IoT Based Smart Vehicle Parking System for Urban Area in Sri Lanka

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Abstract

The use of vehicles is essential to the human lifestyle. Due to the increase in the number of vehicles, the shortage of parking spaces in urban areas is increasing. Although there are many ways to solve these problems, such problems still exist. This research aims to build a smart parking system to overcome the issue of parking space availability using Internet of Things (IoT) technology. This proposed smart parking system is based on Arduino, Firebase cloud application, and android mobile application. The parking area is built and simulated with Arduino components. Further, this system is connected with an android mobile application for users. This smart parking system gives an opportunity for drivers to park their vehicles by eliminating waiting time and excess money. Drivers can see parking slot availability in the parking area using their mobile. Also, the mobile application displays parking times. On the other hand, the parking area is automated, and human interaction is not required. The gate automatically opens and closes when a vehicle enters the parking entry and exit area. This system provides real-time processes and information about the parking slot in the android application. Also, the parking owner can control the main gate remotely. This project leads to reducing fuel consumption. Also, it resolves the problem of growing traffic congestion and could reduce the human time of finding parking slots.

Keywords: Internet of Thing, Arduino, Firebase cloud, Realtime process, Android

I. INTRODUCTION

These days, almost everyone has used a personal vehicle for their transportation and it has become a basic need for humans. On that, it has been statically proven that the usage of the vehicle is increasing rapidly yearly. Due to this, there is the biggest problem in urban areas to find the parking place, especially in malls, stations, airports, schools and hospitals etc. The workers of the above public and private institutions have faced more challenges like a time consuming, trafficking and additional fuel consumption.

The Internet of Things (IoT) concept explains things with identity communication devices. The IoT devices could be tracked, controlled and monitored using remote computers or mobile phones connected with the internet. Two prominent worlds include in the IoT are “internet” and “things”. Internet means a network of devices connected via global such as servers, computers, tablets and mobiles using an internationally accepted protocol. Thing is a term used to refer to a physical object which is connected through the internet.

The microcontroller is the main element used to control IoT devices and sensors. The specific software application is used to control and monitor the IoT devices and can use an android application to access via mobile phones.

This research mainly focuses on IoT technology and android development. The author built a simulation system that was used to evaluate the performance of the system. The Internet of Things (IoT) is a new paradigm that allows electronic gadgets and sensors to communicate with each other over the internet to make human lives easier. Smart devices and the Internet are used to provide new solutions to a variety of challenges and issues faced by businesses, governments, and public/private organizations around the world (Kumar et al.,2019).

Arduino is an open-source platform used for building IoT-based electronics projects. Arduino is made up of a physical programmable circuit board (also known as a microcontroller) and software known as an IDE (Integrated Development Environment), which runs on a computer and is used to write and upload computer code to the physical board. This research has used the Arduino NodeMCU ESP8266 board as the main controller in the parking area (Louis et al.,2018). Android is an open-source Linux-based mobile operating system developed by Google. It

is used primarily for touchscreen devices, like mobile phones and tablets. Its design allows users to intuitively interact with mobile devices, with finger movements that mirror common movements, such as swiping and tapping.

The Firebase cloud application is used for this research work, and it is a Backend-as-a-Service (Baas). Firebase offers several tools and services to assist developers in creating high-quality applications and expanding their users. It is built on Google's infrastructure. Firebase is categorized under the NoSQL database program, which stores data in JSON-like documents. Firebase optimizes the applications with a number of services like Authentication, Real-time Database, Analytics, Storage, Hosting, Testing, and Monitoring (Moroney et al., 2017). This research has used the Firebase cloud application to establish the data transmission between the Arduino board and the Android mobile application.

There is a shortage of vehicle parking spaces, especially in urban areas, due to factors such as urbanization, population growth, and increased vehicle users. Particularly, Cities like Colombo and Kandy in Sri Lanka face these issues. Even, Traditional parking systems need human interaction to control their gates manual, and drivers are facing more difficulty in finding the availability of parking slots for their purpose.

Therefore, this study proposes an automated smart parking system for vehicle users in urban areas. This proposed system is based on IoT technology controlled by an Android application called Smart Parking System. Smart parking system gives details about available parking slots to drivers. Besides, it can control the gates automatically using sensors. This mobile application is user-friendly. Hence, users can access and understand parking details easily. Additionally, a smart parking system can facilitate the user to make payments through online. So, it saves time and expenses and effective uses of parking space in an urban area.

The objective of this study is to build a smart parking system that overcomes the problem of parking space availability of vehicle users in the urban area. The IoT-based smart parking system gives a user-friendly interface for the application user.

The scope of the study mainly includes Arduino, Firebase cloud application, wireless network and mobile application development.

- This research is mainly based on IoT technology. The Arduino platform plays a major role in IoT projects.
- Arduino NodeMCU ESP8266 board to build a connection in the parking area and as well as used Arduino IDE for programming codes into the Arduino board. Th s Arduino board helps to send information to a mobile app through the firebase cloud using Wi-Fi.
- Used IR sensors, servo motors and RTC modules for the operation of the parking area. IR sensor provided data to Arduino board, when the vehicle was detected or not. Se vo motor operated the parking gates and the RTC module provided time information.
- Firebase real-time database feature used to create data communication between both the NodeMCU board and the Android mobile application.
- Android Studio software is used to develop an Android mobile app. Android Studio is the official IDE for android application development.

II. LITERATURE REVIEW

Problems such as urbanization and population expansion are common in all countries. Scholar around the world proposes IoT technology to solve such kind of issue from a different angle. IoT plays many roles in people's lifestyle changes such as smart city projects, automobiles, agriculture, transportation, public security, environment monitoring etc (Alan T.,2021). This section describes and illustrates a few recent research articles more related to this research.

IoT-based cloud integrated smart parking system was presented by Khanna et al., the Smart Parking system consists of an on-site deployment of an IoT module that is used to monitor and signalize the state of availability of each single parking space. A mobile application is used to check the availability of parking slots and confirm the slot accordingly. This presents a high-level view of the smart system architecture. The working model is explained with a use case model that proves the correctness of the proposed model (Khanna et al., 2016). Gulam et al., proposed a framework based on a deep long short-term memory network to predict the availability of parking space. The authors use IoT, cloud and sensor networks to produce the Birmingham parking sensors dataset data. The experimental results showed the superiority of the proposed model over the state-of-the-art prediction models (Gulam et al., 2020). Luque-Vega et al., presented a novel sensing

solution that is the cornerstone of the smart parking system for vehicles. The system is named as SPIN-V. The SPIN-V is built with a small single-board computer, distance sensor, camera, LED indicator, buzzer, and battery and is devoted to obtaining the status of a parking space (Luque-Vega et al., 2020). Vehicular Crowdsourcing for Congestion Support in Smart Cities (VACCS) proposed by Olariu, Stephan. VACCS provide benefits to Smart City and driving the public to use resource efficiently. Timing planes respond to current traffic conditions, overall traffic flow will improve, fume emissions will be reduced and economic impact will mitigate. VACCS system work efficient in certain conditions (Olariu, Stephan, 2021). Ashok et al., proposed a Smart Parking Energy Management solution for a structured environment. The authors presented an IoT technology to mold with advanced Honeywell sensors and controllers to obtain a systematic parking system for drivers. Unused vehicle parking slots are indicated using emitting lights and users are guided to an empty parking slot, thus eliminating the users' searching time for a parking slot. The entire system that is fully automated reduces workforce involvement and improves the lighting aesthetics of the parking area. This paper aims to improve the time value of the user and the convenience of the parking system (Ashok D, et al., 2020)

III. METHODOLOGY

Research methodology is the specific procedures or techniques used to achieve the research objectives. This section explains how the parking simulation systems are built, software and hardware requirements, data flow diagram, etc.

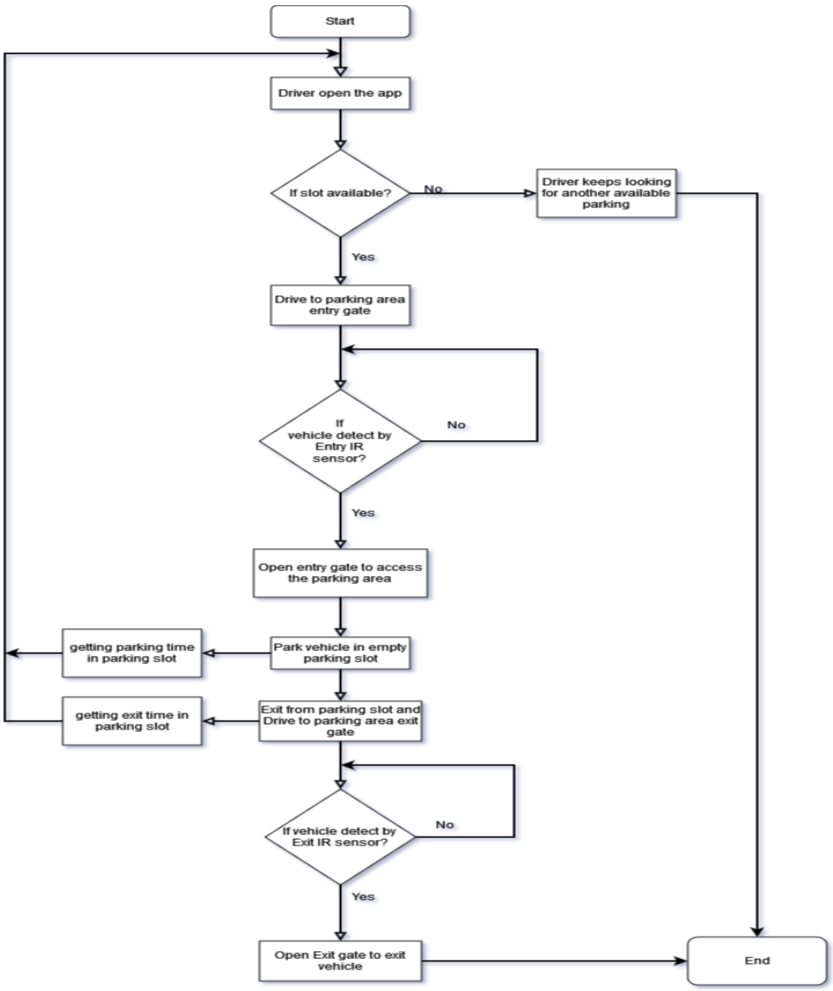

Figure 9: Data flow diagram of the smart parking system

A. *Smart parking system overview*

Figure 1 describes the data flow diagram of the parking simulation system. The parking simulation system consists hardware system controlled by an Arduino microcontroller and android application software for controlling the hardware devices. The Firebase cloud is always connected with both the Arduino system and the android application. Figures 2 and 3 explain the top and front views of the simulation system.

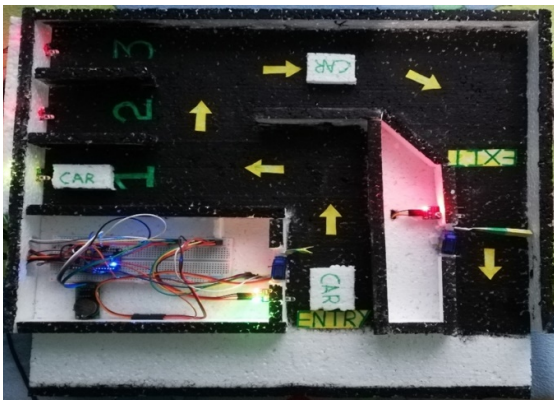

Figure 2: Top view of parking simulation

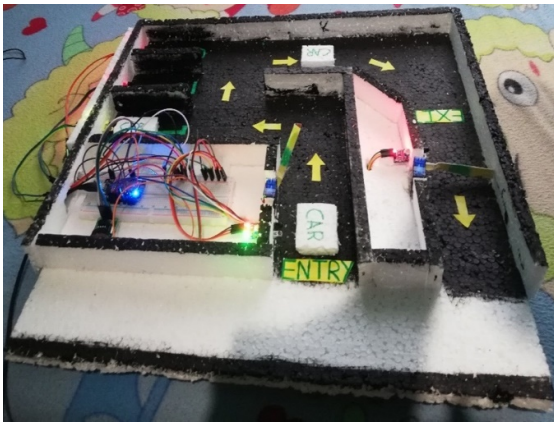

Figure 3: Front view of parking simulation

Whenever the driver wants to park his vehicle, the driver should access the android application. While the driver searches for a parking slot, then the system notifies the availability of the parking slot. If the parking slot is available, then the driver will move to the parking area. If the vehicle comes near the entry gate of the parking area, the IR sensor detects the vehicle near the gate and sends a signal to the Arduino microcontroller. The Arduino microcontroller sends instructions to the servo motors to open the entry gate. Then the vehicle moves to the parking slot, and the microcontroller sends the parking information such as time and date to the android application via the Firebase cloud. The same procedures will follow when the vehicle exit from the parking slot. All these information is sent to the user's mobile phone.

The researchers are building a simulation system to evaluate the research objectives. This system is built using the following electronic hardware item and software.

- Hardware
  - NodeMCU ESP8266 Arduino Wi-Fi board
  - Five IR sensors
  - Two Servo motors
  - DS1302 RTC module
- Software
  - Firebase application
  - Android Studio
  - Arduino IDE

1) *NodeMCU ESP8266*

The Arduino platform plays a major role in IoT projects. There are many kinds of Arduino microcontrollers available for different usage, but in this project, the researchers used NodeMCU ESP8266 Arduino Board because it enables the Wi-Fi module.

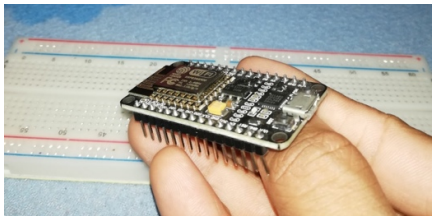

Figure 4: NodeMCU ESP8266

2) *IR sensor (infrared sensor)*

The IR sensor is a type of electronic component that emits or detects IR radiation to detect specific characteristics in its surroundings. An IR sensor can detect motion as well as measure the heat of an object. These sensors only measure infrared radiation rather than emitting it, which is known as a passive IR sensor. IR sensor detection range is 2cm – 30cm, and it can be adjustable using a potentiometer. Vacuum, atmosphere and optical fibers media are used for infrared transmission.

This project used two IR sensors to send data to the entry and exit gates. Another 3 IR sensors are used to detect if the parking slot is available or occupied and send the data to NodeMCU. The IR sensors placed in parking slots identify a car has or is not in their slots. After that, the sensor sends data to NodeMCU. NodeMCU program for

sending those data to firebase database. This database stores those data & sends it to the android app for the view.

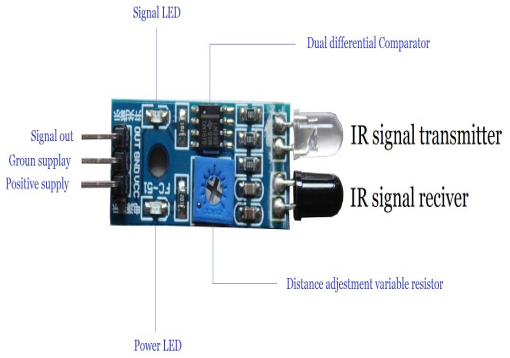

Figure 5: IR Sensor overview

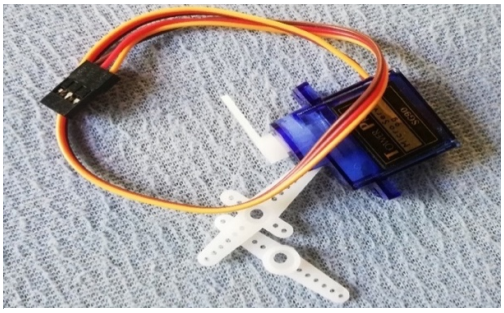

Figure 6: Servo Motor

3) *Servo motor*

Figure 7: Servo Motor Pin

A servo motor is a linear actuator or rotary actuator that allows for precise control of linear or angular position, acceleration, and velocity. If we want to rotate an object at some specific angles or distance, then can use a servo motor. A servo motor is made up of a control circuit that provides feedback on the current position of the motor shaft; this feedback enables servo motors to rotate with great precision.

In this project, two servo motors are used as an entry and exit gate, so whenever the IR sensor detects a car, the servo motor automatically rotates and returns to its initial position after a delay.

4) *RTC module*

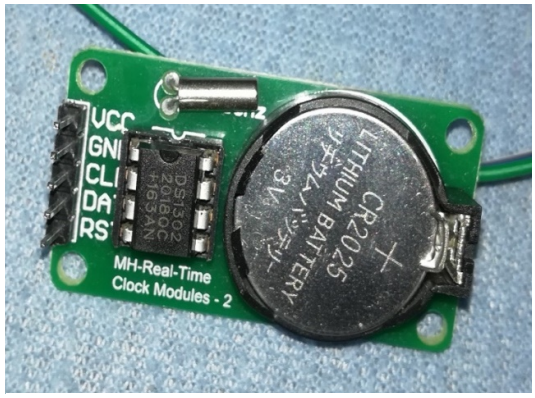

Figure 8: DS1302 RTC Module

RTC (Real Time Clock) modules are simply TIME and DATE remembering systems with a battery setup that keeps the module running in the absence of external power. This keeps the TIME and DATE up-to-date. Therefore, this project used RTC (DS1302) module because it keeps track of the real-time using an internal clock mechanism.

5) *Firebase application*

Firebase is a mobile application development platform from Google with powerful features for developing, handling, and enhancing applications. Firebase has three main services a real-time database, user authentication, and hosting. This project used Firebase Real-time Database and Firebase authentication for Mobile applications. This project involved with Firebase's real-time database to get parking details from the NodeMCU board and store that data in the database. Besides, Firebase sends that parking data to the android mobile application to view parking availability details for users.

6) *Android Studio*

Android Studio is an IDE used for developing android apps, which is officially supported by Google. It is based on IntelliJ IDEA which offers a powerful code editor and developer tools. It is an integrated development environment for Google's Android platform.

Android Studio supports application development within the Android operating system by utilizing a Gradle-based build system, emulator, code templates, and GitHub integration. Every Android

Studio project has one or more modalities with source code and resource files. Library modules,

7) Android mobile application

displays the Admin login and the User login. The owner of the parking may only use Admin login because, it has an authentication process. Admin login allows to view parking availability details, the number of vehicles in the parking area. The Admin can control parking entry and exit gates using this application. User login can access drivers without authentication. The user tab includes parking availability and parked time details. If parking is available, the driver can drive the vehicle to the parking area. This application was developed by using java and XML files. Java language is used to execute the running process, and XML language is used to design the app (Nikolov et al., 2019) (Moroney et al., 2017).

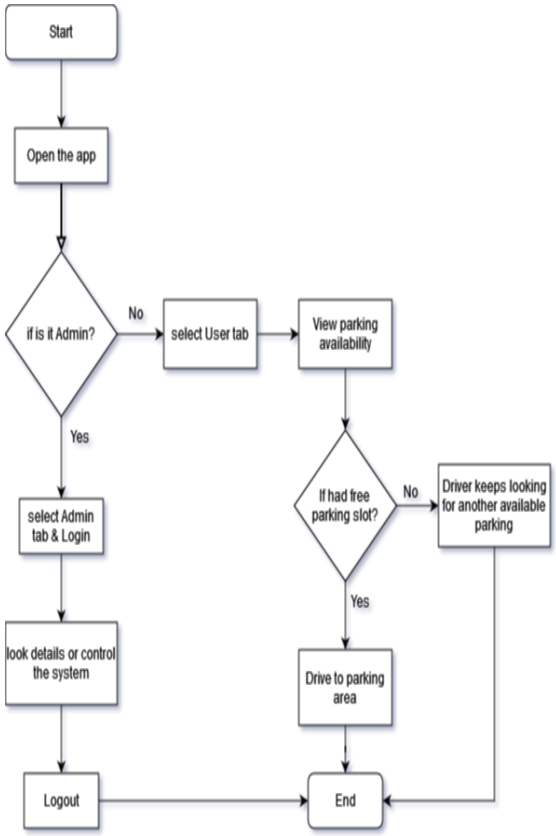

Figure 10:Data flow diagram of Android application

Figure 9 describes the data flow of the Android mobile application. The play store allows installing this application. The application

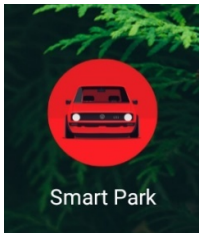

Figure 10: App Icon

IV. RESULTS AND DISCUSSION

The demand for parking systems is increasing because of the increasing number of vehicles in busy areas. On that design, many parking systems with new technology. This system allows real-time access to parking availability. This smart parking system provides a solution for parking in urban areas. Using this system, people can reduce the time of finding parking slots, reduce fuel consumption in vehicles and reduce traffic on the road.

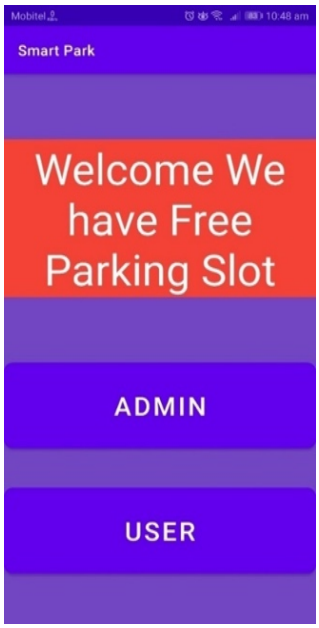

Figure 11: Main User Interface Image

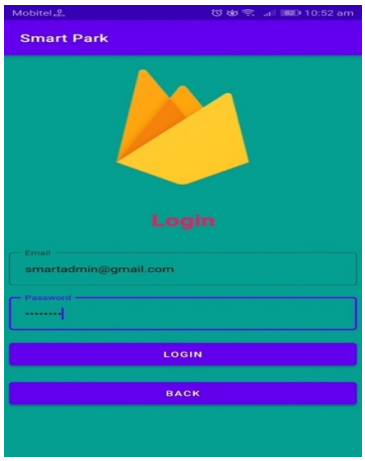

Figure 12: Admin Login Interface

Figure 13: Admin User

Figure 14: Driver Interface Image

Figure 11 shows the main interface of the system. Admin can login by using the 'ADMIN' button, and it navigates to the login page which is shown in figure 12. Admin needs to login using his username & password. Figure 13 shows the user interface of the admin. This interface displays the number of slots in the parking area as well as the availability of parking slots. And also displays parking entry and exit times. Other than that, the admin can control the open and closed gate using the console button displayed on the penal. Admin can logout using the logout button available at the bottom.

Figure 14 shows the driver's interface. Drivers can access the driver interface using the 'USER' button in the main interface. The driver can notify parking slot availability and available slot numbers and place. For this driver interface no need to login, which means anybody can view the interface. In future, we can build an interface for login, which limit access, and the driver can book prior to parking the vehicle. But, at the movement, this system provides open access for all who can access the parking details if they have only an android app. The parking space owner can control the parking area remotely. Here the sensor modules are used to identify the vehicles. Also, sensors count the number of vehicles in the parking area. Servo motors are used to control the open and closed gates of the parking. Other modules are used to record the entry and exit times of the vehicles. We used this simulation set-up to test our objectives and design and evaluate the number of random test cases. The system shows 90% good results. The results of the project could reduce the fuel consumption of the vehicle which is used for searching for parking and could reduce traffic on the road. Also, could reduce the human time of finding parking slots.

V. CONCLUSION

The concept of a smart city has always been a dream for humans. Over the past few years, the smart city concept has become a reality with great progress. The development of the Internet of Things and cloud technology has provided a new opportunity for designing smart cities.

Various modules are involved in this IoT-based parking system to maintain this system such as NodeMCU board, IR sensors, servo motors, and RTC module. Also included an android app. This system provides real-time processes and information on the parking slot in the android app. This project enhances the performance of saving time and fuel. Also, it resolves the problem of growing traffic congestion.

As for future work, the users can book a parking space from a remote location using their mobile.

Also, can send parking fee details for mobile, and users can pay the parking fee online.

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