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Sewage information monitoring system based on wireless sensor

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ABSTRACT

In order to carry out real-time monitoring of water quality, this paper developed a set of remote real-time water quality monitoring system based on ZigBee protocol wireless sensor network technology, and chose Qingshan Lake in Nanchang as the experimental field of water quality monitoring system. In addition, running and testing are conducted for the water quality monitoring system for a period of time. The results show that the designed system achieves effective water quality and real-time monitoring, wireless data transmission monitoring, storage and display of software platform for data, and remote control of monitoring equipment. What's more, on-site testing and inspection of related functions are carried out, which can work stably in the harsh environment. It is concluded that real-time collection of water quality monitoring data and transmission through the wireless network to the monitoring center achieve the goals of research.

Keywords: Water quality monitoring; ZigBee; Wireless sensor network; Water quality early warning

1. Introduction

The safety of water quality is related to the daily life of people and the production work of all walks of life. With the development of China's economic construction, production activities caused a large area of water pollution. Domestic sewage has become an important source of urban pollution so that China's ecological environment and people's living environment have been greatly threatened. Therefore, the real-time monitoring of water quality is rather essential for water resources protection and water pollution prevention. In water quality monitoring, it is very difficult to collect data through traditional way, and the application of wireless sensor network technology provides convenience for field acquisition and monitoring of water quality.

The widely used wireless network technology includes WiFi, Bluetooth and ZigBee. The reliability of data transmission in ZigBee network lies in the collision avoidance mechanism adopted by the protocol, and the specialized slot is reserved to the communication service which needs fixed bandwidth, so as to avoid the competition and conflict between the data transmission in the network. The MAC layer also adopts a data transmission mechanism that needs to be fully confirmed that each packet sent by the network must wait for receiving the confirmation information of the receiver; thus the task is completed, which ensures the high reliability of data transmission in the network. ZigBee technology has the characteristics of small transmission range, low data transmission rate, low power consumption, low cost, short delay, large network capacity and so on [1]. Therefore, it is appropriate to choose ZigBee technology to apply in each node of field monitoring equipment to compose wireless sensor network.

Through the research of wireless sensor network technology and ZigBee protocol, the remote real-time water quality

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monitoring system is designed. The remote real-time water quality monitoring system based on ZigBee protocol and wireless sensor network technology is researched, designed, manufactured, integrated, deployed and tested, and the monitoring data collection and transmission of water quality is realized.

2. Overall framework and design scheme of the system

2.1. Overall framework of the system

This paper will develop, integrate, deploy and test a whole set of water quality monitoring system based on wireless sensor network technology. Monitoring device of system front-end makes effective real-time monitoring on water quality; a plurality of monitoring node based on ZigBee protocol composes wireless sensor network; the master node conducts wireless communication by GPRS and management center; the back-end, as monitoring warning software platform of monitoring management center, receives the data sent from front-end monitoring equipment through the GPRS, for data storage and management. In addition, data are shown in a variety of forms, and the software platform has the functions of the water quality early warning, remote control and so on at the same time.

System network coordinator node MCU uses low-power mode, and both sensor nodes and routing nodes use module sleep, idle and other low power technology, so the whole system equipment energy consumption is very low. In the whole system, it is possible to freely increase or decrease the number of sensor nodes without affecting the overall performance. The network coordinator, in the absence of a network connection, will automatically store data for more than 2 years. When the network is connected again, data can be accurately uploaded to the server [2].

The system requires real-time, on-line and automatic receiving water quality parameters and surface photo of the object. It can query and retrieve by maps, tables, graphics and a variety of displaying forms. Through the early warning analysis engine, the parameters of prediction model set in advance are analyzed and judged, timely displaying the water conditions and warning information, and warning with flashing alarm mode on the map.

The system model of the water quality monitoring system is shown in Fig. 1.

This paper will take the following steps for water quality monitoring system research and design work:

To research and design the overall framework of water quality monitoring scheme and water quality monitoring system;

To select and purchase the water quality sensor equipment;

To fully carry out the system research and development work according to the overall framework of the monitoring system;

To research and develop wireless sensor network communication technology and equipment based on ZigBee protocol. On the KeilC51 platform, C language is used for programming and development of wireless communication module.

To design and develop water quality monitoring and early warning platform software system (including storage, management, display, early warning, control and other functions). With SQL Server 2005 as the database management system, on the MyEclipse enterprise work platform, Java language is applied to develop monitoring and early warning platform, and C++ language is adopted on the Visual Studio 2008 platform for programming and developing software platform remote control module and data interface.

To conduct research and development, procurement, integration, testing and improvement of water quality sensors, communication equipment (including GPRS module), equipment and power supply unit of water monitoring station, water quality monitoring early warning platform software system and so on.

To select water quality monitoring test site.

To study and make specific water quality monitoring scheme, monitoring equipment installation and deployment plan and security measures, as well as test scheme.

To perform the installation, deployment, operation and test of the whole water quality monitoring system in the test site.

To carry out the daily maintenance of the monitoring system and its later improvement and upgrade.

2.2. System network topology selection and design

Sensor network systems usually include sensor nodes, sink nodes and management nodes. A large number of sensor nodes are deployed in and around the monitoring area, which can form a wireless communication network in a self-organizing manner. The data obtained by sensor node monitoring are transmitted through other sensor nodes hop. In this way, the monitoring data in the transmission process may be through many nodes, through multi-hop routing to the sink node, and eventually through the Internet or satellite transmission to a management node. Users can configure and manage the sensor network, publish monitoring tasks and receive monitoring data through management nodes [3].

The sensor node consists of four parts: sensor module, processor module, wireless communication module and energy supply module. The sensor module is responsible for acquisition of data of monitoring indexes to monitor objects in the monitoring area as well as the necessary data conversion. The processor module is responsible for the control of the sensor node operation, storage and processing of the collected data and data sent by other nodes. The wireless communication module is responsible for wireless communication transmission with other sensor nodes, exchanging control information exchange and sending and receiving data. The energy supply module provides the energy required for operation for the sensor node [4].

There are two types of address modes in Zigbee networks: star topology, network number + device identifier; point to point, direct use of source/destination address. The common topology of Zigbee networks is star topology and mesh topology, in which the mesh topology is used more. Mesh network communication is actually multi-channel communication. In the Zigbee protocol, the dynamic routing is adopted, that is, the path of data transmission in the network is not preset, but before the data transmission. Through the search and analysis of the current available path of the network, an optimal path is selected for transmission. In the

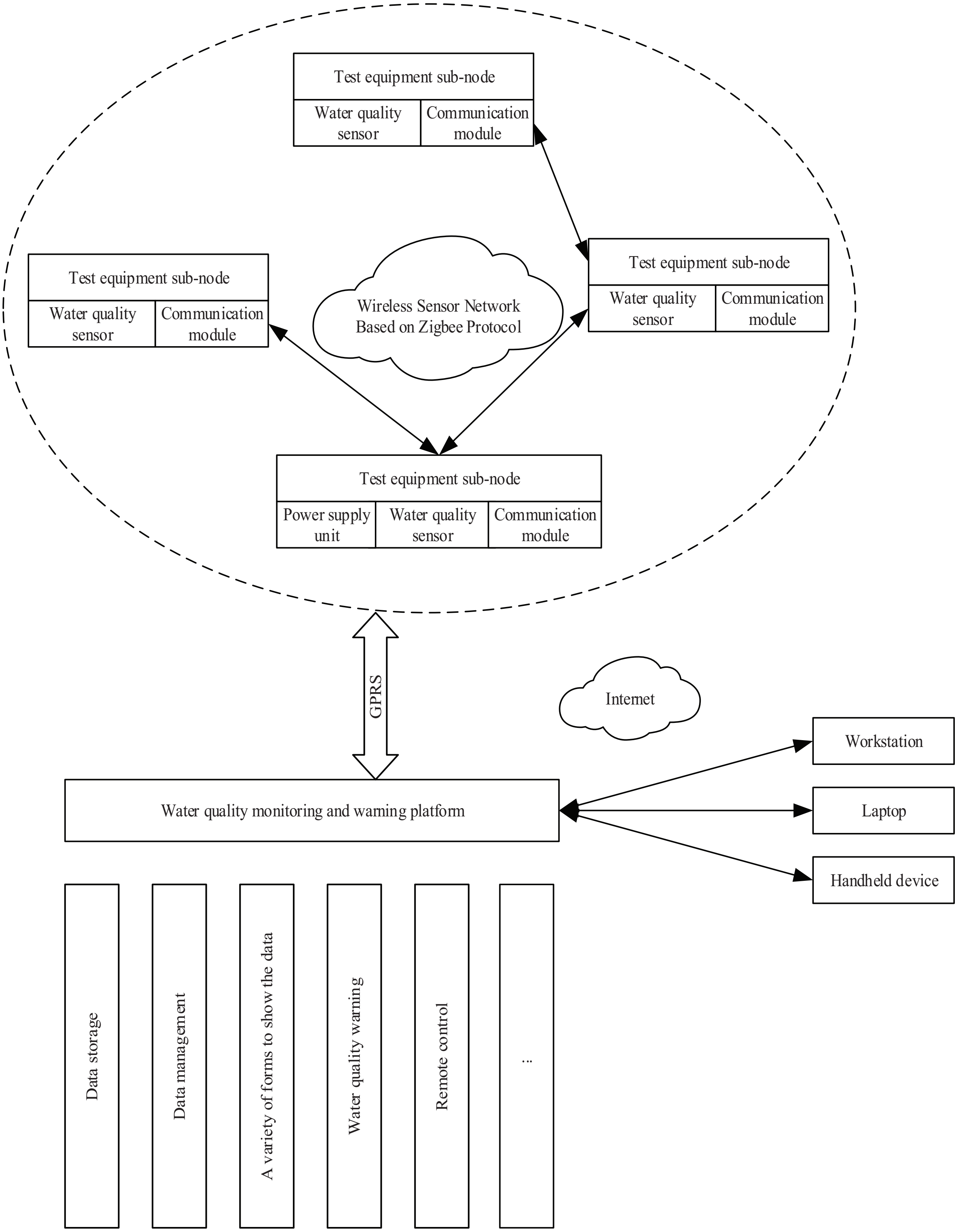

Fig. 1. System model of water quality monitoring system.

network management software, the path selection uses the "gradient method", that is, to choose the shortest path for transmission. If it cannot pass through, then it tries another slightly farther path and so on until the data is successfully delivered to the destination. In practical site applications, the predetermined transmission paths may change at any time, or interrupt due to various reasons, or cannot be processed promptly because of the busy task. The network topology combined with dynamic routing can well solve the problem in field application and ensure the reliability of data transmission [5]. The tree network topology of the system is shown in Fig. 2.

In practical application, the distance between rain sensor nodes and network coordinator is close, so there is no jump though the routing sensor, directly communicating with the network coordinator. When the rain sensor node and the network coordinator node cannot communicate directly, the routing sensor node can be chosen as the relay [6]. The distance between the temperature and humidity sensor nodes and the network coordinator is far away, and cannot communicate directly with the coordinator node of the network. In the process of data transmission, the sensor node is used as the relay, and it is indirectly communicated with the network coordinator.

The network topology of water environment quality monitoring system is tree structure. Tree structure is a hierarchical centralized control network, whose communication path is short in length, low in cost, easy to expand nodes, and convenient to find paths. The advantage of tree topology is that it is easy to expand and easy to isolate faults.

2.3. Overall design scheme of the system

Each data acquisition point in the system collects the data of the point through the wireless transmission to the main control board in the center, and then controls the main control board through the command of the server. Next, it transfers the collected data to the database and stores them, and calls them through the web page.

When the distance from data collection sub-node to the main control board is near, the sub node, through wireless, can be directly transmitted to the main control board (PH sub-node and rain quantum node). When the data collection node is far away from the control board, the sub nodes can, through the intermediate node jump pass way, transmit data to the main control board (temperature and humidity data, through the PH sub-node jump, passes to the main control board).

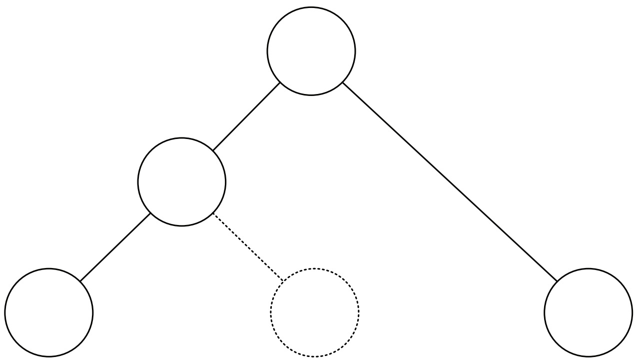

Fig. 2. System tree network topology.

The PH collection points and rain collection points, through the wireless module, directly communicate with the main control board. The data collected will be transmitted directly to the main control board. The temperature and humidity acquisition point, by PH acquisition point jump, establishes communication links with the main control board. The temperature and humidity data acquired is first transmitted to the PH node, and then passed to the main control board through the PH node.

The temperature and humidity acquired by temperature and humidity acquisition node, the water pH value collected by PH node, and rainfall collected by rain node, through the wireless module, are transmitted to the network coordinator. The network coordinator, through the data transfer unit (DTU) module, store the data collected by Internet in the database. Through the page calling the contents of the database, the data collected will be displayed on the terminal. If an emergency occurs (water quality data problems) and alarm phenomenon occurs, and the monitoring center is unattended, the data can be transmitted to the mobile terminal (such as mobile phones) and so on.

2.4. Sensor layout scheme and working mode

The network coordinator node is arranged in the northeast corner of the Wetland Center, mainly collecting OPR, dissolved oxygen, electrical conductivity and other data, and sensor probe is placed on the upper water surface. The temperature and humidity sensor nodes are placed beside the main road of the Wetland Center, so as to collect temperature and humidity data. PH sensor nodes are placed in the middle of the network coordinator and temperature and humidity sensor nodes, mainly to collect the pH value of water quality, and PH probe is placed near the upper water surface. The rainfall sensor nodes are located in the east of Wetland Center, which is mainly used to collect rainfall information.

The conductivity sensor, the dissolved oxygen sensor and the ORP sensor in the main control board are directly supplied by city power, so they work 24 h/d. PH sensor is powered by a battery. In order to ensure the battery use time, only when the server has the query command can the sensor work. The temperature and humidity sensor and rainfall sensors use less electricity (in which the rain sensor does not consume electricity), and it needs to be monitored at any time, so the temperature and humidity sensor and rain sensors work 24 h. All sensors can automatically query and query at any time through the web page. The whole point query is 1 hour apart.

3. System hardware design

The system uses STCMCU as the core to realize the functions of parameter detection temperature, humidity, rainfall, pH value, dissolved oxygen, conductivity, redox potential and underwater temperature, and the data transmission is carried out through ZigBee ad hoc network. And a clock module and TF card storage module are attached. While ensuring stability, the function is more powerful and the utilization is more flexible.

3.1. Sensor node design

The sensor node structure is shown in Fig. 3.

Sensor node uses STC12C5A40S2 micro-controller produced by the Hong Jing company, Shenzhen, China. The micro-controller is the new generation 8051 microcomputer with a strong anti-interference ability and low power consumption, with faster speed and suitable for strong interference environment applications [7]. The corresponding sensor of each wireless network sensor sends the collected data to the MCU for data processing, and sends the processed data through the wireless module according to the instruction of the sink node.

3.2. Sink node design

The sink node receives an instruction from the Internet through DTU, and MCU, through the analysis of instruction, makes the corresponding action. If it is the query of sink node sensor data, then the collected data will be sent by DTU to the corresponding server. If it received photo instruction, the photos photographed by camera will be sent by DTU to the server. If it is the query of the collected data of other sensor nodes, through wireless module, they are sent out. And it receives the replied data acquisition and sends the data to the server through DTU.

The sink node MCU adopts the 90C58AD series micro-controller of the Hong Jing company, which has strong anti-interference ability and low power consumption. The structure is shown in Fig. 4.

DTU used by sink node is the wireless terminal device specially used for serial data and IP data conversion and receiving and sending data. System DTU products have industrial GPRS/CDMA wireless module, 32-bit processor and embedded operating system arranged inside, to support UDP and TCP protocol.

3.3. ZigBee module design

In the ZigBee protocol, only the PAN coordination point can be used to build a new ZigBee network. When the PAN coordinate point prepares to establish a new network, first of all, it conducts channel scanning and find a free channel in the network. And then, use the idle channel to establish the new network. Next, ZigBee coordination will select a unique PAN identifier (PAN identifier is used to identify in the whole network) for the new network. Once the PAN identifier is selected, the new network is established successfully. Thereafter, if the other ZigBee coordination points are scanned to the channel, the coordination point of the network will through the response declare that the channel has been used by a network. The ZigBee coordination point also selects a 16-bit network address for itself. All nodes in ZigBee network have a IEEE extended address of 64 bit and a network address of 16 bit, and the network address of 16 bit is also unique in the whole network, that is, MAC short address in 802.15.4.

After the ZigBee coordination point selects the network address, it begins to accept the new node to join its network. When a node prepares to join the network, we must first determine the existing network around it by scanning the channel. If an existing network is found, it will join the network through the associated process; and only with the node routing function can it make other nodes linked to relational network through it. If a node in the network loses contact with the network and wants to rejoin the network, it must use the isolation notification procedure to rejoin the network. Each node with routing function in the network maintains a routing table and a routing discovery table. The routing node has the functions of routing discovery, packet forwarding, and routing maintenance, and it can extend the network by associating with other nodes.

The networking of monitoring system based on the ZigBee protocol is shown in Fig. 5.

The data transmitted in ZigBee networks can be divided into three categories:

Periodic data, such as the transmission of a variety of information data in the ZigBee network. The transmission rate of such data is determined according to the difference of the application;

Intermittent data, such as data generated by changes in the working state of the front-end water quality sensors, to determine the transmission rate of such data by work application or external excitation;

Repeatable and low reaction time data, such as a variety of water quality parameters measured by the water quality sensor. The transmission rate of this kind of data is determined according to time slot allocation. In order to reduce

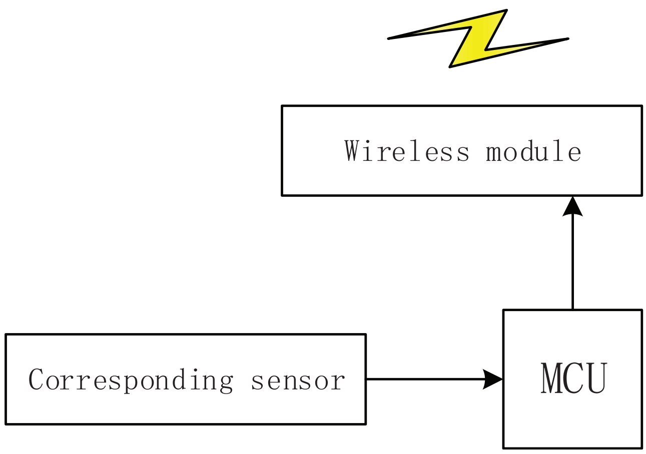

Fig. 3. Sensor node diagram.

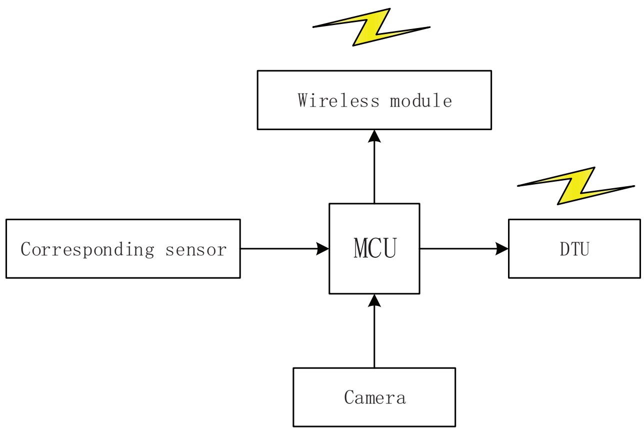

Fig. 4. Collection node diagram.

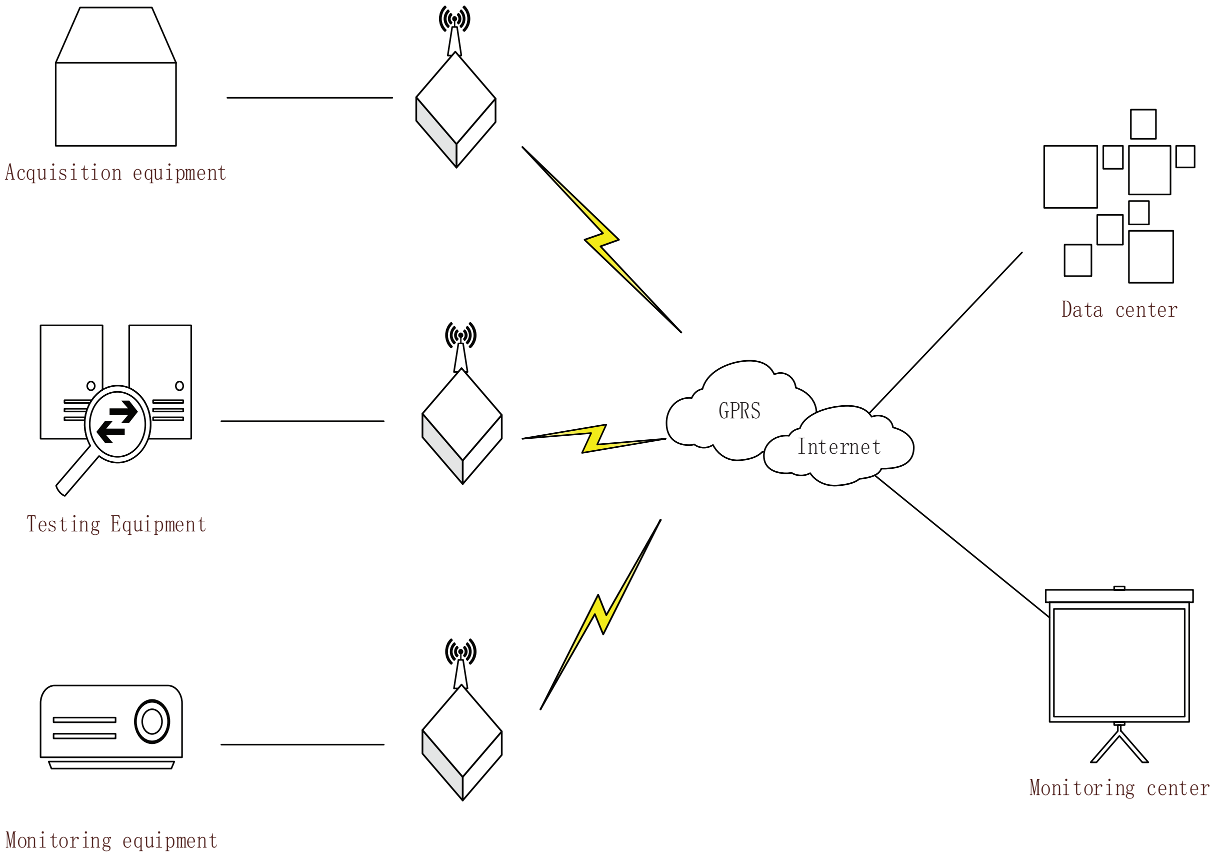

Fig. 5. System design of the network.

the average power consumption of ZigBee nodes, the ZigBee protocol adopts the sleep mechanism, and the ZigBee node will be in the two states of activation and sleep. Only when the two nodes of the communication are in active state, the data will be transmitted.

In a beacon network, ZigBee coordination point, through periodically broadcasting beacon network, achieves synchronization of each node in the network. In the network with absence of beacon, terminal nodes are regularly sleepy and regularly activated, and all nodes outside the terminal node must ensure it always activated. After the terminal node activation, it will take the initiative to ask the coordination point if there are data to be sent. In a ZigBee network, the coordination point caches the data to be sent to the sleeping node.

WSN nodes are often energy-constrained, and nodes may be placed in the area difficult to maintain, so the efficient use of node energy is a basic requirement of sensor network design. WSN nodes also need better design structure, maintainability, scalability and so on. In the past, the design has the characteristics of strong pertinence, difficult to expand, large design difference and so on. As a result, this paper proposes an extended flexible wireless sensor network modular architecture [8]. The module designed by this system is not designed for special data acquisition. It can change the collected data by changing the sensor, and on the basis of the existing nodes, other nodes can be extended to collect other data.

IEEE 802.15.4 defines two physical layer standards for 2.4 GHz and 868/915 MHz. Both of them are based on direct-sequence spread spectrum technology. 2.4 GHz is the world free ISM frequency band. Because the use of frequency band requires applying for, 868/915 cannot be used in China, so ZigBee technology uses 2.4 GHz in China.

According to the requirements of the primary transmission bytes, current consumption, work change and communication distance, the system selects HSD-1M as the wireless transmission module.

The MCU in the ZigBee module is integrated with 10-bit precision high speed A/D converter. P1.7-P1.0 has eight channels, which can be used for button scanning, battery voltage detection and spectrum detection. A single conversion takes 89 clock cycles to complete.

PCB board of ZigBee module is double design, having both positive and negative sides. Most of the electronic components are on the front line and placed on the PCB front board. The back part is mainly used for making line from the opposite when components are difficult to make line in positive cases, and placed part of the components.

3.4. Design of water quality monitoring module

Telemetry rainfall sensor uses tipping bucket rainfall sensor, designed to meet the national standard GB/T11832-2002 “tipping bucket” and GB/T11831-2002 “hydrology telemetry gauge”. The instrument has two signal outputs, one of which is used for field metering and the other for telemetry.

The temperature and humidity sensor uses AM2301. AM2301 humidity sensitive capacitance digital temperature and humidity module is a temperature and humidity composite sensor. Its performance is reliable, stable, small in size and low in power consumption. The signal transmission distance is more than 20 m, and the application situation is more extensive.

PH sensor and ORP sensor adopt PHG-2026B, conductivity sensor adopts DDG-2022B and dissolved oxygen sensor adopts DOG-2028B.

In this system, the data collected by sensor probes are analog data, and the analog data is not easy to transmit, process and identify, but the analog quantity converted by the circuit is easy to identify, transmit, process more stable digital quantity.

The system uses DS18B20 digital temperature sensor (Anma, China), the product uses networked digital temperature sensor chip packaging produced by the American DALLAS company. It has wear resistance, touch, easy to use, available in diverse packaging forms and suitable for small space applications. The measuring circuit of the temperature sensor is shown in Fig. 6.

4. System software design and development

This system adopts Visual Studio 2008 platform and C++ language.

4.1. Database design

The process of designing database is divided into six stages as follows:

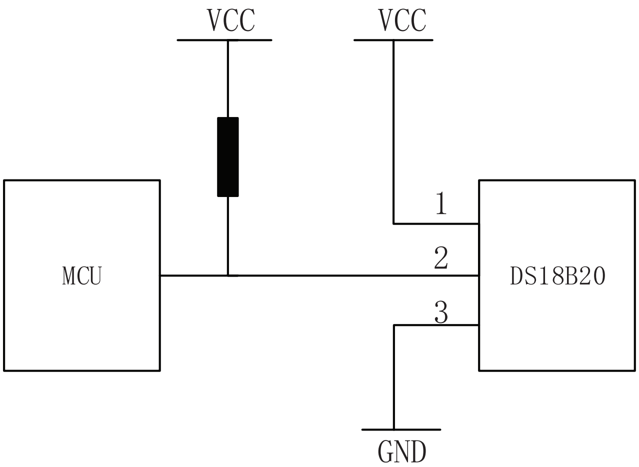

Fig. 6. Temperature sensor measurement circuit.

Requirements analysis: to communicate with users, and to understand, analyze and determine the needs of database users (including data collection and processing);

Conceptual structure design: to make synthesis, induction and abstraction of user's requirements, and to design a conceptual model independent of specific DBMS;

Logical structure design: to transform conceptual structure into data model supported by DBMS;

Database physical design: according to the logical data model, to design the most suitable physical structure for the application environment (including storage structure and access method);

Database implementation: according to the logical design and physical design scheme, DBMS database language, tools and so on are adopted, to establish a database, to write and debug applications, to import data to the database, and to make pilot run test;

Database operation and maintenance: database application system, after trial operation is successful, will be put into operation, and in the process of running, the system is evaluated, adjusted, and modified [9].

The database user table is shown in Table 1.

The data table of the database is shown in Table 2.

4.2. System topology structure

The water environment quality monitoring system chooses the browser/server (B/S) structure software architecture, namely browser and server structure. In the B/S structure, the user interface is implemented on the browser, the main transaction logic is implemented on the server, and the server side accesses the database. The biggest advantage of the B/S structure is that the system only needs a computer that can access the Internet when it is operating anywhere. It does not need to install any software specially. It can work with the browser of the computer itself, and the client is maintained as zero. The system extension is also very convenient, and a user name and password can be assigned by the system administrator to use [10].

4.3. System software function

4.3.1. Map navigation

Map navigation site is displayed on the real map by icon. After clicking the icon of the site, it pops up the suspended window to display the latest data of the node. For this, open the water environment monitoring system website and click

Table 1
User information

Field name	Data type	Whether to allow blank	Instructions
ID	int	NO	ID automatic gain
User Name	varchar(50)	Yes	username
User Password	varchar(50)	Yes	password
Role	varchar(50)	Yes	Character
Limit	varchar(50)	Yes	Permissions
Area	varchar(50)	Yes	Jurisdiction
Email	varchar(100)	Yes	E-mail

Table 2
Water data

Field name	Data type	Whether to allow blank	Instructions
ID	Int	No	ID automatic gain
Area	varchar(50)	Yes	The Area to which the site belongs
Site	varchar(50)	Yes	Site name
Monitor Time	datetime	Yes	Get data time
Equipment Power	varchar(50)	Yes	Battery power
PH	varchar(50)	Yes	PH value of water quality
Under Temperature	varchar(50)	Yes	Underwater temperature
Up Temperature	varchar(50)	Yes	Water surface temperature
Humidity	varchar(50)	Yes	Air humidity
Rainfall	varchar(50)	Yes	Rainfall
Turbidity	varchar(50)	Yes	Turbidity
Conductivity	varchar(50)	Yes	Conductivity
Dissolved	varchar(50)	Yes	Dissolved oxygen
ORP	varchar(50)	Yes	Redox potential (ORP)
Receive Data	varchar(MAX)	Yes	Received raw data
Water Level	varchar(50)	Yes	Water level
State	varchar(1)	Yes	0 is failure, 1 is successful

on the site map navigation on the left of the page. In the site map navigation page, it can display the field satellite images, click the star icon of the node, and the latest data of the node and the node state are displayed.

4.3.2. Data query

Water quality timing query: in the water quality timing query, input the query time and data type, and set the frequency of the server to node remote monitoring data. For this, open the water environment monitoring system web site, click on the water quality timing query on the left side of the page, and click and add timing instructions. In the timing command window, we can choose the timing query data interval, and set the week, time period and monitoring command. The time interval chosen is different, and the time interval of web query data is also different. The monitoring command selects query and monitor photos or monitor data.

4.3.3. Real-time query of water quality data

In the water quality data query, the monitoring node can be selected for real-time remote monitoring of hydrological data, and the data will be displayed in the data query list after returning. For this, open the water environment monitoring system web site, click on the water quality data query options on the left side of the page, and then click on the real-time data query options. In the pop-up window, choose the name of the monitoring station and the corresponding test items, and click OK to make real-time data query for the selected projects.

4.3.4. Historical query of water quality data

Through the choice of node type and time range, complete the historical data query in the time period. For this, open the water environment monitoring system, click on water quality data query options on the left side of the page, and then click on the historical data query options, and select and the time of the query and the monitoring station in the pop-up window. The display can choose forward or reverse display, and click OK for historical data query of the selected items.

4.3.5. Data analysis

According to the selected time and data type, draw the linear graph and histogram of the data of multistation in the time period. For this, open the water environment monitoring system website, and click on data chart analysis on the left side of the page. In the analysis page of the chart data, we can select one of the data in the attribute view to view the changes of the numerical data. In the types of graphics, we can select a linear graph or histogram for related data view.

4.3.6. Forewarning management

When the data exceeds the warning threshold settings, the device will send alarm messages to the set mobile phones. For this, open the water environment monitoring system, and click on early warning information management on the left side of the page. In the early warning information management page, click on the newly added warning information. In the monitoring site name, choose WSN master node, and set the battery range, pH range and turbidity range. When it is beyond the scope, the system will alarm automatically by sending text messages to mobile phone users set in advance.

4.3.7. SMS management

By inputting the name of the station, inquiring the data type and connecting the mobile phone number, the alarm data type and the mobile phone number of the receiving center can be set up. For this, open the water environment monitoring system, click on SMS user management on the left side of the page, and then click add SMS users. In the monitoring site name, choose WSN master node and set the SMS query user permissions, data types and query instructions on the page. The user can, through the message, conduct relevant query and setting of system parameters and system state. For example, we can send commands through SMS to set up the server port, and also can send messages to restore the system.

5. System test

5.1. Selection of test field for system test

Qingshan Lake is located in the northeast of Nanchang city corner, north of Ganjiang River, which was the Ganjiang River in history. After great dyke (later became an independent city flood control dyke) is the largest lake in the city. Qingshan Lake is wide in north and narrow in south, which is a typical cattle choke Lake (bow type). North and South length is nearly 3.6 km, East and West length is nearly 1.5–2 km, water area is 4,600 acres, and land area is 2,000 acres. Because Qingshan Lake in Nanchang is located in the city of Nanchang, it is an important ecological area in Nanchang city. It is also a tourist leisure scenic area, and flood control and drainage area. It has important ecological function, people's livelihood function, public welfare function and flood control function. Therefore, it is very necessary to monitor the water quality of the water body.

This topic selects Qingshan Lake as the test site of water quality monitoring system, for installation, deployment, operation, testing and monitoring system. Selecting Qingshan Lake as an experimental site, the deployment of monitoring system can not only play a certain role in monitoring the water environment of Qingshan Lake but also facilitate the installation, deployment, testing and maintenance of field monitoring equipment by the researchers.

The monitoring system selected the sensors of pH value, water conductivity, water dissolved oxygen, water temperature, air humidity, air temperature, rainfall and other parameters to monitor Qingshan Lake. Because the water surface of Qingshan Lake is vast, and the solar charging technology is very mature, this project will choose the positions with vast Qingshang Lake and no shelter from buildings or trees for the monitoring node equipment of installation and monitoring system.

According to the principle of reasonable and effective water quality monitoring, stable and reliable wireless communication, convenient installation and maintenance, beautiful deployment of equipment, secure equipment (natural and human factors) and other principles, we research and develop installation and deployment programs and security measures of the monitoring equipment.

5.2. Test results and analysis of wireless communication

The system uses wireless communication technology from network coordinator, routing node to sensor node. According to the field exploration, the spectrum analyzer is used to test, analyze and troubleshoot the wireless signal strength. Finally, the layout scheme is determined. After the field wireless signal communication test is carried out for 1 week, it is found that there are severe wireless signal interference in some places, resulting in weak radio signal intensity of the system. Some of the buildings also have interference on the wireless signal. In the process of layout design, we choose to avoid places with strong signal interference, and try not to pass through the building for wireless communication.

Point to point effective transmission distance test: The test time is about 1 week, and the test objects are ZigBee TTL module and ZigBee485 module.

ZigBee module communication stability test time is 2 d; the ZigBee module BER testing method detects whether the connection required time will cause packet loss phenomenon, and the test time is 4 d. The test method between the ZigBee module communication strength and distance is the comparison table between the statistic of communication intensity and distance, and the test time is 4 h. ZigBee communication signal is affected by the weather, and the test method is to test the signal in a rainy day, and the test time is 2 d [11]. The above test also samples 232 serial line and notebook computer.

After a week's testing, the statistical data are summarized, as shown in Table 3.

The test statistics show that ZigBee TTL and ZigBee 485 can realize stable communication between each other. Due to the interference of actual environment, such as buildings, other neighbouring bands, and the same frequency radio interference, the communication distance, compared with the theory of communication distance, is decreased. In addition, when the test board uses ZigBee 485 module, it needs RS485 converter to realize communication with the computer. The converter may cause error data with very low probability. The weather will also have a certain impact on the communication distance.

The minimum transmit power test based on effective transmission distance: The setting of wireless module transmission power has two sides. On the one hand, based on meeting the basic requirements of the normal communication, we try to reduce the transmit power. On the other hand, in some cases, in order to ensure the quality of communication, mobile phone transmission power must be large. In consequence, in the choice of wireless module power, it is necessary to consider both low power consumption of

Table 3
Test statistics

Test points-child nodes Test conditions	Close-range stability test	Bit error rate	Field communication distance	Rainy day communication situation
ZigBee485-Zigbee485	Stable communication	Very low	80 m	60 m
ZigBee485-ZigBee TTL	Stable communication	Very low	80 m	60 m
ZigBee TTL-Zigbee485	Stable communication	No	80 m	60 m
ZigBee TTL-ZigBee TTL	Stable communication	No	80 m	60 m

module and stable reliability of communication. We select the ZigBee module of 50 and 100 mW for testing (in sunny day), as shown in Table 4.

Because the system adopts the data transmission mode of ad hoc network, it can select the small power wireless module to meet the communication requirements under the premise of ensuring the stable communication of each node. In this way, it can save power consumption and nodes can work longer, so we choose the 50 mW ZigBee module.

5.3. System accuracy test

The overall construction diagram of the system is shown in Fig. 7.

The system is completed by the network coordinator and it operates the display terminal data transmission and instruction transmission. Through the terminal control of the operation of the sensor nodes, it reads the data parameters in the terminal, so as to achieve the purpose of remote monitoring [12]. The system accuracy test results are as follows:

System conductivity: measurement range: 0–2,000 uS/cm; basic error: ±0.5%F + S.

System dissolved oxygen: measurement range: 0.2–25 mg/L; basic error: ±0.2 mg/LF + S.

Table 4
Test statistics

Distance power	50 mW ZigBee module	100 mW ZigBee module
5 m	Stable communication	Stable communication
10 m	Stable communication	Stable communication
20 m	Stable communication	Stable communication
50 m	Stable communication	Stable communication
80 m	Stable communication	Stable communication
100 m	Unstable communication	Stable communication

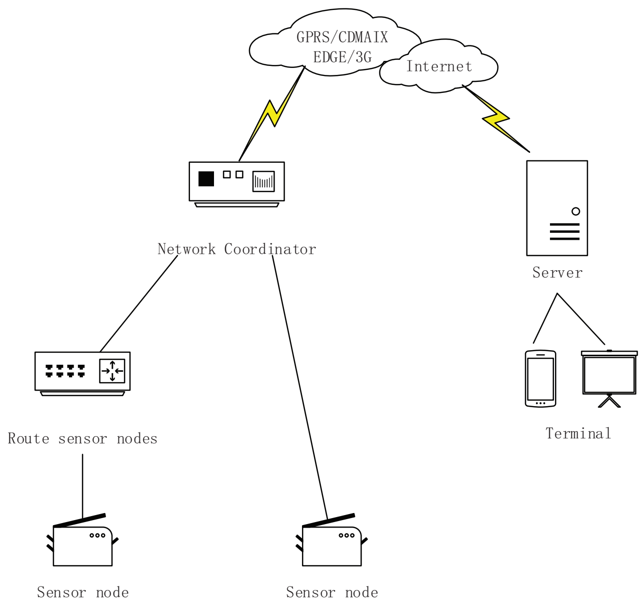

Fig. 7. System overall construction plans.

System ORP: measurement range: –1999 to +1999 mV; basic error: ±2 mV.

System PH: measurement range: pH 0–14.00; basic error: ±0.01.

All instruments have the function of temperature compensation and it reduces the system error; we use RS-485 interface digital output to ensure that the transmission process will not produce errors.

In practical application, through repeated measurements, the instrument data will be compared with the data collected, which did not appear error. The data acquired is consistent with the instrument data. And in order to prevent possible errors when using continuous acquisition instrument, we read three times and take the average value as the final results stored and uploaded in the data processing.

Through testing, it is determined that the error of each parameter is within the effective range. According to the actual situation of the field, the measuring range and measurement error of each instrument can be determined, which meets the field test requirements, and the sensor can accurately measure the data.

5.4. System maintenance scheme

System maintenance includes front-end equipment maintenance, server background maintenance and user web terminal maintenance.

A staff monitors the equipment work situation. When the equipment power supply is insufficient, we replace the battery of the node ZigBee module; when the equipment is not normally working, we will go to the field for troubleshooting and equipment maintenance.

We provide background technical personnel and we are responsible for data command receiving and processing, to ensure the connection of equipment DTU and server, and database management.

We also provide technical personnel to control the operation of web pages, display real-time data and historical data and optimize the user interface.

6. Conclusion

This paper designed the water information monitoring system based on wireless sensor technology (ZigBee). The overall system architecture, hardware system and software system were described emphatically. In addition, we chose the water quality of Qingshan Lake in Nanchang to test wireless communications test and accuracy test. For the whole hardware and software, the system made field-related function testing and inspection, and simulation verification is made. The test results show that the system can work stably in the harsh environment, and make real-time acquisition of water quality monitoring data through the wireless network to transmit to the monitoring center. As a result, it improves the reliability of water quality monitoring and timeliness of water quality forecast and warning, expands the water area monitoring and greatly reduces the construction cost of monitoring system. It can meet the actual requirement of water multi-parameter monitoring, and has broad application prospects. This research conforms to the development trend of environmental monitoring automation, intelligence and networking, and has the advantages that traditional technology does not have.

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