Study on the Unified Data of Power Regulation System for Guizhou Power Grid

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Abstract. The grid structure of the Guizhou Power Grid is becoming more and more complex, and the deepening of regulatory integration has made the information and work of regulators more and more onerous. Combining artificial intelligence, big data technology and grid control business is an inevitable trend of development. In this paper, a unified data model of the power system is established based on the Guizhou power grid’s regulatory operation requirements. It can analyze the impact of big data on dispatching business and define the power busines demand model in the big data environment. This model also integrates and manages the multi-source heterogeneous data of power grid business by reflecting data and relationships of power regulation business. The research results are of great significance to improve the level of safe and stable operation of the power grid, and to promote intelligent operation of regulation and control, and also lay a solid foundation for intelligent dispatch.

1. Introduction
Guizhou Power Grid Corporation integrates dispatching and monitoring functions in accordance with the requirements for the integration of China Southern Power Grid’s regulatory integration, established a regulation and operation major. The number of unattended substations included in the centralized monitoring of dispatching has gradually increased, the amount of dispatch operations has increased dramatically, and the pressure on the controller has continued to increase. There is an urgent need to combine artificial intelligence with the development needs of the grid control business to promote the intelligentization of the control operation business, reduce the work intensity of regulators, and improve the safety and efficiency of grid operation [1, 2].

In recent years, based on the concept of artificial intelligence, a lot of research and practical work has been carried out in the field of intelligent scheduling at home and abroad [3]. In response to the current actual application of dispatching automation systems and the turmoil of emerging technology changes, there is still a strong demand for improvement and ample room for development in the control and operation support technology. A series of artificial intelligence technologies, such as unmanned driving based on intelligent perception and decision-making, Alpha Go game based on in-depth learning, speech and face recognition based on intelligent pattern recognition, have made significant theoretical innovations and application breakthroughs worldwide, which provide useful reference and support for solving some of the difficulties in the field of dispatch control [4-5].

Most current researches focus on a more specific application or problem point [6], some of the research results have achieved good results, but more research is far from being practical, the key problem is that the complexity of the data science and physical model of the problem faced makes it
difficult to build a decision model, the construction model of the knowledge model has not been well resolved, and there is still a long way to go to regulate business intelligence [7, 8].

This paper presented a unified model for the big data of power regulation and control, and provided a method for power data modeling to guide the integration and management of large data of power regulation and control. Also, the design method of the unified data model, and the architecture of the unified data model including power regulation big data were studied and described by this paper. The research results are of great significance to further enhance the intelligent level of grid control operation, greatly reduce the pressure on regulators, and improve the level of safe and stable operation of the grid.

2. The propose of the data model
The application of power grid control big data is mostly reflected in data analysis and mining technology, especially the correlation analysis of multiple applications and multiple sources. Traditional grid CIM focuses on the entire network or system model, the big data analysis data model for power regulation needs to use the core data model of the power grid as the skeleton and the application models as branches to effectively support multidimensional analysis.

For this reason, this paper proposed to establish a unified data model of power regulation big data, extract data from different business systems, and generate tables and keys between tables through the specified entities and their relationships, which can break the original vertical management, so that the business systems can no longer be separated from each other and each department has its own management. It can further comprehensively analyse multi-source data, generate derived tables and summary tables with higher granularity, and provide end users with visual problem solutions and deeper understanding.

The unified data model modelling method of regulatory big data adopts the overall design method of power grid business driven, top-down and particle size from large too small. The specific power grid business is divided into several functional independent subject areas. According to the function of each subject area, the entities of input class, reference class, derived class and summary class are designed, and the corresponding conceptual model is established. Then, based on the data structure of the conceptual model and the external data source, a logical model corresponding to the entity is established. Finally, the logical model is used to build the physical model in the physical database. Supporting the future development of the power grid is of great significance to power companies, power users and government departments. The unified data model is a means to connect and integrate various data sources. It is also where the business rules and processes of the power industry are stored and reflected. It is the basis for supporting advanced data analysis.

3. Design method
The unified data model is a business-driven top-down model that involves business applications, requirements, conceptual models, logical models, and physical models.

3.1. Overall modeling process of the model
The overall modeling process of the unified data model is shown in Figure 1. In consequences, they are: determining business applications, clarifying requirements, establishing conceptual models, establishing logical models, and establishing physical models respectively.
Identify business applications. For the power grid business to be analysed, it is divided into one or several business domains by professionals. A service domain is a conceptual grouping of services and a definition of a service in a broad sense.

Identify business needs. For a business domain, business personnel determine their KPI indicators according to the needs of business analysis. KPI indicators are key performance indicators and are quantitative indicators for business analysis. For example, some statistical KPIs of generating units may be divided according to feeders/substations, with the former P% generating units providing output; divided according to the regional division, the former P% power generation unit output; the daily/weekly/monthly peak output of the selected power generation unit; the daily/weekly/monthly average output of the selected power generation unit; peak generation capacity by feeder/substation; peak power generation capacity by region; output of last P% power generation unit divided by feeder/substation, etc.

Building a conceptual model of the business domain. The conceptual model is a description and description of specific business processes. It is a unified data model for the regulation and control of big data by professionals in specific business, and it is the basis for the application and development of the big data of power regulation and control. It provides a data barrier-free exchange solution between systems to realize multi-source system, multi-sampling frequency, multi-life cycle, multi-format data analysis and mining, and explores the interrelationships, interactions, and complex relationships among them, improves the operation management level and user service level of power companies, provides decision-making support for the government, and expands the bridge between new and analytical technicians. The purpose of designing the conceptual model is to avoid data redundancy as much as possible without affecting performance and to avoid inconsistencies in data and business communication. This approach also promotes data reuse and sharing, reducing development and maintenance cycles and costs.

Establish a logical model corresponding to the conceptual model. The logical model is a reification of a conceptual model and gives the data attributes of an object.

Establish a physical model corresponding to the logical model. The physical model is a model oriented to the physical representation of a computer and a machine implementation of a specific data model.

3.2. Business domain and subject domain
The business domain is a generalized domain in the entire unified data model. In the business domain, all tables (reports, metadata, data mining, OLAP, 3NF) in related business processes can be accessed through the same GUI. A business domain is a conceptual grouping that is used in the default report level. The business domains regulated in this paper include: account management, user management, network operations, asset management, power outage management, weather model, and job management.
The topic domain is a small part of the unified data model grouping table for the entire power system, which is mainly at the basic layer and covers specific concepts, business processes or problems. Taking the network operation service domain as an example, the network operation service domain includes the following subject areas: service interaction, connection mode, curve schedule, generator set, line model, load model, network operation, phase model, and so on.

The network operation business domain provides information on dispatching, power distribution, and transmission networked operations, such as monitoring the geological conditions of major substations, controlling the status of equipment, and handling network connectivity and load conditions. It can also locate and monitor the position of field staff.

3.3. The Unified Model Architecture of the Big Data of Regulation and Control

This paper proposed a power regulation data warehouse architecture that includes a unified data model, consisting of a data source layer, a segmentation layer, a foundation layer, and an analysis layer, as shown in Figure 2.

Data source layer includes data sources from multiple systems such as energy management system (EMS), dispatch management system (OMS), production management system (PMS), and distribution automation system (DMS).

Segmentation layer is usually used for data conversion and data cleaning from various regulated business systems, and sometimes used as operational data storage (ODS), especially in real-time business reports.

Base layer is usually used to store all the lowest granularity fact data, business data, master data, reference data and dimensional data to form a basic table, reference table and lookup table, while the internal ETL forms a control table. All data tables in this layer are required to be designed according to the third normal form principle to avoid data redundancy. Most of the different data tables in the base layer have corresponding entities, and the relationships between the entities are defined by the primary and foreign keys between the corresponding tables.

Analysis layer means through OLAP cube, data mining model, materialized view and other analysis tools, a higher granularity derived table and summary table can be generated to answer statistical business questions such as the number of substations, regional installed capacity, regional reserve capacity, etc., or to complete deeper data mining tasks such as equipment failure risk assessment, grid failure risk early warning, etc.
4. Case Analysis
This section takes the application of power quality analysis as an example to illustrate the design process of a unified data model for power regulation big data, as shown in Figure 3. The processes were described as follows.

(1) Determine the business application to be studied, here means the business of user power quality analysis;

(2) Clarify the needs included in the business, that is, the statistical KPI indicators required in the power quality analysis, specifically includes locating the top N power grid areas with the most serious power quality problems, counting the total number of power points with power quality problems for each feeder, counting power points with power quality problems within a certain period of power consumption, N geographical regions with the most serious power quality problems, and the number of power points with power quality problems based on the statistics of the distance between substations.

(3) After the KPI indicators were clarified, establish a conceptual model of power quality on this basis to determine the relationship between entities. The entities include accident records, power outages, power points, feeder locations, loads, voltage control areas, etc.

(4) Specify the conceptual model of power quality, and determine the specific structure of the table corresponding to each entity, so as to obtain the logical model of power quality.

(5) According to the structure of the electric quality related table determined in the logical model, build the table a specific database, then a physical model is obtained, and the work of designing indexes and creating views can be conducted in the database.
5. Conclusion
This paper proposes a unified data management model for the power regulation system of Guizhou Power Grid. First, the basic modeling idea of the unified data model is explained, that is, the overall design method of grid-driven, top-down, granularity from large to small. Secondly, the design method of the unified data model is introduced. It described the overall modeling process of the unified data model, and then used the business domain of network operations as an example to give examples of related conceptual models and logical data models. Thirdly, the architecture of the unified data model in power system is given. Finally, an example of regulating the construction of a unified data model for big data is given to illustrate the modeling ideas and methods of the unified data model for power regulation big data. The analysis showed that, to establish a unified data model, define the power business demand model in the big data environment, and reflect the power regulation business through data and relationships, is the important theoretical basis for the integration and management of multi-source heterogeneous data in power grid business.

References
[1] Guo Chao. Research on power regulation of Guangdong Province in the context of a new round of power reform [D]. South China University of technology, 2019.
[2] Lu Zhenxiang, Huang Wei. Overview of global power futures market and analysis of contract characteristics [J]. Securities & Futures of China, 2018 (5): 23 – 27.
[3] Kontokostas D, Brümmer M, Hellmann S, et al. NLP data cleansing based on linguistic ontology constraints [C]. European Semantic Web Conference. Springer International Publishing, 2014: 224 - 239.

[4] Song Y, Zhou G, Zhu Y. Present status and challenges of big data processing in smart grid [J]. Power System Technology, 2013, 37 (4): 927 - 935.

[5] Lund H. Large-scale integration of optimal combinations of PV, wind and wave power into the electricity supply [J]. Renewable Energy, 2006, 31 (4): 503 - 515.

[6] Fang X, Misra S, Xue G, et al. Smart grid - The new and improved power grid: A survey [J]. IEEE transactions on Communications Surveys & Tutorials, 2012, 14 (4): 944 - 980.

[7] Ipakehi A., Albuyeh E. Grid of the future [J]. IEEE Power and Energy Magazine, 2009, 7 (2): 52 - 62.

[8] Wu X, Zhu X, Wu G Q, et al. Data mining with big data [J]. IEEE transactions on knowledge and data engineering, 2014, 26 (1): 97 - 107.