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ZIGBEE BASED WIRELESS MESH NETWORK CONTROLLING THROUGH WEB SERVER

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Abstract-

Mesh networking is a powerful way to route data. Range is extended by allowing data to hop node to node and reliability is increased by self-healing, the ability to create alternate paths when one node fails or a connection is lost. ZigBee is the new standard that has been developed for low cost, low data rate and low power consumption wireless network. And mesh is a type of network architecture. This paper provides a brief overview of the available IEEE 802.15.4 topologies, and then developing the mesh topology, describing its advantages, disadvantages and application, and presents a detailed study on open research issues in ZigBee mesh networks. But mesh network is limited by space. In This research paper we introduced ZigBee mesh network with webserver interface. Any router node can transfer data to coordinator node of ZigBee and coordinator is connected with webserver. All data is sent to webserver for monitor. With a real IP these data can be viewed from anywhere in the world. It makes ZigBee network Internet connected, monitored and controlled.

Keyword: ZigBee, mesh networks, routing analysis, web server.

1. Introduction

IEEE 802.15.4 [1] defines the "physical layer" (PHY) and the "medium access layer" (MAC). PHY defines a low power spread spectrum radio operating a t 2.4 GHz with a basic bit rate of 250 kilobits per second. There are also PHY specifications for 915 MHz and 868 MHz that operate at lower data rates. MAC layers defines frame formats for forming a network based on short(16-bit) and long (64-bit) addresses. A long address is unique to each physical node and does not change, a short address is assigned to a node when it joins the network. The ZigBee Specification [2], released in December 2004 and recently turned publicly available, specifies the protocol layers above IEEE 802.15.4. the network(including security services) and application (including device objects and profiles) layers.

2. MESH NETWORK TOPOLOGY

The ZigBee Protocol defines three types of nodes: Coordinators, Routers and End Device, with a requirement of one Coordinator per network. While all nodes can send and receive data, there are differences in the specific roles they play.
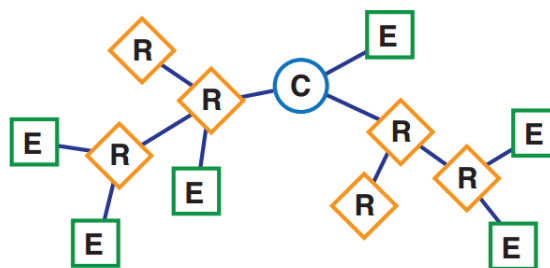

Fig1. Zigbee Wireless Mesh Network

Coordinators are the most capable of the three node types. There is exactly one coordinator in each network and it is the device that establishes the network originally. It is able to store information about the network, including security keys.

Routers act as intermediate nodes, relaying data from other devices.

End Devices can be low-power / battery-powered devices. They have sufficient functionality to talk to their parents (either the coordinator or a router) and cannot relay data from other devices. This reduced functionality allows for the potential to reduce their cost.

ZigBee offers these advantages:

- Open standard with interoperability between vendors
- Option for lower cost, reduced function end nodes
- robust multi-hop communication.
- network is more flexible.
- lower latency.

Disadvantages include:

- cannot form super frames.
- route discovery is costly.
- needs storage for routing table.

The size of network address is 16 bits, so ZigBee is
capable to accept about 65535 devices in a network.
Transportation time is 15ms between nodes. In fact, the capacity of ZigBee networks is effected by many factors such as Network coverage and response time.

The system adopts the ZigBee technology as the mainly wireless communication mean and uses the self-organizing wireless mesh networks for data transmission medium. The full duplex data transceiver is employed and the data acquisition by the system terminal is uploaded to the control center through ZigBee self-organizing wireless mesh networks. The control center monitors the temperature remotely by sending orders through ZigBee Wireless mesh networks.

A. Network Design of System

The system is made up of data acquisition monitoring
module, ZigBee wireless transmission module and control center. Its structure is shown in Fig.2.
Data acquisition node is a ZigBee node which has refine function, it can perform the data acquisition, simple computation and communication with other node. Coordination point is a full-function device (FFD). The mesh network is made of several coordination points. Every coordination point is connected with several data acquisition nodes. Data acquisition node send data to the coordination point through ZigBee wireless communication module, coordination point send data to the control center PC. In mesh network, coordination point is access point and router, every node of mesh network can send and receive information, they also can communicate with one or more equity nodes. When some nodes have something wrong or been destroyed, data can also be reached to control center by bypass other coordination points, because mesh network has ability of self-configuration and self-adaptation. So this network has advantages of fast disposition, easy fix, non-line of sight transmission, good robustness, wide bandwidth, etc.

3. SYSTEM DESIGN

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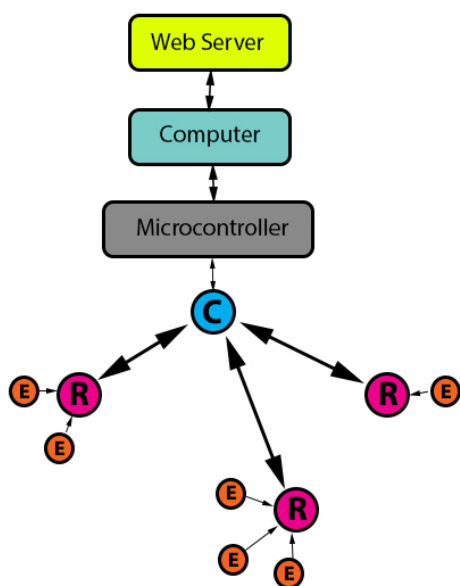
Figure 2. The system network structure

This will not only solve the problem of blind spots   in mobile communications networks, but also achieve a long distance transmission, and save cost.

B. Wireless Mesh Network Establishment

The first step of establishment of a wireless mesh
network is placing the coordination points (access point) at the monitor region need to be covered. The coordination point complete of the formation of wireless mesh network in accordance with the protocol. Then the data acquisition   nodes access to the wireless mesh network through the located coordination point to establish of a wireless mesh network. If a new node needs to be added, we only need to place coordination point in the new region and they will get access to the network in accordance with the protocol. Then, the access connection work will be completed through the steps of search of the network, establishment of coarse synchronization
and physical coadjacent point list, selection for

the responsible nodes, opening the responsible channels, high-level access, and connection to an adjacent point. The specific agreements are as shown in reference [4]. If a regional monitor needs to be deleted, we only have to remove the coordination point from the region and the wireless mesh network routing table will be automatically revised to achieve the deletion of a monitoring region. The process is shown in Fig.3.
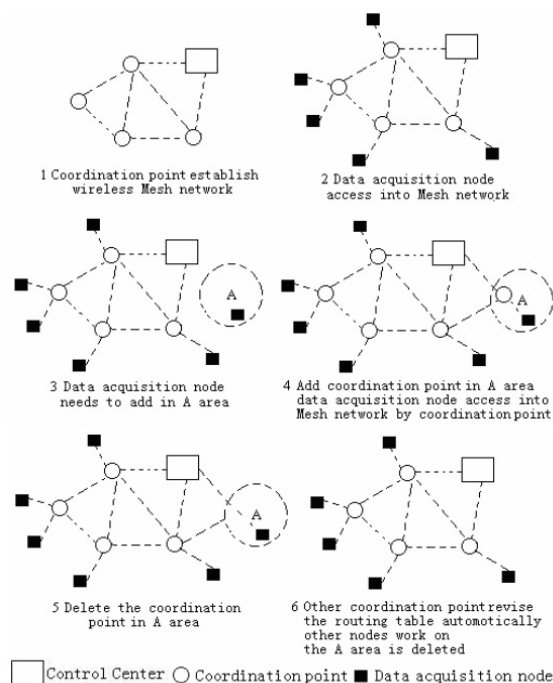

Figure 3. The process of the establishment of the wireless mesh network and the addition and deletion of new node

C. Design of Data Acquisition Monitoring Module

Data acquisition monitoring module is made up of radio frequency transceiver, Arduino microcontroller, lm35 temperature sensor, Ethernet shield. The Arduino is used as the control and process center. Arduino calculates the temperature by analog to digital conversion. Then radio frequency transceiver sends the test result to the coordinator. The structure diagram of data acquisition monitoring module is shown

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in Fig.3. Data acquisition monitoring module circuit is shown in Fig.4. Radio frequency transceiver is ZigBee chip CC2420 [5]. The chip can content the need of high performance and low power in 2.4 GHz IEEE 802.15.4 band based ZigBee, RoHS compliant 7x7mm QLP48 package, CC2420 is a low-middle frequency transceiver, which includes a high-performance 2.4 GHz DSSS (Direct Sequence Spread Spectrum) radio frequency transceiver core, and integrated VCO, LNA, PA as well as power supply rectifier internally. It needs low voltage power supply (2.1 to 3.6 V), and is easier to configure the microprocessor interface (4 SPI bus interface).

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, The controller contains a six-channel Timer/PWM generator, 6-channel 10-bit ADC and 12 universal I/O interface and so on. The device configuration other than the system processor of the system circuit is greatly reduced through comprehensive, common on chip peripherals. In addition, the cost of the system is thereby minimized.
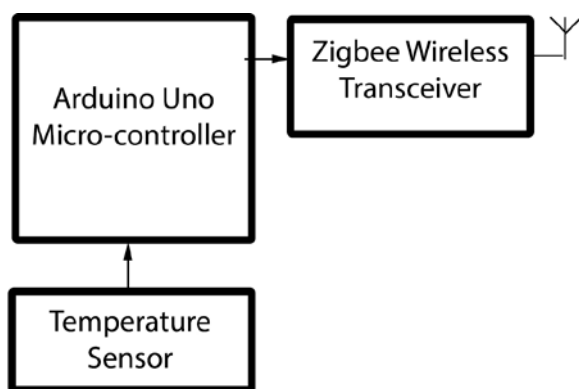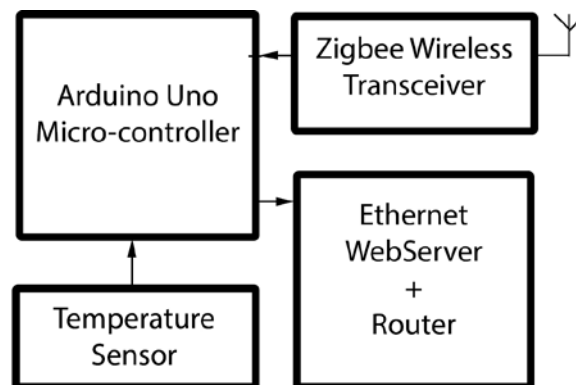

Figure 4. Block diagram of End Device.
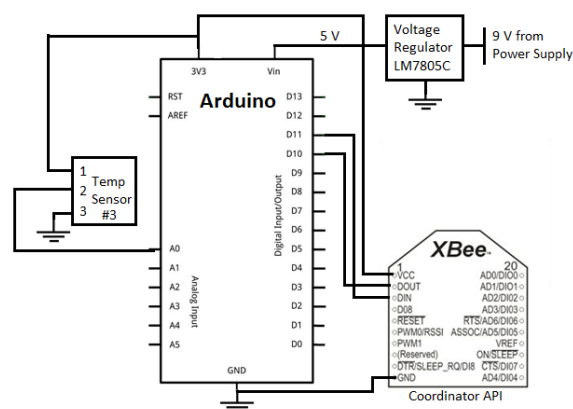

Figure 5. Block Diagram of Coordinator.

Figure 6. Circuit Diagram of End Device

4. SOFTWARE DESIGN

A. The Frame Structure of System Network Protocol
IEEE 802.15.4 ordains the frame structure of ZigBee
protocol is made up of data model, destination address, data length, data message and checkout, the format is shown in Fig.7.

Data model	Destina-tion address	Data length	Data message	Checkout

Fig. 7 The frame structure of ZigBee protocol

"Destination address" is the location where the frame will be sent, namely network node

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number. The "data message" presents the order or effectual data that will be sent, its byte is decided by data length. The "data message" is designed in this system, the "data message" is divided into "node message", "function coding" and "data" three parts, it is shown in Fig.8.

Node message	Function coding	Data

Fig. 8 System data message

"Node message" length is a byte, lower four bits are data acquisition node numbers, higher four bits are network coordination numbers. "Function coding" is divided into two parts: direction bit and function type. The system function includes upstream and downstream, it is decided by direction bit. Function type can distinguish the date type;

Direction Bit	Function Type

Fig. 9 The form of "function coding"

B. **System Reliability Analysis**

The higher reliability is an important marker for the wireless network, the ZigBee technology use the symmetry key security mechanism. The symmetry key is generated by the network layer and application layer according to the actual needs, which is managed, stored, transmitted and updated by the two layers. ZigBee supplies a set of security class and software which based on 128 bits AES algorithmic and integrates the security element of the 802.15.4. The security mechanism could be chosen to apply on the MAC layer, network layer or the application layer according to the actual needs. If the application needs high quantity security protection, just protect if in the application layer. The security measure has a session key which could only be recognized and decrypted by an equipment that has the key. In this way, the method not only could prevent internal attack, but also could prevent outside attack. But it may need more storage equipment to realize. In addition, in order to improve the anti-jamming ability of the monitoring system in advance, we use the simple filtering method. When the detection is needed every time, we can continuously measure three groups data, and take the average of the three groups as the monitoring reference.

C. **Software Flow**

The software flow mainly includes network coordination and data acquisition point. As to network coordination, micro-controllers are initialized firstly, then the protocol stack is initialized and the interrupt is opened. After that program begins formatted the network, if the network is formatted successfully, and network coordination connect to computer by serial port, we can find the physical address of network coordination, network ID and channel number by software. Then network coordination is in monitoring state, if a node will add to the network, it will distribute a network number. If data acquisition node sends some data, it will judge that where the data come from, it is which parameter, and send the message to control center. As to data acquisition node, the program also initialize micro-controller firstly, then open the power of sensor and initialize protocol stack, begins send signal to add to network, wait for network coordination's answer, distribute network address. After it adds to network successfully, if it is connected to computer by serial port, we also can find its physical address, network ID and physical address of network coordination. After the data acquisition node is added to network, it is in monitoring state, monitoring the temperature.

5. Output

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Output are displayed by webserver. Any user can see the output by browser from computer or mobile. Server codes are written in HTML and display outputs are automatically updated after 5 seconds. This time duration can be adjusted. The output is shown bellow
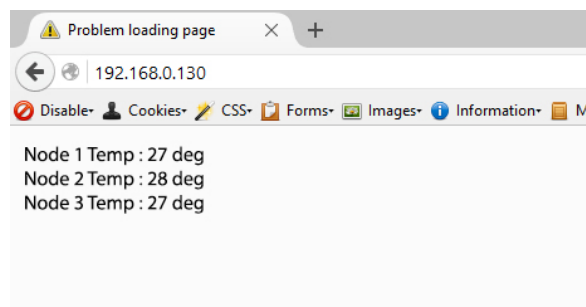

Figure 10. Output in webserver.

Different nodes temperature is logged in base node and transmitted to webserver through Ethernet module. Here the Ethernet is connected with router. The main IP is 192.168.0.1 and IP of Ethernet module is 192168.0.130.

6. CONCLUSION

Wireless sensor network is a hotspot of research on
communications and other fields in recent years, ZigBee technology is a new kind of short distance wireless communication technology, is application of key technologies in the field of Internet of things in the years to come. ZigBee technology of low transmission delay, lower power consumption, low cost, high safety of these advantages, make people more and more attention to the research and development. ZigBee wireless sensor network application in the monitoring system, monitoring system has been from the traditional video monitoring development to monitoring based on wireless sensor network (WSN), different functions of sensor outside all kinds of information collection, information system can to sensory information, process information, and even all kinds of equipment in control system.

This paper briefly introduces the wireless sensor network and wireless communication technology, the technology of ZigBee and protocol stack of a detailed analysis of various levels, choosing the appropriate
hardware platform and operating system platform, to build a monitoring system based on ZigBee wireless network.

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