Design of Water Quality Monitoring System for Aquaculture Based on ZigBee

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ABSTRACT

The aquaculture industry is developing on a large-scale. Now most aquaculture households use the artificial way of water quality diagnosis, decision-making and adjustment, the data cannot accurately reflect the water quality status. The data acquisition node used distributed self-organizing network structure, it accomplished the detection of water temperature, pH value, dissolved oxygen, conductivity and other water quality parameters. ZigBee wireless communication module was used to the data exchange between the data acquisition node and router node, router node and coordinator node medium. The synchronization of the whole network node to sleep and wake up was realized using the time synchronization algorithm, it greatly reduced the system power consumption. The system was tested in Sanya university natural lake, it can realize the monitoring function of aquaculture water quality parameters, all-weather real-time transmission of information and automatic regulating or remote manual adjustment according to the preset dissolved oxygen content.

INTRODUCTION

The Chinese aquaculture industry occupies a pivotal position in the world. Take one of the main bases of aquaculture industry in China as an example, according to preliminary estimates, Hainan Province has developed and utilized aquaculture area of more than 800 square kilometers. Among them, the sea aquaculture area is nearly

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233 square kilometers, freshwater aquaculture area is more than 567 square kilometers. The aquaculture industry has been rapid development. However, aquaculture industry still exists more problems to solve, such as conductivity in water quality monitoring, water temperature, pH, dissolved oxygen and so on. Most of the problem is judged by the experience of the farm operator or technician, or a simple test.

In view of the importance of water quality monitoring in aquaculture, it is particularly important to propose a practical, economical and easy-to-use on-line water quality monitoring system. In recent years, the development of the wireless network communication technology is very fast. ZigBee has the advantages of low cost, high transmission efficiency and low power consumption. Using ZigBee to build a wireless sensor network in the data transceiver has an advantage such as free for cabling, construction and maintenance convenience, low cost of use and so on. It can be monitored in real time for water quality data in data center. The system can also be compared with the setpoint based on the data collected by the sensor. For the data beyond the set range, the system will promptly take sound and light alarm, remote automatic controlling to aerator and water pump. ZigBee can also solve the problems of low reliability, high cost and poor real-time performance of existing traditional monitoring methods, so it provides a reliable reference for scientific farming.

SYSTEM OVERALL PROGRAM DESIGN

This on-line monitoring system for aquaculture water quality consists of three layers: data acquisition layer, route forwarding layer and central data processing layer. In bottom, the data acquisition node adopts the distributed structure, selects the latest sensor technology to collect the information of the aquaculture water body parameter, and converts the analog signal into the digital signal suitable for wireless transmission through the data acquisition node signal conditioning circuit, and sends it to the superior node[1]. The working power source is provided by the solar panel. Router node is in the middle layer, it is responsible for receiving the data collected by the data collection node sensor, and through the wireless transmission to the higher node[2]. The top level is the coordinator node and the monitoring center server, the coordinator node receives and processes the router node data and sends it to the monitoring center server for data analysis processing. The overall frame structure is shown in Figure 1.
HARDWARE DESIGN AND IMPLEMENTATION

Data Acquisition Node Circuit

The data acquisition nodes can complete the following functions: parameter collection, basic data processing and wireless transmission of data, and they consist of sensor, date transmission circuit, STM32, CC2530, etc. The structure diagram of data acquisition nodes is shown in Figure 2.
**Router Nodes Circuit**

In the hardware function, the router nodes are mainly responsible for collecting the water quality data collected by each node, and then all data is sent to higher-level router nodes or coordinator nodes in single-hop or multi-hop modes by ZigBee[3].

**Coordinator Node Circuit**

Coordinator node is the core node of ZigBee, which is responsible for the formation of communication network, network address allocation, network management and so on in the system[4]. At the same time, it sends all the data processing to the monitoring center server by serial interface data cable[5]. The block diagram of the coordinator node is shown in Figure 3.

![Coordinator Node Structure Diagram](image)

Figure 3. The coordinator node structure diagram.

The coordinator node is designed as a portable suitcase. The device can be placed in the monitoring center, usually with electricity supply[6]. It also can be built-in battery charge, carrying to the data collection site for on-site networking[7]. So that field operations, temporary networking debugging and other work has become easy.

**SOFTWARE DESIGN AND IMPLEMENTATION**

The software is consisted of two parts, including monitoring center software design and node software design. The monitoring center software mainly includes the design of subroutine such as human-computer interaction interface, data analysis and processing, and data storage[8]. It is used to complete system usage and maintenance, data analysis and processing, report generation and printing, data storage and query function. The node software includes data acquisition node, router...
node and coordinator node[9]. It mainly implements networking and management, wireless data transceiver and control, and data acquisition and sending.

The main loop function (osal_start_system) is ZigBee designed to complete the established work, and its task is to continue to browse and call all the tasks and events. In all nodes, the program is in a constant cycle[10]. When no tasks and events are given, the processor goes into sleep mode. When the wake-up condition is reached, wake-up processing is performed and the corresponding tasks and events are started[6]. ZigBee system program flow chart is shown in Figure 4.

![ZigBee system program flow chart](image)

Figure 4. ZigBee system program flow chart

**TESTS The Coordinator Node**

The natural lake was located at the North Campus of Sanya University, and lake water was from Banling reservoir. The lake is oval, east-west direction is longer, narrow north-south direction. The longest lake was about 260 meters, the widest point of about 170 meters, the water area was 44,000 square meters, and the water depth was 1.5-2.5 meters. The test site was similar to the situation of most
aquaculture waters in Hainan, and it had good practical significance. The physical system is shown in Figure 5.

CONCLUSIONS

This paper analyzes the research status and development of aquaculture water quality monitoring system at home and abroad, finds out the shortcomings of traditional water quality monitoring system, puts forward the design scheme of water quality monitoring system based on ZigBee, and applies ZigBee wireless sensor network technology to aquatic product Aquaculture water quality monitoring system. The system is used TI's CC2530 chip as the basis of system development, and built a set of ZigBee-based tree data collection, transceiver and processing system. The hardware and software systems were tested at the lake of Sanya University. From the result of the test, the system is able to operate steadily in harsh environments after several rounds of testing and system commissioning. It could meet the practical needs of multi-parameter monitoring of water quality, basically meet the design requirements, and had a good application prospects.

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