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Design of Real Time Monitoring System for Rural Drinking Water Based on Wireless Sensor Network

Jieping Yu
College of Electronic Engineering
South China Agricultural University
Guangzhou 510642, P.R.China
489398737@qq.com

Huili Yin
College of Electronic Engineering
South China Agricultural University
Guangzhou 510642, P.R.China
76576676@qq.com

Weixing Wang(Correspondence author),
Sheng JiangCollege of Electronic Engineering
South China Agricultural University
Guangdong Engineering Research Center for Monitoring Agricultural Information
Guangzhou 510642, P.R.China
weixing@scau.edu.cn, jiangsheng@scau.edu.cn

Guohui Jiao, Zexin Lin
College of Electronic Engineering
South China Agricultural University
Guangzhou 510642, P.R.China
10353907779@qq.com, 995480993@qq.com

***Abstract*—With the continuous progress of rural construction, the problem of rural drinking water pollution is increasingly prominent. In view of water pollution, a design of rural drinking water monitoring system based on wireless sensor networks is proposed that nodes take STM32 as the core chip and WLK01L39 as well as its peripheral circuits are used as wireless communication modules and Beidou S1216 is used as GPS module to realize node localization. At the same time, the corresponding communication protocol and time synchronization algorithm are proposed. This paper have achieved automatic collection of water quality indicators, and uses GPRS network to achieve data upload. Experiments show the power consumption and data transmission performance of the system, and the packet loss rate is 6.2% when the communication distance of the system data is 150m in open area.**

Keywords-Water Pollution; Real-time monitoring; Wireless Sensor Network; Automatic acquisition; STM32

I. INTRODUCTION

With the rapid development of China's current economy, rural construction has been paid more attention to, and the process of rural modernization has been advancing. However, a series of environmental problems have followed[1-4].At present, there are three main problems in water quality monitoring in China. Firstly, the equipment in the water quality monitoring center is too old, and the allocation of large analytical instruments is inadequate, resulting in limited sampling and low monitoring frequency of the water quality monitoring center; Secongly, on-site monitoring capacity is lack; Last, water quality monitoring automation is not universal[5,6]. Therefore, a real-time monitoring system for water quality based on wireless sensor networks is proposed in this paper, which can remotely monitor water quality, ensure the real-time monitoring data, and effectively ensure the safety of rural drinking water[7，8].

II. OVERALL DESIGN OF WATER QUALITY REAL-TIME MONITORING SYSTEM

Indicators of water pollution include PH, dissolved oxygen, conductivity, turbidity, COD, BOD and so on[9].Water quality monitoring has many characteristics[10], such as large number of monitoring points, long monitoring time and complex monitoring environment. This system mainly consists of data acquisition node, convergence gateway and server monitoring center. Considering the characteristics of scattered points, the route forwarding node is also needed to avoid the loss of data acquisition due to the long transmission distance of nodes. The overall design of this system is shown in figure 1.

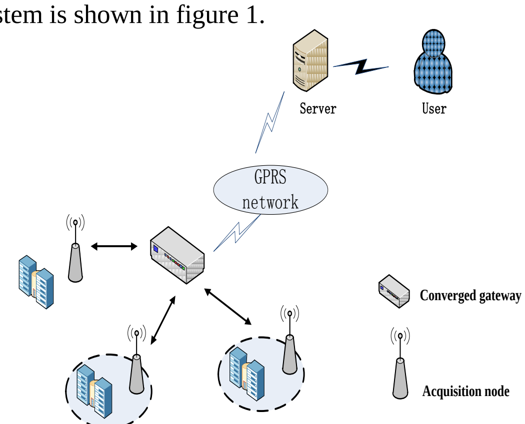

Figure 1. Overall design of system.

Data acquisition node is the foundation of the whole monitoring system. Acquisition nodes are distributed in monitoring waters, which are responsible for collecting water quality parameters and GPS location information which will be broadcast through the wireless module. The routing node is responsible for forwarding the received packets again, which can extend the data transmission distance between nodes, improve the stability of data transmission, and effectively reduce the packet loss rate. The converged gateway is responsible for connecting the server, obtaining the node number from the server, and the synchronization time. The converged gateway then uploads the received data from each node through GPRS, and then sends the synchronous packet to nodes to complete the synchronization of the whole wireless network.

The server is responsible for registering the number of nodes in the monitored area. When receiving the request of the gateway, it sends the matching node number and synchronization time to the gateway, and analyzes the data packet from the gateway. Finally, the relevant data is displayed in the monitoring center, which is convenient for users to query.

Different from traditional network systems[11], wireless sensor network have the characteristic of limited resources including limited power supply. The primary problem of wireless sensor network is the energy consumption[12].In order to prolong the life cycle of the whole network, the standby mechanism is adopted in the design. The data acquisition node and the gateway can complete the synchronization by using synchronous packets. After the end of the round, nodes and gateway will enter the standby mode to reduce the energy loss and prolong the life cycle of the whole network.

III. HARDWARE DESIGN

A. *Design of Acquisition Node*

According to the actual needs, the structure of wireless sensor network will vary, but it is usually composed of sensor unit, data processing unit, power supply and data transmission unit[13].

In this design, the acquisition node takes the STM32 microprocessor as the core, and collects the water quality parameters via sensors. The system uses Five Probe Sensor produced by Shanghai Jingji scientific instrument. The sensor can control the sensor to collect data by sending instructions, so it is convenient and efficient. If there is no location information corresponding to the data, the information is of no value[14],so the node is equipped with GPSS1216, which can be accurately positioned. At the same time, the data acquisition node has wireless communication module WLK01L39, which has low power consumption and long communication distance. On the premise of maximum transmit power, the communication distance of outdoor open area can reach 500m.The power module uses 12V large capacity lithium polymer battery to continuously supply power for all modules. The structure of the acquisition node is shown in figure 2.

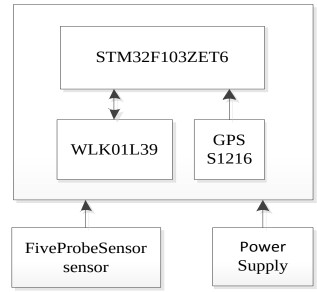

Figure 2. Design of acquisition node.

B. *Design of Converged Gateway*

The converged gateway is the center of the whole network. In addition to the GPS positioning module and wireless communication module, the convergence gateway is also equipped with GPRS module, which can connect to the server remotely, upload data and receive relevant information from the server. The converged gateway structure is shown in figure 3.

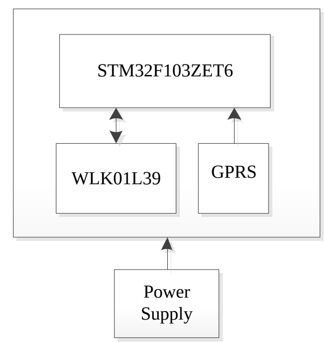

Figure 3. Design of converged gateway.

IV. SYSTEM SOFTWARE DESIGN

A. *Software Design of Acquisition Node*

The acquisition node is the terminal node of the whole network system. As shown in Fig. 4,the nodes performs GPS positioning, and then wait for the node matching packet from the gateway to determine the node network to which it belongs. The nodes wait for the synchronization packet to complete the time synchronization. After synchronization with the network, the water quality parameters are collected and encapsulated into packets, which are then sent out via a wireless module. When the standby time comes, the nodes enter the standby mode with the whole network, which can save the limited energy of nodes and prolong the working cycle of nodes.

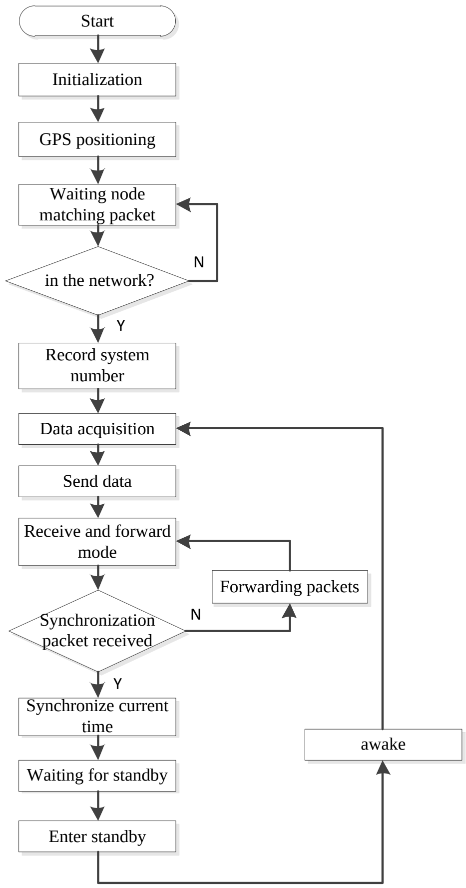

Figure 4. Software design of acquisition node.

B. *Software Design of Routing Node*

In wireless sensor networks, communication among nodes is easily affected by topography such as mountains, buildings and other obstacles[15], so nodes are easily separated from network. To ensure good transport performance, routing nodes are essential. The routing node is responsible for forwarding data packets from nodes and synchronous packets from the gateway. Routing forwarding nodes are shown in Fig. 5,which will be automatically set as forwarding mode after being awakened. When the standby time comes, the nodes enter the standby mode with the whole network, which can save the limited energy of nodes and prolong the working cycle of nodes.

C. *Software Design of Converged Gateway*

The converged gateway is shown in Fig. 6.The main tasks of the converged gateway including making and transmitting the node matching packets and the time synchronization packets and uploading the data from nodes. The gateway attempts to connect to the server after it is switched on. If the gateway successfully connects to the server, the server will return relevant information including node matching number, current time and a preset standby time. The gateway analyzes the received information from the gateway, makes node matching packets and synchronization packets, and then sends them out via wireless module.

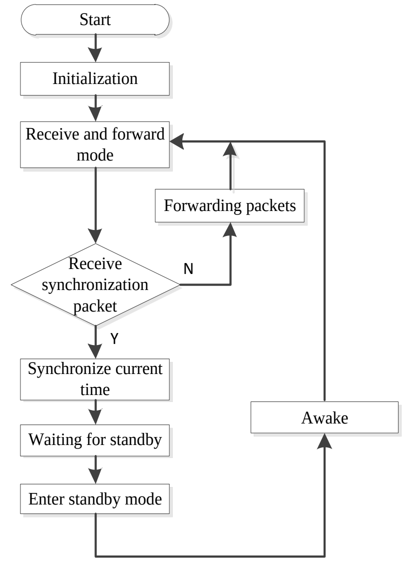

Figure 5. Software design of routing node.

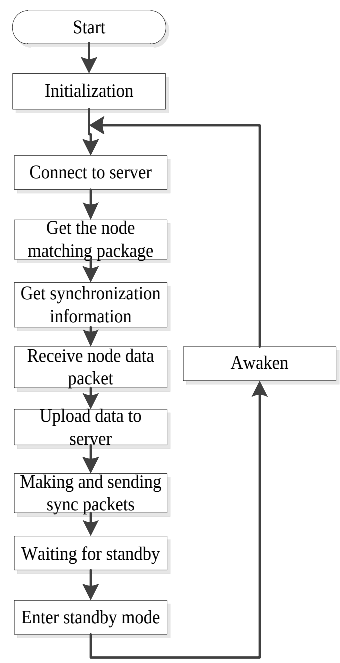

Figure 6. Software design of converged gateway.

V. EXPERIMENTAL RESULTS AND ANALYSIS

To test the power consumption of the system, an experiment was conducted at Hongze Lake in South China Agricultural University, which used a node and a gateway. Both the node and gateway are powered by 6800mAh batteries. The system continues to operate without replacing the battery. The node wakes up every 30 minutes and then works for about 40 seconds. The system started at 20:20 on December 10, 2016, and stopped uploading data at 16:40 on

December 21, 2016, running for about 11 days.In this process, a total of 520 packets were sent, 518 packets were actually received .Test result shows that the packet loss rate is0.38%. The actual test gateway is shown in Fig. 7

Figure 7. Monitoring site

Fig. 8. shows a partial record of the actual monitoring data.

电导率	PH值	温度	溶解氧	时间
3.68	8.43	20.02	7.9	2016/12/13 11:55:27
3.69	8.46	20	8.09	2016/12/13 11:25:35
3.67	8.42	20.04	8.83	2016/12/13 10:55:31
3.67	8.34	20.01	7.9	2016/12/13 10:25:31
3.68	8.28	19.88	7.9	2016/12/13 9:55:29
3.68	8.29	19.81	7.9	2016/12/13 9:25:24
3.67	8.28	19.72	6.91	2016/12/13 8:55:22

Figure 8. Recording of experimental data.

In order to test the stability of the transmission performance of the system, the test of packet loss rate of outdoor data transmission was carried out in Huashan stadium, South China Agricultural University, Guangdong Province. Without using the routing node, we selected the open area, sent a test data to the converged gateway every 5 seconds, and then counted the number of packets received. The test results are shown in table 1.

TABLE I. TRANSMISSION PERFORMANCE TEST

Distance	Number of data sent out	Number of data received	Packet loss rate
50m	500	500	0
100m	500	499	0.2%
110m	500	494	1.2%
130m	500	485	3%
150m	500	469	6.2%
200m	500	443	11.4%

VI. CONCLUSION

A real-time monitoring system based on wireless sensor networks is designed in this paper. In this paper, the whole structure of the system is described in detail, and the hardware design and software flow analysis are described, and the system operation and transmission performance were tested accordingly, which is of great significance in water quality monitoring. In the following design, it is necessary to do more in-depth research on the node energy consumption, networking methods and so on.

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