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IoT Based Disabled Parking System (DiParkSys) v2.0 Arduino Uno

R.A. JM Gining[1], S.S.M. Fauzi[2*], T.R. Razak[3], M.N.F. Jamaluddin[4], M.N.M. Fuad[5], N.A. Zaki[6], R. Maskat[7]

[1,2,3,4,5]Faculty of Computer and Mathematical Science, Universiti Teknologi MARA, Perlis Branch, Arau Campus, 02600, Arau, Perlis, Malaysia

[6]Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Perlis Branch, Arau Campus, 02600, Arau, Perlis, Malaysia

[7]Faculty of Computer and Mathematical Science, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

*Authors' Email Address: *[1]ray_adderley@uitm.edu.my, [2]shukorsanim@uitm.edu.my, [3]tajulrosli@uitm.edu.my, [4]nabilfikri@uitm.edu.my, [6]nurulain86@uitm.edu.my, [7]ruhaila256@uitm.edu.my*

*Corresponding Author

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ABSTRACT

The urbanization in the urban area can lead to many effects, and one of them is limited parking space. In the context of disabled parking spaces, many easily violate that allocated spaces without guilty. For the authorities to monitor the violation of the disabled parking spaces are quite challenging. That is, the authorities would still need to look out for the parking violation by manually observing and looking around, in other words, through their observation. The purpose of this study is to improve the current Disabled Parking System (DiParkSys) v2.0 by integrating it with GSM notification system. The GSM module assembled in DiParkSys will immediately notify authorities of any violation by giving the coordinate of the violated parking slot. The prototype was first designed using system visualization and schematic diagram. The integration between the alarm and GSM module was then validated using an integration test before the functionality of the prototype was tested using a Test Cases method.

Keywords: *Disabled Parking Management, Notification System, Arduino, Functionality Evaluation, IoT*

INTRODUCTION

The population of the urban area has overgrown within these last few years. According to the population growth projections, the urban area will undergo massive expansion which will become a global phenomenon in the next 30 years. The urban residential population will grow approximately 60 million every year. Generally, more people are living in the urban area than in rural area. According to statistics, about 54% of the world's population lives in urban areas in 2014. By 2050, 66% of the world's population is projected to undergo urbanization (World Urbanization Prospects 2009 Revision, 2010). One of the problems envisaged by the growing population is the increased energy consumption - expected to rise by more than 50% in the various areas. The activities in these areas are

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expected to generate 60% of carbon dioxide (CO2), which will contribute to global warming (Muhammad, Nanthakumar, Rashid, & Talat, 2015). One of the contributing areas, transportation, though it contributes to global warming, it is undoubtedly an important means which granted people the capability to travel. As the overall income of the population progressed, most people opt to purchase their mode of transportation. This will expand the number of transportations being used on the road; which would further increase the existing problem and possibly breed new issues.

Parking spaces issue is not a brand-new problem in the transportation field. Concerning the urbanization process, the increased population has contributed to the limitation of the parking spaces. The demand for the parking space increased as the number of citizens rise and has resulted in the violation of disabled parking space when non-disabled people parked in the disabled designated area. This usually happened in multilevel parking areas such as shopping malls, hospitals, offices and others. Although the sign for disabled parking was prominently displayed to stop the non-disabled, the violation still occurred as no action are taken on the violators. The violation would be an inconvenience to the disabled as the facility provided for them are not utilized as intended. Due to this matter, a solution to produce more reliable management of the disabled parking spaces is required. With the development of new innovative technology, mainly Information and Communication Technology (ICT) and Internet of Things (IoT), a wide range selection of tools is available to be adapted in the solution. Moreover, the tools could be acquired freely and at a low cost.

Therefore, the study proposes a system known as the Disabled Parking System (DiParkSys) v2.0, which assist the management of disabled parking spaces through the use of IoT. This study is the continuation of the DiParkSys v1.0 which prevents the disabled parking violation by providing an alarm which goes off if any unauthorized person parked in the parking provided for the disabled (Hadi, Fauzi, & Gining, 2017). However, the previous study had a major disadvantage where the City Council would still need to look out for the parking violation by manually observing the parking spaces. This action could not fully prevent the non-disabled from violating the disabled parking (Dinh & Kim, 2016). This is because DiParkSys v1.0 does not include any notification to alert the City Council if any parking violation occurs.

This study main objective is the integration of a notification system to the existing DiParkSys v1.0 using a GSM module. The GSM module which assembled in DiParkSys 2.0 will immediately notify the City Council of any violation by providing the location of the parking spot violation through the use of SMS.

LITERATURE REVIEW

Disabled Parking System (DiParkSys) v1.0

The previous Disabled Parking System (DiParkSys) v1.0 is designed to assist disabled people through the use of IoT. It attempts to prevent the disabled parking spaces from violation by the non-disabled (Hadi, Fauzi, & Gining, 2017). This system provides an alarm system if unauthorized persons park on the disabled parking space. All the components are connected using the jumper wire. The Breadboard that is located between Arduino UNO and the components used as an extension pin since the Arduino has a limited number of pin and power source. The Breadboard enables pins to be assembled without being directly connected to Arduino. The system weakness is the lack of real-time notification to the City Council as they need to be close to the parking violation area to be aware of the alarm.

DisAssist System

DisAssist is developed to alert the disabled on the availability of reserved parking in advance. Hence the authentic verification of the user which enables the organization responsible for monitoring

the reserved n parking to do its job more efficiently (Lambrinos & Dosis, 2013). This system allows the user to access real-time parking availability information gained through Machine-to-Machine (M2M) communication. With the monitoring system, the monitoring organization can observe those who parked at the designated disabled parking space and action can be taken immediately on those who violated this facility.

Advance CAR Parking System

This Advance CAR Parking System is developed to solve parking problems that arise from urbanization. It provides security for the vehicle and the unauthorized user will not be allowed to enter the designated parking spaces (Hemant, Prateek, & Dr B, 2017). A notification on the availability of a parking space will be sent to the mobile phone of the intended rightful car or driver.

Table 1: Comparison of Related Works

	Alarm system	Notification system	Law enforcement monitoring
Disabled Parking System (DiParkSys)	√	X	√
DisAssist System	X	√	√
Advanced CAR Parking System	X	√	√

The related works studies show that the DiParkSys has all the requirements except for the notification system. This highlight the weakness of this system which is the lack of informing function which is crucial in alerting the City Council to take the proper action without the needs of roaming around in searching for parking space violation. By integrating the notification system into the current DiParkSys, improved disabled parking management is in place. The alarm system embedded in the notification system will immediately alert the City Council of any violation and action can be taken against the violators.

IoT Modules

The IoT elements can be divided into three; hardware, middleware and presentation (Mohanty et al., 2016). This study focuses on the hardware element, considering the functions of the project depends on the selection of correct hardware. Hardware is the element that consists of sensors, actuators and any embedded form of communication devices or hardware. The two essential functions needed to be implemented in the project are; notification delivery and car parking detection. There are two candidate modules for each of the function mentioned earlier. Comparison between the modules to select the best module for the project is as shown below.

Table 2: Comparison module for notification delivery function

	Cost	Range	Internet connection
GSM module	Low	Anywhere with the signal detected	No
Wi-Fi Module (ESP8266)	High	100 feet	Yes

The GSM module was chosen for the module for the notification delivery function. The GSM has a lower cost which depends on the number of data sent, meanwhile the Wi-Fi module cost depending on the connection time, which will cost higher in the long run. The notification system

must have a wide range to deliver the notification to the City Council in real-time. The setup required for internet availability for the Wi-Fi module indicating higher cost. The GSM module does not require an internet connection which means it can be accessible at any time as long as the signal of the mobile network is available.

Table 3: Comparison module for car parking detection

	Cost	Range	Detection angle
IR Sensor	Low	2cm – 30cm	35 Deg
Ultrasonic Range Sensor	Low	2cm-400cm	75 Deg

Meanwhile, for the second function, the IR sensor is selected. Even though both sensors have low cost, but the range of the IR sensor is more suitable for this project since the detection range is optimum. The detection angle for the IR sensor is fitting because the surface of the model car matched for the detection angle of the sensor. Moreover, the IR sensor is said to be more stable compared to the Ultrasonic sensor. Both modules; GSM module and IR Sensor are the modules selected for the integration of the notification system to the previous system. The development process and the integration of these modules are described in the next section.

METHODOLOGY

This section describes the methodology applied to design and develop the DiParkSys v2.0. Separated into two sub-sections; (i) the description of the design with a flowchart, system visualization, and schematic design and (ii) the process of programming for functions used with the modules for the system. The methodology utilizes SIM900A GSM module to be integrated with the existing DiParkSys v1.0. Although, the design of the GSM integrated DiParkSys (v2.0) is different from the first version because of the new additional modules required to be assembled in the system. The changes also reflected in the development part where the programming of the functions is changed from the previous version.

The Design of DiParkSys v2.0

Figure 1 illustrates the flowchart of the DiParkSys v2.0 when the system connected to the power source, the system will send the notification to show the GSM Module has been initialized. Once it initialized, the system has set up. When the car enters the parking premise with the specific distance using infrared (IR) sensor, the RFID reader will trigger to scan any RFID tag with the authorized disabled person. The buzzer sound indicates to the non-disabled person parking in that premise. Then the notification will be delivered to the city council via SMS as the parking occupied by non-disabled. By using this simulation, the further step will be explained on the specific approximation of the RFID, sensor and the GSM Module.

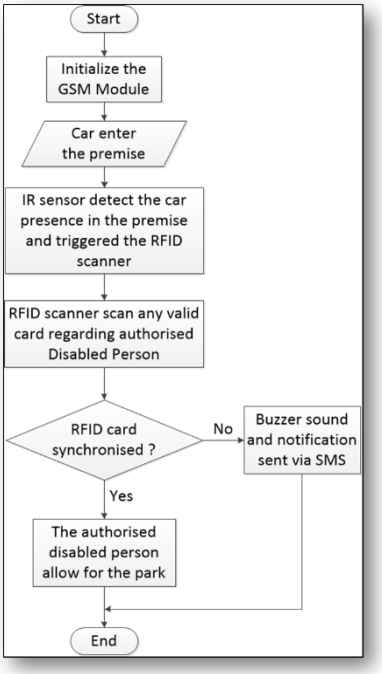

Figure 1: DiParkSys Notification System Flowchart

The design section is continued with the visualization of the system process through a descriptive figure. Both figures below show the process of DiParkSys v2.0. The IR sensor placed at the front of the parking space. Once the car enters the parking space, the IR sensor detects the car then triggered the RFID reader to read any existing RFID tag. Figure on the left in Figure 2 shows the situation car with an acceptable RFID tag for the disabled person's car. Conversely, on the right side of Figure 2 shows the opposite situation where a car without an acceptable RFID tag for the non-disabled. The buzzer goes off and SMS received from the system indicated parking space violation has happened.

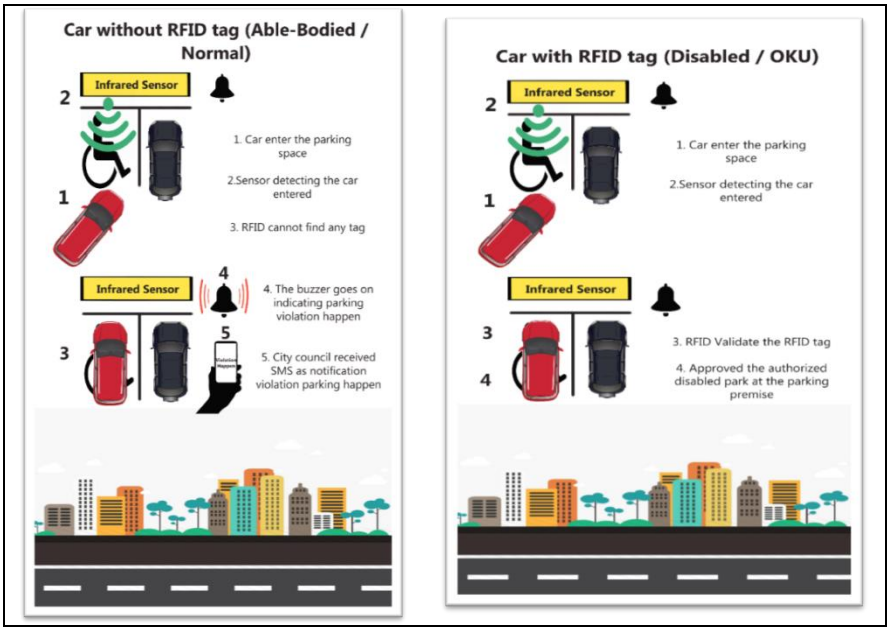

Figure 2: DiParkSys v2.0 Visualization with and without RFID Tag

Following, Fritzing software is used to draw the schematic design as a guide for the assembly of the system components. The software provides a wide range of components required that could be selected and assembled virtually in a schematic design - also showing the error if the assembly has any error. Below is the list of the components identified for the system:

a) Arduino Uno – Microcontroller as a mainboard
b) Infrared Obstacle Avoidance Proximity Sensor FC-51 – Sensor for detecting the car enter the premise
c) RFID RC522 Reader – Passive RFID tag
d) SIM900a – Send notification via SMS
e) Passive buzzer – Sound alarm for the system
f) Breadboard – Additional pin for Arduino Uno
g) Jumper wire - To connect a component with Arduino Uno

The schematic design is done in several stages; based on the priority of the components. The stages also allow for error checking and this reduces the future problem with any other components thereafter. In this system design, the first component that would trigger the entire system to work is the IR sensor – has the highest priority. The design starts with the IR sensor connected to the breadboard together with the Arduino. After that, the RFID reader is integrated into the design as it is the second components that would read the RFID Tag. Subsequently followed by the buzzer as the alarm for a parking violation and the GSM module that acts as the notification system for the City Council to act. Figure 3 shows the full schematic design produced from the stages described.

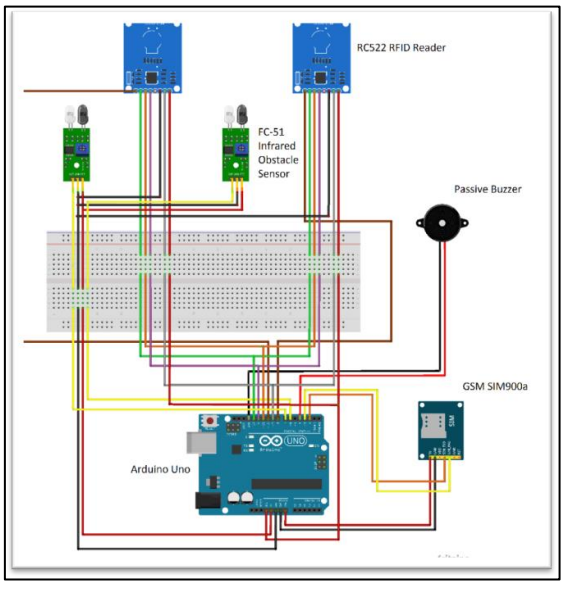

Figure 3: Full schematic design for DiParkSys

The Development of DiParkSys v2.0

Based on the schematic design produced in the previous phase, the system components are assembled. In order to complete the DiParkSys, this phase is crucial. The development phase consists mostly on the programming; writing a function in making sure the assembled system works as intended. The main software used in the development phase is Arduino IDE which supports C programming language as the main language for the Arduino microcontroller. There are two main functions in the program; void setup and void loop. Before utilizing any of the components connected

to the microcontroller, the setup processing must be done first – in the void setup. All the pins used by the components are defined, together with the unique library used by each of the system components. When the setup function is launched, several variables are initialized, and the use of library and pin mode occurred. The setup process is done only once when the system is launched. In the void loop function, the loop process known as the primary function acts as the heartbeat of the program – which executed repeatedly. The loop process is divided into several sections based on the components assembled. Each of the components is initialized and feedback is measured where appropriate output is provided. As an example, the infrared sensor will be defined as *proxy1* for the infrared sensor '1' and *proxy2* for the infrared sensor '2' as stated in Figure 4.

```
void loop()
{
  int proxy1=digitalRead(ir1);
  int proxy2=digitalRead(ir2);
  gsm.TurnOn(9600);                  //module power on
  gsm.InitParam(PARAM_SET_1);//configure the module
  gsm.Echo(1);                  //enable AT echo
  gsm.SendSMS("0162698492","OKU Parking System Initialize");

  pinMode(alarm, OUTPUT);
  pinMode(ir1,INPUT);
  pinMode(ir2,INPUT);
}
```

Figure 4: Program segment-defining IR sensor component

Next, in Figure 5, both infrared sensors are declared in HIGH which means there was no obstacle. The *milis()* here refers to the delay time to ensure the loop run as often, moreover, it more accurate in the execution of time. When one of the infrared sensors in LOW condition within 10 seconds, if there is no RFID tag detected, the SMS will be delivered to the user's number and state which area disabled parking been occupied by the non-disabled. The buzzer would sound, indicating the parking has been occupied.

```
if(proxy1==LOW && ((millis()/1000) % 10 == 0)) // (LOW refer to the IR Sensor detected anything)
{
  gsm.SendSMS("0162698492","PARKIR OKU DI BANGUNAN KWSP TELAH DIAMBIL ORANG!!!");
  Serial.println("ONLY FOR DISABLE VEHICLE. PLEASE PARK AT NORMAL PARKING AREA ASAP!!!!");
  digitalWrite (alarm, HIGH);
  delay(30000);
}

 else if(proxy2==LOW && ((millis()/1000)% 10 == 0)) //milis refer to delay time [change value 10]
{
  gsm.SendSMS("0162698492","PARKIR OKU DI BANGUNAN PERSEKUTUAN TELAH DIAMBIL ORANG!!!");
  Serial.println("ONLY FOR DISABLE VEHICLE. PLEASE PARK AT NORMAL PARKING AREA ASAP!!!!");
  digitalWrite (alarm, HIGH);
  delay(30000);
}
```

Figure 5: Program segment IR sensor triggering buzzer and GSM module

RESULT AND DISCUSSION

The testing for the system is conducted by using the developed small-scale prototype. A remote-controlled car is simulated as a car as the parking spaces are built from materials combined with the completed DiParkSys v2.0 system.

RFID Reader Validation Testing

For this testing, the RFID reader was tested by how the height of the RFID reader can reach to the RFID card. The RFID reader must reach as low as possible with the RFID tag. The type of RFID use, in this case, was MiFare tag with 13.56 Megahertz (MHz) that would be embedded below the car model. In table 2, all the reading has good range except 3.0cm because it was too far from the RFID reader. The RFID tag height at the car model measure with the RFID reader so they can have the optimum measurable which is 2.0cm.

Table 3: RFID Reader Validation Testing result

No	Testing ID	Testing Description	Answer	
			Yes (√)	No (X)
1	08	Read MiFare Tag from: 0.5cm	√	
2	09	Read MiFare Tag from: 1.0cm	√	
3	10	Read MiFare Tag from: 1.5cm	√	
4	11	Read MiFare Tag from: 2.0cm	√	
5	12	Read MiFare Tag from: 2.5cm	√	
6	13	Read MiFare Tag from: 3.0cm		X

SMS Testing

For this testing, the GSM module was tested by putting the prototype model in various place that is possible for the parking spaces to be situated. For this project, 3 different places were tested which are triple story house, closed space and in a normal room. All the result has the same answer which all the phone can receive the message when a parking violation happened.

Table 4: SMS Testing result

No	Testing ID	Testing Description	Answer	
			Yes (√)	No (X)
1	14	SMS received from: triple storey house	√	
2	15	SMS received from: closed space	√	
3	16	SMS received from: normal room	√	

Execution Testing

Execution testing conducted in table 4 to observing well known about all the components works with the 'True' and 'False' RFID and without RFID at the model car. This test starting with the system initialized. Then the detection of the infrared sensor and move to the RFID reader. Next, the system can give SMS and buzzer sound. The test conducted to measure the correctness of the behavior system well.

Table 5: Execution Testing result

No	Testing ID	Testing Description	Answer	
			Yes (√)	No (X)
1	17	Model car with 'True' tag - Disabled	√	
2	18	Model car with 'False' tag – Non-Disabled	√ - With alarm and SMS	
3	19	A model car without RFID tag – Non-Disabled	√ - With alarm and SMS	

The outcomes of the testing suggested that DiParkSys v2.0 functionalities are responding positively. All the conducted testing achieved the expected outcome and the system could be used as a proof of concept to be adopted in a real-life situation.

CONCLUSION

This paper described a study on the design and development of the disabled parking system based on the previous study (DiParkSys v1.0). The literature review has been done, and the design and development process for the project is described. The evaluation results suggest that the DiParkSys v2.0 strength is it can be adopted in managing the disabled parking spaces from violation by the non-disabled. Apart from that, DiParkSys v2.0 could further notify the City Council for any violation that occurred in disabled parking spaces. Thus, it eliminates the manual checking to be done in the first version of the system. Although it can also be said that the SMS features is the system strength, it can also be considered as its limitation. Currently, more systems choose to integrate with the internet-based platform (e.g. Telegram). The user of the system might not prefer SMS as they are used to the more common internet-based platform. This limitation can be seen as an opportunity to further improve the system with the integration of an internet-based platform.

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REFERENCES

Dinh, T., & Kim, Y. (2016). A novel location-centric IoT-cloud based on-street car parking violation management system in smart cities. Sensors (Switzerland), 16(6), 8–10. https://doi.org/10.3390/s16060810

Hadi, A. F. A., Fauzi, S. S. M., & Gining, R. A. J. M. (2017). Disabled Parking System Using Arduino and RFID, 3, 383–386.

Hemant, C., Prateek, B., & Dr. B, V. (2017). Advanced CAR Parking System using Arduino. International Conference on Advanced Computing and Communication Systems, 1–5. Retrieved from http://ieeexplore.ieee.org.ezaccess.library.uitm.edu.my/stamp/stamp.jsp?tp=&arnumber=8014701

Lambrinos, L., & Dosis, A. (2013). DisAssist : An Internet of Things and Mobile Communications platform for Disabled Parking Space Management, 2810–2815.

Mohanty, S. P., Choppali, U., & Kougianos, E. (2016). Everything you wanted to know about smart cities: The Internet of things is the backbone. IEEE Consumer Electronics Magazine, 5(3), 60–70. https://doi.org/10.1109/MCE.2016.2556879

Muhammad, S., Nanthakumar, L., Rashid, S., & Talat, A. (2015). The effect of urbanization, affluence and trade openness on energy consumption: A time series analysis in Malaysia. Renewable and Sustainable Energy Reviews, 47, 683–693.

United Nations. (2010). World Urbanization Prospects 2009 Revision (United Nations 2010) | Urban Area | Urbanization. Retrieved from https://www.scribd.com/document/78681125/World-Urbanization-Prospects-2009-Revision-United-Nations-2010