Low Cost Wireless Parking Module Design and Implementation

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***Abstract*— Finding a parking space in a large parking area becomes a problem for a driver these days. This paper presents a design and implementation for a low cost, wireless parking module, which contains of a parking sensor to detect a vehicle, and an LED display available parking space. This module uses a PING ultrasonic sensor and a NodeMCU as a microcontroller. The module connected wirelessly to the main server via a router. The module should cost less than average retail prices of similar module available on the market. A better approach for the vehicle detection scenario is also presented as a result.**

Keywords*— *vehicle detection; parking, low cost; design

I. Introduction

Parking is a mandatory process for a vehicle. Growth in the automotive industry, along with affordability of personal vehicle (specially car) requires more parking space. Parking area grows bigger and bigger. The nature of the most indoor parking area makes it difficult to find one empty space. This is because most parking areas are built in a level terrain.

When land become limited, vertical parking area such as basement and multi-story parking building become more common. A typical ten-story building can have up to 300 or more parking spaces. Parking in this area requires much more challenging effort. When the driver enters the parking area, especially in the busy hours, finding an empty space could be challenging, or even frustrating. Some parking management then uses a tool to inform the driver for an empty space.

Fig. 1. Sample of LED Usage for Available Parking Information [1]

The basic type of this tool usually includes a sensor to detect the presence of a vehicle in a parking space, and a device such as an LED or a lamp to inform parking condition. The LED or lamp usually located above each space, as shown in Fig. 1. To detect the presence of a parked vehicle, a sensor is used. The common type of sensor used detect vehicle includes loop detector [2], infrared sensor [3] [4], and ultrasonic sensor [5].

Loop detector senses the change of the magnetic field near its environment. The magnetic field will change if a vehicle is near, since it contains metal. The infrared sensor emits light in the infrared (IR) spectrum and can detect obstacle within the detection range, by calculating reflected IR bounced by the object.

This main principle is similar to ultrasonic sensors. Instead of IR, ultrasonic sensor uses sound emitted in ultrasonic wavelength. Ultrasonic and infrared sensor is mainly used to detect vehicle because they are small and relatively cheap. The sensor can be placed in various positions against the vehicle. In our previous research, we compare sensor placement on the parking floor, above the car and at the side of the car [6]. Sample of parking sensor placement can be seen in Fig. 2. The sensor can be placed separately or integrated with an LED, to inform the driver for the availability of a parking space.

Fig. 2. Parking Sensor [7]

One issue for the parking sensor implementation in a large parking area is connectivity. Conventional system uses cables. While cable is a relatively cheap solution for implementation in small to medium size parking area, maintenance cost is relatively high. This is because maintenance is needed along the cable path. Cable also prone to water and electromagnetic

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interference. Alternative solution for water threat is to use additional, waterproof coating or using a pipe. To minimize electromagnetic interference, the shielded cable can be used [8] [9]. However, the effectivity of the shielding depends on the type of electromagnetic interference. Customizing shielding for every possible interference in a parking area could be difficult, and costly. For a large parking area, this will be a nightmare. Other alternative uses a wireless network to connect parking sensor, parking indicator, and the controller. The implementation of this alternative could cost more than the previous solution, but has a lower maintenance cost. There are no physical media between every node, which means maintenance cost only allocated at on the node itself. Such concept of using wireless networks for parking detection and solution has been proposed by previous research, such as the use of wireless sensor networks for on the street parking [10]. Other research proposed the use of active RFID and wireless sensor network for car park [11]. A research, also conducted to formulate the optimal sensor placement [12].

Another issue for the parking sensor implementation is "false detection", when the sensor failed to detect whether a vehicle has been on its final position (parked or exit a space) or sill in the intermediate state.

The 'low cost' version of similar module available in the market today range between US$15-US$55. This price acquired by survey to the various wholesale or distributor in online market [13] [14] [15] [16]. This approach is done to search "lowest price" possible on the market.

Hence, this paper proposes a design and implementation of a wireless parking module. Main requirements are (1) the module should cost less than IDR200,000 (about US$15), and (2) it also presents a detection scenario to overcome the "false detection".

II. The Design

The system proposed consists of three main parts, the main server acts as a central node which records parking data and control overall system, as shown in Fig. 3. Wireless network provides connectivity between all parking nodes at each parking space in the main server.

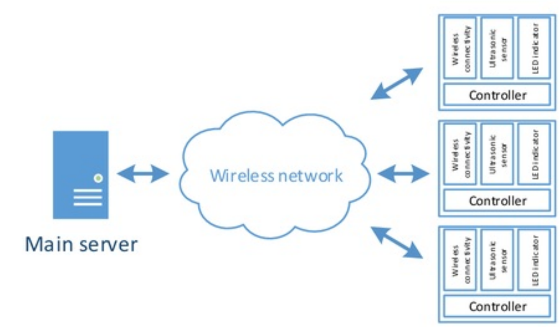

Fig. 3. System Design

A. Main Server

Main server hosts the database and also acts as a web server. The server records activity of the parking spaces, such as when a vehicle enters or leaves a space, and calculates how long it has been parked. This data can be fetched for further purpose, such as security or tax calculation. Technical specification of the server is detailed in Table I.

TABLE I. Main Server Specification

Component	Specification
Processor	Core i5 7500
RAM	8 GB
HDD	1 TB
Operating System	Ubuntu 16/04
Web server	Apache
Database	MySQL
Other	Mikrotik Router Management Tool

B. Wireless Network

We use dedicated network for the implementation. An access point, also acts as a router, was used to handle communication between the parking detector module and the main server. Technical specification of the access point is detailed in Table II.

TABLE II. Access Point Specification [17]

Component	Specification
Access point	Mikrotik RB951Ui-2HnD
CPU	AR9344 single core
RAM	128MB
Radio	2.4GHz 1000mW
Wireless standard	802.11b/g/n
Power cons.	Up to 7 W
Power supply	24V, 0.8A

According to its specification, the access point is classified as a SOHO device. However, this device can manage 30-40 devices, enough to accommodate our testing scenario. The access point itself costs IDR786,000 (about US$59).

C. Wireless Parking Module

The module is located at each parking space. This module consists of four main parts:

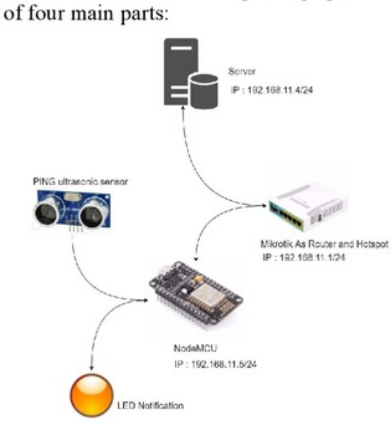

Fig. 4. Wireless Parking Module Diagram

- A NodeMCU, acts as a microcontroller. This module is equipped with ESP8266 Wi-Fi System on Chip (SoC), which is used to communicate with the main server. It has 128 kBytes of memory and 4 Mbytes of storage.

- Ping HC-SR04 ultrasonic sensor, as a vehicle detector.
- LED notification, provides information to the driver whether a space is free or occupied. Occupied space will turn the LED red, while free space will turn the LED green.

The diagram of the module is shown in Fig. 4. For the sensor, we use PING HC-SR04 ultrasonic sensor. For the indicator to the driver, an array of LEDs is used. The sensor and LEDs are connected to the microcontroller.

The ultrasonic parking sensor is located at the 'inside' of the parking space, at the floor, about 30 cm from the stopper, as shown in Fig. 5, The LED indicator is located above the space.

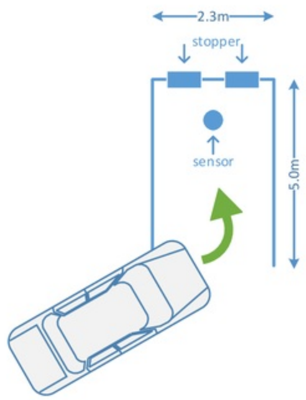

Fig. 5. Sensor Placement

To avoid "false detection", we averaged time needed for a vehicle to enter a spot, let the driver do necessary maneuver to correct his parking position, and finally parked. Time needed for corresponding scenario also calculated when the vehicle exits the spot. Maneuver by the driver is potential to "false detection" and appropriate timing is needed for the sensor before changing the parking status.

III. System Testing and Discussion

We tested the system in our university parking area. The area consists of 33 perpendicular parking spot, divided into two rows. The first row consists of 18 spots and the second one consists of 15 spots. Each spot has a dimension of 2.3m by 5.0m. This is classified as class 1 parking space by the government. Ground clearance of the vehicle ranges between 15cm-40cm. From the experiment, the sensor's detection time for both incoming and outgoing vehicles averaged at 500 milliseconds.

The system also successfully records the activity in the main server's database. We tested a vehicle which gets into the spot by driving forward and backward. All tests were conducted with the speed below 5 km/hr., and in all tests, vehicle detected by the sensor successfully. We also tested maneuver which potential for "false detection", such as when an incoming vehicle exits the space for a while before re-entering the space, simulating a driver who wants to correct the parking position, or when leaving vehicle entered the spot for a while before permanently exits the spot.

While the detection process successfully conducted for all testing scenarios, the nature of the sensor makes it prone to "false detection", if the sensor is covered accidentally. This can be caused by trash or fallen leaves from nearby trees. Adjusting the threshold for the distance measurement between the sensor and the object can solve the problem. Moving the sensor to the top of the parking spot also can be used as an alternative. For outdoor parking area, mounting the sensor on a pole and facing it at an angle could solve the problem. This scenario will extend the distance between the vehicle and the sensor. However, from the previous research, the sensor still can detect objects at 1.5m distance [6].

Changes from the sensor's reading should not instantly detected as a change of the parking space. This accommodates if a driver purposely drives out the space for a while, but not with the intention to leave the space (see Table III). For example, if the driver exits the space for a while to correct the parking position.

TABLE III. Vehicle enters a space scenario

Time (ms)	Sensor Reading	Parking state	Time (ms)	Sensor Reading	Parking state
0	0	Initial: SPACE = EMPTY	10500	0	EMPTY
500	0	EMPTY	11000	0	
1000	0		11500	0	
1500	0		12000	0	
2000	1	change detected, start counter	12500	1	change detected, start counter
2500	1	counting	13000	1	counting
3000	1		13500	1	
3500	1		14000	1	
4000	1		14500	1	
4500	1		15000	1	
5000	1		15500	1	
5500	0	change detected, counter < 5s, reset counter	16000	1	
6000	0	EMPTY	16500	1	
6500	0		17000	1	
7000	0		17500	1	no change detected in 5s, SPACE = OCCUPIED
7500	1	change detected, start counter	18000	1	OCCUPIED
8000	1	counting	18500	1	

Time (ms)	Sensor Reading	Parking state	Time (ms)	Sensor Reading	Parking state
8500	1		19000	1	
9000	1		19500	1	
9500	1		20000	1	
10000	0	change detected, counter < 5s, reset counter	20500	1	

This also accommodates if a vehicle accidentally triggered a sensor, but the driver has no intention to park in the spot. If a change is not followed by another change for a specific of time, then the LED change color. A five second waiting time proven to be sufficient for the scenario. While in the five second waiting time, the LED can be turned yellow or blinked, informing that the driver should enter the space if he/she wants to park there. When a vehicle leaves a space, another driver who wants to enter the space also have to wait for the same period of time, giving the system to change the status (see Table IV). Otherwise, the new vehicle will be detected as the previous one (see Table V).

TABLE IV. INTERCHANGE BETWEEN VEHICLE

Time (ms)	Sensor Reading	Parking state	Time (ms)	Sensor Reading	Parking state
0	1	Initial: SPACE = OCCUPIED	10500	1	change detected, start counter
500	1	OCCUPIED	11000	1	counting
1000	1		11500	1	
1500	1		12000	1	
2000	1		12500	1	
2500	1		13000	1	
3000	1		13500	1	
3500	0	change detected, start counter	14000	1	
4000	0	counting	14500	1	
4500	0		15000	1	
5000	0		15500	1	no change detected in 5s, SPACE = OCCUPIED
5500	0		16000	1	OCCUPIED
6000	0		16500	1	
6500	0		17000	1	
7000	0		17500	1	
7500	0		18000	1	
8000	0		18500	1	
8500	0	no change detected in 5s, SPACE = FREE	19000	1	
9000	0	FREE	19500	1	

Time (ms)	Sensor Reading	Parking state	Time (ms)	Sensor Reading	Parking state
9500	0		20000	1	
10000	0		20500	1	

Table V shows the sample of "false detection", when a vehicle enters a space (at 5000ms) 2.5 seconds after the previous vehicle exits (at 2500ms).

TABLE V. FALSE DETECTION AT INTERCHANGE BETWEEN VEHICLE

Time (ms)	Sensor Reading	Parking state
0	1	Initial: SPACE = OCCUPIED
500	1	OCCUPIED
1000	1	
1500	1	
2000	1	
2500	0	change detected, start counter
3000	0	counting
3500	0	
4000	0	
4500	0	
5000	1	change detected, counter < 5s, reset counter
5500	1	OCCUPIED
6000	1	
6500	1	
7000	1	
7500	1	
8000	1	
8500	1	
9000	1	
9500	1	
10000	1	

IV. CONCLUSIONS

The sensor costs IDR45,000 and the parking module costs IDR55,000. Plastic housing costs around IDR10,000 to IDR15,000, depending on the material. Overall, the wireless parking module costs around IDR115,000 (around US$8.6), below the target of US$15. The price is possibly going lower when produced in a large number. Adjusting the distance threshold or placing the sensor at the top of the space, or mounting it at the pole at the end of the space, and facing the sensor down at an angle can reduce the problem of sensor covered accidentally, and preventing a "false reading".

The parking sensor is capable to detect vehicles in 500ms. A waiting time is needed between the changes of the parking state, to make sure a vehicle in its final state of enters or exits the spot. From the experiment, a five second delay and detection scenario explained in the discussion above is proven to be sufficient to overcome the "false reading" problem. Data from the sensor can be used for further use, such as to calculate parking tariff or parking reservation. Wireless design provides easy installation and less maintenance cost of the sensor.

V. ACKNOWLEDGEMENTS

This research is funded by The Government of the Republic of Indonesia, through *Penelitian Produk Terapan* scheme. We would like to thank the Government for financial support, and School of Applied Science of Telkom University, which provides testing ground for the system.

VI. BIBLIOGRAPHY

[1] V. N. V. Sai Pavan, N. V. Nishanth and J. Kathirvelan, "Automation of Vehicular Parking Using Loop Detector with single lane traffic: A Design Approach," *International Journal of Engineering and Technology,* vol. 5, no. 3, pp. 2471-2475, 2013.

[2] S. Srikurinji, U. Prema, S. Sathya and P. Manivannan, "Smart Parking System Architecture Using Infrared Detector," *IJAICT,* vol. 2, no. 11, 2016.

[3] G. Gunasekara, A. Gunasekara and R. Kathriarachchi, "A Smart Vehicle Parking Management Solution," in *Proceedings of 8th International Research Conference*, 2015.

[4] S. B. Baglane, M. S. Kulkarni, S. S. Raut and T. S. Khatavkar, "Parking Management System," *Journal of Modern Engineering Research,* vol. 4, no. 2, 2014.

[5] "Parking Guidance System," Kyosis Smart Parking Technologies, [Online]. Available: http://www.kyosis.com/parking-systems/parking-guidance-system/. [Accessed 31 8 2017].

[6] G. A. Mutiara, A. A. G. Agung and R. Handayani, "Sensor Comparation for Smart Parking System," in *ICWT*, Manado, 2015.

[7] S. Robarts, "Bosch sensor connects parking spaces to the Web," New Atlas, [Online]. Available: http://newatlas.com/bosch-active-parking-lot-management/39629/. [Accessed 31 8 2017].

[8] A. Fröbel, "Cable Shielding to Minimize Electromagnetic Interference," in *Proceedings of International Conference on Environment and Electrical Engineering*, 2009.

[9] F. PALMIERI and A. VIOLETTA, "Analyzing the effects of Electro Magnetic Interference on state-of-the-art copper twisted pair Ethernet cabling," WSEAS International Conferences, Skiathos, 2002.

[10] Z. Zhang, X. Li, H. Yuan and a. F. Yu, "A Street Parking System Using Wireless Sensor Networks," *International Journal of Distributed Sensor Networks,* 2013.

[11] E. Karbab, D. Djenouri, S. Boulkaboul and A. Bagula, "Car Park Management with Networked Wireless," in *IEEE International Conference on Electro/Information Technology (EIT)*, Dekalb, IL, 2015.

[12] A. Bagula, L. Castelli and M. Zennaro, "On the Design of Smart Parking Networks in the Smart Cities: An Optimal Sensor Placement Model," *Sensors,* vol. 15, no. 7, 2015.

[13] Alibaba, "Automatic Car Parking Lot Sensor System Ultrasonic Sensor for Parking Guidance System," Shenzhen Gos System Tech Co., Ltd., [Online]. Available: https://www.alibaba.com/product-detail/Automatic-Car-Parking-Lot-Sensor-System_60681454179.html?spm=a2700.7724857.main07.164.2bd139756wTjMy. [Accessed 31 8 2017].

[14] Alibaba, "Parking lot ultrasonic sensor/ Parking Guidance System/Parking Guidance Information System For Parking Lots," Xiamen Keytop Communication & Technology Company Limited, [Online]. Available: https://www.alibaba.com/product-detail/Parking-lot-ultrasonic-sensor-Parking-Guidance_1243498272.html?spm=a2700.7724838.2017115.91.3c93b095m0rCBO. [Accessed 31 8 2017].

[15] Alibaba, "Parking space detector vacant parking indicator light for parking lot sensor system," Shenzhen Tenet Technology Co., Ltd., [Online]. Available: https://wholesaler.alibaba.com/product-detail/Parking-space-detector-vacant-parking-indicator_60532444331.html?spm=a2700.7782932.1998701000.139.187bd15bOM9lcV. [Accessed 31 8 2017].

[16] Alibaba, "RS485 Parking lot ceiling ultrasonic sensor system with garage red green light parking space indicator," Shenzhen Tenet Technology Co., Ltd., [Online]. Available: https://wholesaler.alibaba.com/product-detail/RS485-Parking-lot-ceiling-ultrasonic-sensor_60610048855.html?spm=a2700.7782932.1998701000.152.187bd15b5IvHRO. [Accessed 31 8 2017].

[17] Mikrotik, "RB951Ui-2HnD," 31 8 2017. [Online]. Available: https://mikrotik.com/product/RB951Ui-2HnD.

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