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ZIGBEE BASED SOLAR POWERED FOREST FIRE DETECTION AND CONTROL SYSTEM

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ABSTRACT

Compared with the traditional techniques of forest fire detection, a wireless sensor network paradigm based on a ZigBee technique was proposed. The proposed technique is in real time, given the exigencies of forest fires. The architecture of a wireless sensor network for forest fire detection is described. The hardware circuitry of the ZIGBEE network node. The process of data transmission is discussed in detail. Environmental parameters such as temperature and humidity in the forest region can be monitored in real time. This system consists of three fire sensors, if any sensor activated it automatically turn on water pump and send the data to base station using zigbee then base station zigbee receiver receive the data and upload into server using IOT. From the information collected by the system, decisions for firefighting or fire prevention can be made more quickly by the relevant government departments.

Keywords: Forest Detection, Control System, Solar Powered, Zigbee Network.

1. INTRODUCTION

Forests are part of the important and indispensable resources for human survival and social development that protect the balance of the earth ecology. However, because of some uncontrolled anthropogenic activities and abnormal natural conditions, forest fires occur frequently. These fires are among the most serious disasters to forest resources and the human environment. In recent years, the frequency of forest fires has increased considerably due to climate change, human activities and other factors. The prevention and monitoring of forest fires has become a global concern in forest fire prevention organizations. Currently, forest fire prevention methods largely consist of patrols, observation from watch towers and lately satellite monitoring (Lai, 2004; Huang et al., 2005). Although observation from watch towers is easy and feasible, it has several defects. In the first place, this method requires many financial and material resources and a trained labor force. Second, many problems with fire protection personnel abound, such as carelessness, absence from the post, inability for real-time monitoring and the limited area coverage. The scope of application of satellite detection systems is also restricted by a number of factors, which reduces its effectiveness in forest fire detection. For example, a

satellite monitoring system has a long scanning cycle and the resolution of its saturated pixel dots of images is low. Another problem is cloud layers may mask images during the scanning period and the real-time mathematical quantification of fire parameters is very difficult to achieve (Shu et al., 2005; Yu et al., 2005; Calle et al., 2006). Given these shortcomings of traditional monitoring, we suggest the ZigBee wireless sensor network technology and explain its application as a monitoring system. This system can monitor real-time related parameters, e.g., temperature, relative humidity, and send the data immediately to the computer of the monitoring center. The collected data will be analyzed and managed by the computer. Compared with the normal meteorological information and basic forest resource data, the system can make a quick assessment of a potential fire danger. The analytical results will then be sent to the relevant department as the policy-making basis by which the department will make the decision of firefighting or fire prevention. Forest Fires are one of the most important and prevalent type of disasters and they can create a great deal of Environmental Impacts due to which their early detection is very vital. The main need for choosing this particular application for the detection of forest fires is to overcome the demerits present in the existing technologies of MODIS and Basic Wireless Sensor Network-based Forest Fire Detection Systems and an advanced system is developed for the detection of forest fires. The two main modules present in the project are the Monitoring Area Module and the Forest Area Module. All these together are split into five sub-modules for step-by-step development and implementation. Those include Sensors' Module, Serial Communication Module using Zigbee, Optimized Solar Energy Harvester using Maximum Power Point Tracking (MPPT), PC-based Web Server and Mechanical Modeling. The first three sub-modules belong to the Forest Area Module. They are integrated together and mechanical modeling is done to place it in the forest, whereas, the PC-based Web Server is developed for the Monitoring Area. The outcome of the above implementations reveal that various sensors used in addition to the temperature sensor improves security level for areas located near the forests. It also shows that the Optimized Solar Energy Harvester increases the efficiency to about 85 % and the use of PC-based Web Server reduces the bulkiness and cost of the entire system. Forests are part of the important and indispensable resources for human survival and social development that protect the balance of the earth ecology. However, because of some uncontrolled anthropogenic activities and abnormal natural conditions, Forest Fires occur frequently. These fires are among the most serious disasters to forest resources and the human environment. In recent years, the frequency of forest fires has increased considerably due to climate changes, human activities and other factors. The prevention and monitoring of Forest Fires has become a global concern in Forest Fire prevention organizations. Currently, Forest Fire prevention methods largely consist of Patrols, Observation from watch towers, Satellite Monitoring (Fu et al.) and lately Wireless Sensor Networks (Han et al.). Although observation from watch towers is easy and feasible, it has several defects. In the first place, this method requires many financial and material resources and a trained labor force. Second, many problems with fire protection personnel abound, such as carelessness, absence from the post, inability for real-time monitoring and the limited area coverage.

2. LITERATURE SURVEY

In 2012, P.S. Jadhav and V.U. Deshmukh suggested a ZigBee Wireless Sensor Network Forest Fire Monitoring System.[1], which includes of monitoring nodes base stations, communication systems, internet access, and the monitoring hardware and software system structure, is designed for habit monitoring automation, agricultural, and security. The author has constructed a device based on the WSN protocol that contains temperature, smoke, and humidity sensors, as well as the processor LPC2138 and ZigBee as an RF device. The processor module in this system is in charge of controlling the sensor nodes, as well as storing and processing the data they acquire. U. Arun Ganesh, M. Anand, S. Arun, M. Dinesh, P. Gunaseelan, and R. Karthik presented Forest Fire Detection Using Optimized Solar-Powered ZigBee Wireless Sensor Networks [5] in 2013. When the temperature surpasses a particular threshold, an alert is sentto the base station through SMS (Short Message

Service) and a call is made using the GSM module, according to the suggested system solution for early forest fire detection. GSM modems were employed in all previous study efforts to notify theforest department of the forest's danger situation. The ZigBee module is utilised in this system to perform serial communication between two nodes, allowing forest fire information to be conveniently relayed. The suggested system has the potential to save the lives of countless humans and animals, as well as important forest. Three factors compose the basis of a forest fire: the fire source, environmental elements and combustible material. A forest fire usually occurs as the result of their combined effects (Song et al., 2006). According to the Canada Fire Weather Index Forecast Model, the moisture content of the combustible material plays an important role in forest fires, which means the probability of forest fires depends on the moisture content (Tian et al., 2006). Therefore, the moisture content of combustible materials is a major point of assessment and predicts whether a fire will take place. The moisture content has much to do with relative humidity in the atmosphere, air temperature, wind and similar factors (Shu et al., 2003; Zhang, 2004). Water evaporation can be directly affected by relative humidity. At the same time, the physical properties of combustible materials can be changed indirectly by air temperature. Thus, relative humidity and air temperature are regarded as the two main factors which affect the moisture content of the fuel. Therefore, to reflect the moisture content indirectly, these two parameters are the main objects of our investigation, which should provide an important basis for the prediction and monitoring of forest fires. Certainly, forest fires are also caused by other factors, such as the active degree of thunder and lightning above the forest, human factors, wind speed, and condition of area vegetation. However, these factors will be ignored in our discussion. A ZigBee wireless sensor network system includes sensor nodes, gateways (routers) and a monitoring host computer. To decrease the loss of energy and data packets, a clustertree network topology structure (Tillett et al., 2004) (shown as Fig. 1) is applied in this design. Sensor nodes fitted with microprocessors of low processing capacity are distributed randomly in the forest and nearby areas to collect fire monitoring parameters such as relative humidity and atmospheric temperature (Zenon and Fady, 2005). Depending on the part the different sensor nodes play in the whole network, they are divided into three categories: ordinary bottom nodes, cluster heads and network coordinators. Data collected is transmitted to its own cluster head by an ordinary bottom node. A cluster head mainly handles data fusion and data packet transmission. Via the cluster head, data collected by ordinary bottom nodes in the cluster can be fused and transmitted to the nearest network coordinator and data packets transmitted by the network coordinator can be broadcast to related clusters. A network coordinator mainly deals with basic network. The sensor module is responsible for data analogdigital conversion and collecting parameters such as relative humidity of the atmosphere and air temperature. The processing module is responsible for controlling the operation of the whole sensor node and saving and coping with data collected by its own node and the binary information transmitted from other nodes. The wireless communication module is responsible for communication with other nodes and exchanging control information and receiving or transmitting data. The power module supplies power for the other three modules and drives the nodes, making it the key factor for the effective operation of the network (Ren et al., 2003).

The sensor node is a basic unit and platform of the wireless sensor network. A sensor node is commonly composed of a sensor module, a processing module, a wireless communication module and a power module. Figure 2 shows the structure of the sensor node. The sensor module is responsible for data analogdigital conversion and collecting parameters such as relative humidity of the atmosphere and air temperature. The processing module is responsible for controlling the operation of the whole sensor node and saving and coping with data collected by its own node and the binary information transmitted from other nodes. The wireless communication module is responsible for communication with other nodes and exchanging control information

and receiving or transmitting data. The power module supplies power for the other three modules and drives the nodes, making it the key factor for the effective operation of the network (Ren et al., 2003).
Nowadays, many natural disasters have been caused in various way all over the world. Forest fire are one of the most important disasters and they can create a great deal of environmental impacts due to which their early detection is very vital. As the number of causing forest fire is rapidly increased in the world, the number of fire accident also increased that is huge problem for the world. Most of people, animals are died because firefighting or fire prevention cannot be provided in time and forest fire information cannot be provided the emergency facilities to the fire department as soon as possible. This proposed system was constructed with sensors (temperature, humidity and gas). They detect the forestconditionand send the signal to the main station and report information. In this proposed system, there are three nodes (node1, node2 and main node). Each node has temperature sensor (LM35), humidity sensor (DHT-11) and gas sensor (MQ2) along with the Arduino and ZigBee wireless module. ZigBee wireless module is used to communicate with other nodes and send and receive data. In this work, program will bedeveloped on Arduino Mega board using the Arduino IDE software. For this system, ZigBee is a suitable technology to be adopted as the communication infrastructure in fire detection and monitoring system. In this way, many people and animals of lives can be saved Some of the previous important literatures that have been studied are discussed below. P:SJadhav, V:U. Deshmukh, 2012 proposed Forest Fire Monitoring System Based on ZigBee Wireless Sensor Network [1]. The purpose of this system aims at using for habit monitoring automation, agriculture and security and it consists monitoring nodes base stations, communication systems, internet access and the structure of monitoring hardware and software system. The author better has designed based on WSN protocol includes sensors such as temperature, smoke, humidity along with the processor LPC2138and ZigBeeas aRF device. In this system, the processor module controls the operation of the sensor nodes, stores and processes the collected data. Wireless communication module communicates with other nodes, exchanges control information and sendsand receive data. The power modular provides the energy to the sensor module, processing module and wireless communication module. U. Arun Ganesh, M. Anand, S. Arun, M. Dinesh, P. Gunaseelan and R. Karthik 2013 proposed Forest Fire Detection Using Optimized Solar- Powered ZigBeeWirelessSensorNetworks [5]. This system consists of two part the monitoring area module part and the forest area module part. The hardware includes sensor's module, serial communication module using ZigBee, Optimized solar energy harvester using maximum power point tracking (MPPT). Wireless Sensor Network Technology was used to detect forest fires and send the information to computer in the Monitoring centres. The collected data will be analysed and managed by the computer. Harjinder, 2016 presented Forest Fire Detection using Wireless Sensor [3]. This paper highlights the powerful feature of wireless sensors for forest fire detection. The sensor data is collected using Arduino development board and transmitted to base station wirelessly. Also an alert is send using GSM module.

3. PROPOSED SYSTEM

This system incorporates Raspberry pi pico, ESP32 controller, fire sensor, buzzer, lcd, IOT and ZigBee module. Fig.1. Block diagram of overall system This paper is concerned with a practical model of a forest fire detection and monitoring system, which can do firefighting or fire prevention. Actually this system consists of three nodes. These sensors continuously sense for fire parameters in the forest and send the sensor values to node2 by using ZigBee wireless communication module. In node2, it can work two things that are transmitter and receiver. Firstly, it receive sensor values from node1. Secondly, read sensor values on node 2 and transmit the sensor values from node1 and node 2 to main station. In main node, read sensor values on this node, receive sensor values from node2 and display on LCD. A. ZigBee Module ZigBee is wireless network protocolspecificallydesigned for low data rate sensors and control networks. ZigBee is a group of software,

hardware and service companies that have developeda commonstandard forwireless,networking of sensors and controllers. While other wireless standards are concerned with exchanging large amounts of data, ZigBee is for devices that have smaller throughout needs. The other driving factors are low cost, high security, low battery usage, simplicity and interoperability with other ZigBee devices. In this research, the XCore2530 ZigBee module is used.

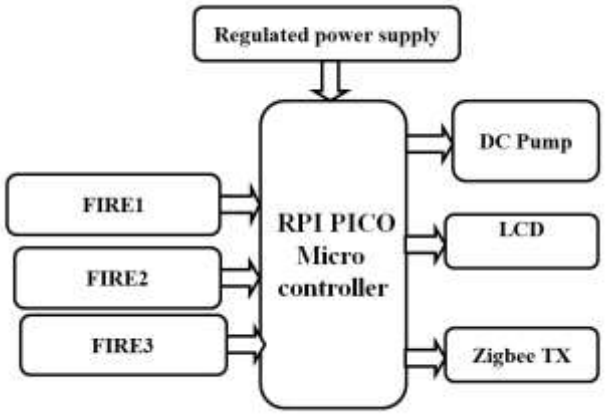

Figure 1: Zigbee Transmitter:

XCore2530 is a ZigBee module based on CC2530F256. Combined with our Coordinator/Router firmware, the XCore2530 allowstransparenttransmission of UART data, just as easy to use any UART module. Fig.2. XCore2530 ZigBee module B. Arduino Mega The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog, 4 UARTs (hardware serial ports), a 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and aresetbutton. It contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with AC-to-DC adapter or battery to get started.

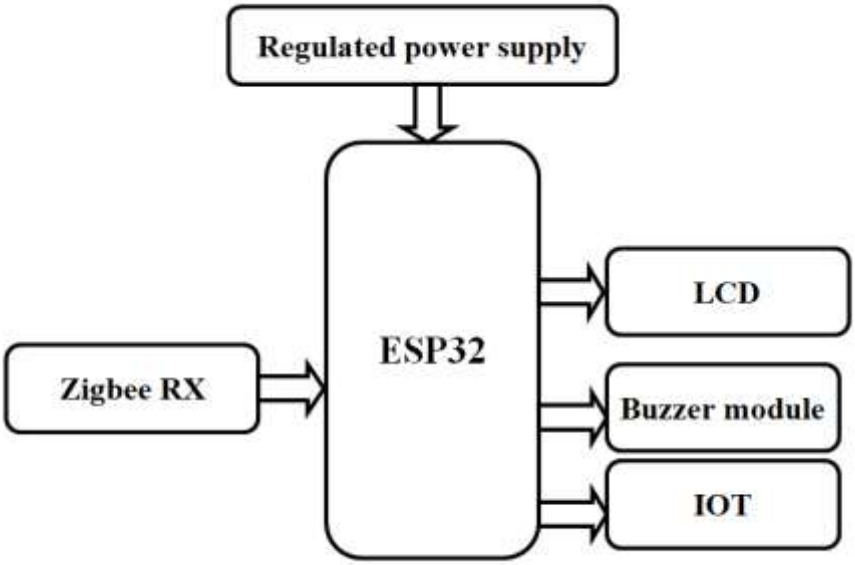

Figure.2: Zigbee Receiver

This system consists of three fire sensors, if any sensor activated it automatically turn on water pump and send the data to base station using zigbee then base station zigbee receiver receive the data and upload into server using IOT. From the information collected by the system, decisions for firefighting or fire prevention can be made more quickly by the relevant government departments.

4. RESULT

Zigbee Based Solar Powered Forest Fire Detection and Control System.

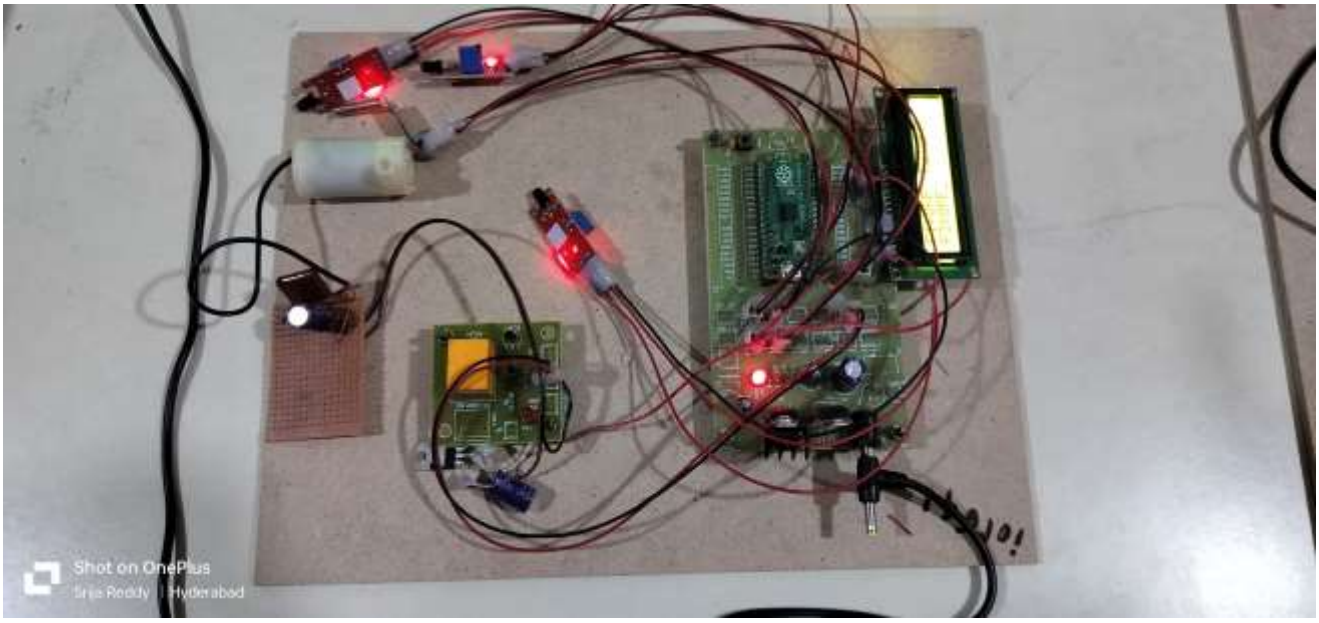

Figure.3: Zigbee Based Solar Powered Forest Fire Detection and Control System

Figure.4: Working of System

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S.No	Fire1	Fire2	Fire3	Date
1	OFF	OFF	OFF	2024-01-27 13:57:48
2	OFF	OFF	OFF	2024-01-27 13:57:22
3	OFF	OFF	OFF	2024-01-27 13:56:55
4	OFF	OFF	OFF	2024-01-27 13:56:28
5	OFF	OFF	OFF	2024-01-27 13:56:02
6	OFF	OFF	OFF	2024-01-27 13:55:35
7	OFF	OFF	OFF	2024-01-27 13:55:09
8	OFF	OFF	OFF	2024-01-27 13:54:43
9	OFF	OFF	OFF	2024-01-27 13:27:49
10	OFF	OFF	OFF	2024-01-27 13:27:23
11				2024-01-25 17:13:13
12				2024-01-25 17:12:55
13	OFF	OFF	OFF	2024-01-25 15:44:39
14	OFF	OFF	OFF	2024-01-25 15:44:13
15	OFF	OFF	OFF	2024-01-25 15:43:46
16	ON	OFF	OFF	2024-01-25 15:43:20
17	OFF	OFF	OFF	2024-01-25 15:42:54
18	OFF	OFF	OFF	2024-01-25 15:42:28
19	OFF	OFF	OFF	2024-01-25 15:42:02
20	ON	OFF	OFF	2024-01-25 12:02:29

Figure 5: Displayed the fire detected data.

5. CONCLUSION

The Project designed and implemented zigbee based smart forest fire detection system using IOT successfully. Se verified all output parameters. Using Zigbee wireless communication technology, the system detects and monitors fires. In locations where there is no wired infrastructure, wireless communication provides a low-cost and straightforward approach to provide network connectivity. In this concept, Zigbee enables low power consumption and simple wireless communication to communicate fire parameter values for maximum coverage area. This system is very compatible with any system due to the flexibility of wireless technologies. In the long run, this approach will benefit the planet and save human lives. As we can see, fire accidents are becoming more common, resulting in loss of life and property. To lessen the damage, various systems are utilized, which assist in detecting fires and gas leaks and taking appropriate action to mitigate the harm. As a result, this technology is utilized to detect fires, transfer data to neighboring authorities, and provide the necessary information about the situation. This system consists of three fire sensors, if any sensor activated it automatically turn on water pump and send the data to base station using zigbee then base station zigbee receiver receive the data and upload into server using IOT. From the information collected by the system, decisions for firefighting or fire prevention can be made more quickly by the relevant government departments.

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