Sensors & Transducers
ISSN 1726-5479

http://www.sensorsportal.com

Application of Wireless Sensor Network in Indoor Alarm

Fang Li, Yin Yue Hong
Advanced Electronics Manufacturing Center, Shanghai Jiao Tong University
1954, Hua Shan Road, Shang Hai, 200030, the P.R.China, Phone (+86) 2162933037
E-mail: Lfang@sjtu.edu.cn, Yhyin@sjtu.edu.cn

Received: 14 June 2004 /Accepted: 18 June 2004 /Published: 30 June 2004

Abstract: The digital electronics, embedded systems and wireless communications together result in wireless sensor networks. A general wireless sensor network consists of a number of sensors spread across a geographical area. Each sensor has wireless communication capability and sufficient intelligence for signal processing and networking of the data. So these networks have a wide range of potential applications, including security and surety and surveillance, control, actuation and maintenance of complex systems, and fine grain monitoring of indoor and outdoor environments. In the paper, a small scale of wireless sensor network is presented and applied to indoor alarm in detail.

Keywords: wireless sensor network, indoor alarm, communication protocol

1. Introduction

The great progress has made in wireless sensor network [1] with the development of the digital electronics, embedded systems and wireless communications. Wireless sensor networks differ from conventional network systems in many aspects. They usually involve a large number of spatially distributed, energy-constrained, self-configuring and self-aware nodes. These systems are designed to be self-organizing in the sense of establishing and maintaining their own network without the need for specialist operators [2, 3]. So these networks are fit for indoor alarm because of these characteristics.

The indoor alarm networks adopting wireless sensor network are composed of many nodes with different sensors, such as infrared sensor, the gate of magnet, fire alarm, CO gas induction, alarm switch, the generated infrared, the detection apparatus, etc. The nodes of this network can be easy

distributed randomly in room without any damage to expensive upholster compared with wire alarm networks. The different information can be detected by the variable kinds of sensor nodes in the same space, and all alarm information can be transmitted and analyzed together so that the wrong alarm rate can be reduced as low as possible.

The rest of this paper is organized in the following way, Section 2 describes the general structures of wireless sensor networks and introduces the characteristics of alarm networks. In Section 3, we explain the structure of the nodes of wireless alarm network in detail; in section 4, we will discuss how to communicate between neighbouring nodes safely. In section 5, the communication algorithm based on the route table is represented to communicate between any two nodes. Finally, the advantage and disadvantage of this indoor alarm network are discussed.

2. Structure of Wireless Alarm Network

The structures of wireless sensor network have been studied for a few years and many structures of network are discussed. Wesson et al [4] described the anarchic committee (AC) structure AC can be viewed as a fully interconnected network without hierarchy, where each node can communicate with any other nodes, but AC structure is expensive to implement and also hard to extend. On the other hand, the dynamic hierarchical cone (DHC) structure provides hierarchical structure, also called a tree structure. It only allows communications between nodes in adjacent layers, but not within the same layer.

A hybrid structure, which is called flat tree network, was proposed in [5-7] to overcome the drawbacks in both AC and DHC. The nodes in this network are organized as many complete binary trees, and the roots of which are completely connected, Even though flat tree structure improves wireless sensor network from both hierarchical and robustness aspects.

In the paper, the wireless alarm network will be placed in the different environments, such as house, office buildings, hotels, villas etc; the nodes of this network can be distributed randomly in space. The alarm networks need the functions of self-organizing with random nodes, nodes of the network can be increased and combined arbitrarily; so we adopted the multi-center structure, shown on Figure 1, to meet the demand of the alarm network.

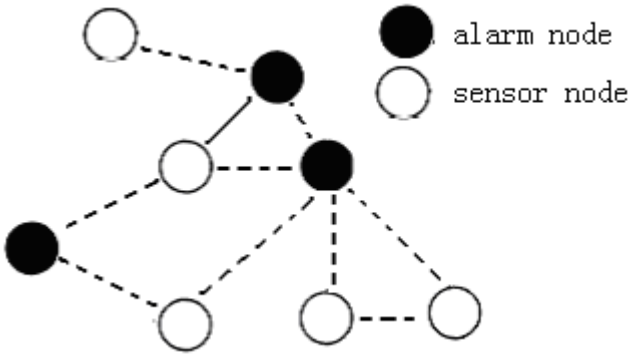

Fig.1. *Structure of Alarm Network.*

This multi-center alarm network has capacity of extending the nodes and reconfiguring the structure. In general, the alarm network consists of a set of low-cost sensor nodes monitoring environment and a set of expensive alarm nodes connected to the wire phone or mobile phone system. The sensor nodes

are used to acquire data or information in a room, such as the temperature and fire sensors. The alarm nodes are the center nodes of alarm network, whose tasks are to analyze the information form sensor nodes and decide whether to call master or policemen or not when the dangers happen. So the data acquiring and data processing and data transmitting can be done only in same network. Much data can be collected together to reduce wrong alarm rate because of the merits of this network.

3. Structure of Nodes in Alarm Network

Nodes in alarm network will have capabilities for self-assembling networks that are incrementally extensible and dynamically adaptable to device failure and degradation, mobility of sensor nodes, and changes in task and network requirements. Nodes are aware of their own capabilities and those of other nodes around them, which may provide the networking and system services, or resources that they need.

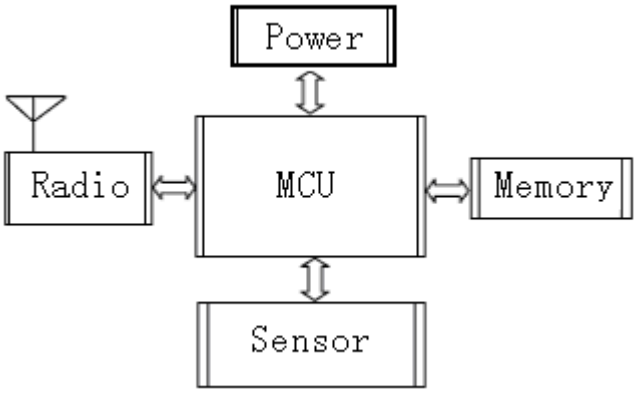

Fig.2. *Structure of Node.*

The sensor nodes of alarm network, in general, consist five parts: Radio, MCU, Memory, Power, Sensor and Conditional Circuit, illustrated as Figure 2. The alarm nodes of alarm network are composed of the additional ports that connect wire telephone or mobile phone compared with sensor nodes.

MCU (Embedded Process): The nodes of network typically should use low-consume and high-performance embedded microprocessors to acquire the data, to preprocess and to pack them by changeless format to communicate with other nodes according to given protocol, so It is the core block of node.

Memory: An amount of memory is used for data capturing, network queuing, and as storage space for the microprocessor's applications.

Sensors and Conditional Circuit: There are many different sensors in same alarm network. The standard interface that the output voltage of sensors is limited between 0V and 5V or the range of output current of sensors is between 4mA and 20mA is designed to meet the variable sensors. So sensors meeting this requirement can be connected to nodes without any difficultly.

Radio: Under the help of radio block, the node can communicate with nearby nodes. At the same time, Radio blocks can connect MCU by RS232, I^2C.

Power: Since sensor nodes are self-contained; they must be equipped with their own sources of energy.

Table 1. Parameters of Sensor Node.

Feature/Function	Performances
Connection type	FSK
Spectrum	912Mhz ISM Band
Communication Rate	9.6Kbps
Range	30m
Sensor type	Infrared sensor, the gate of magnet, fire alarm, CO gas induction, etc
MCU	At89c52
Power	5V

4. Communications Between Neighbouring Nodes

According to the transmission range of the wireless communication, the nodes of the alarm network can be divided into two classes: neighbouring nodes and reachable nodes. Neghbouring nodes can communicate with each other directly. Reachable nodes may communicate with each other under the help of the interim node. In Figure 3, Node A and Node B, Node B and C are neighbor nodes. However, Node A and Node C, Node A and Node D are reachable nodes.

In alarm network, much data sampled by sensor nodes must be transmitted to the center nodes (alarm nodes) to process. This process can be divided into two phases: In first phase, any two neighbouring nodes in alarm network can communicate with each other safely. Next, a node can send message to other nodes over interim nodes according the schemed path.

Because of a limited communication range and the limited bandwidth. The collision will happen under following two conditions shown on Figure 3.

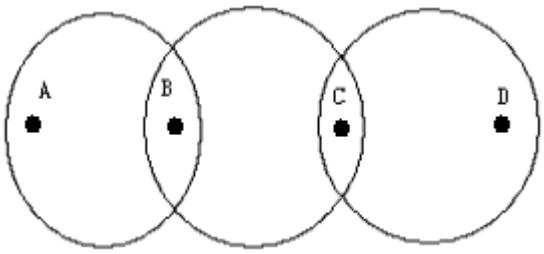

Fig.3. *Relation of the Nodes.*

Figure 3 shows that Node B is located in the communication range of Node A and Node C, but Node C cannot communicate with Node A directly. If the Node A and Node C transmitted data to neighbouring node B at the same time, Node B will received the wrong data because of disturbances of the limited communication bandwidth. Similarly, when Node C is transmitting the data to Node D. Node A transmits data to Node B. Node C will interfere with the communication between Node B and Node A. In order to solve the above two problems, the decent algorithm is considered here for a successful communication between neighbouring nodes. The transmitting Node detects the channel to confirm that none of neighbouring nodes is sending data and the channel is empty. Then this node will request the receiving node whether receiving node can be ready to received data. After getting confirmed response from receiving node, the transmitting node will send data to receiving node. Then receiving node checks the data packet by CRC and returns confirmation. If there is some wrong during

this process, the process will be done again. If these errors happen beyond triple, the data will be given in and the wrong codes are broadcasted in the alarm network to solve. The successful process can be listed in Figure 4.

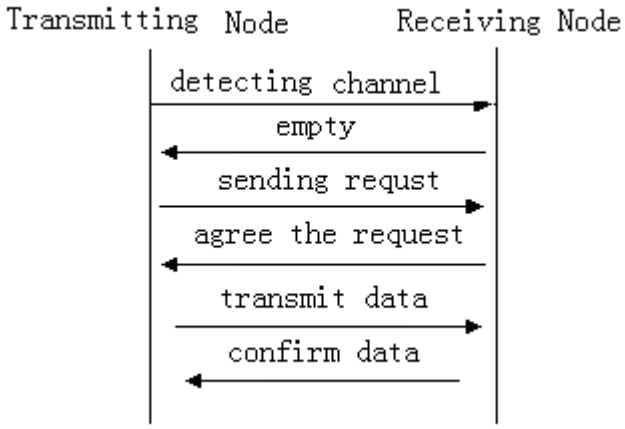

Fig. 4. *Successful Communication Between Neighbouring Nodes.*

5. Data Route Algorithm

On the base of the communication between neighbouring nodes safely, the single route algorithm is proposed to communicate among nodes in route phase.

5.1 Description of the Node

Nodes in this network can be described as the structure.

```
structure network_link{
    char ID;
    unsigned int  Level;
    structure network_link * Last_link;
    structure network_link * Next_link;
    structure network_link * Reac_link;
    } Node
```

ID: ID presents uniquely node in a same alarm network. So ID can be used to distinguish different sensors nodes in the network.

Level: It is equal to the number of interim nodes over which the data are transmitted from initial node to destination node. Neighbouring nodes mean the value of level is zero.

Network_link *: It is the pointer of this structure by which many node structures can be linked together to form list or table.

5.2 Establishment of Route Table

In general, route tables of nodes set up when alarm network begins to work. A node in alarm network can broadcast the neighbouring nodes to get the ID of neighbouring nodes, the neighbouring node lists can be set up by the returned ID from neighbouring nodes, Level in this list is zero. Next the orders are sent to neighbouring nodes according to the neighbouring node list one by one in order to get the route tables of neighbouring nodes. So the reachable lists can be established, then level plus one

increasingly. Then these lists are optimized. In same reachable list, the same ID nodes are exterminated and the lowest level value of them will be hold. So that there is no same ID Node in the same reachable list to avoid dead circle transmission. The structure of route table of a node is described in Figure 5:

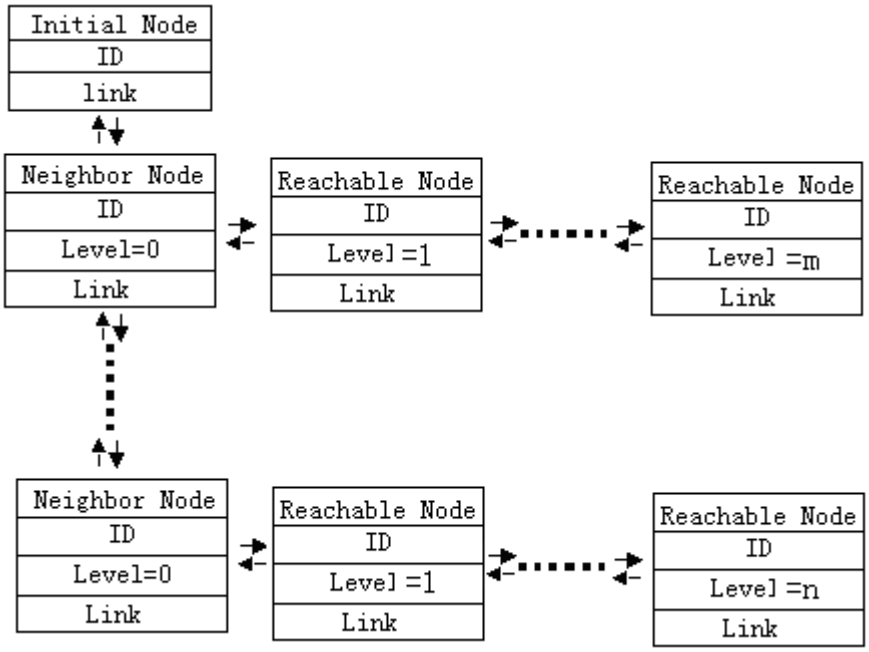

Fig.5. *Structure of Route Table of a Node.*

In order to meet the characteristics of self-organizing, the route tables of nodes can be refreshed when the following conditions

A, the route table of every node updates in interval time.
B, the network detects the new node.
C, wrong happens during the course of data transmission.

The route tables can describe the topology of the alarm network after the route tables are refreshed many times.

5.3 Route Algorithm

The route algorithm is on base of the communication between neighbouring nodes and route tables. Data can be transmitted from initial node to destination node safely and rapidly. The process of route algorithm is listed:

Step 1: Creating the packet of transmitting node
Step 2: Searching whether the destination node is in its neighbouring node list or not.
Step3: Yes, carrying out communication between neighbouring nodes, then this communication is over.
Step 4: No, then itinerating whole route table to search whether the destination node is located in one of the lists of the reachable nodes or not.

Step 5: If there is no destination node in whole route table, transmitting node sends wrong order and broadcasts destination node in network. If the destination node cannot be searched, error occurs.

Step 6: If the destination node is in one of the reachable nodes, then looking up same node whose level is the least in whole route table.

Step 7: The head node of the reachable node list where exists the least level destination node is found. Then the communication between transmitting node and the head node is implemented; finally the head node is changed as new transmitting node. Then go to step 2

6. Conclusions

The alarm network with the general characteristics of the wireless sensor network are designed in the paper, this network can contain 254 nodes and adopt FSK. Multi-center or multi alarm node will keep the security of the alarm network, much data can be fused together to reduce wrong alarm rate. Because of the feature of self-organizing, the alarm network can be installed easily in room. The experiment shows that the system can work well. But the relative relationship of nodes in alarm network alternated frequently or too many nodes are contained in same network. The communication effectiveness of the alarm network will decrease rapidly. The next work is to improve the communication effectiveness of route algorithm and to power functions of radio block.

References

[1].Vikram L. Shirgur and Vittal S.Rao. Distributed Intelligence in Wireless Sensor Networks, In *Proc. of SPIE* Vol. 5055, pp.328-338.

[2].Alvin Lim, Distributed Services for Information Dissemination in Self-organizing Sensor Networks, *Journal of the Franklin Institute*, 338, 2001, pp.707-727.

[3].Stefano Chessa, Paolo Santi Crash faults identification in wireless sensor networks *Compute Communications*, 25, 2002, pp. 1273-1282.

[4].R. Wesson, F. Hayes-Roth, J.W.Burge, C.Stasz, C.A.Sunshine, Network Structures for Distributed Situation Assessment, *IEEE Trans. Systems, Man Cybernet,* SMC-11(1), 1981, pp. 5-23.

[5].D. N. Jayasimaha, S. S. Iyengar, R. L.Kashyap, Information Integration and Synchronization in Distributed Sensor Networks, *IEEE Trans, Systems, Man, Cybernet*, SMC-21(21), 1991, pp.1032-1043.

[6].L. Prasad, S. S. Iyengar, R. L. Kashyap, R. N. Madan, Functional Characterization of Sensor Integration in Distributed Sensor Networks, *IEEE Trans. Systems, Man, Cybernet*, SMC-21(5), 1991, pp.1082-1087.

[7].Hairong Qi, S.Sitharama Iyengar, Krishnendu Chakrabarty. Distributed Sensor Networks a Review of Recent Research , *Journal of the Franklin Institute* ,338, 2001, pp. 655-668.