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Forest Fire Monitoring System Based On Gprs And Zigbee Wireless Sensor Networks

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Abstract — **In order to increase the accuracy and real-time in the forest fire monitoring, this paper proposes a forest fire monitoring system based on GPRS and ZIGBEE Wireless Sensor Network. The wireless sensor network is a new information acquisition and processing technology. It has self-organizing network topology. Wireless Sensor Networks (WSNs) are used for various applications such as habitat monitoring, automation, agriculture, and security. Since numerous sensors are usually deployed on remote and inaccessible places, the deployment and maintenance should be easy and scalable. This article presents the design of a system for detection of temperature and humidity and smoke for the prevention of forest fires using wireless sensor networks to prevent a disaster (forest fire) that could lead to loss of a significant number of natural resources. In this project, several tests had been conducted in order to prove the viability of the system. Test results indicated that the reliability of the system in propagating information directly to the base station could be gained excellently in various conditions.**

Index Terms—Wireless Sensor Network (WSNs), Forest Fire, Humidity, Temperature, Zigbee, Fire Detection, Data Transmission.

I. Introduction

The forest is considered as one of the most important and indispensable resources, furthermore, as the protector of the earth's ecological balance. Fire has been a major influence on the development and management of many of the world's forests. Some forest ecosystems have evolved in response to frequent fires from natural as well as human causes, but most others are negatively affected by wildfire. Every year millions of hectares of the world's forests are consumed by fire, which results in enormous economic losses because of destroyed timber, burnt housing, high costs of fire suppression, damage to environmental, recreational and amenity values and loss of life and livelihoods. Most wildfires in forests and woodlands today are caused by people as a result of the misuse of fire for conversion of forests to agricultural lands, maintenance of grazing and agricultural lands, extraction of non-wood forest products, hunting, and clearing of land for mining, industrial development or resettlement. Forest fires may also result from personal or ownership conflicts and negligence (e.g. campfires, cigarette butts).

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. Forest fires, also known as wild fires, are uncontrolled fires occurring in wild areas and cause significant damage to natural and human resources. Forest fires eradicate forests, burn the infrastructure, and may result in high human death toll near urban areas. Common causes of forest fires include lightning, human carelessness, and exposure of fuel to extreme heat and aridity. It is known that in some cases fires are part of the forest ecosystem and they are important to the life cycle of indigenous habitats. However, in most cases, the damage caused by fires to public safety and natural resources is intolerable and early detection and suppression of fires deem crucial.

II. EXISTING WORK

At present, traditional forest fire monitoring measures include ground patrolling, watching tower, aerial patrolling, long-distance video monitoring and satellite monitoring and so forth [1]. But there are a lot of deficiencies, e.g. limited application and unsatisfied monitoring results, of these measures. Currently, forest fire prevention methods largely consist of patrols, observation from watch towers and lately satellite monitoring. 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. The drawbacks of the existing system are Man power is needed to monitoring and is difficult to find the fired forest areas. It consumes more time and requires many financial and material resources and also a trained labor force.

III. PROPOSED MODEL

In proposed system, we can design a new system to monitor the forest areas. Here the three sensors are used to monitor the environmental condition of that particular area and transmit that monitored information to the collecting section using Zigbee technology and GPRS [3] – [6]. 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 fire fighting or fire prevention.

The gas diffuses into the sensor, through the back of the porous membrane to the working electrode where it is oxidized or reduced. This electrochemical reaction results in an electric current that passes through the external circuit. In addition to measuring, amplifying and performing other signal processing functions, the external circuit maintains the voltage across the sensor between the working and counter electrodes for a two electrode sensor or between the working and reference electrodes for a three electrode cell. At the counter electrode an equal and opposite reaction occurs, such that if the working electrode is an oxidation, then the counter electrode is a reduction. A temperature sensor is used to convert temperature value to an electrical value. Temperature Sensors are the key to read temperatures correctly and to control temperature in medical applications. The temperature sensors contain a sensing element enclosed in housings of plastic or metal.

The Fire sensor is used to detect fire flames. Fig. 1 defines the block diagram for the proposed system the module makes use of Fire sensor and comparator to detect fire up to a range of 1 meter. Humidity measurement can be done using dry and wet bulb hygrometers, dew point hygrometers, and electronic hygrometers. There has been a surge in the demand of electronic hygrometers, often called humidity sensors.

On the proposed system, the PIC 16f877a is chosen as the hardware core of general network node. In the external of PIC controller, temperature, Gas, Humidity, Fire and MEMS sensors are configured to monitor the corresponding data. The data are processed in the PIC microcontroller and the processed data are transmitted to the receiver unit through GSM. The receiver decides whether the environmental status leads to Forest fire or not. Fig. 2 explains the forest side office section and Fig. 3 tells the receiver side section. And it updates the values in the Mobile through GSM modem and also wirelessly monitors the PC through Zigbee[2][3]. The sensor values are processed and transmitted from the transmitting section through GSM. In forest office section monitor the status of the all forest area through wireless network.

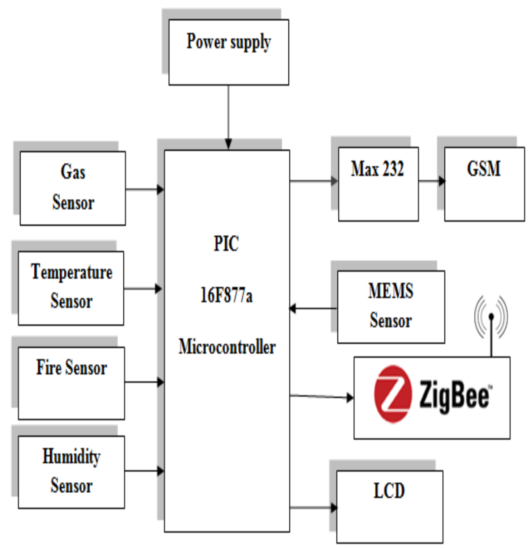

Fig. 1 Forest Section

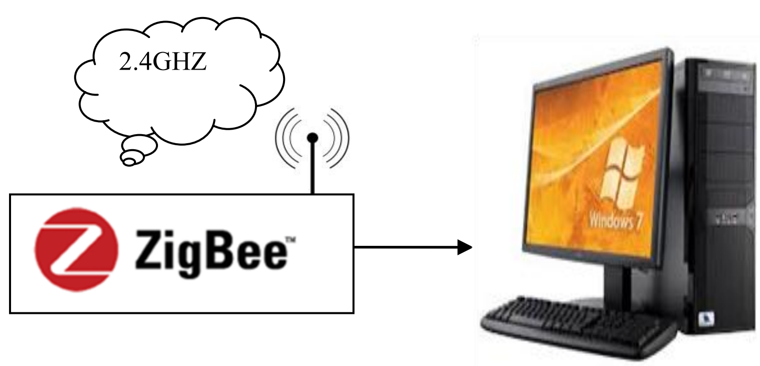

Fig. 2 Forest Office Section

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Fig. 3 Mobile Section

A. WIRELESS SENSOR NETWORKS

A wireless sensor network is a group of specialized transducers with a communications infrastructure for monitoring and recording conditions at diverse locations. A wireless sensor network (WSN) of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. Fig. 4 explains the Basic types of sensor networks. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used

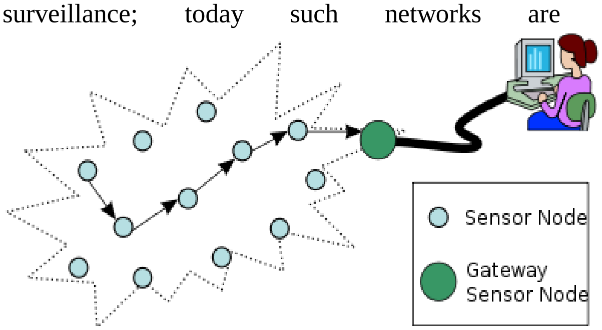

Fig. 4 Types of Sensor Networks.

in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

B. ARCHITECTURE

The architecture of the precision Forest fire detection system based on wireless sensor networks consists of the monitoring nodes, base stations, communications systems, Internet access and the structure of monitoring hardware and software system. According to different functions, a large number of the different sensors can be placed in the field and constructed a self-organized network to monitor the value change including temperature, humidity, smoke or gas detector etc. The collection data is send to the sink by wireless mode. The control center can send the control information to any node in the network. Likewise, the remote data could be transmitted to the control center with the sink. The system adopts the cluster topology and hierarchical routing protocols. All sensor nodes are divided to some cluster. Each cluster is equivalent to a relatively fixed self organizing network. The nodes are divided into the common node and cluster-head node. The common nodes will collect the data which transmitted to the cluster-head node. The data is stored to the database.

1) FIRE CHARACTERISTICS

There are three phases for fire formation

Phase I: Gas sensor for sensing Invisible Gases Carbon monoxide (CO), Carbon Dioxide (CO2), Molecular Oxygen (O2), Methane (CH4), Molecular Hydrogen (H2), Ammonia (NH3), Isobutene (C4H10), Ethanol (CH3CH2OH), Toluene (C6H5CH3), Hydrogen Sulphide (H2S)Nitrogen Dioxide (NO2)

Phase II: Optical sensor for sensing smoke and large carbon particles.

Phase III: Fire and Temperature sensor

2) TEMPERATURE AND HUMIDITY SENSOR

The capacitive humidity and temperature sensors provide digital and fully calibrated output which allows for easy integration without the need for additional calibration. The excellent long term stability has been very well perceived and the cutting edge low energy consumption is unachieved and makes them the right choice for any remote application.

3) OPTICAL SMOKE DETECTOR

A smoke detector is a device that detects smoke, typically as an indicator of fire. An optical detector is a light sensor. When used as a smoke detector, it includes a light source (incandescent bulb or infrared LED), a lens to collimate the light into a beam, and a photodiode or other photoelectric sensor at an angle to the beam as a light detector. In the absence of smoke, the light passes in front of the detector in a straight line. When smoke enters the optical chamber across the path of the light beam, some light is scattered by the smoke particles, directing it at the sensor.

C. APPLICATION OF ZIGBEE WIRELESS SENSOR NETWORK IN A FOREST FIRE MONITORING SYSTEM

A wireless sensor network, which combines computer and communication technology with the technology of a sensor network, is considered to be one of the ten emerging technologies that will affect the future of human civilization. This network is composed of numerous and ubiquitous micro sensor nodes which have the ability to communicate and calculate. These nodes can monitor, sense and collect information of different environments and various monitoring objects cooperatively. ZigBee is a low-rate, low-cost and low-power kind of short range wireless network communication protocol. Compared with other wireless technologies, ZigBee has unique advantages of safe and reliable data transmission, an easy and flexible network configuration, low equipment costs and long-lasting batteries. Thus, it has great development potential and a promising market application in the field of industrial control.

1) STRUCTURE OF THE SENSOR NODE

The sensor node is a basic unit and platform of the wireless sensor network which is shown in Fig. 5. A sensor node is commonly composed of a sensor module, a processing module, a wireless communication module and a power module.

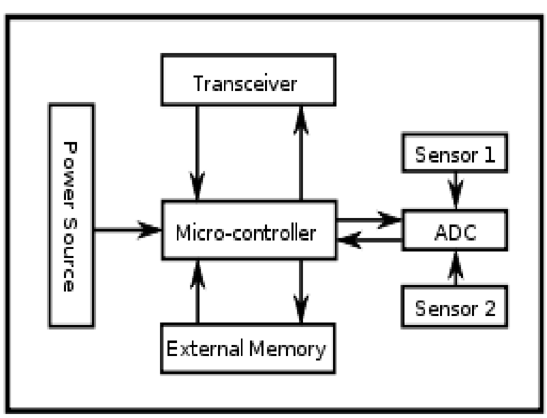

Fig. 5 Structure of the Sensor Node

The sensor module is responsible for data analog to digital 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.

D. THE DESIGN OF SYSTEM

1) SYSTEM SOFTWARE DESIGN

The software architecture of sensor node is divided into embedded OS kernel layer and API layer. Embedded module provides tasks, power management and communication protocol. The kernel also provides a low-level node driver of all hardware devices. API layer provides sensor acquisition module and RF communication module. Task debugging module controls the control flow throughout the operating system, which is mainly responsible for the initialization of the wireless sensor and the maintenance of the operating status. Task debugging module controls the control flow throughout the operating system, which is mainly responsible for the initialization of the wireless sensor and the maintenance of the operating status. The power management module supports processor, RF transceiver, sensors and other parts of the state control of energy consumption. Energy management is able to ensure that nodes wake up at the right time, run in the low-power mode and maximize the use of energy.

3) THE FUNCTION OF WSN PROTOCOL

Wireless network communication protocol provides the wireless communication standards between the cluster-head nodes and nodes. It achieves registration, sleep the node, data acquisition, device controller, parameter settings and debugging.

1) Registration: When the nodes work on, the node registers MAC to the cluster-head node and accesses to the network subnet number. It is assigned to a node ID.
2) The Node Sleep: The cluster-head node sends a data packet to notify the next node sleep time.
3) Data Collection: According to testing requirements, the cluster-head node assigns the task of data collection, such as temperature, humidity, light intensity and gas concentration.
4) Equipment Control: The cluster-head node analyzes the data and makes decision. The packet of control instructions is sent to the node.
5) Parameter Settings: The cluster-head node sends the modified equipment parameters to the child nodes.

6) Debugging: It is the equipment development and debugging functions.

D. DATA TRANSMISSION PROCESS

To deliver data transmission inside the ZigBee network in this design, a system of active requests for information by the monitoring host computer and passive responses by the sensor nodes is used. When the monitoring computer, operated by a telecommunications worker, sends an order to inquire about the state of forest temperatures and humidity, the order is transmitted to the router via the internet. The router then scans the routing tables according to the order and decides the target coordinator, which then broadcasts in the attached cluster branch to activate the target cluster head. The cluster head broadcasts towards its member nodes to activate the dormant nodes to carry out data communication. After receiving the data collected and sent by the nodes, the cluster head integrates and returns the data to the monitoring host computer along the original line. If the target network is not found or not connected, the cluster head will desert the data packet and generate a report to the monitoring host computer. Most nodes in the system are in a dormant state to save energy and extend the lifetime of the network.

IV. PROSPECT AND CHALLENGE

In the Forest fire monitoring system, all nodes always work under the adverse environmental condition, so they are different from the design of the traditional sensor network. Due to a larger monitoring area of forest, the sensor network has a large number of nodes while it ensures the cost of the network. The node will be scattered in various regions to achieve a comprehensive monitoring on forest field. Because the sensor node energy is limited, the possibility of node failure is very large. The monitoring system must solve the reliability problem. The lifetime of WSN depends on the failure of the sensor node. In short, the forest fire monitoring system must solve the following problem:

A. THE LARGE-SCALE HIGH-DENSITY NETWORK STRUCTURE

The requirement of monitoring material movement in geographical space is intrinsic motivation of the sensor networks. Compared with the traditional mode base on radar or satellite, WSN has some unique technical advantages on a distributed multi-dimensional and multi-angle information processing. It can significantly improve the signal noise ratio, reduce the possible exploration in the region, and eliminate shadows and blind spots. The network nodes must be a large-scale, high-density deployment method to keep monitoring the area coverage and connectivity [5]. A large number of nodes in the network will inevitably increase the cost which will affect the network in the practical application. The premise of agriculture application is to design an available and economic deployment mechanism for WSN.

B. DATA PROCESSING AND NODE ENERGY

Communication is the maximal energy consumption. Each node has data independent processing ability. It reduces network transmission cost by processing and extracting the original data. A well-designed network networking, data transfer and data integration algorithms are important to the lifetime of the network.

C. THE NETWORK REDUNDANCY AND TOLERANCE

The validity and accuracy of data in agricultural monitoring system is very important. The optimization of node distribution is studied to reduce the energy consumption and ensure the effective information acquisition in wireless sensor network. Network fault tolerance includes node failure detection and failure recovery. Node failure needs to locate. If each node has the portable GPS devices, it will inevitably increase the cost of the entire network[4]. How to balance between the costs of network configuration and node failure detection is a problem to be solved. Node failure recovery adopts the replacement of the general failure of redundant nodes, but it needs to design the number and the location of redundant nodes.

V. CONCLUSION

Wireless sensor networks are increasingly applied in the field of environmental and ecological monitoring. Especially in difficult and harsh environments, it has advantages that traditional monitor systems lack. In addition, wireless sensor technology has a broad application background in the field of real-time forest fire monitoring. But given the complexity and peculiar features of the forest, the system has not been extensively applied in practical forest fire monitoring. To monitor temperature and humidity in the forest in a more timely and precise way, we pointed out unique advantages of safety in data transmission, flexibility in building the network, and low cost and energy requirements for a forest fire monitoring system based on a ZigBee wireless sensor technology that we designed. The topology structure of the system is an adaptation of a cluster-tree. Compared with a reticular structure, a cluster-tree structure can be built more easily and the information path takes less memory space. At the same time, the chain structure needs to be stable and its scale is limited, which needs to be improved in future investigations. In other words, we propose this system as a first attempt and complement to existing forest fire monitoring and prevention methods. It provides a solid basis in terms of hardware for the application of advanced wireless sensor network technology. To extend the potential of the system and improve forest fire monitoring technology, the problems of energy consumption, nodes location and clock synchronization need to be addressed in the future. These are some of the remaining problem areas to be considered, before the level of forest fire monitoring can be improved.

This project is designed the hardware and software based on WSN protocol which includes Sensors such as temperature, smoke, humidity along with the processor LPC

2138 and Zigbee as a RF device. We have tested on field and taken reading of above parameters which is transmitted to base station where data logging is done daywise. Our hardware works on battery operated system, in future we will use solar power for the same. The forest fire monitoring system was developed which detects fire in the forest. The real time sense data is recorded in database.

Forest fire has multidimensional negative effects in social, economic and ecological matters. It is difficult to say that fire fighting can be successful without enough data about fire such as spread direction and speed etc. The more data about forest fire means the more effective fire management. Economically, fire fighting is well known to be a costly task. It is wise to invest in early warning systems which are definitely much less costly on the whole. WSNs are thus the right choice and the least costly of all surveillance and early detection systems. The ongoing research in wireless sensor networks is promising that cost effective systems shall immerge for forest fire sensing and detection applications.

Finally, we conclude that wireless sensor network is a very powerful and suitable tool to be applied in this application.

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