

# The Design of Building Fire Monitoring System Based on ZigBee-WiFi Networks

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**Abstract**—With the rapid development of wireless communication technology, people's life has undergone great changes. In recent years, the comfort and safety of the building environment have become a universal concern. However, building fire is the greatest threat to building safety. In consideration of the current issues on building security, the design applies the important part, the wireless sensor network technology to building fire safety monitoring system and establishes the wireless sensor network by using ZigBee technology and ZigBee-WiFi gateway which transforms ZigBee network into WiFi network. In addition, taking advantage of the ZigBee wireless sensor network locates a fire place so that the fire information is uploaded to the handheld terminal and the building security personnel work out the retreat and rescue plan in time. This paper provides a new solution for building fire monitoring system.

**Keywords**—Wireless sensor networks; ZigBee-WiFi; building fire; Monitoring system; Fire localization

## I. INTRODUCTION

In recent years, wireless communications, wireless control, wireless localization and mobile digital technology emerge more and more frequently in our daily lives [1]. The wireless communication technology is widely used in building automation, changing the traditional wired communication way. For the complex environment in building, the application of wireless sensor networks to a comprehensive building monitoring has become a new trend.

Modern building fire safety system mainly focuses on the fire alarm[2]. However, the monitoring center can't take effective evacuation and guidance in time. When the fire occurs, it is particularly important for people in danger to escape quickly [3]. Therefore, this paper designs a long-distance transmission mode of fire information within the entire building by ZigBee-WiFi network, and then the signals detected by sensors are transmitted to the monitoring center by WiFi network, which connects with personal terminal easily. Decision-making controllers need analyze the critical situation and the development trend of fire quickly and effectively. Then the investigation should be carried out on the fire place in order to accurate the scope and range of the accident, and determine the number of people trapped and ascertain their location, choose the most rapid rescue plan. And the system can real-time monitor the corners where fire disasters most frequently take place. The design can ensure the safety of buildings and people comprehensively and effectively.

## II. THE STRUCTURE OF THE SYSTEM

Building fire monitoring system includes data collecting module, wireless transmitting module and remote monitoring module. The system adopts the idea of ZigBee wireless sensor network nodes, which collect detected signals and locate the fire place. Then ZigBee network transforms to WiFi network, by which signals are transmitted to the monitoring center. Fire signals and localization information will be showed on the handheld terminal and control center, so as to be real-time obtained by the security personnel. ZigBee based on IEEE802.15.4 protocol[4] and WiFi based on IEEE802.11b protocol are combined to provide a broader and more convenient building monitoring network. A low operating cost, less wires and suitable for building construction fire monitoring system at present is designed and developed. The structure of the system is shown in Fig.1.

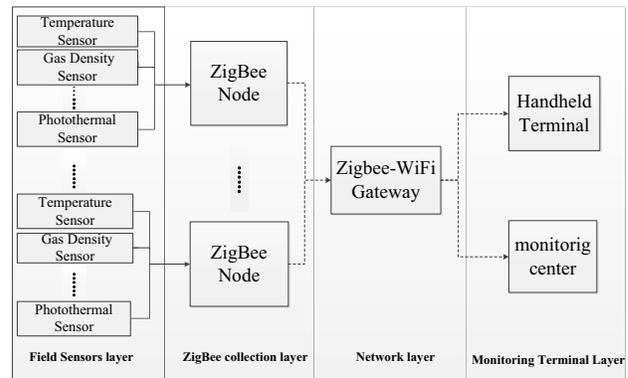


Figure 1. Figure 1. Structure of the system

The innovation of the design is that ZigBee network and WiFi network are combined to form ZigBee-WiFi network. The ZigBee-WiFi network is applied to building fire monitoring, the advantages are showed as follows:(1) The design not only utilizes the feature of ZigBee that network easily, but also the feature of WiFi module that technologies mature, more popular and wide. Users can use mobile phones and other hand-held terminal to access network.(2) ZigBee communication distance is within 100 meters, by contrast, the transmission distance of WiFi is 300 meters. ZigBee-WiFi network extends the coverage and transmits distance farther than ZigBee network, which ensures the monitoring center and security personnel everywhere receive monitoring signals.(3) ZigBee is fit for transmitting the low

power, small rate information such as fire signals. At the same time, WiFi transmits easily the image video of every corner in buildings to the monitoring center, so as to monitor fire more accurately.

### III. THE HARDWARE

Field data signals are collected by ZigBee nodes based on CC2530 core chip, ZigBee sensor nodes are distributed in every corner of the building to constitute strongly self-organized wireless sensor networks with wide range[5]. CC2530 has an excellent RF transceiver, industry-standard enhanced 8051 CPU, programmable flash memory, 8-KB RAM and many other advantages. CC2530 has different kinds of operating modes, making it suited for low power consuming systems. ZigBee wireless sensor network nodes distributed in the whole building monitor the safety of each floor. The fire disaster mainly includes home fire, public fire and electrical fire. The ZigBee node module is shown in Fig.2.

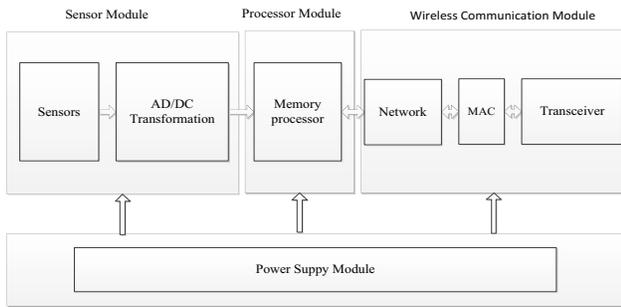


Figure 2. The structure of ZigBee node module

ZigBee-WiFi network has ZigBee's features such as low complexity, low power consumption, high cost performance, self-organization, good flexibility and high fault tolerance, integrated with WiFi's features that a high communication speed, good stability, wide range, positioning function and convenient access to terminals[6]. The transformation of both networks requires ZigBee-WiFi gateway, which integrates with ZigBee module based on CC2530F256 core chip, WiFi module based on RT5350 and serial ports. The CC2530 chip figure is showed in Fig. 3, and the RT5350 chip figure is showed in Fig. 4.



Figure 3. The CC2530 Chip



Figure 4. The RT5350 Chip

### IV. THE SOFTWARE

The core technology of ZigBee is ZigBee stack, which refers to the sum of the network protocol layers[7]. Users receive and transmit data through the use of the protocol stack. Protocol stack programming environment is IAR compiler, and IAR Embedded Workbench is a highly effective integrated development environment (IDE), which allows users to develop and manage embedded applications engineering fully and effectively.

Wireless gateway is block-based design, consists of hardware driver layer, the operating system layer, network protocol layer. Hardware driver layer includes drivers ZigBee module, WiFi module, operating system transplant layer-ARM Linux, network protocol layer that includes ZigBee protocol stack and WiFi protocol stack. This design is realized by the Linux operating system. Gateway extracts data from the sensor nodes and sends to WiFi module by data frame. What's more, WiFi gateway wirelessly transmits data to the PC and personal handheld terminals[8].

Wireless gateway can greatly improve the problem of remote transmission, allowing managers to obtain information with a remote terminal timely and accurately. These data can be analyzed, processed and operated. The remote monitoring center is mainly programmed by using LabVIEW software to, LabVIEW is a visual graphical programming language, it avoids the complex codes, and it provides a more intuitive image, widely used in the PC interface programming. The software working flow chart is showed in Fig. 5.

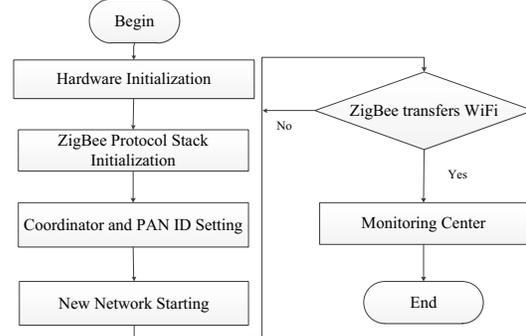


Figure 5. Software Working Flow Chart

### V. ALGORITHM ANALYSIS

Taking into account the structural features of the building interior, this design uses RSSI localization algorithm, which is based on the signal attenuation model. Compared with other localization algorithms, RSSI is a low-requirements,

low-cost, low-complexity positioning method, suitable for building occasions. This design improves the accuracy of the original localization algorithm. It calculates the signal attenuation distance by means of the position relations of the blind nodes and anchor nodes, and the new model is greatly different from the original one, aiming to make sure the accuracy in such a special environment of building. ZigBee localization algorithm is based on the relationship between the blind nodes and anchor nodes to achieve the blind node position[9]. The blind node sends RSSI signal to the same anchor repeatedly to calculate the average distance between two points as the final RSSI value. The spatial relationship between blind nodes and anchor nodes is shown as Fig.6.

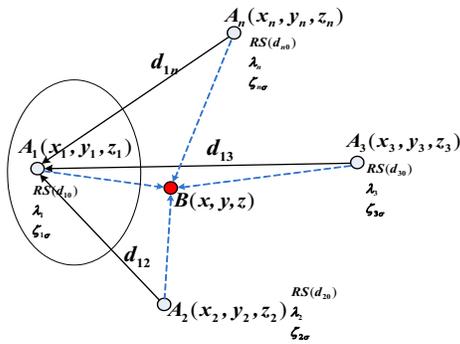


Figure 6. The Spatial Relationship between Anchor Node and Blind Node Graph

Current general model is Shadowing model[10], which is based on a statistical model, and has been applied and verified in a variety of actual environment. The general model is:

$$RS(d) = RS(d_0) + 10\lambda \lg\left(\frac{d}{d_0}\right) + \zeta_\sigma$$

It can be deduced from the above equation:

$$d = d_0 \times 10^{\frac{RS(d) - RS(d_0) - \zeta_\sigma}{10\lambda}}$$

In the formula, RS (d) is the received RSSI value from the emission point.

RS (d<sub>0</sub>) is the received RSSI value from the launch point d<sub>0</sub>, also called the reference distance, and it is usually valued 1m.

λ is the path dynamic attenuation index.

ζσ is the Gaussian random noise, of which the standard deviation is σ and the average is 0.

Estimate the localization of the fire place in accordance with the positional relationship between distance and RSSI signal attenuation model.

## VI. CONCLUSION

This paper focuses on the issue on building fire monitoring, combined with thought of wireless sensor network technology, and comes up with a ZigBee-based wireless sensor network to collect the information from the entire building, and making use of ZigBee nodes to locate

the fire stations. Taking full advantages of WiFi and ZigBee, this design builds a ZigBee-WiFi network. The purpose is to design a real-time building fire monitoring system which is more facilitative to contact with the personal handy terminal and has wider covering range. The scheme has a good practical value.

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