Intelligent Diagnosis and Analysis of the Station Area Line Loss Based on Big Data Platform

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Abstract: With the popularization of smart meters and the rapid advancement of the construction of electricity information acquisition system, in view of the complex site situation of the station area, through the study and analysis of the factors affecting the line loss rate of the station area, real-time and accurate analysis of the reasons for the change of the line loss rate, it is convenient for personalized and detailed management of the line loss of the station area, and more accurate positioning of the problem platform area. On the basis of large data of intelligent power consumption, the causes of abnormal line loss in low-voltage power station area are analyzed by data mining and analysis technology, which provides management basis for formulating reasonable power supply area in power station area. We will further promote the transformation of line loss management from result management to process management, and improve the level and quality of line loss management in public transformer stations.

1. Analysis of Current Situation of Line Loss of the Station Area

Line loss refers to the loss of electric energy generated by the conductor, transformer and other equipment during the transmission and distribution of electric energy [1]. At present, power enterprises generally use "four management" for line loss, those are zoning, voltage, line and station area for line loss management [2]. Among them, the line loss management in substation area refers to the management mode of power loss statistics, analysis and assessment according to the power supply area of each public distribution transformer in the power grid, so the mode is commonly known as the line loss management in substation area [3].

The traditional theoretical line loss calculation has its own limitations, and it needs to be used after judgment based on the actual grid operation and available data information. In terms of online damage anomaly determination, anomaly determination methods based on data mining technology are becoming more mature. The abnormal determination of line loss is affected by many factors, so it is difficult to accurately determine the cause of the line loss. There are many factors that cause abnormal line loss. Electricity theft, line problems, and mis-operation of related staff will all make the line loss rate of the power grid abnormal. At present, a lot of research work is underway in this field. Literature [4] proposed a calculation method of station line loss rate based on improved K_Means clustering and BP neural network. Literature [5] proposed an evaluation method of the theoretical line loss level based on the variable weight of the correlation degree. The literature [6] [7]

introduced the application dynamics of data mining technology in power systems, and looked forward to its future development trends. Therefore, the combination of data mining technology and big data technology to determine the abnormal line loss has high research value.

2. Research of the Key Technology

Aiming at the problems of low intelligence, poor real-time performance and inconsistent file relationship in line loss analysis, a line loss intelligent diagnosis and analysis system based on big data platform is constructed by adopting the platform design concept of big data and relying on the functions of real-time calculation, distributed storage and intelligent analysis functions. In the intelligent diagnosis and analysis, the data mining and analysis technology is used to make statistics of station area table, phase line loss information, household table files, power consumption information and metering information, etc., to carry out online analysis and processing, retrieve all existing abnormal information, mark out the abnormal information, and then push it to other platforms for key users, electricity meter monitoring, etc.. Because in the intelligent diagnosis and analysis platform, the number of users and the number of meters are very large, the data is also very large, so the calculation needs a long time. Using the distributed computing technology can support interactive calculation and complex algorithm. Dividing these huge data into many small parts for distributed calculation can improve the efficiency and time of calculation. This also can reduce the occurrence rate of human error and high loss and provide scientific decision support for line loss management.

3. Intelligent Line Loss Analysis Process

After line loss analysis of the system, the person responsible for line loss can find out the state of line loss, such as high loss and negative loss. However, good supporting means cannot be found in the specific analysis of the causes of line loss. It can only be judged by experience or checked one by one from multiple analysis interfaces. The analysis of line loss causes is not intelligent. At the same time, the person responsible for line loss can only find the function to support the analysis through personal experience in the analysis process. In the whole analysis process, there is no guidance to solve the problem, and the analysis of line loss causes will consume a lot of time of analysts.

At present, the line loss analysis has the following problems: first, the analysis of abnormal causes has not realized intelligent analysis recommendation, resulting in long analysis cycle and inaccurate analysis; second, the line loss analysis is only calculated on a daily and a monthly basis, but not on a phase basis, so the analysis is unitary; third, the relationship between the account table is inconsistent, and the marketing collection files are inconsistent.

The off-line calculation of the line loss of the station area are based on the collected data to judge whether there is any abnormality in the line loss of the station area according to the off-line calculation results. If there is any abnormality, the exception handling should be carried out. After the exception handling, recalculate the line loss of the station area to verify the abnormal handling of the line loss of the station area. If the line loss of the station area returns to normal, the diagnosis process is over. If there is still any abnormality in the line loss of the station area, the intelligent diagnosis should be carried out again. Flow chart of line loss analysis in station area is shown in Figure 1.

3.1.Offline Computing

The collected power consumption data shall be combined with the archive data for daily line loss calculation. Among them, line loss = power supply - electricity sales; if there are photovoltaic users or distributed power users, line loss = power supply - electricity sales + online electricity; line loss rate = line loss / electricity supply.

3.2.Line Loss Abnormal Judgment

The key factors affecting line loss are classified and decision rules are generated. According to the types of exceptions, they can be divided into five categories: table area table analysis, line loss analysis by items, user table file analysis, user power consumption analysis, power consumption exception analysis and metering exception analysis. The number of related exceptions under each exception item is comprehensively viewed.

3.3.Intelligent Diagnosis and Analysis of Line Loss Abnormality in Station Area

According to the offline calculation results, judge whether there is any abnormality in the line loss of the station area. If there is any abnormality in the line loss of the station area, carry out intelligent diagnosis and Analysis on the line loss of the station area. First, judge whether there is any abnormality in the station area and user files. If there is any abnormality, compare it with the marketing files, and synchronize the marketing files to the collection system. Then judge whether there is any measurement abnormality. If there is any measurement abnormality, the measurement exception information will be pushed to the relevant operation and maintenance personnel for on-site processing; finally, judge whether there are other exceptions, if there are other exceptions, carry out other exception processing.

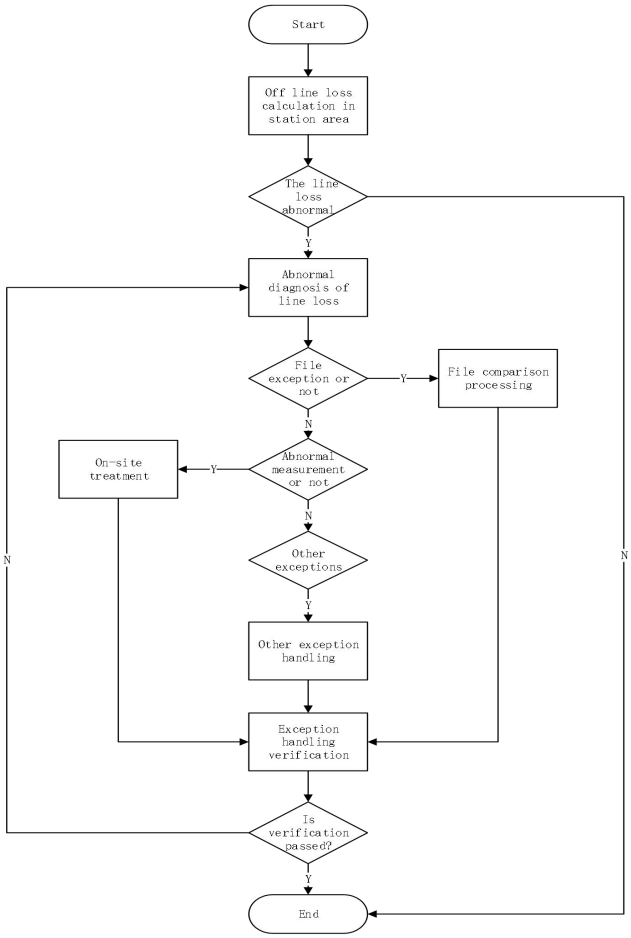

Figure 1: Flow chart of line loss analysis in station area.

3.3.1. Rule of Abnormal Judgment of Files

Compared with the collection and marketing files, if the number of users increases, and users decreases, it is judged as the user file exception; compared with the collection and marketing files, if the number of meters decreases, it is the meter indeed abnormal; compared with the collection and marketing files, if the number of meters increases, it is the meter redundancy abnormal. These two situations are the meter file exception; based on the file analysis, the calculation judges the photovoltaic users for the users of photovoltaic power generation; based on the file analysis, the calculation judges the users who change the table for the users who change the table.

3.3.2. Rule of Abnormal Measurement

If the acquisition fails, but the estimation succeeds, the meter will be judged as the estimated meter; based on the event analysis, if there is a cover opening record in the acquisition system, it will be judged as the cover opening record; if the reverse active indicator of the meter is greater than the positive active, the abnormal situation will be the reverse active prompt; based on the current analysis, the current within one day after excluding photovoltaic is less than 0, and if the current of the meter is negative, the abnormal prompt will be the transformer is connected reversely.

3.3.3. Other Abnormal Judgment Rules

Among other anomalies, there are table anomalies, phase angle anomalies and power consumption anomalies. Counter direction meter is abnormal if the counter direction meter is greater than the sum of the counter direction meter or less than the sum of the on grid energy; if the voltage loss of each phase of the meter is less than 100V in one day, it is abnormal if the voltage loss of the meter is abnormal; if there is no current curve in the meter, the current of each phase is broken, and if all the points are equal to 0 in one day, it is abnormal if the current loss of the meter is abnormal; Through vector diagram display, UA and IA are not in a phase limit, if the phase angle is greater than 30 degrees, it is judged as phase angle abnormality; if the power factor is less than 0.8, it is judged as power factor abnormality.

In the analysis of abnormal electricity consumption, based on the event analysis, the abnormal electricity meter that fails to collect is judged as the collection failure; based on the event analysis, the abnormal electricity meter that flies away is judged as the meter flies away; based on the event analysis, the abnormal electricity meter that goes backward is judged as the meter goes backward; based on the event analysis, the electricity meter that succeeds in collecting but has 0 electricity quantity is judged as the zero electricity quantity.

In the abnormal judgment of split phase line loss, the judgment rule of A-phase line loss, B-phase line loss and c-phase line loss is that the line loss rate is 0-10 normal, others are abnormal.

4. Design of Line Loss Intelligent Diagnosis and Analysis Architecture based on Big Data Platform

Big data support platform supports big data distributed computing, it has the ability of visual analysis, statistical analysis, mining analysis, etc., so it can meet the analysis and mining needs of real-time and offline applications, and provide basic platform support for line loss analysis and decision-making application construction. Among them, power failure event analysis, station load analysis, anti-stealing analysis, online measurement monitoring, meter reading fault analysis, real-time calculation of line loss are based on mining analysis, conventional statistics can be completed by statistical analysis, and the final results can be presented based on visual analysis.

4.1.System Functions

The intelligent diagnosis and analysis platform generates exception analysis report after pair exception analysis. It includes daily and monthly station area overview, station area line loss overview, station area table analysis, phase separation line loss analysis, household table file analysis, abnormal event analysis, etc. all abnormalities can be linked to the abnormal details, and the intelligent diagnosis and analysis architecture is shown in Figure 2.

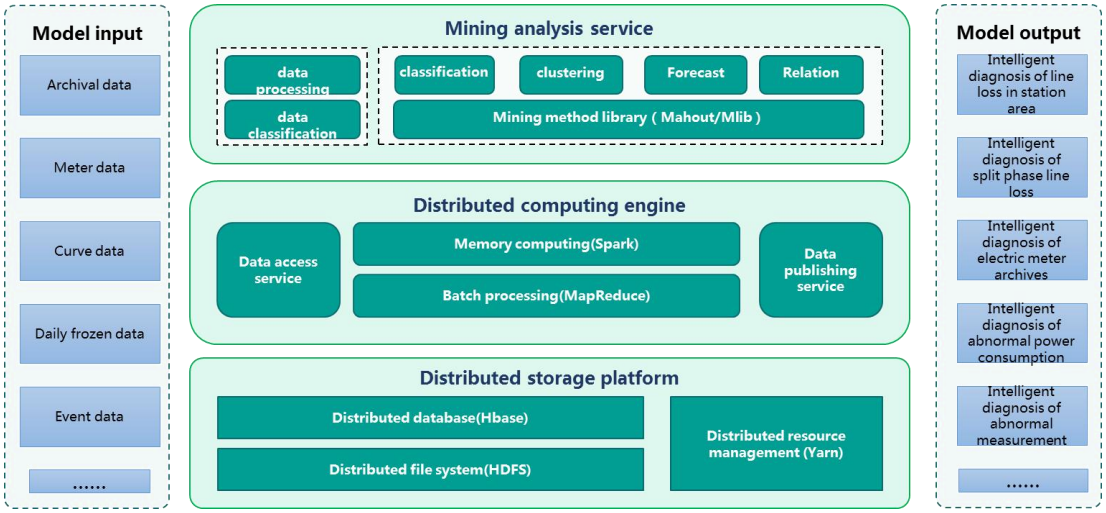

Figure 2: Architecture of intelligent diagnosis and analysis platform.

The analysis of station area table mainly completes the analysis of voltage, current, phase angle and electric quantity according to the station area table, it provides the basis for the line loss management personnel to check the station area abnormity, and analyzes whether there are any factors affecting the station area line loss abnormity at the station area level. The specific analysis contents include abnormal reverse electric quantity of the meter in the station area, abnormal voltage loss of the meter, abnormal disconnection of the meter, abnormal phase angle and abnormal power factor.

The analysis of line loss of phase separation specifically analyzes the three-phase line loss in the station area, it analyzes the line loss of each phase, and specifically which phase has the abnormal line loss. The specific analysis contents include phase A, phase B and phase C line loss abnormality.

The analysis of household table files realizes the analysis of the causes of line loss caused by household table problems in the station area. The specific analysis contents include the sudden increase of user files, the sudden decrease of user files, the abnormal loss of electricity meters, and the abnormal redundancy of electricity meters.

The analysis of the abnormal power consumption realizes the analysis of the line loss caused by the abnormal power consumption of the electric energy meter. The specific analysis contents include quantitative electricity quantity, photovoltaic users and meter changing users.

The analysis of measurement abnormity realizes the analysis of the cause of line loss due to the existence of measurement abnormity. The specific analysis contents include acquisition failure, meter flying away, meter reverse, zero power, open cover record, large reverse active power and reverse connection of transformer.

After the application and analysis of intelligent diagnosis is launched, it provides a line loss analysis support tool for company. Before the application analysis of intelligent diagnosis, it takes about one day to one week for the person in charge of line loss to analyze the abnormal line loss in the station area manually. By using the application analysis report of intelligent diagnosis and hierarchical positioning analysis of the specific causes of line loss, the analysis of all abnormal causes can be completed within one minute, greatly reducing the labor cost. At the same time, the intelligent diagnosis and analysis can verify whether the processing is completed and the actual processing effect.

5. Experimental Verification

Take a provincial level of master station system as an example. The power consumption information collection master station system of a provincial electric power company is implemented based on the Hadoop framework, which is deployed on-site and runs on a multi-node and cluster environment composed of 20 servers. The system needs to process more than 13 million abnormal data every day. The experiment selected four real power consumption business application scenarios, including full frozen-data collection of user daily power consumption, low-voltage data integrity rate statistics, daily line loss calculation, and station load analysis. The data sample is three-month power data (1.224 billion pieces). Table 1 shows the performance comparison between the big data platform and the centralized system in data collection, storage, calculation, application and real-time data sharing.

Table 1: Comparison of line loss diagnosis performance in station area.

Comparison Index Items	Centralized System	Big Data Platform
Full frozen-data collection of user daily power consumption	90 minutes/time	13 minutes/time
Data storage capacity	<=1 million records/minute	>=5 million records/minute
Data collection delay	>=2 hours	<=3 minutes
Low pressure daily data integrity rate statistics time	2 hours	15 minutes
Daily line loss calculation time	4 hours	20 minutes
Daily load analysis time of the station area	3 hours	2 minutes

From the comparison results of the above table, it can be seen that the system based on the big data platform has obvious performance advantages in terms of massive data collection and processing compared with the centralized system based on the IOE architecture, and the system service capability is greatly improved. In addition, in terms of supporting high-frequency real-time collection tasks, the centralized platform can achieve up to 24 data collections per day, while the big data-based platform can support at least 96 data collections per day. After the intelligent diagnosis application analysis is launched, it provides a line loss analysis support tool for the power company's line loss analysis. Before using the intelligent diagnosis application analysis, it takes about one day to a week for the person responsible for the line loss to manually analyze the abnormal line loss in the station area. The intelligent diagnosis application analysis report is used to locate and analyze the specific reasons for the line loss in several levels. The analysis of all abnormal causes is completed within hours, greatly reducing labor costs. At the same time, for the abnormal line loss that needs to be processed, intelligent diagnosis and analysis can verify whether the processing is completed and the actual processing effect.

6. Conclusion and Prospect

Through the intelligent diagnosis and analysis of line loss, it is beneficial to improve the line loss management data, provide data support for the marketing decision-making, facilitate the line loss management and performance evaluation, implement the more precise management, and form a deeper closed-loop management. At the same time, it can respond to the problem in time, solve the problem practically, and find out the wiring error and file error of the electric energy metering device in time. Timely statistics, intuitive and rapid control of line loss abnormalities, effectively

prevent high loss and negative loss of line loss in the station area. Through the intelligent diagnosis and analysis of "phase separation" line loss in the substation area, the low-voltage line shall be reconstructed in time and the terminal user's connection phase and load distribution shall be adjusted to make the three-phase load of distribution transformer basically balanced, reduce zero sequence current, line loss and achieve the purpose of overall loss reduction.

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