Software development for water quality's monitoring centre of wireless sensor network

Liang Li*

Jiangsu Institute of Commerce, Nanjing, Jiangsu, 211168, China

Received 12 May, 2014, www.cmnt.lv

Abstract

Water quality's monitoring centre software of wireless sensor network is designed through applying C#.net and SQL database technology. The monitoring and querying of sensor node data is realized through adopting C/S (Client/Server) pattern. Standard structured query language (SQL) and ADO.NET database access technology are adopted to realize the rapid operation and efficient management on database. Graphical interfaces could display the topology and node status of sensor network, as well as the real-time and history parameters collected by each sensor node and so on. The practice has proved that this software could satisfy the data collection, as well as monitoring and management requirements of wireless sensor network monitoring system.

Keywords: wireless sensor network, water quality parameters, database, c#.net

1 Introduction

Traditional methods of water quality monitoring mainly contain following 2 points: (1) Record analysis is performed through artificial sampling laboratory or data collection is made through adopting portable monitor. (2) Automatic monitoring station of water quality is constructed .The former has low sampling frequency and intense automatic monitoring station; it could not reflect the continuous dynamic changes of water environment. The latter has high investment cost and long construction period. Laying cable and land acquisition for constructing station have influence on the environment of tested waters. In recent years, as the rapid developed technology of wireless sensor network has advantages of flexible node configuration, rapid ad-hoc network, low cost and low power consumption etc, they are very suitable for monitoring outdoor environment parameters [1, 3]. Through aiming at the requirement of wireless sensor network's water quality monitoring system, this paper has developed water quality monitoring centre software on the basis of wireless sensor network technology. C#.net and SQL database have developed water quality monitoring centre software, which is linked with wireless sensor network, and realize network status monitoring, storage of water quality parameters measured by each node and real-time dynamic display. Meanwhile the alarm level of water quality status is set up according to the anomaly degree of data .Control strategy is collected in accordance with corresponding parameters ,by which to realize the requirements of intelligent sampling and security control.

2 Introduction of wireless sensor network

Wireless sensor network [1] (Wireless Sensor Network, WSN) is composed of sensor nodes in different function and quantity, and it has wireless self-organizing ability. The sensor node has wireless communication module, sensor unit, data processing unit and power module etc. Each acquisition node which is dispersed in examination area of wireless sensor network obtains corresponding environmental monitoring data through sensor, such as temperature and humidity, light intensity, and pressure etc. Then corresponding computing process is performed on collected data, and these sensors have the ability of communicating information with their neighbour nodes at the same time [2, 3]. A typical system architecture in wireless sensor network is shown as Figure 1. We could see clearly from figure that it is composed of sensor node, PC computer, aggregation node, Internet or satellite network and task management node.

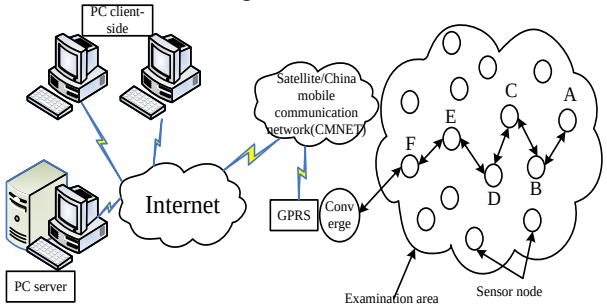

FIGURE 1 Typical architecture of sensor network system

Generally speaking, sensor nodes have relatively weak ability of processing and storing collected data due to its characteristics of structure miniaturization, and

* ***Corresponding author*** e-mail: llliliang_1@163.com

communication capability is also restricted by that[4]. Its main function includes (1) taking charge of obtaining the data information in physical environment. (2) Routing function. It stores the data forwarded by other nodes, performs integration, management and processing. (3) Accomplishing task with other task collaboratively [5]. Integrating node ability of processing, storage and communication is stronger relative to the sensor nodes; it does not needs the ability of physical environment data as sensor node. Its responsible task contains (1) connecting with sensor network through wireless approach, the collected sensor data would be passed on to external network (PC computer) through wireless network cable or network with high reliable communication quality (PC computer). (2) The detection task of management station equipment (it is generally PC computer) would be sent to sensor nodes .As the scale and the covering scope of wireless sensor network is not restricted, intensively distributed sensor could be composed of various sensor, and it has characteristics of miniaturization and micromation. The overall network is self-organizing and reliable, and it could be used in unattended, extremely hostile environment due to its advantage of taking the data as the core.

Wireless sensor network has changed the traditional interactive mode between human and environment. As a kind of comprehensively new method of information acquisition and processing method, it has been widely applied in human activities, such as intelligent furniture and intelligent living environment [6], medical health monitoring and treatment [7], urban transportation and so on in various fields. For example, corresponding number of wireless sensors could be deployed in the place which is easy to occur forest fire for detecting the real-time information in this region, the feedback information could effectively avoid and reduce the loss of human being. Wireless sensor network could also monitor the change of climate and soil environment in farmland, farmers could ensure the crop harvest through timely taking appropriate measures according to this information.

3 The water quality monitoring system construction of wireless sensor network

Water environment monitoring system of wireless sensor network is shown as Figure 2, it includes wireless sensor networks and data monitoring centre. Wireless sensor network installed on the monitoring waters is composed of various water parameters' sensor nodes (sensor node), wireless router nodes (routing node) and aggregation node (sink node) with the capacity of sensing, computing and transmitting wireless data, IEEE802.15.4/ZigBee protocol is adopted to realize self-organizing network between nodes, the quantity of sensor nodes and routing nodes could be set up according to the actual size and monitoring requirements of measured area. Sensor nodes adopt the construction approach of embedded technology, which could configure sensors like temperature, PH value, DO (Dissolved Oxygen) and so on. Local processing is first performed on the data collected by sensor node, distributed measurement data of various sensor node would connect with data monitoring centre through the approach of asynchronous serial mode or GPRS remote communication way after simple processing at aggregation node. The monitoring centre software receives the wireless sensor network packets sent by aggregation node, and the data would be stored in database after analysis and processing. Analysis result will be represented in the form of graphic interface through analysing data. At the same time, comparison among the data received this time, history data and water quality standard data stored in database are performed to determine whether the data is reasonable and abnormal change would occur or not. Abnormal warning level of water quality status is set up according to the abnormal degree, and control strategy would be gathered according to corresponding parameters [8].

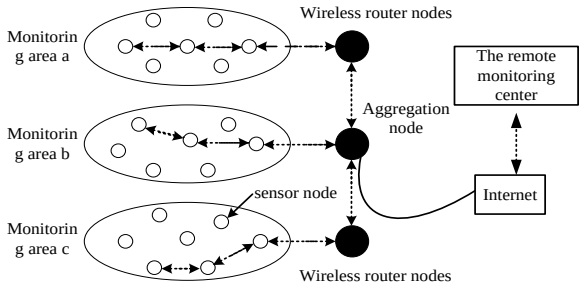

FIGURE 2 Structure of water quality monitoring system in wireless sensor network

4 Function modules of data monitoring center software

As the system shown in Figure 2, the sensor nodes send the collected data through adopting ZigBee protocol based on the triggering mode of combing timing and events. Sink nodes send the data to local monitoring centre in real time through RS232 serial port trunk, the monitoring centre receives and makes analytical processing on the data sent from Sink nodes, send it to local database for storage or remote client-side through Internet, and answer the query from users or application. Compared with the information collection system constructed by B/S (Browser/Server) [9], such C/S (Client/Server) query mode has gotten rid of the frequent confirmation time of sensor network node during customer search, and avoid network congestion etc when simultaneously sending a large number of sensing information, it has the characteristic of fast response speed and strong real-time property.

Data monitoring centre software requires to realize following function: (1) monitoring the serial port, node acquisition parameters, node state, node residual energy, network topology and other information would be obtained from Sink nodes. (2) Check, parse, store and chart shows will be performed on the received data. (3)

Updating, management and maintenance of database (4) Management function of client user: querying and displaying network status, querying and printing node data or history data in certain period of time etc. (5) Analysis, judgment and evaluation would be performed on the water environment of monitoring area through combing with water quality standard database. (6) Parameter settings and system synchronization: such as sampling interval, alarming threshold, releasing synchronization information of system time etc. When performing system's functional division, data would be taken as the main line, modular design method would be adopted to divide the whole procedure into serial port communication module, data processing module, database module, human-computer interaction module and so on, each module would complete the corresponding function. The monitoring centre software adopts C# language and SQL DBD (Database Design) under Visual Studi environment. The procedure flow charts of wireless sensor nodes are shown as Figure 3.

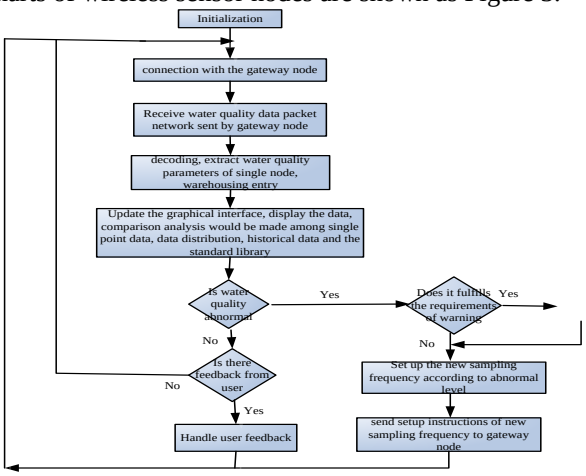

FIGURE 3 Program flow chart of wireless sensor node

5 Implementation technique of key function module

5.1 SERIAL PORT COMMUNICATION MODULE AND DATA PROTOCOL

Communication connection between monitoring centre software and wireless sensor network would be constructed first. Its process is as following: link order would be sent to sink nodes from monitoring centre software. Sink contains the topology information of wireless sensor network. After constructing communication connection, monitoring centre would send data acquisition order according to set acquisition interval. Sink nodes would send confirmation information to monitoring centre after receiving the connection instructions; such information contains the topology information of wireless sensor network. After constructing communication connection, monitoring centre would send the data acquisition order to aggregation node according to set sampling interval. After Sink nodes' receiving data collection order, it would send such order to the node broadcasting of wireless sensor networks, then wait to receive the node packets of each sensor node. After collecting the data package of all nodes, the data would be converged and integrated into network monitoring data packets and sent to monitoring centre. The application layer protocol data could be formulated according to the actual size and monitoring parameter of wireless sensor network.

The main frame format:

(1) Information data frame of wireless sensor network topology is composed of start code(1 byte), information source address (2 bytes), the number of nodes passing through the information (1byte), the passed routing number of information (10 bytes), check code (l byte), epilogue code (1 byte).

(2) The data collection command frame sent by monitoring centre is composed of starting byte (1 byte), slave computer address (1 byte), identifier (1 byte), sample time interval (2 bytes), check code (1 byte) and end byte (l byte).

(3) Parameter data frame of monitoring centre sent by Sink nodes is composed of start code (l byte), sampling time (6 bytes), node numbering (1 byte), and PH value (2 bytes), dissolved oxygen (4 bytes), temperature (3 bytes), and check code (1 byte), epilogue code (1 byte).

The design of serial port communication program applies serial port control, and it is composed of serial port setup, open port, sending command of serial port as well as reading data of serial port. The reading of serial data adopts interrupt mode. After monitoring centre has received data, check and parsing would be made on data package, useful data would be extracted and turned into displaying data at the end.

5.2 DATABASE MODULE

The design objective of database module is security (database storage structure would be of foreign shielding), universality (all kinds of data services would be provided externally through port), high efficiency (efficiency of data storage and query is enhanced internally). The main module has database structure design module, which mainly takes charge of building up backend database. The database management module takes charge of managing daily database, including establishment of the log, maintenance of the database etc. Database query and analysis module is used to optimize the query of big data table and enhance access efficiency etc.

(1) 1Database structure design

The design of database structure is the key of database module, it focuses on the design table structure and the relationship between tables, which is to store the possibly involved data and related information .In our system, database storage information could be divided into two types: data sheet and the information table. The data sheet is used to store collected data. Table of information is

used to store some basic information, such as temperature, PH, solubility.

(2) The storage and query of data.

This system adopts the technology of ADO. NET database access [10].ADO.NET has two core components: ADO.NET Dataset and ADO.NET Data Provider, namely the provider class (Provider) and the user class (Consumer). The provider class would accomplish the data source reading and write in etc, after the data is read to storage medium, function like access and manipulating of database would be completed by the user class.

The main code of reading data source and write in is as following:

StringContr=”DataSoure=CHINA-D3CD2701A\\SQLEX-PRESS; Initial Catalog=db1; Integrated Security=True”;//declare a string, it acts as linking data base ‘auditing the password’

SqlConnection conn=new SqlConnection(Contr);

conn.Open();//Open the connection channel;

System.Data.SqlClient.SqlCommand cmd=new System.Data.SqlClient.SqlCommand();

cmd.CommandType=System.Data.CommandType.Text;

cmd.CommandText=”insert into sensor(ph temperature,temperature,time) values(‘”+SteA+”’,’”+StrB+”’,’”+StrC+”’,’”+Time+”’);cmd.Connection=conn;

cmd.ExecuteNonQuery();//data would be placed into data base through performing SQL interposition predict

5.3 SOFTWARE FUNCTION INTRODUCTION

The main function of the software is briefly introduced as follows:

(1) Warning function: When there is some abnormity detected among temperature, PH, DO (Dissolved Oxygen), the system software will start alarm function immediately and send out a warning message to remind the staff of detection software centre, who could also start off-limit alarm button for sending out warning notice.

(2) Set sampling rate: changing sampling rate is to adjust the time scale of observation data. Under normal status, in order to reduce energy consumption, wireless sensor network could perform data acquisition with low sampling rate. When there is abnormality in parameters, the system would publish anomalous event, sensor node would increase sampling frequency, and then the resolution ratio of data would be enhanced.

(3) Synchronizing function: as the sampling frequency of system is not high, sampling interval is 1 minute at least, thus local computer clock is taken as master clock, and time synchronization information would be sent to other nodes in WSN through aggregation node at regular intervals, the transmission delaying between two nodes would be not more than 100ms and could satisfy the requirement of synchronization.

The monitoring centre software structure is shown as figure 4.

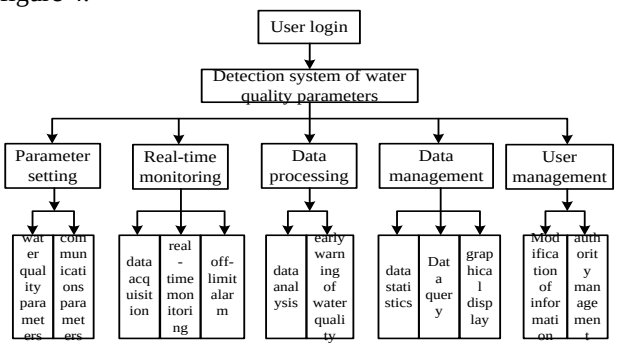

FIGURE 4 Structured flowchart of the monitoring centre software

5.4 THE TEST OF EXPERIMENTAL RESULT

PH value, temperature, dissolved oxygen degree in experimental design is shown as Table 1, the scope is within the range of pond water quality, the data collection interval is 1h. Specific design of experimental design is shown as Table 1, the results of wireless sensor network monitoring is shown as Table 2. The real time monitoring interface of monitoring centre is shown as Figure 5.

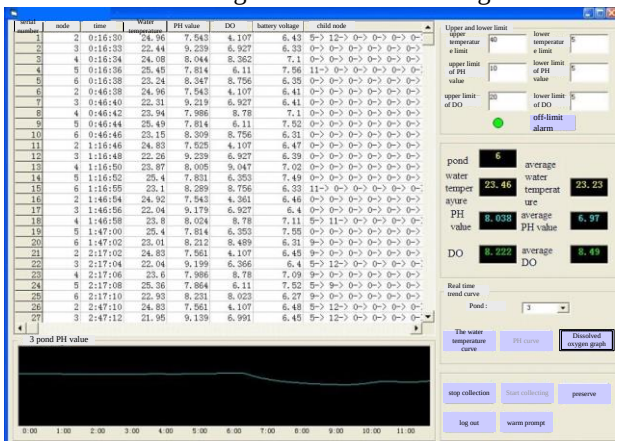

FIGURE 5 Real-time monitoring interfaces

TABLE 1 Artificial simulation test results

Number	1	2	3	4	5	6	7
PH	7.5	7.7	7.2	6.7	8.5	7.9	6.4
Temperature ℃	21	25	23	18	26	27	24
Dissolved oxygen degree %	19	16	27	21	23	14	17

TABLE 2 the actual test results

Number	1	2	3	4	5	6	7
PH	7.1	7.5	6.8	6.9	8.9	7.6	7.2
Temperature (℃)	23.5	26.8	24	19.4	25.4	28.6	23.7
Dissolved oxygen degree (%)	20.5	17.3	26.6	20.3	24.3	15.7	16.2

Comparison would be performed on the measured actual data and data from monitoring system, the relative error is limited within 5 %, thus the system has good quantitative detection performance.

6 Conclusion

This software has realized the collection of sensor node data through adopting the technology of wireless sensor network, serial port programming techniques and ADO.NET database access based on c# language. Graphical interface display is realized through Cl Chart module. Integrating this software and wireless sensors network at the front end could be applied in aquaculture water quality detection, and has obtained better detection effect. The water quality inspection system based on wireless sensor network could realize the online collection and safety inspection of real time data in two-dimensional space and time within certain water areas under low cost condition. This would provide a kind of reliable security technology for water quality analysis and management.

References

[1] Pattichis C S, Kyriacou E, Voskarides S, et.al. (2002) Wireless telemedicine systems: An overview *IEEE Antennas and Propagation Magazine* **44**(02) 143-5

[2] David E C, Hong W. et al 2004 Wireless sensor networks *Communication of ACM* **47**(6) 30-3

[3] Jiang Peng, Xia Hongbo, He Zhiye, et al 2009 Design of a Water Environment Monitoring System Based on Wireless Sensor Network *Sensors* **9**(8) 6411-34

[4] Liming Sun, Jianzhong Li et al 2005 *Wireless sensor network* Beijing: Tsinghua university press *(in Chinese)*

[5] Boqi Mai, Jiapin Chen et al 2009 Test platform of wireless sensor node's localization function *Computer Engineering and Design* **13** *(in Chinese)*

[6] Li J, Lazarou G, et al 2004 A bit-map-assisted energy-efficient MAC scheme for wireless sensor networks *The 3rd Int'l Symp. On Information Processing in Sensor Networks (IPSN04)*

[7] Xu Y, Bien S, Mori Y, et al 2003 *Topology control protocols to conserve energy in wireless ad hocnetworks*

[8] Sai Zou, Changming Liu, Faping Li, et al 2010 Water environment monitoring system based on wireless sensor network *Sensor and micro system* **29**(9) 104-9 *(in Chinese)*

[9] JieZhang, Weiren Shi, Qiaoling Tu et al 2009 Information detection system design based on wireless sensor network *Journal of transducer technology* **22**(6) 861-4 *(in Chinese)*

[10] Renpeng Sun 2010 Research for the application of ADO.NET under multi-layer mode *Computer Engineering and Design* **31**(16) 3621-4 *(in Chinese)*

Authors

Liang Li, born in 1976, Anhui Province of China

Current position, grades: lecturer
University studies: Master degree was earned in major of computer application technology, Southeast University in 2004.
Scientific interest: software engineering, data mining