Parking Management System Using Mobile Application

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***Abstract*— In recent years, malls containing a concentration of shops and restaurants flourished in cities all over the world. This concentration is the cause of problems in parking spaces and traffic jams. This paper introduces a parking management system using mobile application to address the parking problems in malls. The contribution in this system is two folds. The hardware part which consists of custom-made sensor units based on a phototransistor with an infrared transmitter that is responsible for determining if a certain parking space is occupied or free. The units connect to a central controller wirelessly using Arduino microcontrollers with Ethernet shields. The central controller is a server hosting a database that is accessible through the developed mobile application. The mobile application is developed using the Eclipse IDE and runs on the Android platform. It connects to the database using JSON (JavaScript Object Notation) format. The users are able to use this application when they enter the mall. They can locate free parking spaces, check the parking fees, locate their cars, and even pay using the mobile application. A prototype for a parking mall is developed and tested. The functionality of the system is also tested and the results are encouraging.**

***Index Terms*— Parking Management System; Mobile Application; Arduino; JSON; Proximity Sensor.**

I. INTRODUCTION

In the past few years, cities in all countries are experiencing a huge growth in the number of cars used for transportation [1]. A general trend toward increased mobility and the concentration of shops and restaurants in malls have created parking problems and traffic jams. Frustration with parking is a major concern for all stakeholders involved [1]. Parking Management Systems were developed to help people find parking spots quickly, thus reducing traffic jams and the resulting frustration, and enhancing the visitor's experience [1].

Yanfeng and Cassandras [2] show the importance of parking management as a policy tool in suburban downtowns, especially in north-eastern Illinois. First, they compare conventional parking policy to actively managing parking. Then they discuss the success of the parking management in downtown using the key strategies taken in Oak Park. Wanner et al. [3] gives an advanced solution for managing and finding free parking lot and guides the user to the car in order to deal with the traffic and parking management problem. Implementing advanced parking guidance system significantly reduces time at the parking. The infrared sensors used in this system check the status of the lot and send the information to the AVR controller (Atmel, San Jose, CA, USA). The AVR sensor senses the existence of a car at the parking space and displays the information on LED screen for the user. It leads to reducing the time for the driver to find an empty space and reducing the chances of entering into the wrong space which might lead to traffic jam. Moreover, Wanner et. al. [4] present a wireless sensor network solution is discussed for parking management system. In [5], an interface between software and hardware module for car parking management systems is provided. This system provides an advanced management for cars and leads to a secure and organized parking. Many tests and experiments are implemented to show the viability of this smart parking system. Academic and industrial communities are very interested in wireless sensor networks that can be implemented in different settings to get information and use in different systems [6].

A vision-based automated parking system to describe a situation of managing a parking area is used in [7]. The system depends on coordinates in order to detect the free spaces and indicate their locations. The functionality of the system for a 4 space car park is shown. After implementing the system, it is concluded that this system is able to detect the free places and indicate their locations in the parking area [7]. O'Donovan et al. [8] proposed a system that could be used to monitor cars in a parking area. The driver can be informed, using this system, about the number of free parking spaces and their locations. Problems caused by implementing the wireless sensor network system in parking areas are explained, and solutions are proposed. On the other hand, Jin et al. [9] proposed a solution for the security issues available at the parking systems and eliminated the need of user interaction to simplify the parking procedure. The near field communication technology is used in order to identify the user's car.

Gwo-Jiun et. al. [10] validated the use of wireless sensor networks by developing SPARK: Smart Parking Management System. The system possesses advanced features, such as remote parking monitoring, automated guidance, and parking reservation mechanism. Hirakata et. al. [11] developed Spot and Park, a parking and event management system. It provides a way for users to find parking using their mobile devices. The

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system is composed of three main parts: the mobile web-application, the database, and the admin website. The user interface is adapted based on the user type, of which are three: visitor, staff/student, and admin.

The next section in the paper introduces the proposed solution which is a parking management system using mobile application. Then, the materials and methods used in the design and development of the system are described. Afterwards, the results of the testing of the system are discussed along with conclusions and future works.

II. Proposed Solution

The objective behind introducing this system is to have a well-organized parking system. The system automates the parking process. When a user reaches the parking, he/she will be automatically connected to the parking network, establishing connection between the client mobile and the mall/center network. Starting with the gate; the gate could be controlled by the application where the user can open the gate before entering and leaving. Note that the existing parking system is maintained, which means that if there is a user that does not have a smart phone, he/she might use the existing system. Furthermore, the user checks the application for a vacant parking space. Moreover, the space where there is a car parked is also shown. The user chooses a place to park, and he/she is able to see this location on a real map showing the exact place and whether it is close to the elevator or to the section that he/she is visiting. The user is just allowed to choose one space which is reserved for the user and is shown in blue, differentiating it from other spaces. After choosing a location, a timer records the time spent at this mall. The user is allowed to choose the time interval he/she wants and is notified as soon as this time interval ends (e.g. one hour). Every one hour, the user is notified that he/she has parked for one hour and specific amount of credit is withdrawn from his/her account. Note that the user must buy a prepaid card to pay his/her parking fees. After spending a long time at the mall/center and when the client decides to leave the mall, he/she simply clicks on “find my car” button.

III. Materials and Methods

The project fundamentally consist of two parts, the user interface part (the android mobile application), and the control part. To design a parking system, the project should be divided into stages; each stage is related to the steps that the client should follow in order to benefit from the system. Those parts are related to each other in order to have a coherent system that facilitates the client’s problems (Fig. 1). At the entrance of every parking, due to the ticket dispensers, the number of cars waiting in queues increases and causes traffic. That is why calculating the number of cars waiting at the entrance gate, the number of clients at the parking searching for a place, the number of clients who have found a place and the number of clients that exit the parking has been worked on. This allows the new client to know about the number of clients waiting and searching at each floor so that he/she can choose at which floor he/she can park his/her car. This method is used in order to reduce traffic at the entry gate of each floor, because after getting this information the client can choose the floor with fewer cars at the entry gate and also in the floor itself. When the client decides in which floor he/she can park his/her car, he/she uses the “choose floor” button available on the application to choose the floor at the application so he/she can enter the parking. This method allows the owner of the parking to benefit from reducing the traffic at the entrance of his/her parking.

When the client enters the parking, a map appears on his/her mobile application showing him/her the empty and full places in this floor so the client can choose one of the free spaces to park his/her car. When the client parks his/her car, the time is saved into the database to calculate, at the end, the time spent by the client at the parking lot and tell him/her about the amount of money related to this time. The time at which the user enters the parking is taken from the web server in order not to let the user change the phone’s time and cause problems to the system. When the client decides to leave, the navigation starts to show him/her the road in order to reach his/her car. This method is used by taking the distance from the mobile phone of the client to three routers in order to locate the user and then let him/her move step by step to his/her car. Using this method, the client does not spend a lot of time to find his/her car; he/she simply pushes the “find my car” button and the navigation starts till he/she reaches his/her car

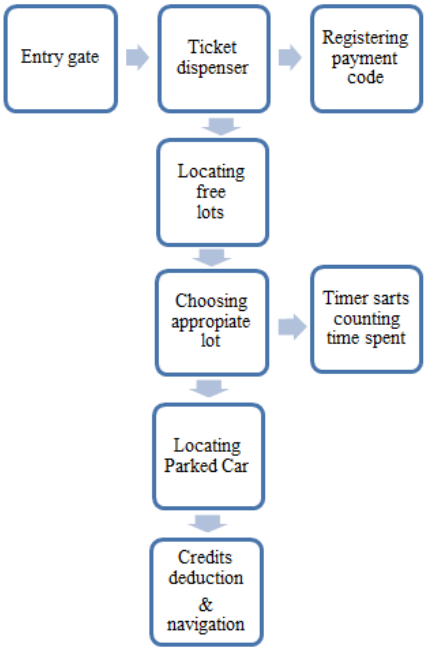

Fig. 1. System design.

At first, the circuit of the sensor and the amplification part of the distance covered by the sensor are made very small and simple to be able to sense the existence of the car. The value of the sensor is sent to the router using Arduino and Ethernet, in order to be read from the application. At the application stage, the work begins by receiving the number of cars at the entry gate and the number of cars in each floor to be displayed

at the main activity of the application. This work is done using JSON that allows the application to read a certain string from the web using a router. JSON: JavaScript Object Notation is an open standard format that transmits data between a server and web application, as an alternative to XML.

The "choose floor" button allows the user to choose in which floor he/she can enter. The design of the map shows the client if each space is free or reserved, and at the same time it lets him/her choose the space where he/she can park his/her car. When the client parks his/her the current time is taken from the web server and then saved at the application to be used later for the payment method in order to calculate the time spent by the user at the parking so the team is able to deduct money from the user's account. After choosing his/her space, the client fills certain information (first name, middle name, last name, phone number and plate number) to be saved in the web server database using Wamp server in order to have certain references for each user. This helps the owner to contact his/her clients if something wrong occurs at a specific situation. Wamp Server: is a windows web development environment. It allows creating web applications with PHP.

The user is given a certain time that is free of charge until he/she parks his/her car. Then the application asks the client to recharge his/her amount by buying a recharge card and filling the code number at the corresponding field in the application. Each hour costs the client a certain amount of money. A fee of 1000 L.L. is used for each one hour as an example. The client is notified about the remaining time, especially when this time is less than an hour so he/she is able to reach his/her car and leave the parking before the end of his/her remaining time, and if the client decides to stay at the parking, he/she can recharge his/her amount again. The time left is saved in the database to be used when the client comes back again to the parking.

Concerning the navigation, when the client decides to go to his/her car and leave the parking navigation starts to guide him/her to his/her car. At first screenshots of the parking are taken and the road for the client to follow in order to reach his/her car is marked. After that real triangulation consisting of finding the place of the client using routers, then calculating the distance between the client and the routers in order to guide him/her step by step to the car is made. When the client reaches his/her car and goes to the exit gate, the application asks him/her to push the "open barrier" to leave. At this stage, verifying that the client has paid the amount of money related to the time spent at the parking is checked. If not, the application asks the client to go back and recharge his/her amount to be able to leave the parking.

In a parking system, it is very important to take into consideration the measurement side of the project. At first, it was very important to validate the existence of the client at the entry gate of the parking, so the area covered by the router to cover the entry gate is reduced, so when the client presses the "choose floor" button, a specific code is written to check if the mobile phone of the client is connected to the router available at the parking before allowing the gate to open. If this mobile phone is not connected, a message appears on the application telling the client that he/she is not at the entry gate of the parking so the gate does not open. Then, the range covered by the sensor available at each lot is specified in order to eliminate any conflict with the other lot's sensor.

When a client enters the parking lot, the system checks if he/she is an old or a new user. The SQLite database in the mobile application is used to create a database for the application itself. This database consists of saving the information (especially the time left that is related to his/her amount) about the client when he/she enters the parking for the first time. When he/she enters the parking next time the system checks if the database is empty so the client is new, or if it is filled with specific information the client is an old user. In addition, a web server database is created to save all the information of all the clients entering the parking. This work is done by using JSON in the android eclipse to communicate with the server. When the client chooses the space where he/she decides to park his/her car, a code is written to check if the sensor of this space has changed its value from zero volt to five volt to verify that the client has really parked at this specific space. This is done by communication between the Arduino and the mobile application. If the value of the sensor related to the space chosen by the user is 1 at the Arduino code and at the same time it has the value "true" on the eclipse code, the system allows the user to continue using the system.

Concerning the payment method, a database is created using the Wamp server, containing all the recharging codes to be compared with the corresponding one entered by the client and verifies that it is valid and not used before. If this code is used before, an error message appears on the phone screen telling the user that the code is wrong and asks him/her to enter another code. In addition, while the client is at the parking, he/she receives notifications telling him/her about the remaining time especially when this time is less than one hour to give him/her time to recharge again his/her amount or exit the parking.

IV. RESULTS AND DISCUSSION

Before the whole project is tested, each of the hardware and the software is examined. The sensors implemented, the Arduino microcontroller interfacing with the sensors, and the software parts are tested to be sure that everything is functioning and performing the desired task. The project was tested on a mock-up that is formed from two floors where each floor is capable of having six cars to be parked. The moment the user is connected to the mall/center Wi-Fi, he/she is capable of examining the parking lots from his/her cell, able to manage the parking fees and determine the location where he/she has parked the car, all using the mobile application. Once the client is present in the mall/center, before getting connected to the mall/center Wi-Fi, the system takes the permission to establish this connection. After the client's agreement, if the client is a new user (Fig. 2), he/she must enter his/her initials (first name, middle name, last name, plate number and phone number), otherwise he/she is automatically recognized as an old user and skips this stage. In the built model, matchbox cars for trial and for demonstrating the

functionality of the system are used. When a car arrives to the parking lot, the sensor is activated. Accordingly, the sensor status is updated in the database and shown in the mobile each time the application is running, and, automatically, after every time interval the client is notified of the time spent at the mall and notified of the amount of money withdrawn from his account. The sensor status in the recognition process is based on the Arduino microcontroller that sends the data to the server through the network shield, after that data is updated to database (Fig. 2).

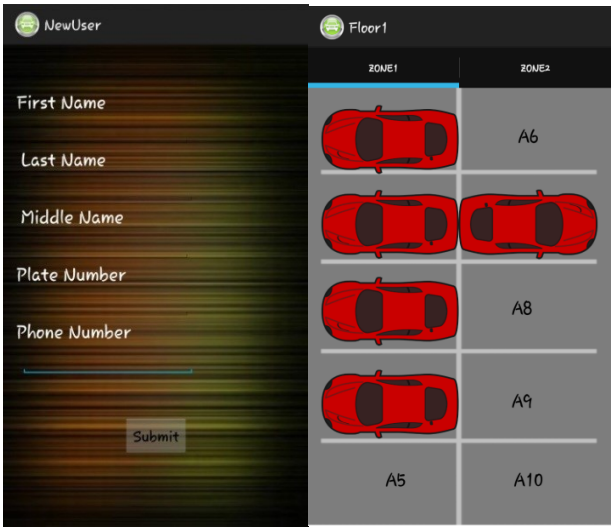

Fig. 2.User intials and Parking lots

The complete project is used to manage the parking lots using the mobile application, identify the free and reserved spaces, save the client chosen space and managing the payment fees.

V. Conclusions and Future Work

To sum up, Parking Management System using mobile app is a prototype of a parking and event management system. It consists of a mobile web-based application, the server containing all parking-related information, and database. This project facilitates the parking process, reduces traffic and saves time. Moreover, Parking Management System could be modified in such a way that it can be adapted to other places as universities, institutions and other kinds of organizations on different geographic areas with more features to benefit from.

In Lebanon, parking management systems, using mobile application do not exist yet. Thus, in terms of future work, the plan is to negotiate with the developers of one of the exiting parking payment applications to incorporate this technique in their framework. Moreover, the process of populating the database with real data provided from sensors and the institutions' records needs to be entered in an automated way to avoid the slow manual process. Also, work on extending the admin features on the mobile application to allow adding, deleting and editing events, as well as changing settings can be done (password reset, change email address, etc.). Lastly, the project could be modified in a way to apply navigation in the parking, using Wi-Fi triangulation in order to make the parking process easier.

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