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A Wireless Ecological Aquaculture Water Quality Monitoring System Based on LoRa Technology

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***Abstract*—For the development of the direction and scale of aquaculture, the requirements for aquaculture technology and the environment are constantly increasing. In the process of aquaculture, the high requirements of parameters such as dissolved oxygen content and PH value of water quality make water quality monitoring an indispensable link in aquaculture. However, at present, most of the traditional water quality monitoring systems have exposed many disadvantages such as cable laying, inconvenient maintenance and maintenance, and lack of intelligent management and control behavior. At the same time, consider the characteristics of the long-node propagation distance of large waters such as Dongting Lake, this paper proposes a LPWAN water quality monitoring system based on LoRa technology with long single-hop transmission distance. The monitoring system fully utilizes the characteristics of long life, low power consumption, simple network protocol and topology, and low deployment and maintenance cost of the LoRa technology node.**

Keywords—wireless sensor networks; water monitoring; LoRa; Dongting Lake

I. INTRODUCTION

With the development of IoT technology, many solutions based on wireless sensor networks have been proposed for water quality monitoring applications. Most of them use short-range and multi-hop transmission technologies represented by ZigBee. For small waters, the ZigBee protocol can still meet the application requirements due to the distance between the data collection points [1]. However, for large areas such as large rivers and lakes whereaquaculture operations are located, the distance between monitoring points does not need to be very close [2]. Therefore, if ZigBee and other short-range multi-hop technologies are still used, it will inevitably lead to unnecessary increase in the number of nodes, which will increase deployment costs and overall failure rate, and reduce the reliability of water quality monitoring [3].

At present, for large-scale waters like Dongting Lake, satellite remote sensing technology is usually used to detect water quality through spectral analysis and image processing. However, this method does not provide comprehensive and detailed water quality data [4].

In order to better improve the monitoring effect of water quality in large-area waters, the author will use the low-power wireless wide area network (WWAN) technology that has been gradually developed in recent years to propose a wireless technology based on LoRa technology [5]. Water quality monitoring system. Due to its long distance, simple network protocol and topology, and low power consumption, LoRa technology is sufficiently representative and its application field is expanding [6]. The water quality monitoring system established by the characteristics of LoRa technology can meet the water quality monitoring needs of large-area waters [7].

II. OVERALL SYSTEM PLAN

A. System Energy Supply Demand Analysis

The system wirelessly transmits the hydrological information to the fixed monitoring station through the data acquisition unit set up in each hydrological monitoring station, and the monitoring station timely transmits the data to the monitoring center through the operator network for storage, decision-making and control [8].

Each hydrological monitoring unit shall be installed in the waters of Dongting Lake and the designated locations of surrounding rivers and reservoirs according to the requirements of hydrological monitoring, and shall be unattended at the site [9].

In order to meet the system requirements, the design will achieve the following functions [10]:

- The data acquisition unit can send hydrological data to the monitoring center in a self-reported manner at an adjustable time interval.
- Collect hydrological data in real time according to the requirements of the monitoring center.
- Monitoring stations could display, store and manually query the data collected.
- The monitoring center could process data and draw curves in real time and set parameters for each monitoring unit.
- When the collected data exceeds the standard, the monitoring station displays alarm information and sends alarm messages to the administrator's phone.
- Have the function of fault management: when a monitoring unit fails, it cannot complete the normal monitoring tasks, resulting in missing reports. Therefore, the activity status of the site in the system should be monitored in real time, and the fault node in the system should be detected in time. Every time, the monitoring station sends an inquiry message to each monitoring node, and the node sends a response after receiving it. If the monitoring station fails to receive a reply message within a certain period of time, it will report the failure of the hydrological station to the monitoring center.

B. Overall System Structure of Water Quality Monitoring System Based on LoRa

The system is divided into three modules, namely Sensor terminal network module, Data transmission module and Network data service module [11]. The system framework is shown in Figure 1.

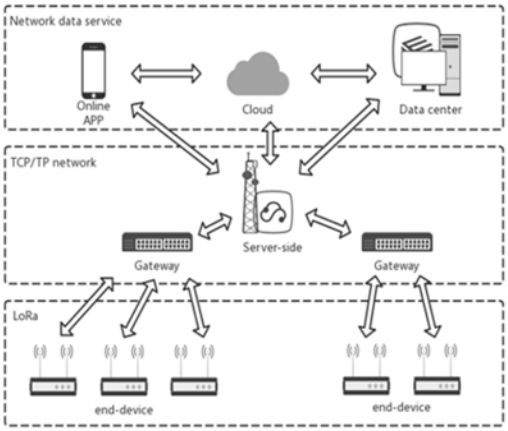

FIGURE I. OVERALL SYSTEM STRUCTURE

The function of Sensor network module is relatively simple. Mainly responsible for data acquisition and sending and receiving of sensor terminals.

Data transmission module is mainly responsible for LoRa network and GPRS network data transformation and data transmission to the other two modules [12], including the gateway leading role in realizing LoRa protocol and TCP/IP protocol conversion, namely by LoRa hydrological data from the network, the protocol data unpack the coordinator node, then encapsulated into a TCP/IP packets sent to the monitoring center; The reverse is true. Meanwhile, as the control center of the network, the server could disconnect the network connection, upload, download and delete terminal nodes.

The data service module mainly realizes the collection, analysis, processing and preservation of the collected information. In addition, data security and real-time monitoring can be realized through cloud data and online APP [13].

III. SYSTEM HARDWARE PLATFORM

A. Terminal Design

The designed terminal node is shown in Figure 2.

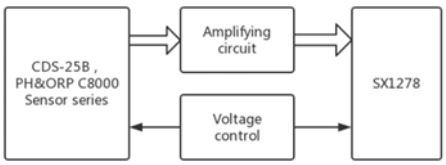

FIGURE II. TERMINAL NODE STRUCTURE

In the design, the sensor terminal network is connected to LoRaWAN using SX1278 chip [14].With low power consumption and sensitivity of -137dbm, it has the advantage of carrying interference on 25dB signals in the suppression band, free from sub-ghz frequency and 4G/LTE signals. In addition, the excellent applicability of supporting various physical layer modulation methods improves the expansibility and operability of the design [15].

B. Gateway Node Design

The gateway node is mainly composed of LoRa network coordinator module, GPRS module and microcontroller. The sensor-end transceiver chip also USES SX1278, the GPRS module USES SIMCOM's SIM808, and the microcontroller USES acer's STC90C51RD+.The designed gateway node is shown in Figure 3.

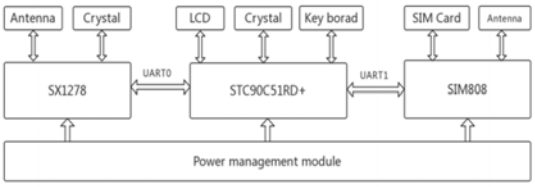

FIGURE III. GATEWAY NODE STRUCTURE

Through the middle of the STC90C51RD + to LoRa and two-way between GPRS data processing, can be as much as possible to reduce LoRa gateway for GPRS handshake protocol to improve frequency, serial port communication interrupt transfer sufficient power to LoRa sensor network at work, so as to improve the operation stability of the gateway and the reliable transmission of data, and give LoRaWAN even good extensibility [16].

IV. SYSTEM SOFTWARE DESIGN

A. Terminal Node Software Design

The workflow of terminal acquisition node is shown in figure 4.

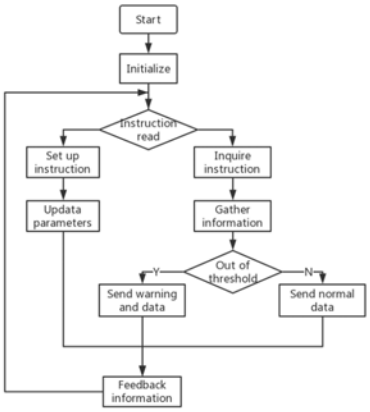

FIGURE IV. TERMINAL NODE WORKFLOW

The MCU master control chip receives the query command or configuration command sent by the data transmission module through serial port communication (setting the configuration information such as reporting period and alarm threshold).Receive the query command to collect data based on the configuration information saved last time. When a configuration command is received, configuration information

such as reporting period and alarm threshold is updated to flash memory. At the same time, according to the latest configuration information, the module will regularly sample data such as temperature and dissolved oxygen, and the collected data cycle will be sent to the LoRa communication module by serial port communication. If the value exceeds the alarm threshold, the alarm information will be sent [17].

B. Monitor Platform Software Design

The upper computer software is written by Qt, which is a cross-platform C++ graphical user interface application development framework developed by Qt Company.

Software developed with Qt is highly portable and can be recompiled to run on other systems after simple modification. The signal and slot mechanism of Qt simplifies the program design, and Qt provides more than 250 classes with high modularity. Qt supports third-party libraries, and the QWT library can be used to complete the chart drawing and conduct more comprehensive quality control and planning for aquatic products [18].

The upper computer software and GPRS module communicate through SOCKET. Since the IP allocated when SIM300 is online is dynamic, SIM300 can only be used as Client and the upper computer as Server. When the SOCKET connection is made, the upper computer must be the external network IP. Since the IP obtained by the school network line is not the external network IP, it cannot connect with the SIM300 SOCKET. In the test of this system, the connected wireless network is connected to acquire the external network IP. The Server program was written to use the QtcpServer class and QtcpSocket class provided by Qt. First, the listen() member function of QtcpServer class was used to listen to the local port. When the Server received the Client connection request, the nextPendingConnection() member function of QtcpServer class was used to establish the SOCKET connection.

V. CONCLUSION

In this paper, aiming at the problem that ZigBee and other short-distance multi-hop schemes widely adopted in the application scenarios of wireless water quality monitoring are not applicable to large areas of water, taking the waters of Dongting Lake as an example, this paper proposes a wireless monitoring method for water quality in vast waters based on LoRa technology. Based on the analysis of application requirements, the corresponding schemes are given for the system's overall framework and software and hardware structure. The scheme is low in cost, easy to develop and deploy, and has the dual management mode of cloud data service with online and offline, which can steadily and reliably improve the monitoring effect of water quality in large areas.

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