Design and Implementation of the Weather Radar Mobile Monitoring System Based on WeChat Enterprise

Haiping Guo
Inner Mongolia Atmospheric Detection Technology Support Center, Hohhot, China

*Corresponding author: 77477000@qq.com

Abstract. In order to solve the problems of China’s new generation Doppler weather radar observation network, such as the lack of mobile monitoring platform, the untimely malfunction alarm and the slow interaction, a mobile operation monitoring system based on WeChat Enterprise has been designed, which is mainly composed of collection, processing, dispersal and feedback of radar’s operational status information, and interactive communication between different radar facilities and support personnel. This system can realize weather radar operating status monitoring based on cell phone, hierarchical automatic warning of operating status information, automatic video push of maintenance support activities and interactive feedback and exchange of information among maintenance support personnel, etc. Based on this system, the operational monitoring and technical support capabilities of China’s new generation Doppler weather radar are greatly improved, and it plays an important role in promoting the operational efficiency of the weather radar.

Keywords: WeChat Enterprise, Weather radar, Operation monitoring system, Design and implementation.

1. Introduction
The new generation weather radar provides essential information for weather forecast, decision consultation, and weather modification operation. To date, more than 210 new generation weather radars have been installed in China, and a vast amount of experience and findings have been obtained about its operation monitoring and technical support. Liang et al. designed an integrated operation monitoring system for meteorological observation [1]. Meng proposed a low-cost remote maintenance and control scheme for the radar software system [2]. An integrated monitoring system and a remote video surveillance support system for the new generation weather radar were developed by Chen et al. and Mao et al., respectively [3, 4]. Jiang et al. accomplished the remote fault diagnosis and emergency maintenance of the new generation weather radar, and gave the specific operation method [5].

Currently, there are 10 new generation radars in Inner Mongolia, including 4 CINRAD/CD radars, 5 CINRAD/CB radars and 1 CINRAD/CA radar. With the planning and construction of the radar network, several new generation weather radars will be put into operational application in Inner Mongolia. In recent years, great achievements have been made in the operation monitoring and the SMS warning of the new generation weather radar, which has played a key role in the technical support service for radar [6, 7, 8]. However, there is still a lack of research on the mobile operation monitoring, the intelligent
warning and the convenient online interaction for the weather radar. The staff usually uses the intranet to monitor the weather radar system. The limitation of time, location and number of people on duty restricts the early detection, early response and early elimination for the malfunction of weather radar. To solve these problems, an operation monitoring system is designed for the weather radar by employing the mobile internet technology. Based on WeChat Enterprise, it allows mobile monitoring, hierarchical push of malfunction information, automatic push of maintenance videos and convenient interaction for the 10 new generation weather radars in Inner Mongolia. It plays an important role in speeding up the failure response and the maintenance, reducing the cost of technical support and improving the operational efficiency of the radar.

2. General design of the system
The Atmospheric Observing System Operations and Monitoring (ASOM) platform has been developed by the Meteorological Detection Center of the China Meteorological Administration [10]. It collects and processes the status files and the product files from the weather radar, and identifies the operation condition of the radar as "status normal and product abnormal", "status abnormal and product normal", etc. Then the corresponding warning information is generated. In addition, the maintenance form submitted from the radar station is available on the ASOM platform. Based on the ASOM platform, the mobile operation monitoring system for the new generation weather radar is further developed by applying the Nutz framework technology and the B/S structure mode. The system undertakes collection, processing and dispersal of information, gathers information feedback and allows user interaction.

The function of the information collection module is to obtain the malfunction warning from the ASOM platform, including "status normal and product abnormal", "status unavailable and product abnormal", "status warning and product abnormal", "no data", etc. The accumulated duration of warning and maintenance is analyzed in the information processing module based on the collected equipment warning information and maintenance form. Then the warning level is determined according to the settings by the system administrator, and it can be adjusted when necessary. The information push module establishes a relationship between the different levels of warnings and the corresponding managers and technicians at provincial, municipal and radar station levels. The warning messages can be sent to the relevant staff through WeChat and SMS. The staff at the radar station can feedback the radar maintenance progress to the superior technicians and managers through WeChat after receiving the warning message. The feedback can be in the form of text, picture, voice, video and document. The interaction module allows convenient communication between the managers and technicians at provincial, municipal and radar station levels through the mobile application.

Table 1 illustrates the corresponding relationship between the type, level, duration and content of weather radar warning. The running conditions of "status normal and product abnormal", "status unavailable and product normal", and the failure shutdown notification are taken as examples.
Table 1. Corresponding relationship of warning information

| Type                          | Level | Duration | Information content                                                |
|-------------------------------|-------|----------|-------------------------------------------------------------------|
| Status normal and product abnormal. | Level 1 | 20 minutes | The running condition of the weather radar at Station A has been "status normal and product abnormal" for 20 minutes. Please pay attention. |
|                               | Level 2 | 30 minutes | The running condition of the weather radar at Station A has been "status normal and product abnormal" for 30 minutes. Please pay attention. |
|                               | Level 3 | 40 minutes | The running condition of the weather radar at Station A has been "status normal and product abnormal" for 40 minutes. Please pay attention. |
| Status unavailable and product abnormal. | Level 1 | 20 minutes | The running condition of the weather radar at Station A has been "status unavailable and product abnormal" for 20 minutes. Please pay attention. |
|                               | Level 2 | 30 minutes | The running condition of the weather radar at Station A has been "status unavailable and product abnormal" for 30 minutes. Please pay attention. |
|                               | Level 3 | 40 minutes | The running condition of the weather radar at Station A has been "status unavailable and product abnormal" for 40 minutes. Please pay attention. |
| Failure shutdown notification | Level 1 | 1 hour   | The weather radar at Station A has been failure shutdown for 1 hour, please pay attention. |
|                               | Level 2 | 6 hours  | The weather radar at Station A has been failure shutdown for 6 hours, please pay attention. |
|                               | Level 3 | 12 hours | The weather radar at Station A has been failure shutdown for 12 hours, please pay attention. |

3. System function design

The mobile operation monitoring system for the new generation weather radar consists of three functional modules: Web-based management platform, background processing program and WeChat application platform. It allows mobile monitoring, detailed malfunction inquiry in the past 24 hours, hierarchical push of malfunction information (completed within 10 seconds), automatic push of maintenance videos and interaction among users for the new generation of weather radar.

3.1. Web-based management platform

The Web-based management platform can be used to manage equipment alarm rules, supervise subscriptions of departments and users, query historical push messages, manually edit and send messages, regulate WeChat users and implement online communication among users. Besides, a "dashboard" is used to show the running conditions of the new generation weather radars in the whole province, and a click on it helps to inquire the detailed malfunction information of each radar in the past 24 hours. Currently, the Web-based management platform of the system has been displayed in real time on the large screen in the monitoring room of Inner Mongolia Meteorological Technology Support Center. On the original ASOM platform, the staffs need to switch multiple pages to check the radar running condition and browse the equipment warning information. An effective solution to this problem is provided in this system.
3.2. Background processing program
The background processing module stores the malfunction information and the maintenance forms of radar obtained from the ASOM platform, and calculates the malfunction duration. Then it generates different levels of warnings according to the warning rules of the system and stores them in the push information table. In addition, the module pushes the radar warning information to relevant users through WeChat and SMS according to the subscription rules. Besides, based on the malfunction type reported by the radar station staff, the corresponding maintenance video can be transmitted to the WeChat application platform of the front-line staff.

3.3. WeChat application platform
The WeChat application platform provides four functions. First, it can automatically receive the radar warning information transmitted by the background processing program of the system. Second, the radar running condition in the whole province can be displayed with a "pie chart", which is synchronous with the information on the ASOM platform. Third, it can provide the radar maintenance video pushed by the background processing program. Fourth, the provincial technicians and the radar station staff can communicate about the maintenance progress online, and the radar manufacturer staff can also join in.

4. Main functions and key technologies
The Eclipse code editing tool, the MySQL open-source database and the Tomcat application server are utilized for the system. Besides, the implementation of the system is based on the Nutz open-source framework, the Java programming language and the technologies of HTML5, bootstrap and JavaScript. The implementation of the main functions will be introduced in the following.

4.1. Information collection and storage
An information collection and processing program is designed in the background module of the system. The program scans the warning form and the maintenance form on the ASOM platform regularly, and then picks out the relevant warning information according to the radar station number, which is finally saved in the original warning form and the original maintenance form of the system.

4.2. Push message generation
A program is designed to automatically calculate the durations of the radar malfunction information and the maintenance form. The program continuously scans the original warning form and maintenance form. At the same time, it can automatically identify whether the warning and maintenance information reaches the corresponding warning level. If so, the information will be written into the information push form of the system. Otherwise, the calculation will be continued until it hits the level or the warning ends.

4.3. Automatic push of message and support video
This program is designed to push messages and technical support videos of radar. It scans the information push form regularly. When it discovers new undelivered records, it will automatically push the warning to the subscriber's mobile phone based on the subscription rules. Moreover, according to the malfunction type, the corresponding technical support video in the system database will be pushed to the radar station staff for reference.

4.4. WeChat user feedback and online interaction
After receiving the pushed message, the user can feedback the radar maintenance progress to the provincial technicians with voice, text, picture, video, document, etc. through WeChat. Similarly, the provincial technicians can also communicate online with managers and technicians at provincial, municipal and radar station levels. This function is particularly practical and convenient for the communication between the provincial technicians and the radar station staff, which solves the previous problem of poor communication.
4.5. Key technologies
The key points of this system are the timely collection of malfunction and maintenance information of weather radar, the quickly match with users according to the warning rules and the rapid push of standardized information to relevant users through WeChat. It satisfies the requirements of early detection, early notification and early response for the hierarchical support and malfunction of weather radar. The Fancy Tree dynamic tree plug-in is used to bind users, stations and equipment malfunction information, and then automatically call the service interface of WeChat Enterprise to instantly push the warning message to the users.

5. Conclusion
Based on the management and support situation of the new generation weather radar in Inner Mongolia, a new idea to hierarchically push radar warning and maintenance information and accomplish mobile operation monitoring through WeChat Enterprise is proposed in this paper. A mobile operation monitoring system for the new generation weather radar is developed. Based on the effective docking with the underlying database of the ASOM platform and the operation monitoring and maintenance information on it, the system allows mobile monitoring, hierarchical warning, video push and interaction for the weather radar. It effectively solves the problems of inconvenient monitoring and untimely warning. After the successful development of the system, the similar functions of the observation equipment in the national automatic weather station, the sounding system, the regional automatic weather station and the soil moisture station are further realized, and the system is finally named as "Observation Treasure".

At present, the "Observation Treasure" system has been included in the technical equipment promotion catalog of scientific and technological achievements of the Comprehensive Observation Department of China Meteorological Administration in 2019. It has been widely used in Inner Mongolia, Guangdong Province and Hebei Province. The system runs stably and plays an important role in the technical support of new generation weather radar.

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