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ZIGBEE PROTOCOL FOR SYSTEMATIC PARKING SYSTEM

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Abstract -- **The increasing number of motorized vehicles in this country creates a high demand of parking space in Malaysia. The car drivers have to spend more time to find out a vacant space especially on weekend and public holidays. Therefore, 'Zigbee Protocol for Systematic Parking System' is developed to solve parking lots congestion. It is a new approach of parking system using Wireless Sensor Network (WSN) technology equipped with Light Dependent Resistor (LDR) sensor. Zigbee is based on IEEE 802.15.4 standard for WSN that is being used in many commercial research applications today where it becomes an attractive solution for low power and low cost applications. Once the LDR sensor detects the new incoming car, the data will be sent to a central database which is Zigbee protocol for verification. Hardware implementation of Zigbee RF Vehicle tags is carried out using XBee Starter Kit DOM Zigbee module. All the information will be displayed using Graphical User interface, Visual Basic 6. Thus, the parking congestion problems can be automatically reduced.**

Keyword: Wireless Sensor Network, Zigbee Protocol, Systematic Parking System

I. INTRODUCTION

ZigBee is a wireless network protocol specifically designed for low rate sensor and control networks [1]. There are a number of applications that can benefit from the ZigBee protocol such as building automation networks, home security systems, industrial control network, remote metering and PC peripherals are some of the many possible applications. Compared to other wireless protocols, ZigBee wireless protocol offers low complexity, reduces resource requirements and most importantly, a standard set of specifications. It also offers three frequency bands of operation along with a number of network configurations and optional security capability.

ZigBee protocol uses IEEE 802.15.4 specifications as its Medium Access Layer (MAC) and Physical Layer (PHY).While IEEE 802.15.4 defines a total of three frequency bands of operations which are 2.4 GHz, 915 MHz and 868 MHz. Each frequency band offers a fixed number of channels. 2.4 GHz frequency band offers a total of 16 channels (channel 11-26), 915 MHz offers 10 channels (channel 1-10) and 868 MHz offers 1 channel (channel 0). The 2.4 GHz band provides 250 kbps, 915 MHz provides 40 kbps and 868 MHz provides a 20 kbps data rate.

Zigbee Protocol for Systematic Parking System' is developed in order to solve the problems of parking space in the busy place. It is a new approach of parking system by using Wireless Sensor Network (WSN) technology equipped with LDR sensors. Zigbee wireless transmission is used in the system as the protocol in the wireless sensor network parking system architecture. ZigBee is a low cost, low power and wireless mesh networking standard. The low cost allows the technology to be developed at various spot in the parking lot to ensure a reliable data transmission. The low power usage allows longer life of operation even with a small size battery which also reduces the size of the device. Mesh networking provides high reliability and wider range as data can be routed between transmitters.

II. LITERATURE REVIEW

ZigBee is the name of a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4 standard for wireless personal area networks (WPANs), such as wireless headphones connecting with cell phones via short-range radio. The technology is intended to be simpler and cheaper than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications which require a low data rate, long battery life, and secure networking. The IEEE 802.15.4 wireless standard is used for low data rate networks. With a maximum speed of 250 Kbps at 2.4 GHz, ZigBee is slower than Wi-Fi and Bluetooth, but is designed for low power so that batteries can last for months and years. The typical ZigBee transmission range is roughly 50 meters, but that can vary greatly depending on temperature, humidity and air quality.

ZigBee protocols are intended for use in embedded applications requiring low data rates and low power consumption [6]. ZigBee's current focus is to define a general-purpose, inexpensive, self-organizing, mesh network that can be used for industrial control, embedded sensing, medical data collection, smoke and intruder warning, building automation,

and home automation. The resulting network will use very small amounts of power so individual devices might run for a year or two using the originally installed battery.

The 802.15.4 standard allows for communication in a point-to-point or a point-to-multipoint configuration as shown in Figure 1.

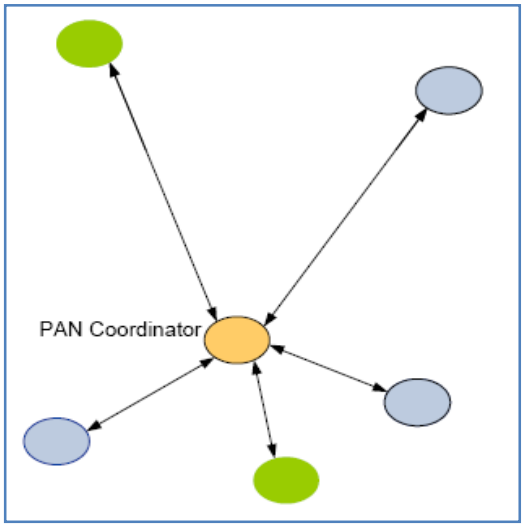

Figure 1: Point-to-point configuration of Zigbee

Maxstream XBee Starter Kit DOM

MaxStream's XBee family of radios can be set up to operate in a point-to-point, point-to-multipoint or a peer-to-peer configuration while standard 802.15.4 always requires a coordinator, the MaxStream radios are set up so that a coordinator is not required.

The XBee and XBee-PRO OEM RF Modules were engineered to meet IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between devices. The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other. The XBee module is shown in Figure 2.

Figure 2: XBee and XBee PRO (module only)

Wireless Connection

Figure 3 show the connection of the XBee module that is used a wireless connection. XBee module has transmitter and receiver that is connected together to get the data through the X-CTU software

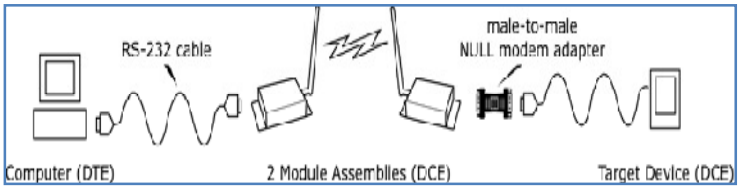

Figure 3: Wireless connection by using XBee Starter Kit DOM

Protocol Stack System of Zigbee standard

The Zigbee specification is a standard that defines a stack protocol enabling the interoperability of wireless devices in a low cost, low power consumption and low data rate network. The Zigbee stack is founded over the IEEE 802.15.4 standard, which defines the multiply accumulate (MAC) and physical (PHY) layer of the protocol. MAC and PHY layers define the RF and communications components of neighboring devices. Zigbee stack layers, on the other hand, include a network layer, an application layer and a security service provider (SSP).

The network layer enables devices to communicate with one another. It is involves in the initialization of the device within the network, routing of messages and network discovery. The application support sublayer also provides these services. The application can configure and access the parameters of the network layer through the ZDO. The IEEE 802.15.4 standard defines the first two layers of the Open Systems Interconnection (ISO) model for low rate wireless personal area network (LR-WPAN). The PHY layer defines radio characteristics and supports the 2.44GHz and 868/915MHz radio bands. As the name implies, SSP offers security mechanisms. However the overall security of the system is defined at the profile level, which defines the kind of security implemented within a specific network as see in Figure 4.

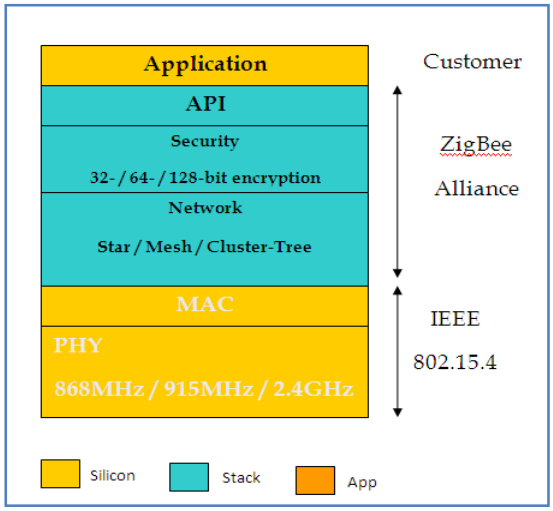

Figure 4: OSI model

III. SYSTEM DEVELOPMENT

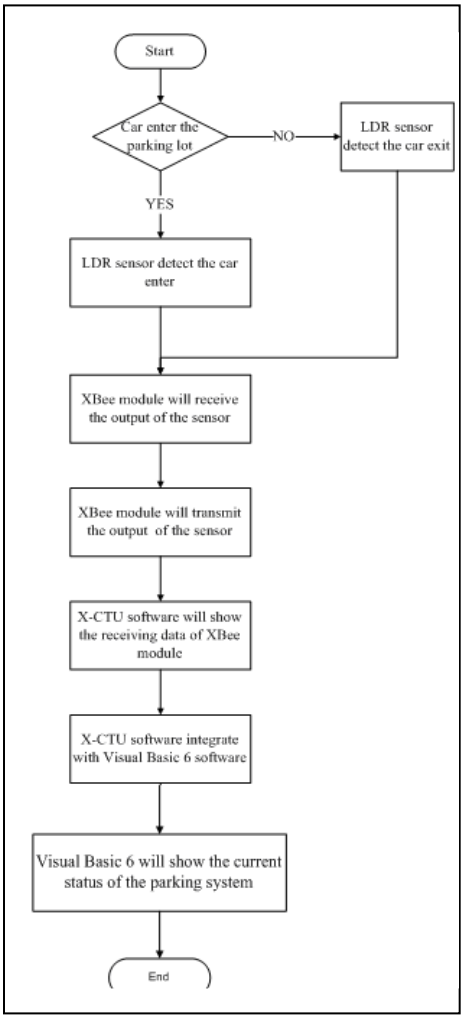

Figure 5: The flow of parking system

Figure 5 shows the flow of parking system. There are two important parts in this project which are hardware and software. For the hardware part, sensor circuit and XBee module are connected together and this hardware will be integrated with Visual Basic 6 to display the current condition of the parking lots.

When there is a car enters into the parking lot, the light intensity of that parking lot is low. LDR sensor will detect the light intensity and send the output to the XBee module. After that, XBee module is connected to the X-CTU software that will show the receiving data from XBee module. This software will be integrated with the Visual Basic 6 to display the status of the parking system.

On the other hand, if there is no car entering the parking lot, the parking lots will have a high light intensity. LDR sensor will detect it and send to the XBee module. XBee module will connected to the X-CTU software and the software will show the data getting from the module. Then, Visual Basic 6 will get the data from the X-CTU software and it will update the status of the parking system. The current status of the parking system will be show in the layout by using Visual Basic 6.

Hardware Development

The first step is to develop the hardware by integrating the sensor with the XBee module where it can detect the car at the parking lots. XBee will program to set output from sensor, and then send the data and count the number of the car at the monitoring center. The sensor used is LDR sensor that functions when any object is lying on top of the sensor.

Software Development

The interfacing process for this project is developed by using Graphical User Interface (GUI) and Visual Basic 6 (VB6) is chose as the software part. Interface will design by using VB6 to monitor the parking system which is shows the location of the car and vacant parking and number of the car on one time. Figure 3.7 show the layout of the parking system.

IV. RESULTS AND DATA ANALYSIS

Analysis of XBee Kit

XBee Starter Kit DOM is used as the wireless sensor network to detect the output of the sensor. Figure 6 show the XBee transmitter that will transmit the output of the sensor via the wireless sensor network. This transmitter is connected to the computer by using serial port. This parallel port is used at

the beginning in order to get the initialize value. XBee transmitter is referred as REMOTE.

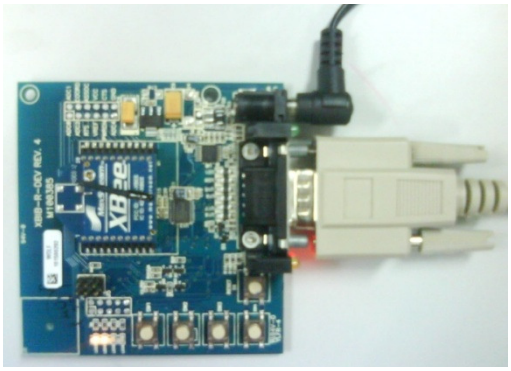

Figure 6: XBee transmitter (REMOTE)

The output of the XBee transmitter will be received by the XBee receiver. XBee receiver is connected to the computer by using RS232 cable and it will interface with the X-CTU software. Figure 7 show the XBee receiver that is referred as BASE.

Figure 7: XBee receiver (BASE)

Once an initial value has been detected from the transmitter, the serial port is removed and serial loop back is connected to the XBee transmitter. *Serial loop back* is used to get the continuous result which is used as the repeater. The connection between serial loop back and XBee transmitter is shown in Figure 8.

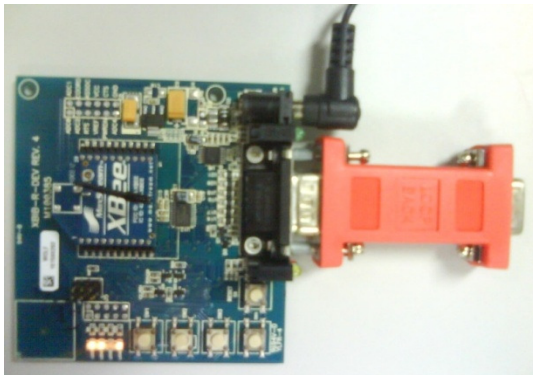

Figure 8: Serial loop back connection with XBee transmitter

Figure 9 show the connection of XBee transmitter and XBee receiver at the computer by using serial port and RS232 cable.

Figure 9: Connection of XBee transmitter and XBee receiver

Analysis of X-CTU software

X-CTU software is used to analyze the results from XBee module. This software will show the connection of the module and give the results from the transmitter and receiver. First, the XBee transmitter and XBee receiver is connected to the computer by using parallel port and RS232 cable. In the X-CTU software, the Digi PKG-U Serial Port Adapter is set as the Com Port. It means that the serial port is used in this software. Before proceed to the next step, the baud and data settings of the com port need to be verified either it is match with the RF module or not. Figure 10 shows the selected com port.

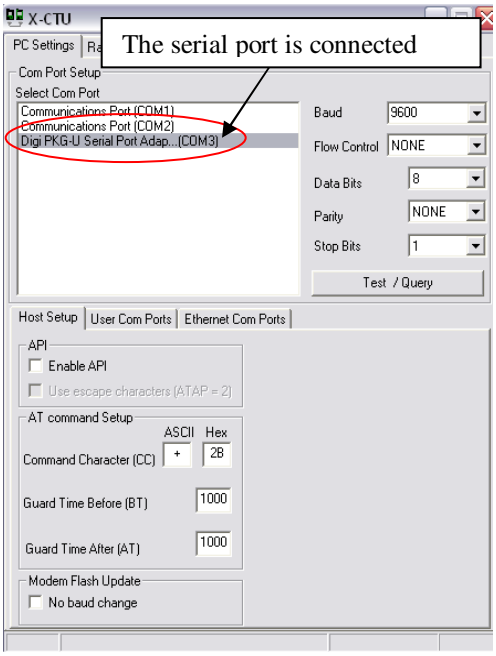

Figure 10: Digi PKG-U Serial Port Adapter is set

Then, the serial port need to be test whether the communication of the port is correct or not. From this part, the

modem type also should be similar with the component used. The result of the com test/query modem is shown in Figure 11.

Figure 11: Results of the Com test/ Query Modem

In order to determine the range capabilities of the XBee modules, the Range Test is done. The RSSI checkbox need to be checked to enable its display. Then, button start is clicked to begin the range test. At first, the REMOTE is used to get the initial value. Figure 12 show the range test.

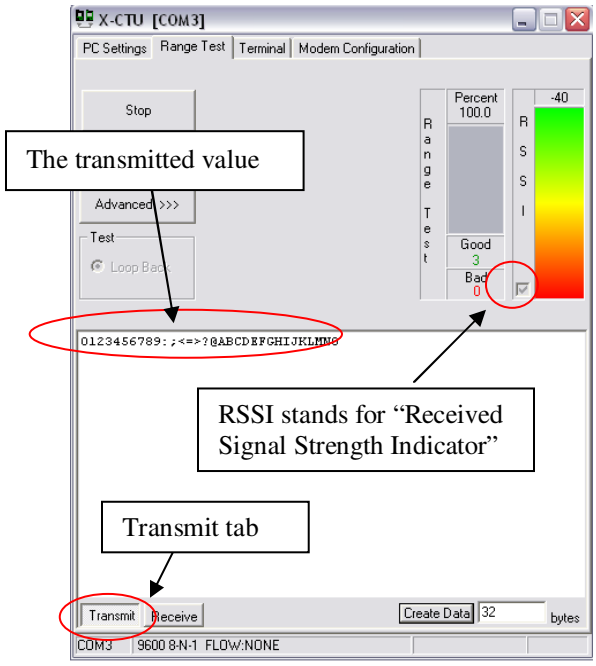

Figure 12: Range Test tab

Next, the REMOTE is moved away from the BASE and it is connected with the *Serial Loopback Adapter* to find the maximum range of the wireless link. The range test will show the continuous results of the received data as in Figure 13.

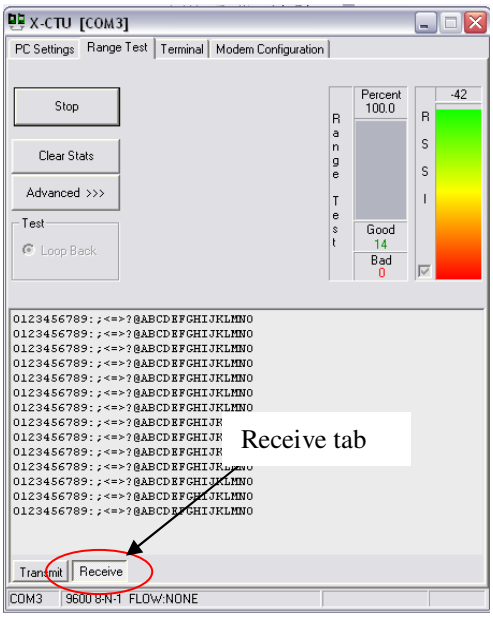

Figure 13: The continuous data from the receiver

Analysis of Visual Basic software

The hardware will be interfaced with the Visual Basic 6 software that is used to display the layout of the parking system. When the car is entering the parking lot, the sensor will detect it and the output of sensor is sent to the XBee receiver through XBee transmitter. The XBee module is connected with the Visual Basic 6 software and the status of the parking system will be display at the layout. Figure 14 shows the layout of the parking system that will be connected with the XBee module.

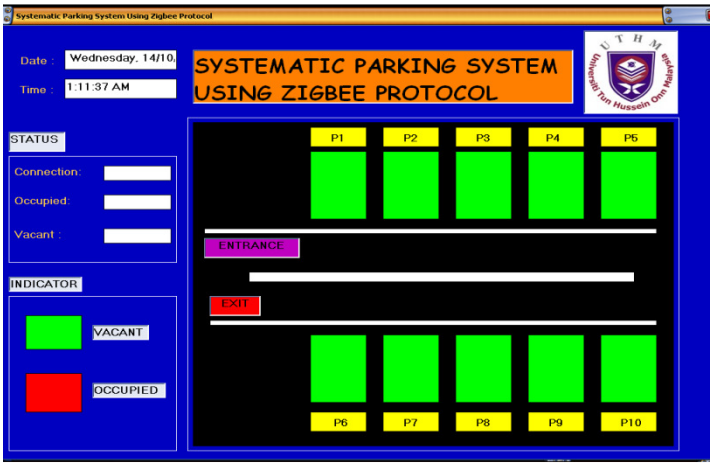

Figure 14: The parking system connected to the XBee module

When there is a car enter the parking system, the color of the parking lots will be changed to the red color and display the "NO" sign for the status of the parking lots. The status of occupied and vacant also will be changed based on

the status of the parking lots. The current status of the parking system is shown in Figure 15.

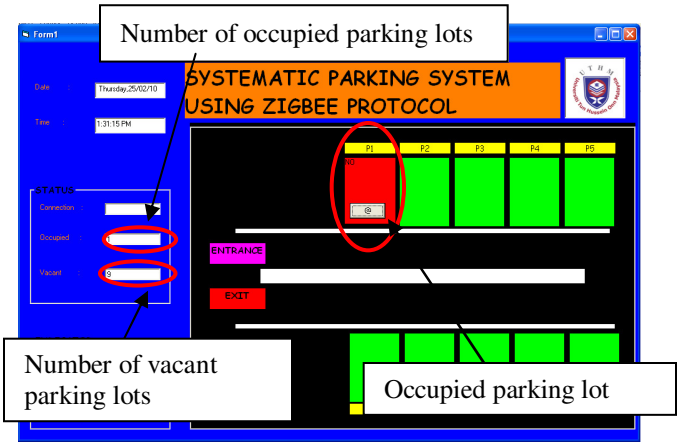

Figure 15: The current status of the parking system

V. CONCLUSION

In this paper, a systematic car parking system based on wireless sensor network is proposed in alleviating the traffic congestion problem whereby the hardware implementation of Zigbee RF Vehicle tags is carried out using XBee Starter Kit DOM Zigbee module. Zigbee protocol has been applied since it provides a low cost, low power and wireless mesh networking standard. Graphical User interface, Visual Basic 6 is used to determine occupancy of the parking space in a WSN environment. Further research and experiments would have to be conducted to find the effectiveness of XBee Starter Kit DOM Zigbee module for parking application.

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