Design of Hydrological Monitoring Information System for Heilongjiang River

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Keywords: hydrology, hydrological monitoring, hydrological information, system requirements, information management.

Abstract. By analyzing the basic concepts, principles and analytical methods of hydrology, this paper introduces the design and implementation of the hydrological information management system in Heilongjiang province, combined with the more advanced programming language and based on the remote data management technology.

Introduction

Hydrological information is the carrier to reflect the data of water quantity, water quality and water temperature. The level of hydrological information monitoring directly reflects the level of hydrology management in a country or a region [1]. Researches both at home and abroad have conducted in-depth studies on hydrological monitoring, trying to find laws from data and detecting potential hydrological hazards and the relevant threats to human survival [2]. In China, a country with lack of water resources, the pollution and abuse of water resources will lead to unredeemable consequences. At the same time, the task of flood control and drought resistance is arduous due to various natural conditions and human factors.

There are many rivers in Heilongjiang Province, especially including several major international rivers. In order to better complete the hydrological information detection of the main rivers in Heilongjiang Province, Heilongjiang Provincial Water Resources Department has conducted a comprehensive investigation of domestic and foreign water conservancy and hydrology management information systems, demonstrated and analyzed the hydrological Monitoring information management system of Heilongjiang Province, and then determines to develop the hydrological Monitoring information system.

Theoretical basis

Basic theory of hydrology. Hydrology, as an integral part of the earth science and an important field of modern technology, is playing an increasingly role in the development of the national economy, providing the necessary hydrological basis for the planning, design, construction and management of civil engineering. Since the 1960s, due to the large-scale effects of human
activities and the emergence of high-tech such as electronic computer and satellite remote sensing telemetry, modern hydrology with some new characteristics of hydrological forecast and prediction, is used to not only detect water quantity and water quality, but also estimate a series of effects of human activities on the hydrologic cycle. Integration of hydrological information collection, model calculation and optimal scheduling, can realize the automation system of the hydrological real-time forecast and the integrated dispatching for engineering management, giving full play to the social and economic benefits of hydrological forecasting and prediction [3].

**C# technical foundation.** C# is a good, simple, type-safe, object-oriented language that enterprise program developers can use to create multiple application [4]. C# can enable you to create stable system level components, based on the following advantages:

1) Full COM/Platform support for existing code integration.
2) Robustness due to garbage collection and type safety.
3) Security provided by the internal code trust mechanism.
4) Full support for the concept of extensible metadata.
5) Users can also use C#’s following features to implement C# interaction with other languages, cross-platform, and traditional data:
   (1) Full support for interoperability between COM+ 1.0 and .NET services and tight library access.
   (2) XML support for the interaction of website components.
   (3) Providing simple management and deployment.

**Theoretical knowledge of correlation analysis.** In hydrologic calculation, the use of the correlation analysis is to find out the approximate relationship between hydrologic phenomena and to reduce the statistical error in the hydrological analysis through interpolating the long data series and extending the short data series in the rationing. For example, with a rather long period of precipitation record, the correlation between precipitation and runoff can be calculated to interpolate or prolongate the flow data; it is also possible to find out the correlation of runoff volume between two rivers with similar natural geographical features, to solve the problem of runoff data by using extending the short data series or interpolating the long data series.

**System Requirement Analysis**

**Analysis of test objects.** At present, the Heilongjiang Provincial hydrological sectors currently use a rainfall data acquisition system developed by a company, which lacks comprehensive hydrological information data. The hydrological monitoring information system in this paper can comprehensively collect information such as water level, flow volume and flow rate. The main objects of the system requirement analysis are more than ten major rivers and boundary rivers in Heilongjiang Province, including Heilongjiang, Songhuajiang, Wusulijiang, Nenjiang, Suifen River, Mudanjiang, Huma River, Xun River, Jieya River and Bulieya River.

**Functional requirements analysis.** Through investigating and analysis of the system administrators, the hydrology departments, the station network departments and the supervisors, it is advisable for developing the hydrologic monitoring information system to have the hydrological monitoring function, the flow calculation function, the hydrological tool, the mathematical calculation, the additional function and the use help and other main modules. The hydrological monitoring function, composed of the hydrologic sensor, the power supply equipment and the...
GPRS transmitter arranged in the main rivers, can collect data of flow rate, turbidity, sediment concentration and etc., and send it to the data collection server, which function module is mainly composed of hardware.

**Performance Requirements Analysis.** The hydrological monitoring information system has certain requirements on performance, including data sensitivity performance, data transmission performance, data analysis performance, data processing performance and etc. These properties directly affect the using efficiency of the hydrological monitoring information system [5]. The specific requirements for each performance indicator of the system are described as follows:

1) Data sensitivity performance
   It mainly measures sensitive periods of the flow rate sensor, the turbidity sensor and the temperature sensor. The system requires each sensor to continuously Monitoring hydrological data for 24 hours. The sensitive period of each sensor is within 1 second, and the interval of sending data to the data collection center is adjustable from 1 minute to 24 hours.

2) data transmission performance
   The system can transmit sensitive data to the data collection server through GPRS, with the rate of 1kbps.

3) Data analysis performance
   The system can complete the statistical analysis and sorting of the key rivers’ hydrological data within 2 hours;

4) Data processing performance
   The system can store, analyze, and process massive data with a data volume of more than 1000TB.

**System Outline Design**

**System function module design.** The overall design of the system is to transform the requirement analysis into an architecture and to divide the module components of the program. The function module design of Heilongjiang hydrological monitoring and management system, as shown in Figure 1, is divided into five modules: Flow Calculation, Hydrological Tool, Mathematical Calculation, Additional Function and User Management.
**System main interface.** The interface of the system is divided into four parts: title bar, menu bar, menu navigation area and operation area. The title bar displays the name of the system, the menu bar shows the functions of the system in detail, and the operation area is the main interface where the user operates each function. The system interface is shown in Figure 2.

**Figure 2 Diagram of the main interface layout of the system**

Table 1 shows the names and main functions of each interface component in the system.

<table>
<thead>
<tr>
<th>Numble</th>
<th>Components</th>
<th>Functional description</th>
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<tbody>
<tr>
<td>1</td>
<td>Title bar</td>
<td>To display the name of system and the title of the user's operation</td>
</tr>
<tr>
<td>2</td>
<td>Menu bar</td>
<td>To display the function items that the system has</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To display the function according to the abbreviated hiding mode of each menu item.</td>
</tr>
<tr>
<td>3</td>
<td>Menu navigation area</td>
<td>The user can select the function module quickly from the navigation area.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To display the contents of specific functional modules, such as midstream data, excel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tables, and binary conversion.</td>
</tr>
<tr>
<td>4</td>
<td>User operating area</td>
<td></td>
</tr>
</tbody>
</table>
**System database structure design.** As shown in Figure 3, the Heilongjiang hydrological information management system consists of 9 data sheets, which are TableDuanmian (section data), TableCeliu (flow measurement data), TableZhonghong (midstream buoy), TableCeliu (tachometer method), TableMingqu (open-channel flow), TableShuipin (hydrological frequency), TableMianbao (area method), TableSandeng (third order leveling), and TableZhuanhuan (conversion).

![System database composition diagram](image)

**System Test**

**System login test.** In order to ensure the access security of the system data, the user needs to log in correctly before accessing the server data. Therefore, the system login test is first performed, and the login interface is as shown in Figure 4.

Comparing Figure 4(a) with Figure 4(b), it can be shown that if the username and password are incorrect, the system prompts the user “the login name and password do not match”, and the system cannot run correctly. The operation interface is shown in Figure 5 after login.

![System login interface](image)  ![Input error interface](image)
Figure 5 the interface after logging in correctly

**Hydrological data transmission test.** GPRS is the main mode of data transmission for hydrological sensors and data servers. The transmission rate of GPRS is the main factor determining the performance of the system. The transmission rate of GPRS is tested in this section. Because the testing process requires multiple GPRS data communication cards, the system performs cards “rxenable” according to the needs, and it enables the next GPRS data receiving card only when reaching the current receiving bottleneck.

The test result of GPRS data reception is shown in Figure 6. After receiving a group of hydrological sensor data, GPRS stops briefly, and then the next hydrological data reception operation starts to make the channel smooth.

Figure 6 GPRS data test results

**Hydrological data transmission test.** When multiple hydrological sensors send data to the server, with the limited GPRS channel resources, it is necessary to provide multiple GPRS receiving terminals. The test for the amount of data transmitted of multiple hydrological sensors sending data to two terminals is performed in this section.

Figure 7 shows the transmission curve of the two groups of hydrological sensors sending data to the GPRS receiving terminal. As can be seen in the figure, both sets of hydrological sensors can send hydrological data to the server steadily through the GPRS terminal, and have little impact on each other.
Figure 7 Multi-hydrological data transmission rate test chart

**Hydrological data request test.** The measurement data request is sent to the designated hydrological sensor through the user terminal, and the response time of the sensor to the user request determines the efficiency of the system’s data request, so the performance of the hydrological data request is tested in this section.

Figure 8 shows the buffer time curve of the hydrology data requesting data. As can be seen in the figure, the preparation time of the maximum data is less than 10 milliseconds, and the system can meet the user's request for hydrological data request time.

Figure 8 Time test for data acquisition

**Server Query Performance Test.** Based on the fact that the hydrologic data query request is sent to the designated hydrological database by the user terminal, the response time of the server to the user determines the efficiency of the system's data query. So the performance of the hydrological data server is tested in this section.

The test results of the server query response time are shown in Figure 9: Each query can be completed within 10 milliseconds; and the system response time increases when the query involves large amounts of data, namely the maximum response time of 21 milliseconds as shown in the figure.
Conclusion

The development and application of this system can improve the efficiency and accuracy of hydrological information acquisition, statistical analysis and water management policy making in Heilongjiang hydrological system, and help hydrology bureaus to fully grasp the hydrological conditions of the main rivers in the province. The hydrological information management system in this paper has a certain universality - easily applied to the hydrological information detection in other provinces, and it can make adjustment and upgrade of functions and interfaces corresponding to subsequent requirements.

Although the system can better implement all the functions desired by the users, as the number of sensors deployed increases, the data collection efficiency is greatly affected, even there will be a packet loss phenomenon; and with the low code rate of the GPRS mode and the long time of port occupancy, there will be some difficulties in the large-scale deployment of the system. The next step will focus on the hierarchical system design - to design the lower-level nodes to collect data, decentralizing the data collection, and improving efficiency and stability of the system operation.

Reference