Towards the Development of a Smart Parking System for Highly Populated Cities

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***Abstract*— Thanks to innovative sensing systems for smart cities that integrate the future into the present, civilization is through one of its brief transitional phases. The congestion of urban areas necessitates the creation of an adaptable strategy formulation that integrates architecture, creativity, and technology to accommodate paradigm change. A unique sensor approach that is the foundation of a smart parking system (SPS) is provided to enhance accessibility in municipalities with an increasing vehicle pool. The SPS consists of a small single-board computer, a proximity sensor, a camera, a LED indication, a buzzer, and a battery and is designed to determine the availability of a parking spot. This smart transportation technology comprises three major components, specifically sensors, a mobile application, and a monitoring centre, all of which collaborate to monitor, regulate, analyze, and show real-time parking spot information to drivers. Also, the design and execution of the three components of the overall system are shown.**

Keywords—Churn prediction, Oversampling technique, Dimensionality reduction, Classification algorithm

I. INTRODUCTION

Inadequate parking systems cause numerous issues as the population grows and the number of vehicles also rises. The growing number of vehicles in cities causes congestion, space and time waste, traffic issues, car vandalism, and other issues that pose challenges for residents [1]. Due to the chaos in Nigeria, it wasn't easy to move around because of the jam-up of vehicles in some areas that were supposed to be free. Some people may have even experienced minor accidents as a result. All of this could have been avoided if a workable parking system had been developed to accommodate at least most vehicles unable to park in the proper locations [2].

Together with human and vehicle-related variables, potholes are acknowledged to be one of Nigeria's most significant contributors to traffic accidents. A mechanical element or carelessness, which includes failing to check and maintain the vehicle at the proper intervals, may also be the immediate cause of a traffic accident. As a result of the operation of vehicles, including bicycles and handcarts, on public highways and roads, road traffic accidents are an unanticipated event. Accidents can be fatal, resulting in the passing away of other road users (passengers, drivers, or pedestrians), or minor, when they do not result in significant difficulty [3].

Many public sites, including shopping malls, multiplex systems, hospitals, businesses, and market areas, currently have a major parking problem. The car-parking lot has many lanes and parking spaces. So, one must check all routes before parking a vehicle. Together with it, it costs a lot of money and labour. It is required to design an automatic parking system that gives a clear signal of the availability of parking spaces in any lane at the entry. Every road is equipped with an infrared transmitter-receiver pair, and each registered user can access a smartphone app to verify the condition of open positions. Hence, the user who wants to park his car is adequately informed about the state of parking space availability [4].

Traditional parking systems lack an intelligent monitoring system, and security officers are responsible for monitoring the parking lots. Because of this, a lot of time and effort must be spent looking for available parking spaces, frequently leading to traffic jams. Several parking lanes with numerous parking spaces in each street make the situation worse. Using a parking management system would increase comfort while reducing the labour and time required from people [5]. Developing a smart parking system would decrease human effort and time while providing more comfort. In the suggested approach, the display unit gives a visual representation of the parking and indicates which spaces are open and occupied, assisting the user in choosing where to park their vehicle [4] [6].

Rapid developments in the internet, communication, and information technology have made it possible to create

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effective smart parking systems at a reasonable cost. This is why numerous researchers have created alternative SPS using various methodologies and sensors [7]. Considering the details mentioned above, several authors analyzed multiple smart parking solutions designed by researchers by giving summaries of their cutting-edge solutions [8].

II. LITERATURE REVIEW

It is impossible to overstate how important transportation is to our everyday lives and how difficult it would be to fulfil our needs without it. Despite how important vehicles may be to our daily lives, numerous drawbacks have also been identified. Because of this, transportation is referred to in the literature as the "builder" and "breaker" of cities. In several metropolitan regions of Nigeria, recent surveys have demonstrated how transportation has built and eventually destroyed towns. This could be attributed to the lack of suitable and poorly maintained infrastructural facilities, accidents, relative immobility of the disadvantaged, prolonged waits at bus stops, transportation-related pollution, traffic congestion, and the growing parking problem.

Communities serve as centres for industry and commerce. Daily, vehicles, trucks, and buses transport people and products in and out of cities. The layout of urban areas creates the potential for the rising demand for motorized transportation. The need for parking follows from the realization that urban centres are characterized by interconnected and complicated land-use activities that necessitate the well-planned intervention of the transport network [8].

More than 20 years ago, certain global cities started using systems to notify people about parking options. These systems are named Guided Parking System and Dynamic Parking Guidance System. Enhancing parking to some level and boosting its effectiveness and success is feasible by using parking guidance and information systems. Shorter travel times and increased traffic flow are just a few examples of how potential system applications positively impact the environment. Other effects include a reduction in noise, a reduction in the number of vehicles on certain roads, a decrease in fuel consumption, and a reduction in exhaust emissions [9].

According to research, there are two types of space in urban centers: exchange and movement, which are related to parking lots, interchanges, etc. More space is needed as the city's transportation system grows. The need for additional traffic space increases as space is devoted to transportation, necessitating the acquisition of some of the exchange space for constructing new roads, extending existing highways, and parking lots [10].

In the current state, the Internet of Things is an emerging topic in computing and sensing device systems, with sensing devices, enormous data collecting, and generating to apply that with AI model is to deliver a fully entrenched system for application utilization. IoT models are, therefore, extremely adaptable, reliable, effective, and easy to use and manage, allowing for extensive use in various applications [11].

Parking is a significant issue for planning both locally and strategically. That is indeed one of the primary issues while organizing and designing any infrastructure project. If neglected, it causes traffic congestion, violations, accidents, injuries, and time and financial waste. In the current state, the Internet of Things is an emerging topic that includes computer and sensing device systems, with sensing devices, enormous data collecting, and generating to use in that with AI model is to deliver fully entrenched system for application utilization [12].

Currently, cities are home to roughly 4.000 million people or more than half of humanity. By 2030, this number will increase to 60%. Large mobility, energy, and environmental issues in cities reduce the quality of life. 35% of people commute during rush hours for scarce free parking spaces. Parking is, therefore, crucial to controlling traffic flow and lowering air pollution [13].

A custom application system called "Park Easy" has been presented. It is based on smartphones, detector tracking methods, and a camera used as a sensor to capture photographs demonstrating parking areas' capacity [14].

Both industrialized and emerging nations experience serious issues with parking in urban areas. Numerous cities are experiencing a shortage of parking spaces due to the sharp rise in vehicle ownership, often seen as the root cause of the city's parking issues. This disparity is partly caused by unsustainable land usage, poor planning, and inaccurate estimates of the space needed in the early planning stages. There are several common parking issues, such as a lack of parking spaces, exorbitant parking fees, and traffic jams caused by people looking for parking spots [15].

Cities now experience more and more congested streets. Problems are being caused by increased private vehicle use and inappropriate parking techniques. Air pollution, in particular, is a serious concern. In cities, parking issues are also causing issues for walkers. It is now necessary to create a more intelligent strategy to solve the traffic problem [16].

Nevon Projects (2019) constructed an Android RFID Parking and Ticket System with RFID scanners at different parking spaces for users to park in and out, after which the user is charged based on the time spent. The system also continuously uses CCTVs to check for open slots [17].

III. MATERIAL AND METHODS

Each registered user gets a mobile app that visually represents the location and the available spots, allowing them to choose where to leave their vehicle. In addition to saving time, the system would also manage automobile check-ins and check-outs using RFID scanners and tags, including features like automatic billing and entry-exit data tracking [18].

The users go through a one-time registration process where they are requested to fill out their personal information, and an account is created for them with information about them and an e-wallet system they may recharge using credit, with this system, after being assigned to a free slot at the parking space's entry, customers are directed to that slot so they can park in it and then exit it.

Upon registration, the individual receives a tag that uses radio frequency identification (RFID) technology and is attached to the top of the user's windshield. It is linked to the user's prepaid account and contains personal information. [19] The tag is scanned in and out during the park-in and park-out process. The user's account is automatically charged for parking based on the amount of time spent inside the parking area.

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The software for the suggested system consists of three modules:

A. The User

The user can log in to check in, add funds to the given E-wallet using credit cards, check their parking and payment history, see which parking lot they are currently in, and reset their password.

B. The Park

The primary use of this program is to scan RFID cards with an RFID scanner, sending the resulting data to the back end for processing both during entry and exit.

C. The Admin

This is the system's back-end application, used to register parking spaces, review transaction histories, and maintain track of users and parking lots currently active.

All users would need to register for the service to get their own RFID tags, which they would then use on their vehicles to scan in and out when parking to operate the proposed system properly.

The user is also given access to an E-wallet system where they may replenish the wallet and then use it to make payments for parking without any issues.

The android phone is connected to the RFID Tracker, Detector, and Scanner by taking over its sound system (hijacking, as the sound system output socket, isn't normally meant for this), and when the Tracker detects an RFID tag, the android phone sends the embedded information in the RFID tag to the system's back-end for processing.

Considering a hypothetical parking space with both entry and exit points, there would be four points of interaction with each user's RFID tag: one at the entry gate to assign a slot to a user to maintain parking order; a second at the place itself to scan in; a third at the exit point to check out; and finally one at the gate to ensure the payment has been made and the person operating the vehicle is the rightful owner.

User Flow

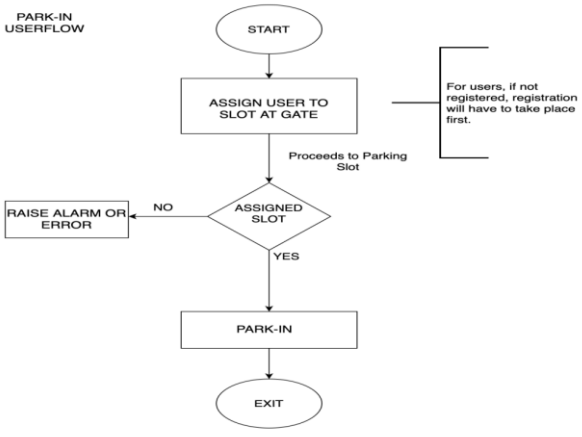


Figure 3.1: Demonstrates user flow

Parking Flow

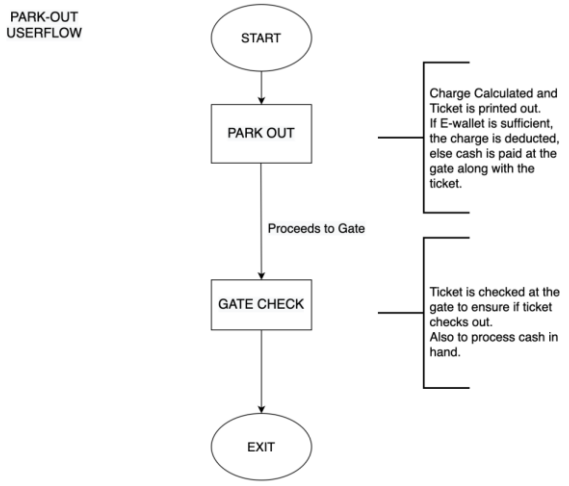


Figure 3.2: Demonstrates the parking flow

IV. RESULTS AND DISCUSSION

The interface displays the different views and features that the android applications can provide, working with the RFID System and the back-end Admin site.



Figure 4.1 Demonstrates the home screen of the UserApp and the ParkApp, two mobile applications. This was done to increase optimization and reduce development costs and time. The programs were therefore named "ParkApp" when they were first installed.

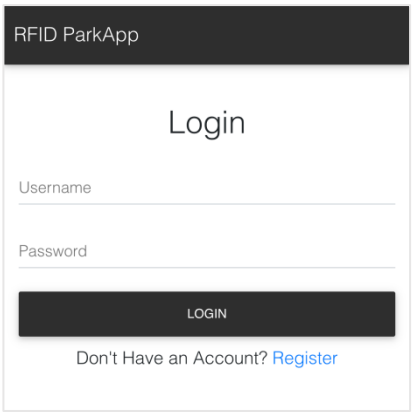


Figure 4.2 demonstrates the Login page as seen by a user; if the intended use does not have an account, they may create

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one; then, the user will be required to log in using their username and password.

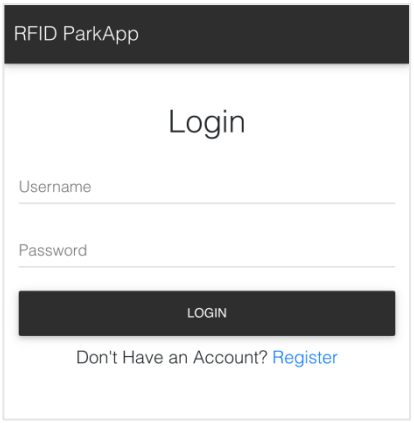


Figure 4.3 Demonstrates the ParkApp login page, which resembles the user's login view but adds a field for a slot to ensure that each android is assigned to a place and cannot be used for another space. This view doesn't allow anyone to register because it is intended for staff and admins only, and it is similar to the user's login view in that it asks for these details.

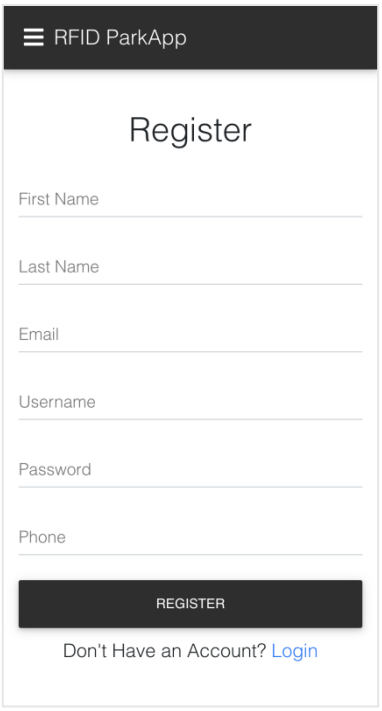


Figure 4.4. Demonstrates the register view, which enables potential users to sign up for this service before receiving their account and RFID tag.

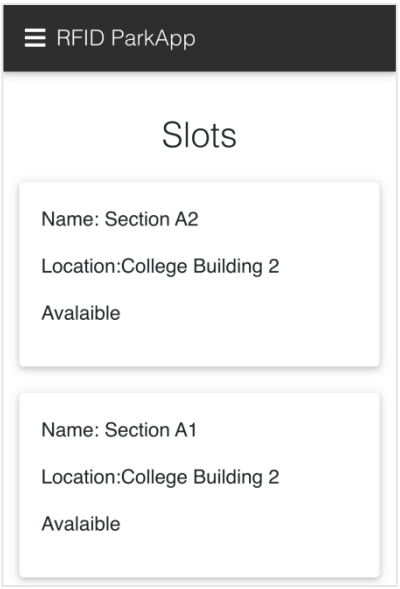


Figure 4.5 demonstrates the parking space's available slots. As previously indicated, the availability of each place is toggled as a user parks in or out of a niche. This view is accessible from both the ParkApp and the UserApp

.

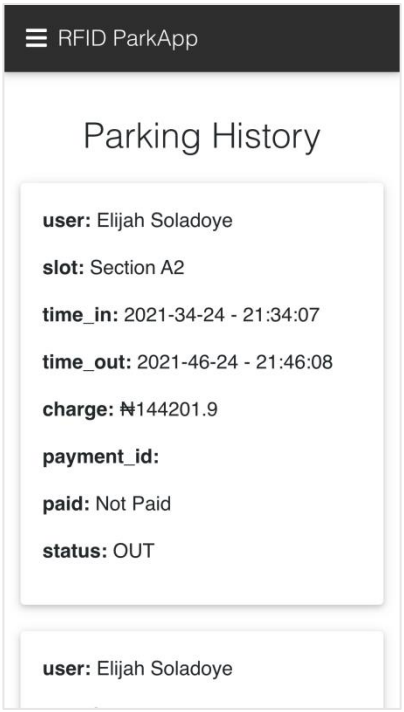


Fig. 4 6. Demonstrates the parking history of each user; on the ParkApp, it shows the history of all users, while on the UserApp, it shows the record for the presently logged-in user.

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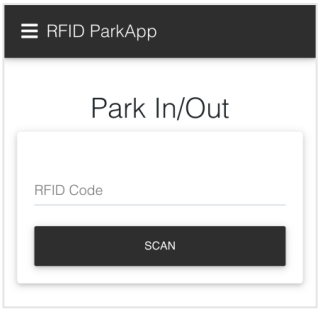


Figure 4.7. Demonstrates the ParkIn/ParkOut view, which collects data from the RFID Tracker and delivers it to the back end for processing.

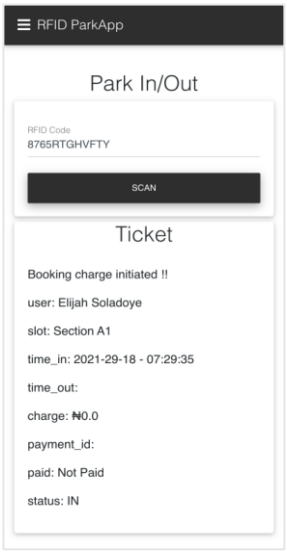


Figure 4.8. Demonstrates the outcome of a user successfully parking in; a portion of the ticket is generated that displays the user, the slot, and the time the user parked in.

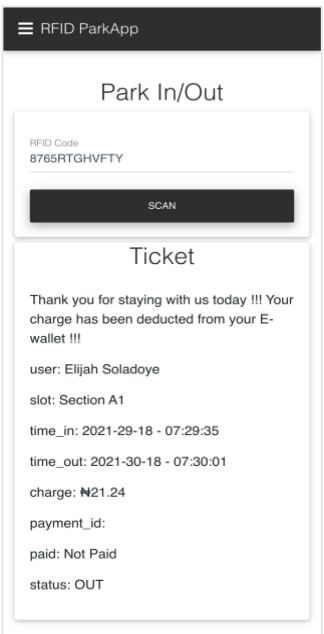


Figure 4.9 Demonstrates the outcome of a user's completed park-out process. It then generates a detailed ticket to be printed and presented at the gate. The ticket displays the user's time in and out of the parking space and the amount charged based on the time spent. It also indicates whether the user has paid (remember that if the user has enough money in their e-wallet, the charge will be automatically deducted; otherwise, they will. If the automobile is still parked there, the status is IN; if not, it is OUT; and if the user has just been given the spot, it is FREE. So, it would be reasonable to assume that the status is OUT.

When the RFID scanner wasn't available, a workaround mimicked the scanning of cards was put in place. As all RFID tags provide the necessary information to identify a person at the back end, the system was created to deliver an RFID code instead, which would be the information read during the park-in/park-out procedure. This is why Figure 4.7 includes a text form field component. The form field in Figure 4.7 has the RFID code filled in.

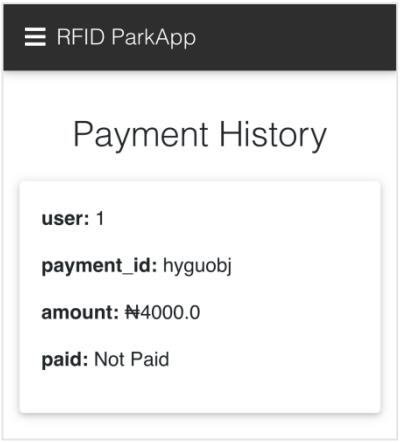
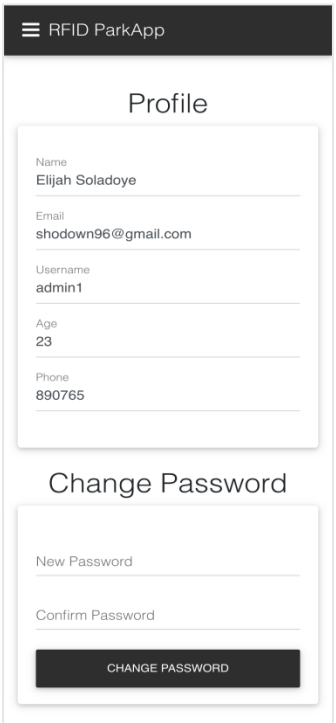


Figure 4.10 This view, which is exclusively accessible in the UserApp, displays the payment history for the currently logged-in user.



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Figure 4.11. displays the user's profile in the UserApp, which includes information like name, age, phone, and other facts. It also gives the user the option to change their password.

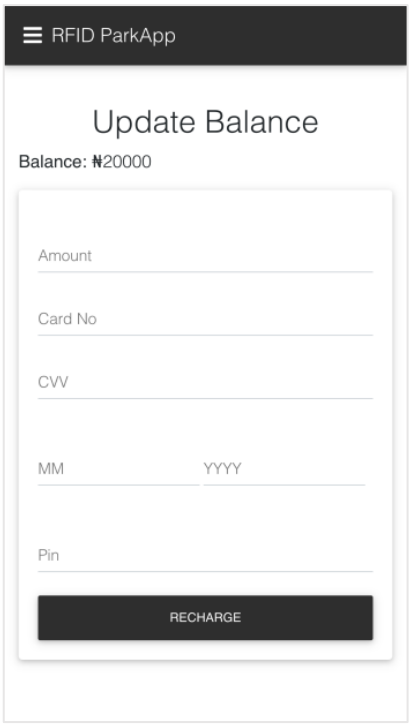


Figure 4:12 Demonstrates the view that lets the user who is currently connected to the UserApp credit their e-wallet account using their credit cards and also displays the amount that is now in the wallet

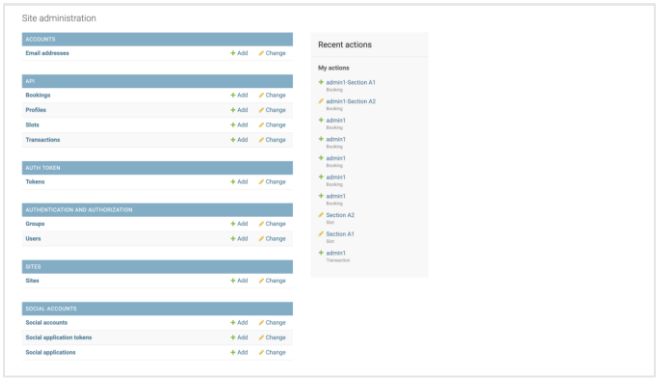
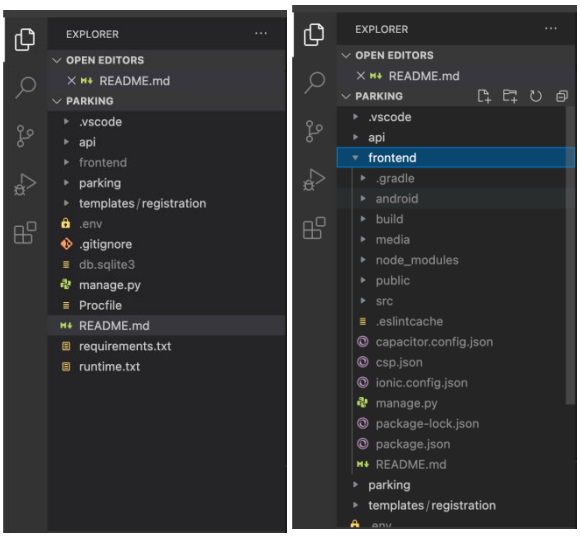


Figure 4.13 Represents the admin site used for administrative tasks, including registering slots, assigning slots, updating users' info, keeping track of payments and bookings, and resolving open issues. An organizational staff member can access this.

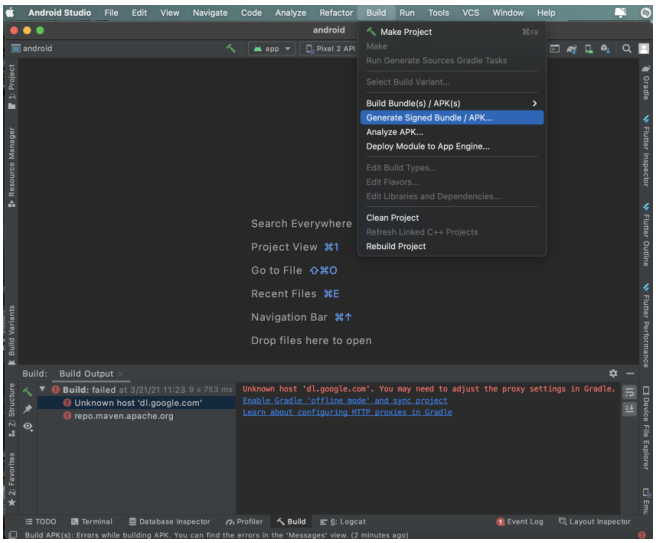
BUILDING THE APP FROM THE SOURCE CODE



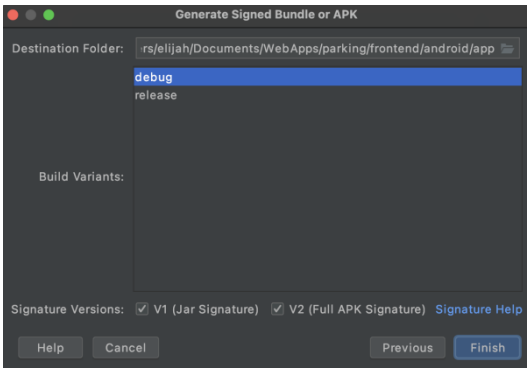
To build the apk file, perform the following actions while looking at the project's base directory:
Initially, you'd need to install NodeJS, Android Studio, and ReactJS locally, along with the other requirements indicated in frontend/src/package.json. Run the following command in the terminal while in the current working directory to install the dependencies (that is, the root directory of the project)

cd frontend/
npm run build
npm install -g @ionic/cli
sudo npm install -g @ionic/cli
npm install @capacitor/core
ionic capacitor add android
npx cap open android

As a result, Android Studio will launch, and if an emulator is installed, the built app will launch there. You can then create the APK file by clicking "Generate Signed Bundle/APK," then following the on-screen instructions to complete the building of either the APK or the bundle that can be uploaded to the Play store to enable simple distribution to users. You may use this approach to build either the release or debug version.



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As for the back-end, using Heroku as our hosting service, you need to install Heroku cli and git and run the following:

git add.
git commit -m "any message you want here."
git push heroku master.

V. CONCLUSION

This study proposes a smart parking system for towns with large populations based on RFID transmission between smartphones and wireless sensor nodes and detectors. It simplified the recognition of cars stepping into and out of parking slots and stored the parking position of each vehicle. The car parking mobile application is handy when the user's smartphone is utilized. In our testing, the suggested system provided reliable parking lot-finding services. The recommended system has a lower implementation cost than the prior technique. In the future, we want to design and execute an intelligent sensor-based strategy for real-time packaging. For future study, a more precise RSSI measuring method will be investigated, and more useful for smart parking spaces, such as accident warnings, the status of the parking reservations, and so on, will be created.

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