Down2Park: Finding New Ways to Park

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Abstract. The purpose of this article is to investigate the problems regarding the time spent in traffic and the proper measures that can be taken to decrease the time spent in traffic. The report focuses on investigating and finding a solution to reduce the time spent looking for parking as it contributes to the time spent in traffic. The information would consist of the problem introduction, literature review, methodology, results and findings, discussions, and a conclusion, all of which relate to increasing the efficiency of the parking process. The solution in mind refers to a smart parking solution that aims to automate the parking-finding process and increase the efficiency of seeking parking within a compound.

1. INTRODUCTION

To digitalize or not to digitalize is one of the most common solutions for everyday problems. Traditional businesses or issues have often been left unsolved and rather just left to their own devices due to the limitations of technology at the time. With the new prospect of digitalization many issues can finally be solved, and in particular, the main point of interest would be tackling the vast amount of time wasted in traffic. According to research done Boston Consulting Group (BCG) in 2017, Malaysians spend a total of 25 minutes daily searching for parking spots. The parking-seeking time is not long but rather when paired with time spent in traffic (41.99 minutes as of 2020) a Malaysian spends on average a total of 1 hour and 11.99 minutes being stuck in traffic and looking for [1-3] parking without accounting for travel distance or even weather conditions (Jerrica, 2021). Although both of the research was done independently and may seem outdated, it can be presumed that the time spent has increased overall given that there are 1.2 million new vehicles 2021 on the road and a total of 15.8 million drivers (as of 2021) (Mamat, 2022). With the yearly increase of vehicles and new drivers, the result would be an increase in driving time, time spent in traffic, and time spent looking for parking.

As a result of the time wasted in traffic, there is a decrease in productivity, an increase in traffic-related incidents, and even a decrease in economic activity (both as consumers and producer). Generally, the time spent in traffic which was to be allocated for economic activity is wasted, which results in after-effects such as lower productivity and lower consumption [4-6]. Other effects such as environmental problems or increase in accidents may occur as well however, merely as a biproduct of the time wasted in traffic.

Hence to combat the issues at hand, this report aims to introduce a smart parking solution known as Down2Park which decreases the time spent in traffic by reducing the time spent looking for parking spaces. Smart Parking refers to a system that digitalizes the parking process with new additions such IOT to automate process and allow real-time data to be collected and increase the efficiency in the parking process to aid the users in matters such as looking for parking, locating their vehicles, and paying for their parking tickets. These components will be connected via a cloud in order for information to be stored and centralized [7,8]. All of these features will not only aid the customers entering a parking premise but aides the management in terms of increasing efficiency all with a mobile phone or portable device.

2. LITERATURE REVIEW

According to R, Seth, Ashritha, & Namith (2019), road congestion is the main issue that is being experienced due to the growth in the number of cars in urban areas. Their research paper's goal is to find a solution to this problem, with an efficient and smart way to automate the management of the parking system that allocates an efficient parking space using internet of things technology. The IoT provides wireless access to the system and the user can keep track of the availability of the parking area. The user often wastes his or her time and energy trying to find a vacant place in a designated parking lot. With their system, the user can receive a notice with the parking information. As a result, the user's waiting time while looking for a parking spot is minimised. To prevent automobile theft, RFID technology is being utilised. Tanti, Hardik & Kasodariya, Pratik & Patel, Shikha & Rangrej, Dhaval (2020) mentioned that an effective parking management system is more necessary than ever with the explosive growth in a number of vehicles on the road. They can provide excellent service to individuals who wish to park their vehicles on the property of any organisation utilising an automated system that is based on the Internet of Things (IoT). In this context, the Internet of Things (IoT) employs sensors to link physical parking infrastructures with information and communication technologies, enabling cloud-based smart management services [8-10]. A mobile application would be created to carry out this notion to enable any end users to check the availability of parking spaces and reserve a specific parking lot as necessary in a convenient way. According to R, Seth, Ashritha, & Namith (2019), road congestion is the main issue that is being experienced due to the growth in the number of cars in urban areas. Their research paper's goal is to find a solution to this problem, with eefficient and smart way to automate the management of the parking system that allocates an efficient parking space using internet of things technology. The IoT provides a wireless access to the system and the user can keep a track of the availability of the parking area. The user often wastes his or her time and energy trying to find a vacant place in a designated parking lot [11-13]. With their system, the user can receive a notice with the parking information. As a result, the user's waiting time while looking for a parking spot is minimised. To prevent automobile theft, RFID technology is being utilised. Tanti, Hardik & Kasodariya, Pratik & Patel, Shikha & Rangrej, Dhaval (2020) mentioned that effective parking management system is more necessary than ever with the explosive growth in number

of vehicles on the road. They can provide excellent service to individuals who wish to park their vehicles on the property of any organisation utilising an automated system that is based on the Internet of Things (IOT) [14,15]. The Internet of Things (IOT) in this context employs sensors to link physical parking infrastructures with information and communication technologies, which in turn enable cloud-based smart management services. A mobile application would be created to carry out this notion to enable any end users to check the availability of parking spaces and reserve a specific parking lot as necessary in a convenient way.

3. METHODOLOGY

The process in which the solution was established was first by researching on current smart parking solutions, the functional requirements along with the system architecture for the proposed solution. The technology behind solution will depend on the architecture diagram along with functional/non-functional requirement. Table 1 shows the functional requirements and table 2 shows the non-functional reqirements.

Table 1 Functional Requirements

Functional Requirement	Description
Detect parking spaces	The system can detect available parking space by using sensors like IR. The spaces detected can be categorized as “occupied” or “empty”.
Display the location of available parking spaces within mobile application	With the use of IR sensors to monitor the parking area, Down2Park is able to display a real time map-like environment of the parking area. The application shows both the occupied and unoccupied spaces along with the quickest route to the selected parking area all within the user’s finger tips via the mobile application.
Display the total number of available parking spaces on relevant displays	The total number of available parking spaces is tallied and displayed on both display dashboards along with the mobile app of the user.
Recognize and record the time each vehicle enters and the time they exit	Via a number plate recognition system, vehicles that entered the premise will be recognized and the entry time and exit time will be recorded and calculated to determine the final cost of leaving the premise.
Restrict vehicle entry to compound when no additional free parking spaces detected	In the event that there are no longer any unoccupied parking spaces, the system should be able to restrict the entry into the premise via denial of entry to prevent traffic built up or illegal parking within the premise and to not waste the users time.

Information registration	Users who are able to register for the mobile app, by providing information such as car-licensing plate along with contact details and other relevant information.
Display details of the parking compound on the app	Users are able to browse the details along with additional information regarding said parking compound such as the number of available bays, the parking levels the designated zones (handicapped, female zones or family zones) within the application.
Upload and modify details of new parking compound(administrators)	The relevant parties such as administrators are able to upload and define details such number of parking spaces, price per hour, etc. of their parking compound during the initial setting up of the Down2Park along with subsequent future updates.
Information Modification	Users are able to update their information within the system such as registering more vehicles, new phone number and any other personal information.
Pay for parking cost through the app	Users can pay for their parking through the app with a variety of payment options such as credit card, debit, QR pay or any other merchants that partner with Down2Park.
Identify and allow vehicles that have paid to exit the parking area	When the vehicle wants to exit, the system can identify whether the driver of the vehicle had paid for the parking costs by scanning their number plate. The barrier will only open if the driver has paid the necessary fees.

Table 2:Non-Functional Requirement

Non-functional requirement	Description
Performance	The system server should be able to handle several simultaneous requests from different users without slowdowns or pauses.
Compatibility	The central database platform should be independent in such that accessing and storing data from both the web application and the mobile app is easily done so , even if the devices used are running on different operating systems.
Reliability	The reliably show all available parking slots and the location of available parking slots including its information without facing much errors.

Security	To make sure user data remains confidential in all circumstances such as in the event of device theft, the system should have proper database encryption and local encryption.
Usability	The mobile app's interface should be simple and easy to use. It should not distract or clutter the user with too much unnecessary information at once.

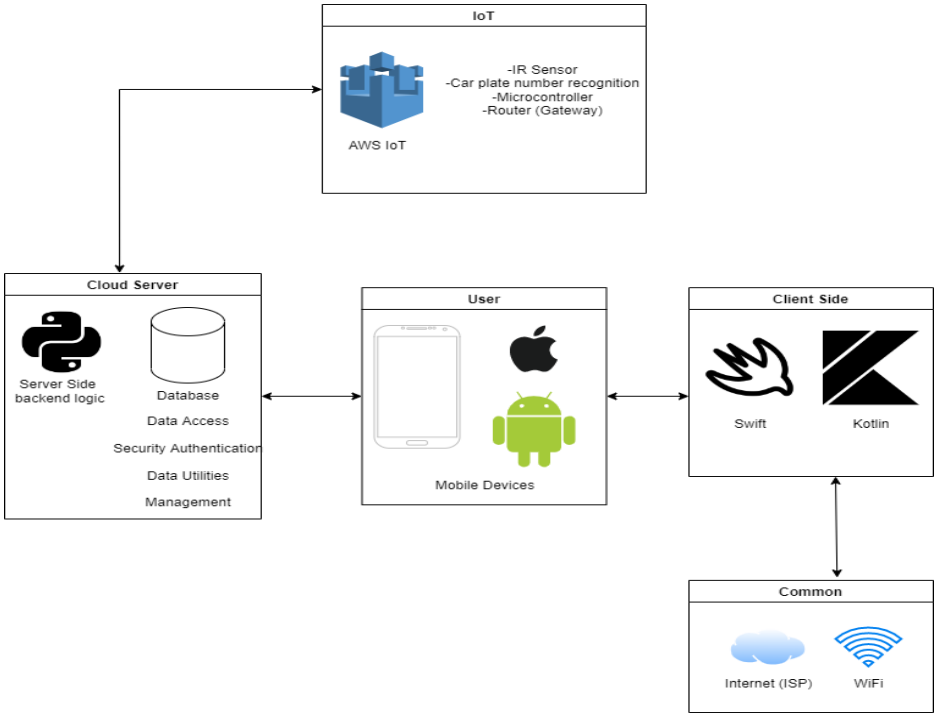

Figure 1 shows the application's architecture diagram which utilizes IOT technology, cloud server, client and user side

The diagram above depicts the application diagram for the solution Down2Park. Users can access the application via either IOS or Android with a phone built with Kotlin and Switch for its respective platform, Fig 1 **shows** the application's architecture diagram which utilizes IOT technology, cloud server, client and user side as long as the device has an active internet connection, either from an ISP or Wi-Fi. The platform will then utilize IoT devices to detect the empty space(s) within the parking compound and update the system with the remaining available space [16-18]. The nearest route to the chosen parking spot will then be processed and displayed on the user's device by our cloud server. Before entering the premise, the user can check the availability of parking spaces in that specific car park. Payment of parking fee is also performed via either the application or autopay machines, will be rather simple and can be done by trusted gateways. As for the security level of the system as a whole, the system utilizes AWS IoT protocol encryption (TLS version 1.2) to encrypt all communication between the nodes and servers.

Within the database, the system will also be recording the entry and exit times vehicles

sorted by car plate number with the help of IoT devices. The timing process utilizes car plate number recognition, to recognise the vehicle and [19-21] record the entry time with a microcontroller, he LED monitor which will then output the user's car plate number to state on a screen provided to show that the IoT device has successfully collected the data. The IR sensors will also be in charge of the data to check on the available parking spaces and send the information relevant to the cloud server through a router. Furthermore, the database will also be in charge of recording the registration details of each of the users via the data central service. During the first use of the application, users are to register their personal information such as the vehicle, car plate number, phone number, payment method or any relevant information. The owner of the parking lot will be given administrator privileges to customize the price of the parking fee, restrict the availability of [22,23]parking space, and post announcements to users parked within the parking compound. Finally, the central service is also tasked with identifying vehicles that have paid the overdue fees before exiting and restricting exit in the case where it has not. Fig 2 demonstrate the same architecture diagram.

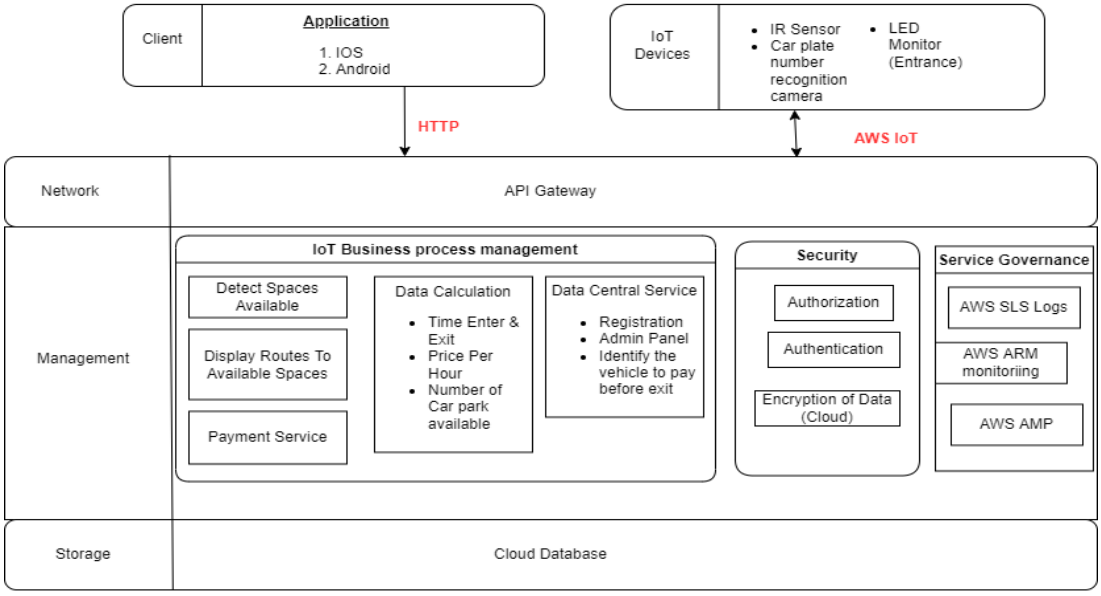

Figure 2 demonstrates the same architecture diagram but in greater detail.

Users are able to utilize our service through mobile applications that are available in Android and IOS platforms, and they are connected through API Gateway with HTTP. Hyper Text Transfer protocol, is the data communication protocol for the WWW (World Wide Web), that allows data to be exchanged between nodes containing text. The IoT devices are connected through AWS IoT, which breaks down into several protocols. Our parking system is built based on AWS [24-26] cloud servers, that is implemented with the AWS IoT technology that is offered with many different types of networking protocols which makes it developer-friendly. AWS IoT core is able to support HTTP, MQTT (Message Queuing and Telemetry Transport), MQTT over WSS (Websockets Secure) and LoRaWAN (Long Range Wide Area Network). As for our service governance, we have AWS SLS logs and AWS ARM monitoring. Which

will then allow us to monitor all problems online. Not to mention about AWS AMP, (Amazon Managed Service for Prometheus), allowing us to request monitoring and give feedback in a real-time database. IoT devices that are involve in this smart parking system:

- IR Sensor – To detect the availability of the parking space
- Car plate number recognition – To detect the number of the car plate
- LED Monitor (Entrance) – To output the detected car plate number
- Router – Function as a gateway for IoT devices to cloud server

5. RESULTS AND FINDINGS

As a result based on the architecture diagram along with the functional requirements the following system was proposed along with the following UI/UX. Fig 3 shows the tinkercad.

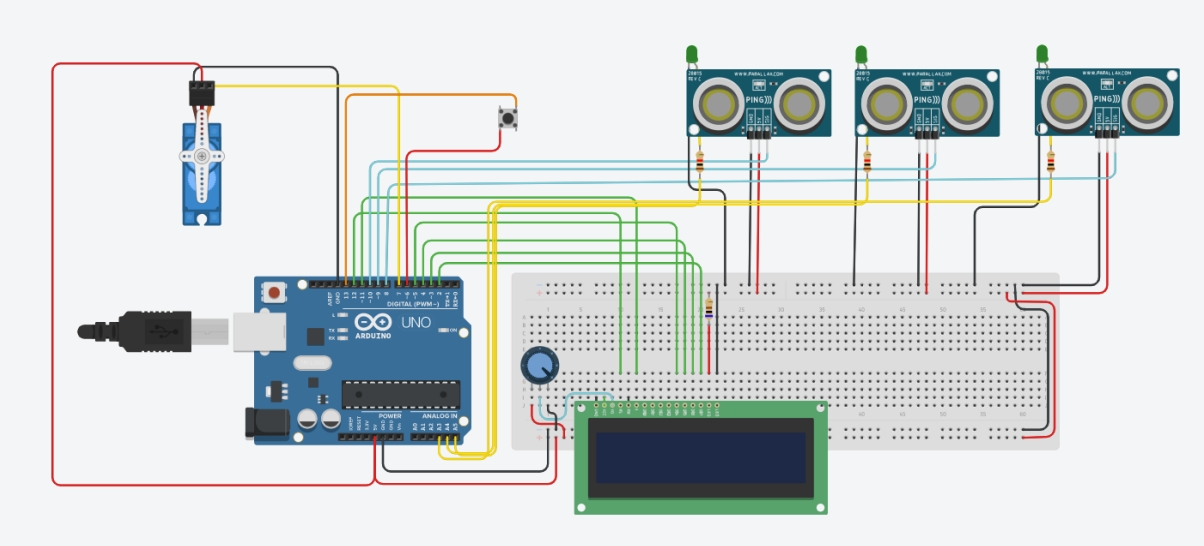

Figure 3 shows the tinkercad

The tinkercad circuit represents our simple real-life smart parking system application. The component used in this circuit are as follow:

- Arduino Uno R3 x 1
- LCD 16 x 2
- Ultrasonic distances Sensor x 3
- 600Ω Resistor x1
- Positional Micro Servo x1
- Pushbutton x1
- 260 kΩ Potentiometer x1
- Green LED x3
- 1 kΩ Resistor x1

The Arduino board acts like a brain to the entire circuit that reads input and turns into appropriate output. The circuit also consists of a breadboard to keep the components connected in a clean manner. The LCD screen is used to display the total number of slots available, as well as the exact slot that is still empty. This represents the dashboard at the entrance of the parking compound displaying similar information in a real life setting. The potentiometer is also used here to act [27-29] as an adjustable voltage divider for the LCD screen to function properly. Next, there are 3 ultrasonic distance sensors to represent 3 parking slots in the compound and it also acts as a sensor to detect vehicles in this circuit. It is worth

noting that in our architectural diagram for the previous assignment, the sensors we suggested to use for detecting vehicle is IR sensor, but here in Tinkercad, IR sensors are not as effective to simulate a real parking compound as the ultrasonic distance sensors, so we will be ultrasonic distance sensor instead. Each parking slots also has a green LED on top of it that will light up when the parking slot is free and stop lighting up when the parking slot is occupied to give users an additional indicator to look for free parking slots However, if the circuit were to detects that the parking is full, it will not lift up and allow vehicles to enter the compound, which is also one of our system's functional requirements. This is because when the parking is full, we would not want vehicles to enter the compound anymore to prevent them from wasting time finding parking. The smart parking circuit we have created using Arduino on Tinkercad is only a small portion of our entire system [30-32] to demonstrate some of the main features of our smart parking system. The above diagram was created to show how the tinkercad circuit is linked with the rest of the hardware interface of the entire system in a single parking building or centre. The tinkercad circuit is located at a parking building as the circuit itself represents the parking area or compound with the components like barrier gate, parking slots, sensors to detect each parking slot, LCD dashboard displaying the information of the parking area, and LED lights to indicate the availability of each parking slot [33-35]. The sensor of the Tinkercad circuit collects the data and it has to be sent somewhere, otherwise the data collected would not serve its purpose fully. Therefore, the circuit will send the data through a network layer which consists of communication technologies like LAN or WAN to the cloud server (Biyik et al., 2021). The cloud server is responsible for processing and computing the data it received before the data was being sent to the final user on their mobile application. The cloud server will also store the relevant data it received at the cloud database for future use.

Finally, after finishing preparing and processing the data, the cloud server will send them to the users' end and display the relevant details on their mobile application of our system. Users will then be able to see details of the specific parking building such as the number of parking slots available, the exact location of these free parking slots, and so on. If the user had successfully parked at one of the parking slots in the parking building, the process of the Tinkercad circuit collecting the data from the sensors, sending it to the cloud server for processing and finally sending back to the user will repeat. This time around the user should be able to see information like the name of the parking building they have entered, the specific parking spot they have parked in, the date and time they entered the parking compound, etc. on their mobile application. The cloud server will also send the same processed data to the admin control centre of the particular parking building, as the admin will need this data or information for monitoring and keeping track of the up-to-date environment of their parking compound. Fig 4 and 5 shows the prototype.

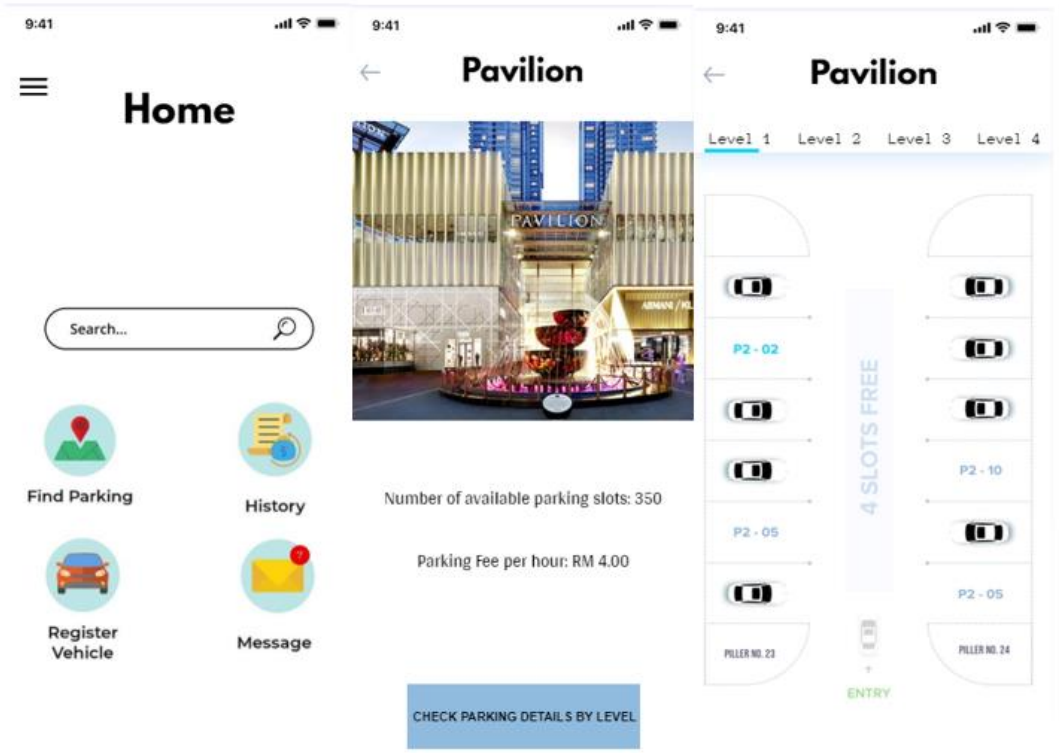

Figure 4 shows the prototype

In order from left to right, 5 a(Homepage), b(Parking Detail), c(Parking Navigation) and d(Parking Payment). Above shows the homepage of the mobile application. Users can perform actions like finding parking, checking the history of their parking and payment activity, checking, or modifying the details of their registered vehicle, checking the messages or notifications of the app, etc. The user can search for a specific parking area/compound that has implemented our system. For instance, in the example, Pavilion shopping mall is one of the places that implement our system on their parking area. When the [36,37] user selects this place, it will show a picture of this selected place to let them know whether they have selected the correct place. Details of the parking area will also be shown at the bottom which is the current number of available parking slots and the parking fee per hour for the selected parking area. There is also a navigation button at the bottom to let the user check the parking details by level. The user can search for a specific parking area/compound that has implemented our system. For instance, Pavilion shopping mall is one of the places that implements our system on their parking area. When the user selects this place, it will show a picture of this selected place to let them know whether they have selected the correct place. Details of the parking area will also be shown at the bottom which is the current number of available parking slots and the parking fee per hour for the selected parking area. There is also a navigation button at the bottom to let the user check the parking details by level. [39] When the user presses the navigation button to check the parking details by level, the above interface will show up. This is for the user to check which exact parking slots are occupied or free in real-time at every level of the parking area, which is the Pavilion shopping mall in this case. Information like

the number of parking slots available on each level will also be shown in the middle of the screen.

After successfully parking at one of the slots in the parking area, the user will be greeted by the above interface. The system can also detect the exact slot the user has parked and show them the unique label of the slot on the mobile app, which is P2-02 in this case. This can also be helpful to prevent users from forgetting where they have parked their vehicles in the parking area. Other details like the date and time the user entered [40] the parking area, the duration of the vehicle's stay inside the parking area, and the current parking fee will also be displayed. The current parking fee will be updated every time the duration reaches an hour. Finally, the user has the option to pay for the parking using the navigation button at the bottom of the screen if they decide to leave the area.

6. DISCUSSION

Wireless capabilities refer to the ability of electronic devices to communicate and exchange data without the need for physical connections. Wireless technology has revolutionized the way we live and work, enabling seamless connectivity and data transfer across different devices and networks.

6.1 Wireless Capabilities

Wireless capabilities are an important resource within Down2Park, without any access to the internet the system will simply not function properly. Most of the possible risks of failure within the system all stem from the reliability of the internet provider itself. The wireless capabilities are essential for all devices to transmit information to each other within the cloud-based database [41]. Of course, wireless capabilities would not be complete without proper security and protection, without the proper infrastructure in play it may lead to piggybacking in which the security of the devices connected to the system is compromised. These risks caused by opening the network to unintended users may include conducting of illegal activities, stealing of files, or gaining access to unauthorized devices. To prevent these issues, proper policies and security systems need to be planned and out in place to prevent this resource from being exploited.

6.2 Functionality

Application functionality is rather important as the application is also the main selling point of Down2Park. Without a proper application, organizations would not invest within the system, and it may even cause delays and problems for the end-users in particular when trying to enter a certain premise. The application may not be perfect for the initial launch and introduction however to resolve this, it has been divided that frequent but small updates or patches will be done in order to improve the functionality of the systems.

Functionality can also be maintained and inspected with periodic functional testing. The testing is rather simple and includes Unit testing, Sanity Testing, [42] Smoke Testing, Integration testing, and usability testing. These testing procedures are rather standardized and would be throughout the implementation of system and will ensure that functionality is always acceptable.

6.3 Secure storage

Secure storage is another key resource as a huge volume of data is stored and accessed within the storage system. Without proper security, the data will be breached, and information will be made public which is

dangerous and causes misuse of data. Generally, this can be maintained by using a proper and certified cloud service provider. Storage security is one of the more prevalent spendings within the development budget however it is a necessary investment to ensure that the data is well encrypted and protected. Proper role-based access management and relevant protocols will be utilized as well to prevent internal misuse of data. Other ways of securing the storage include keeping the software updated, implement firewalls, and encrypting data.

6.4 Power Management

For Down2Park the primary concern is the power usage of the physical system rather than the software side of the system. With a system that must keep track of users entering and leaving the compound all day, the system would consume high volumes of power. This power is generally wasted without proper power management and could cost the organizations/owners unnecessary burdens [43]. This can be avoided with sectioning of the system where different areas within the parking compound have separate circuits. Followed by lights that can be activated via an IR sensor, this could reduce the overall usage of power within the parking compound. Different sleep modes may be implemented such as odem-sleep, light-sleep, and deep sleep mode as well to ensure lower power consumption overall. In doing so, abnormal consumption of power can be negated by lowering overall power usage.

6.5 Efficiency

The overall efficiency of the system is important as well. This resource can be maintained and upheld by upgrading the hardware infrastructure of the whole IoT system. This hardware should be periodically updated maybe once every two years to four years to ensure that the devices are able to efficiently run the tasks. The diagnostics of the system should be done at a frequency of at least quarterly and with maintenance at least yearly. The diagnostics and maintenance are done to ensure that the system is running at maximum efficiency and what better way to do so than to reduce the risks of stopping or compromising. Other ways to ensure efficiency would be to have a person delegated to oversee the system as whole to act as a technological aide in the case where the system faces any issues.

For the application side, the efficiency can be improved as more user input and feedback is collected. The application will be periodically updated with patches and these patches can be quality of life changes which increases the overall ease of usage of the application.

6.6 Future Improvements

Our smart parking system does have room for possible future enhancement. We have an expectation of how the future of the system should look like in the next 3 years with technological progress. In this period of time, one of the possible enhancements of our system is adding even more features to the future iteration of the system. Reservations of parking spaces is one of the useful features that we would like to add to our current smart parking system, where the user is allowed to reserve a parking space at their chosen parking compound to ensure there is a space to park when they have arrived at the compound. People can know that the parking space is booked by having an additional LCD display at each parking slot to display the number plate of the

vehicle. We did not include this feature in the first version of our smart parking system as this would increase the complexity of the system development, and while this feature is useful, we think it is not the most important or fundamental feature of a smart parking system. Fig 6 shows the of user interface prototype.

Figure 6 shows the user interface prototype

Secondly, we also aim for more parking compounds to implement our system in the next 3 years. With technology becoming more advanced and becoming more readily available at a rapid speed, we expect the cost of implementation of our smart parking system to become lower over time as the individual sensors and other hardware needed will probably become cheaper and more durable or mature, hence maintenance of these hardwares will not need to be done [44] as frequent. Lower implementation costs will lead to smaller and smaller organisations being able to afford the implementation cost of our system at their parking compound, therefore extending the coverage of our system in the country. Lastly, we will also enforce a signal repeater system as part of our system requirements for implementation in parking compounds where mobile cellular signals cannot be received, like in underground. A signal repeater system like the one offered by Stella Doradus works by receiving a mobile signal from outside your subterranean parking compound. After that, the signal is amplified and dispersed across the facility. It makes no changes to the signal and just takes what is available outside and transmits it inside. This simplicity has the advantage of being the most cost-effective option on the market. It's also a lot easier to maintain and set up. This repeater is also a scalable and modular system. Additional amplifiers can simply be added to the system to have a wider area of signal coverage (Stelladoradus, 2021). With this signal repeater system, users will no longer experience the situation where their mobile app loses connection to our system due to poor cellular signal coverage underground.

7. CONCLUSION AND FUTURE WORK

In conclusion, our smart parking system solution is unique, at least here in Malaysia, and therefore, we believe that our solution can push our country forward to take a huge step toward the beginning of the era of a smart city. Smart parking solutions are the future. It plays a critical part in the smart city ecosystem, improving ease, reducing congestion, lowering costs, increasing urban mobility, and delivering useful information and data (Oza, 2020). We think the smart parking system solution that we proposed is an overall success and is certainly viable in meeting the goals we set

in the beginning. However, we do acknowledge that no solution can be perfect, as we also do discover that there are also some failures in our proposed solution, which can be mitigated and improved upon with proper funding and user feedback.

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