WSN Based Fire Detection And Extinguisher For Fireworks Warehouse

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Abstract-Security is primary concern for everyone. There are many ways to provide security at industries. For the problem that fast changing of temperature and humidity may cause spontaneous combustion in the process of fireworks warehouse storage, a real-time detection warning system based on wireless sensor network is designed. Wireless sensor networks could be applied in surveillance of military, industry, and so on. Sensing data could be integrated into complete environmental information by wireless communication. Zigbee is used as wireless technology for both transmission and reception. Nodes deployed in the warehouse collect temperature and humidity values and it is given to the microcontroller, after evaluation the microcontroller can take real-time scheduling in order to adjust the ventilation adjustment. When the temperature is close to the warning value, water sprayer module or ventilation module is activated, which will analyze and forecast the temperature trend timely so as to prevent the humans from disaster.

Key Words-Wireless sensor networks (WSN), detection, Forecast, Microcontroller.

I.INTRODUCTION

Wireless Sensor networks (WSN) consist of small nodes with sensing, computation, and wireless communications capabilities. In the upcoming age of pervasive and ubiquitous computing, it is expected that WSN will play an essential role. Security is a challenge in these networks due to various reasons. Deployment of sensor nodes in unsupervised and hostile environments makes individual sensors vulnerable to security compromise and susceptible to physical capture. Sensor nodes constraints in memory, power and computation resources, and using wireless channel for sensor nodes communication, further increase nodes susceptibility to common attacks against wireless network. Many routing and data transfer protocols have been specifically designed for WSNs. Most sensor network routing protocols are, however, quite simple and for this reason are sometimes insecure. In what follow, we present a discussion of major attacks against them.

Wireless sensor network has a very wide range of applications [1-4], and multipoint detection is one of important research areas of wireless sensor networks [5, 6].The network, that can be widely used in the areas human's life, Such as fireworks warehouses agricultural greenhouses and other fields applications such as fireworks warehouse have strict requirements on temperature and humidity, therefore, to detect the temperature and humidity in real time effectively in these areas is a very important issue. In order to ensure that the fireworks do not degenerate in the storage period or happens security incidents (such as spontaneous combustion, etc.), maintaining the temperature and the relative humidity inside the warehouse is an important condition. Higher temperature in warehouse would cause the pyrotechnic components contained in the fireworks break down easily; larger relative humidity would cause fireworks damp which will affect the quality of fireworks, and larger relative humidity would make fireworks absorb moisture and release exothermic, which would easily lead to spontaneous combustion; every 10 degrees rise of temperature, the chemical reaction of the pyrotechnic accelerated 3-4 times, which would vulnerable to spontaneous combustion[7]. Currently, the fireworks industry measures temperature and humidity in warehouse commonly in the way of setting a number of thermometers and hygrometers in warehouse, and that way can only play the role of displaying the values roughly and cannot be real-time accurate reflection of the conditions inside warehouse, it is easy to cause spontaneous combustion and quickly be spread. In addition, the way of using manual records are prone to introduce electrostatic by too many workers entering [8].When temperature exceeds the ignition point or there are so much electrostatic, it is easy to cause, and quickly spread. For the above problems spontaneous combustion exist in traditional measurement of fireworks warehouse, a real-time detection warning system based on wireless sensor network is designed in this paper.

II. SYSTEM STRUCTURE

A. BLOCK DIAGRAM OF THE SYSTEM

Microcontroller (AT89C51) is the heart of the system. As in Fig.1 In fireworks warehouse physical parameter temperature is continuously monitored by temperature sensor (LM 35).The sensed information will be send to the microcontroller through ADC0808.when the sensed temperature goes beyond the predetermined threshold value ,then microcontroller uses the water sprayer to sprinkle water over the affected area. At the same time ventilation will be provided as preventive measure to save the human lives from the disaster. Voice APR used in this proposed system to give audio information to the employers who are working inside the fireworks warehouse. Temperature values will be continuously displayed in the liquid crystal display.

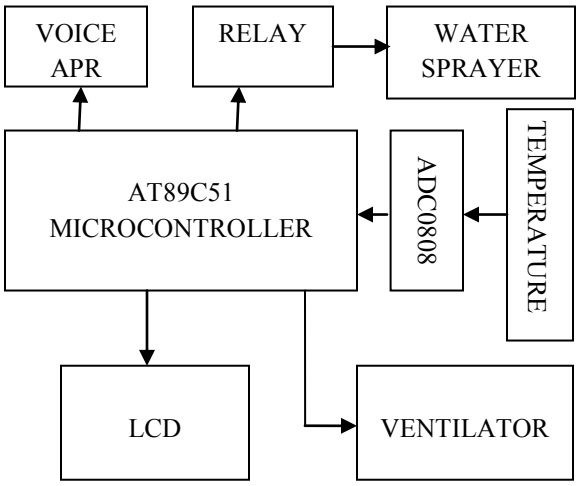

Fig.1.Block diagram of transmitter node

Fig.2 shows the receiver operation. At receiver side when the determined temperature exceeds predicted threshold value, then the disaster will be intimated to the nearby fire station and to concerned government authority through GSM MODEM. Zigbee is used for both wireless transmission and reception.

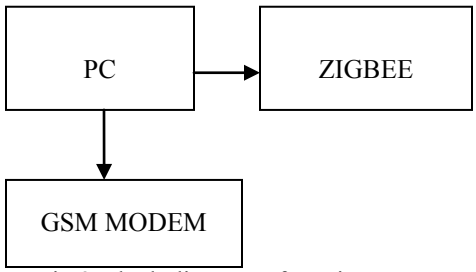

Fig.2.Block diagram of receiver

The structural design also includes following modules: node deployment module, temperature and humidity data collection module, decision analysis module and warning module, the system works as follows:

(1) Hot spot node deployment module is used to plan and deploy the nodes working in hot spot energy and efficiently.

(2)After deployment, temperature and humidity data collection model is used to collect temperature and humidity in warehouse, and later the data are sent to decision analysis module to process, when there is unusual data, it will be reported to gateway timely by wireless communication, and be transferred to control center by gateway through the serial port or other wired and wireless networks, then the data will be processed by computer monitoring software in control center.

(3) Three tasks will be taken in control center: displaying the temperature and humidity data collected by decision module and displaying the trend of environment changes inside the warehouse for control center, and to do a good job of monitoring and prevention.

(4) When temperature and humidity value exceeds the range of stored tolerance threshold, control center starts ventilation adjustment timely to maintain the stability of the temperature and humidity inside the warehouse.

(5)When the monitoring software displays the temperature reaches warning threshold, start the fire facility that has been installed in warehouse to achieve the purpose of starting the fire facilities after warning.

(6) System running for some time, considering the remaining energy of node and demand conditions, hot spot node deployment module is used to adjust the deployment of nodes so as to extend the network lifetime.

B. NODE DEPLOYMENT MODULE

Node deployment module is responsible for planning and deploying nodes energy, and the work includes two aspects, one is that after sensor nodes placed in hot zone, node deployment module guide the node to deploy energy and efficiently under the node redundancy detection algorithm [6], the other work is that considering the remaining node energy and the situation demand to adaptive adjust deployment of nodes timely, when the system running for some time.

1) ASSUMPTIONS AND DEFINITIONS: In order to elucidate the working principle of node deployment module, the assumptions and definitions relevant are given in the following. Assume the location of the node is known; the sensing radius and communication radius of the node are R_{si} and R_c, they satisfy that R_c=2 R_s , so the issues on the basis of network coverage contains connectivity; the sensing area of s_i is $C(s_i)$;the distance between *si* and the

point p satisfies $_{dsi\rightarrow p} < _{Rsi}$, then p is covered by s_i. The number of the node who covers the point p is the

coverage degree of p, denoted by $deg(p)$. If the distance between s_i and s_j satisfies $0 <_{dsi\rightarrow sj} < R_{si} + R_{sj}$, then s_j is the coverage neighbor of s_i.The node that covers the detected node's sensing field ($C(s_i)$) irreplaceably is the effective coverage neighbor of the detected node, else it is the ineffective coverage neighbor. s_j is the coverage neighbor of s_i, when the distance between them satiates $dsi\rightarrow sj \leq R_{sj}-R_{si}$, s_j is the first category neighbor of s_i, we call N_{fec} for short.

When the point between the sensing cycles of s_i's coverage neighbors and the point between the boundary of the network and the sensing cycles of s_i's coverage neighbors exist within C (s_i), the neighbor is the second category neighbor of s_i, we call N_{sec} for short; the other coverage neighbors are the third category neighbors, we call N_{tec} for short. The point between the sensing cycles of s_i's N_{sec}, the point between the boundary of the network and the sensing cycles of s_i's N_{sec}, and the point between the sensing cycles of s_i's N_{tec} and s_i are the key points.

2) REDUNDANCY DETECTION ALGORITHM: The number of N_{fec} in s_i's effective neighbors is at least k; The coverage degree of the key points within C(s_i) in the network formed by s_i and s_i's effective neighbors are at least k(the coverage degree here excludes the cover of s_i); The number of N_{fec} in s_i's effective neighbors is $k0$, furthermore, the coverage degree of the key points within C(s_i) in the network formed by s_i and s_i's effective neighbors are at least $k0$' excludes the cover of s_i and N_{fec} in s_i's effective neighbors, $k0$' satisfies $k_0 + k_{0'} \geq k$.If the condition satisfies any condition of i, ii or iii, si is redundant and the coverage degree of $C(s_i)$is k excludes the cover of s_i.

3) REDUNDANCY DETECTION ALGORITHM: The node gets the relative information distributed, which include the location and the radius of the node. The node takes the selection of effective neighbor in accordance with the information it gets and recognize effective neighbor. The node gets its status in accordance with the rule of redundancy detection.

C. TEMPERATURE AND HUMIDITY DATA COLLECTION MODULE

Temperature and humidity data collection module's main function is to collect temperature and humidity data by sensor nodes distributed in hot zone of warehouse, through the node's processing the information is converted to data, and uploaded to decision analysis module timely, where to be processed and analyzed. The system selects cricket series node, and use nesC programming language to program and design nodes under TinyOS operating system.

In order to achieve the purposes of collecting and transmitting temperature data by node, TempToLedsAndRfm, node's sending and collecting program is designed, in which the interfaces of StdControl, Timer, IntOutput and ADC are designed. StdControl interface complete the function of the application starts and the related hardware initialization, timer interface complete the function of counting, IntOutput interface provides interfaces to IntToRfm and IntToLeds, and ADC interface provides interface to OnboardTemp. node's sending and collecting program uses Main, TempToInt, IntToLeds, IntToRfm, TimerC and Onboard Temp components, and the relationship between components and interfaces is shown in Fig.2 with the graphical representation, in the figure circles represent components, arrows represent interfaces. Components of Main, TempToInt, IntToLeds, IntToRfm, TimerC, and OnboardTemp implement the logic function of program. The program starts at main component, and it connects to other components through StdControl interface. TempToInt component is the core of the program. IntToLeds component displayed the temperature value on Led through IntOutPut interface, and at the same time, IntToRfm component broadcasts temperature data out by IntOutPut interface.

D. DECISION ANALYSIS MODULE

Decision analysis module using Eq. (1) and (2) to do denoising with the temperature and humidity received first, so that to eliminate the errors caused by instruments and noise, where t and h are the temperature estimation after denoising, t and h are the current temperature and humidity received, Δq_1 and Δq_2 are the error adjustment factors (adjusted according to environmental conditions).

$$t = t\,(1+\Delta q_1) \quad \ldots \quad (1)$$

$$h = h\,(1+\Delta q_2) \quad \ldots \quad (2)$$

After denoising a general assessment method is used, removing the high temperature and humidity value and the minimum value of decision analysis module, and obtain the average value of the remaining temperature and humidity value, and take the average value as real-time value of warehouse, and then compare the value to the range of stored tolerance threshold, if it doesn't meet Eq. (3), the value will be sent to gateway by decision analysis module timely, and decision analysis module will also send the temperature and humidity collected from the warehouse at this time to the gateway node to prepare for monitor center.

$$t_{min} + \Delta t \leq t_n \leq t_{max} + \Delta t$$

$$h_{min} + \Delta h \leq h_n \leq h_{max} + \Delta h \quad \ldots \quad (3)$$

where, tn and h_n are the current temperature and humidity of warehouse, t_{min} and t_{max} are the extremes

of storage tolerate temperature, h_{min} and h_{max} are the extremes of storage tolerate humidity, and Δt Δh are the range of tolerance temperature and humidity.
Table 1.The average data of random experiments

III. EXPERIMENTAL RESULTS

A. THE MAIN INTERFACE

The main interface of monitor center where users can choose the operation is shown in Fig.3. In the main interface, the serial port should be set. Select the serial port 1, baud rate is 115200bps and take 8 data bits with no parity. After successful set up, the situation of working node, dormant nodes and the coverage of the warehouse will be displayed in the main page after the working of deployment module. Click the button of temperature monitor in the main interface, temperature monitor sub interface will be bring up as shown in Fig.3.

B. THE EFFICIENCY OF DEPLOYMENT MODULE

To verify the performance of deployment module, in this paper we conducted 20 times random experiments, and get the average data as shown in Table 1. We can see from Table 1 that after the work of deployment module, there are only 24% nodes working, under the conditions of the same quality of coverage, which means the number of node activated by deployment module, is greatly reduced, and the lifetime of monitoring network will be effectively extended.

	On-duty node number (ge)	Coverage percentage (%)
Original network	100	99
The network after redundancy detect	24	99

C. THE TEMPERATURE OF WAREHOUSE

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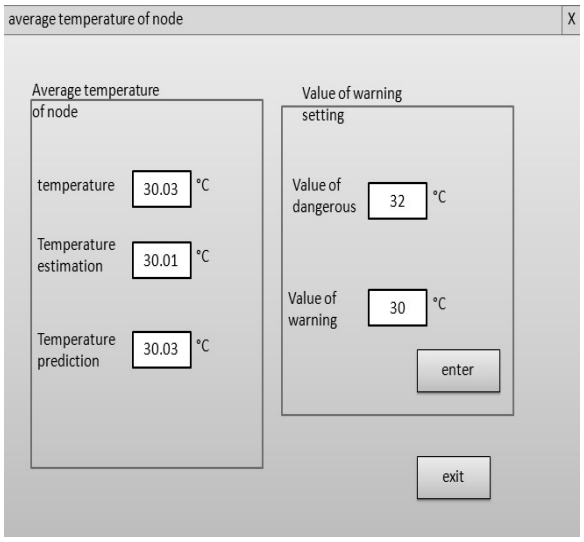

Fig.3.The sub interface of the temperature

Monitoring the average temperature of the warehouse in real-time, setting the value of dangerous and warning, when the average temperature does not meet the warning value, the interface will display "security ", here the warning value is set as 30^{o}C. Fig.3 shows the temperature interface of actual value of the warehouse when we do simulation tests.

D. TEMPERATURE PREDICTION

When temperature reaches warning value (take 30 degrees as warning value in simulation experiment), warning module is activated immediately and the prediction on temperature. In order to facilitate the monitoring personnel more directly to observe temperature data changes, the system displays the predictive value and the real-time value of temperature in the graphical interface, which is shown in Fig.4.

The performance of warning module is better, when temperature rapidly changes, warning module can do early warning and disasters can also be prevent from happening .The nodes temperature, average temperature and predicted curve temperature are also indicated in the warning system.

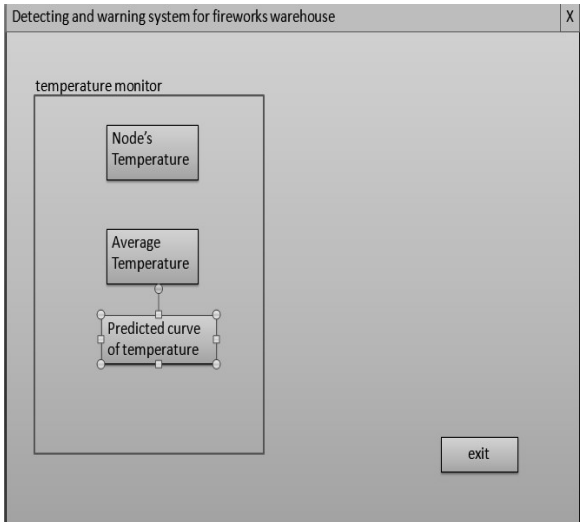

Fig.4.the interface of the temperature prediction

IV. CONCLUSION

In this paper we have proposed a system which prevents fire accident in the fireworks warehouse. This system is implemented based on wireless sensor network and Zigbee wireless technology. Temperature prediction and temperature estimation are tabulated.A real time scheduling is proposed along with hardware node deployment which provides preventive measures in accurate and timely manner.

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