Design and Implementation of Ground Meteorological Data Storage Alarm System for Other Provinces

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Abstract: The provincial information center receives meteorological data from other provinces through satellite broadcasts. In response to the low efficiency and inability to promptly address issues such as data nonexistence and data loss caused by malfunctions in the manual monitoring mode, an analysis of the data transmission process and user access methods was conducted. Based on the Python language, a ground meteorological data storage alarm system was developed for the Northwestern region. This system enables real-time monitoring of the storage status of hourly ground data, facilitates the generation of statistical reports on missing station information within any given time frame, and promptly sends alarm notifications via enterprise WeChat. The results indicate that this system assists operational and maintenance personnel in promptly identifying and addressing faults, ensuring the orderly and timely storage of meteorological data from the Northwestern region into the local database and thereby providing users with higher-quality data services.

Keywords: Meteorological Data; Data Transmission; Monitoring; Alarm; Data Services

1. Introduction

Due to the rapid development of the meteorological industry, there is a wide variety of meteorological products, and the timely transmission of massive meteorological data is highly demanded. Currently, ground minute data is updated every minute, and the exchange of complex data types among different systems is frequent, placing heavier tasks on operational and maintenance personnel. The Information Center of the Gansu Provincial Meteorological Bureau receives ground meteorological data from four other provinces in the Northwestern region (Qinghai, Ningxia, and Shaanxi) through satellite broadcasts. However, issues such as computer software and hardware failures, network problems, etc., can lead to data nonexistence and data loss, which adversely affect the quality of services provided to users. Furthermore, the Northwestern region has a large amount of meteorological data, with only approximately 282 automatic stations and around 4,287 regional stations. Monitoring and tallying missing station information, using traditional manual methods, would be laborious and cumbersome. Moreover, it cannot promptly and proactively detect anomalies in the data storage process[1], leading to delayed detection and repair of faulty points, severely affecting the timeliness of ground meteorological data storage and the quality of data transmission observation. With the rapid advancement of the automation level in comprehensive meteorological observation systems, meteorological forecasting and services have increasingly higher requirements for the timeliness of data transmission processes[2]. Meteorological observation serves as a crucial foundation for accurate forecasting and precise services. It acts as the forefront of the first line of defense for meteorological disaster prevention and reduction, making it urgent to strengthen the automatic monitoring and early warning capabilities during the process of ground meteorological data transmission and processing[3]. To timely and accurately monitor meteorological data from other provinces and regions and effectively alleviate the workload pressure on operational and maintenance personnel, Xu Ning et al. [4] proposed a monitoring and transmission scheme for ground meteorological minute data.

It mainly achieves the monitoring of BUFR data from ground meteorological stations and automatic retransmission of missing data. Xu Haobin et al. [5] designed a regional station data monitoring system based on practical business needs and sent missing report information to operational and maintenance personnel via email. They introduced the design of a comprehensive meteorological data flow monitoring system and proposed a method for rapid localization and monitoring of data updates. Wu Guiyi et al. [6] elaborated on the design principles and implementation methods of the comprehensive meteorological data monitoring algorithm and the construction of the data monitoring chain. Wang Shuofei et al. [7] implemented automated monitoring of the operating status of communication equipment and the transmission of meteorological data, with alarm functions enabled through a messaging platform. Currently, there is no unified real-time monitoring of the meteorological data transmission status in the four other provinces of the Northwestern region. However, the observed meteorological data from these provinces are crucial for studying the climate in the Northwestern region, such as analyzing trends in warmth and humidity and predicting future climate changes [8]. In order to further strengthen the monitoring of meteorological data storage in the Northwestern region, this study proposes a python-based data storage alarm system for data from other provinces and regions. It enables real-time monitoring of missing data from national automatic stations and regional stations in the Northwestern region. Maintenance personnel can promptly detect and locate data gaps through WeChat alarm notifications. This system ensures the orderly and timely storage of ground meteorological data from the Northwestern region into the database, thereby providing users with higher-quality data services.

2. System Design

The Meteorological Big Data Cloud Platform, known as “Tianqing”, is the most critical foundational platform for meteorological information technology. It is primarily built around big data resources and provides massive data storage, data sharing, and integrated “data-computation fusion” platform services. It integrates various data resources and processing workflows of meteorological departments, eliminating data silos and information islands. By achieving the convergence and interconnection of meteorological business data resources and facilitating their co-construction and sharing, Tianqing plays a vital role in supporting the accuracy of meteorological forecasting and the refinement of meteorological public services through its data capabilities [9]. In our province, meteorological data from the four other provinces in the Northwestern region is downloaded via satellite broadcasting. Tianqing distributes the broadcasted and downloaded meteorological data to the downstream Service-Oriented Data Storage System (SOD) through the China Telecommunication System (CTS) and Data Processing and Conditioning System (DPC) for decoding and storage processing. The Meteorological Unified Service Interface Community (MUSIC) provides data application services to users, and business units utilize the MUSIC service interface to access meteorological data. The MUSIC, based on the Meteorological Big Data Cloud Platform, is designed for meteorological operations and scientific research. It offers a nationally unified, standard, and comprehensive data access service and application programming interfaces (APIs), providing authoritative data access services for various levels of application systems. However, throughout the entire data transmission process, data loss can occur due to communication node failures, software freezes, and other malfunctions, making it impossible for users to access such meteorological data through the interface. Currently, our province has conducted in-depth research on the overall business processing flow and key components and technologies of the big data cloud platform. Real-time monitoring and data collection of the operational status of each processing component have been implemented, and the collected information has been transformed into alarm notifications. Nevertheless, the existing monitoring and alarm platform does not provide unified real-time monitoring of the ground meteorological data transmission status in the four other provinces of the

Northwestern region. Therefore, it is crucial to organize and monitor the meteorological data of the Northwestern region in real time, as it can effectively enhance the overall understanding of the transmission status of ground meteorological data from the four other provinces in the Northwestern region [10].

Based on the different functions of the system, it can be divided into three main functional modules: real-time monitoring, WeChat alarms, and logging. The general workflow of the system is depicted in Figure 1. Initially, the entire transmission process of ground meteorological data in the Northwestern region was organized, including the processes of broadcast distribution, platform downloads, data distribution, decoding, and storage. This helped establish the complete flow of data from distribution to user access through the interface. The catalog of meteorological data from national and regional automatic stations in the Northwestern region, which is disseminated through satellite broadcasting, was compiled. This catalog includes station numbers, station names, as well as information on the respective cities and counties to which the stations belong. Information on corresponding databases and data table names where such meteorological data is stored was also organized. Next, a program was developed to retrieve this type of data in real-time, validate the real-time storage status of the meteorological data, and send alarms based on different storage status information. Additionally, the existing station information table was dynamically updated in real-time based on the validation results, ensuring accurate updates of station network information. By continuously monitoring the storage status of ground meteorological data in the Northwestern region, the program generates corresponding alarms and sends them to the enterprise WeChat platform in case of any abnormal data storage situations. Timely awareness of the data storage status in the Northwestern region facilitates quick problem identification by maintenance personnel and timely resolution of ground meteorological data loss issues. This helps improve data transmission quality, reduce the workload of operation and maintenance personnel, and establish a solid foundation for providing higher-quality data services.

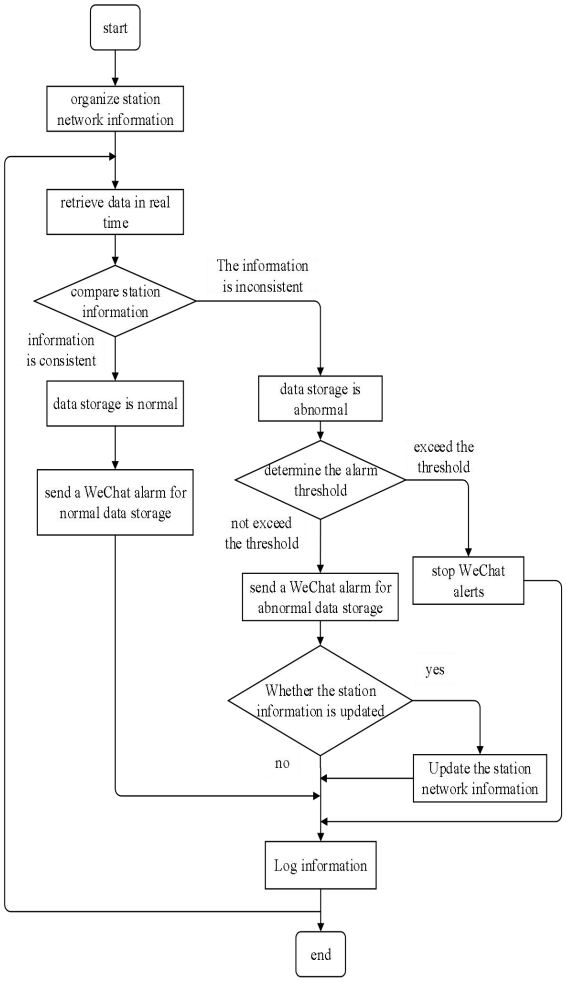

Figure 1. System Workflow

2.1 Real-time Monitoring Program

Real-time monitoring is the foundation of normal operation in meteorological service businesses. It is also an essential tool for detecting faults in meteorological services and performance issues with meteorological equipment. The real-time monitoring program is developed using the Python language. It calls the service interface every hour to retrieve relevant meteorological data from the four other provinces in the Northwestern region and saves the output. By modifying the service interface parameter, interfaceID, it is possible to retrieve station network information within a specified time period. For example, setting 'timeRange' to [20230924000000, 20230925010000] allows retrieval of station network information within that time range. The output results are then processed and

compared with station information using Python code. The monitoring results are generated, and statistical reports on missing station network information in the Northwestern region for the specified time period are quickly generated. These reports mainly include data time, missing station numbers, station names, and their corresponding cities and counties. Furthermore, when new stations are added or existing stations are removed in each province, the real-time monitoring program dynamically updates the local station network information table by comparing the station information. It can append newly added stations and delete corresponding stations, ensuring the dynamic update of station information. The real-time monitoring module seamlessly provides refined monitoring alarms for ground meteorological data from external provinces and regions. It also serves as an effective supplement to the existing automated monitoring system.

2.2 WeChat Alarm Program

When developing the WeChat alarm program using Python, the API interface provided by WeChat Work is utilized to send alarms for data storage exceptions. Based on the retrieval results from the monitoring program, one or more alarms for stations with storage exceptions can be sent to WeChat Work, enabling operation and maintenance personnel to promptly view the faults. Additionally, operation and maintenance personnel can use WeChat Work to monitor various key assessment data in real-time. However, frequent alarm notifications from this system in the event of long-lasting faults in individual stations or widespread station failures can significantly impact other operation and maintenance tasks, increasing the workload for personnel. To avoid excessive alarm notifications caused by equipment or software failures, the program sets reasonable thresholds for WeChat alarms. If the number of repeated alarms exceeds the threshold, WeChat alarm notifications will be suspended. The program continuously monitors the output results of the real-time monitoring program on an hourly basis and will only restart WeChat alarm notifications once the repeated alarms are resolved. The alarm thresholds can be modified according to actual operations and maintenance requirements during operation.

2.3 Logging Information

Logging management encompasses the entire process of handling log events generated by the application program and related devices. This includes activities such as log collection, parsing, analysis, storage, and archiving. The goal of logging management is to provide critical information for system fault tracing and analysis. The log information generated by the real-time monitoring program and the WeChat alarm program is recorded in logs, enabling the retrieval of information such as the time of program interface calls for data retrieval and the results of retrieval and comparison. It also provides details about the time range, geographical scope, and station numbers that exceed the alarm threshold. Log information is highly valuable for operation and maintenance personnel in real-time troubleshooting, system fault analysis, and localization. If the log file exceeds a specific capacity, it can be redirected to a new log file.

3. System Application Effect

The development of the ground meteorological data storage alarm system, based on the Python language, aims to improve the timeliness of manual intervention and emergency response through WeChat alarms. This system enables seamless and refined monitoring of ground meteorological data in other provinces and regions. It serves as an effective complement to the existing monitoring system and demonstrates good practices for customized monitoring of complex business logic failures. Currently, there are a total of 282 national automatic stations and 4,287 regional stations in Shaanxi, Ningxia and Qinghai provinces, which require high data timeliness and are crucial meteorological datasets. The system's various functional modules are currently operating normally. It can monitor the data transmission status of automatic stations and regional stations in other provinces and regions on an hourly basis. It sends alarm messages in case of storage exceptions. The system demonstrates an average response time of 0.6 seconds for monitoring and alarming. The average response time for each province is shown in Figure 2.

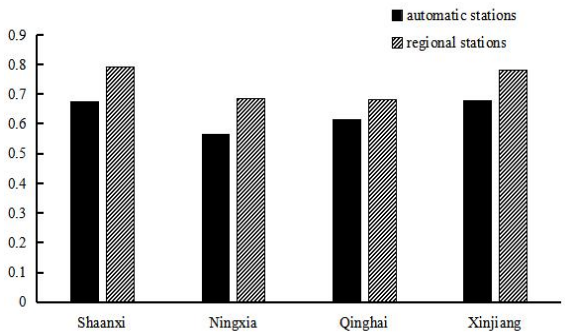

Figure 2. Comparison of Average Response Time

4. Summary

Based on the operational requirements of the business, this paper describes the design of a ground meteorological data storage alarm system for other provinces and regions. It successfully validates the data storage of national automatic stations and regional stations in those areas, and can promptly alarm maintenance personnel of any storage exceptions through WeChat notifications. This system enables quick and accurate identification of business issues, greatly improving operational efficiency and establishing a solid foundation for high-quality data services. In the future, further analysis will be conducted on the data transmission service process for ground meteorological data. The existing problems in data transmission during business operations will be identified, and an automated statistical analysis program will be utilized to provide graded warnings for faults caused by different reasons. This will significantly enhance the quality and application efficiency of observation data transmission while reducing the workload of operation and maintenance personnel.

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