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Data Sharing of Power Grid Meteorological Disaster based on Metadata

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Abstract. Based on metadata technology, this paper proposed a preliminary design of power grid meteorological disaster data sharing system. This paper analysed the composition of the meteorological data of the multiple disasters in the power grid, put forward the principle of sharing the meteorological data of the power enterprises at all levels, studies the making method of the meteorological metadata of the power grid, described the access process of the meteorological metadata and the solid data, and introduced the vertical exchange method of the structured and unstructured meteorological data. The building of the data sharing system of the power grid meteorological disasters can realize the sharing of meteorological disaster data in three levels of the group headquarters, the provincial company, and the prefectural company.

1. Introduction
The main types of meteorological disasters in power grid are: heavy rainfall, typhoon, thunder and lightning, rain and snow, gale, mountain fire, geological disasters, etc. At present, the main source of meteorological data of provincial and prefecture power enterprises is the local provincial and prefecture meteorological bureaus. Most of the databases and their application environments are scattered in different business departments \cite{1-3}. In addition, power enterprises have also built automatic meteorological observation stations, ice monitoring devices, fire monitoring devices and other on-line monitoring devices, real-time monitoring the operation of substations, transmission lines and the surrounding environment. As a result, there are many problems in the meteorological data sharing among power enterprises at all levels: uneven technical forces, scattered data management, lack of unified planning, inconsistent data standards, data information can not be shared, inconsistent application functions, resulting in duplicate construction, waste of investment, and the maintenance costs of all systems are huge.

The National Integrated Meteorological Information Sharing Platform, led by the National Meteorological Information Center, integrates meteorological data collection, processing, storage, management and sharing services. It runs at the national level and 31 provincial meteorological data centers and realizes data synchronization and real-time historical data integrated management \cite{4}. In this paper \cite{5}, a scheme of distributed traffic meteorological information sharing based on Web Service is proposed. The middleware of application service is developed, and the traffic meteorological information sharing platform based on WebGIS is developed. Based on the distributed data management model, the literature adopts a multi-tier system architecture to realize the organization and sharing of meteorological data resources in the Yangtze River Delta region, which is physically distributed and logically unified \cite{6}. The website of meteorological scientific data sharing...
in Gansu Province has been established, which provides users with fast and reliable remote network inquiry, download and other means to obtain climatic data [7]. This paper [8] introduces the basic structure and key technology of Guangxi meteorological science data sharing platform, and describes the function and content of the sharing website in detail.

Based on the characteristics of meteorological disaster data of power grid enterprises, this paper establishes a three-level meteorological disaster data sharing system of headquarters-provincial company-prefecture company by formulating a unified data standard and adopting a unified data sharing interface specification, thus solving the problem of sharing distributed heterogeneous power grid meteorological disaster data among power grid enterprises at all levels.

2. Power Grid Meteorological Disaster Data
The power grid meteorological disaster data mainly consists of public meteorological data, fine monitoring data of power grid disasters and emergency monitoring data of power grid disasters.

2.1. Public Meteorological Data
Public meteorological data are meteorological data that are purchased by meteorological departments at all levels, includes the following contents:

1) Weather conditions: weather conditions in cities, observation data from conventional weather stations, satellite cloud maps, radar mosaics, forest fire monitoring (satellite remote sensing images), etc.

2) Numerical weather prediction: routine urban weather forecast (short-term proximity forecast, short-term weather forecast), refined grid forecast, radar precipitation forecast, etc.

3) Disaster weather warning: disastrous weather warning for lightning, rainstorm, snowstorm, cold wave, wind, sandstorm, high temperature, drought, hail, fog, debris flow.

4) Typhoon: typhoon position, typhoon grade, radius of wind circle of grade 7, radius of wind circle of grade 10, radius of wind circle of grade 12, moving direction, moving speed, wind power, maximum wind speed, forecast path, etc.

5) Climate prediction and other reports: Ten-day weather forecast, monthly weather forecast, seasonal weather forecast, special forecast (holidays, special periods, etc.), important weather announcement, mountain fire monitoring report, etc.

2.2. Fine Monitoring Data of Power Grid Disasters
The fine monitoring data of power grid disaster refers to the meteorological data collected by on-line monitoring devices built independently by power grid enterprises.

1) The data of six elements automatic weather station: temperature, humidity, wind speed, wind direction, air pressure and rainfall.

2) The data of ice monitoring device: the ID of monitored equipment, equivalent icing thickness, comprehensive suspension load, unbalanced tension difference, wind deflection angle of insulator string, deflection angle of insulator string, scene photos, etc.

3) The data of mountain fire monitoring device: the ID of monitored equipment, scene photos, infrared photos, scene videos, etc.

2.3. Emergency Monitoring Data of Power Grid Disasters
Emergency monitoring data of power grid disaster refers to meteorological data collected by local power grid enterprises using mobile Cloud Radar vehicles and other emergency monitoring equipment when natural disasters occur, mainly including radar maps, scene photos, infrared photos, scene video and so on.

3. Meteorological Data Sharing Principles

3.1. Sharing Principles of Public Meteorological Data
There are two ways to share public meteorological data:
1) Bottom-up: Prefectural companies and provincial companies upload the purchased meteorological data to the meteorological data server of the company headquarters regularly and step by step. The provincial companies open the collected meteorological data to the whole province. The headquarters of the company opens the collected meteorological data to all provincial companies in the whole network, providing queries and downloads.

2) Up-bottom: The headquarters of the company purchases fine meteorological data from the China Meteorological Bureau, stores them in the headquarters meteorological data server, and sends the meteorological data to the corresponding provincial companies regularly. The provincial companies send the meteorological data to the corresponding prefecture companies regularly.

3.2. Sharing Principle of Power Grid Disaster Monitoring Data
The fine monitoring data and emergency monitoring data of power grid disasters are uploaded to the meteorological data server of prefecture companies regularly, and then uploaded to the provincial company and the headquarters of the company.

3.3. Meteorological Data Storage Principles
The meteorological data server of the headquarters of the company stores the meteorological data of the whole network, the provincial company stores the meteorological data of the province, and the prefecture and city company stores the meteorological data of the city. When the provincial (prefectural) company needs to inquire the adjacent provincial (prefectural) meteorological data, it can apply to the higher units for data access.

3.4. Meteorological Data Recovery Principles
When the meteorological data of the prefectural company is damaged, it can apply to the provincial company for data recovery; when the meteorological data of the provincial company is damaged, it can apply to the headquarters for data recovery; when the headquarters data is damaged, it can apply to the provincial companies for data recovery.

The shared topological structure of meteorological disaster data at all levels of power enterprises is shown in Figure 1.

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Figure 1. Topological structure of power grid meteorological disaster data sharing.
4. Meteorological Metadata

4.1. Metadata Design
Metadata is generally defined as "data about data", that is, information about the content, quality, status and other characteristics of data. It can be seen that metadata is a bridge connecting users and entities database [9-10].

Table 1. Typhoon forecast metadata

| classification       | name                      | content                                                                 |
|----------------------|---------------------------|-------------------------------------------------------------------------|
| data name            | typhoon forecast          |                                                                         |
| data classification  | high altitude meteorology |                                                                         |
| collection frequency | 1 hour                    |                                                                         |
| data content         | typhoon position, radius of wind circle 7, radius of wind circle 10, direction, velocity, wind force, maximum wind speed, forecast path |                                                                         |
| forecaster           | China, China Taiwan, USA, Japan |                                                                  |
| geographical scope  | Western Pacific, East Asia, Southeast Asia |                                                      |
| start time           | 00:00, August 16, 2017    |                                                                         |
| termination time     | 24:00, May 31, 2018       |                                                                         |
| data source          | China Meteorological Administration |                                                              |

Table 2. Ice (fire) monitoring station metadata

| classification       | name                        | content                                                                 |
|----------------------|-----------------------------|-------------------------------------------------------------------------|
| data name            | data collection of ice monitoring station |                                              |
| data classification  | Ground Meteorology          |                                                                         |
| collection frequency | 5 minutes                   |                                                                         |
| structured data      | equivalent icing thickness, comprehensive suspension load, unbalanced tension difference, wind deflection angle of insulator string, deflection angle of insulator string |                                                                         |
| unstructured data    | scene photos(infrared photos, scene videos) |                                               |
| geographical scope  | 27°N-30°N,110°E-114°E       |                                                                         |
| location of electrical equipment | 220kV GAOHAI-Line #1-#100 |                                              |
| start time           | 00:00, July 1, 2016         |                                                                         |
| termination time     | 24:00, May 31, 2018         |                                                                         |
| type of monitoring station | NRJD-OLFB-01 |                                                             |

Table 1. Typhoon forecast metadata

| data quality | general evaluation of data quality | excellent |
|--------------|-----------------------------------|-----------|
| reference system | time reference system | Beijing Time |
| space reference system | WGS-84 | |
| distribution | contacts | Zhang San |
| contact telephone | 010-11111111 | |
| data format | two dimensional table relational data structure | |
| restriction | secrecy grade | open |

Table 2. Ice (fire) monitoring station metadata

| data quality | general evaluation of data quality | excellent |
|--------------|-----------------------------------|-----------|
| reference system | time reference system | Beijing Time |
| space reference system | WGS-84 | |
| distribution | data set production unit | Changsha power supply company |
| contacts | Li Si | 0731-11111111 |
| contact telephone | 0731-11111111 | |
| data format | two dimensional table relational data structure, jpeg, flv | |
| restriction | secrecy grade | open |
The core metadata of meteorological disasters in power grid mainly includes identification information, data quality information, reference system information, distribution information and restriction information, in which identification information, data quality information and reference system information are required subsets, distribution information and restriction information are optional subsets.

The following is an example of a power enterprise typhoon forecast and ice (mountain fire) monitoring station metadata to illustrate the specific content of the grid meteorological disaster metadata, as shown in Table 1-2.

4.2. Meta Database
Meta database is mainly used to store and process metadata, providing support for users to find metadata and meteorological data resources. Metadata records constitute a meta database in accordance with the set of database specifications. Users can understand and query metadata by sharing platform, and can query or download some interesting meteorological data through metadata navigation. Meteorological metadata database mainly implements the maintenance, publishing and management of metadata, and provides users with metadata query, browsing and downloading services [11].

4.3. Metadata Retrieval Protocol
The sharing of meteorological disaster metadata among different units of power system requires that the metadata management systems of each unit can be interconnected to realize the network exchange of metadata. For this reason, metadata query service must follow a general protocol. At present, the most important protocol in the search and extraction of Meteorological Metadata network is the Z39.50 protocol [10]. Z-client/Z-server system is the main body of Meteorological Metadata retrieval. The client and server communicate by establishing an application connection called Z connection. Metadata Gateway is used for the conversion between Z39.50 protocol and HTTP protocol. It is the hub connecting WEB and Z39.50 network.

4.4. Meteorological Disaster Data Access Process
To sum up, the power grid meteorological disaster data access process is shown in Figure 2.

![Figure 2. Power grid meteorological disaster data access process.](image-url)
5. Meteorological Data Transmission Interface

5.1. Data Types of Power Grid Meteorological Disasters

Power grid meteorological disaster data can be divided into two types: structured and unstructured data.

Structured data of meteorological disasters include weather data of ground observation stations, six-element automatic meteorological observation stations, ice-covered monitoring stations, conventional weather forecast, disaster weather forecast, typhoon forecast, grid disaster forecast and other fixed format row data, which are stored and managed mainly through relational database.

Unstructured meteorological data include: Doppler radar mosaic, visible light cloud, infrared cloud, satellite remote sensing images, field photos, live video and other data which are not suitable for the database two-dimensional table. Unstructured data only saves summary and path information in relational database, and its specific information is stored in unstructured data management platform.

5.2. Structured Data Exchange

Based on the data exchange platform and data center of electric power enterprises, the vertical data transmission is realized, which is suitable for exchanging structured data of meteorological disaster data between headquarters and provincial companies, provincial companies and prefectural companies. Data Exchange Platform provides unified access services in the form of Web Services to achieve loose coupling with business systems [12].

Exchange process (take provincial company's reporting company headquarters as an example):
1) The formatted meteorological disaster data to be uploaded by provincial meteorological data server is assembled according to the designed XML format specification;
2) Provincial meteorological data server calls data exchange access service to send assembled XML meteorological disaster data;
3) Provincial company data exchange platform exchange data to company headquarters data exchange platform;
4) Headquarters meteorological data server monitors the arrival of data notification queue, timely identification of meteorological disaster data to the headquarters of the company;
5) The headquarters meteorological data server obtains the meteorological disaster data, parses the data according to the designed data pattern, and stores it in the headquarters meteorological data server.

5.3. Unstructured Data Exchange

Based on the data exchange platform of electric power enterprises, the vertical data transmission is realized, which is suitable for exchanging unstructured data of meteorological disaster data between headquarters and provincial companies, provincial companies and local companies.

Exchange process (take provincial company's reporting company headquarters as an example):
1) The unstructured meteorological disaster data that provincial companies will send will be read into data stream and encapsulated as parameter objects required by data exchange platform to send file services;
2) Provincial meteorological data server calls data exchange to send file service to send meteorological disaster data;
3) Provincial company data exchange platform exchanges meteorological disaster data to company headquarters data exchange platform;
4) The headquarters meteorological data server monitors the data notification queue and calls the headquarters data exchange interface service to read the meteorological disaster data when the data arrives.

6. Data Sharing Security Management

6.1. Metadata Access Control

Access to metadata for power grid meteorological disasters needs to be restricted. In application, we should provide a separate operation interface for meteorological metadata, and strictly control the
permissions of the operation interface. When sharing meteorological disaster metadata with other systems or applications, data access should be realized by interface service method.

6.2. Meteorological Data Access Control
Meteorological data application system should strictly control user authentication, encrypt and store user passwords, transmit sensitive information safely, and strengthen authority management, input and output verification, session management, exception management, etc. to protect system security.

7. Pilot Application
Based on the above design ideas, the meteorological disaster data sharing system of power grid has been preliminarily constructed, and the three-level sharing of State Grid Corporation - Hunan Provincial Power Company - Power Supply Companies in Hunan Province has been realized. The system uses B/S architecture, the database server uses Oracle 10g, and the client uses IE8 browser. Front-end functions mainly include metadata navigation, meteorological data retrieval, meteorological data download, etc. Background functions mainly include metadata editing, user management, data interface configuration and so on. After half a year of stable operation, the system has played an important role in the acquisition and application of meteorological data for three levels of power enterprises.

8. Conclusion
Power grid meteorological disaster data sharing platform combines Internet, database, metadata technology and grid meteorological information. Its construction and application will standardize meteorological data of power enterprises at all levels, and realize the unification of storage management of meteorological data, metadata production and data service interface, provides a standard and consistent data environment for meteorological data sharing business of power enterprises at all levels, and provide meteorological data retrieval and download services for power operation, scientific research and other users, so as to give full play to the application benefits of meteorological data of power grid, especially disaster data.

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