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Research on Application Scenario of Large Data Cloud Service Platform for Power Energy Measurement

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Abstract. This paper studies the technical framework and composition of the large data cloud service platform for power energy measurement, and discusses the application scenario design of the platform for government, enterprises and users. Three typical application scenarios of city perspective, suspected power theft intelligent diagnosis and intelligent analysis and application of residential power load characteristics are discussed in detail. Finally, the development of cloud platform and its application in business field are prospected.

1. Introduction

In our country, the power industry has already taken the big data analysis technology as the key research object, and has achieved some application results, mainly focusing on user behavior analysis, line loss multi-dimensional analysis, on-line monitoring and intelligent diagnosis of metering devices, load characteristics and orderly power consumption analysis, economic trend analysis and so on[1-3]. In the aspect of user's electricity consumption behavior analysis, according to customer's electricity consumption, electricity consumption characteristics, business management, payment information, customer complaint record and other electricity consumption information, user's load characteristics and electricity consumption behavior habits are studied, and precise service for target users through different service channels is carried out. In multi-dimensional line loss analysis, the system automatically calculates daily loss by configuring line and station area loss model, realizes on-line monitoring of 10 kV transmission and distribution lines and station area line loss, discovers abnormal line loss in time, grasps the on-site power supply situation, and realizes line loss visualization graphical display and analysis. In the field of on-line monitoring and intelligent diagnosis of measuring devices, the functions of abnormal analysis of measuring devices, fault analysis of acquisition devices, fault analysis of acquisition devices, analysis of various events and abnormal analysis of power consumption are realized by data sharing and interaction of telecommunication information acquisition system and marketing system, and fault diagnosis of measuring and acquisition devices and analysis of overall working conditions of devices by using large data analysis technology. In terms of load characteristics and orderly power consumption analysis, the characteristics of peak-valley location, duration of peak-valley duration, peak-load occurrence point and frequency of peak-valley occurrence in the characteristics of user load curve are analyzed, and the potential of peak-valley shifting and valley filling for special transformer and special line is analyzed. In the aspect of economic trend analysis, according to the historical electricity trend of different regions and industries, combined with electricity consumption and load forecasting, this paper analyses the increase, proportion and change of electricity consumption of different industries in different regions, and understands the industrial structure, industrial chain, industrial transfer and upgrading, industrial regional migration, and the development of local characteristic industries. According to the electricity output value of industry degree, the data of electric power elasticity coefficient, electric power density and electric power GDP are analyzed. Combined with the trend of electricity use, the utilization ratio of production capacity of factories and enterprises, and the expansion of industry, the electric power productivity is analyzed, and the prosperity index of various industries is issued with reference to PMI index[4-6].

At present, in the construction and data utilization of power metering data system, we have completed the construction of power users' electricity information collection system, marketing business application system, 95598 customer service, energy service management platform, demand side management system and other systems and platforms. We have accumulated a large number of data resources, and business data have been quite large-scale in terms of total amount and type. According to different types of users, combined with business scenarios, data acquisition range is classified. With the powerful data analysis and model prediction ability of big data technology, a large data analysis model of power consumption load is constructed, which can be used to calculate and analyze the whole data set, calculate and analyze the whole dimension, and predict the load curve, load time and spatial distribution of each cycle. It can provide information support for marketing decision-making, power grid planning and power allocation of power companies[7-8].

2. Overall Architecture Design of Cloud Platform

Firstly, it analyses the information interaction requirement, designs the information interaction interface and information security architecture under the environment of energy internet, and then studies the storage, processing and mining technology of large data of power energy measurement. Finally, combined with the requirements of information exchange technology and big data technology, the functional requirements, business processes and services of the large data cloud service platform for power energy measurement are analyzed, the technical framework of the cloud platform is studied, and the prototype design of the cloud platform is carried out.

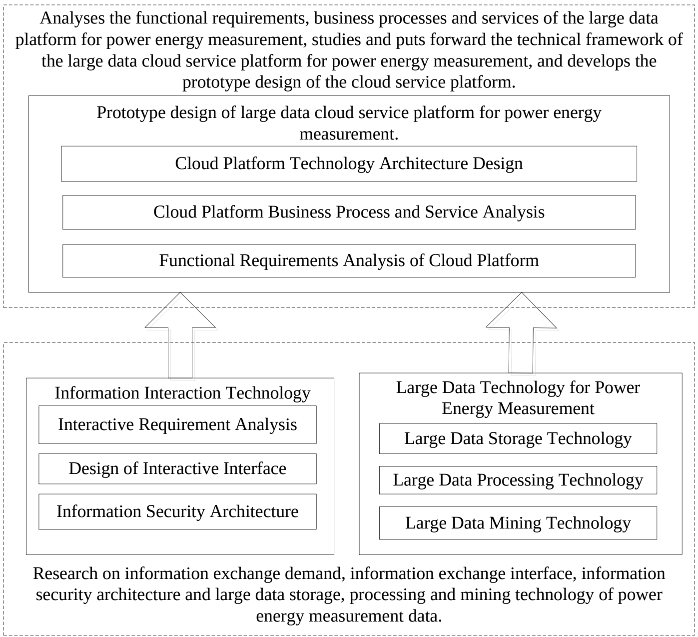

Fig.1 Research roadmap of large data cloud service platform for power energy measurement

The technical framework of the large data cloud service platform for power energy measurement is designed as shown in the following figure. From the data management layer, the data computing layer and the application layer, the structure of the large data cloud service platform for power energy measurement is designed layer by layer. The data management layer is designed from three aspects:

data storage management, data model management and data integration management to realize efficient and reasonable storage, data extraction and model transformation and integration after source data acquisition. The basic computing engine model of large data processing mining is designed. On the basis of guaranteeing the real-time, batch and flow computing ability of data, the large data analysis module of electric power is designed to realize historical data mining analysis and business trend prediction. The specific application scenarios are analyzed and the service objects (government, enterprises and power users) are docked. The service topics are analyzed for each service object.

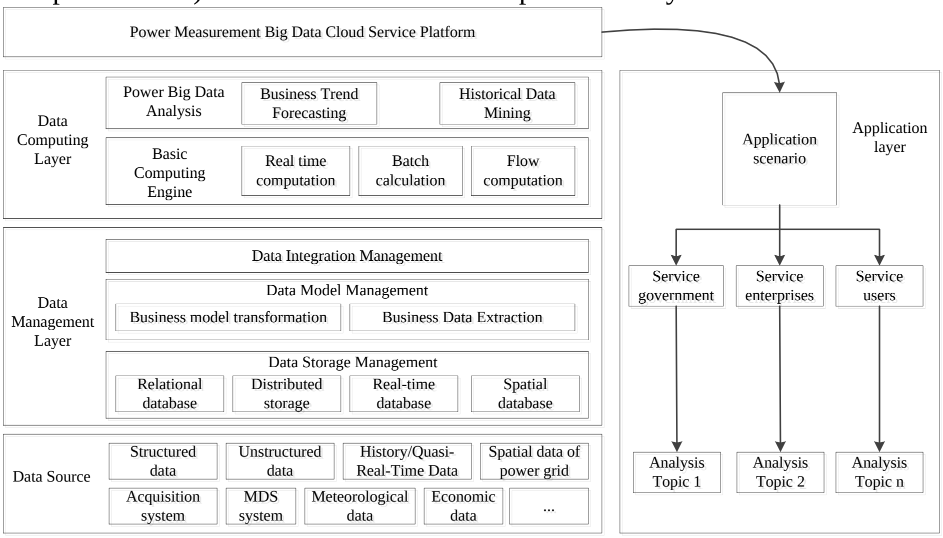

Fig.2 Architecture of large data cloud service platform for power energy measurement

3. Research on Application Scenario of Cloud Platform

Cloud platform services are mainly composed of application services and data services. Application services are mainly provided to users in a direct visual way. Users complete access through browsers or intelligent terminals. Data services are provided in a non-visual way. Users complete access through data interfaces to support subsequent personalized processing. The application scenarios are divided into three categories according to the different service objects: government-oriented, enterprise-oriented and user-oriented. Provide the government with data analysis services such as "policy effect analysis of de-inventory and de-production capacity based on power economic data", "policy price economy and leverage effect analysis", "power consumption forecasting analysis", "comprehensive error analysis of measuring instruments", and realize the sharing of energy measurement information resources with government departments. Provide enterprises with services such as "large data-based power meter replacement analysis", "customer credit rating and power risk prevention analysis", "potential tapping of power substitution", "anti-theft analysis, early warning and processing analysis". Provide the basis for enterprises to achieve fine management, effective energy saving and consumption reduction. Provide customers with "customer energy diagnosis and demand response", "customer electricity behavior analysis" and other services.

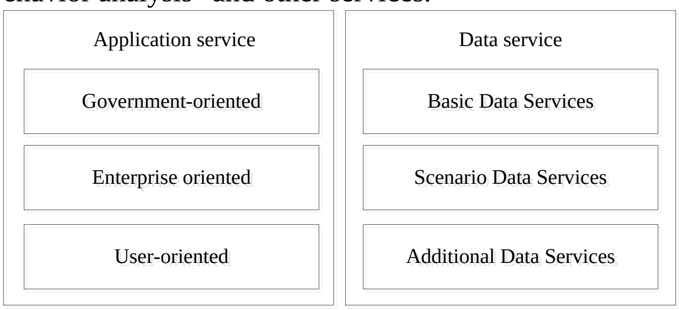

Fig.3 Cloud service types

3.1. Government-oriented application scenarios

Take the typical application of city perspective as an example. The overall idea of the design is based on residential electricity data, through the comprehensive analysis of electricity data and related information through big data technology, to form a series of valuable data products for the public, commercial organizations and government departments, to form a high-frequency interaction and highly cohesive interaction with customers, and gradually build a brand-new business ecological environment with the company as the core. A new closed-loop of value-added service is formed, which is "driving customer resource value discovery by data resource value discovery, and then driving company commercial value discovery". The product is positioned as a residential power data cloud, in which residential power data are analyzed and mined, and valuable data information is provided to target user groups. The structure of system technology is mainly divided into data layer, analysis layer, application layer and access layer.

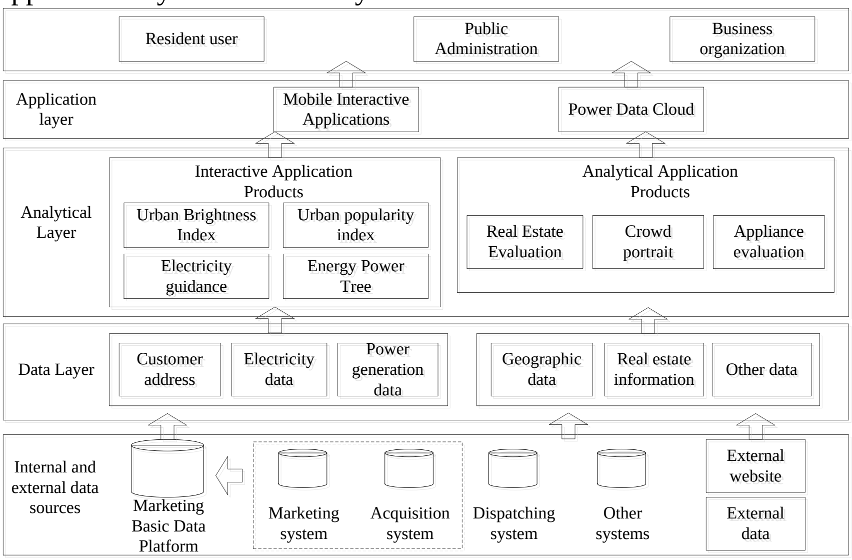

Fig.4 The technical structure of urban perspective

Urban Brightness Index: Visually depict the relative level of electricity consumption of residential households in the whole city by map spot brightness, thus forming the Brightness Index, which is updated once a month. Calculating method: Brightness index of a residential area = daily average electricity consumption of a residential area / maximum daily average electricity consumption of all residential areas in the city*100.

Urban popularity index: reflects housing use in residential areas. The use of housing in the main urban area of Chengdu can be shown by thermodynamic chart. The vacancy rate can be used to represent the use of housing in figures. It has become a new measure of vacancy of housing in China, except for the Bureau of Statistics, and is updated every six months. Calculating method: For a continuous period of time (can be set to more than 90 days, more than 120 days and 180 days, etc.), the percentage of zero electricity (or less than 30 kWh/month of low electricity) households to the total number of households in the district is the vacancy rate.

Urban Green Index: Measure household clean energy use by describing the proportion of clean energy in the total electric energy used by residents in a day. Calculating method: ∑(Proportion of clean energy output during peak-valley period in a day * power consumption in corresponding period)/total power consumption of users in a day *100.

Urban Migratory Birds: By comparing the changes of electricity consumption of vacant households during the Spring Festival, National Day holidays and before and after holidays, the index is updated every three months. Evaluating method: Outflow family: The average daily electricity consumption during the holiday is much less than that before the holiday, and the average daily electricity consumption during the holiday is close to that of the vacant households. Influent households: The

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average daily electricity consumption during holidays is much larger than that before holidays, and the average daily electricity consumption before holidays is close to that of vacant households. Finally, according to the comparison of the proportion of inward and outflow households in each district, if there are more inward households, the district is an inward one; if there are more outflow households, the district is an outflow one.Migratory Bird Coefficient = Number of Inflow (Outflow) Users/Number of Total Users*100.

3.2. Enterprise-Oriented Application Scenarios

Take the intelligent diagnosis of suspected electricity theft as an example. On the basis of on-line monitoring function module of measuring device, large data arithmetic is introduced, and an intelligent architecture of "four databases, one diagnosis and one learning" is constructed. A multi-dimensional, high efficiency and self-learning intelligent diagnosis function module of suspected power theft is established by using large data technology. The function module innovatively introduces the "two threads" analysis mechanism of suspected power theft, and calculates the suspected power theft correlation of abnormal measurement events and electricity consumption behavior data independently and synchronously. The abnormal event correlation database uses Apriori algorithm to find the "sick" measuring device in a large amount of abnormal event information, uses visual clustering algorithm to find the abnormal electrical curve of "arrhythmia", and then uses the characteristic library of stealing behavior to "diagnose" the abnormal electrical curve screened out. According to the results of consultation on two technical routes of meter abnormal event and power consumption behavior waveform, the suspected power theft index and the degree of suspected power theft of sample users are synthetically evaluated in the suspected power theft online diagnosis model. According to the diagnosis results, the field operation support library pushes the field operation instruction to the operators, instructs them to locate the suspected power stealing users quickly and identify the key inspection sites. After on-site verification, the operator must reply to the conclusion in the operation instruction. According to the on-site reply conclusion, the dynamic perfection mechanism of machine learning automatically input the new abnormal measurement events and the data samples of electricity consumption behavior into the abnormal event Association database, the electricity consumption behavior sample database and the electricity stealing characteristic sample database, so as to make the suspected electricity stealing intelligent diagnosis technology self-perfecting and full of vitality.

3.3. User-Oriented Application Scenarios

Take the intelligent analysis and application of typical residential power load characteristics as an example. Intelligent analysis of residential power load characteristics is based on the large data analysis method with load feature identification algorithm as the core. The algorithm is divided into three key links: data acquisition and processing, load feature extraction and load matching.

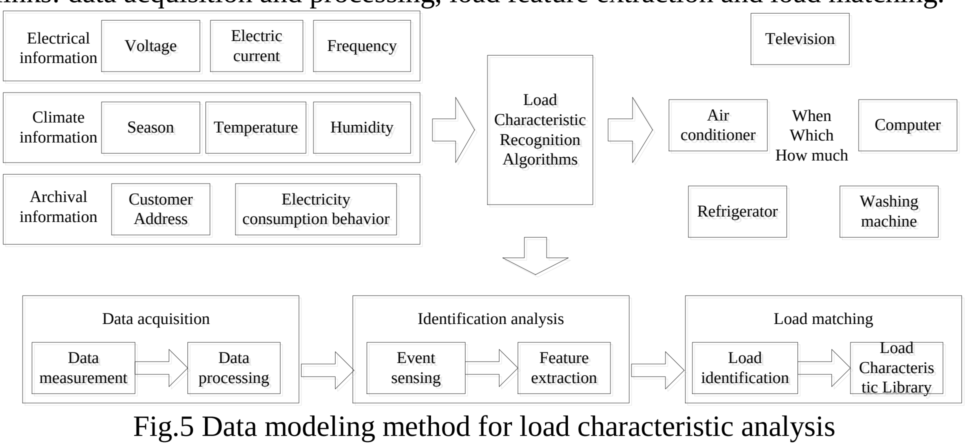

Fig.5 Data modeling method for load characteristic analysis

Data acquisition and processing is the first step of load characteristic analysis. The project developed a load characteristic identification watt-hour meter, which sampled 1600 current and voltage points per second at 1.6 kHz sampling frequency, and then preprocessed by integration and Fourier transform to obtain the original waveforms of current, voltage, active and reactive power, harmonic current and other electrical information.

On this basis, signal denoising, anomaly removal, information compression and other means are used to control the original waveform just obtained, so as to improve data availability. The governed data are extracted from the load characteristics of load identification, which are mainly divided into three categories: steady state, transient state and operation time. Steady-state characteristics refer to waveforms with gentle amplitude and slow change of electric signals such as active power, reactive power and harmonic current, which are suitable for identifying single-state electrical appliances with stable load curve. Transient characteristics refer to the large fluctuation of power sudden change, oscillation and other signals, which is suitable for multiple household appliances running at the same time and difficult to identify. Running time refers to common-sense data such as start-stop time and operation cycle of electrical appliances. Referring to seasonal climate, user files and other information, the accuracy of load identification can be further improved.

Load matching is the key and difficult point of load identification algorithm. One of the difficulties is to establish a complete residential load feature library, which contains load characteristic curves of various common electrical appliances under different working modes, accurately reflects the real power consumption situation of residential users, and provides a full and detailed and highly differentiated feature basis for load identification. For this reason, a large number of measured and recorded waves of various mainstream household appliances are carried out, and the active/reactive power change, start-stop impact, harmonic current, running time and other characteristic information of various electrical appliances are extracted from a large amount of real operation data. A multi-dimensional multi-source feature set and a residential load feature library with rich types and models of electrical appliances are established, which is an important basis for load identification.

After building the load feature library, it is another difficulty to match the load feature with the feature library hierarchically and efficiently, and to accurately obtain the power consumption information such as the types of electrical appliances, the corresponding start-stop time and the power consumption used. This project adopts a hierarchical classification load matching method based on multi-layer tree classifier.

Firstly, the load is divided into slow variable load and step load by power increment classifier. For slow variable load, the variable frequency air conditioning and other loads are distinguished by comparing the slow variable power with the threshold value of slow variable power in the feature library. For step load, impulse current classifier is used to distinguish frequency-fixed air conditioner from non-impulse load by means of impulse current threshold and duration in feature library. For the non-impact load, the reactive current classifier is used to compare the reactive power and the reactive power threshold in the feature library, so as to distinguish the electrothermal equipment from the microwave oven. On this basis, water heaters, rice cookers or electric furnaces are further identified by referring to the data of steady-state active power, harmonic current threshold and operation time in the feature library. By allocating classification criteria and classification hierarchy, the algorithm effectively solves the problem of similarity of single load characteristics of different electrical appliances. It can identify the characteristics of various types of household appliances after 3 to 5 classifications, and has high accuracy and operation efficiency.

4. Conclusion

In the era of big data, cloud computing and big data technology are a new mode to solve business problems. It is of great significance to analyze and design the functional requirements, business processes and service contents of the large data platform for power energy measurement, to study the business and function design scheme of the large data cloud service platform for power energy measurement, and to study the typical application scenarios. Clarifying the demand and technical route of supporting the energy and Internet based electric energy metering big data cloud service platform, and putting forward the technical architecture system of cloud computing service platform for large scale data metering of power energy metering, and constructing the cloud application platform application scenario ecology, is of great significance for supporting the "Internet +" smart energy development.

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