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Design and Implementation Monitoring and Booking Systems for Smart Parking at Engineering Faculty Campus

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Design and Implementation Monitoring and Booking Systems for Smart Parking at Engineering Faculty Campus

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Abstract. Parking our vehicles sometimes become troublesome and situation gets worse when the user is required to park their cars at the unknown parking availability. Not to mention, this situation also occurs within the new Campus of Engineering Faculty of Universitas Hasanuddin. This campus has a motto to be the centre of technology, so it is something unfortunate that the parking management does not incorporate technology to support the parking system. This paper emphases on designing smart parking model which is suitable to be adopted within this new campus. Technology based Internet of Things is used to modernised the parking system with advanced features of monitoring and booking mechanisms. These features are accessible through smart phones which increases the usability of the proposed smart parking system. The experiments show that the parking management system can function accurate and effectively in enhancing the quality of parking system, with the two-mentioned features of the proposed smart parking system, which are monitoring and booking capabilities.

1. Introduction

The increasing use of vehicles and community mobilization from one place to another parallel with the community's need for land or parking spaces. In Makassar city there are at least 717 parking points spread across 14 sub-districts [1]. In terms of government regulations, particularly in the Makassar city area, South Sulawesi, local government regulations have been issued to regulate the Makassar City roadside parking system [2], and in general have been stipulated in regional regulations regarding the Makassar City regional spatial plan [3].

However, the increasing population of vehicle users, especially car users, is becoming a problem for the campus community today. The limited available parking space in the campus area and the lack of information regarding the availability of parking space creates a mismatch between vehicle users and the available parking space capacity. At the Engineering Faculty of Hasanuddin University itself, the parking information system used is still not able to inform the availability of parking lots to vehicle users. Drivers who want to park their vehicles must first check directly the availability of their parking locations. The impact is, in addition to the time loss experienced by the driver of the vehicle, this can also be a trigger for congestion on the streets around the parking area [4, 5].

This problem should be solved by creating an online parking lot monitoring information system. With the development of IoT technology and the use of smartphone technology, technological devices can monitor the availability of parking lots and then provide that information to vehicle users in real-time, so users can find out the available parking locations and make parking reservations before arriving at the parking location [6]. Therefore, in this paper, the author will try to make the design and

implementation of an online parking reservation system on car parking lots at the Faculty of Engineering, Universitas Hasanuddin.

2. Technology Peripherals
The following descriptions provide details of peripherals to be used to develop the smart parking hardware design.

2.1. Sensor Unit
In order to detect the presence of objects, in this case, vehicles, a device is used and one of the commonly used to perform this functionality is ultrasonic sensors.

A technology that is often used for object detection applications and object height measurement is ultrasonic technology. Ultrasonic sensors work by utilizing the principle of sound waves. Ultrasonic terminology means waves with frequencies above the frequency of human hearing where these sensors use a type of frequency that cannot be heard by humans. This is important for sensor performance because certain frequencies are rarely generated for other functions which are useful for avoiding interference effects with other sound sources. Ultrasonic sensors transmit sound waves in sequence or series which will be reflected back by the object to be detected. Mileage is obtained by calculating the travel time of sound waves since they are transmitted until they are reflected back. The microprocessor can then calculate the level, the content and even open the channel flow. This mechanism is also used to detect the presence and profile of an object in a particular application.

Figure 1. Physical look ultrasonic sensor

However, this technology has several limitations, for example the shape of the object's surface detection, distance, size and angle can affect the accuracy of the reading. The ideal surface for this sensor application is a smooth and hard surface. This type of surface is able to reflect a large number of signals rather than soft or uneven surfaces. Grain and flour ingredients will reduce the operating distance from the sensor and lower measurement accuracy. Ultrasonic sensors require an unobstructed air column to be detected. In addition, the distance from the object can also affect the accuracy of the ultrasonic signal. If the object is to be measured or detected far away, it requires better reflection characteristic ability than closer objects [7]. Examples of ultrasonic sensor shapes can be shown in Figure 1 and a brief illustration of the sensor working system shown in Figure 2.
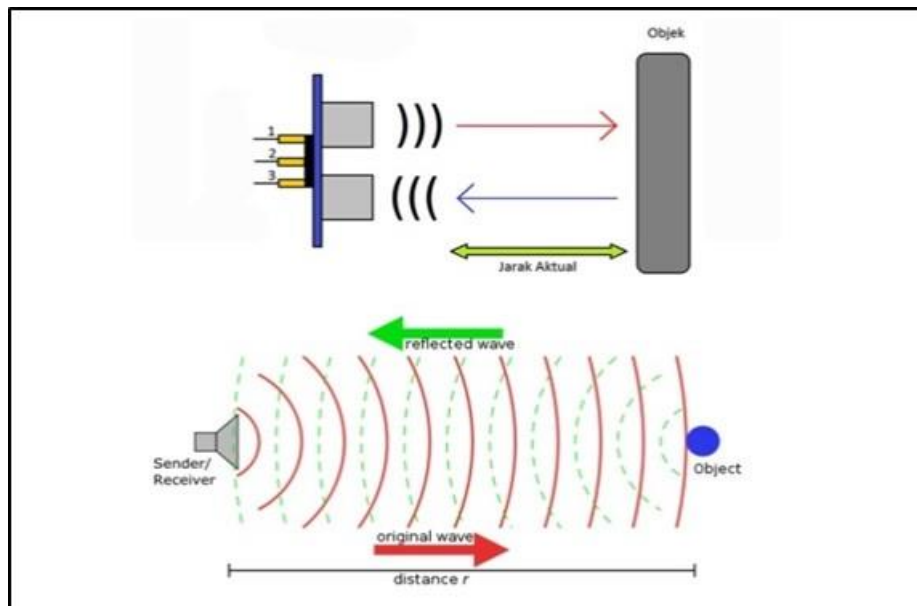
Figure 2. How Ultrasonic sensor works

2.2. Control Unit

Currently, the integrated system technology is increasingly dominating the market and microcontroller technology is a technology that is widely adopted, both among academics and industry. Some of the developments in this microcontroller system have evolved into user-friendly systems, among which the most popular are Arduino and Raspberry-based systems.

2.2.1. Arduino Unit. Arduino technology is a microcontroller with small dimensions that is equipped with a universal serial bus (USB) plug to connect computers and several connection sockets that can be connected by cables to electronic components such as motors, relays, light sensors, laser diodes, loudspeakers, microphones and so on. This system can be supplied with a voltage source via a computer USB, or from a 9-volt battery voltage source or from another DC voltage source. This technology can be controlled via a computer or programmed with a computer and then released and then the system can function alone or independently. The Ardunio Board is designed open source so that everyone can access and make boards that are compatible with Arduino [8]. Examples of Arduino board shapes can be seen in Figure 3.

Figure 3. Arduino board

2.2.2. Raspberry Pi. The Raspberry Pi device has various interfaces for installing hardware sensor devices. For example, by using the I2C bus for simple sensors (light, temperature, motion, sound) and USB for more complex sensors (Wifi). By using a Linux system, the use of daemons to collect realtime sensor readings and cache data in local memory. This data is periodically stored to the server via a secure TCP / IP connection. Each board currently requires two physical connections, for wired ethernet and DC power supply via an electrical transformer [9]. Figure 4 shows an example of a Raspberry-based board.

Figure 4. Raspberry Pi model

2.3. Communication Unit

One of the fast-growing devices used in Internet of Things is the LoRa technology (Long Range) which is a long range with low power wireless device. This device used a spread spectrum modulation technique originated from chirp spread spectrum or CSS technology. LoRa technology with the LoRaWAN protocol has enabled IoT utilisation which tackle some challenges facing out current technology, which are energy management, infrastructure efficiency, disaster related applications, etc [10,11].

It is mentioned in [12] that LoRa is the creation of a long-range communication link through physical layer or via wireless modulation. As the LoRa is based on CSS, it allows to maintain low power characteristic as those wireless systems that utilises frequency shifting (FSK) modulation and at the same time, it can increase significantly its communication range. Figure 5 shows an example of LoRa board available on the market.

Figure 5. LoRa board

3. Smart Parking Diagram Design

Figure 6 below shows the overall diagram design of the Smart Parking System to be implemented in the parking management system at the Campus of Faculty of Engineering UNHAS.
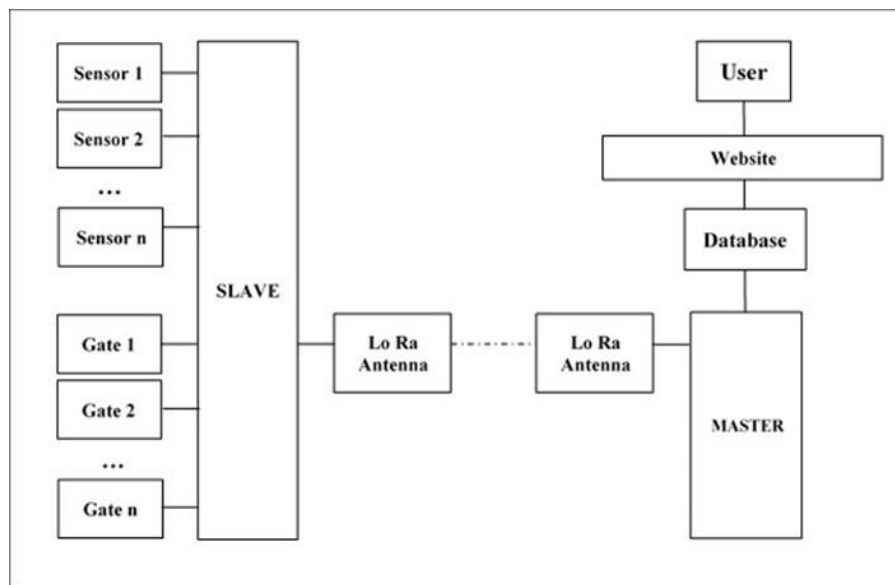
Figure 6. Smart parking block diagram

It can be seen from Figure 6 that the overall system is divided into three main sections, the Slave, the Master, and the Server/Database sections. The Slave part is a part of the system that is directly related to the parking lot to be detected. The main task of the Slave is to detect the presence of vehicles at the parking point and control the activity of the gate / indicator located on the parking lot. The Master part is in charge of acquiring and processing data, then to be sent to the database located on the server. The system offers two features, which are monitoring and booking features, that are available through a dedicated website and are accessible via personal computer or smart gadgets. Between the Master and Slave communication is done using wireless radio frequency technology, so that the Master and slave can be placed in separated distance.

Figure 7 is a picture of the data flow in the system. The sensor that has read the condition of the parking point then sends data to the Slave. The slave then collects data from each sensor and sends it to the Master. The Master part that has received the data then processes the data and then stores it. Data that has been stored by the Master will be forwarded to the database located on the server. The process of sending data from slave to Master is sequential process. Thus, the slave will only send the parking conditions to the Master periodically when all sensors have successfully sent the detection results to the slave.
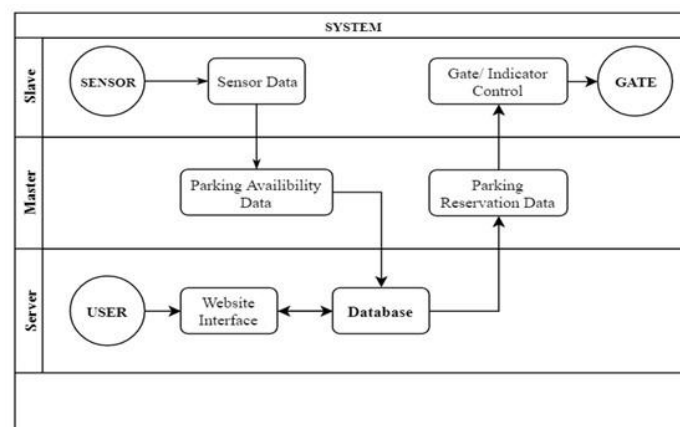
**Figure 7.** Flow data of the smart parking system

The Master not only receives data on parking conditions from the slave, the Master also receives data from the database about the points that have been reserved by the user. This data is then processed in accordance with the availability of parking lots that would be reserved. If parking is available, the Master will send an order to the slave to activate the gate / indicator at the reserved parking point.

4. Experiments and Results Analysis

There are several elements of the smart parking system and most of them are viewable from the webpage.

4.1. Webpage

The front webpage in which users can access the monitoring and booking features is shown in Figure 8 below.
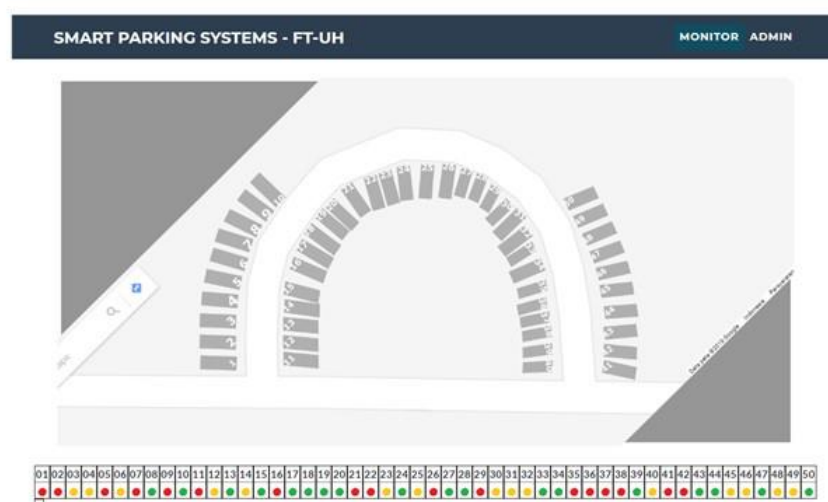
Figure 8. Front page of the webpage smart parking

Figure 8 is the front display of the website page of the online parking reservation system interface. Through the web page, users can find out the availability of each existing parking slot and latter to make a reservation at the desired parking lot. The picture shows the conditions of the indicators that exist on the website. The green circle indicates that the parking lot is empty, the red circle indicates that the parking lot is filled, while the yellow circle indicates that the parking lot has been reserved. Steps to access the features of the smart parking can be described as the following.

- Open web browser (either pc, laptops or smart phones
- Type **smartparking.unhas.ac.id**
- Check availability of slots by the colour of the indicators (available slot 18 to slot 33, others for future development)
- Click on the available slot (green indicator) by first activating GPS

Figures 9 and 10 show the booking appearances whether its is a successful booking or unsuccessful reservation.

Figure 9. Successful reservation

Figure 9 shows the notification window when the users successfully book their parking spot. The page shows the position of the parking spot and the number of the parking slot. Figure 10 depicts the notification window when the user fails to book their parking spot. The page also shows the reason why the user unable to reserve the parking spot. To successfully reserve the parking spot, the system must know the location of the user and calculate the distance of the user to the parking point. So, the user needs to turn on the GPS on their smartphone and allow the system to know the location from the user internet browser. This procedure needed to avoid user reserve the parking spot from very distant places and making another user unable to reserve a parking spot.

Figure 10. Unsuccessful booking

4.2. Measurements Delay Data
One set of data is collected from the delay time from the sensor reading detects a vehicle until the changing in the associated indicator colour (Table 1). It can be seen from Table 1 that there are some time delays occurs when sending data to the server or when retrieving data from the server with only three parking points. The longest delay in the table is 11.14 seconds while the shortest delay is 2.51 seconds. There are several factors contributes to the delay, one of them is the internet speed during the reservation or the number of the sensor used in the system.

Table 1. Delay Time of the Booking System

Cycle No.	Delay (s)	
	Sensor to Database	Database to Gate
1	5.19	5.41
2	2.82	7.87
3	3.72	2.51
4	5.63	1.54
5	3.01	11.14
6	3.29	3.42
7	10.48	4.78

The effect of the number of sensors used on the delay that occurs in the slave of the system is shown in Table 2. Each sensor takes approximately 68 ms to read the conditions of each parking point. The more sensors being installed, the longer delays generated for establishing data communication of the server (master)-slave. Hence, it will accumulate the delay of the overall existing sequential system.

Table 2. Delay by Slave (sensors being Utilised)

Number of Sensors	Delay (ms)
1	68
2	134
3	201
5	337
10	674
20	1350

4.3. Measurements Distance Data

Table 3 depicts the distance of the user to the server that could affect the success of a reservation. In the system that has been made, a maximum distance limit of reservation system is set in order to avoid users making reservations from places that are too far from the parking point.

Table 3. Distance access

No	Distance (m)	Result
1	210	Succes
2	400	Succes
3	850	Fail

It can be seen that the booking feature of the smart parking system is at maximum 400 meters and beyond that no reservation is allowed, however, only the monitoring feature that can be accessed by the users.

5. Conclusions

The system we design can work appropriately for handling parking spot detection and online reservation. Time requires to make a reservation is considerably fast with 11.14 seconds of delay time.

For user convenience, the booking feature is only accessible within the radius of 400 meters from the parking lots. In the future, there are some improvements to be made as to increase the usability of the smart parking system and to integrate with a complete opening-closing gate mechanism. There are still some delays in the process of sending and receiving data which needs to be tackled. Also, the system used today is still a sequential system in which the system will update data periodically even though there are no changes in the system. This also makes the system less responsive when changes occur in the system.

Acknowledgments

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