Intelligent Water Affairs Integrated Information Management System Based on Microservice Framework

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Abstract: The smart water management system is an important part of the country to promote the construction of smart city. In order to effectively promote the informatization process of the county water area, in view of the current water and rain situation in the county water area, the system selects the mainstream lightweight micro service framework from the requirements of instrument acquisition, data acquisition, data transmission, data storage, data processing and analysis,Using the development mode based on the separation of front and back platform, namely spring cloud + Vue system development framework, the integrated water affairs information management system of a county in Henan Province is designed and implemented.The analysis shows that this mode reduces the software development cycle, reduces the development cost, improves the system efficiency and robustness, and proves the security and feasibility of its development framework.

1. Introduction

Premier Li Keqiang pointed out in the "two sessions" work report: promote the wide application of big data, cloud computing and Internet of things, and strengthen the research and application of new generation artificial intelligence.The development of informatization is brewing major changes and new breakthroughs, and the intelligent development at a higher stage has become an inevitable trend[1-2]]. In 2008, the concept of "smart earth" was proposed by IBM, which led to the upsurge of building "smart city" in various countries. As an inevitable product of the development of "smart city", smart water came into being[3-4]. At present, with the development of high-speed urbanization in China, along with high-speed industrialization, environmental deterioration, resource shortage, traffic congestion and other "urban diseases" are becoming increasingly serious, which leads to profound variation of water cycle in rivers and lakes and continuous decline of urban water system, which seriously threatens economic and ecological security[5-6]. As an important part of smart city construction, actively planning and promoting the construction of smart water has important practical significance[7].

2. Overview of Smart Water

Based on the "report on the development research and analysis and development trend forecast of China's smart water industry in 2019-2025" provided by China Industry Research Network in 2016, it is found that the market scale of China's smart water industry has not been released. At present, there are more than 660 central and local cities above the county level, more than 2500 county-level counties and more than 30000 administrative villages and township level towns above the township level,Each village and town basically has a large water supply station and a drainage system at the same time, but most water companies are in the stage of expanding to the direction of smart water.With the Internet of things, big data, cloud computing, mobile Internet and other new technologies continue to integrate into all aspects of the traditional industry, the emerging industry electronic information technology and modern intelligent water business continue to deeply cross integrate. The rapid development of this emerging industry makes its market demand space huge

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and has broad market prospects.

With the wide application of information network technology, the social impact of big data analysis and application is expanding.In the process of urban water industry construction and development, big data technology can be fully used to effectively form and integrate urban water resources, water environment, water saving, environmental protection, meteorology and other water resources, so as to ensure scientific city command and management and decision-making;At the same time, relying on cloud computing technology to realize the seamless interaction between the "smart mobile water" system and the general public, and efficiently support the water management ability of primary and secondary service residents in Chinese cities.Using cloud computing technology, Internet of things, big data analysis, intelligent ecological hardware, augmented virtual reality and other new technologies, it provides favorable support for the analysis of ecological evolution law of urban water resources and water environment, analysis and diagnosis of water potential problems, analysis of future development situation and prediction and prediction, and timely and accurate meteorological warning of urban water environment and comprehensive optimization, intelligence, and multi-level water sourcesLow consumption and dispatching management provide intelligent social services, improve the comprehensive application service ability of urban water management socialization, and bring new development opportunities for the informatization of urban water industry and the development and construction of smart city.

Smart water system mainly refers to the use of large data analysis and acquisition instrument, wireless network, water resources monitoring instrument, large and medium-sized urban water consumption change detection instrument and other online devices to carry out on-site monitoring, so as to understand and perceive the basic situation of the whole urban water supply and drainage resource management service system in real time,Through the way of information data visualization, the city's water resources comprehensive management service department and the infrastructure of the whole city's water supply and drainage management system are organically integrated to form the "urban water affairs Internet of things". At the same time, the city carries out real-time collection, analysis and processing of information and data related to the city's huge water resources,Then make the corresponding processing results and make suggestions for the government to assist the decision-making department of urban water affairs management, and effectively connect the whole process of the production, operation and management of urban water resources with a more refined and dynamic modern new urban service management mode, so as to truly and effectively achieve the "smart" urban water service management state.

At present, the informatization and intelligent construction of county water affairs in China is still in the initial stage, and there are a lot of common technical and functional requirements in different business applications. In order to realize the rapid construction of business system, reduce the development and maintenance costs, and meet the needs of rapid technology iteration in the future, in order to establish the actual development of the county area, systematically sort out the water business in the county areaOn the basis of water users and related cooperation systems, the framework of county water lightweight intelligent management platform based on microservice architecture is proposed.The smart water integrated information management platform aims to solve the core needs of county water management, takes the core business as the function traction, takes the professional model and numerical algorithm as the intelligent engine, and takes the personalized customization as the user expansion. Through the functional decomposition and common extraction and combination of the business processes of the water affairs system, the platform constructs a micro service group that can be shared by each business system,Based on the unified application support platform, it can realize cross system data, process and business collaboration, reduce the repeated development and investment of local government in informatization construction, improve the management and service level of county water industry, and assist relevant departments to do a good job in water affairs early warning and assistance.

3. System Architecture Analysis

In order to effectively meet the needs of comprehensive information management, analysis and

collection data management, monitoring and analysis services of water areas in various regions, the intelligent water affairs integrated information management system can fully connect with the data of various types of sensors and monitoring equipment at the front end, so as to realize the automatic collection of all information data such as the overall ecological water quality, water volume, water level, rainfall and so onIn order to collect, store and process the data in real time, the local government can collect, store and process data in real time;This paper studies the risk alarm and forecast in the water resources ecological environment management of each water area, and realizes the intelligent display of the comprehensive monitoring of water resources, water environment and water resources ecological conditions in each water area by using the automatic event analysis simulation and risk early warning monitoring analysis algorithm;According to the pre-set risk alarm data model of the system, the flood alarm and forecast of various water areas are automatically simulated. At the same time, the comprehensive information of various water affairs in various waters is analyzed automatically and displayed intelligently based on GIS.

3.1. Overall System Architecture

Intelligent water integrated information management system consists of data collection layer, transmission layer, data storage layer, analysis application layer and data display layer. The overall design and network architecture are shown in Figure 1.

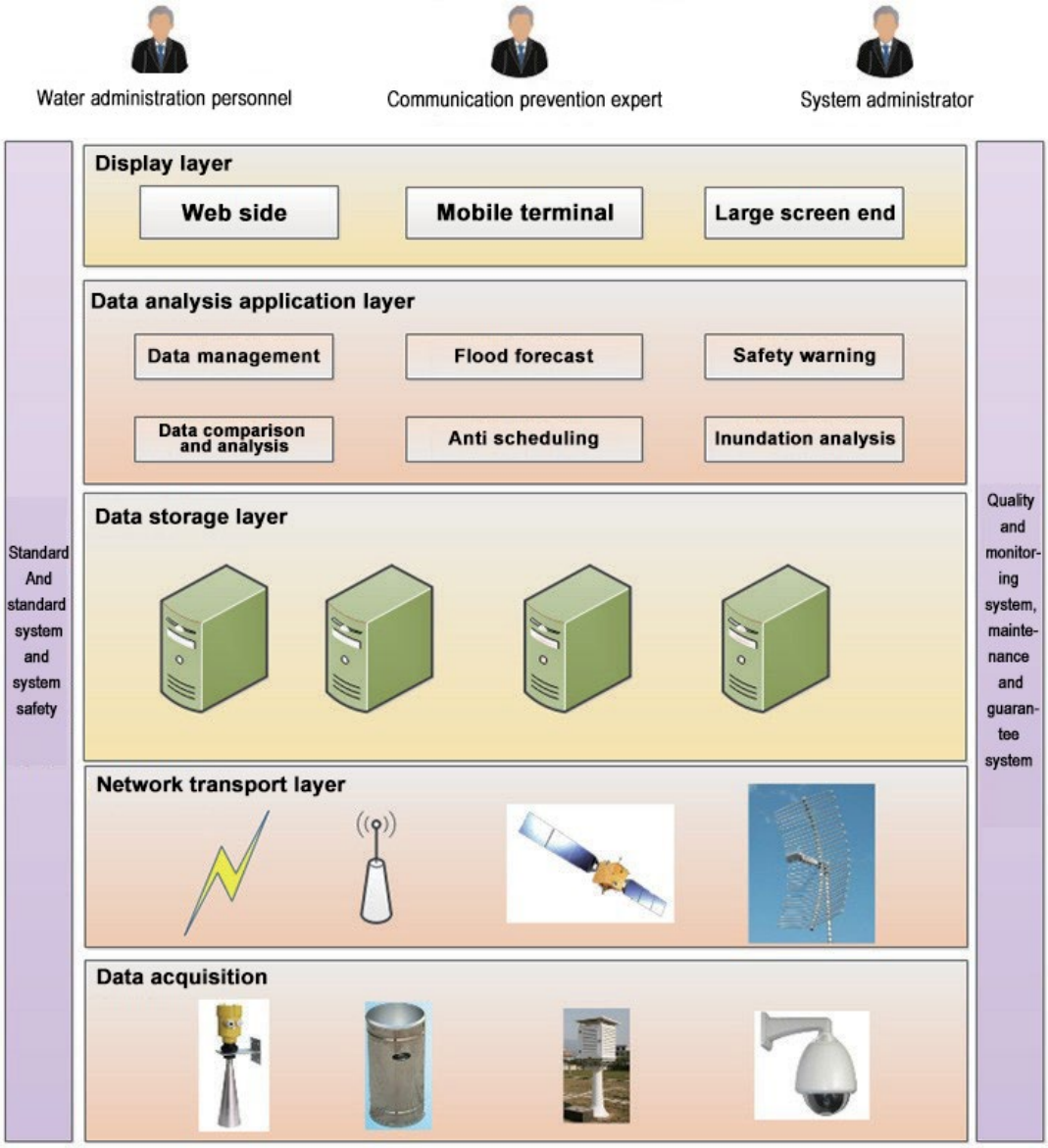

Figure 1 Overall design and network architecture of intelligent water integrated information management system.

Among them, the data collection layer mainly completes the instantaneous perception of water and rain conditions, as well as the timely collection of water level, rainfall, weather, temperature, video and other water and rain information data.The network transmission layer is mainly used for the real-time network transmission of water and rain data information. The transmission mode is mainly divided into wired network, GPRS, GSM, low-power wireless network, self-organized networking, etc. It mainly completes the Internet transmission of water and rain data in various waters.The data storage layer is mainly used for the distributed network storage of water and rain data information of various water areas and the information processing of in and out storage.The data analysis application layer mainly completes the unified management and comparative analysis of water and rain data of various water areas, and obtains the corresponding flood prevention situation forecast, flood control work scheduling, inundation situation analysis and safety accident warning according to the water and rain data analysis of these waters.The data display layer is mainly used to display all kinds of water affairs data information, including the application web page interface of basic rain situation mathematical information of various waters, the use page of basic rain information data management and the webpage interface of rain data information analysis of various waters.

3.2. System Technology Selection

The software development mode of decoupling separation between front and back end is adopted. Through decoupling, the system has higher scalability, and it is easier to obtain the improvement of system performance and multi terminal application support.The decoupling and separation of front-end and back-end enables front-end developers to focus more on page design performance, user operation experience, comprehensive analysis of dynamic data and scene rendering, and enables back-end developers to pay more attention to the implementation of business processing logic and "three highs" (high concurrency, high availability, and high performance), so that professional developers can do professional things,To maximize the core technology advantages.Due to the separation of the front end and the back end, the data communication between the front end and the back end can be realized based on the Josn data format provided by restful API, which improves the scalability of the development system.

3.2.1. Back End Framework

3.2.1.1. Microservice Architecture

Microservice architecture is a lightweight structure mode, which uses the architecture of a group of multiple services to build an application. Different businesses, i.e. various services, are independently deployed in different application processes. Different business as services are connected through interactive mechanisms, such as RPC, HTTP, etc.Each business service can scale independently, and each service has a clear business boundary.Different businesses can even be realized directly through different programming languages and maintained by independent software development teams[8].

Compared with the traditional single application architecture, microservice architecture decouples the whole application system by decomposing multiple functional modules into different and discrete service domains, which has prominent advantages[9-10] The specific performance of]is as follows:

(1) Controllable complexity

Each microservice focuses on a single function, with small coding workload and low program complexity. Different microservices communicate with each other through multiple communication interfaces, and the boundary between each microservice is clear.

(2) Flexible choice of Technology

We can select different business technical support platform or software products according to different industry demand characteristics, which is conducive to the targeted processing of specific customer business problems.

(3) Easy to deploy independently

Each microservice runs in its own independent process. When the content of a microservice changes, there is no need to recompile or deploy the whole application. It only needs to deploy the changed service business independently, which makes the service business release faster, reduces the risk of production environment changes, and shortens the whole application development run delivery cycle.

(4) Easy to expand

Each microservice can expand some module functions independently according to the actual needs of customers.

(5) Strong fault tolerance technology

In the microservice architecture, faults are completely masked in the corresponding microservice programs.The internal real-time security fault-tolerant processing in microservice system level can be realized quickly by means of time-out device to modify and retrying errors, and multi replica policy mechanism, so as to avoid some global unreliable error applications in real-time.

3.2.1.2. Spring Cloud Microservice Architecture and its Key Technologies

Spring cloud is a microservice solution of spring system. It is not only an orderly collection of a series of frameworks, but also a combination of relatively complete microservice framework technical solutions.It not only provides all the modules needed to build a distributed system, but also provides various technical basic functional modules necessary for users to build a distributed system. On the basis of the original spring boot, it integrates Services Registration and discovery of underlying software system, configuration service data center, gateway, service center data protection and system automatic melting point diagnosisDistributed system automatically configures software service data management, load balancing and other low-level development frameworks that are easy to deploy, easy to use and easy to maintain. It does not need users to integrate other components to complete the development and deployment of microservice architecture. At the same time, it also supports integrated development with other third-party components. It can complete the software development and automatic deployment of a set of microservice system architecture without the user installing and integrating other development system components. It fully supports the simultaneous integration with other third-party application development system components for system development together.

The five core components commonly used in spring cloud are described below.

The first core component is Eureka component, namely service center, whose functions are service governance, registration and discovery, and responsible for the unified management of all services.It includes server, client and server. Its main function is to provide registration, offline and renewal services for service providers;To provide service consumers with access, call and offline services.The existence of service registry makes the automatic registration and discovery of each microservice instance easier.

The Second core component is Ribbon component,Which is responsible for the load balancing of the application layer,In order to achieve the function of back-end service balance, the server-side list and the server-side user load balancing list are automatically configured in the client to polling access.

The third core component is the hystrix component, which is a fuse.At the same time, it has powerful security functions, such as request service signal degradation, welding interruption between request thread services, isolation between threads and service signals (based on dependent thread isolation), request service caching, request service merging and request service status monitoring.

The fourth core component is zuul component, which is a network service management gateway. It is mainly used to provide network dynamic routing management, monitoring, flexibility, response, security control and other main functions. Its core function is a series of filters (including pre filter, post filter, routing filter and error filter). It can be used with the above components,Cooperate to complete the specified function.

The fifth core component is fegin component. Its key mechanism is to use dynamic proxy

mechanism to complete remote service call.This paper defines the request method of other software services that need to be called into abstract method and encapsulates it to construct a set of simple request interface. It does not need any components to build requests such as HTTP.

The schematic diagram of the spring cloud framework is shown in Figure 2.

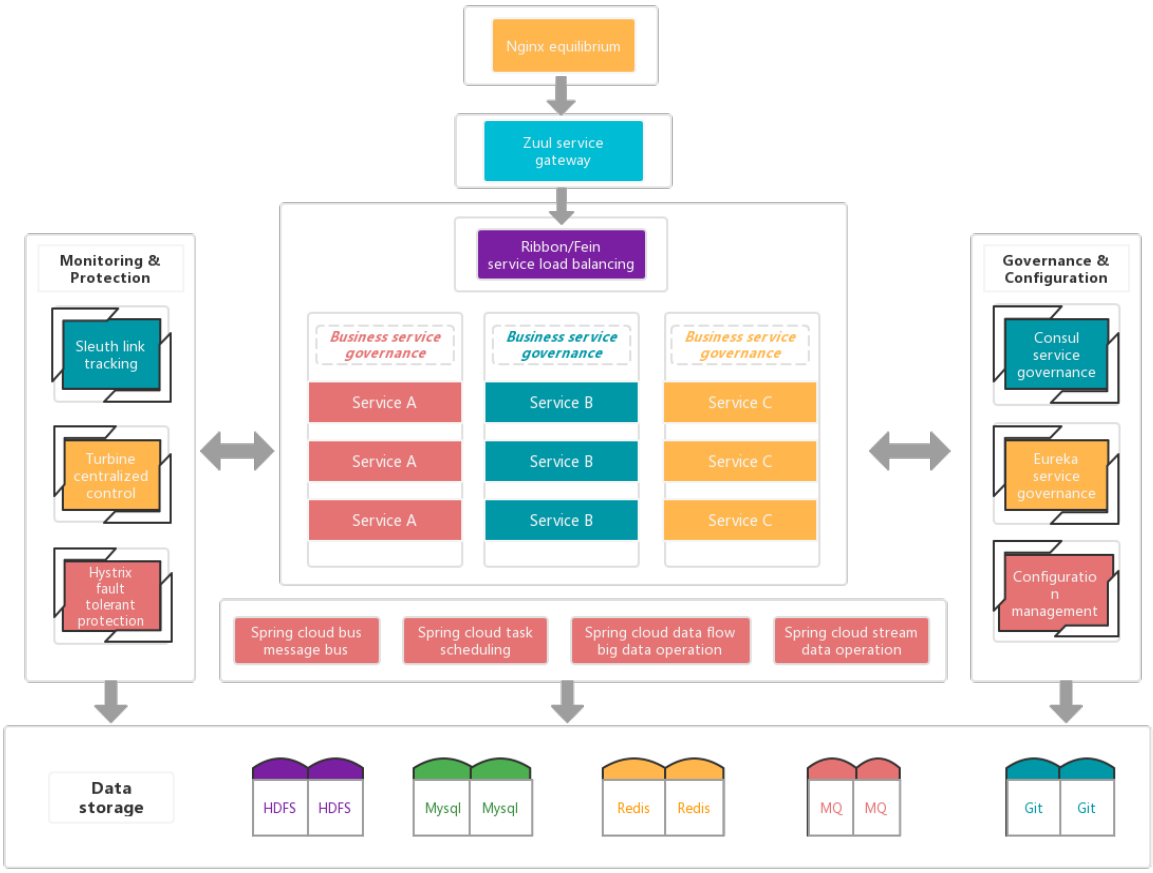

Figure 2 Schematic diagram of spring cloud framework.

Spring boot framework is the foundation of spring cloud, so it can be used independently to develop application systems. However, spring cloud relies on spring boot and cannot be developed and used independently. Spring cloud has a complete life cycle of micro service framework for composition management of single microservices developed with spring boot.

3.2.2. Front End Frame

Vue core framework architecture is a progressive front-end development and programming framework for building user core interface.Different from other mainstream application front-end development programming frameworks, such as angular JS and react, Vue is widely designed to develop mobile applications from bottom to top.Vue's core library only provides a layer of user experience view, that is, view layer, which needs users' attention. It has low learning cost and is very easy to use.Seen.The goal of JS is to implement the data binding of the response and the combined view components through the simplest API possible.

Vue's template integrated management function of this view is a view system component core template integrated management engine. On this basis, we can easily build a complete system view core framework by automatically adding system view core component template, client adding view component routing, large-scale adding view management state table and data collection management.At the same time, the core functions of these views are independent of each other. Developers can choose other view base integration components flexibly and easily based on the core functions of this view.Vue, the development of virtual components and DOM, lightweight framework, animation system and other advantages, the framework principle is shown in Figure 3.

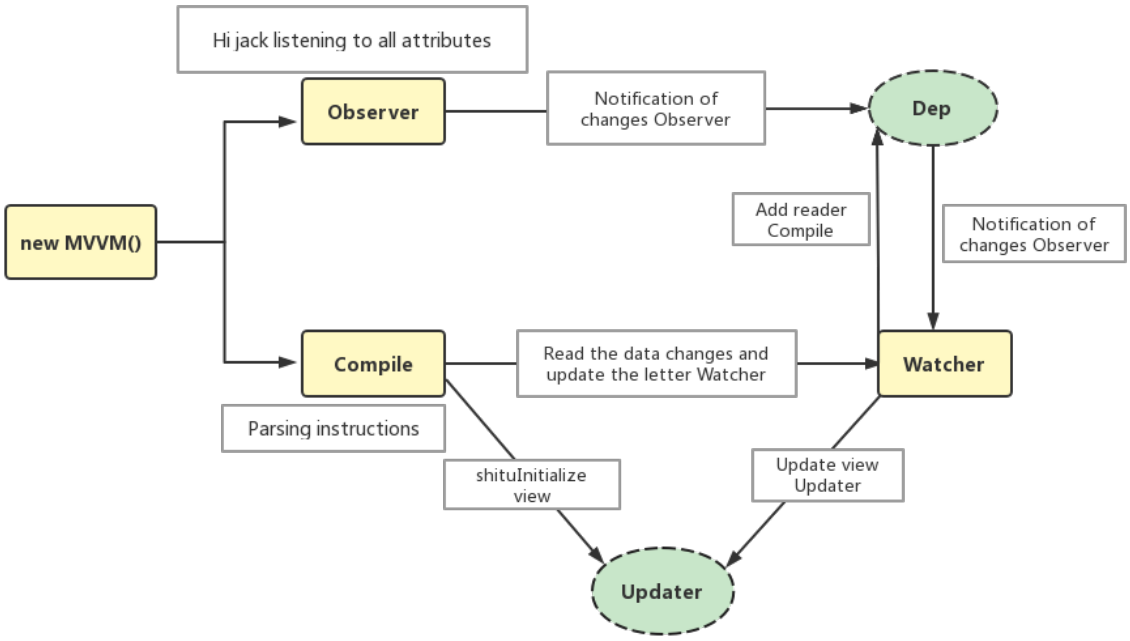

Figure 3 View frame principle of Vue.

3.3. System Function Module Architecture

The intelligent water integrated management information system needs to complete the monitoring, display, scheduling and other related water management functions. The complete functions and technical realization are composed of intelligent water integrated management information platform system, intelligent water affairs comprehensive monitoring and early warning system, water resources management information system, water environment management information system and intelligent security monitoring system, as shown in Tables 1 to 5.

Table 1 System function modules and contents of intelligent water affairs integrated management information platform.

Serial number	Functional module	Concrete content
1	Comprehensive display of water resources	Comprehensive research shows the dynamic balance of water resources, water resources scheduling, and equipment operation status.
2	Comprehensive display of water environment	According to the national basic geographic data, comprehensive research and display of river and surrounding water environment, soil environment, atmospheric quality, basin meteorological data.
3	Comprehensive display of water ecology	The comprehensive study shows the distribution of vegetation and woodland, the distribution of aquatic ecological species (in the form of list) and human activities (residential areas, commercial areas, leisure areas, roads, etc.) around the river.
4	Decision support	The water quality of the river and the river basin is modeled, the water body is evaluated and classified, and the river water pollution is analyzed scientifically.
5	Intelligent law enforcement	According to the feedback of the comprehensive early warning system, intelligent supervision, mobile inspection (reporting problems based on smart water APP), video sharing monitoring, and personnel command and dispatch.
6	Project management and protection	To integrate and analyze the data of the approval of non construction projects, the supervision of projects under construction (in the form of project status list), and the benefit evaluation of existing projects.
7	Assessment and evaluation	Monthly comprehensive ranking, map event display, typical problem photos, problem type proportion analysis, assessment payment details, etc.
8	Digital management of drainage network	To monitor, display and analyze the data of the pump station in real time, including monitoring, monitoring and data collection of the drainage system.
9	Smart water app	Check the comprehensive information of water resources and environment, the distribution of monitoring points, real-time data, water quality monitoring, river circulating pipe network pressure, pump station monitoring and alarm information on the mobile phone.

Table 2 Function modules and contents of intelligent water affairs comprehensive monitoring and early warning system.

Serial number	Functional module	Concrete content
1	Real time data monitoring	Based on the monitoring map, the water quality, flow, water level, rainfall, video and other monitoring points are monitored in real time, and the real-time monitoring data are collected and statistically analyzed.
2	Event simulation	Event analysis and simulation focuses on three watersheds: fixed source, mobile basin source and risk basin source. Potential water environment sources and risk source basins are identified. A two-dimensional water table shallow water resource flow dynamic prediction model is constructed to manage and analyze early warning strategies and early-warning events.
3	Statistical analysis	The data obtained from the real-time monitoring of the front-end monitoring points are counted and analyzed according to the water quality and water quantity model constructed in the project. In order to carry out the project performance evaluation, the data statistical chart and data report are generated.

Table 3 Function modules and contents of water resources management information system Specific contents of serial number function module.

Serial number	Functional module	Concrete content
1	Water resources utilization	Through the water resources sensor monitoring network, real-time monitoring, inquiry, statistics and analysis of river water supply and water level are carried out to provide decision-making basis for water resources development and utilization.
2	Water resources regulation	According to the database and control interface of 48 field control stations of the whole basin automatic control system provided by Party A, all signal monitoring and control functions can be provided for controllable points;For uncontrollable points, video images, can provide remote monitoring of all signals.
3	Comprehensive supervision	It realizes the functions of sewage supervision, river circulation network pressure management, on-site abnormal situation identification and alarm, data analysis, parameter setting, authority management and so on, which provides decision support for managers.

Table 4 Function modules and contents of environmental management information system Specific contents of serial number function module.

Serial number	Functional module	Concrete content
1	Water environment monitoring map	The function of real-time map of water environment monitoring realizes the grid viewing and printing of water environment monitoring stations based on GIS, real-time evaluation, monitoring, monitoring and early warning of water environment, prediction and analysis of water environment development trend, query of water environment monitoring statistical data, and real-time display in various forms of rectangular column map, process line or real-time data analysis list,The real-time water environment assessment can be realized by real-time rendering of water environment monitoring results of each river basin.
2	Water environment assessment	According to the monitoring data, the water environment assessment is carried out according to the water environment evaluation standard, and the exceeding multiple, exceeding rate and evaluation index are calculated, including surface water evaluation, drinking water evaluation, sewage outlet evaluation, precipitation water quality (inferred from river water quality change). The manual input interface of external sample evaluation data is provided.
3	trend analysis	Through hydrodynamic model and multidimensional water quality model, the development trend of water environmental pollution events is analyzed according to the data of pollution source discharge and hydrological situation.
4	Report statistics	The report forms dynamic statistics to generate water environment monitoring reports, mainly for the statistical monthly report, annual report and notification of water environment quality monitoring management, as well as water environment monitoring overview, water quality inspection station and monitoring section situation list, water resources and environment monitoring management results statistics table, trend data analysis and monitoring results statistics table, etc,The specific content and format of the form are designed and customized according to the national standard and the actual application requirements.

Table 5 Function modules and contents of intelligent security monitoring system Specific contents of serial number function module.

Serial number	Functional module	Concrete content
1	Video surveillance system integration	According to the established video monitoring station, the secondary development is carried out based on the relevant interface provided by the video manufacturer, and integrated in the information system for display and control.
2	Audio alarm system integration	According to the established video and audio system, the secondary development is carried out based on the relevant interfaces provided by the manufacturer, and integrated in the information system to display and control.

4. Demonstration of Application Examples

On the basis of the research on the overall structure of the software system and the selection of the main technical nodes, this paper, relying on the software transformation and development project of the automatic safety monitoring system for water and rain conditions in a certain water area of Henan Province, has completed the development of a comprehensive information platform system software for intelligent water affairs management.The system mainly includes five modules: intelligent water integrated management information platform, intelligent water integrated monitoring and early warning system, water resources management information system, water environment management information system and intelligent security monitoring system.These five core modules successively completed the collection, management, transmission, storage, analysis and comprehensive application of the water and rain monitoring information from the observation station node processing state, and realized the safe automatic operation management, data analysis and early warning of the water and rain monitoring system in the water area.

5. Summary

This paper briefly expounds the basic necessity of the design and development of the intelligent ecological water affairs integrated information resource management system in water areas, and develops a water affairs integrated information management system in a water area of Henan Province Based on the micro service model with the separation of front and rear functions and the spring cloud + Vue framework by combining the water and rain business in water areas and on the basis of the overall system architecture design. The first version of the system has achieved good results in practical application.

The practical research results show that the system development model with independent front and rear ends and parallel separation greatly improves the efficiency of software development, enhances the reliability and scalability of the system work, and reduces the cost of software development. At the same time, the selection of development frameworks such as spring cloud+vue also greatly improves the work efficiency of software development technicians. It has the advantage of solving the core problems of the system, and is worthy of wide application and promotion. Based on the application and development route of this new technology, the "Huaxia software union" team of our industry university research institute will continuously improve, optimize and innovate its functions, so as to more effectively meet the requirements of the new era of rapid and healthy development of informatization of modern intelligent water management system in China.

References

[1] Liu Mei, Yan jianzhuo, Yu Yongchuan. Research on data resource system under the framework of "smart water" in Beijing [J]. Water conservancy informatization, 2014 (4): 5-10.

[2] Zhang Xiaojuan, Tang anchor, Liu Mei, et al. Beijing smart water construction concept [J]. Water conservancy informatization, 2014 (1): 64-68.

[3] Wang Shaohua, Lu Hao, Huang Qian, et al. Research on Key Technologies of intelligent

transportation system [J] .Surveying and spatial geographic information, 2013, 36 (S1): 88-91.

[4] Tian Yu, Jiang Yunzhong, Yang Mingxiang. Research on the foundation and development strategy of smart water construction [J]. China water resources, 2014 (20): 14-17, 75-79.

[5] Wang Jianshe, Xu xiuchao, Liu Shoujie. Planning and treatment measures and Countermeasures for the current situation of urban water system [J]. Henan water conservancy and south to North Water Diversion, 2012 (16): 22-23.

[6] Wu Yanhua, Fu Hua. Characteristics of urban water system, tourism development and protection in Beijing [J]. Journal of Capital Normal University (NATURAL SCIENCE EDITION), 2004, 25 (2): 66-70.

[7] Liu lulu. Discussion on the path of urban smart water construction [J]. Journal of Anqing Normal University (SOCIAL SCIENCE EDITION), 2016, 35 (1): 99-101.

[8] MARTIN Fowler,JAMES Lewis. Microservices[EB/OL].(2014-03-25)[2022-01-22]. http://mart-infowler.com/articles/microservices.html.

[9] KETAN Parmar. Microservice Architecture - A Quick Guide[EB/OL].(2014-06-25)[202201-22]. http://www.kpbird.com/2014/06/microservice-archi- tecture-quick-guide.html.

[10] CHRIS Richardson. Introduction to Microservices [EB/OL].(2015-05-19)[2022-01-22]. https://www.nginx.com/blog/introduction-to-microservices/.