Advanced Fire Monitoring System

An Optimized approach for Monitoring

[1]Abhishek.M.V.H.K., [2]Mr. V. Natarajan
[1]M.Tech, Embedded Systems Technology, [2]Professor
Department of Electronics and Communications, SRM University, Chennai-603203, Tamil Nadu, India
[1]abhishekmajeti@yahoo.com, [2]vy.natarajan@gmail.com

***Abstract*— Fire accidents are one of the major problems at present which when occurs, results in destruction of various resources. To be specific, wild fire is a major problem in this category. Many traditional measures are present like ground patrolling, aerial patrolling and watch towers which include human power as main resource. However, these measures are not effective in terms of time and accuracy. Thus, here a system is proposed to overcome the disadvantages of traditional measures. It employs wireless sensor networks and is also a cost effective one when compared to other systems. The principle is that, a message is generated when wild fire occurs and is sent to the host or forest department to take an immediate action to eradicate the same.**

***Index Terms*— Wild Fire, Zigbee, S-MAC, GSM, Network node, Coordinator node.**

I. INTRODUCTION

Forests are one of the natural resources which are to be preserved as they are one of the key elements that alter the environment cycle. Such forests are becoming exhausted day by day by the activities performed by humans. The activities include wood extraction, development of infrastructure etc. The others are due to the negligence of us. The other reasons contributing to the wild fire include global warming. Wild fire can be spread easily within a less span of time and releases huge amounts of gases like carbon dioxide and carbon monoxide which in turn increases the temperature of the atmosphere. There are many measures existing at present to stop these wild fires, but are having some disadvantages as well, which make them as ineffective measures. There are systems to control the fire accidents that occur in residential areas and offices but these existing ones are not suitable in such large areas (forests). Thus a system is proposed and the same can be made generalized and use in the residential areas and offices.

II. EXISTING AND PROPOSED SYSTEMS

Fire accident when occurred in forest is termed as Wild Fire. As the name itself indicates, these are very difficult to stop and have the capability of destructing number of hectares in no time, if not controlled in time. The present existing systems or measures that fight with wild fire are: Aerial patrolling, Ground patrolling, Watch towers, Public hotlines [1]. However, these all measures commonly include one key element as their major resource i.e. man power. Thus, an accurate human observation can be limited by operator fatigue, time of day, time of year and geographical location. The other problems with these systems are: not economical in terms of cost, patrolling includes fuel consumption and maintenance of these also is very difficult.

As stated above, we now know the disadvantages of the current wild fire fighting systems and hence a system is proposed in this paper to overcome the disadvantages of traditional systems. Here, the key advantage is that the man power needed is very small and also the maintenance of this system is quite easy when compared to the old ones. The proposed system include a wireless sensor network paradigm with two types of nodes, called: Network node and Coordinator node. The Coordinator node and the network nodes employ different sensors to measure the environment parameters like smoke, humidity, temperature etc. The network nodes are employed in different regions across the forest region. Each network node is given an ID and is maintained in a database regarding its placement in the forest region. A Coordinator node is placed in the base station and is connected to a PC to monitor the values of the network nodes. The Coordinator node reception and the network node transmission of the sensor data is carried through the Zigbee modules which are also employed on the nodes. We set threshold values to each sensor and when the sensed data exceeds the predefined threshold value, a message is generated and is sent to the respective authorities to take an immediate action. This message is generated and sent with help of a GSM module which is already connected to Coordinator node which is at the base station. Thus there is no time delay in intimating the authorities about the wild fire and hence the loss associated might be reduced. In terms of accuracy, the contents of the message are: Node ID and the sensor name that exceeds the threshold value. As stated earlier a database is maintained regarding the positioning of the node and hence the authorities can reach the place with more degree of accuracy and also in less time.

III. HARDWARE DESIGN AND DETAILS

The main components that constitute the system are given below and the same are elaborated. The nodes can be configured with different hardware other than the specified ones because this system can be generalized in different ways.

Coordinator and Network Nodes

Both the nodes employ the same microcontroller i.e. PIC 16F877A as the means for processing the instructions. The advantage of this is that, up to nine sensors can be interfaced with it due to the inbuilt ADC module (absent in 8051), which gives a 10-bit result and there are eight ADC channels in the controller. Another additional feature is the Brown-out Reset (BOR). The sensors that are employed in this prototype are: gas sensor, temperature sensor and light sensor (LDR). The Coordinator node additionally is interfaced with the GSM modem through the Zigbee module which in turn is connected to PC for sensor data monitoring.

Zigbee Module

Zigbee is WPAN standard, basically designed for low data rate applications. It is designed by ZigBee Alliance and is built upon the IEEE 802.15.4 specification to meet the requirements of the modern data transmissions. There is a wide range of System-on chip (Soc) for zigbee. Some of the well known Soc are: Texas Instruments CC2530, CC2430; Microchip MRF24J40MA, MRF24J40MB series [9]. The features of MRF24J40MA [8] are:

- Simple to understand interface.
- A 4-wire Serial Peripheral Interface (SPI).
- Up to 400 feet range.
- Extremely low power consumption.
- Compatible with all PIC16F, PIC 18F families.
- Supports Zigbee, MiWi P2P and proprietary Wireless Networking Protocols.
- An IEEE 802.15.4 standard compliant RF transceiver.
- Quicker time to market because of easy integration into final product.

Under IEEE 802.15.4 specification the devices are classified as:

- Full Function Device (FFD): These are in the functioning state most of the time. They are generally employed at data collection terminals and are powered by power supplies. Coordinator node will have similar functionality.
- Reduced Function Device (RFD): As the name indicates, they can be in the dormant state for some time and active at other time. These are generally powered by batteries and hence should use power efficiently. Network nodes are similar to this kind of functionality.

GSM Module

The GSM module is the main module in terms of intimating the respective authorities. This module is basically configured and checked with the help of "AT" (Attention) commands [6]. Using these commands we configure this module to send a message when a condition is met i.e. when sensed values exceed the threshold values. Upon every successful execution of AT command, a carriage return is to be received, if not the command is to be resent. The interface of the GSM modem for RS-232 link is through 15 pin SUB D connector. The WAVECOMM SIM 900 is employed in this demonstration. The GSM module should be configured in software as shown in the Fig. 1. The variables X1, X2, and X3 indicate the sensed values and the variables Y1, Y2, Y3 indicate the threshold values. The functionality is illustrated in the flowchart:

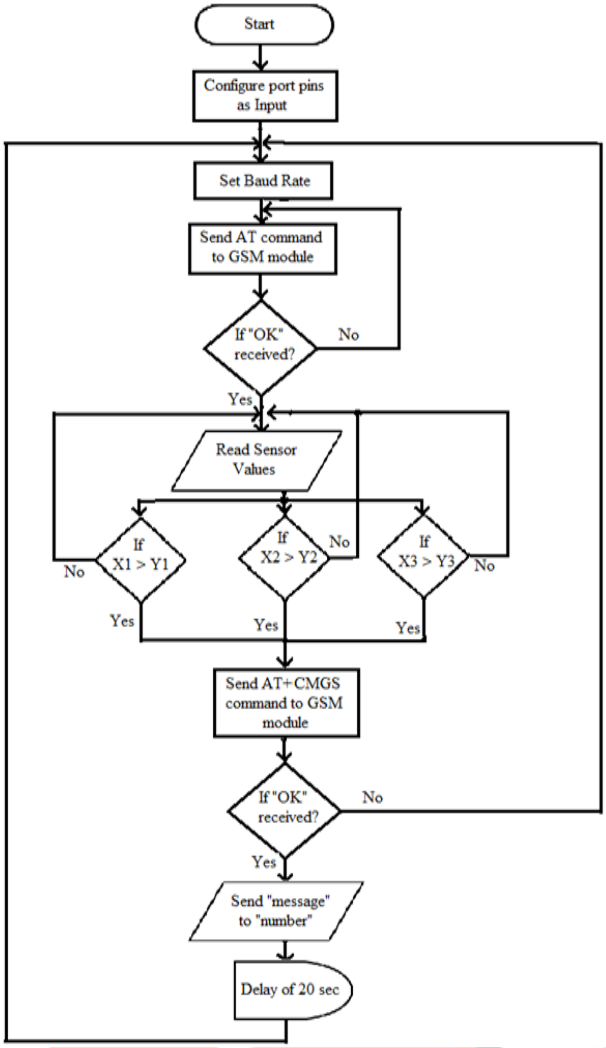

Figure 1. Configuring GSM Module

IV. WSN PROTOCOL SELECTION AND IMPLEMENTATION

WSN has emerged as one of the best standards in the present technology. It is being used aggressively for fulfilling the purposes of robotic exploration, environment monitoring and medical systems. Wireless Sensor Network has a building block called "Sensor Node", which are powered by batteries. Hence, they can only provide limited processing capability. The energy loss parameter is a vital one for such networks and we should carefully reduce this parameter and adopt a perfect protocol. The major sources of energy loss [3] in WSN are:

- Collision
- Idle Listening
- Over Hearing
- Over Emitting
- Control Packet Overhead

S-MAC Protocol

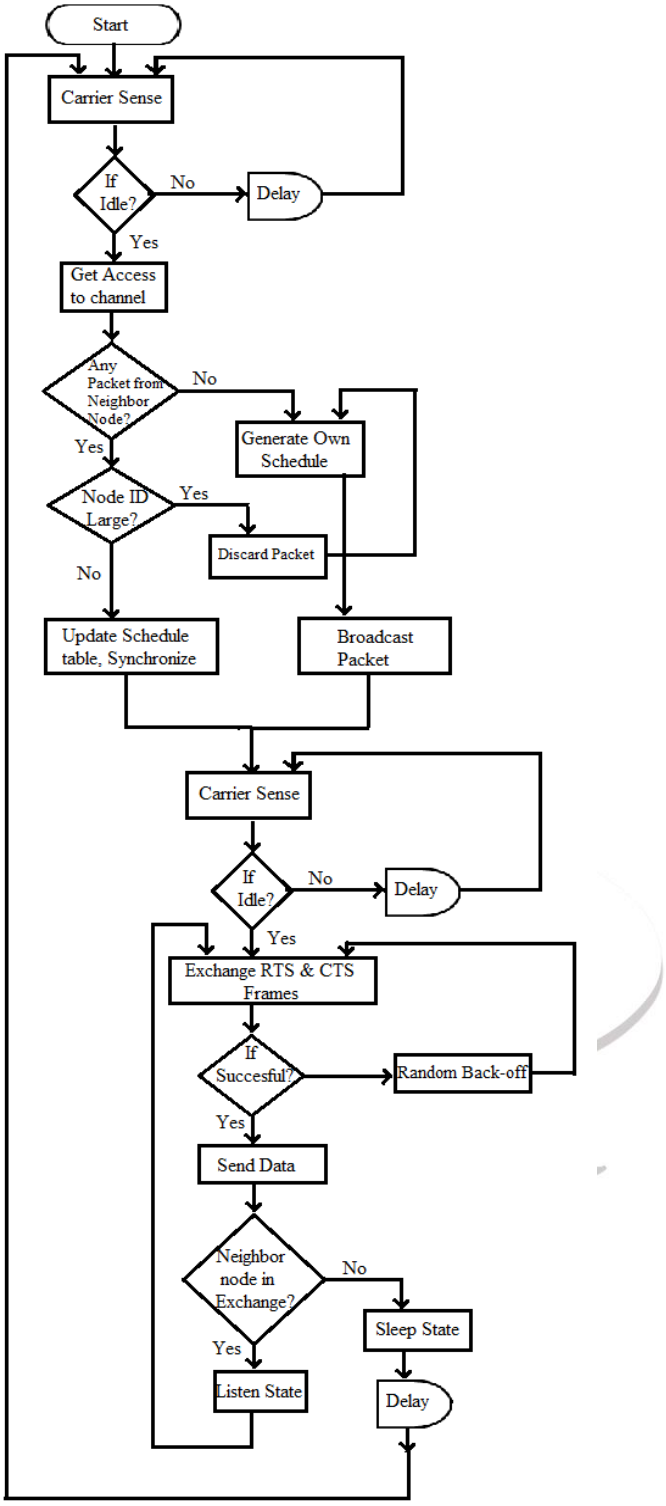

Figure 2. S-MAC Protocol Implementation

Fig. 2 shows the S-MAC protocol mechanism [3]. S-MAC is an acronym for Sensor Medium Access Control protocol. The S-MAC protocol is considered to have better performance and minimal power consumption. S-MAC protocol is a medium access control protocol which is widely used in WSN for energy conservation. It inherits the flexibility from contention based protocols like IEEE 802.11. The S-MAC protocol overcomes the energy consumption sources by using mechanisms like message passing and periodic listen and sleep [3][4].

The messaging mechanism [4] of the S-MAC is as shown below in Fig.3:

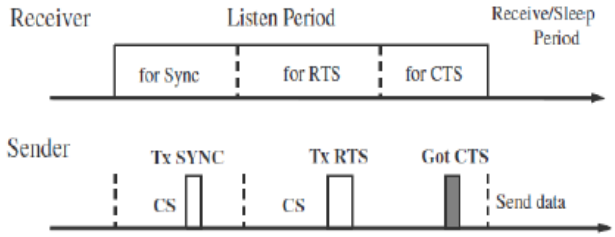

Figure 3. S-MAC Messaging Mechanism

The entire protocol is executed in two phases: Synchronizing phase and Data transmission phase as illustrated by the twice carrier sensing in the Fig.2.

Let us consider sensor nodes 'A' & 'B' to explain the S-MAC functionality. Node 'A' starts with sensing the carrier, if found idle it gets access. Once the access is granted, node 'A' checks for any packet transmission from the neighbour node 'B'. This packet consists of two parameters: Node ID & Scheduling time (next sleep time). Upon receiving the packet from 'B', 'A' checks whether the node ID in the packet is large or not, if found to be large, it is an indication that this node is a 'new node' which joined the network recently and thus indicating that its operation is not critical, discards the received packet and generates its own schedule (node 'A') & broadcasts it on the accessed carrier. On the other hand if the node ID is not large, then the received packet itself is broadcasted after the updating of schedule table of node 'A'. This is the initial phase of the S-MAC protocol called "Synchronization phase" and the packet transmitted is SYNC packet. This process is continued by all nodes and as result synchronization in the network is achieved i.e. each node knows about its neighbour nodes' sleep time. Thus the network latency is reduced.

Under the second phase the actual data is to be transmitted by eliminating collision problem. Now the carrier is sensed again by node 'A', upon getting the access a pair of frames called RTS (Request to send) and CTS (Clear to Send) are exchanged. If this exchange is successful then the actual data packet is sent to the other node in the network. If the exchange is not successful, after a random back off time the node 'A' again sends RTS frame. This process continues until CTS frame transmitted by the destination node is successfully received by node 'A'. Upon completing the transmission of data, node 'A' doesn't go to sleep period immediately but overhears for its neighbour node 'B's RTS frame. If it finds the frame, it remains in listening state till some time, otherwise go to sleep period to save the energy. Thus a collision free exchange with reduced latency and reduced energy consumption is achieved through unified scheduling S-MAC protocol.

The network latency associated in the networks can be reduced by a mechanism called "Adaptive Listening" in S- MAC. It is the situation where a node before going to sleep state, checks its neighbor for any RTS frames. If a transmission of the frame is noticed, the node remains in listen state for some additional time for completing the transmission of the message or packet without any delay.

V. SOFTWARE REQUIREMENT

MP Lab

MP Lab is one of the key software to program the Microchip PIC families. It includes various compilers like:
Hi-Tech C compiler and CCS compiler which allows the programmer to write the code similar to the syntax of 'C' and PICKIT software is used to dump or download the code into respective PIC microcontroller. The features include [5]:

- It is a 32-bit application on Microsoft windows including several free software components for application development.
- Both assembly and c programming is allowed here.
- Fully customizable text editor with Integrated Debugging, Recordable Macros, Context sensitive color highlighting, "Mouse Over Variable".
- Simple, powerful source level debugging including auto- alignment of break points, Drag & Drop variables into watch window, Automatic single – step "animate" feature
- Free Components like different compilers.

MP Lab also has many built in components [5], namely:

- Project Manager
- Editor
- Assembler/Linker
- De-bugger
- Execution Engines

The Sensor interfacing to PIC is carried in an easy way with the help of MP Lab and also zigbee module interfacing through UART is carried in Hi-Tech C compiler.

The sensor data is collected by the Coordinator and is sent to PC, which is displayed in a form window as shown below in Fig. 4, created using VB because the GUI can be configured again in future and GSM can also be activated to send message as shown in Fig. 5, by programming the AT commands in VB, which makes the task much simpler.

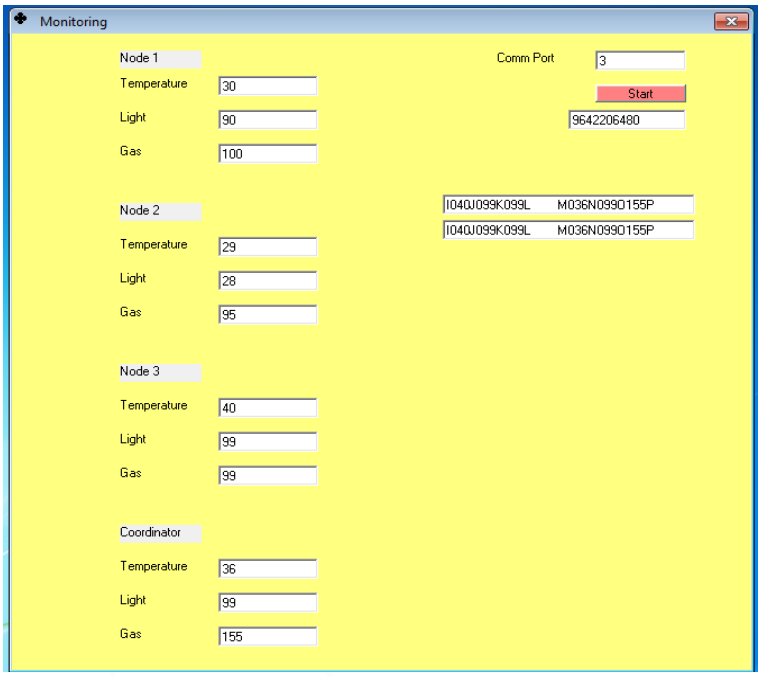

Figure 4. Monitoring output window

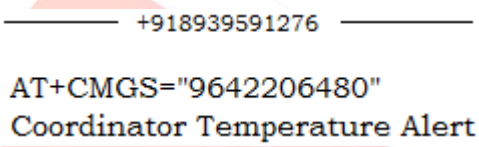

Figure 5. An Alert message in mobile when respective sensor threshold value exceeded.

VI. CONCLUSION

Here, a system is proposed to achieve wild fire monitoring in an optimized manner based on zigbee wireless sensor network and GSM module. This system is flexible, cost-effective and also uses less man power which is a great advantage compared to traditional measures of forest fire monitoring. Also this system can be generalized to use in residential areas, offices, industries and factories.

In future, this system can be extended to various triggering options up on detecting fire like activating fire extinguishers (sprayers) to cut off the fire, sprinklers to flush water instead of sending a notification alert to the respective authorities.

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