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Research on data acquisition and fusion system based on wireless sensor

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Abstract. In recent years, wireless sensor network as a new information technology has been subject to scientific and industrial sessions at home and abroad with the rapid development of Internet of things. Based on this, the data acquisition and fusion system based on wireless sensor was studied. In this paper, the structure of the wireless sensor was introduced, and the design of the data acquisition system based on ZigBee wireless sensor network was studied, then the design of the monitoring software of the data acquisition and fusion system based on wireless sensor was carried out and the actual application was implemented. Experiments show that the data acquisition system based on wireless sensor network can be used for collecting and realizing all kinds of information data.

Key words. Wireless sensor network, data acquisition, temperature and humidity, data fusion.

1. Introduction

In recent years, new short-range wireless communication technology has emerged with the rapid development of computer networks, wireless communication technology, microcomputer and sensor technology. Wireless sensor network makes a large number of sensor nodes form a network in a self-organizing manner, and integrates information awareness through wireless short-range communication technologies. The embedded system and wireless communication technology is one of the main research subjects in the world. The wireless sensor networks reviewed by the Massachusetts Institute of Technology as one of the ten technologies that changes the future of the world. Traditional data acquisition system usually collects data of equipment by wiring and manual mode, industrial production equipment appears in the dispersed areas with the development of productivity technology. High temperature and high pressure equipment for on-site data collection and maintenance are difficult and dangerous, which needs to invest a lot of manpower and financial resources. Wireless sensor network based data acquisition system can not only solve the problems in the

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artificial cable system, but also can improve the market competitiveness of enterprises. Extensive use of sensor network data acquisition system can be made on the basis of power consumption of industrial production. On the one hand, temperature and humidity control effects can be improved by wireless monitoring of some process temperature and humidity, so as to improve product quality; on the other hand, the power consumption of the power plant is monitored in real time, and the equipment maintenance and replacement can be carried out, so as to realize the purpose of saving cost and reducing energy consumption.

2. State of the art

The United States first used wireless sensor network in military areas. The application of wireless sensor network in the United States expands from the military field to civilian areas such as home automation, environment, energy monitoring and building automation [1]. Intelligent dust engineering of branch of University of California at Berkeley achieved a cubic millimeter application platform in July 2010 [2]. According to the project in 1999, the development of ultra-small operating systems was still the first choice for wireless sensor network operating systems [3]. In addition to the University of Berkeley, Massachusetts Institute of Technology was also engaged in the research of wireless sensor network with very low-power [5]. While Auburn University was engaged in self-organizing sensor network [4]. In addition, the University of Pennsylvania and Cleveland State University were also engaged in related research. In addition to universities and research institutions, major foreign manufacturers have also conducted a wireless sensor network research [6]. Philips and Motorola and other well-known international companies set up the ZigBee Union in 2001, the alliance was committed to the study of ZigBee technologies such as short distance, low power consumption and low cost. ZigBee has become one of the best technologies in the field of wireless sensor network [7]. All kinds of commercial organizations represented by academicians of the Chinese Academy of Sciences as well as representatives of major scientific research institutions and operators have explored and researched the theory and application of wireless sensor network [8]. The Institute of computer science of the Chinese Academy of Sciences has developed a wireless sensor network node GAINZ, which has been compatible with the mainstream 2.4G wireless sensor network nodes in the market, and transmission distance and power consumption have had certain advantages. The Institute of information engineering of the Chinese Academy of Sciences has done a great deal of work in wireless sensor network security protocols [9].

3. Methodology

Wireless sensor is defined according to three kinds of nodes from the perspective of network logic: PAN coordinator, coordinator and terminal node; the PAN coordinator is unique across the network, and it is usually used as a network setup and initialization to implement a more powerful [10]. The coordinator is determined by

the number in the network, which assumes the function of network maintenance. The terminal node is generally the terminal node of the network, the function is simple and the cost is the lowest. In this paper, the convergence nodes on the PAN coordinator, the temperature and humidity sensing points, and the instrument nodes of the end nodes play the important role. MAC structure is divided into star, topology and peer structure. In topology, all communications are built on the PAN coordinator and other devices. There are three transport modes in peer to peer topology: data transformation from the terminal device to the coordinator, data transformation from the coordinated to the terminal, and data transformation between the coordinator and coordinator. Physical map of wireless sensor is shown in Fig. 1.

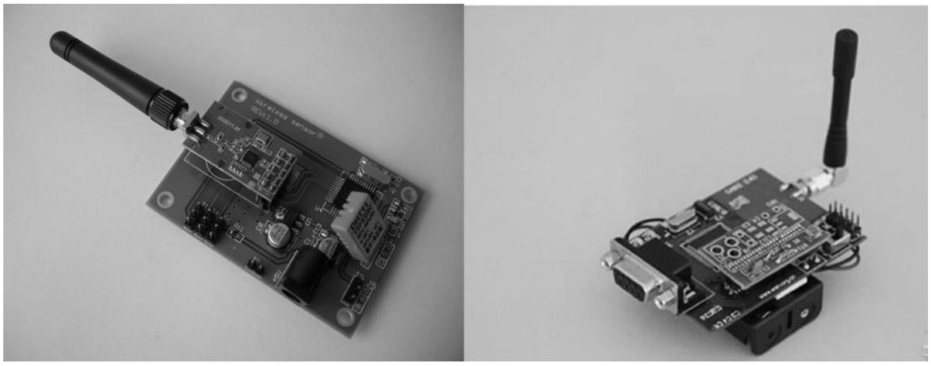

Fig. 1. Wireless sensor

The physical layer includes home automation, PC peripherals, games and personal care, the use of peer-to-peer network nodes can form more complex networks, the network topology has a wider range of applications and higher security, the mesh network topology used in this paper is also based on peer-to-peer network topology. The main function of the network layer is routing addressing and establishment and maintenance of network. ZigBee network is a kind of wireless self-organizing network, the nodes in the network are communicated and organized each other through single hop or multi-hop, and are distributed flexibly throughout the network. ZigBee network topology is rich and diverse, such as star network, tree network and mesh network topology, the network based on peer-to-peer network and mesh network.Network topology control can automatically generate a good network topology through topology control, which can improve the efficiency of routing protocols and MAC protocols, lay the foundation for data management, and save node energy to prolong network lifetime. The sensor network protocol is responsible for the formation of a multi-hop data transmission network for individual nodes; the sensor network is compatible with the IEEE 802.15.4 standard. The standard physical layer is used O-QPSK coded modulation, and radio frequency signaling is transmitted by differential means to form a peer to peer network (hierarchical routing). CSMA/CA access channel is used at the data link layer, two addressing modes: 16 bit short addressing and 64 bit IEEE addressing are used, at the same time, a cache mechanism

with reduced power consumption is adopted to allow the energy devices to sleep in most of the time, whether or not a message is waiting for processing by periodically listening to the radio channel to balance energy consumption and message latency and ensure low power consumption management, the transport layer uses a complete handshake protocol.

The design of data acquisition system based on ZigBee network mainly includes three parts: terminal node, data acquisition node and monitoring software, of which the terminal node and the data acquisition node are implemented in the two part of the ZigBee network. The terminal node corresponds to the temperature and humidity sensing nodes and instruments of the ZigBee network, and the terminal node and the data collection point form a mesh network, the main function of monitoring software PC is to monitor the ZigBee network in real time and end the node perception data. The terminal node-aware information data is sent to the GPRS DTU through a string at the convergence point of the data collection point. GPRS DTU will receive TCP data packets, and finally sent to the monitoring software for real-time display, the structure of data acquisition system based on ZigBee network is designed as in Fig. 2.

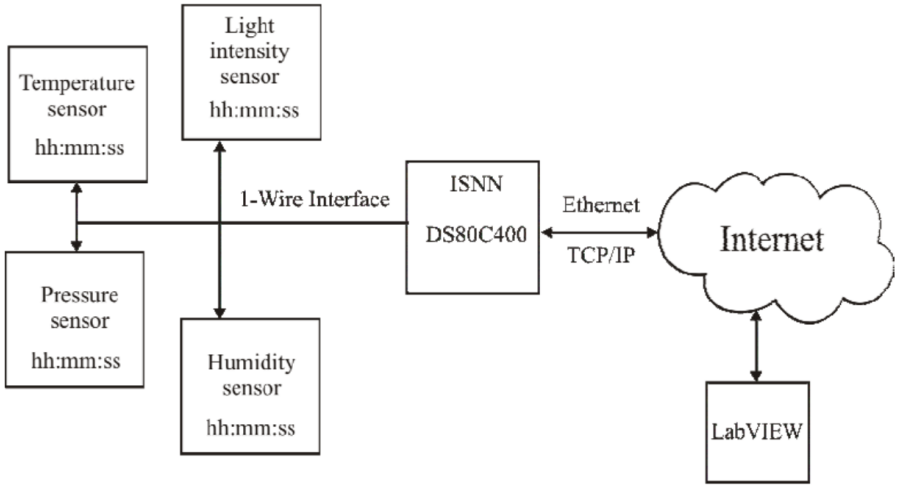

Fig. 2. Structure of data acquisition system based on ZigBee network

The ZigBee network includes both terminal nodes and data acquisition contacts. There is only one data node and the rest is the routing point in all data collection points. The data sensing point is powered by the battery, and the data acquisition node requires a stable power supply, and all nodes use a mesh network and tree network as an alternative. Endpoint nodes are sensed by temperature and humidity data and instrument data, ZigBee transmits wireless power to monitor point processing. The monitoring point will receive data through three types of nodes to the network node, as shown in Table 1.

WPF is a technology developed by Microsoft, which uses the new presentation layer framework technology and integrates many framework technologies, including user GDI, GDI + and HTML. WPF has done the separation of the front desk inter-

face designer and the daemon developer. It has also flexible layout system, powerful data binding, advanced graphics animation support, and easy-to-use template styles. ZigBee monitoring software needs to dynamically display changes in each terminal node, such as the terminal node to join the network or leave the network, and it needs to dynamically display the value of each terminal node acquisition. WPF can not only easily realize the 3D effect display of each terminal node, but also can realize the animation effect of each terminal node easily. WPF will automatically handle these details, and we just need to explain how we move the animation, other things are completed by the WPF system.

Table 1. Nodes of ZigBee network

Converged nodes	In the initial processing phase, the ZigBee sink node is used to initialize the network structure, select the channel, PAN ID and extend PAN ID. After the completion of the network, on the one hand, the sink node acts as the role of the ZigBee router and is responsible for forwarding data; on the other hand, the sink node will also be responsible for network channel management and handle the binding requests of the new terminal nodes. If the security protocol is used, it also acts as a trust center.
Routing nodes	The ZigBee routing node is used to transfer information sent by other nodes in the network. In default, the network layer is used in tree addressing and meshes networks. ZigBee routing nodes select routes to forward messages through training. When the node's memory is not enough to run a mesh network, a tree network with lower memory requirements is automatically selected.
Terminal nodes	The terminal node is the node that realizes temperature and humidity sensing and meter reading. The first one is needed to join the ZigBee node or the ZigBee coordinator node, and then managed by the ZigBee sink node and the routing node.

In this paper, there were 10 terminal nodes and 1 receiving nodes in ZigBee network and the terminal node had four temperature and humidity acquisition nodes and six meter reading nodes. The circle represented a node, and 11 circles were drawn. Each terminal node dynamically joined the network or left the network, which needed to be embodied in the graphical monitoring interface program, so the timer was set for each terminal node. After the terminal node joined the network, the monitoring data and the 64-bit long address were sent to the monitoring software, and the terminal node graph automatically displayed the animation in 5 seconds. The terminal node temperature and humidity and meter reading value were sent once every 1 second, but packet loss was sometimes taken into account in the network state, accordingly, each terminal node corresponded to a timer count of 10 seconds,

that was, if there was no terminal node sending the successful data in 10 seconds to the monitoring software, the timer would cause the terminal node to disappear within 5 seconds.

In order to reflect the relationship between the terminal node and the starting node, each terminal node and the destination node were connected to the network through a line segment. When the terminal node joined or left the network, the corresponding rows would also display or disappear animation. The data received from the TCP was the network type that contained the network address, and the terminal node sent both numeric and numeric fields. After parsing the data, the network address needed to be stored in an array, and each item in the array corresponded to the terminal node pattern. This was because when a terminal node left the network and rejoined the network, the array would be able to find which graphics the terminal node should display. If the 64 bit address was indicated, the ID of the terminal node would become very long, so the last 16 bits in 64 bits were displayed in hexadecimal numbers. The sink node was connected to the monitoring terminal, it could be used to configure and manage the wireless sensor network node, issue the monitoring task, and receive and process the monitoring data. The tone generator was just an exception alarm and added a serial communication interface to the computer. The components of the terminal, SQL, Postgres, database, and user interface were monitored through the user interface, and the user interface provided the interface between the monitoring terminal and the wireless sensor network through the sink node. The Postgres SQL database stored various types of sensor data for querying, scheduling, and analysis. The user interface was based on the Java application interface, which was consisted of a set of Java classes and some applications, including the following contents: user interface, graphical interface, display sensor, experimental data tables and change charts, analysis of monitoring results, visual dynamic network topology, and warning the abnormal work environment on node.

4. Result analysis and discussion

The system can regularly collect data of temperature and light intensity and data storage. The main program flow chart of the system is shown in figure 2. When the system was running the acquisition program, first of all, the sensor node determined whether the collected temperature or illuminance was greater than the threshold value or not, and the environment anomaly near the node was indicated if the condition was satisfied (this node was treated as an exception node in this paper), sink node alarmed, monitor terminal displayed alert; system automatically stored data and maps at that time, and sensor nodes continued to acquire. At this point, the monitoring terminal could first be used to calculate the abnormal cause of the node according to the saved distribution map at that time, then all the data collected that were deployed with 6 sensor nodes inside the room were placed next to one device, meanwhile, the fluorescent lamps just above the nodes 2, 6, 5 and 3 were in the open state. Node 0 was the sink node, which was connected with the monitoring terminal. Firstly, the sink node sent the commands to the sensor nodes

for continuous collection of ambient temperature and illuminance, and then each node sent data to the sink node and displayed it at the monitoring terminal in real time. The interval of data sampling was 2 s, and the temperature threshold was set to 30 °C, and the illuminance threshold was set to 650l. The data collected by the 6 nodes temperature sensor at a certain time is shown in Table 1. There was a gap of 2 °C between the maximum and the minimum, which was much more accurate than the single point acquisition, and also showed that the temperature values in each region weren't the same. The experimental results show that the wireless sensor network technology can achieve fine sampling in the monitoring area.

Each terminal node was represented by a text box. The default template for a text box was rectangular, but each rectangle could be changed to a circle by replacing template. Data sent by temperature and humidity sensing nodes was displayed by analyzing three rows of data: the first line of data was the 64 bit long address after 16 bits and sixteen decimal numbers; the second line of data was the temperature, the unit was centigrade; the third line was the relative humidity, the unit was the degree. For power meter nodes, the data was displayed by analyzing the two rows of data sent: the first line of data was 64 bit long address with sixteen hexadecimal numbers;the second line of data was numeric. There were 4 temperature and humidity sensing nodes, 6 power meter reading nodes, and a sink node consisting of ZigBee networks. The GPRS DTU simulation software was sent to the display interface of monitor software, as shown in Fig. 3.

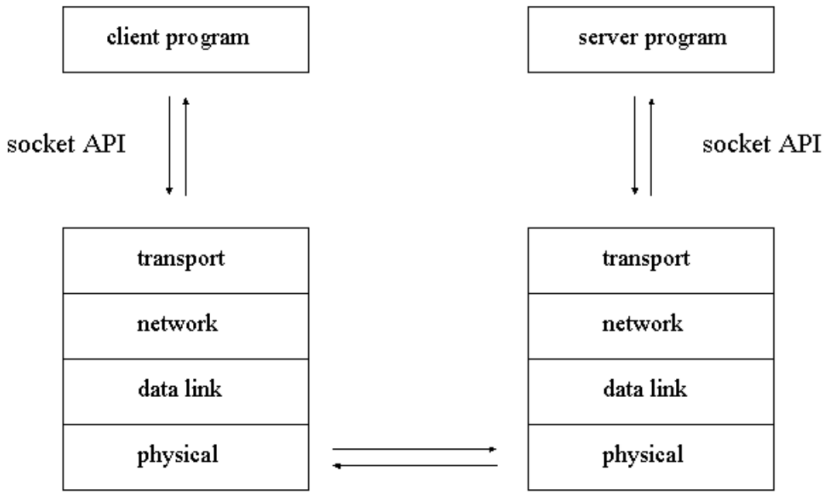

Fig. 3. Program of monitoring software interface

In Fig. 3, the API was used to enter the IP address of the data monitor. The "listen port" text box allowed us to enter the TCP port number that the data listener had. Listening of data was monitored by starting TCP sockets, the server stopped listening to data through "Stop listening" button. Sink nodes and information collected from each terminal node are as shown in Table 2.

Table 2. Information collected by terminal node

Sequence of nodes	Types of nodes	Value of information
1	Temperature and humidity nodes	Temperature: 26.5; humidity: 39
2	Temperature and humidity nodes	Temperature: 25.5; humidity: 37
3	Table lookup node	Meter reading value: 0.23
4	Table lookup node	Meter reading value: 0.25
5	Temperature and humidity nodes	Temperature: 25.8; humidity: 36
6	Table lookup node	Meter reading value: 0.26

As can be seen from the above table, the maximum temperature was 25.47 °C and the minimum temperature was 25.040 °C. The difference between the highest and lowest temperatures was less than 0.6 °C. The meter reading value was the same as the meter reading of each instrument, so the collected instrument read the data accurately. For temperature and humidity data, the monitoring value of the monitoring software was changed every second. For meter reading data, when the power meter was connected to blower with power supply 1 kWh, monitoring meter readings of monitoring software would increase by 0.01 kWh every 36 seconds, therefore, the effect of real-time monitoring was also realized.

5. Conclusion

The data acquisition accuracy of traditional single point data acquisition system is not high enough to achieve the purpose of accurate monitoring. Multiple sensors can monitor the environment in many directions. Therefore, a scheme of environment data acquisition system based on wireless sensor network was proposed, in this paper, the data acquisition system based on ZigBee wireless sensor network was designed and implemented, and the data types collected included air temperature, humidity, and meter reading data. Based on the full study of ZigBee network, the networking of ZigBee mesh networks and data transmission were realized, and network layer security related interface was called to realize data security transmission of ZgBee network layer. In addition, high-precision temperature and humidity data and accurate meter reading data were collected. Finally, it is found that the difference between the highest and lowest temperatures is less than or equal to 0.5 °C through experiment; in addition, the monitoring software developed in this paper can be used for wireless meter reading. The monitoring software developed in this paper has a simpler function, the number of ZigBee network terminal nodes displayed can't exceed 10, and monitoring software cannot send information to the terminal node because of the limited time and effort. Therefore, the further improvement of the function of monitoring software is needed.

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