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SYSTEM FOR PARKING PLACE RESERVATION

This paper focuses on describing the realization of an automated solution for parking place reservation. The architecture of the system and main workflow algorithms are given in details. The technologies used in development are described and the choice of them is justified. The relevancy of the topic is given to present the problem statement. The results of the work with detailed description are given. Practical meaning of obtained results: the developed parking reservation system may be implemented on real-life sites both independently and as part of large integrated systems.
Keywords: parking, automation, mobile application, cloud computing Wi-Fi, Arduino.

У статті описано реалізацію автоматизованого рішення для бронювання місця на парковці. Детально наведено архітектуру системи та основні алгоритми робочого процесу. Описано технології, що використовуються при розробці, і вибір їх обґрунтовано. Актуальність теми надається для представлення постановки проблеми. Наводяться резуль-тати роботи з детальним описом. Практичне значення отриманих результатів: розроблена система бронювання місць на парковці може бути впровадження на реальних об'єктах як самостійно, так і як частина великих інтегрованих систем.
Ключові слова: паркування, автоматизація, мобільний додаток, хмарні обчис-лення, Wi-Fi, Arduino.

Introduction

This study seeks to develop an intelligent parking system that efficiently allows users to locate an empty parking lot in the shortest possible time and keeps track of the activity of the parking lot. The system is able to provide information exchange by wireless data transfer provided by Wi-Fi technology for user interaction with client application and system installed in the parking area.

To achieve this goal, the following tasks were performed: hardware basis analysis for model construction, analysis of technologies and services for the software component, development of an experimental model, testing and verification of the system.

Relevancy of the topic

The relevancy of the question concerning parking in cities increases every year. An effective process of arranging parking areas can solve the current problems of urban planning, as well as increase the income of local budgets and create a new space for business development. Besides the financial aspect, the mindful organization of comfortable parking areas significantly improves the quality of life and satisfaction of residents. In particular, the development of infrastructure has a significant impact on the development of the tourism industry of the city.

The parking bay or simply parking is a specially designated space for parking vehicles. The boundaries of each parking space (parking lot) are determined by the layout. There are three types of parking bay: aboveground, on-ground, and underground parking. The analysis of parking presented on the real estate market shows that in Ukraine there are popular parking bays designed not as separate structures, but as attached to an existing building: a house building, office, or shopping centre.

The problem with the parking system of Ukrainian cities, Lviv in particular, is that the demand for parking spaces is growing and what the city offers to drivers is not enough. This leads to congestion and blocking car traffic on the streets, which causes inconveniences not only to drivers but also to pedestrians, violates the environmental regulations and more. [1] According to statistics for 2016, 180,000 car owners are registered in Lviv and their number is constantly growing. If in 2014 39% of respondents said they had a car, in 2019 there were already 43%. [2]

In accordance with the UNIP website, every third car on the road is looking for a free parking space, and drivers spend an average of 5 to 20 minutes looking for parking. As a result, drivers waste time, cars burn petrol, which constantly pollutes the air with carbon dioxide emissions.

In general, 95% of the time cars spend in parking lots, so solving the problem of organizing such zones and setting parking rules in cities is a good way to regulate the use of cars. [3]

Users of automobiles spend a lot of time in the parking lot trying to locate where to park. In today's ever busy working environment, drivers hardly have time to spend in parking bays looking for where to park. In many places, especially around shopping malls, universities, city centers, and many other busy working environments, finding parking have been noted as one of the major causes of stress in the lives of those who drive.

In busy towns and cities, parking management still poses a challenge that keeps growing more complex. The need for efficient parking management systems can't be emphasized enough for such cities.

In Ukraine and around the world today there are many solutions to improve the quality of parking bays in cities, which are useful for both their owners and the drivers themselves. One of the most common solutions is parking automation.

Implementation of automated systems helps to reduce the cost of operators involved in parking maintenance, promotes security and gives a hand in control and audit.

There are few levels of parking automatization: from automatizing only a part of it to complete automatization.

Also, many ways of driver or vehicle identification exist. These include paper tickets, with or without bar- or QR-code, RFID tag cards, tokens, remote controls, license plate identification and more.

Amongst many functions and features of various automated parking bays solutions, with all the ways of time accounting and payment for services, counting the number of free parking spaces in many cases is presented as an additional feature that is not present everywhere.

Justification of mobile application as the solution

Every year, mobile applications tend to develop faster and faster and have already become a necessity in almost any field of life or business.

According to We Are Social, in 2017-2018, 58% of Ukrainians used smartphones every day, 71% used mobile applications, and about 55% of users ordered goods and services via the Internet.[4] In addition, smartphones were used for many other things, such as online banking, booking vacations, studying, communicating, searching and viewing any information, and many other things that can be done by using a personal computer. More and more companies are offering their customers mobile applications as an alternative way of getting information or services, on a par with websites.

According to the statistics collected by App Annie company, back in 2017, revenues from mobile applications amounted to about $17 billion. Moreover, in the same year, more than 60% of traffic to the web resources of microfinance organizations in Ukraine was transferred from mobile devices.[5] The domain of mobile applications is now developing even faster than before. They have taken a strong position and

popularity among users, as their use has a number of advantages over web versions, including portability, the ability to be used from literally anywhere having access to the network.

Software development for mobile devices process differs from other types of software because each of them has its restrictions or limitations. They need to be kept in mind while creating a mobile solution.

Such restrictions are represented not only by another user interface appearance and a wide range of display sizes but mainly consist of hardware capabilities. These include lower CPU capacity, memory, and battery power.

However, mobile devices, except portability, have benefits that personal computers cannot provide. For example, the ability to use the built-in camera, geolocation service, as well as cellular technology for calls and SMS. Software development for mobile devices requires the use of special programming environments that include emulators and the possibility to connect physical devices for debugging and testing programs.

The purpose and functionality of mobile applications are very diverse. All applications can be separated into 2 categories: native and hybrid. Every one of them has its peculiarities and use cases.

Native applications are those which are developed especially for a specific mobile operating system - Android or IOS for Apple devices. While working on such applications developers must take into account the specifics of the platform configurations and access to all of its resources and hardware capabilities.

The advantages of the type described above are simplicity and intuitiveness of the graphical interface since designers inherit design concepts created for that very platform. Therefore, mastering the application is easy for the user, because the native gestures for the platform, animations, positions of elements, etc. are used.

Besides, native applications have relatively higher speed and stability of work, because their functions are optimized for a given operating system. Application data is often stored locally on the device, which also has a positive impact on the speed of work and decreases application dependency on the Internet. Such a type of application has access to usage of all the operating system resources and components: GPS, camera, contact list, audio devices, microphone and so on. Given so they can embody wider functionality.

On the contrary, hybrid applications are more versatile, because they are created simultaneously for different platforms, have the same design and functionality, regardless of the OS of the device. It can be said that it is a website in the mobile application form. They are cheaper, faster in development and entering the market. Due to their adaptability, hybrid applications are more accessible to a wider range of consumers. [6]

One can make the most of the functionality and all the benefits of mobile applications by accessing the Internet. Smartphones have two options for that. The first one is to use wireless technology, Wi-Fi. The second one is cellular networks. Certainly, from the point of view of organization and automation of the parking area, access to the Internet is also important. It is required for data exchange with databases. In addition, real-time data transfer is needed for the parking bay client and its automated system.

Nowadays a lot of mobile applications allows making the parking process more convenient exist.

In particular, one of the most common parking applications in Ukraine is UNIP. It is designed so that you can find a parking lot, get information about it, pave a route to it, book and pay for a parking space directly via smartphone.

Overview of used technologies

Nowadays automated systems based on microcontrollers are used in any part of human life. From complex systems aimed to automize and improve the accuracy and quality of industrial processes to daily home use for improving comfort and safety.

Smart networks, houses, intelligent city infrastructure, vehicles are systems that connect our everyday life more than we ever thought possible. The common vision of such systems is usually associated with one concept - the Internet of Things (IoT). IoT refers to the interconnection of uniquely identified embedded computing devices within an existing Internet network, where the entire physical infrastructure is closely

linked to information and communication technologies, where intelligent interoperability can be achieved through the use of embedded network devices.

The top layer of the IoT concept is represented by various applications managed by different popular platforms, such as Android, Windows, IOS, and so on.

The important role in the development of the concept of the Internet of Things was played by wireless technologies, of which one of the most common is Wi-Fi. The implementation of the technology allowed the creation of contactless microcontroller systems, providing flexibility in their usage. Unlike using wire standards, such as Ethernet, wireless technologies do not require cabling. It makes the implementations of intelligent systems easier in locations that are hard to reach and expands the capability, scope, and ways of their appliance.

The segment of wireless technologies in telecommunications does not stop its growth. The rapid development of mobile devices, which are mainly built on wireless technology, is quite conducive to this.

Wi-Fi has become the most popular wireless network protocol of 21 century. When other wireless protocols work in specific situations, Wi-Fi technology supports the majority of home, business and public networks. Some people, by mistake, refer to all types of wireless networks as "Wi-Fi", when in fact Wi-Fi is just one of many wireless technologies.

Wi-Fi, which stands for Wireless Fidelity, is a technology by Wi-Fi Alliance trademark based on the IEEE 802.11 standard. IEEE 802.11 is a set of specifications for medium access control (MAC) and physical (PHY) layers for implementation of computer communication of a wireless local area network (WLAN) in the frequency bands 900 MHz, 2.4, 3.7, 5 GHz and 60 GHz. [7]

They are the world's most common standards for wireless computer networks, which are used in the majority of home, office and industrial networks to allow laptops, printers, smartphones and other devices to communicate with each other and access the Internet without wires. They are created and maintained by the Standardization Committee LAN / MAN (IEEE 802) of Institute of Electrical and Electronics Engineers (IEEE). The Committee aimed to develop a standard that would become the best wireless alternative for wired networks TCP/IP standard.

The main requirement for Wi-Fi availability of a device that can transmit a wireless signal, such as a router, phone, or computer. With the spreading of wireless technologies in microcontroller systems, its interaction process with the user becomes much more simple. After all, providing access to the system to the Internet, everyone with a smartphone can access it from almost anywhere on the planet.

Furthermore, having access to cloud services, the process of developing and implementing many systems has been facilitated by the fact that their usage does not require customers to have high-performance software and hardware computing resources. Cloud computing technologies allow to combine information and computing resources of hardware platforms into one single integration and to provide the user with access to them via the Internet.

In other words, cloud computing technologies are hardware and software remedies, methodologies and tools, that are given to a user as Internet services for implementation of his tasks and objectives.

Main capabilities of cloud computing:

1. Access from any computer to powerful computing resources via the network when those are located on remote servers not operated by the user directly.

2. Possibility to work with information from diverse devices (personal computers, tablets, smartphones, etc.)

3. Work with services does not depend on the operating system.

4. Users can view and process the same information simultaneously from different devices.

5. There are a plethora of popular cheap or even free services.

6. Information is independent of user device memory, so its safety and integrity are guaranteed.

7. Information is always relevant.

8. Services provide high data processing speed, safety, and fault tolerance.

Certainly, besides the advantages, there are also a couple of disadvantages. These include the need for a constant connection to the network, not all software is capable to work with cloud technologies. Confidentiality and security are contentious issues. Although cloud storage by itself is a quite secure system, however, intruders can gain access to vast amounts of information.

One of the most popular types of cloud services is Database-as-a-Service. It allows working with databases as though a database management system was deployed on a local resource. In the case of using the cloud service, the process of access sharing between different executives and clients are simpler and more economical. That is because the deployment of computing capacities locally is far more economically unprofitable.

Description of developed solution

The solution that aims to improve the parking process is an automated parking place reservation system, developed with Wi-Fi wireless technology and a mobile application.

In the system, the wireless connection to a Wi-Fi network is performed with help of the ESP-01 module based on the ESP8266 microcontroller designed by Espressif Systems and its interaction with the Arduino Uno board.

The system developed in this study consists of several parts. An LCD connected to an Arduino board is installed in the parking area near its entrance. The Wi-Fi module is also connected to the board and receives power from it. The module transmits data for LCD via a serial data interface. The ESP-01 Wi-Fi module is connected to an Internet network that is provided by connection to the router with SSID and password authentication.

The overall system interaction is provided by using real-time cloud database service Firebase by Google. All parking bay and reservations data is stored in Firebase Realtime Database. The client authentification service, that allows drivers to keep all their activities in a separate account, is Firebase Auth [8].

A QR code is attached at the entrance, which must be scanned through the mobile application for registration. When leaving the parking lot the driver also must scan a second QR-code which is located at the exit. That action registers the departure of the car.

The driver who comes to the parking bay has a native Android mobile application installed on his smartphone. The driver must create an account to perform any operation in the application. The mobile application is developed in Java programming language.

The following picture demonstarates the overall structure of the developed parking reservation system.
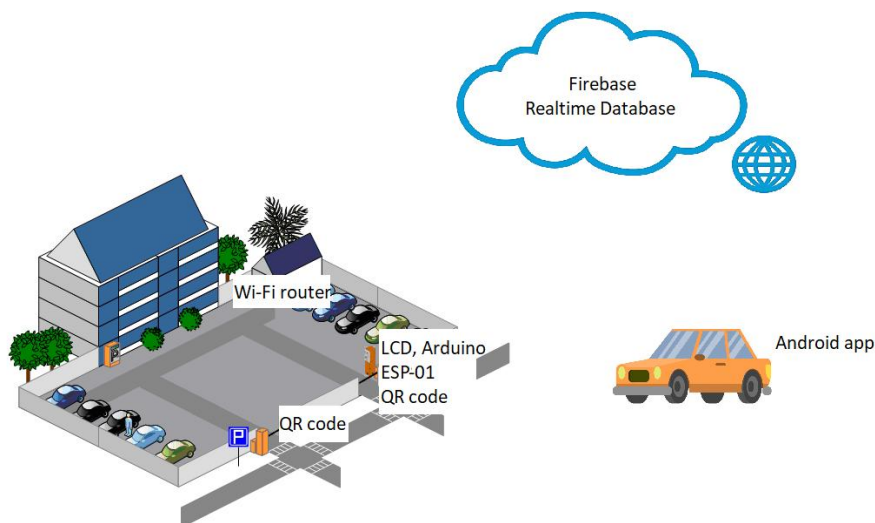

Figure 1. Context diagram of the structure of the developed system

The connection circuit of the hardware part, which is installed directry on the parking bay, is given below.
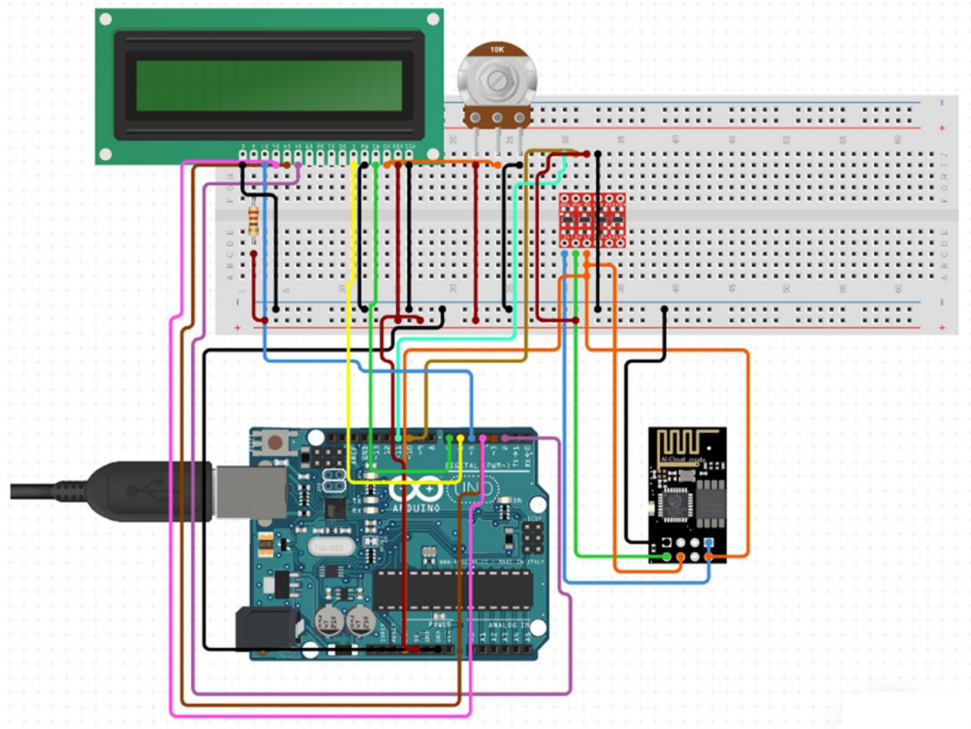

Figure 2. Wiring diagram of the hardware parking system

The application administrator can register a new parking bay in the application. To do this, a user logs in with the administrator's login credentials, opens the admin panel in the application and creates a new parking bay by entering the necessary information.

When developing a mobile application, three use cases for using the system were consideres in the project. The first one allows an administrator to register a new parking bay in the application. The other 2 are for a driver to use parking. He has 2 options. He can enter the parking bay with a prior reservation of a lot in it. The last use case describes the process of entering the parking without having a booked parking lot. In this case, the driver can take a free lot if there are such just after arriving at the parking.
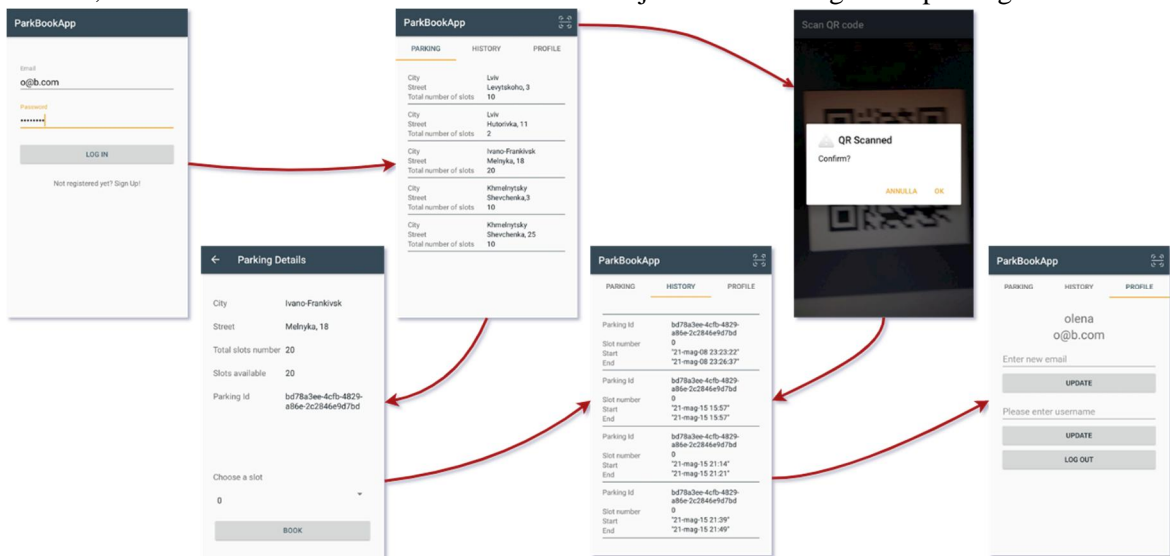

Figure 3. Screenshots of main mobile application activities

Conclusion

A native mobile application was developed for the Android platform for booking a parking lot and registering every entry and exit of a vehicle by scanning a QR code through a built-in camera of a mobile device. The system has been developed for the parking bay to display up-to-date information on the number of free parking spaces on the LCD installed so everyone can see the information provided. The data is synchronized with the real-time cloud database and transmitted using wireless Wi-Fi technology, which is based on the ESP-01 module and the Arduino Uno platform.

There are many information technology solutions to improve the quality of life in cities. Facilitating the process of finding free spaces in parking areas is one of the domains where automated systems can be used. The implementation of such solutions not only increases the level of comfort of drivers and ordinary citizens but also can have a positive impact on the environmental situation of the city. Reducing the time spent searching for a free parking space has a direct effect on reducing the amount of harmful gas emitted by the car into the atmosphere while it wanders the city. The implementation of such systems can also help parking owners or managers by providing metering of traffic flow for analysis of use and future improvement.

The chosen technology of wireless data transmission Wi-Fi is justified by the fact that it is not always possible to use wired communications in parking areas, while the wireless Internet access point can be located literally anywhere in the signal range. Even in the case of interference or a weak signal, the problem of delayed transmission of relevant information is not so critical.

The system can be expanded with the ability to pay service fees by connecting payment systems, as well as with integration with automatic access systems, such as a barrier.

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