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Design of Greenhouse temperature and humidity measuring system based on ZigBee technology

Xuejun Tian, Jianliang Li, Lihua Luo

Electromechanical Engineering Institute of Lingnan Normal University, Zhanjiang 524000, Guangdong, China

In this paper, the wireless network communication system based on ZigBee protocol is design using CC2530 chip as the processor together with front-end CC2530. In the system, the temperature and humidity information collected by DHTII temperature and humidity sensor is gathered and processed by CC2530 chip; the data of temperature and humidity sent back by the receiving nodes of main module will be sent to the upper compouter by serial assistant; then the upper computer recieves and displays the data so that users can check them conveniently. The application of the aforementioned ZigBee wireless communication technology in greenhouse is quite practical and promising.

Keywords: ZigBee technology, CC2530 chip, DHT11 temperature and humidity sensor, temperature and humidity monitoring

Introduction

With the promotion and development of greenhouse agriculture, greenhouse has brought great convenience for agricultural cultivation and improved the quality and yield of crops. The growth of greenhouse crops is affected by environmental factors. For example, the essential factors - temperature and humidity have direct influences on the growth of crops. Based on this, this study aims to design a greenhouse that can timely and accurately monitor the temperature and humidity in it and make them precisely controlled by the system to provide a sound environment for the healthy growth of crops. If implemented successfully, this project will bring the technology in this industry to a new level, promote the integration of agriculture and the Internet of Things, and accelerate the overall development of intelligent agriculture, therefore, the design is surprisingly marketable. Meanwhile, greenhouse also plays an important role in increasing economical benefits for farmer households and facilitating the development of agricultural economy.

Generally, traditional temperature and humidity monitoring system collects data by means of on-site manual recording or wired remote data collecting. The manual way demands a large amount of workload and leads to low efficiency[1]. Aiming at the problems in traditional data collection and transmission such as difficult wore arrangement, large power dissipation, high costs and so on, this paper proposes to use the ZigBee wireless communication technology to design the hardware of wireless temperature and humidity data collecting system which evades the limitation of ligature between points in wired temperature and humidity monitoring system and makes up for the shortcomings of the wired system.

1. SYSTEM ARCHITECTURE

Intelligent agriculture covers computer, Internet of Tings technology, modern communication technologies and many other subjects[2]. But in the development of intelligent agriculture, the integration and processing of numerous and redundant physical information is an critical obstacle.

In this paper, the technology of multiple sensors information fusion, the technology of timely data feedback, and the Key technology of large-scale ZigBee wireless data transmission are studied for the intelligent temperature and humidity monitoring system. The system can ensure timely transmission and feedback of the data of temperature and humidity in greenhouse, therefore, the precise measurement of crop growing environment is achieved, and the growth situation of crops can be mastered by users without delay.

This study refers to DHT11 temperature and humidity sensor, ZigBee wireless communication module, CC2530 demoboard and TFT liquid crystal display. DHT11 temperature and humidity sensor includes a resistance-type humidity-sensing element and a NTC temperature-measuring element, and is connected with the high-performance 8-bit single-chip microcomputer. It is a sensor with the output of corrected digital information and provides precise measuring data for the system.

The central control software platform in the system can transmit and display the data of temperature and humidity using ZigBee wireless communication technology. The process of data transmission is as follow: the node obtains the data from DHT11 temperature and humidity sensor and sends them to the coordinator via ZigBee wireless transmission, then the coordinator sends the data to computer via serial interface to be displayed, meanwhile, the coordinator also displays the real-time data on display screen.

The software system also involves node sleep working mechanism. The frequency of node collecting data is adjusted by software program. If the time interval is long, let the node be in light sleep, which not only reduces the power consumption of system but also extends the working life of node.

DHT11 temperature and humidity sensor, terminal node and coordinator node make up the ZigBee wireless network monitoring system of lower computer. The DHT11 temperature and humidity sensor and the terminal node are responsible for collecting, restoring and uploading the data information of temperature and humidity[4]. The coordinator module is mainly in charge of receiving and transiting the data of temperature and humidity. The ZigBee wireless network monitoring system of lower computer communicates with the upper computer through serial interface and the data are displayed by the upper computer finally. The coordinator constructs the ZigBee network which awaits the participation of node terminal and temperature-humidity sensor, then the node of the sensor in greenhouse begins to measure the temperature and humidity. The design of single wireless temperature and humidity measuring hardware system is shown in Fig.1.

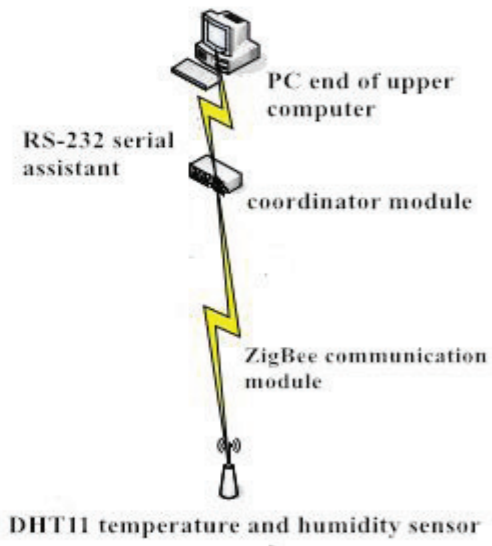

Figure 1 The entire wireless temperature and humidity measuring hardware system.

2. ZIGBEE INTELLIGENT BUS TECHNOLOGY

2.1 Characteristics of ZigBee Technology and Selection of Node Hardware

ZigBee has its own wireless standards. It is a low-consumption LAN protocol (local area network protocol) made by ZigBee Alliance and IEEE802.15.4 together based on IEEE8.2.15.4 Standards. Only requiring a little power, ZigBee can realize the coordination and communication among many sensors. It possesses a totally integrated high-performance RF transceiver, a 8051 microprocessor, 8kB RAM, 32/64/128/256 KB Flash and other powerful supportive functions and peripherals. The core module provides 101dB link quality, excellent sensitivity and robust anti-interference performance of the receiver, four power-supply modes, multiple sizes of flash memory and an extensive set of peripherals which includes two USARTs, a 12-bit ADC, 21 common GPIO and many others[5]. Apart from the brilliant RF performance, selectivity and industry standards which enhances the core of 8051MCU and supports general low-consumption wireless communication, the development can also be simplified by equipping the system with a standard compatibility of TI (Texas Instruments) or exclusive network protocol stack (RemoTI, Z-Stack,or SimpliciTI).

2.2 Structure of Protocol Stack

IEEE 802.15.4 is the basis of ZigBee communication protocol whose structure is divided into four layers: application layer, network layer, MAC layer and physical layer. The function of each layer is written strictly according to the primitive format specified by IEEE 802.15.4 Standards and ZigBee 2007 Specifications. Meanwhile, an operating system is embedded into the protocol stack for the unified management of tasks. Users only need to understand the function of application layer and call it if its necessary. Through this way, a ZigBee wireless network with comprehensive functions and stable performance can be built[6].

The ZigBee application layer(APL) includes application support sublayer(APS), ZigBee equipment objects (including ZDO management platform) and the application objects defined by manufacturer. The application support sublayer (APS) provides the following port: the common service set of application objects from ZDO to supplier between network layer and application layer. The service is achieved by two entities: application support sublayer data entity(APSDE) and application support sublayer management entity(APSME).

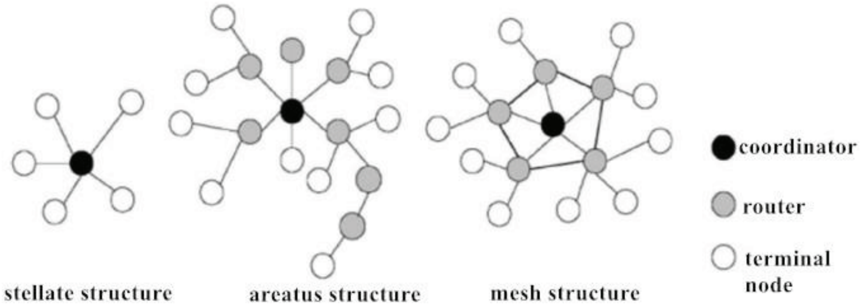

Figure 2 Three network topological structures.

2.3 Selection of Node Hardware

Note circuit is a crucial part of greenhouse and also the core content of the design in this paper, responsible of collecting and restoring the data of temperature and humidity. To realize low consumption is a difficulty in the design of wireless sensor network as well as the vital consideration in node circuit design. In the design of node hardware circuit, we selected a chip which can not only process the data from sensors but also send or receive data in a wireless way, as the typical example CC2530 chip does. In addition, it has four power modes which enables the system to sleep to maintain low power consumption when nodes don't work. According to the total design scheme of greenhouse crops monitoring system, the nodes includes coordinator nodes and terminal nodes.

2.4 Network Framework Topology

ZigBee network supports three network structures: stellate structure, areatus structure and mesh structure which are shown is Fig. 2.

In stellate structure, coordinator controls the whole network and takes charge of network construction and information management and maintenance. The coordinator must be FFD, and apart from this central node, all the other nodes in the network are terminal nodes which can communicate with the coordinator directly. In areatus structure, the range covered by the network is extended by router, and both router nodes and terminal nodes can be connected to the coordinator node.

In ZigBee mesh structure, router nodes must be FFD, and communication between any two FFD nodes is possible in the communication range. Multi-hop transmission could be employed to extend the transmission distance of nodes. What's more, the network has high self-healing ability so that it can be well adapted to the changes of network structure. In the mesh structure, the wireless multi-hop self-organizing network between nodes is adopted[8]. The coordinator constructs and manages the whole network, implements the functions including link status information management and equipment identification, and transmit the data from each node to the upper computer through serial interface for processing and analysis. A router can get contact with the coordinator and other routers; it's major task is to transmitting data, hence it is an important link in expanding the range of network. What's more, it's supportive of child devices. The terminal devices can send or receive a message but can not execute any route operation. So they must be connected to the coordinator or a router to transmit the collected data to the control center, or finish the actions according to the order of control center. In addition, terminal device does not support child devices.

2.5 Process of Network Construction by Coordinator

The construction of a network must be done by the coordinator which never joins any other network. The coordinator tries to construct network at the beginning. For the first, the coordinator finishes the initialization of its own program and attempts to construct network. When the network has been built, the coordinator starts to monitor the signals sent from subordinate routers. If there is no subordinate routers joining the notes, monitoring goes on; if there is application from subordinate routers for joining the network, the central coordinator allocates the physical address with geographical location information to the subordinate router and receives the signals from it timely. The steps of network construction by central coordinator is shown in Fig. 3.

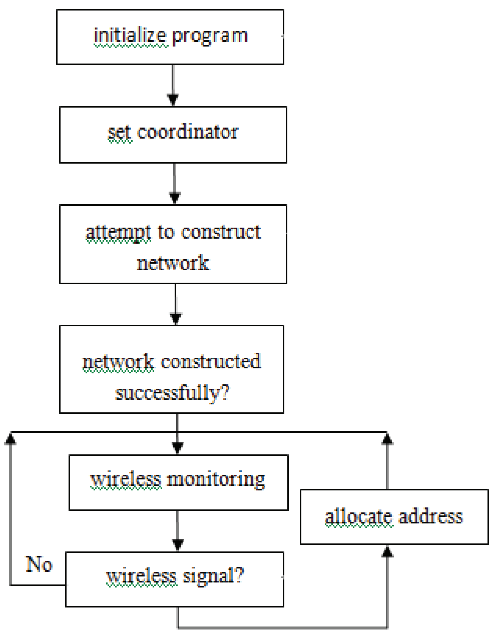

Figure 3 Process of network construction by coordinator.

Only when a new ZigBee network is successfully built will the coordinator and routers in it allow isolated node equipment connect to the network. Setup parameter OXFF indicates that isolated nodes are allowed to join the ZigBee network at any time[9]. When a node has successfully joined the network at a point, a new parent-child node equipment relation which transmits data and exchanges information is finished. The flow chart of a node joining the network is as Fig.4 shows.

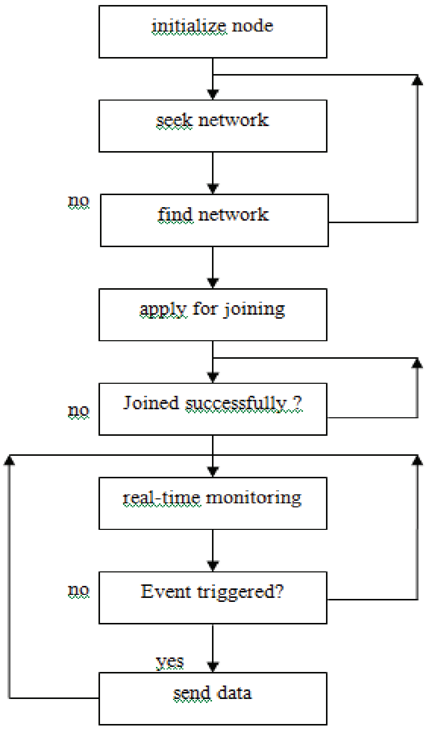

Figure 4 Process of a node joining the network.

When sensor nodes are connected to the constructed ZigBee network, the system has completed the network construction and connection. Put it in to-be-measured environment and it will starts its normal work.

2.6 Dynamic Routing and Self-healing Ability

2.6.1 Route Discovery

Aiming at a destination address, a source device requests a routing by sending a routing request message to its neighbor device. When a node receives a routing request message, it passes the message which carries relevant routing information successively. This way, when all the routing requests have arrived at the destination node, the source node gains the information of all the paths, thus a routing list can be made[10].

2.6.2 Rout Selection

Through route discovery, the source node is informed of the total connection consumption of all possible paths. If the source node needs to send a datum to destination node, it can chose the path with minimum total connection consumption.

2.6.3 Route Maintenance

Route maintenance means the maintenance of the existing routing list. When a node fails, the messages from the source node can not reach the destination node, thus the source node won't receive the response from destination node in a period of time. At this point, the source node generates an overtime message, sets the total connection consumption of this path as infinite, and updates the routing list accordingly[10]. Then, the source node selects the path of minimum connection consumption from the updated routing list and sends out the data again. The steps of sending and updating will be repeated until the data are sent out successfully.

3. SYSTEM HARDWARE SOLUTION AND DESIGN

3.1 CC2530 Chip Module

CC2530 chip integrates 51 single-chip microcomputer core. It is more commonly used compared to many other ZigBee chips. The ZigBee development kits specific to CC2530 chip can be used in combination with the integrated development environment IAR Embedded Workbench integrated[11], which provides convenience for the operation and connection.It can be connected to computer through USB to download the codes with high speed. The functions include online debugging, observation of breakpoints, single step and variables, the observation of register and so on. CC2530 can build strong network nodes with low-cost total materials. Furthermore, the outstanding operation performance of RF transceiver and the standard enhanced 8051 CPU all contribute to the high performance of the system which is capable of flash memory programming, 8kB RAM and many other powerful functions. The schematic diagram is shown in Fig.5.

3.2 ZigBee Coordinator Node

CC2530 chip is employed by ZigBee coordinator node which takes the role of coordinator node in ZigBee network in the system where the coordinator won't join in the collection of temperature and humidity information. The coordinator is responsible for data transmission and network construction. When the terminals get the data from DHT11 sensors, they send them to the coordinator via wireless transmission. Then the coordinator transmit the data to PC through RS-232 serial port[12].

3.3 ZigBee Terminal Node

Similarly, CC2530 chip is chosen for terminal node whose appearance is the same with that of the ZigBee coordinator mentioned above. ZigBee terminal nodes are equipped with temperature and humidity sensors which gather relevant data in greenhouse. Each data collection site possess a terminal node, and all the terminal nodes are connected to the network with ZigBee network technology. Therefore, the data collection which covers the whole greenhouse is achieved and the temperature and

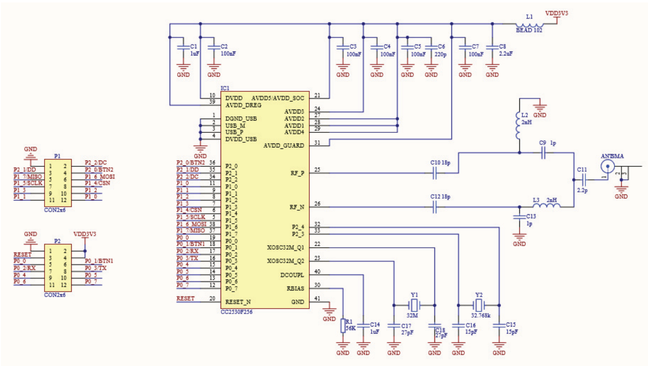

Figure 5 CC2530F256 schematic diagram.

humidity in greenhouse can be mastered timely.

3.4 Selection of Temperature and Humidity Sensor

The DHT11 temperature and humidity sensor is selected. Its single-wire serial interface makes system integration easier and faster, and its tiny volume demands very low power consumption[13] so that USB or battery is enough for its power supply. Therefore, the DHT11 temperature and humidity sensor is the best choice in this application. What's more, the package type of this product is four single-row pins which can be used directly for connection.

The humidity measurement range of DHT11 temperature and humidity sensor is 20∼90%RH with an error of ±5%RH, and its temperature measurement range is 0∼50 °C with an error of ±2 °C, which meets the hardware requirements of this project. DHT11 temperature and humidity sensor connects the ZigBee terminals of CC2530 through RS232 serial interface to transmit the collected data. Fig.6 is the interface circuit diagram.

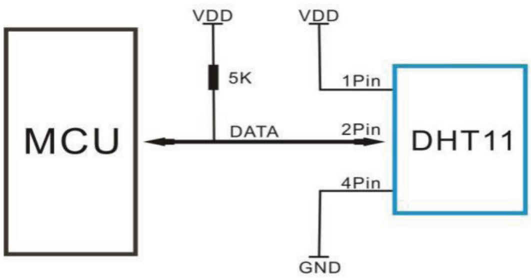

Figure 6 Interface circuit diagram.

Specifications of the pins are shown in Table 1.

Table 1 Pin Specification.

Pin	Name	Note
1	VDD	Power supply 3—5.5VDC
2	DATA	Serial data, unibus
3	NC	Empty pin, keep dangling
4	GND	Grounded, negative electrode

The attention points in practical use are as follows:

1. Don't use it when there is dew.
2. Conditions for long-term custody of the component: temperature 10∼40 °C, humidity below 60%[14].

4. SYSTEM SOFTWARE DESIGN FRAMEWORK AND KERNEL PROGRAM

System software design means to develop relevant software on the basis of hardware, so that sensors can collect data and send them to relevant devices; the upper computer can display the data and some other functions can be achieved. According to different functions, the design of system software can be divided into three parts: data collection of terminal devices, data management of coordinator device and data display of upper computer. The overall framework of the software is shown in Fig. 7.

The APP of the application layer in ZigBee protocol stack is mostly developed by users according to specific applications. It maintains the function properties of the device, finds the work of other devices in the work space of this device, and communicate among a number of devices according to service and demands[15]. The experiment of the design mainly simulates the real-time temperature and humidity monitoring in intelligent agriculture. Data are collected by DHT11 temperature and humidity sensors, and sent to coordinator directly or indirectly via router in package. The collected data of temperature and humidity are displayed simultaneously.

There is a part of the program related to temperature and humidity data collection:

```
void DHT11(void)
   //start temperature and humidity sensor
 {
    DATA_PIN = 0;
    Delay_ms(19);
//host delays for 18ms
    DATA_PIN = 1;
//pull-up resistor pulls up bus
//host delays for 40us
    P0DIR &= 0x40;
//relocate IO port direction
    Delay_10us();
    Delay_10us();
```

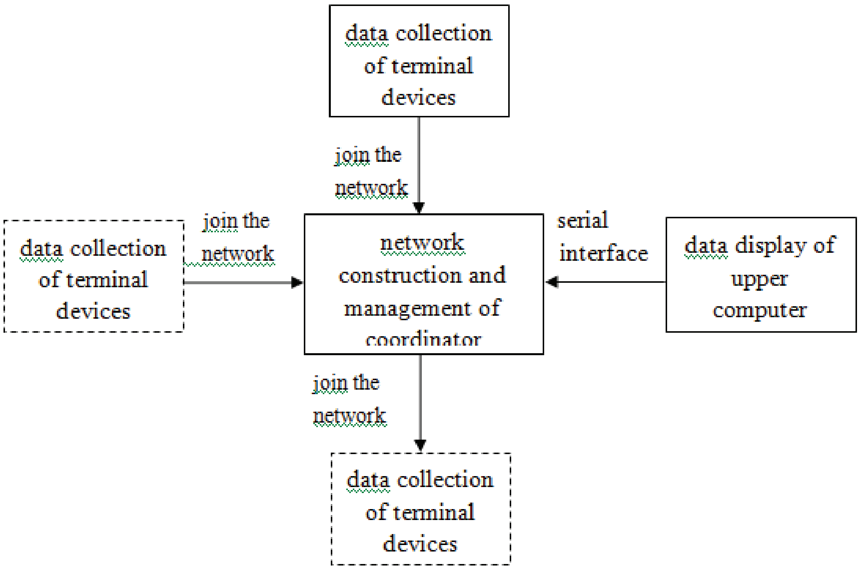

Figure 7 Software overall framework.

```
    Delay_10us();
    Delay_10us();
      //judge whether slave has low
  //level responsive signal,
  //if no, exit; if yes, go on running
     if(!DATA_PIN)
       {
          U8FLAG = 2;
  //judge whether
  //host has sent out 80us low
  //level responsive signal and
  //whether it has finished sending signals
          while((!DATA_PIN) && U8FLAG++);
            U8FLAG = 2;
//judge whether host has
//sent out 80us high level;
    //if yes, turn into data accepting state
         while((DATA_PIN) && U8FLAG++);
           COM();//data accepting state
           U8RH_data_H_temp = U8comdata;
           COM();
           U8RH_data_L_temp = U8comdata;
           COM();
           U8T_data_H_temp = U8comdata;
           COM();
           U8T_data_L_temp = U8comdata;
           COM();
           U8checkdata_temp = U8comdata;
           DATA_PIN = 1;
           WenDu = U8T_data_H;
           ShiDu = U8RH_data_H;
      }
    P0DIR |= 0x40;
}
```

Apart of the program related to temperature and humidity data display on TFT color screen:

```
voidSampleApp_Send_P2P_Message(void)
{
chartemp[3], humidity[3],
 strTemp[7], strBuf[20];
DHT11();
 //collect data of temperature and humidity
 //convert temperature and humidity information
 //into character string for LCD display
temp[0] = wendu_shi+0x30;
temp[1] = wendu_ge+0x30;
temp[2] = '\0';
humidity[0] = shidu_shi+0x30;
humidity[1] = shidu_ge+0x30;
humidity[2] = '\0';
 //integrate data to send
 //them to coordinator for display d

sprintf(strBuf,"%s%s-%s",
   DeviceId, temp, humidity);

 //output to LCD for display

if(InitFlag == 0)
 //display unchanged data for
 //only once to improve efficiency

 {
 InitFlag = 1;
 Color = BLACK;
 Color_BK = WHITE; //background color
 LCD_write_CN_string(7, 56, "temperature:");
 LCD_write_CN_string(7, 76, "humidity:");
 LCD_write_CN_string(64, 56, "degree Celsius");
LCD_write_CN_string(64, 76, "%");
ShowImage(90,57,32,32,gImage_logo);
//picture display example

}

Color = RED;
HalLcdWriteEnString(49, 56, temp);
HalLcdWriteEnString(49, 76, humidity);
if (AF_DataRequest(&SampleApp_P2P_DstAddr,
&SampleApp_epDesc,
```

```
    SAMPLEAPP_P2P_CLUSTERID,
8,
      (uint8 *)strBuf,
&SampleApp_TransID,
AF_DISCV_ROUTE,
AF_DEFAULT_RADIUS) == afStatus_SUCCESS)
{
}
else
{
// Erroroccurredinrequesttosend.
}
}
```

5. TEST OF TEMPERATURE AND HUMIDITY MONITORING SYSTEM

5.1 Preparations for Project Experiment

Before the system experiment, problems possibly existing in hardware should be ruled out first, such as poor contact or short circuit of sensors, instability of power, no path for data transmission between upper computer and lower computer and so on. For the first, only a small number of nodes are chosen for the system testing experiment. With the correctness of single-node data transmission ensured, a large scale of nodes can be involved in the test to finish the system experiment gradually and successfully.

After ZigBee protocol stack is transplanted, perform the programming and modification of some parts of the software, and then download the program to coordinator and terminal nodes. The test selects the stellate topological structure; terminal nodes are powered by battery; the coordinator is powered through USB and connected to computer via USB port for data communication.

The test of the stability and security of terminal nodes and the coordinator is essential for system wireless data communication which has influences on the normal work of the system.

5.1.1 Stability Test

Set the power mode of terminal node as full functional mode; coordinate demands no setting in that it does not have sleep mode. Run it for a long time of 48 hours, and check whether every module runs normally, whether the voltage is in proper range and whether the liquid crystal screen is clear without splash.

5.1.2 Security Test

Check all the interfaces to ensure no short circuit. After long-time running of program, check the temperature working voltage of the chip for fear of burnout.

After hardware test ends, check whether the temperature and humidity data collected by sensors are normal, and test the communication of 9-pin serial interface using ScomAssistant.

5.2 ZigBee Network Construction and Data Collection

Relevant parameters have been set for CC2530 demoboard. Connect the ZigBee wireless communication module with the temperature and humidity sensor by way of modular connection. Before data collection, ZigBee coordinator node needs to construct the network and adds in ZigBee terminal nodes to enable data communication between the nodes and the coordinator. To ensure the security and reliability of data, ZigBee coordinator needs to control the participation of wireless nods. The process of ZigBee network construction is shown in Fig. 8.

After the construction of ZigBee network is finished, the coordinate device releases the order of data collection which will be transmitted to terminal devices through ZigBee network. ZigBee terminal devices are two devices directly interacting with DHT11 temperature and humidity sensor, responsible for informing DHT11 temperature and humidity sensor to collect data, receiving data from the sensor, and sending the data to coordinator node according to ZigBee protocol using ZigBee module. Therefore, the data transmission is achieved through this way[16].

5.3 Network Test

If the tests of hardware and all the parts show no abnormality, the test of network can be started. If the ZigBee network constructed by coordinator is regarded as a logistics company, the network-layer routing is like the management operating mechanism of the logistics company, with which the data packages that are parallel to mails can be directly or indirectly sent to the coordinator accurately. The coordinator contains network addresses. When a new ZigBee device joins the network, it gets a 16-bit network address as its unique identification in the whole topological network. Therefore, the ZigBee network in this system can hold 216=65536 nodes at most theoretically[17].

5.3.1 Configuration of Terminal Senor Node

After the transplantation of Z-Stack protocol stack, start the network testing program using IAR integrated development software; select SensorBB; select Project->Rebuild All compiling. After the compiling is passed completely, connect PC, simulator and target board Q2530BB; press the "Reset" key of simulator whose indicator lamp should be normal at this point; click the "Debug" button to download; when the downloading progress bar disappears and the debugging window shows at the top left corner, click "quit debugging"; pull out Debug cable; restart the power of target board or press the "Reset" key of it. At this moment, LED1 and LED2 flicker slowly and the target board has been set as terminal sensor node. The TFT color screen will show the addressees of the Router and the parent node as well as the data of temperature and humidity it has collected[18].

5.3.2 Configuration of Coordinator Node

Select CollectorBB; select Progject->Rebuild All compiling; After the compiling is passed completely, connect PC, simulator and target board Q2530EB; press the "Reset" key of simulator whose indicator lamp should be normal at this point; click the

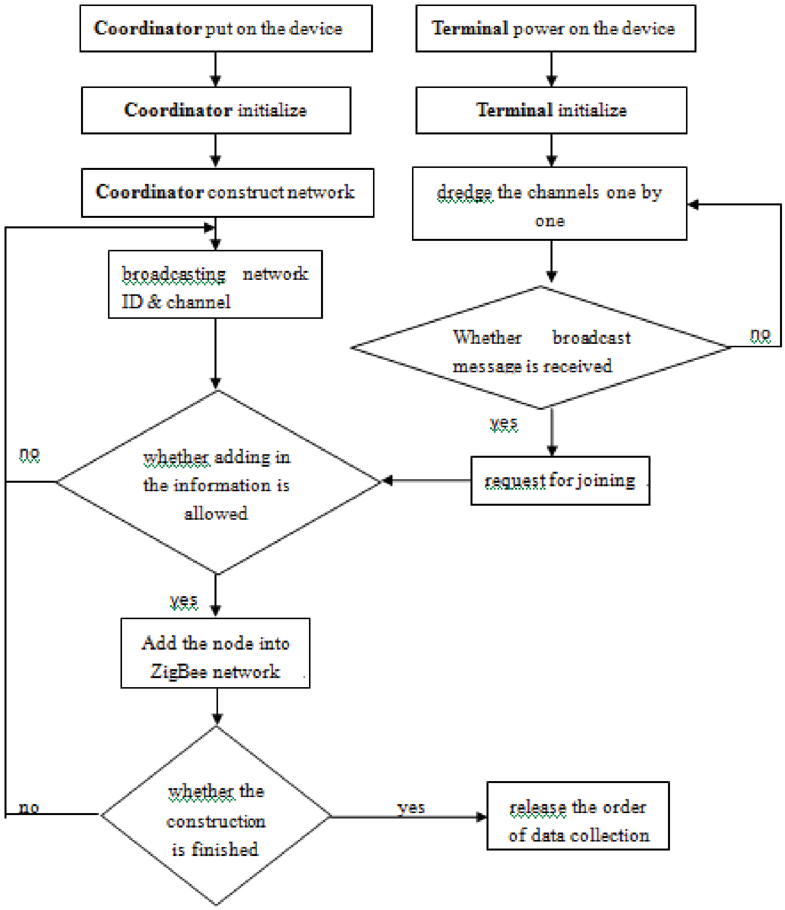

Figure 8 Process of ZigBee network construction.

"Debug" button to download; when the downloading progress bar disappears and the debugging window shows at the top left corner,click "full-speed running"; at this moment, both LED1 and LED2 flicker and LCD shows the IEEE address of the present node. If the "UP" key of U3 is pressed, LED1 and LED3 will be on eternally while LED2 flickers. Click "quit debugging"; pull out the Debug cable from the target board; restart the power of target board or press its "Reset" key; then LED1 and LED3 is on eternally while LED2 flickers, and the target board has been set as network coordinator node. The TFT color screen will show the data of temperature and humidity sent from each node.

Turn off the power of all the nodes in the network; connect the serial interface of coordinator with computer; open ZigBee protocol analysis software; select port COM1 where Baud rate is 115200; and turn on the power of coordinator. Therefore, the ZigBee network construction is completed[19].

When terminal node is powered on, its running mechanism and indicator lamp regularity are the same with those of the router, whereas the only difference is that it can only send the data of temperature and humidity collected on its own to the router or coordinator rather than accepting data from other nodes or transferring data packages[20].

After the binding of terminal node, the collection of temperature and humidity data could be started. The data will be transmitted to coordinator according to ZigBee protocol and then sent to the upper computer for display by coordinator according to serial communication protocol. In the experiment, the frequency of collection of temperature and humidity data is once a second, and the data collected in the experiment is shown in Fig. 9.

Using the software, users can observe the latest data of temperature and humidity clearly, which is an achievement of real-time monitoring and a visual way of mastering the changes of data.

5.4 Data Analysis

Repeated experiments show that the data collecting nodes are capable of collecting the data of temperature and humidity, and the network constructed by coordinator also can correctly transmit data which are to be displayed by upper computer. However, it's discovered through many experiments that the distance between every two nodes can only be within twenty meters, otherwise the signal will be missing, which means that the transmitting distance between two nodes is too short. Nodes seek the optimal path to pass data packages upward to the coordinator finally.If path is very long, routers can be employed to transmit the data for many times, which indicates that if long-distance data transmission is required in actual agricultural production, routers can be placed in several regions as data transfer stations to prevent data lose. What's more, data can also be transmitted for a longer distance through modifying the software program and increase the transmitting frequency of ZigBee wireless module. There-

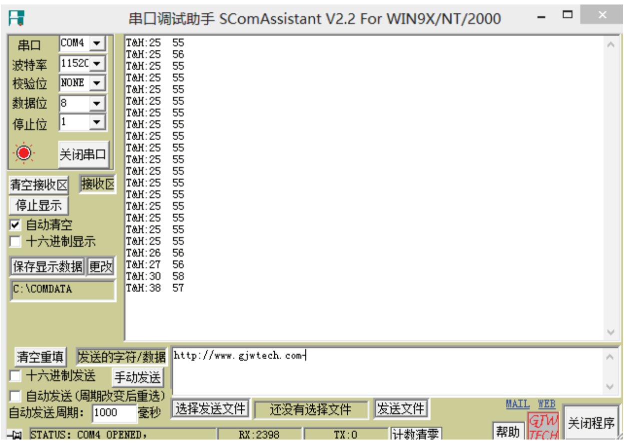

Figure 9 Real-time collected data.

fore, it can be confirmed through experiments that the system is capable of wireless long-distance monitoring of the environment temperature and soil humidity in greenhouse.

6. IMPLEMENTED FUNCTIONS AND INDUSTRIAL PROMOTIONS

Temperature and humidity are important impact factors for the growth of greenhouse crops. Accordingly, the sensors of the system is enabled to collect the data of temperature and humidity. But the sensors only collect external environment data which can not be transmitted directly but stored in sensor cache with fixed format. The nodes connected with sensors regularly collect the data in the sensors, converge and process the data, and then transmit them through a long distance to coordinator by ZigBee wireless topological network technology. Having received the data, the coordinator transmits them through serial interface to the computer software for display, so that users are able to know the temperature and humidity timely and take appropriate measures to help the healthy growth of different crops according to seasonal changes.

As the old saying goes,since food is people's greatest concern, agriculture should be list on the top of priorities for a country. In addition, the 13^{th} Five-year Plan also actively guides the development of agriculture informationization, indicating that agriculture takes an important position in our country. How to use information technology to build an intelligent agriculture system will be one of the emphases of the agriculture development in our country for a period of time[21]. With the continuous improvement and application of the product studied in this paper, it's expected that the intelligent agricultural greenhouse with the new technology will lead a technology innovation trend in the industry, which will thoroughly change the traditional manual recording or wired long-distance monitoring data collection. This technology evolution will greatly improve monitoring efficiency, reduce farmer's workload and costs, and bring more economic benefits to agriculture. Therefore, it's of great significance for guiding practical agricultural production and the development of intelligent agriculture.

7. CONCLUSION

The network of the temperature and humidity monitoring system is a short-distance low-consumption wireless communication network based on ZigBee protocol, usually used for greenhouse, garden and so on. Aiming at crops rigorous demands on temperature and humidity, the compound temperature and humidity sensor DHT11 and the CC2530 are selected to build the sensor node. The wireless sensing network built by ZigBee portocol stack allows wireless data transmission, and the data is displayed by the serial assistant of upper computer. Therefore, the users can monitor the temperature and humidity in greenhouse without paying a visit, which means that their work becomes lighter and easier.

Experiments show that the system is advanced in that it completely realized the functions of flexible network construction, huge network capacity, high self-healing ability, and stable data transmission. Therefore, the network topological structure in the system basically meets the wireless communication requirements in intelligent agriculture. Apart from that, due to the rational selection of elements and the design of low-consumption circuit, the system is also featured by low costs, good augmentability and high practical value. All these advantages can bring about numerous marketing opportunities.

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Tian Xuejun, Associate Professor of Electromechanical Engineering Institute of Lingnan Normal University, Senior Engineer, Master's degree, engaged in teaching and studying in aspects of electromechanism, numerical control machining, etc. Phone:13702888969 E-mail: 13702888969@139.com

Li Jianliang, 2017 graduate of Electromechanical Engineering Institute of Lingnan Normal University. Phone:18312686475

Luo Lihua, 2017 graduate of Electromechanical Engineering Institute of Lingnan Normal University. Phone:18320359042