Wireless Sensing and Controlling System using Zigbee

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***Abstract*— This article discusses the use of technology for electrical power management. The Zigbee devices are applied to control turning on/off electrical power through a wireless technology according to IEEE 802.15.4 standard for the remote device control. These Zigbee devices have a benefit in saving electrical power. However, these devices do not have an ability to verify that at any time equipment is in use or not. In addition, the use of this wireless communication technology consumes high power and if applied to systems it will be very complicated and high cost as well.**

The concept of wireless sensor technology applications includes ZigBee technology which is IEEE802.15.4 standard offering benefits in the term of low cost and energy saving. The system is easy to be installed and maintained with operational details and can be applied to control electrical devices. Applications are limited based on distances and environments but can be connected to be a larger network system.

Keywords-Wireless Sensing; Control System; Zigbee

I. INTRODUCTION

Electrical power plays an important role with critical requirements, this power is then widely used in households and industries those results in increasing power generated to meet the higher demand. However, on the contrary, natural resources used to generate the power are declining and can be run out at the end. With the fact mentioned previously, many realize how important of energy saving and design devices to on/off electrical power through wireless communication technologies such as Bluetooth Infrared Wi-Fi, etc. The devices are designed for the electrical remote control purpose as well as offered energy saving. However, these devices are unable to verify that at any time equipment is in use or not. In addition, the use of this wireless communication technology consumes high power and if applied to systems it will be very complicated and high cost as well.

This article is then propose the idea of applying wireless sensor technology that includes ZigBee technology which is IEEE802.15.4 standard for electrical power saving.

II. RELEVANT THEORIES AND TECHNOLOGIES

A. Zigbee Technology Theory

Zigbee is a wireless communication technology developed to have more advantages than another technology in the term of low cost and low electrical power consumption results in long term use and network creation. This technology is then suit for wireless sensors, targets and environments monitoring.

Zigbee or Xbee is a device with Microcontroller and RF IC as internal components or a Half Duplex transceiver (signal transmitter-receiver) in the 2.4 GHz frequency range. The operation consumes low power and easy to use with an interface for receiving and transmitting data with Xbee as UART (TTL). As for this Microcontroller, UART communication port of Xbee is connected to UART port of the same Microcontroller. This Xbee can perform functions according to Zigbee's standard without requiring any Zigbee network creation program because the firmware that will be downloaded into Xbee set parameters through software interface(X-CTU or written program) through At command(same as controlling GSM Module) using Hyper terminal or through receiving/transmitting data by this Microcontroller after setting Xbee as Zigbee's network device. Each Xbee is then called Node (Xbee's parameter) which have more than one.

Table 2.1 and Fig. 2.1 show the comparison between Zigbee's technology and another technology. Wherever Times is specified, Times Roman or Times New Roman may be used. If neither is available on your word processor, please use the font closest in appearance to Times. Avoid using bit-mapped fonts if possible. True-Type 1 or Open Type fonts are preferred. Please embed symbol fonts, as well, for math, etc.

Table 1: Comparison between different wireless technologies

Standard	Zigbee 802.15.4	WIFI 802.11b	Bluetooth 802.15.1
Transmission Range (meter)	1-100	1-100	1-10

Table 1: (Cont.)

Standard	Zigbee 802.15.4	WIFI 802.11b	Bluetooth 802.15.1
Battery Life (days)	100-1,000	0.5-0.5	1-7
Network Size (# of node)	>64,000	32	7
Application	Monitoring & Control	Web, Email, Video	Cable Replacement
Stack Size (KB)	4-32	1,000	250
Throughput (kb/s)	20 – 250	11,000	720

B. Wireless Sensor Network

Wireless Sensor Network is an important network to collect data such as environments, constructions, utility companies, industries, households, automatic communication systems, etc. and as for terrorist cases and guerrilla fighter are required sensor networks that are apart, able to use any aircrafts to deploy these sensors and re-integrate. Such the requirement cannot accomplish applying electric wires or cables, sensors networks are then fast growing demanded. In addition, these sensor networks are easy to be installed and maintained.

The applications of sensor networks require relative data matching, detection, monitoring, data collection, data evaluation and analysis, regulation creation, decision and warning. The required data and information are from distributed WSNs that response for the 1st sensor transmission to adjacent sensor.

Routing table for distributed networks increases according to higher number of nodes. NxM mesh network has NxM links and many routes from origin to destination. The stacked up network structure is enable to help searching any routes mentioned easily.

III. TECHNIQUE PROPOSED

Technique proposed is shown as in Fig. 2 including 3 important parts for the procedure: (1) The design of device communications (2) The design of operator discussions and (3) Transmission-Reception data testing.

A. The design of device communications

The design of device communications by UML and using Use Case Design to show the wireless control and system monitoring operations is shown in Fig. 1

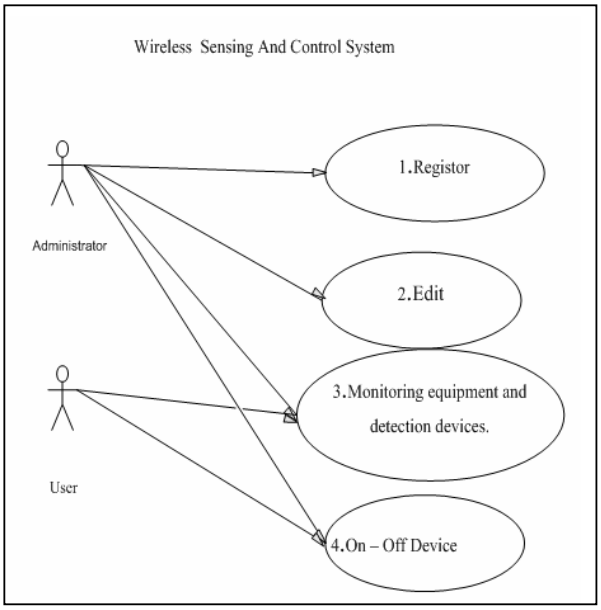

Fig. 1: Use Case Diagram showing wireless control and system detection operations

The Deployment Diagram design is shown in Fig. 2

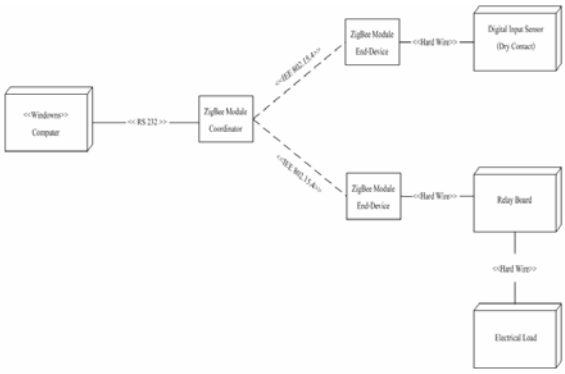

Fig.2: Deployment Diagram showing connections of system detection and wireless control.

The prototype of the design is shown as in Fig. 3.

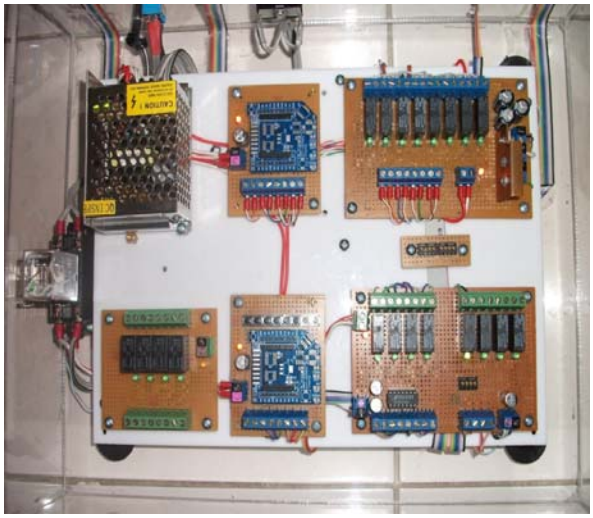

Fig. 3: The prototype of system detection and wireless control using Zigbee

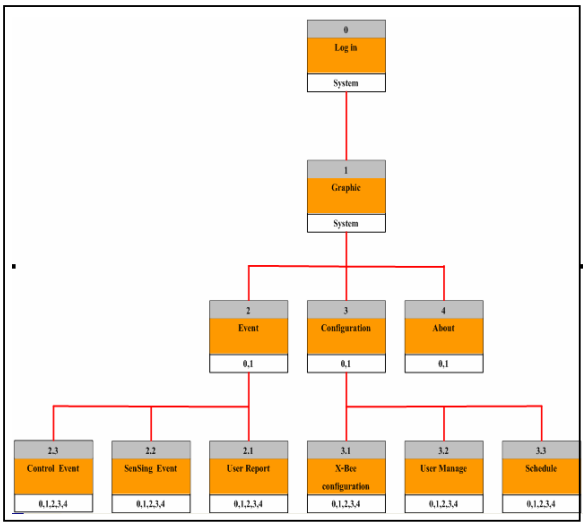

Fig. 4: User Interface diagram

The designed User Interface diagram is System Graphic showing device's status inside the system in the form of animations when operations of the system started. Operators are required to start any operations through Graphic User Interface by pressing On-Off of components as shown in Fig. 5.

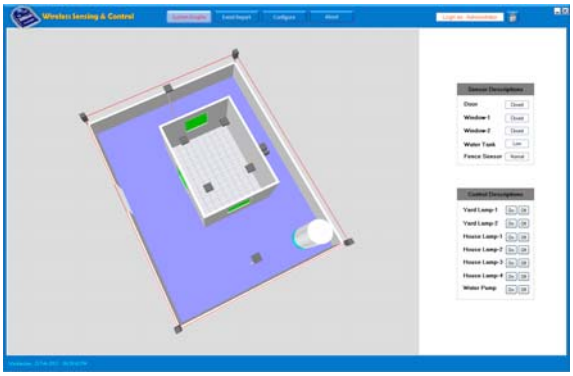

Fig. 5: System Graphic window

IV. RESULTS

A. Electrical Control

Test by writing programs in different forms to control set of relay circuits and let electrical devices start.

As the results, after writing programs in different forms, on/off of electrical devices can be controlled and electrical status at relays can be monitored using these commands with accuracy. In conclusion, how accurate electrical control circuits perform, depend on how accurate the programs written.

B. Data Reception-Transmission

There will be data transmission at three stages that are

- Between computer and Zigbee (Base RF Module).
- Between Zigbee (Base RF Module) and Zigbee(Remote RF Module).
- Between Zigbee (Remote RF Module) and Control Relay.

Testing Techniques use reception-transmission program writing into Application web that works on computer and use configures that Zigbee (Base RF Module) at each stage of reception-transmission is required to interface with devices.

Table 2: Testing in Open-Air

Distance (M.)	ZigBee Module Coordinator	Packet Error Rate (%)	ZigBee Module End-Device
10	Transmit (DATA)	0	Received
20	Transmit (DATA)	0	Received
30	Transmit (DATA)	0	Received
40	Transmit (DATA)	0	Received

Table 2: (Cont.)

Distance (M.)	ZigBee Module Coordinator	Packet Error Rate (%)	ZigBee Module End-Device
50	Transmit (DATA)	0	Received
60	Transmit (DATA)	0	Received
70	Transmit (DATA)	0	Received
80	Transmit (DATA)	0	Received
90	Transmit (DATA)	10	Received
100	Transmit (DATA)	20	Received
110	Transmit (DATA)	40	Received
120	Transmit (DATA)	65	Received
130	Transmit (DATA)	100	Not Received

Table 3: Test results from In-door Building with Obstructions.

Distance (M.)	ZigBee Module Coordinator	Packet Error Rate (%)	ZigBee Module End-Device
10	Transmit (DATA)	0	Received
20	Transmit (DATA)	0	Received
30	Transmit (DATA)	5	Received
40	Transmit (DATA)	20	Received
50	Transmit (DATA)	55	Received
60	Transmit (DATA)	80	Not Received
70	Transmit (DATA)	100	Not Received

Test results: show that the system is able to receive-transmit data in different positions with accuracy but still have errors in reception-transmission between Zigbee (Base RF Module) and Zigbee (Remote RF Module) since Zigbee is a Wireless Sensor Network, this results in data reception-transmission to be limited by distance and signal strength. From the Table 2, if the operation is performed for the distance greater than 100 meters and in the open-air, there are data errors. For in-door testing, if the distance is greater than 30 meters, there are also data errors.

C. Applications for users to contact

This can be categorized into 2 parts as following,

- User interface, in the form of windows that users will use to communicate to systems.

Testing: Let users try User interfaces. Users who would like to try will have different ages, educations, levels of experiences to use computers, etc.

Test Results: Most users understand, operate with accuracy and satisfy with the operations. While the rest have difficult time to understand and end up with errors and results in dissatisfaction. This may be because the variety of users in different statuses. The developers think that can modify this part by adding more details and more clearly of the user manual into the application to make users more understand and more satisfy.

- Communicate with Database, that involves data management of users, for example storing data that filled out by users into database and upload data from the database for users, etc.

Testing: Using program writing to communicate with database in the different form, for example, insert select update into the web and let users try to use, etc.

Test Results: Able to communicate with Database with accuracy and allow data management with accuracy and fast. However, how well to communicate with Database, depends on the ability to write programs to communicate with database in Application of the developer as well. Poor programming slows down Database communication in addition with errors.

V. CONCLUSIONS AND SUGGESTIONS

- Able to develop the system to control on/off of many electrical devices at the same time, this because Zigbee supports Point-to-multiple Network.
- Able to develop the system to be smaller or directly be a part of electrical device's component for better ease of installations and works together with other devices in additional with remote controlling of electrical devices.
- Able to develop the system for turning on/off of electrical devices that have the voltages exceed 220 VAC.
- Able to develop and apply this project with variety of sensors for less manual controls, for example the Infrared Sensor applications to detect human movements, to turning on/off electrical devices, etc.

ACKNOWLEDGMENT

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