Zigbex Wireless Sensor and Actuator Network (WSAN) Home Alarming System for Fire Detection

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Abstract— **As home network technologies are improving, sensors collecting environmental information such as temperature, humidity, and illumination in a building or a house are evolving. One of the many available home network technologies is fire detection. Many sensors have been developed for fire detection using closed-circuit television (CCTV) cameras or fiber-optical sensors. This project presents the application of zigbex wireless sensor/actuator network (WSAN) for fire detection home alarming system. The sensor node will sense the level of temperature and sends the data to the base node and actuator node. The results were display on the oscilloscope Graphical User Interface (GUI) whereas the actuator node would activate the alarm. It can be concluded that fire detection can be controlled wirelessly using zigbex WSAN test-bed.**

Keywords- wireless sensor/actuator network, fire detection, home alarming system,oscilloscope GUI.

I. INTRODUCTION

Traditional fire detection system using wired system is not flexible, messy and requires a lot of times and cost for cabling for large scale and when there are many other smart home applications to implement in a system. Wireless sensor actuator network (WSAN) is one of solution to overcome the traditional fire detection system problem. Using wireless sensor/actuator network (WSAN) is more flexible as sensors and actuators can easily be added or placed at new positions, does not need messy wiring and also solve problem where the walls is made of glass or other material that are not suitable for wiring to place a sensors at the wall. Management of system also become easy as all sensors and actuators can be connected to the PC and monitored in real time. WSAN also can improve the quality of control signal compared to control signal is send wirelessly from base node because an actuator nodes generates the control signal directly to the actuatotors [1]. Using WSAN also allows other smart home application implemented in the system e.g. door locked system, electric appliances control, gas detection, and many more because other sensors and actuator application can be attached to the nodes[2].

The objective of this project is to implement a WSAN for fire detection system that based on temperature. The sensor node will sense the level of temperature in a room and send the data wirelessly to an actuator node to activate the alarm.

II. ZIGBEX UBIQUITOUS SENSOR NETWORK

Ubiquitous sensor network is a technology of using wireless sensor that can sense many environmental information (temperature, humidity, pressure, lights and infra red), managed in real-time by attaching electronics tags radio-frequency Identification (RFID) and can be placed anywhere [3]. Zigbex is a device developed by Hanback Electronics from Korea that consist of Atmega128L microprocessor, CC2420 wireless communication chip, sensors, and interface for serial communication. Fig. 1 shows the zigbex node and its components. Zigbex are programmed in tinyos using nesC language. TinyOS is an operating system made exclusively for wireless sensor network. It is developed to support minimal hardware, low memory, low central processor unit (CPU) performance and limited energy of wireless sensor nodes. NesC is the language used to in tinyOS.

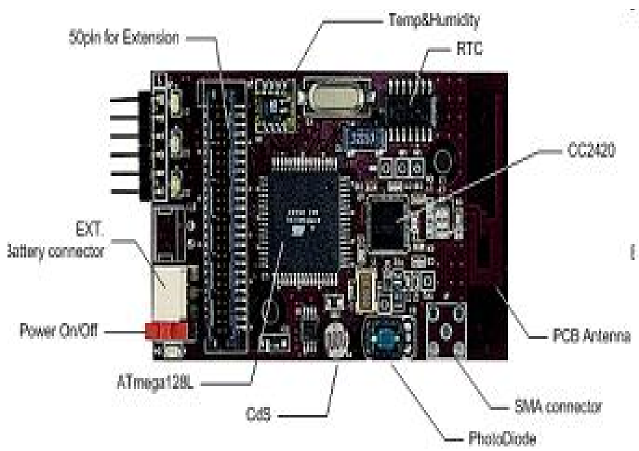

Figure 1. Zigbex and its component.

Fig. 2 shows the picture of a Zigbex Relay Module and its main components. There are two relays powered with external steady-state 5V voltage to operate the relay coil for switching purposes. There are also two sets of Common, Normally Open (NO) and Normally Closed (NC) pin, labeled as ‘C’, ‘+ ‘and ‘-‘respectively. Each of the relay has access only to its own Common, NO and NC pin. The 50 pin connector is female type, which can be attached to any Zigbex mote to for communication.

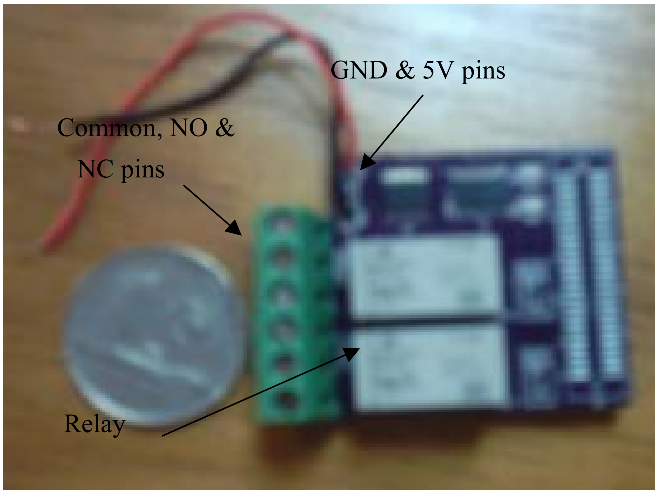

Figure 2. Relay Module and its compenents

Beside Zigbex, there has other sensor platform developed such as MICA mote by Berkeley, iMOTE from Intel, iBadge from UCLA and u-AMPS series from MIT. Table 1 show the comparison between MICA2, iMote and Zigbex.

TABLE I. COMPARISON OF SENSOR PLATFORM SPECIFICATION

Mote Module		**MICA2**	**iMote**	**Zigbex**
Processor Performance	***Speed (MHz)***	4	12	8
	Program Flash (K bytes)	128	512	128
	Flash Serial (K bytes)	512	-	512
	SRAM (K bytes)	512	64	4
Radio	***Frequency (MHz)***	916	916	2400
	Data Rate (kbps)	38.4	100	250
	Power Transmit (dBm)	-20	-20	-25
	Range for Indoor (m)	20-30	20-30	20-30

III. METHODOLOGY

The overall system architecture of this project consists of a sensor node, an actuator node and a base node. The flowchart of overall system is shown in Fig.3.

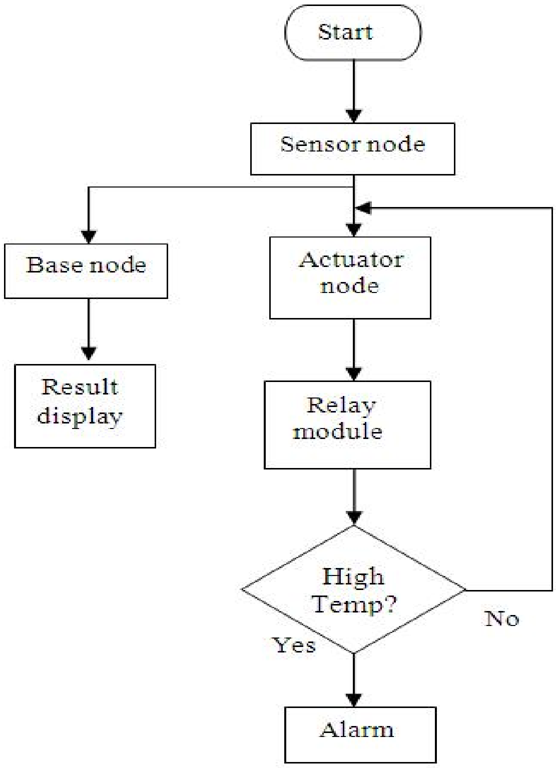

Figure 3. Overall system overview

The simulations of the projects were divided to three programs in order to execute different task for the three nodes. Each program contain of three file which is configuration file that maps the connection between each component used in program, module file which contains actual operations of the each program and declaration of packet structure for wireless communication.

The first program is the sensor program. In this project, temperature/humidity sensor has been used. To control this sensor, TinyOS provides the SHTII temperature sensor component and HumidityC component. These interfaces allow estimation of value from temperature sensor and turn it into digital value by Analogue to Digital Converter (ADC). The other components used are TimerC, LedsC, HumidityC, and UARTComm. The code in OscilloscopeM starts with initialization. Then timer triggers the sensor to sense temperature value with event ADC.getData command. The simplified program for the sensor is shown in a flow chart below. The data are included in the packet along with other packet information and broadcast the packet to other nodes.

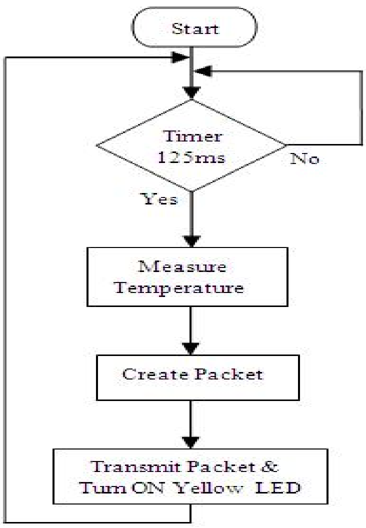

Figure 4. Overall sensor node flow chart

TinyOS provide the TOSBase program that allows serial communication to PC. This program receives any packet in wireless medium, check the group ID between base node and sensor node and forwards the packet to serial communication (UART). The packet received from serial is used to display the value senses from the sensors using various java tools developed for tinyOS. This project uses oscilloscope GUI tools to display the temperature in degree Celsius on the PC.

The actuator node received packet transmits from sensor node and extract the data from the packet. Two conditions are used to manage the data which is below fire temperature and above fire temperature. The condition is used to generate the control signal to the alarm system. During the temperature above the fire condition, the alarm system produces the alarm. The condition is declared in hex for 16 bit as shown in Fig. 5.

```
}
command result_t StdControl.start(){
        call CommControl.start();
        return SUCCESS;
      }
      command result_t StdControl.stop() {
        call CommControl.stop();
        return SUCCESS;
      }

      // display is a module static function
      result_t display(uint16_t data)
       {
       atomic {
         if (data < 0x31) {
```

Figure 5. Temperature control sample code in NesC.

To generate an alarm, the speaker with 9V DC supply was connected to the Zigbex Relay Module as shown in Fig. 6 and relay module directly attached to the Atmega 128L of the Zigbex mote as shown in Fig. 7. The 50 pin connector attached to the flash image programmed that has been used to control the relay switches on the Relay Module [4].

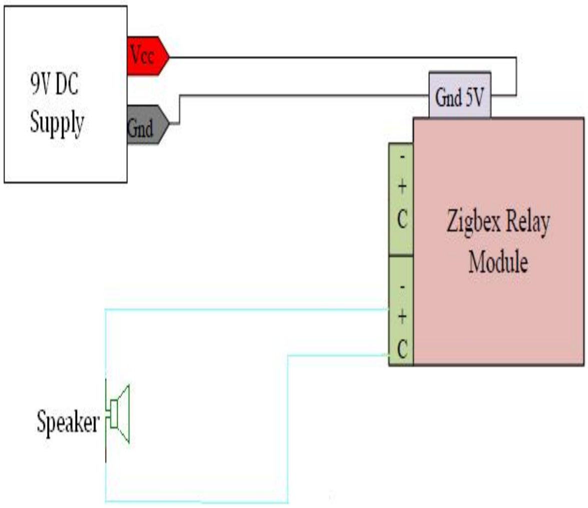

Figure 6. Alarm circuit with 9V DC

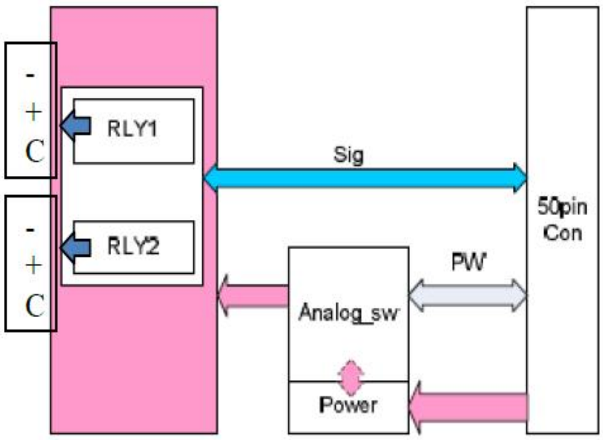

Figure 7. Relay Module block diagram

The system set up for fire detection alarm monitoring system are shown in figure 8. The test was conducted in a lab at room temperature. For fire detection purpose, the test was conducted with the condition of high temperature as shown in figure 9. When the sensor detected the increasing level of temperature, it will send the data to the actuator node and the alarm will be trigger. The high temperature condition was set to be within the range of 49ºC to 144ºC [5].

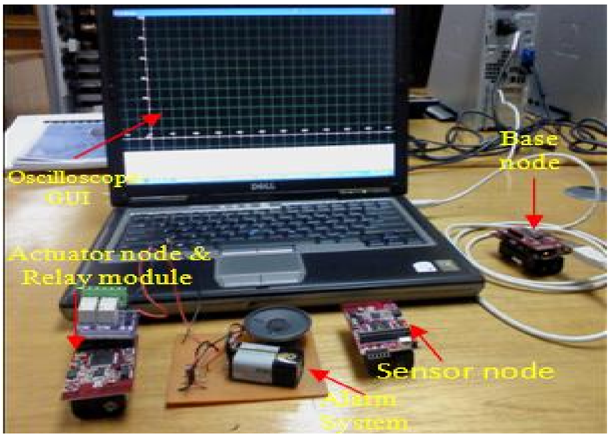

Figure 8. Actuator and base nodes

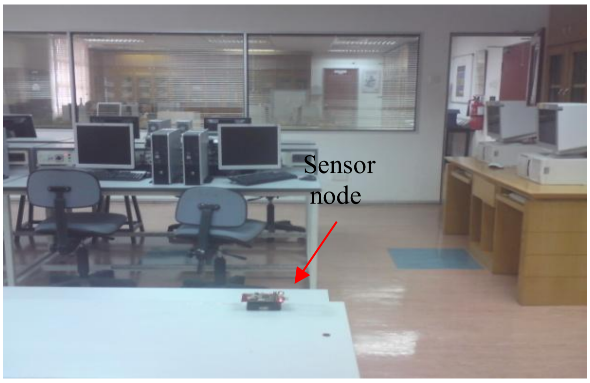

Figure 9. Sensor nodes place in different room from actuator and base nodes

IV. RESULTS AND DISCUSSIONS

The results for actuator node are shown in LED display while data sensed from sensor is displayed on oscilloscope GUI as shown in Fig. 10. The test is conducted on 10th October 2010 and the duration of test is about 2 minutes and 30 seconds.

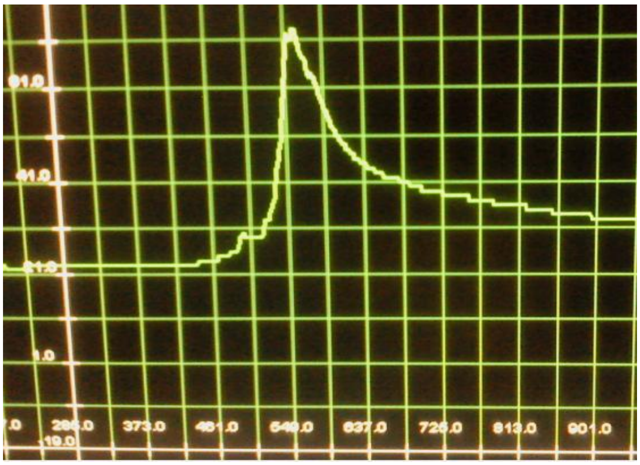

Figure 10. Graph temperature against reading packet number

From the graph, y-axis represents the temperature in degree Celsius (°C) while x-axis represents the packet reading number. The range for packet reading is from is 0 to 1000 packets and the range for temperature is from 0°C to 70°C. From the graph, we can see that for the first packet send until 450 packet reading, the temperature is at 23°C. For the next 450 to 550 packet reading, the temperature was exponentially increased until 72°C. This is the condition of fire detection due to detecting of heat by sensor node. After that, the temperature was decrease exponentially until the last packet reading number. Figure 11 shows the graph on Oscilloscope GUI in excel format.

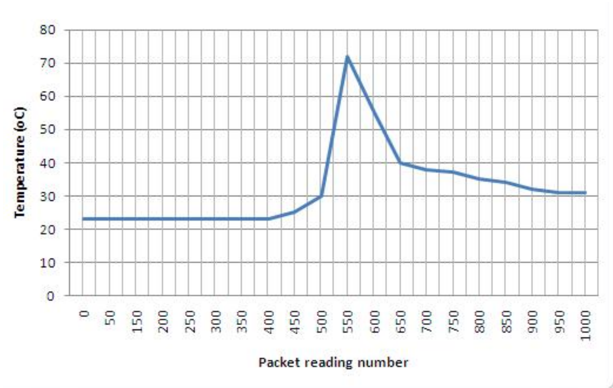

Figure 11. Graph Temperature against Packet reading number

The last packet number in oscilloscope GUI is near 1000. The last reading is minus with the first reading to get the number of reading display and divide by 10 to get the number of packet receive by the sensor node, the calculation is shown in Fig.12.

For this project, the maximum packet number send was set to be 1000. Number of packet receives was calculated by using the formula as below;

Number of packet receives = Last packet reading number
- First reading number
= (1000 - 0) /10
= 100

The time for sensor node to run its program and send a packet is also measured by measuring the time for yellow LED on sensor node to toggle ON or OFF which is 1.2seconds. Then to calculate the time for all packets to be receives or duration of the experiment, the formula below was applied;

Time to receive all packets = Time to send a packet x all Packet receive
= 1.2s x 100
= 120s

From the calculation, the result shows that the time to receive all packets is 120s, which is less time required compared to 150s, the actual duration of the test. This shows that there are packets losses during the test and this cause the delay in the transmission and less packet received.

V. CONCLUSION

This project implements home alarming system for fire detection using WSAN. The system was designed to detect the changes of temperature and alarm would be trigger if the temperature increases. From the result, fire detection home alarming system could be design using zigbex. This allows more smart application in smart home using zigbex. The system also can be monitor in real time on PC using a base node that receive packet from wireless sensor, forward packet to serial communication and the values is displayed in oscilloscope GUI application. The main objective of this project is to apply WSAN for home alarming system that would reduce the cost of installation compared to wired network. For future recommendation, the system should be design with sensor that not only can sensed fire but also would act as smoke detector and also data monitored can be access through internet which is web base application.

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