

Design and Implementation of Online Water Quality Monitoring System

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Abstract. Water quality detection plays an important role in water pollution alarm, water source pollution detection and water source diagnosis and treatment. The online water quality monitoring system based on the Internet of Things technology can monitor the water quality in real time and dynamically, and can serve the strategic requirements of the country for water resources. Currently, the water quality on-line monitoring system is mainly composed of upper computer system and lower base station in domestic researches. This mode of construction has deficiencies such as lack of channel diversity, large investment in communication network, and insufficient capacity of data. Aiming at these problems, this study attempts to use LoRa network technology, cloud architecture combined with water quality monitoring sensors to build a low cost and high reliable water quality monitoring system. Indexes of water quality are collected by intelligent sensors, and are transmitted to cloud server through LoRa network. They can be intelligently analysed by the technology of big data. The system includes both mobile and computer terminals. Indexes of water quality can be monitored timely and accurately by the system, which can further enhance the omnidirectional intelligent management of rivers. By case analysis to verify that the system has certain value of promotion and application.

Keywords: LoRa network, Online Water Quality Monitoring System, Cloud Computing Platform, Acquisition End.

1. Introduction

As we all know, the average per capita water resources of China are very small and water pollution is serious in China (Ahmed Sameh S. et al,2021). As an important part of waterbody pollution prevention, water quality detection plays a key role in water pollution detection and warning, water source diagnosis and treatment (SUN Hai-lin, etc.2009). The water quality on-line monitoring system, which is composed of modern sensing technology, automatic measurement technology, automatic control technology, computer technology, communication network and other related special analysis software, can monitor the water quality real-timely and accurately (ZHANG Hengfei, etc.2021). Online water quality monitoring systems are built in many countries and regions.

Currently, the water quality on-line monitoring system is mainly composed of upper computer system and lower base station in domestic researches. The upper computer system is connected to the Internet to receive data and to monitor the operation of the application software. The lower base station is mainly composed of integrated induction terminals, which can obtain data of water quality indexes in real time. Although this mode can improve work efficiency, save manpower and material resources, there are also problems such as lack of channel diversity, large investment of communication and insufficient storage capacity of data.

With the maturity of wireless communication network, Wireless intelligent induction network communication technology and induction terminal are also constantly improving (Li S, etc.2015). The Internet of Things (IOT) centered on interconnection has greatly promoted the development of life, work and intelligence (Zhang Zhiwei, etc.2021). Based on IOT, Water quality monitoring system has the advantages of low input, wide monitoring area, low energy consumption and response to water quality dynamically. low power wide area network (LPWAN) data transmission technology represented by Long Range Radio (LoRa) has become the best solution (Liu Zhan,2021).

LoRa colligating the technologies of digital spread spectrum, signal processing and FEC (forward error correction) encoding has the advantages of high data reliability, low power consumption and

large network capacity (SHI Xinlong.etc,2021). As a typical technology used in wireless radio modulation and demodulation, LoRa supports 1GHz or even lower communication wave carrier, and can complete ultra-long-span communication with ultra-low power consumption (CHEN Shifeng, etc.2021: MIAO Kebin,2021). LoRa, which is suitable for large network volume and low power consumption, has been widely used in practice (J Li Huimin.etc.2021).

Based on existing research, this paper used LoRa, combined with water quality monitoring sensors to build a low cost, high- reliable and high- available water quality monitoring system, in order to deepen the application field of LoRa, realize the intelligent monitoring of water quality, and carry out the protection and management of water resources.

2. System Design

2.1 Overall Design

The correlation index of water resource is collected by the sensors laid in the river. In the wireless LoRa network, the data after processed and integrated is transmitted to the cloud. The cloud uploads the data to the background management system, and people concerned can see the information directly, so as to have a clearer understanding of the water resource quality. Online water quality monitoring system composed of sensor equipment, LoRa network and cloud architecture can realize intelligent management of rivers omnidirectionally, so this will be helpful to further strengthen the management and control of water resources.

The system mainly consists of sensor layer, data layer, business layer and display layer. The sensor layer is at the bottom of the system and is in charge of sensor cluster data collecting; The data layer, realized by LoRa is responsible for integrating the data collected by the sensor and transmitting it to the background management system; The business layer handles business logic primarily; The display layer is responsible for visualization of the monitoring data and information.

2.2 Function Design

The online water quality monitoring system can be divided into two parts: water quality acquisition end and online management platform. From the perspective of function, it can be divided into three parts: data acquisition and processing part, system management platform part and consumer application part.

Functions of data acquisition and processing terminal mainly include the collection of water quality, the storage of vector data such as rivers and sensors, the construction of mathematical models such as monitoring model and early warning model, and other data such as the position of the sensors. In addition to the privilege management, user management, log management and other functions of the conventional management system, the system management platform can monitor the operation of the sensor. The consumer application part includes computer end and mobile end. Its main function is to realize the statistical analysis of water quality, real-time query and display, and receive early warning and monitoring information in time.

3. Realization of System Main Function

The online water quality monitoring system integrates a variety of technologies such as IOT, cloud computing, mobile applications, and comprehensively applies one map management platform of the river and lake river chief information management platform, river and lake data acquisition platform which meet the demand of intuitive display, real-time monitoring, collaborative work, intelligent assessment, safety and good use, etc.

3.1 Realization of System Main Functions

3.1.1 Composing Network LoRa

networks are deployed around the world currently. According to the actual situation of the study area, combined with the stability of data transmission and the full coverage of the study area, the system selects a certain number of LoRa stations. Star network topology is adopted so that the gateway unit can still connect the relay network in the span distance node. LoRa network can not only contain the basic equipment of wide area network, but also make use of equipment used in local area network (Yang Hang,etc.2021). Loading the LoRa chip and corresponding modules into the IOT, and it can be easily and efficiently used to build network (Thamrin R,etc.2020). Both wide area network and local area network can build network favorably.

3.1.2 Acquisition End

Bus connection was used to connect multiple sensors by water quality sensor acquisition end. Firstly, indexes of water quality were collected, and then they were sent to the LoRa terminal through the data bus. LoRa terminal will transmit the data to LoRa station at a fixed time. LoRa station stores and transmits data to the server. So the water quality status can be observed directly from the server. Water quality data collection process is showed in Figure 2.

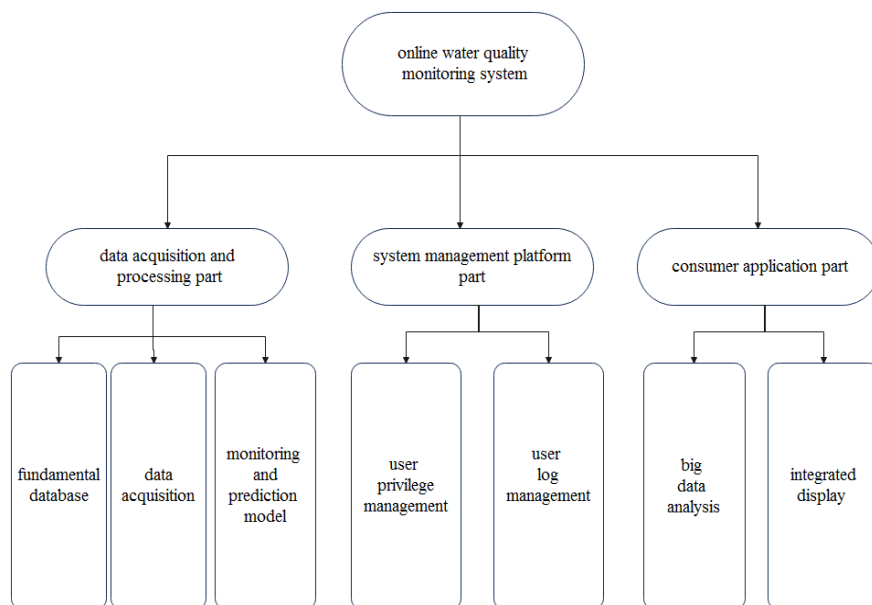


Figure 1. Design of system overall function

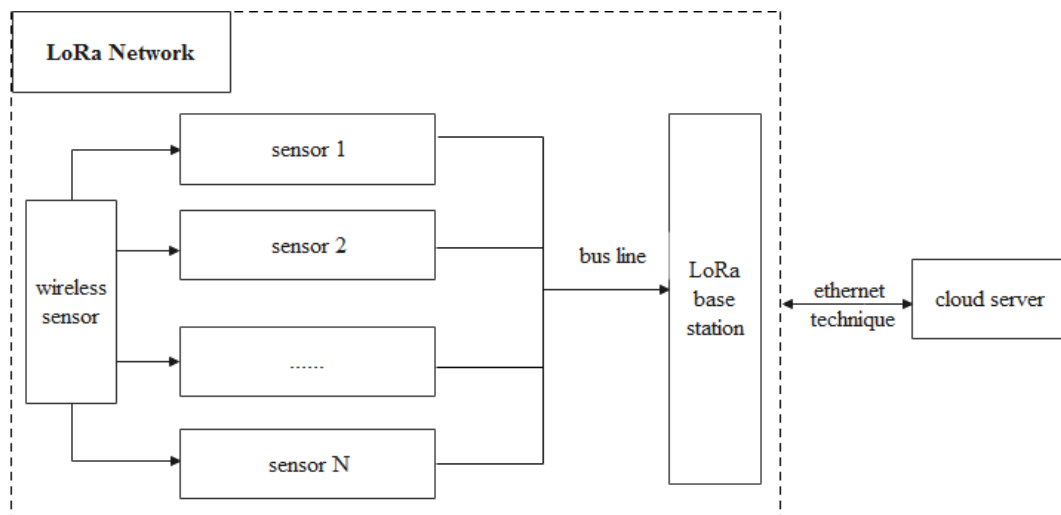


Figure 2. Process of water quality data acquisition

3.2 Realization of Cloud Platform function

3.2.1 Cloud Computing Platform

OpenStack cloud platform was used in the system. Modular design was used in OpenStack cloud platform, that can be easily coupled with third party technology and better support business requirements (Guo Qifang,etc.2022). OpenStack is very suitable for team software development. OpenStack cloud computing technology have been verified in the practice of many industries and areas around the world. It is widely used in IOT, universities and small and medium sized enterprises.

3.2.2 Main Functions in Application

Mobile application is mainly used to facilitate daily river patrol work. Its functions mainly include mobile office, work communication and river patrol management. Mobile office is to view river data through mobile terminal applications, river water quality and work status of staffs in time. Work communication includes document notification, experience exchange, online answer services and other parts, aiming to improve the professional ability of personnel and enhance communication and coordination between various institutions. River patrol management records river patrol personnel walking path, work report, river patrol photos, video, voice and other content, in order to realize the electronic computerization for work.

The computer functions of online water quality monitoring system mainly include water quality monitoring, water affairs prediction, business acceptance and scheduling, etc.

Water quality monitoring function can monitor the chemical oxygen demand, ammonia nitrogen and other parameters of rivers in real time and accurately. Based on these parameters, the system can generate trend diagrams to reflect the change trend of water quality. Based on big data analysis technology, the system can extract the law of pollution diffusion and change, and deduce the location and pollution degree of water sources in various places, so as to realize the real-time and accurate grasp of water resource quality. Water affairs prediction is mainly based on national standards and regional actual requirements to set the water quality level, and set the threshold. When the pollution level of water resource exceeds the threshold, the system will automatically analyze the causes and sources, and push the pollution information to the person liable. In addition, the historical governance situation and effect of water resources in a certain area can be traced back through this module. Business Acceptance and Scheduling module is set up for mass supervision and reporting. The administrators can assign tasks and dispatching personnel in time through the scheduling module when they receive the mass report, system warning and other message. Staff members can also feedback the progress of work through this module.

4. Experiments

4.1 Experimental Setup

Due to the existence of heavy metals in soils, it is difficult to detect soil heavy metals directly in actual environment. The concerned Laboratory Surveillance is still in the experimental environment presently. The data collected by sensors are selected to accomplish the experiment in this paper. The data displayed directly by the sensor is voltage, rather than metal concentration. Therefore, firstly, the data collected by the sensor without access to the LoRa network are obtained. The relationship between the concentration of heavy metal ions and voltage is also obtained by preprocessing. The processing results would be as a reference for data reading subsequently. Then, the sensor is connected to the wireless sensor network system of LoRa to collect water quality indexes and to do measurement and analysis. The effectiveness of the online water quality monitoring system based on LoRa network was verified by comparing and analyzing the two experimental results.

4.2 Results and Analysis

In this experiment, the indexes of cadmium ions and copper ions in water were obtained and measured by means of mean value through multiple measurements. After that, the mv-ppm diagram were drawn separately.

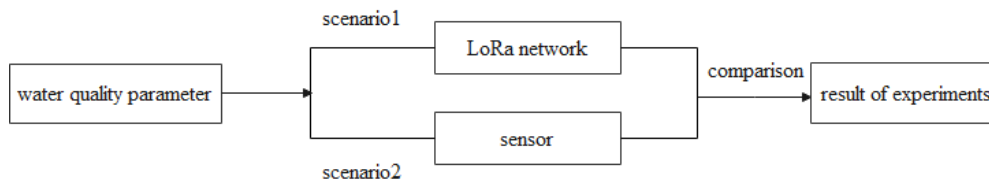


Figure 3. Experimental scheme

It can be seen from the results that under the two experimental methods, the collected data are relatively stable and basically linearly distributed, and the standard concentration – voltage line can be drawn. Unknown concentration of heavy metal ions in solution can be measured directly by reference coordinate diagram. In the obtained line relationship, the linear error is small and can be ignored within a certain error range. The constants are slightly different. The possible reason maybe that the soil in the solution containing has a certain influence on the measurement results. When the soil concentration reaches a certain degree, the best measurement time point disappears, and the measurement has no significance.

5. Conclusion

LoRa network has the advantages of long transmission distance, wide signal coverage, large node capacity and low power consumption, etc. In this study, an online water quality monitoring system is constructed by using LoRa network, cloud computing, wireless sensor and mobile application technology. The system can monitor the exponential change of water resources and give feedback to critical situations in real time. This system has certain application value after practical verification. This study deepens the application of LoRa technology and promotes technical means of water quality monitoring. Subsequently, we will deeply combine LoRa networking technology and IOT technology to explore their application in other fields and promote the sustainable development of Internet of Things plus.

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