs to offer e-services and to digitalize the request, store, view read and report for parking and tracking data about each vehicle access in these parks. Implementation of the VASAUC website over the proposed system decreases the time of renting servers, increase the security and privacy, which the VASAUC website is administrated and monitored under an authorized person and to accommodate any development process in the VASAUC website. The parking slots can be reserved by the registered user by sending a request to the administrator. The system calculates the number of vehicle of each parking lot automatically at access and leave time. The automation process is expected to reduce the waiting time for the users.

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