

The Design and Realization of Wireless Sensor Network Gateway Node

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Abstract—this paper presents the design and realization of wireless sensor network gateway nodes based on s3c2410 Processor. And introduced the design of gateway hardware and software. Also introduced the implementation method of software. A new data transmit protocol was designed to eliminate the differences between ZigBee protocol and TCP/IP protocol, and this paper also designed a data transmit management module and data communicate module. This gateway can convert the data between ZigBee wireless sensor network and internet. This gateway has a good extensibility.

WSN; Ethernet; embedded gateway; ARM; ZigBee

I. INTRODUCTION

Wireless sensor network[1] is consist of spatially distributed autonomous wireless nodes using sensors to cooperatively monitor physical or environmental conditions, such as temperature, humidity, voltage, pressure in the monitoring area. These wireless nodes compose a multi hop and self-organizing network system by the way of wireless communication. Wireless sensor network is designed to collect, process and transmit information within a fixed range or area of coverage. The data collected by sensor nodes can be transmitted to the observer using the way of wireless communication. Development and application of wireless sensor network improve people's understanding of the world.

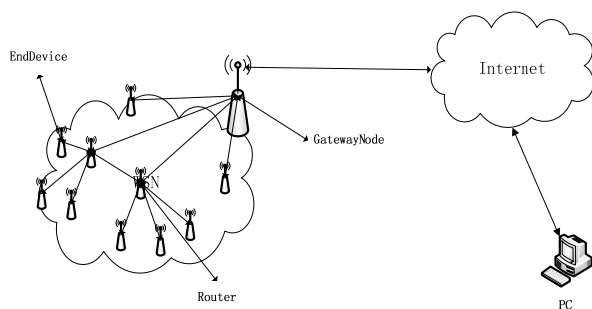


Figure 1. The structure of WSN management model

This paper provides a novel method for the design of a wireless sensor network gateway node based on ARM, this gateway nodes implement transparent connection between ZigBee [2] based wireless sensor networks (WSN) and Internet. Most traditional WSN gateway nodes lack of flexibilities in applications, so it's difficult to apply in a certain environment. With the improvement of the traditional WSN gateway nodes, the users on the internet can access the

data of the wireless sensor network flexibly through wired or wireless mode. This paper designed a new data transmit protocol to eliminate the differences between ZigBee protocol and TCP/IP protocol, also designed a data transmit management module to manage and control the data from the wireless sensor network ,data storage structure as shown in Figure2. In order to enhance the ability of the data management of the WSN gateway nodes, a wireless sensor network gateway nodes based on s3c2410 Processor is designed and realized to make it can not only transmit, store and also process the data. System structure is depicted in Figure1. The access method of this WSN gateway node is convenient. First, Data can receive from a WSN via the gateway at any time and any place. Secondly, ZigBee nodes can easily control by PC, mobile phone and pad.

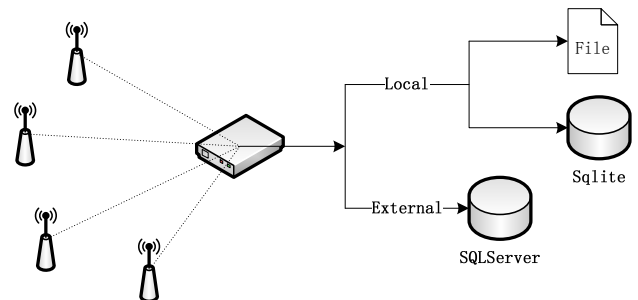


Figure 2. Data storage structure

II. SUMMARY OF WSN GATEWAY NODE

A. Working Principle of Gateway Node

Wireless sensor network management model [3] is consisted of end device, router, gateway node and management monitoring center, as shown in Figure3. End device is responsible for collecting wireless sensor network data, and sending them to parent node after simple operation, then data are send to gateway node from parent node directly or by router. After receiving data from wireless sensor network, gateway node extracts data after analyzing and packaging them into Ethernet format data, sends them to management monitoring center. The transmission process of data from Ethernet to wireless sensor network is contrary. In the data transmission of wireless sensor network and Ethernet, gateway node mainly completes the address mapping and data message transformation between ZigBee protocol and TCP/IP protocol.

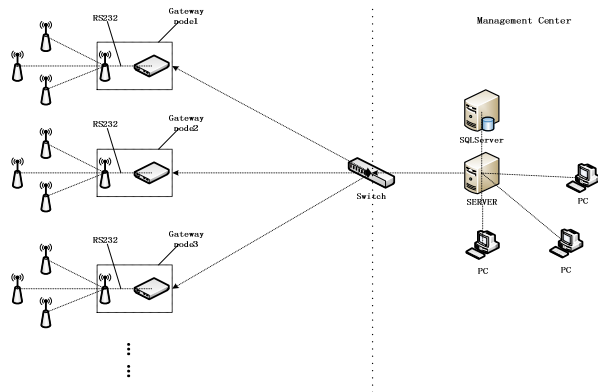


Figure3. Wireless Sensor Network management model

B. Address Mapping

In the ZigBee wireless sensor network, gateway node transfer data and control wireless sensor network nodes according to address. There are two addresses in ZigBee: 64bit IEEE address (Physical Address) and 16bit short address. Physical address is sole in the ZigBee device around the world and can be used as global address in the whole network; Short addresses are used as Personal Area Network address only in intercommunication. In order to realize the transparent access between wireless sensor network and Ethernet and make the communication between WSN nodes convenience, build address mapping table store node address in gateway internal, and each short address corresponds an device number, gateway operate different device according to the device number. Address mapping table is shown in Table I .

TABLE I .ADDRESS MAPPING TABLE

Gateway IP	Device Number	Short Address	Physical Address
192.168.253.9	0x0002	0x143E	00.15.8d.00.00.00.39.0d
	0x0003	0x143D	00.15.8d.00.00.00.61.f2

192.168.253.9 is the IP which belongs to gateway node in Ethernet and used in information interaction in Ethernet; 0x143E is a 16bit PAN address in wireless sensor network; 00.15.8d.00.00.00.39.0d is an IEEE 64bit long address. The data can be transferred and the node can be controlled between wireless sensor network and Ethernet with address mapping.

C. Data Message Transition

Address mapping overcome the problem of addressing in data transition, and bilateral switching between ZigBee data message and Ethernet message [4] should be released if wireless sensor network and Ethernet can recognize data each send. Two kinds of protocol format are shown in Table II and TableIII.

TABLE II.ZIGBEE DATA MESSAGE

PHY	MAC	ZigBeeNWK	ZigBeeAPS	PAYLOAD	FCS
6B	23B	8B	7B	Variable	2B

TABLE III.ETHERNET DATA MESSAGE

Ethernet head	IP	TCP	PAYLOAD	FCS
14B	20B	20B	Variable	2B

PHY and MAC in ZigBee protocol stack [5] are defined by IEEE 802.15.4 standard; ZigBee Network Layer, ZigBee Application Support sub-layer are defined and maintained by ZigBee union. Bytes of PAYLOAD can change to maximum 127B. RF modules of wireless sensor network gateway node analysis payload after receiving the data, then attach TCP/IP frame head and be handled and transferred by Ethernet network interface card; Ethernet data message receive data through TCP port and extract payload with attaching ZigBee device number, then they are send to RF modules of wireless sensor network gateway node and packaging into ZigBee message to send.

III. PROTOCOL CONVERSION

A. The Design of Hardware

The design and development of this wireless sensor network gateway node is completed in the laboratory, the main devices of the gateway including a ARM9 development board with the s3c2410 processor produced by Samsung Electronics and several JN5121 wireless microcontroller modules produced by Jennic company. This wireless microcontroller has a lot of advantages, such as low cost, low power consumption. As shown in Figure 4 is the structure of hardware.

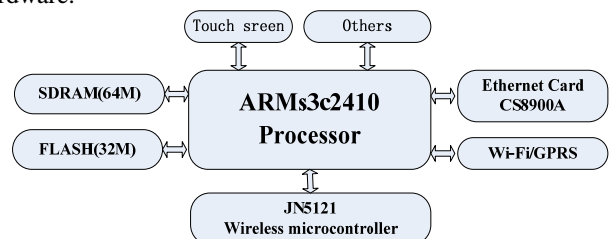


Figure4. The structure of the hardware

B. The Design of Software

In order to realize the function of protocol conversion of gateway, This paper presents the following solutions: Establish address mapping table at the application layer, Mapping ZigBee and Ethernet Addresses to the address mapping table of application layer to provide a basis for data transfer; Unified the format of data transmission, which is a good solution to the data conversion issues, Build a frame by bytes transmitted in the application layer, the format is shown in Table IV.

TABLE IV.THE DATA FORMAT

Mark	Device Number	Protocol	Device Type	Length	Data	Mark
1	2	1	1	1	Variable	1

The protocol frame take 0x3F (0011 1111) as the mark of beginning and end. The length of device number field is 2 byte, range from 0x0001 to 0xFFFF, can accommodate 65535 zigbee nodes. The length of protocol field is 2 byte too, which used to identify the type of networks where the data source from, such as, 0x01 said the data from the Ethernet, 0x10 said the data from the wireless sensor network, and 0x11 said the data from the Wi-Fi network. The length of device type field is 1 byte, and different types represent different data. Such as, 01 represents temperature,

02 represents humidity, 03 represents voltage, 10 represents off and 1F represents on. Length field represents the length of protocol frame data field and variable. Data check rules:

- 0x3f is encoded as 0x3c, 0x1f.
- 0x3c is encoded as 0x3c, 0x1c.

Each octet with value less than hexadecimal 0x20 is checked. Control octet will be replaced, and the control octet is exclusive-or'd with hexadecimal 0x20. To make this clear we have an example: 0x01 is encoded as 0x3c, 0x21.

Address mapping layer is built on the ZigBee protocol and Ethernet protocol. As shown in Figure 5, the mapping table is realized by a single linked list. After receives control or query instruction from the Ethernet, the gateway node, firstly, gets one of the device number, check the list, if there exists a corresponding node, gets the short address, and sends the instruction to the node according to the short address.

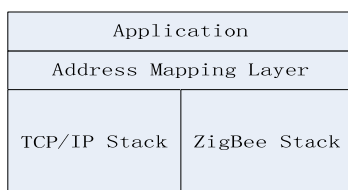


Figure5. Address mapping layer

The service logic program of the gateway running in the embedded Linux as process and it's mainly used for realize the service logic of the gateway. The programs included ZigBee-Ethernet process program and Ethernet-ZigBee process program. The application run on the ZigBee board used to receive process and transmit data which comes from ZigBee wireless sensor network. The method of sharing memory is used for realizing the synchronism and communication of data in different processes. As shown in Figure 6 is the running process of the program.

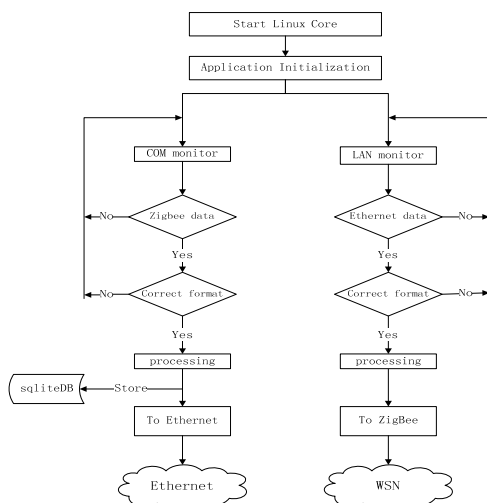


Figure6. Running process

IV. TEST OF GATEWAY FUNCTION

After complete the basic function of the gateway node, such as addressing and protocol conversion, an embedded Web Service [6] was used to test the function of the gateway node. The test parameters are set as follows: the gateway node address is 192.168.253.9, run as a server and communicates with PC through 80 port ; version of the Embedded Linux core is 2.6.18[7]; the address of PC is 192.168.253.1. The gateway consists of four functional modules: the device management module, the data query module, the real time curve module and configuration module. As shown in Figure 7. Its can proved after a long time test that the gateway node is good at forwarding, processing and providing the data obtained from the sensor network to the client via the web service. It is also in charge of responding to the client's request, issuing the client's commands to the specified node.

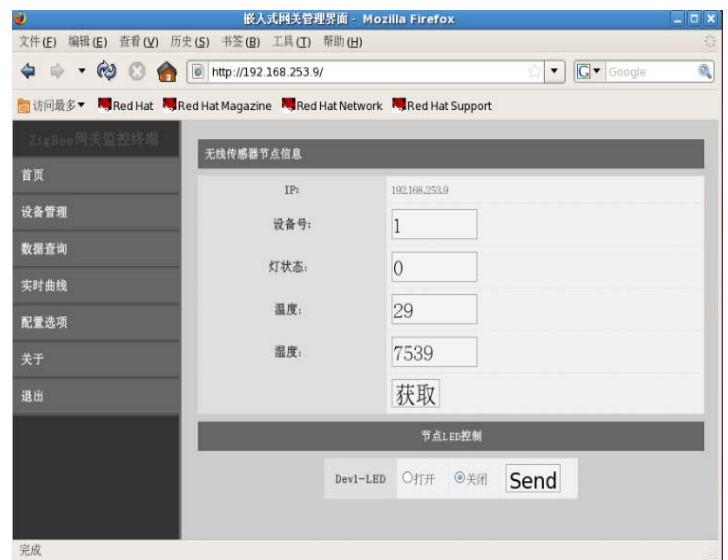


Figure7. Function modules

V. CONCLUSION

In this paper, an intelligent wireless sensor network gateway node is designed and realized, which can be a good solution to wireless sensor network and Ethernet transparent access problems. This wireless sensor network gateway node give a good solution to data transmit between heterogeneous networks. We transplant a boa web server [8] in the WSN gateway to make the operation convenient. User can configure, monitor and control WSN nodes in remote or on-site. The gateway is still in research stage, to make the gateway function more perfect we have a lot of work to do. In order to increase the gateway robustness and universal, add Hear-Beat Module [9] and Domain Name System. And how to reduce the energy consumption of the wireless sensor network also one of the problems we have.

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