Research on Fishery Water Quality Monitoring System Based on 6LoWPAN

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Abstract. A fishery water quality monitoring system, based on 6LoWPAN, is proposed which can automatically implement various kinds of supervising tasks according to the changing environment. This system is applied to water quality monitoring of fisheries, realizing remote automatic online monitoring of water quality parameters such as temperature, salt content, pH, and dissolved oxygen, which have a significant impact on the aquatic product growth environment. The monitoring centre software performs the received data analysis, processing, storage, graphic display and alarm, providing the best growth environment for aquatic products. Compared with the existing fishery water quality monitoring methods, the system uses the IPv6 over IEEE 802.15.4 standard to construct a wireless sensor network. 6LoWPAN technology is easier to integrate into larger networks and easier to integrate with Internet-based services. This system can effectively improve the level of water quality management, reduce the risk of aquaculture, and achieve sustainable development of the aquaculture industry.

1. Introduction

In recent years, with the strategic transformation of China's agricultural development and the continuous expansion of the fishery scale, farmers cannot monitor the changes in fishery water quality in a timely manner. This will further cause problems in fisheries production. Therefore, it is imperative to strengthen the real-time monitoring of fishery water quality and timely feedback information to fishery farmers.

At this stage, scholars at home and abroad have conducted a series of researches on the monitoring of water environmental parameters of fisheries by wireless sensor networks. Some typical examples include the EMNET system produced by Heliosware in the United States and the Fleck system by CSIRO in Australia[1]. However, these systems have the characteristics of low communication speed, large product size and large power consumption, which cannot be suitable for practical production applications. Li Jin et al. proposed an application of ZigBee wireless network in pond water quality monitoring[2]. Miao Lei et al. proposed a wireless sensor network based on ZigBee in aquaculture[3]. The above two monitoring systems have adopted the ZigBee protocol to monitor various parameters of the water environment. Its limitations are that the Zigbee protocol does not support end-to-end communication, and restrictions on Internet integration and scalability. Liang Huanhuan et al. proposed a water quality online monitoring system based on wireless sensor networks[4]. The monitoring system collects data and transmits it to a remote data management center via a GPRS network. However, the system does not consider the problem of limited network address resources when many devices are connected to the network, which has application limitations. Zhang Qin et al. proposed a new type of aquaculture water quality monitoring system for the problems of short communication distance, high...
power consumption and complicated network in the aquaculture wireless water quality monitoring system\textsuperscript{[5]}. Taking STM8L low-power microcontroller as the core and combining LoRa modulation technology to customize network communication protocol, a low-power and long-distance wireless sensor \textsuperscript{[6]}network node is designed to complete the collection and transmission of aquaculture water quality parameters.

Most aquaculture monitoring systems use ZigBee\textsuperscript{[7]}wireless communication technology to monitor the main parameters of the water body. Most of them use battery-powered solutions. For battery-powered WSN nodes, energy consumption is a key issue affecting their life.

Narrow Band Internet of Things (NB-IoT) is built on a cellular network and consumes only about 180kHz of bandwidth. NB-IoT is an emerging technology in the field of Internet of Things that supports cellular data connection of low-power devices in a wide area network. Also known as low power wide area network. NB-IoT supports high-efficiency connections for devices with long standby times but high requirements for network connections. Therefore, this paper uses 6LoWPAN\textsuperscript{[8]} technology to achieve low power consumption and solve the defects in existing systems.

Therefore, this article proposes a 6LoWPAN-based fishery water quality monitoring system, which uses wireless sensors and the Internet to extend the antenna of the network to fishery water quality monitoring, replacing the existing system.

2. Related Technologies

2.1. IPv6 Overview
With the development of the Internet, more and more smart devices are connected to the Internet, network address resources have been exhausted. So IPv6 emerged at the historic moment. IPv6 address length is 128 bits, which can effectively solve the problem of limited IPv4 network address resources. IPv6 technology has many characteristics that IPv4 does not have, such as new protocol header format, huge address space, stateful and stateless address configuration, built-in security, better support for QoS and scalability, and soon. The characteristics of the IPv6 technology applied in this paper have a huge address space, automatic address configuration and packet header structure.

2.2. 6LoWPAN Overview
6LoWPAN is a low-power wireless personal area network standard based on IPv6, namely IPv6 over IEEE 802.15.4, which aims to introduce IPv6 into wireless personal area networks with IEEE 802.15.4 as the underlying standard. The research focus of the 6LoWPAN working group is on the adaptation layer, routing, header compression, fragmentation, IPv6, network access, and network management technologies. At present, a draft of the adaptation layer technology has been proposed. Other technologies are still being explored.

Since most wireless sensor nodes run the IEEE 802.15.4 standard, in order to enable IPv6 data packets to be transmitted at the physical layer and the MAC layer using the IEEE 802.15.4 standard, 6LoWPAN introduces adaptation at the network layer and the MAC layer of IEEE 802.15.4. This mechanism addresses the differences between the two protocols.

2.3. 6LoWPAN Adaptation Layer
As shown in Figure\textsuperscript{1}, the adaptation layer of the 6LoWPAN protocol stack is located between the physical link layer and the network layer of the network model. The network layer uses the IPv6 protocol, the transport layer uses TCP / UDP, and the application layer uses the existing universal socket interface. Because the application direction of the IPv6 and IEEE 802.15.4 standards is different, the 6LoWPAN adaptation layer is required to encapsulate the link layer interface to provide a standard interface for the IP layer. The adoption of such a protocol structure enables each wireless sensor node to be seamlessly connected end-to-end with the next-generation IPv6 Internet.
2.4. The Advantage of 6LoWPAN

6LoWPAN has the following advantages: it can use various existing IP-based services, tools, applications; it can easily and seamlessly connect with various deployed IP networks; it can run on a variety of physical layers for easy expansion; Can achieve true end-to-end control and communication; has a larger address space, can be assigned an independent IP address for each device; does not need to configure a dedicated management server to run automatically; does not require NAT technology, has a more general network architecture is more suitable for high-density sensor networks; it has a high degree of openness. Since the IP protocol is an open protocol, this brings a huge advantage to 6LoWPAN.

3. System Structure

According to the design characteristics of fishery water environment, the overall design of 6LoWPAN wireless sensor network for fishery water environment detection is proposed. The whole system consists of IPv6 sensor nodes, 6LoWPAN gateway and Web application server. IPv6 sensor nodes connect sensors through a control bus or an integrated chip to collect water quality parameters, such as temperature, pH, transparency, and dissolved oxygen. The 6LoWPAN gateway is the bridge between the 6LoWPAN network and the Internet. The web application server is deployed on a remote IP network. A common Tomcat server is selected to run Java-based web applications.

The physical layer of the system consists of sensors at the measurement terminal. DS18b20 sensors, DHT11 sensors, pH sensors, dissolved oxygen sensors, and salt sensors are distributed at various measurement points in the fishery water environment. They are used to collect data in real time. Filters are transferred to the local database. The web uses data visualization technology to observe the real-time changes of the data more intuitively.

3.1. Wireless Sensor Module

Each test module is mainly used to collect water quality parameters at a specific point in the fishery. Each monitoring point has 5 parameters (including air temperature and humidity, water temperature, dissolved oxygen, salt content and pH value). The data collected by the sensor is processed by the CC2538 CPU and transmitted to the router using the IPv6 protocol through the network module, and then transmitted to the database of the local computer through WIFI and uploaded to the Internet. Five sensor nodes were deployed at each test point. The specific structure is shown in Figure 2.
The sensor module includes a temperature sensor, a temperature and humidity sensor, a pH sensor, a salt content sensor, and a dissolved oxygen sensor. The selected models are DHT11 temperature and humidity sensor, E-201-C PH composite electrode, DS18B20 digital temperature sensor, DSS-600 salinity sensor, DOS-600 oxygen content sensor, etc. Digitally convert the collected analog signals. The processed signal will then be transmitted to the network module via CC2538. The model of the network module is ENC28J60. 6LoWPAN technology is used between the network module and the wireless router to transmit data to the wireless router. The wireless router and the network module provide a local area network for the sensor module. After the data is processed, it is transmitted to the local computer database using Wi-Fi. The system will monitor 5 points in different areas of the same water area to ensure the accuracy of the data.

4. Experiment Procedure

The system interface design uses JavaScript and consists of a login registration page and a line chart of each parameter. After the user enters the login interface, a real-time query will be displayed. As shown in Figure 4, the user can click on the content to be viewed according to the tree on the left and drag the scroll bar to view the historical data at any time according to his own needs. The right side of the figure displays the current data in real time. Due to the large amount of data collected, the line chart can intuitively reflect the change law of parameter values in different time periods.

![Figure 3. Login Interface.](image3.png)

![Figure 4. Temperature change in air.](image4.png)
4.1. Database Design

The system uses a MySQL database, the advantage of small volumes of software, installation is simple, and easy to maintain, low cost installation and maintenance; open source and no copyright restriction, autonomy, low cost; support multiple operating systems Provide multiple API interfaces and support multiple development languages.

The main purpose of the database is twofold. First, users log in and register. The database is used to store usernames and passwords and other user information. Secondly, during the work of the system, it is used to save the data collected by each sensor. In this system, the database is created by the user. The key point is to create the database first, and then create the required data tables. The database is created using SQL statements.

5. System Test

After the system design is completed, in order to ensure the effectiveness of the system test and the accuracy of the sensor data, a system test, a sensor standard solution test, and a temperature sensor test were first performed in the campus innovation laboratory. First, the pH sensor is calibrated with a standard buffer solution, and then the standard buffer solutions of pH 6.0, 7.0 and 11.5 are compared with the data collected by the sensor, and the data measured with the thermometer are compared with the data measured by the temperature sensor. It shows that the relative error between the measured value and the standard value of the system is within 4%, and the measurement accuracy fully meets the requirements for the collection of fishery production water environmental parameters.

| Parameter | Standard | Wireless sensor node | Measured Value | Relative error/% |
|-----------|----------|----------------------|----------------|------------------|
| PH value  |          |                      |                |                  |
| 6.0       |          | 5.98                 |                | 0.3              |
| 7.0       |          | 7.12                 |                | 1.7              |
| 11.5      |          | 11.35                |                | 1.3              |
| 18.5      |          | 18.10                |                | 2.1              |
| Temperature |        | 22.5                 |                | 2.6              |
| 30.4      |          | 30.68                |                | 0.9              |

Then, the system was tested in Chuncao Lake, Shandong Technology and Business University, and a moat in Laishan District, Yantai City, Shandong Province. It collected specific environmental parameters such as temperature, pH value, air temperature and humidity, dissolved oxygen, and salt content, and saved this information locally. Database. The visualization of data is achieved with interactive charts on the terminal. This system mainly uses the front-end to dynamically generate data, and AJAX asynchronous requests to implement partial refresh pages, so that users can intuitively see the real-time changes of various environmental parameters. As shown in Figure 5.

Figure 5. Line chart of temperature.
The system was tested at different times of the day. The test was first performed at the Innovation Lab of Shandong Institute of Business and Technology. The data collected was water environment data from 6 am to 8 am, and then tested at Chuncao Lake of Shandong Technology and Business University. The collected data was from 13:00 to 15:00. Finally, the test was carried out on the moat in Laishan District. The collected data was from 9 to 11:00 in the morning. The system test results are all good, and some data are shown in Table 2.

Through data comparison, it can be seen that the multi-point monitoring and alarm system for water quality parameters can be used to obtain water temperature, PH value, dissolved oxygen and salt content information online in real time, and can provide alarm prompts in time to meet design requirements.

### Table 2. Water quality parameter measurement.

| Date         | Time   | Temperature/°C | Dissolved oxygen/(mg/L) | Humidity | Salt/% | PH  |
|--------------|--------|----------------|-------------------------|----------|--------|-----|
| 2019.09.28   | 11:00  | 23             | 13.25                   | 18.5     | 0.3    | 8   |
| 2019.09.28   | 10:00  | 22.5           | 12.38                   | 20.2     | 0.3    | 8.75|
| 2019.09.28   | 9:00   | 19.2           | 13.25                   | 22.6     | 0.3    | 8.6 |
| 2019.09.24   | 13:00  | 24.0           | 10.22                   | 33.2     | 0.28   | 7.6 |
| 2019.09.24   | 14:00  | 24.5           | 9.85                    | 32.5     | 0.28   | 7.6 |
| 2019.09.24   | 15:00  | 25.0           | 8.20                    | 29.0     | 0.28   | 7.52|
| 2019.09.22   | 6:00   | 18.5           | 13.0                    | 28.5     | 0.27   | 7.8 |
| 2019.09.22   | 7:00   | 19.0           | 13.2                    | 27.96    | 0.27   | 7.65|
| 2019.09.22   | 8:00   | 19.5           | 13.35                   | 27.5     | 0.27   | 7.72|

### 6. Conclusion

The purpose of this system design is to improve the insufficiency of traditional fishery water environment monitoring, and introduce 6LoWPAN technology to improve it, so that it meets the requirements of fishery water environment parameter information collection. This system has been tested several times in Chuncao Lake, Shandong Technology and Business University, and the moat in Laishan District, Yantai City, Shandong Province. The test results show that the system measured values are effective.

Although the system monitors the fishery water environment, it does not perform data mining on the collected data. The next step will be to use machine learning knowledge to perform data mining on the collected data. Discovering its rules can predict the data direction in advance.

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