Zigbee Based Intelligent Forest Monitoring System Using Wireless Sensor Network

Santhanam Suganthi, Palevesanadar Thiruvalar Selvan

Abstract: ***Development in recent sensor technology with wireless communications gives much contribution to wireless sensor networks. This paper proposes the ZigBee based wireless sensor network technique for intelligent forest monitoring. It illustrate the design of hardware for sensor network and its related protocol programming having three sensors for theft identification, fire alarming and tree fall detection. The designed system can conduct effective monitoring of forest environment using Zigbee in establishing the local area network for signal communications and Arduino UNO ATMEGA-328 microcontroller programmed by aurduino software and connected to three sensors collects the sensed information to controls the entire operation. The output of this system has alarm to alert the human to prevent the theft and falldown of tress in forest with support of GPS receiver to locate the position of service need. The proposed system is tested in real time for its performance in terms of low cost effective environment monitoring and functional fulfillment.***

Index Terms: Wireless sensor network, Zigbee, forest, sensors, GPS receiver, microcontroller, arduino software.

I. INTRODUCTION

An embedded system, combination of hardware and software is one kind of a computer system mainly designed to perform several tasks like to access, control the data, process and store in various electronics-based systems. Embedded systems offer many benefits like task specific cover a wide variety of environment and can cope with demanding conditions, less likely to encore errors and use of less power than desktop system ensures there is no need for coding. Some of the characteristics of embedded systems are:

- Generally an embedded system executes a particular operation and does the similar continually. For instance: A pager is constantly functioning as a pager.
- All the computing system has limitation on design metrics, but those can be especially tight. Design metric is a measure of an execution features like size, power, cost and also performance.
- Several embedded system should constantly react to changes in the system and also calculate particular results in real in real time without any delay. For instance, a car cruise controller, it continuously displays and responds to speed &brake sensors. It must calculate acceleration/ deacceleration frequently in a limited time, a delayed computation can consequence in let down to control the car.
- It must be based on a microcontroller or microprocessor based.
- It must require a memory, as its software generally inserts in ROM. It does not require any secondary memories in the PC.
- It must need connected peripherals to attach input & output devices.
- An embedded system is inbuilt with hardware and software where the hardware is used for security and performance and software is used for most flexibility and features.
- An embedded system is software embedded into computer hardware that makes a system dedicated to be used for variety of application.
- Embedded system generally used for do specific task that provide real-time output on the basis of various characteristics of an embedded system.
- Embedded system may contain a smaller part within a larger that used for serving the more specific application to perform variety of task using hardware-software intermixing.

The applications of embedded system basics include smart cards, computer networking, satellites, telecommunications, digital consumer electronics, missiles, etc.

- Embedded systems in automobiles include motor control, cruise control, body safety, engine safety, robotics in assembly line, car multimedia, car entertainment, E-com access, mobiles etc.
- Embedded systems in smart cards include banking, telephone and security systems.
- Embedded systems in satellites and missiles include defence, communication, and aerospace.
- Embedded systems in computer networking &peripherals include image processing, networking systems, printers, network cards, monitors and displays.
- Embedded systems in digital consumer electronics include set top boxes, DVDs, high definition TVs and digital cameras.

Forest monitoring describes the processes and activities to characterize and monitor the quality of the trees. Now a day's preservation of trees is essential for getting rain and threat of forests resources like tree poaching has high impact in environment safety. The sandalwood tree in India becomes rare in now and the government has trying to control the loss of it. Smuggling of sandalwood has created socio economic and law and order problems in areas bordering in India. The main objective of this paper is to frame the Zigbee based

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wireless sensor network with three sensors that monitors the sneaking of trees. The functions of sensors are as follows:

1. **Tilt sensor:** If the trees are fall down due to some cyclone the tilt sensor will monitor them and send the information through Zigbee. In the receiver side the Zigbee receiver will receives the information and initiate them to the users with the support of GPS that track the location of the tree.
2. **Fire sensor:** The fire sensors will alarm if the firing occurs by LCD display and the buzzer sound alerts the user to take preventive actions.
3. **Sound sensor:** This sensor analyzes the sound to detect the cutting of tree and send the information to the receiver side.

The Zigbee plays a vital role in establishing the local area network for signal communications and Arduino UNO ATMEGA-328 microcontroller programmed by aurduino software and connected to three sensors collects the sensed information to controls the entire operation.

II. SYSTEM DESCRIPTION AND HARDWARE IMPLEMENTATION

The block diagram of the proposed intelligence forest monitoring using Zigbee wireless sensor network has been shown in Figure.1. Zigbee is an IEEE 802.15.4 is a low-power, low data rate, and close proximity wireless ad hoc network which can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. Zigbee has a defined rate of 250 Kbit/s, best suited for intermittent data transmissions [1] from a sensor or input device. Zigbee system structure consists of three different types of devices such as Zigbee coordinator, Router and End device. Every Zigbee network must consist of at least one coordinator which acts as a root and bridge of the network. The coordinator is responsible for handling and storing the information while performing receiving and transmitting [3] data operations.

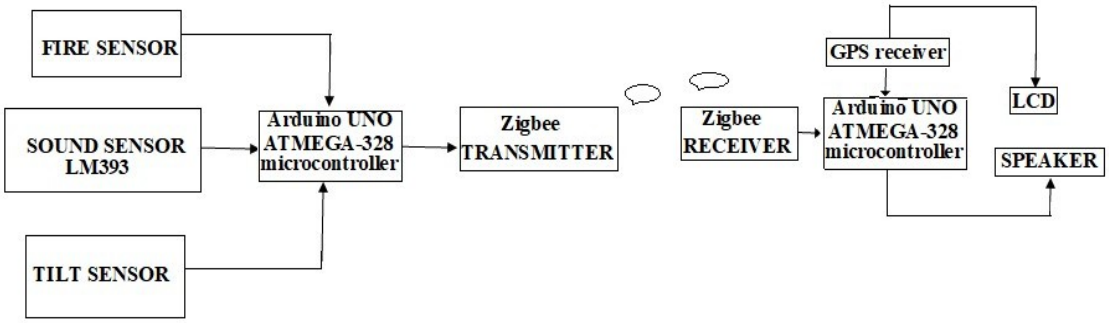


Figure.1. Block diagram of the proposed forest monitoring system

Zigbee routers act as intermediary devices that permit data to pass to and fro through them to other devices. End devices have limited functionality to communicate with the parent nodes such that the battery power is saved as shown in the figure. The number of routers, coordinators and end devices depends on the type of network [2] such as star, tree and mesh networks.

a. Interfacing Zigbee with Arduino

If two ZigBee modules are of same types, then they can communicate with each other. To achieve communication between two ZigBee [4], one ZigBee has to be connected with Arduino and the other ZigBee connected to sensor, microcontroller or computer as shown in figure.2. There is no need of additional electronics to connect the ZigBee with Arduino. The figure shows that the transmitter and receiver pin of ZigBee is connected to the transmitter and receiver pin of Arduino along with power supply of 3.3V for V_{CC}.

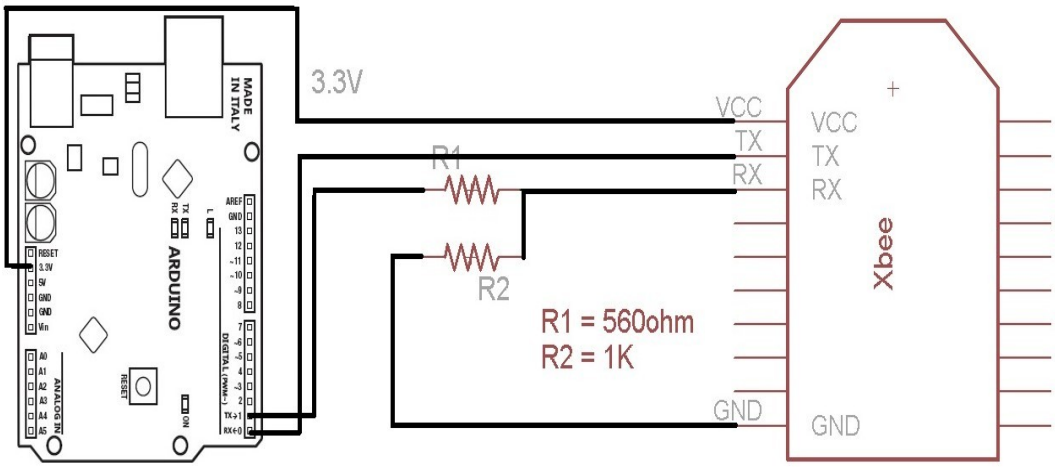


Figure.2. Interfacing Zigbee with Arduino

b. Modes of operation

Basically, Zigbee modules are capable of doing two types of communication - wireless communication and serial communication. The wireless communication takes place between Zigbee devices so that the devices act as radio frequency (RF) devices. For data to transmit and receive from one Zigbee module to another, both devices should be on same network. The data between two devices is transmitted wirelessly.

By serial communication (UART), the Zigbee modules can communicate with microcontrollers and processors. A microcontroller, processor or PC can send data through the serial interface to the Zigbee module (transmitter) and the Zigbee module wirelessly transmits the data to other Zigbee module (Receiver). The receiver Zigbee module transmits the data through the serial interface to controller, processor or PC to which it is interfaced. The controller interfaced to the Zigbee module processes the information received by the Zigbee devices. This way, controllers can monitor and control remote devices by sending messages through the local Zigbee modules.

The Zigbee modules communicate with each other in two modes - Transparent mode and API (Application Peripheral Interface) mode which is used in this work. In transparent mode, Zigbee modules act as serial line replacement and all data received through serial input is immediately transmitted over the air. When other Zigbee module receives data wirelessly [5], it sends that exactly as it receives through the serial interface [6] and vice versa. Contrary to this, in the API mode, the data is transmitted with some additional information.

In our project, two Zigbee modules will be interfaced with Arduino boards which are configured to communicate data with each other [7] in transparent mode. One of the Arduino devices has been interfaced with LED and configured as Zigbee router and the other Arduino device configured as Zigbee Coordinator. The Coordinator device controls the LED interfaced at router device by passing messages over Zigbee protocol. The Zigbee modules interfaced in both devices act as coordinator or router using XCTU software.

c. ATMEGA 328

The Atmega328 is 8-bit microcontroller with 32K flash memory, 1K EEPROM, 2K internal SRAM and having 28 pins in which 14 pins for digital I/O pins, of which 6 can be used as PWM outputs and 6 analog input pins. This chip has an analog-to-digital converter (ADC) with 3 pins set aside for it to function- AVCC, AREF, and GND. AVCC is the positive voltage power supply, GND is the power supply ground and AREF is the reference voltage that the ADC uses to convert an analog signal to its corresponding digital value.

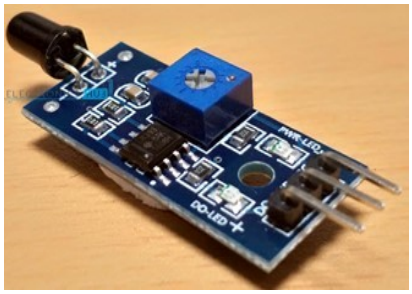
d. Tilt sensor

This switch is an electronic device that detects the orientation of an object with reference to gravity and gives its output High or Low accordingly. It has a mercury ball as shown in figure .3(a) inside it which moves and makes the circuit makes the circuit turn on or off based on the orientation. These sensors can also be called as inclinometers because the sensors just generate a signal but inclinometers generate both readout and a signal.

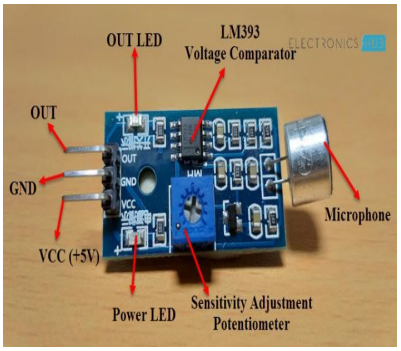
e. Fire sensor

A flame detector is a sensor designed to detect and respond to the presence of a flame or fire. When fire burns it emits a small amount of Infra-red light received by the Photodiode (IR receiver) on the sensor module as shown in figure.3 (b). With use of operational amplifier to check for change in voltage across the IR receiver the fire is detected if the output is low and 5V otherwise.

(a)



(b)



(c)

Figure.3. Sensors used in this work a. Tilt b. Fire c. Sound sensors

f. Sound sensor

Sound sensor senses the sound and transmits the output signal through the output pin. Interface circuit connects the sound sensor with Arduino and detects the sound with the help of an LED as shown in figure.3 (c). In our work we have used LM393 Voltage Comparator IC.

III. WORKING OF PROPOSED MODULE

The proposed work has been implemented by connected the module with PC for configuration. The step by step connection used in this work has been given below:

1. Place Zigbee to Zigbee Shield and connect module with an Arduino. The Zigbee module can be provided power by an external power supply or from the Arduino.

2. The Arduino UNO or Arduino Mega acts as a USB converter for Zigbee modules. Before using Arduino UNO with Zigbee modules, a bare minimum sketch must be uploaded on it or the Atmega microcontroller must be removed from the board.
3. The Zigbee module and the Arduino board must communicate serially according to the following pair of connection: TX: TX, RX: RX, 5V:3V3 and GND:GND.
4. Keep the rest of the values as default and write the settings of all Zigbee modules with the 'write radio modules' button at the top of radio configuration.
5. Once the configuration is completed, click on the discover radio modules on same network [8] button of any of the radio module. Now, the radio modules for the same network can be found. For this, connect the modem using FTDI cable to the PC, open XCTU, select the COM port and choose radio module among the multiple baud rates available like 9600, 115200, 57600. If radio module is not found, then open XCTU legacy, select the possible baud rate and in the modem configuration window select the correct modem firmware/ function set, then enable 'always update firmware' and select write.
6. After that, when the info box (action required) appears, then reset the Zigbee by connecting RST to GND or simply unseat the Zigbee and again place on seat. Now info box will disappear. It will then re-flash the radio modules automatically.

The coordinator Zigbee controls the LED of router Zigbee. The Zigbee modules are interfaced with the Arduino boards which are programmed to communicate specific messages. First, the coordinator bee continuously listens for any serial message. The Arduino board on coordinator Zigbee issues the commands 0 or 1 through the serial monitor to the coordinator Zigbee. The router Zigbee continuously listens for any wireless radio message. The coordinator Zigbee passes the same information (0 or 1) to the router Zigbee in wireless mode. Now, the router Zigbee serially passes the same information with no additional data to the Arduino board interfaced to it. The table .1 shows the Arduino software programming line for three sensors operation to identify and preventing tree cut, identify the fire location and tree fall places.

Table.1. Program for three sensors used in this work

Sound sensor: to identify tree cut	Fire sensor: to prevent tree burning	Tilt sensor: to identify tree broke

if (d1 == "Sound Detected")
{
digitalWrite(13,HIGH);
delay(1000);
digitalWrite(13,LOW);
delay(1000);
lcd.clear();
lcd.setCursor(1, 0);
lcd.print("Some One Try to");
lcd.setCursor(4, 1);
lcd.print("cut the tree");
delay(4000);
lcd.clear();
lcd.setCursor(1, 0);
lcd.print(d2);
lcd.setCursor(4, 1);
lcd.print(d3);
delay(4000);
}
	if (d1 == "Fire Alert")
	{
	digitalWrite(13,HIGH);
	delay(1000);
	digitalWrite(13,LOW);
	delay(1000);
	lcd.clear();
	lcd.setCursor(1, 0);
	lcd.print("Fire Alert");
	delay(4000);
	lcd.clear();
	lcd.setCursor(1, 0);
	lcd.print(d2);
	lcd.setCursor(4, 1);
	lcd.print(d3);
	delay(4000);
	}
		if (d1 == "Tree Fall Down")
		{
		digitalWrite(13,HIGH);
		delay(1000);
		digitalWrite(13,LOW);
		delay(1000);
		lcd.clear();
		lcd.setCursor(1, 0);
		lcd.print(" Tree Felt ");
		delay(4000);
		lcd.clear();
		lcd.setCursor(1, 0);
		lcd.print(d2);
		lcd.setCursor(4, 1);
		lcd.print(d3);
		delay(4000);
		}

Figure 4 Shows the output for the transmitter of the Zigbee Based Wireless Sensor Network for Forest Monitoring, in which the sensor is used to sense the problem occur in the tress and transmit them through the Zigbee. This information is used to analyze the happening of tree and transmit the information. The GPS antenna is used to track the location, longitude and the latitude of the tree.

Figure 5 shows the output for the receiver side which contains LCD to display the output received from transmitter in three conditions: 1. Display of "tree is falls down" when the tree is falls down sensed by tilt sensor 2. Fire alert with the buzzer sound when the tree is having fire sensed by fire sensor 3. Display of "someone is try to cut the tree" when someone is try to cut the tree sensed by sound sensor.

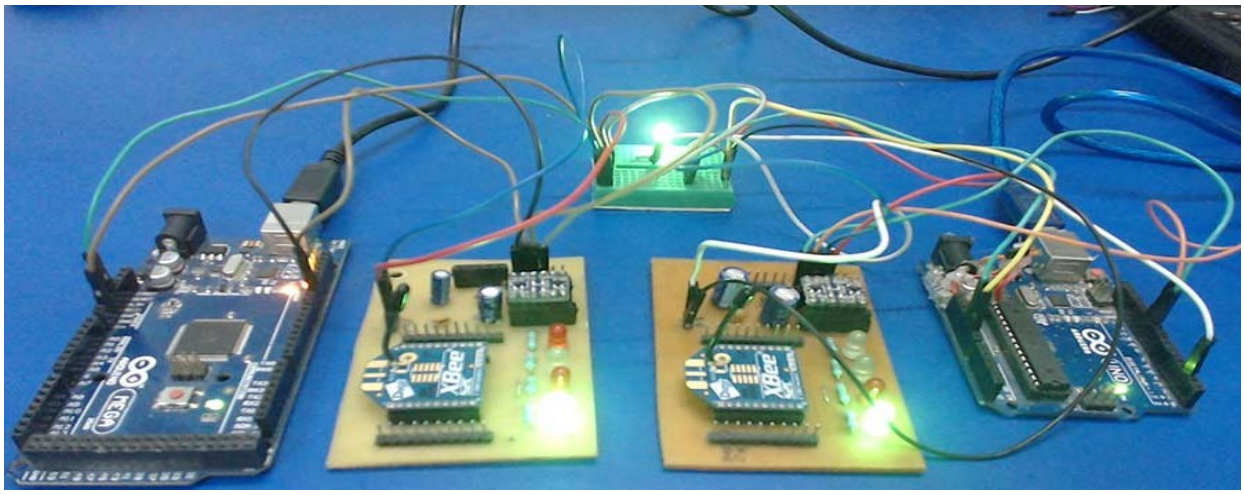


Figure.4. Hardware connection for transmitter in forest monitoring and its output

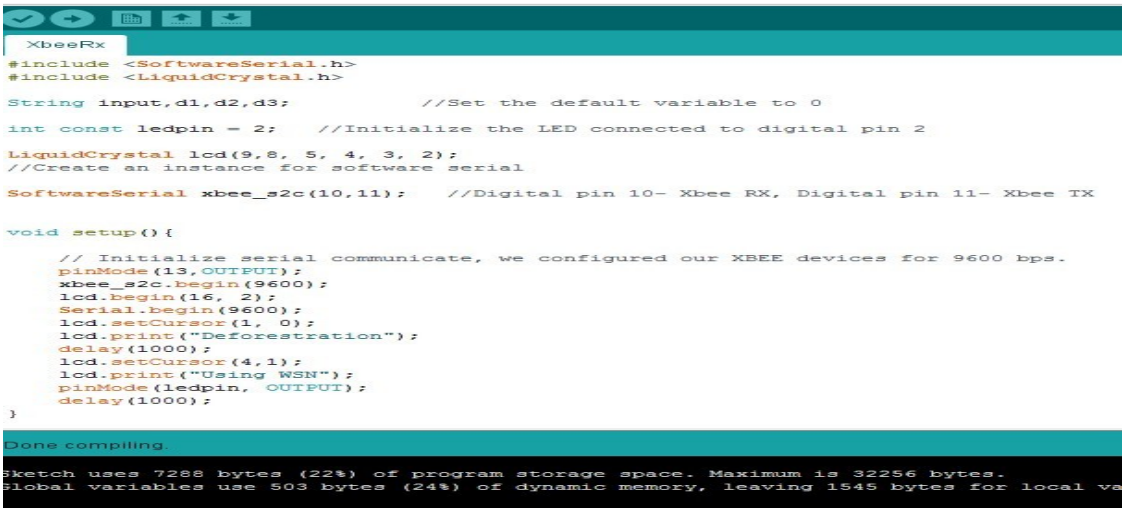
Figure.5. Hardware connection for receiver in forest monitoring and its output

dfor

```
#include<SoftwareSerial.h>
#include <TinyGPS++.h>
TinyGPSPlus gps;
//Create an instance for software serial

SoftwareSerial xbee(10,11);    //Digital pin 10- Xbee RX, Digital pin 11- Xbee TX

String lat_str,lng_str;
float latitude , longitude;

const int soundPin = 4;
int soundVal = 0;

//Fire sensor
int ledPin = 13;
int flame_sensor = 3;
int flame_detected;

//Tilt Sensor
int tilt_sensor = 2;
int tiltVal=0;

void setup() {

 // Initialize serial communicate,

 //we configured our XBEE devices for 9600 bps.

 Serial.begin(9600);
```

Done compiling.

(a)



```
XbeeRx
#include <SoftwareSerial.h>
#include <LiquidCrystal.h>

String input,d1,d2,d3;            //Set the default variable to 0

int const ledpin = 2;    //Initialize the LED connected to digital pin 2

LiquidCrystal lcd(9,8, 5, 4, 3, 2);
//Create an instance for software serial

SoftwareSerial xbee_s2c(10,11);    //Digital pin 10- Xbee RX, Digital pin 11- Xbee TX

void setup(){

     // Initialize serial communicate, we configured our XBEE devices for 9600 bps.
     pinMode(13,OUTPUT);
     xbee_s2c.begin(9600);
     lcd.begin(16, 2);
     Serial.begin(9600);
     lcd.setCursor(1, 0);
     lcd.print("Deforestration");
     delay(1000);
     lcd.setCursor(4,1);
     lcd.print("Using WSN");
     pinMode(ledpin, OUTPUT);
     delay(1000);
}
Done compiling.
Sketch uses 7288 bytes (22%) of program storage space. Maximum is 32256 bytes.
Global variables use 503 bytes (24%) of dynamic memory, leaving 1545 bytes for local va
```

(b)

Figure .6. Sample program for interfacing of arduino (a) Transmitter (b) receiver

Figure.6 (a) & (b) shows the sample arduino software program upload to the Atmega328p for interfacing of arduino to transmitter and receiver of the portable device connected to the tree respectively.

IV. CONCLUSION

In this paper we have implemented a portable device based on Zigbee wireless sensor network for forest monitoring. The low cost, low power consumption, and easy to maintain proposed system has microcontroller Atmega 328p with the software Arduino for collection and forwarding information to monitor the poaching of trees. We used the area based routing protocol to detect theft of cutting trees, fire alarm and sound system for protection of trees. The experimental results have been conformed to real time testing to validate the proposed design. Future work can include the coding and implementation of the proposed protocol with field testing of the sensor nodes under different environmental conditions. The power consumption monitoring can also be included for the designed protocol strategy.

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