Research and practice of "internet + hydrological monitoring" of the Yangtze River

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Abstract. In 2015, China issued the “Guiding Opinions on Actively Promoting “Internet+” Actions”, and implemented a top-level design for the implementation of the “Internet+” action plan for all walks of life. The essence of "Internet +" is connectivity, and it is a cross-border integration. This paper explores how to effectively integrate traditional Internet monitoring with Internet technologies such as mobile Internet, cloud computing, and big data to solve the “inefficient point” of traditional hydrological monitoring, and to achieve sustainable development of the hydrological industry and meet various economic and social fields.

1. Introduction
Hydrological monitoring is a complex and comprehensive system engineering that monitors, measures and analyzes the spatial and temporal distribution and variation of water bodies in nature through scientific methods [1]. In order to meet the needs of hydrological basic data collection, flood control and disaster mitigation, watershed planning, urban construction and ecological environmental protection in the Yangtze River Basin, as of the end of 2017, the Hydrology Bureau of the Changjiang Water Resources Commission has deployed 118 hydrological stations, 200 water level stations, 29 rainfall stations, 2 evaporation stations, 327 water environment monitoring sections, and more than 4,700 fixed sections in the main stream of the Yangtze River and important tributaries, collecting relatively complete hydrological monitoring data of nearly 28,000 station years, achieving great social and economic benefits.

Traditional hydrological monitoring (figure 1) mainly includes task management, tool inspection, hydrographic survey, data reorganization and product delivery [2]; According to the requirements of the ISO 9001 quality management system, it is implemented based on the PDCA (Plan Do Check Act) mode. After years of practice, it can effectively guarantee the quality of the results of hydrological monitoring products. However, with the continuous promotion and implementation of the Yangtze River protection strategy, the strictest water resources management and the water ecological civilization construction in the basin, the traditional hydrological monitoring system has gradually revealed that the monitoring products have low timeliness and public awareness. With the lack of participation and the difficulty of internal management of the industry, the shortcomings have not been able to meet the needs of economic and social development and sustainable development [3]. Therefore, there is an urgent need to upgrade and transform existing monitoring systems, identify “inefficiencies” of existing monitoring systems and seek effective solutions to promote technological advancement and efficiency improvements to improve hydrological monitoring innovation and productivity.
"Internet +" is to integrate the innovation achievements of the Internet with various fields of the economy and society to promote technological progress and efficiency. The essence of "Internet +" is connection and cross-border integration [4-6]. "Internet + hydrological monitoring" is the penetration and application of Internet-based information technology (including mobile Internet, cloud computing, big data, Internet of Things, etc.) in the process chain of hydrological monitoring, task management, testing tools inspection, hydrological survey, data reorganization and other links, and establish a two-way mutual feedback between each operation process and the testers and management personnel, which can effectively solve the "inefficient point" of hydrological monitoring and build a modern monitoring system of "Internet + hydrological monitoring". It provides solid support for the sustainable development of the hydrological industry and the needs of all sectors of the economy and society.

2. Purpose
"Internet+ hydrological monitoring" can integrate advanced technology, to promote the materialization and intelligence of hydrological monitoring, and accelerate the construction of hydrological monitoring in the fields of intelligent task management, technical equipment management, hydrological survey, data reorganization, product delivery, etc., improve timeliness and the quality of the results, and continuously improve the production methods of traditional hydrological monitoring. Through the deep integration of traditional hydrological monitoring and information communication technology, hydrological monitoring is more thorough, interoperable and comprehensive, and smarter in operation.

More thorough perception—Instrumented: By connecting the various components of the hydrological monitoring system through fixed networks, wireless networks, mobile communication networks, and sensor networks, it can help hydrological monitors and managers to analyze and solve problems in real time from a global perspective, work and tasks can be shared by multiple parties. Possibly, resources are allocated more effectively, changing the way in which hydrological monitoring is managed and operated.

More comprehensive interconnection—Interconnected: Through data exchange and sharing, the various aspects of hydrological monitoring are no longer information islands, and they will work more efficiently together, thus promoting a virtuous circle of hydrological monitoring management.
Deeper intelligence—Intelligent: Based on massive hydrological monitoring information resources, through comprehensive IoT and efficient sharing, using advanced intelligent technology to achieve identification, prediction and real-time analysis and processing, the human factors in hydrological monitoring operation management are reduced, and resource utilization is improved. At the same time of efficiency, the fairness of information disclosure and management is guaranteed.

3. Research on "internet + hydrological monitoring"

3.1. Overall design

The construction of "Internet + hydrological monitoring" should follow the basic principles of covering the entire business process chain of hydrological monitoring, using modern information communication technology, platform unification, and full compatibility with existing systems [3], based on SOA architecture (Service Oriented Architecture), to build a "smart hydrological monitoring" business paradigm.

The overall design of "Internet + Hydrological Monitoring" is shown in figure 2. As can be seen from the figure, "Internet + Hydrological Monitoring" is in a 4 horizontal and 2 vertical architecture mode. "4 horizontal" represents 4 business logic layers, and "2 vertical" represents 2 major support systems. The business logic layer includes a sensing layer, a network layer, a platform layer, and an application layer. Support systems include standardization systems and data security systems.

![Figure 2. Overall design of “Internet + hydrological monitoring”](image)

3.2. Design of business logic layers

3.2.1. Sensing layer. The human body perceives changes and stimuli through five senses, while smart hydrological monitoring collects various types of monitoring information through the sensory layer. Based on modern sensor technology, it can realize the dynamic perception of rainfall, water stage, water discharge, sediment, water temperature, water quality, water ecology, video image and other elements in the Yangtze River Basin, and support comprehensive monitoring of various water information.

Hydrological monitoring system: The intelligent hydrological monitoring system is divided into space-based monitoring, air-based monitoring and land-based monitoring from the spatial location of the sensor, and the three constitute a hydrological stereo perception system [7]. Land-based monitoring is based on the Internet of Things to form a hydrological information-aware network; air-based monitoring can be obtained by accessing its ground control and data receiving equipment to the
network or offline, and the space-based monitoring can share the data received by its ground station through the network [8].

Intelligent hydrological sensor: Traditional hydrological monitoring sensors are "Instrumented" using technologies such as radio frequency identification (RFID), infrared sensors, global navigation satellite systems (GNSS), two-dimensional codes, and embedded operating systems. It can give “intelligence” and “conversation” capabilities to traditional hydrological monitoring sensors.

3.2.2. Network layer. The network layer mainly implements a wider range of interconnection functions, and can transmit information perceived by the sensing layer with high reliability and security. The network layer is composed of various private networks, the Internet, wired and wireless communication networks, network management systems, etc., which is equivalent to the human nerve center and brain, and is responsible for transmitting and processing the information acquired by the sensing layer.

3.2.3. Platform layer. The platform layer provides basic services for the application layer, including information technology, communication technology and data centers. The platform layer should have map services, data indexing services, data analysis and mining services, cloud computing, big data analysis and other functions.

3.2.4. Application layer. Through the information processing and intelligent analysis, the application layer forms a specific solution for the application of various fields of smart hydrology monitoring. Business applications cover station network management, personnel management, tools management, tasks management, hydrological survey, data reorganization, site inspection, results display, video surveillance and instant messaging.

Station network management: It can realize the dynamic management of the intelligent hydrological monitoring station network, and carry out the life cycle management for the activities of adding, revoking, upgrading and downgrading the sites in the network. When the station network changes, the topology relationship can be automatically reconstructed. The intelligent hydrological network is a network of traditional hydrological network upgraded with modern information and communication technologies. The intelligent hydrological network can compute the real station network density, available station network density, network composition, monitoring items, monitoring frequency, monitoring method and other information in real time; establish the topological relationship of the upstream and downstream and dry tributary stations in the basin; Using cloud computing, big data analysis and mining, machine learning and other means, it can have many functions such as intelligent analysis of station characteristics, timing recommendation of measurement deployment, patrol route planning, intelligent curve rating between stage and discharge, automatic alarm of station equipment failure, etc.

Personnel management: It can have the basic information maintenance of the hydrological staff, workload statistics and other functions.

Tools management: It has multiple functions such as account management, inspection process tracking, verification of smart reminders, and use of trajectory tracking.

Tasks management: It can have many functions such as task assignment, task statistics, task assessment, and so on. Traditional task books are unstructured data and not convenient for quantification. By quantifying and decomposing the task book, the real-time comparison between the planned workload and the actual completed workload can be performed, and the task can be evaluated online.

Hydrological survey: Using space-based, air-based, and land-based sensors, hydrological surveys can collect a variety of hydrological information based on the form of the workflow; It is divided into two categories: online monitoring and manual monitoring. Online monitoring enables automatic acquisition, automatic transmission and automatic processing. Manual surveys are uploaded directly to the data center via mobile apps or smart terminals. The whole process of hydrological monitoring
achieves “paperless” operations, and business processes require the integration of location services and video services.

Data reorganization: Based on the cloud platform, online reorganization of hydrological elements is realized. It has the automatic verification of the base surface, the water level zero elevation, the automatic rating of stage and discharge, the rational analysis of the single station results and the comprehensive comparison analysis of the multi-station results.

Achievements show: The original results of hydrological monitoring and the results of the reorganization are released to the public through mobile APP, online media and display terminals. The technology can be combined with electronic sandbox and virtual reality to enhance the experience of hydrological products.

Video surveillance: should have the functions of AI intelligent identification water level, video flow measurement, site security, and monitoring process monitoring, which constitute the “thousands of eyes” that sense the Yangtze River.

3.3. Support systems

3.3.1. Standardization systems. With the aim of improving standardization and aiming at refined management, we will use information construction as a means to improve various management systems and working standards for hydrological monitoring, and establish a refined hydrological monitoring and management system covering the entire process [8,9].

![Figure 3](image)

**Figure 3.** The construction of the perception layer of the “Internet + hydrological monitoring”. (a) Unmanned surface vehicle, (b) Unmanned aerial vehicle, (c) Cableway radar, (d) Side-scan radar, (e) Laser Sediment Detector, (f) Integrated monitoring platform and (g) Domestic Laser Particle Size Analyzer.
Currently, it is necessary to standardize construction from both hardware and software [10]. In terms of hardware construction, it is necessary to upgrade and renovate the main testing facilities, set up a unified warning protection sign and publicity notices, to achieve a clean and tidy station appearance, an orderly environment, and a unique style and unique hydrological features. In terms of software construction, we should build a unified software resource and prepare a detailed management work manual. Software resources include various work forms, workflows, management systems, and data processing software. The standardization of software resources is based on informationization, in order to realize all informationization from information collection to data processing and display, and create a “paperless” hydrological monitoring business chain.

3.3.2. Security systems. The construction of data security system includes two aspects: one is the construction of data security assurance system to ensure the integrity and availability of data; the other is the construction of network security assurance system to protect data network hardware and software from being damaged, changed and leaked.

4. Application practice in Yangtze River

Under the background of hydrological informationization, the Bureau of Hydrology Changjiang Water Resources Commission started the research of “Internet + Hydrological Monitoring” based on the overall structure of “Internet + Hydrological Monitoring”, and carried out a series of explorations on the construction of the sensing layer and the application layer.

- Sensing layer: The water level and rainfall observation have been automatically collected, automatically transmitted and automatically processed. The discharge measurement uses flow meters and ADCPs. Realtime discharge monitoring uses horizontal ADCP, cable channel radar, side-scan radar and so on. The unmanned boat is also equipped with an ADCP, and the drone is equipped with a video camera or a radar flow meter for flow measurement. The sediment concentration of suspended sediment is quickly tested by on-site laser measuring instrument, turbidity meter and ADCP. The granulation analysis of the sediment particles utilizes a laser particle size analyzer. In recent years, it has cooperated with water conservancy, environmental protection, transportation, marine and other departments to coordinate the comprehensive monitoring of water quantity, water quality, sediment and water ecology, and built the Shanghai Xuliujing Hydrological Platform Water Quality Automatic Monitoring Station and Nanjing Hydrological Experimental Station Realtime Discharge Measurement System. The comprehensive monitoring site provides reliable monitoring information for the protection and restoration of aquatic ecology in the Yangtze River (see figure 3).

- Application layer: A station management information system, a hydrological monitoring APP and a hydrological data reorganization platform were developed (see figure 4). The station management information system initially realizes the dynamic management of the monitoring station network; the hydrological monitoring APP initially completes the real-time uploading and process management of water level, rainfall, evaporation, water temperature, flow and other factors, and initially has data entry, test task management, inspection image management, Test message management and test statistics; we have completed the development of the hydrological data reorganization platform online version, and initially realize the online reorganization of hydrological data.
5. Conclusion

"Internet + hydrological monitoring" is not simply equivalent to the informationization of hydrological monitoring. Its essence is the onlineization, dataization and virtualization of hydrological monitoring. Through the implementation of "Internet + hydrological monitoring", a virtual image of traditional hydrological monitoring is formed, and ICT technology is used to penetrate all aspects of virtual mirroring, which can effectively solve the shortcomings and shortcomings of traditional hydrological monitoring, and construct a modern hydrological monitoring system for the hydrological industry. It can provide solid support for its own sustainable development and meeting the needs of all sectors of the economy and society.

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