Design and Implementation of an Electric Power Communication Platform based on Large Data

Hu Bo¹, Liu Jun¹, MA Hongbo², JIN Xin²
1. State Grid Anshan Electric Power Supply Company 114000, China
2. Beijing KeDong Electric Power Control System Co., Ltd 100092, China

Abstract — Electric power communication is a hot research topic in the world. A number of agreements have been formed on power communication and realized in practice. Through detailed research on power system and exploring big data technology, this paper designs an overall framework of power communication platform for large data. We give the overall structure of the power communication platform and its various modules, and introduce the function of each module and the function of the power system. Then we analyze the power information reasoning and decision making technology based on ontology, which endows it with the ability for intelligent decision making to improve the communication efficiency. In the realization module, we give a detailed design and function realization of the key modules, and put forward the realization method of communication platform for protocol adaptation and data recognition, processing and storage. Also we design the database of electric power communication platform based on the database of traditional communication system. Finally, we test the protocol adaptation function, communication function and data separation and storage function for it. The test results show that the power communication platform can be used to determine the appropriate communication protocols and methods according to the specific business features and link conditions. It has no effect on the quality of communication in the process of communication switch, and the power communication platform based on large data has high correctness and reliability.

Keywords - Electric power communication, big data, ontology technology, data separation and storage.

I. INTRODUCTION

Electric power communication has been a hot research topic in the world, and it has formed a number of agreements on power communication, and has realized the practical application [1]. In the smart grid system, power communication is the key to connect the various modules of the system, only with efficient, intelligent, automated communication; the system can support the normal operation of the smart grid system [2-3]. However, the current power communication system design and research mainly focus on how to achieve efficient communication mechanism, the lack of intelligent and effective communication decision-making mechanism, which is difficult to achieve intelligent control system.

The application of big data in power system is mainly divided into two aspects: internal application and external application [4]. The internal application of electric power big data is relatively good understanding, which can analyze the running state of the whole power system and the problems in the deep level by recording the operation status of power equipment, system, power network, equipment information and load load. For electric power big data internal application, the relevant research results are more abundant. Some scholars have proposed a variety of methods to monitor the operation of power equipment by using electric power data, in these methods, power equipment has been added to the corresponding data acquisition function. For this purpose, different scholars have designed a special sensor network for the monitoring of power equipment and power system. Combining data analysis and decision method, the operation state of power system or equipment can be monitored and judged by these data. Through these monitoring data and the method of data processing can not only improve the scientific level of power system management, but also improve the operation efficiency and economic level of power system.

In this paper, we will fit the latest data of electric power, analyze and study the function of big data technology in electric power system. Based on the big data technology, the research and design of electric power communication platform are carried out, which makes the power communication system have the ability of intelligent decision-making, and improve the communication efficiency and the intelligent level of power system.

II. OVERALL DESIGN OF ELECTRIC POWER COMMUNICATION PLATFORM

In this chapter, the main research and design of the overall structure of the power communication platform

A. Functional Module Design of Electric Power Communication Platform

In this paper, the structure and the overall framework of the power communication platform we studied has retained the traditional electric power communication system architecture in a certain extent. And to new requirements, we add the important function module. The functional module of the power communication platform is shown in Figure 1 below. It mainly includes the following modules: communication module, A/D conversion module, protocol
adapter module, data processing module, data processing module, data storage module.

Figure 1 The function module of electric communication system.

Communication decision module: the module is the key module of intelligent communication, which is connected with the data center, which not only receives the control and communication instruction of the console, but also receives the data center's automatic communication command.

A/D conversion module: the module is the key module of achieving the digital signal and analog signal conversion. In the communication system, the original communication data and signaling are produced and run in the computer system using the digital signal and it need to be converted into analog signals to be able to communicate in a communication link or a cable. In order to adapt to the current mainstream communications technology and the use of a wide range of power line communication technology, the module needs to signal conversion;

Protocol adapter module: the module is connected with the A/D module, and the digital signal is transmitted to the A/D module. Power communication platform needs to be able to support a variety of communication protocols, and fit different types of equipment and communication protocols, and it needs to be automatically converted between different communication protocols. In order to achieve this goal, converts the upper communication instruction and data into the corresponding protocol format and sends it.

Data separation and processing module: the module is a new module of the paper; we need to have the module in order to realize the power communication system for data recognition, storage [8-9]. At the same time of the communication of the electric power equipment or system, the module will monitor transmission of data, and identify the category of the communication data and according to the set of in advance, to separate different kinds of data, and classification of storage. At the same time in order to ensure the availability and reliability of the data, the module is also responsible for the basic data processing before the data storage, such as data noise, etc...

Data storage module: the function of the module is to store the data processed by the separation and processing module in data center, and to make further analysis and utilization. The module is a software module, which is connected with the data center, and is the interface module of the database.

The ontology knowledge base is the basis of the whole system. It uses the ontology model to describe the ontology model. The ontology model is the abstract model of the system knowledge by ontology description language, and the process of building the model is the process of describing the system knowledge. Through the ontology model, the system can understand and apply the knowledge.

B. Database Design

In electric power communication system, the database is an important part of the electric power communication system. The database contains a variety of data structures, power generation, transmission, distribution, substation equipment, power communication protocols, etc... Through this database, we can realize the integration and resource sharing of power grid communication resources, improve the overall work efficiency of the whole power communication system and the accuracy, credibility and authority of the data, and provide the calculation data for the scheduling and planning of power system [5-6].

In electric power communication platform, power information database is mainly contained in four aspects: the equipment library, database, instruction Library, parameter library; The main content of the equipment library is fixed part of power communication network, including the model parameters of the equipment and control system, the network topology and so on; The main contents of the database are all data generated during the course of the communication of electric power communication equipment [7]; The main contents of the instruction Library are all instructions sent by the electric power communication console to the controlled power equipment; The main contents of the parameter library are the legal parameters and measures used in the process of electric power communication.

Through the above analysis, we can determine that the following entities should be present in the electric power communication database: power equipment entity, transmission data entity, the transmission link entity, the manager entity, and the communication instruction entity.

III. IMPLEMENTATION OF POWER COMMUNICATION PLATFORM FOR LARGE DATA

According to the last section, the key role of the whole communication process is: protocol adaptation module, communication module, data separation and storage module. In this section, we will introduce the method and the working mode of these modules in detail.

A. Protocol Adapter Module

The role of protocol adaptation module is to select the appropriate transmission protocol according to the signaling protocol, and realize the conversion between different communication protocols. The overall design of the protocol adapter module is shown in Figure 2. There is a protocol register in the protocol adapter module, which records the signaling standard for the protocol which is supported by the protocol, and the kinds of the protocol stored in the register types can be extended, thus it can support more communication protocol according to actual needs. In the work process, protocol registers store the form is similar to
the template, which provides a format for the test message and the response message, by using the template it can generate a valid test message for a protocol, and judge whether the response message is valid or not. At the same time, it also has the priority management equipment in the protocol register. By setting up a higher priority to the common communication protocol, it can be used to control the priority of the process, so as to improve the operation efficiency of the protocol adapter module.

In the protocol adaptation module, a communication transponder is also present, which generates an exploratory message using the template in the protocol register, and sends the test message to the communication object, and sets up the corresponding timeout clock. When a test message is sent out, if the communication object is sent within the specified time, we can consider the current use of the protocol as appropriate, if the response is timeout, the communication protocol used in the communication is replaced. Repeat the above process until you can get the answer that can be identified, and then determine the current protocol to use, if you are unable to get the right answer, it is considered that the current communication protocol is not supported, and to send an error report to the administrator. Since the process of the communication response may take longer, the protocol adapter is usually independent of the work, and monitoring should be carried out in real time, and we should be in advance to determine the need to use the protocol prior to the launch of the communication, and cooperate with the corresponding priority management function.

B. Data Separation and Storage Module

The function of data separation and storage module is to identify the data of communication, and then extract the data to classify and preprocess, then carry out the storage, and then provide the data center for data analysis and mining [11]. Data separation and storage module is used in the way of bypass interception, which is embedded in the data receiving part of the power communication system. It mainly includes the following steps: data identification, data classification, data de-noise, data conversion.

Data identification is the identification of the data transmitted in the communication process. Due to different communication protocols used in the process of communication, the format of the data and organization is not the same. In the process of data recognition, it also needs to be in accordance with the corresponding communication protocol. Therefore, in this process, the protocol is needed to get the current usage from the protocol adapter module, and select the corresponding data receiver. The data separation and storage module contains a variety of data receivers, which correspond to different communication protocols. Before receiving the data, the receiver determines the appropriate data receiver and then sends the data to the receiver to extract the data.

Data classification is to classify the data according to the type of data. By data classification, it can provide convenient data processing. Data to noise is to point to in order to guarantee the availability and reliability of the data, to eliminate some obviously abnormal, incorrect data [10]. Data conversion is the structured data that the original data is converted into to be stored.

C. Communication Decision-making Module

Communication decision-making module role has two parts; the specific situation is shown in Figure 3. First of all, the module can be determined according to the current communication needs communication protocol, way, link, etc., to ensure the communication unobstructed, efficient and real-time; secondly, the module can analyze and mine the communication data, monitor and judge the running state of the communication link, and then carry out the real-time control to ensure the normal operation of power communication system. Because the power equipment need to monitor a variety of data and information in the process of power system operation, and these data are often have the characteristics of real-time, large and unstable. So it is necessary to coordinate the relationship between the various traffic in the process of communication to ensure smooth communication process stability and the integrity of data transmission and effective.

There is a communication information database in the communication module. The database record is not the communication process of transmission of information, but the communication link, the environment, signaling, such as user information. Through this information module, we can make a detailed understanding of the current communication needs and communication environment, at the same time; we can make the corresponding decision rules in advance. In the process of actual use, the module will use the monitoring real-time data and decision rules to select and control the protocol and the way of communication so as to achieve the smooth and reliable communication process.

1) Construction method of ontology model
In this paper, the basis of the ontology model is mainly derived from two aspects: the various concepts and knowledge involved in the process of electric power communication and power system operation, and the public information model (CIM). The overall structure of the model is as follows. The main categories are: core class, topological class, line class, protection class, load model, power generation, and the domain class.

(1) Core class: core class is the main class of the whole information model, which includes all the resources of the power system, electrical equipment and power control equipment.

(2) Terminal class: terminal class is a subclass of the core class, which includes a variety of power generation equipment, electrical equipment and power control equipment, etc...

(3) Topological class: the class is a subclass of core classes, it establishes connectivity with terminal class model, and defines the network topology. The topological definition has nothing to do with the other electrical characteristics.

(4) Line class: this class is a subclass of core class and topology, and establishes the information model of the electrical characteristics of transmission and distribution network. It is mainly used in the following scenarios, such as state estimation, power load flow, the optimal current, etc.

(5) Protection class: the class is an extension of the terminal class, which establishes the information model of the protection device, such as the relay.

(6) Power generation class: the class is divided into two subclasses, one is the electricity class, the other one is generating attribute class, and the cost of production information model is established and used for generator between economic demands allocations and calculated the spare quantity size.

(7) Domain class: this class is the data dictionary of the volume and unit, which defines the type of data that may be used by any other class.

2) Mechanism of Ontology Model

Ontology using mechanism can complete the process of injection, extraction, reasoning, production and so on, which will be used as the ontology model of the external knowledge base and the system's actual realization mechanism.

There are three main aspects of the Ontology: ontology compiling, ontology reasoning, and ontology mapping. The function of ontology mapping is to map the data in the system itself or from the outside to the ontology model according to the definition of the ontology model, and generate the corresponding examples. The role of ontology reasoning is to achieve the knowledge of reasoning and generation on the basis of complete ontology knowledge according to the definition of the inference rules, and it is the process of updating the original Ontology. The role of ontology is to transform and compile the information, data and concepts needed in the ontology model into a data structure that is actually present in the system according to the actual needs, so as to further use and run.

IV. TEST AND RESULT ANALYSIS

In this chapter, the work efficiency of the system is tested; on the one hand, we verify the correctness of the theory. On the other hand, we verify the availability and efficiency of the system.

A. Protocol Adaptation Function Test

Protocol adaptation function test data sets and test results are shown in Table 1 and Table 2.

### Table I The test data set of protocol adapter function

<table>
<thead>
<tr>
<th>Original agreement</th>
<th>Handoff protocol</th>
<th>Switching interval</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 61850</td>
<td>IEC 61970</td>
<td>500ms</td>
<td>nothing</td>
</tr>
<tr>
<td>DLMS/COSEM</td>
<td>DLMS/COSEM</td>
<td>500ms</td>
<td>nothing</td>
</tr>
<tr>
<td>IEC 61970</td>
<td>IEC 61850</td>
<td>500ms</td>
<td>nothing</td>
</tr>
</tbody>
</table>

### Table II The test result of protocol adapter function

<table>
<thead>
<tr>
<th>Original agreement</th>
<th>Handoff protocol</th>
<th>Test result</th>
<th>Time consuming</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 61850</td>
<td>IEC 61970</td>
<td>500ms</td>
<td>270ms</td>
</tr>
<tr>
<td>DLMS/COSEM</td>
<td>IEC 61850</td>
<td>500ms</td>
<td>712ms</td>
</tr>
<tr>
<td>IEC 61970</td>
<td>DLMS/COSEM</td>
<td>500ms</td>
<td>324ms</td>
</tr>
</tbody>
</table>

(1) When the communication protocol is IEC 61850 and IEC 61970, the power communication platform can automatically identify the communication protocol, and can carry out the effective data transmission, and we can see the correct reception of data in the power communication platform.

(2) When the communication protocol is DLMS/COSEM, power communication platform is able to identify the use of the communication protocol, and carry out the correct data receiving;

(3) During the switching process of the two protocols, there is no response. At this time, the power communication platform is still the original communication protocol, which has the problem of response time. Then the protocol adapter module of power communication platform has started the recognition process of communication protocol and it has identified the communication protocol. This phenomenon indicates that the process of establishing the connection in the power communication process should be added to ensure that the connection is not lost and the loss of data.

B. Communication Decision-making function Test

In the function test of communication decision, two kinds of different environments will be simulated and tested. Communication decision function test data set and result set are shown in Table 3 and Table 4:
The results of the tests are shows that: when the link is normal, the data of the traffic flow is low. When the communication link is bad, it shows that the communication link has a strong interference or a failure, and the time delay and packet loss are all beyond the normal range. Then the communication decision-making module is based on the ontology of knowledge inference module, which needs to change the transmission link, so as to choose the more stable and better performance of the cable into the line transmission; when the traffic flow is an important level of the power communication platform, it is very important to explain the data at this time.

C. Data Separation and Storage Test

In the test of data separation and storage function, we will use different protocols to transmit data in different formats to test the recognition and conversion of the data. Data separation and storage test data sets and results are shown in Table 5 and 6.

TABLE III The test data set of communication strategic function

<table>
<thead>
<tr>
<th>Link state</th>
<th>Data type</th>
<th>Switching interval</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adverse</td>
<td>Important</td>
<td>500ms</td>
<td>nothing</td>
</tr>
<tr>
<td>Normal</td>
<td>Daily</td>
<td>500ms</td>
<td>nothing</td>
</tr>
<tr>
<td>Good</td>
<td>Daily</td>
<td>500ms</td>
<td>nothing</td>
</tr>
</tbody>
</table>

TABLE IV The test result of communication strategic function

<table>
<thead>
<tr>
<th>Link state</th>
<th>Data type</th>
<th>Test result</th>
<th>Time consuming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adverse</td>
<td>Important</td>
<td>Success</td>
<td>1443ms</td>
</tr>
<tr>
<td>Normal</td>
<td>Daily</td>
<td>Success</td>
<td>1761ms</td>
</tr>
<tr>
<td>Good</td>
<td>Daily</td>
<td>Success</td>
<td>1224ms</td>
</tr>
</tbody>
</table>

TABLE V The test data set of data separation and storage

<table>
<thead>
<tr>
<th>Original agreement</th>
<th>Handoff protocol</th>
<th>Switching interval</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 61850</td>
<td>IEC 61970</td>
<td>500ms</td>
<td>nothing</td>
</tr>
<tr>
<td>DLMS/COSEM</td>
<td>IEC 61850</td>
<td>500ms</td>
<td>nothing</td>
</tr>
<tr>
<td>IEC 61970</td>
<td>DLMS/COSEM</td>
<td>500ms</td>
<td>nothing</td>
</tr>
</tbody>
</table>

TABLE VI The test result of data separation and storage

<table>
<thead>
<tr>
<th>Original agreement</th>
<th>Handoff protocol</th>
<th>Test result</th>
<th>Original agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 61850</td>
<td>IEC 61970</td>
<td>Success</td>
<td>IEC 61850</td>
</tr>
<tr>
<td>DLMS/COSEM</td>
<td>IEC 61850</td>
<td>Success</td>
<td>DLMS/COSEM</td>
</tr>
<tr>
<td>IEC 61970</td>
<td>DLMS/COSEM</td>
<td>Success</td>
<td>IEC 61970</td>
</tr>
</tbody>
</table>

The results of the tests are as follows:

1. When the communication protocol is IEC 61850, the data analysis and storage module can identify the normal data, and convert the data into a suitable format, and can connect to the database, and realize the storage of the data in the database.
2. When communication protocol is DLMS/COSEM, it can be observed that the received data format changes. The data separation and storage module can also be the correct identification of the data, and it is successful to store data in the database.

V. CONCLUSION

In this paper, we propose a method of data classification and analysis based on ontology, and use the ontology in power communication system to model the transmission of power communication system. And at the last, we verified the power communication platform proposed in this paper. Through the actual test, we can determine that the power communication platform we designed in this paper is capable of determining the appropriate communication protocols and methods according to the specific business features and the link conditions, and it has no effect on the quality of communication in the process of communication switch. At the same time, the electric power communication platform which is oriented to the big data has higher accuracy and reliability, and it has a good effect.

REFERENCES


