An Integrated Device for Online Monitoring Water Quality

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Abstract. For a long time, worsening water pollution has always been an important threat to the safety of water sources in most cities at home and abroad. Statistics show that in recent years, sudden pollution accidents caused by oil spills and toxic chemical leakage have occurred frequently all over the world, causing serious environmental pollution and huge ecological losses. Therefore, there is an urgent need to improve the water quality monitoring of water sources and the early warning and forecasting capabilities of sudden environmental pollution. The urban inland river water quality monitoring system is an application demonstration developed by using Internet of Things technology for urban inland river water quality monitoring and water source security. In this article, we build a real-time monitoring network for inland river water quality monitoring to effectively solve the existing offline water quality monitoring workload and timeliness. Poor performance, water pollution warning and emergency response are slow to ensure the water quality and environmental safety of urban inland rivers.

1. Introduction
With the emergence of wide-area Internet of Things (IoT) application requirements such as smart meter reading, smart water supply and smart agriculture, the wireless connection technology is developing in the direction of longer distance and wider coverage, and low-power wide area network (LPWAN) came into being [1-7]. Typical LPWAN wireless technologies include LoRA, Sigfox, NB-IoT, etc. Among them, the LoRa industry chain is relatively mature and commercial applications are earlier. It works on unlicensed spectrum and has strong application flexibility and adaptability. NB-IoT has officially become an international standard in June 2016. It will be dominated by operators, and it is clearly different from LoRA in application mode [8-15].

In this paper, by building a good ecosystem of innovation and application of the Internet of Things, and ultimately promoting the vigorous development of Internet of Things applications represented by low-power long-distance applications, a certain scale of sensor networking applications and practices are carried out to verify that LPWAN networks are effective for things. The application of networked water quality monitoring, and through the verification results to promote the revision and evolution of LPWAN technology, provide key support and reference for the development, standardization and application of LPWAN technology.
2. Related Works

2.1. Online water environment monitoring system
The water environment monitoring system was developed in the 1970s and has been applied on a considerable scale in Finland, the United States, the United Kingdom, Japan, the Netherlands and other countries, and has been included in the networked "environmental assessment system" and "natural disaster prevention system". The existing online automatic monitoring system for water quality is a combination of multiple index analysis instruments, from sampling, analysis, recording, and data processing to form a system to realize real-time multi-parameter automatic monitoring.

At present, most domestic water quality monitoring still uses manual sampling and monitoring station testing methods, and conducts fixed-point sampling and laboratory analysis and testing of water quality. Some departments have also introduced some more advanced monitoring instruments, but most of various instruments monitor a few indicators separately. Each instrument is generally used alone, with limited coverage, requires a lot of human and financial intervention, and the real-time performance of data acquisition and analysis is not high.

With the rapid development of the Internet of Things in the past two years, many scientific research units including the Shanghai Microsystems Institute of the Chinese Academy of Sciences have carried out research on integrated sensors and mobile networks for water quality monitoring, and conducted field monitoring experiments. These experiments were also used in the initial stage of the research. At present, the more expensive sensors on the market are partially integrated, and then the mature cellular network is used to transmit the data; and these sensors can only be limited to the detection of water quality samples without pre-treatment process, for total phosphorus, total nitrogen, five-day biochemical aerobic. The detection of parameters such as volume, ammonia nitrogen and other parameters that require sample processing must rely on laboratory analysis methods.

2.2. Environmental emergency response decision-making system
The study of forecast models of sudden pollution accidents abroad began in the 1970s. At present, the internationally famous emergency simulation systems for oil spills and chemical spills in the water environment mainly include the MIKE PA/SA system developed by the Danish Institute of Water Environment, OILMAP (oil spill model) developed by the American Academy of Applied Sciences (ASA), and CHEMMAP (Chemical model), OSIS in the UK, OILSPILL/STAT in Norway, MU-SLICK in Belgium, SM4 in the Netherlands, etc.

The study of the sudden pollution accident model in my country began in the 1980s, and most of the models belong to the improved version of the Fay theoretical model. At present, many areas in China have established early warning and emergency response systems for water pollution emergencies, but they are basically limited to the early warning and emergency treatment of marine oil spills, such as the Zhoushan Port Oil Spill Simulation Information System, and the Dalian Sea Oil Spill Emergency Forecast Information system, etc. The frequent occurrence of oil and toxic chemicals in China has caused major water pollution accidents such as the Yangtze River and the Yellow River to establish emergency response mechanisms for major water pollution incidents. For example, the Three Gorges reservoir area has integrated GIS, RS, network, and 3D simulation technologies. An emergency response system for sudden water pollution incidents has been established. The Yellow River Committee has established and gradually improved the "Pollutant Transport Model for Sudden Pollution Accidents in the Mainstream of the Yellow River", and established a water pollution early warning and forecast system for the Yellow River; Zhangjiagang City, Jiangsu Province launched the "Zhangjiagang City" Research on the Three-dimensional Monitoring and Guarantee System for Water Quality of Drinking Water Sources" (2005), the system is composed of four parts: automatic monitoring and early warning of water quality of water sources, mobile emergency monitoring, fixed laboratory monitoring and emergency response plans. However, there is no inland river water pollution accident early warning and emergency treatment system that integrates a database, early warning and forecasting model system, and emergency treatment plan. The rapid response mechanism
and emergency response technology research of sudden oil spills and toxic chemical leakage in rivers are still in initial stage.

3. An Integrated Device for Online Monitoring Water Quality

3.1. Water quality sensor data collection
Optional sensors can be used to monitor multiple different parameter values online at the same time, including temperature/PH/conductivity/dissolved oxygen/ORP. It is used in water quality monitoring in sewage plants, water plants, water stations, surface water, industry and other fields. Both water quality sensors and boundary sensors work in the field and are powered by batteries. How to further improve the miniaturization and low power consumption of system equipment is one of the key technologies. Each sensor uses physical transducers and chemical transducers to realize information collection and conversion. It also integrates multiple functions such as transmission, networking, positioning, and processing. By adopting hardware function software, circuit design modularization, device selection miniaturization, function realization time slot and other measures, it can effectively reduce equipment volume and power consumption, and improve Miniaturization level.

Water quality monitoring mainly refers to the acquisition of temperature, pH, dissolved oxygen, turbidity, algae, ammonia nitrogen, organic matter and other water quality information through water quality sensors such as temperature, pH, dissolved oxygen, turbidity, algae, ammonia nitrogen and organic matter, and comparison with the sample database, One or more indicators obviously exceed the range of normal substantial parameters. Water quality monitoring excavates abnormal patterns in order to discover the laws, and thus guide the identification of risk sources. Abnormal pattern mining mainly includes abnormal pattern discovery, abnormal pattern mining and abnormal cause analysis.

3.2. Research and verification of IoT transmission scheme in water environment monitoring
Study the important network system performance indicators of IoT nodes under different sleep cycles and different transmission strategies, such as power consumption and delay; by changing the frequency of data collection, the sleep strategy of transmission nodes, etc., study the requirements of IoT nodes for various information collection Support; verify the support of indirect, underwater and underground environments for IoT communication capabilities; research and development of low-power IoT node equipment and key technologies, development and deployment of water quality monitoring sensor buoys, including multi-parameter water quality monitoring sensors, data collection, and storage, sending and automatic intelligent control, power supply, etc.

The new low-power long-distance transmission technology represented by LPWAN (LoRa, SigFox) and NB-IoT has become the core of future IoT applications due to its 20dB link budget exceeding GPRS and the 100,000-level connection support capability of a single base station Key transmission technology. LPWAN uses unlicensed frequency bands and is flexible to use. It has been commercialized globally and is a relatively mature technology; NB-IoT uses licensed frequency bands, which is led by operators, and is a technology promoted by major operators in my country.

3.3. Sensor network QoS guarantee mechanism
Flexible and diversified access methods and the differences of various types of connections have brought huge challenges to the QoS (Quality of Service) guarantee in heterogeneous multi-connection systems by selecting diverse features for heterogeneous multi-connection systems. Under the premise of ensuring QoS, we plan to select the most suitable connection as the target access connection to achieve business continuity and QoS guarantee at the lowest possible resource cost, while improving the network Resource utilization efficiency. When the network information is incomplete or the measurement is inaccurate or part of the parameter information cannot be measured, the problem of missing parameter values and incomplete information during connection selection should be resolved.

In view of the different characteristics of heterogeneous multi-connection systems, it is planned to provide QoS-oriented solutions from the terminal side and the network side respectively. On the user
side, through the comparison between the error and error threshold between the theoretical value of load distribution and the actual transmission value, different service segmentation methods are adopted according to different comparison results to obtain the improvement of QoS guarantee performance. On the network side, by placing the decision-making function on the network side, and at the same time, according to the arrival status of the packet, it decides and controls the sending of data packets at the sending end, which not only reduces the reordering delay, but also saves energy consumption for the terminal.

Figure 1. New low-power long-distance wireless transmission network.

4. Conclusions
In this paper, we focus on the major needs of urban inland rivers for water quality and environmental safety, in view of the large workload and poor timeliness of offline monitoring of the existing inland river water quality, the early warning and delayed response of water source pollution, the technical achievements represented by the LPWAN network have been fully utilized to establish a large number of water source areas. The parameter online water quality monitoring system forms a real-time monitoring network for inland river water quality, realizing real-time online uninterrupted monitoring of inland river water quality, achieving "pre-warning, delaying in the event, and obtaining evidence after the event" to ensure inland river water quality and environmental safety. At the same time, this project will verify the ability of the LPWAN network to support low-power long-distance applications represented by water quality monitoring under different scenarios and different network configuration conditions, and provide valuable field test and verification data with LPWAN technology.
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