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Design of Wireless Sensor Network Nodes of Thermal Pipeline Based on Zigbee

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Abstract. To avoid the explosion of thermal pipeline and control the flow, pressure and temperature of thermal pipeline, the wireless sensor network (WSN) nodes should be designed and arranged. A new information monitoring system is developed baded on ZigBee. Based on MPLAB® ICD 2, with three sensors, using low-power PIC18F4620 controller chip and CC2420 processor integrated ZigBee technology, the WSN nodes were designed. The data collected by sensors can be sent to management center by wireless network. Manager can control the thermal flow consulting by the message from sensors and find out thermal pipeline danger in time. The system realizes real-time monitoring on the thermal pipeline. The test result showes that the perfomance of the system is stable and can reach the design requirements.

Intorduction

In urban life there are two major types of thermal pipeline, industrial thermal pipeline and heating supplies pipeline.

Over the past years, the management and adjustment of thermal pipeline mainly relied on manual operation. If the temperature is high, the managers will lower the switch, otherwise increase the switch. This method is troublesome and inaccurate.

Meanwhile, there are security risks in thermal pipeline. Some explosions have occurred in the past few years at home and abroad. The well-known explosion occurred in New York in July 20th 2007, resulted in property damage, human casualties and traffic standstills. Even some people mistakenly think that it was a terrorist attack and this explosion caused great psychological impact on residents. The explosion of pipeline occurred mostly becase of the aging pipeline leaking, or the high internal pressure of the pipeline. The explosion is a threat to the pedestrians and public facilities, also it can cause the waste of thermal resources.

In response to these issues, the thermal pipeline detection system is designed. In this system, the core technology is the design of wireless sensors node[1].

ZigBee Technology

Brief Introduce of ZigBee. ZigBee is a short distance, low-power consumption wireless communication technology. There are some important characters of ZigBee, short distance, low power consumption, low transmission rate and low cost. It is suitable for automatic control and remote control, and it can be embedded into many devices.

ZigBee is based on IEEE 802.15.4, connecting to other devices under the free frequency. The communcation distance is 10~75 meters and the data rate can reach 250 kbps. The wireless nodes can reach each other via coordinator, and one coordinator can link 255 nodes and several coordinators can organize one wireless netowrk.

ZigBee Protocols and Network Architecture. ZigBee protocols include five main levels, physical layer, MAC layer, data-link layer, network layer and application layer. ZigBee protocol is carried out by ZigBee Union and IEEE 802.15.4 task force. The coordinator and the terminal device are most important parts of the ZigBee network. The coordinator is a full-function device and it can implement most services of the ZigBee protocols. The terminal device can only implement the basic services of ZigBee. We can organize star topology, net topology and cluster-tree topology using ZigBee devices[2].

The Construction of ZigBee Protocols Network. In ZigBee protocols, only coordinator can construct the new wireless network. In the process of the network construction, fisrtly, MAC layer carries out the energy scanning job. This step will scan all the channels, then ZigBee will choose those with lower power consumption as the backup channals. The power consumption refers to the amount of communication, which is also described as the peak level of the communication. If there are not available channels, active scan will be proceeded. The purpose of active scan is to find out the channels are activated or not. Only the activated channel can be used in the communication. When there are suitable channels, it is network layer to choose suitable channel, and arrange one PAN(personal area network) ID to this new network. The PAN ID is a unique 16-bit address. Then network layer assign a 16-bit network address randomly. Network layer sends PAN ID booting request to MAC layer. If network layer receive the acknoledement from the MAC layer, network layer will report to the application layer that the new network construction is successful.

Design of the System

Design of the Nodes. There are many schemes to choose about the design of the nodes. In this paper, PIC18F4620 and CC2420 are selected. PIC18F4620 is a micro controller of Microchip company.This chip has 13 analog signals input interfaces, and those analog signals can transfer into the corresponding 10-bit digital signals. In this scheme, PIC18F4620 collects data such as temperature, pressure and flow from three corresponding sensors.It uses three registers, ADCON0, ADCON1 and ADCON2 to control the A/D transform, to avoid the conllision of different signals.

CC2420, released by TI company, is the first radiofrequency transceiver meeting with 2.4GHz IEEE 802.15.4 standard. And it is also the first RF(Radio Frequency) chip meeting with ZigBee standard. CC2420, used as communication module, can assure the validity and reliability of the communication.

Fig.1 shows the schematic of the wireless network nodes module.

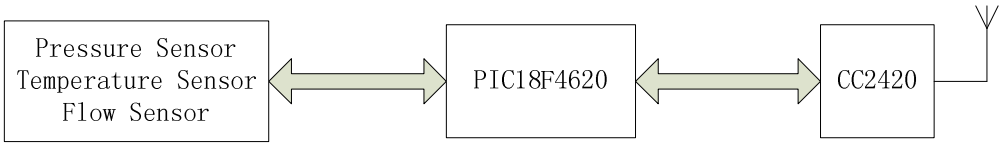

Fig.1 The Schematic of Nodes Module

As shown in Fig.1, PIC18F4620 communicates with CC2420 via SPI(Serial Peripheral Interface) interface, and transports data under the help of ZigBee protocols in wireless network. PIC18F4620 also has many analog interfaces and switch interfaces, which implement the collection of field current and voltage information and control the switch signals.

Design of Wireless Sensors Network. Fig. 2 shows the design of the wireless sensors network. Along with the thermal pipeline, sensors are installed every 30 meters. The wireless data collection/sending modules are installed in each detection point. When the data of the pressure, temperature and flow of the thermal pipeline are gathered and digitized, they will be sent to ZigBee coordinators nearby, then sent to monitoring center together. The information can be shared in the network and make the management of thermal pipeline easier[3,4].

Managers of Heating Company can control the pressure, temperature and flow reasonably and effectively through monitoring system. By this way, the energy is saved and managers can locate dangers such as high pressure or thermal leak timely, avoiding the human casualties and energy waste.

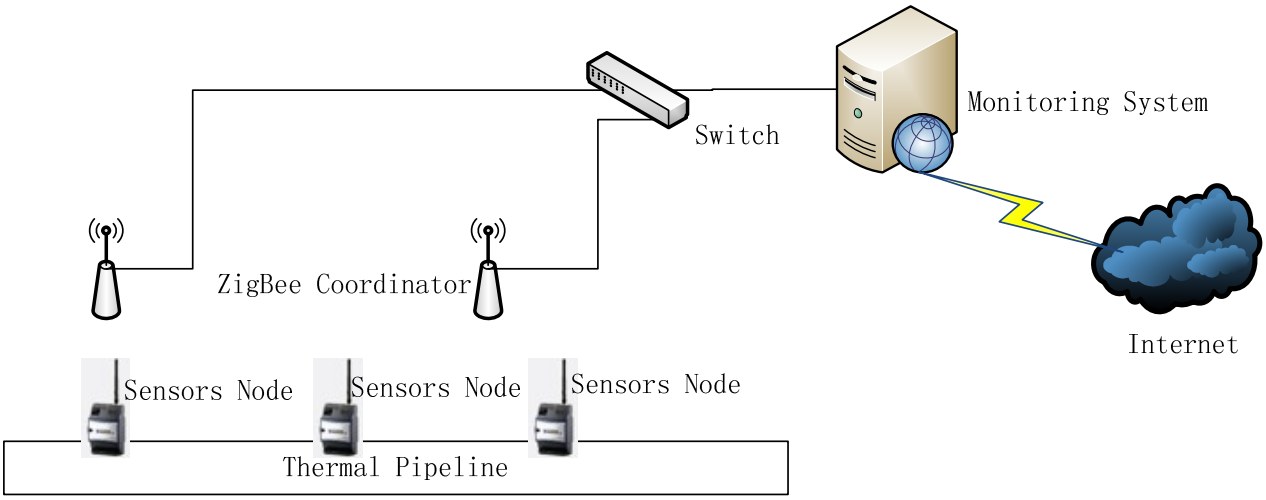

Fig.2 Design of Wireless Sensors Network

Design of Software

Design of Coordinator Software. The software of coordinator mainly refers to the underlying codes in the nodes. In this system, ZigBee2006 protocols, provided by TI CC2420 free of charge, are used. This software bases on the GericApp sample programs in Zstack version, using C language. Under the general template of Zstack, the needed projects are build by modifying APP programs. The realtime operating system is embeded in the program to manage the construction of the network, joining of the nodes, data sending and receiving. Coordinators use the function NLME_Network_Formation.Reguest() to build up the network. Then coordinators change into binding mode using function zb_AllowBind(Oxff), to answer the binding requests from sensors. If the request is accepted successfully, coordinators begin to gather data from sensors and use function zb_SendDataConfirm() to answer back.

Design of Sensors Software. The sensors can join into the network automaticly, then sending out the binding request using function zb_BindDevice(). When receiving the response from coordinator, the binding is finished. Otherwise sensors will scan coordinators periodically.

After binding with the coordinator, sensors will send pressure, temperature and flow information periodically to coordinator. If sensors does not receive the answer from coordinator, the binding will be removed, and sensors will scan and bind coordinators again.

There is SPI communication between CC2420 and PIC18F4620 by means of SPI_WRITE and SPI_READ subprocess. Before the communication, assembly program of register SECCTRL0 should be modified as below.

```
MOV HIGH_BYTE, #01H
MOV LOW_BYTE, #0C4H  ;  select SECCTRL0 address
MOV A,#19H ; select WRITE operation
CLR CSn ; begin of SPI communication
LCALL SPI_WRITE
MOV A, HIGE_BYTE
LCALL SPI_WRITE
MOV A, LOW_BYTE
LCALL SPI_WRITE
SETB CSn ; end of SPI communication
```

Design of Management Software. The software installed in the host computer is developed by Java language. Managers can view the whole network topology by management software. The address of sensors, temperature, pressure can be checked by managers by touching the corresponding nodes. The host computer and coordinators are connected by ethernet network. The host computer can gather information from different nodes and view the realtime information by chart, also the data can be stored in database, convenient for future inquiry and analysis.

Summary

In this thesis the wireless sensor network of thermal pipeline was presented. Firstly the ZigBee technology was introduced. Then the nodes and wireless network were designed. At last the software of this system was programed. Overall the thermal pipeline monitoring system was carried out. In practice, this monitoring system work well and can gather information, learn the network topology and choose nodes correctly. Under the help of this system, managers can avoid explosion in advance by monitoring the status of the thermal pipeline, and adjust the pressure, temperature of the thermal flow suitably.

Acknowledgments

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