Design of Monitoring System for Rural Drinking Water Source Based on WSN

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Abstract*—In order to solve the existing traditional rural drinking water monitoring in a lot of manpower, material resources, real-time, this paper introduces a WSN based on the rural drinking water source monitoring system design, the system consists of five parts: water quality monitoring, soil monitoring node node, node, routing node and gateway server. Water quality monitoring node, soil monitoring nodes send the collected data to the gateway node through the wireless module sent directly, or through the routing gateway node to the gateway node, each node of the data collection, unified by the GPRS module to upload server. The system can periodically detect the water quality and the important indicators of the soil in the rural water sources, and combine the water pollution with the soil non-point source pollution to realize on-line monitoring and provide guidance for pollution control. Network test shows that the designed system can realize data acquisition and remote transmission, stability, range of dissolved oxygen system for 1.09%~1.86% acquisition error, pH error is in the range of 0.64%~1.68%, Cu concentration in the range of error is 1.98%~2.22%, Cu concentration in the range of error is 1.58%~ 2.01%.

Keywords-Wireless sensor network; Water quality monitoring; Soil monitoring; Rural drinking water; Water source

I. INTRODUCTION

Wateris the source of life, a direct impact on human health. In rural areas, due to the lack of safety awareness and professional knowledge, the lack of attention to the safety of drinking water, agricultural great significance to the accelerating of the agricultural production process using pesticides, fertilizers, garbage, human and animal manure and other improper handling, often cause drinking water Or non-point source pollution of the soil in the water source [1, 2].

Domestic monitoring of rural drinking water is mainly concentrated in the process of drinking water for all aspects of sampling, so that artificial collection and then to the laboratory processing methods [3], need to spend a lot of manpower and material resources, and the existence of time difference, Could not determine whether the recent water pollution or long-term non-point source of water pollution caused by water pollution and so on limitations.

With the rise of Internet of Things, wireless sensor networks are widely used. Wireless sensor networks, nodes through the wireless channel connection, self-organizing network topology, collaboration between nodes, timeliness, with a strong flexibility[4, 5].

At present, wireless sensor networks are used in many water quality detection scenarios, but basically are focused on the monitoring of a single small-scale water [6-8], However, the water quality and soil linkage of rural drinking water sources proposed in this paper can not only detect water and soil pollution in a large scale and real time, but also play a guiding role in governance.

II. SYSTEM STRUCTURE

The overall framework of the system as shown in Fig .1, in the drinking water source to deploy water quality testing nodes, soil detection nodes and gateway nodes. The gateway node has a timer, the timer will wake up the monitoring node, and the gateway waiting for all monitoring nodes to upload data; water quality and soil nodes on the sensor to collect data through the wireless sensor module to the gateway node; gateway to confirm all monitoring nodes Have been uploaded after the data, notify the monitoring node to sleep and the monitoring node data through the GPRS module upload background server.

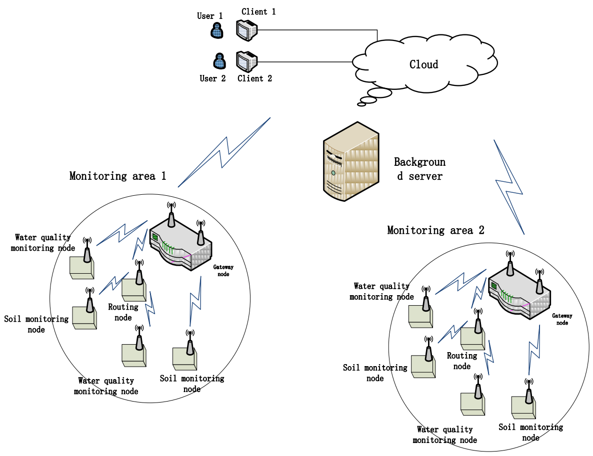

Figure 1. System block diagram

III. SYSTEM HARDWARE DESIGN

A. Water Quality Monitoring Node

The water quality monitoring node is composed of a processor module, a sensor module, a GPRS module, a wireless communication module, a power supply module and a solar charging module. The hardware structure is shown in Fig .2.

Water quality monitoring node usingSTM32F103VET6 processor module to do the main control center, the chip has low power consumption, high stability, real-time strong, cost-effective features, can achieve equipment management, task scheduling, data fusion processing [9].

As the water source is generally wide area, and the requirements of the power supply is more demanding, so the choice of wireless communication module WLK01L32 as a hub between the routing node, the module power consumption is low, in the receiving mode, the current is about 8mA; Point-to-point send and receive time is 20ms ~ 30ms; transmission distance, open ground up to 2km; and support for wireless wake-up function [10], for our system is very suitable.

The ATK-S1216F8-BD positioning module is used to obtain the GPS position of the water quality monitoring node, which is a high performance GPS / Beidou dual mode positioning module, which is small in size and has FLASH and backup battery inside. It can be kept within half an hour Ephemeris data, support TTL level, can be directly connected with STM32F103VET6 serial port [11].

Taking into account the lack of rural drinking water supply conditions, the system uses battery-powered and designed solar charging module, the battery power toadd.

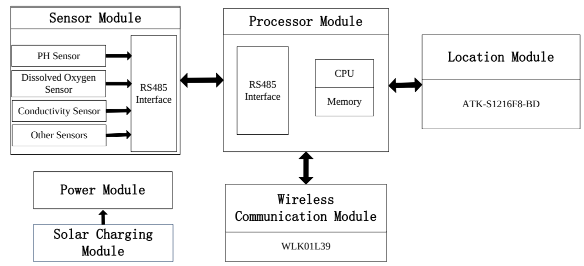

Figure 2. Water quality monitoring node hardware block diagram

It is very important to dissolve oxygen, pH, ammonia, phosphorus and other heavy metal ions in rural drinking water. The system uses ASI's water quality ion selective electrode series sensor probe to collect dissolved oxygen, pH, conductance Rate, ammonia, copper ions, cadmium ions and zinc ions, the physical sensor shown in Fig. 3, the sensor collected data, through the RS485 conversion module to transfer data to the processor module, the processor module to send data packets sent by the wireless communication module To the gateway node, or through the routing node forwarded to the gateway node.

Figure 3. Sensor physical map

B. Soil Monitoring Node Nodes

The soil monitoring node is composed of a processor module, a sensor module, a wireless communication module, a GPRS module, a humidity supply module, a power supply module and a solar charging module. The hardware structure is shown in Fig. 4.

Considering the monitoring of soil contamination, the sensor needs to be buried in the soil, and the system uses a five-in-one integrated sensor that monitors temperature, pH, conductivity, copper ions and cadmium ions.

The system selected sensors are required for soil moisture, thus increasing the humidity sensor and humidity supply module. The humidity sensor uses Star et al. CSF11 soil moisture sensor, the sensor operating current less than 50mA, the response time of 1S, in the water range of 0-100% error is ± 2%. When the detection of soil moisture is insufficient, the CPU will call the humidity supply module to add moisture to the soil, humidity supply module mainly by the control circuit, solenoid valve and distilled water supply device.

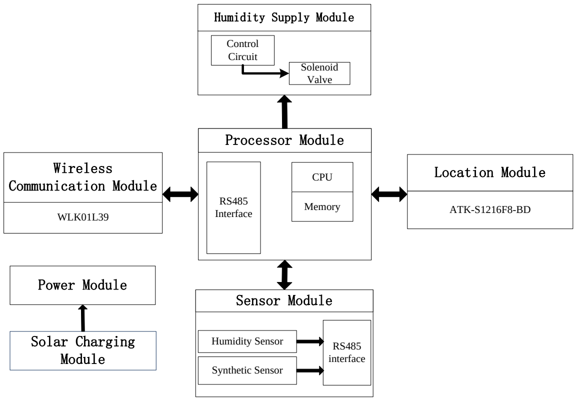

Figure 4. Hardware Block Diagram of Soil Monitoring Node

C. Routing Node

In order to reduce the packet loss rate and improve the robustness and reliability of the network, the routing node is added to the monitoring node and the gateway node. The role of the routing node is to forward the packet from the monitoring node to the gateway node. As shown in Fig .5, the routing node consists of a processor module, a wireless communication module, a positioning module, a power supply module and a solar module.

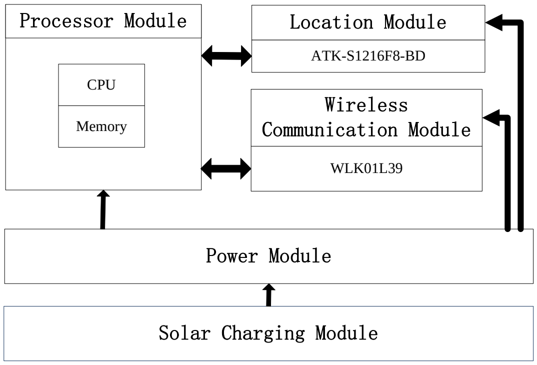

Figure 5. Routing node hardware block diagram

D. Gateway Node

As shown in Fig .6, the gateway node consists of a processor module, a wireless communication module, a GPRS module, a display module, a data memory, and a power supply module.

Taking into account the actual needs, in the gateway node to increase the display module and data memory, so as to monitor the data can also be observed changes. Display module main LCD capacitive screen and key module, through the key module to control the LCD screen and flip the screen and other functions. With the SD card as the primary external data memory power-down cause data loss.

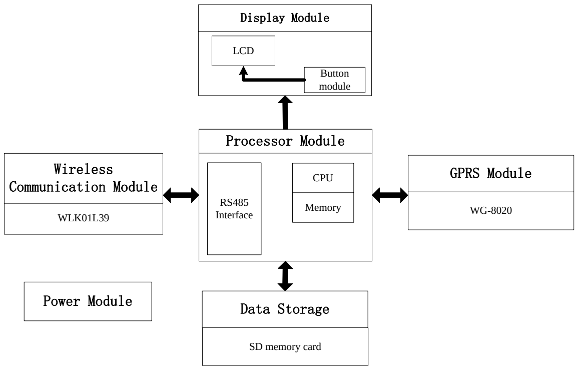

Figure 6. Gateway node hardware block diagram

IV. Software Design

A. Monitor the Node Program

Monitoring node program flow shown in Fig .7, the node starts to determine whether the first boot, if the first boot waiting for the gateway to download the synchronization package, access to system time, node number and other information into sleep, if not the first The next boot is to collect the appropriate data and get GPS information packaged sent to the gateway, and then enter the sleep state to wait for the next wake up.

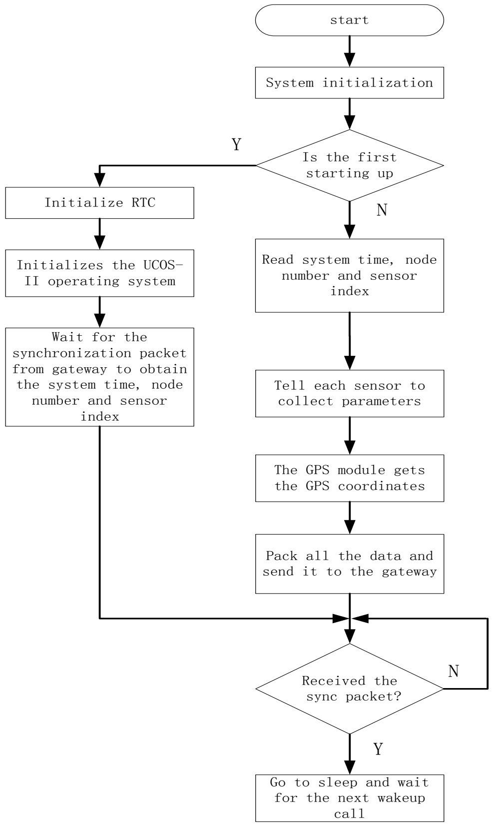

Figure 7. Monitors the node program flow

B. Gateway Node Program

Gateway node hardware program flow shown in Fig .8, the node starts to check whether the first start, if it is the first start from the server to obtain time and node information table, send the synchronization package to the entire network to synchronize the entire system Time and name the node number. The gateway node receives the data of the monitoring node to register the node number and save the data to the SD card. When all the nodes are set up or the set acquisition period arrives, the gateway node sends all the data to the upload server and sends the synchronization packet to all the nodes in the system.So that all nodes into the dormant state, after their own into the sleep state, waiting for the next wake up.

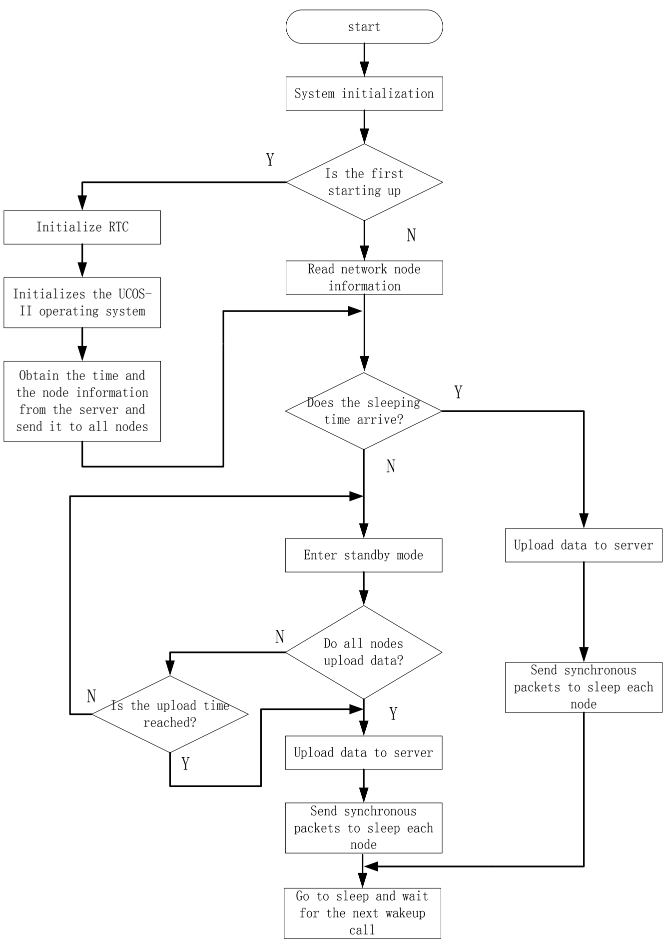

Figure 8. Gateway node program flow

C. Routing Node Program

Routing node program flow shown in Fig.9, the routing node to receive data packets to determine whether the packet has been forwarded, if not forward will record the packet information and forward, if the packet is discarded, received the gateway Synchronize the packet when the synchronization package forwarded automatically into the sleep state waiting for the next wake-up.

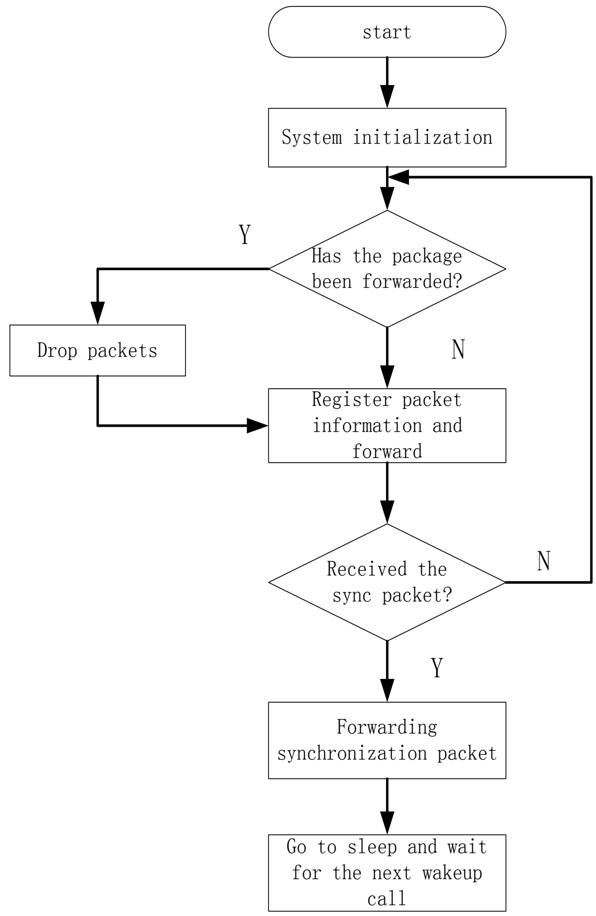

Figure 9. Routing node program flow

V. NETWORKING TEST RESULTS

The system selects South China Agricultural University the deployment of two water quality monitoring node, two soil monitoring nodes and two nodes, a gateway node of the network test, simulation tests were carried out for a period of three months, in order to ensure the accuracy of monitoring parameters of the system, each a week on water quality and soil sampling monitoring points to the professional laboratory testing, table 1 is pH, dissolved oxygen of water node 1 and the same time to collect comparative laboratory measurements, fig .10 and 11 respectively in January 1, 2017 to April 1, 2017 1 soil monitoring node of copper ions variation and soil monitoring node 2 cadmium ion change map. By contrast, the error range of the dissolved oxygen obtained by the system is 1.10%~2.20%, the error range of pH is 0.64%~1.67%, the error range of Cu ion concentration is 1.98%~2.22%, and the error range of Cd ion concentration is 1.58%~2.01%.

TABLE I. SPECIFICATIONS OF WATER QUALITY SENSORS

Test index	Laboratory test	Acquisition node data	error
pH	9.58	9.42	1.67%
	9.61	9.65	0.64%
	9.54	9.62	0.84%
	9.55	9.41	1.47%
	9.65	9.58	0.73%
dissolved oxygen /mg/L	8.15	8.03	1.47%
	8.13	8.3	2.09%
	8.2	8.02	2.20%
	8.16	8.32	1.96%
	8.21	8.3	1.10%

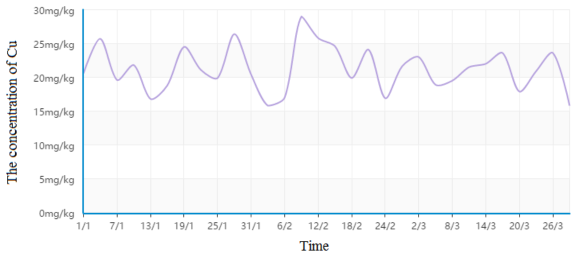

Figure 10. Variation of Cu concentration in soil monitoring node 1

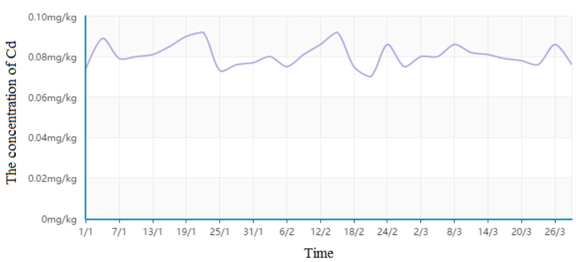

Figure 11. Variation of Cd concentration in soil monitoring node 2

VI. CONCLUSIONS

Based on the wireless sensor network, the system designs the water quality monitoring node, the soil monitoring node, the routing node, the gateway node and the background server. The various parts communicate with each other through the wireless communication module. The gateway is the control center. When the gateway receives all the nodes Information detection data after uploading the server and broadcast the synchronization package, so that all nodes in the network sleep waiting for the next wake-up collection. The system solves the problems of large amount of manpower, material resources and real-time difference in the traditional rural drinking water monitoring. Through the monitoring of water quality and soil linkage, the system has a certain guiding effect on the pollution control problem in the monitoring process.

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