Research of Mobile Inspection Substation Platform Data Analysis Method and System

Peng Li[✉], Ruibin Gao, Lu Qu, Wenjing Wu, Zhiqiang Hu, and Guang Guo

State Grid Jinzhong Power Supply Company, Jinzhong, China
5259355@qq.com

Abstract. With the extensive construction of mobile inspection substation platform, various kinds of substation information is going to be digitized into databases. The scale of data is increasing day by day, which is large enough to provide a data base for data mining technology. Association rules has been applied successfully in various fields which makes it as one of the most active branches in the field of data mining research, development and application. Association rules used in smart substation data analysis to find some rules that people cannot find easily and it can find laws of equipment aging and failures also. This will benefit substation management, as well as equipment maintenance. In this article, we present a data analysis system based on mobile inspection substation platform. And the improved Apriori algorithm is used in substation data analysis to dig out some of the basic laws which provide effective information for substation management.

Keywords: Mobile inspection substation platform · Data analysis · Data mining · Association rules · Improved Apriori algorithm

1 Introduction

Substations play a key role in the sphere of power transmission and information collection. They generate large amount of data which ensure informationization of Mobile inspection substation platform. Substation applications also rely on data integration system. That's why data analysis is essential.

Development of computer technology and increase in demand for electric power system promote standardized management of substation. With the research of smart grid developing throughout the world, standardization of information has become a key technology of the future development of the power system. Construction of standardized data centers which has information on achieving data integrity substation, consistency, accuracy and standardization is very meaningful. It will also promote research on substation data analysis. Gradually building and development of mobile inspection substation platform will produce millions of data in a single day, which would provide data foundation for data analysis applications. Association Rules (AR) becomes one of the most active branches of data mining research, development and application [1]. There are a lot of researchers have been involved in the association rules on the issue of data mining research.

In this paper, a mobile inspection substation platform data analysis system contents data acquisition, data storage, data analysis and application of analytical results. The proposed implementation method of substation data analysis is based on an improved Apriori data analysis algorithm. It combines a variety of professional data and discovers the hidden information of substation data and brings convenience to the operation and management of substation.

2 Mobile Inspection Substation Platform Data Analysis System

Mobile field work platforms have changed the traditional working methods of artificial paper registration procedure by using the mobile terminals. This can improve the efficiency and quality inspection, electronic of substation equipment inspection. It can also minimize mistakes, ensure inspection officers work effectively.

Firstly, the platform collects data through the mobile terminals and storage it into database. Secondly, the system finds the hidden laws by mining and analyzing the data in the database and sends the results to management Platform. Thirdly, the substation management personnel screens the results and selects effective ones. Finally, the effective results are used in guiding new inspections.

The mobile inspection substation platform data analysis system is divided into four parts. They are mobile terminals, management platform, server and database [2] (Fig. 1).
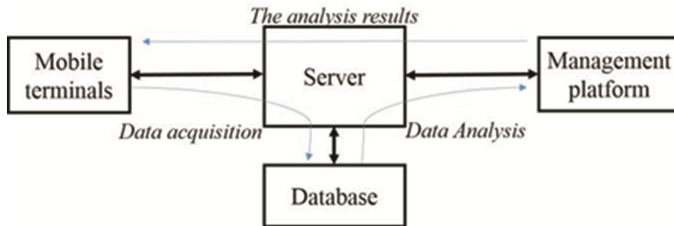

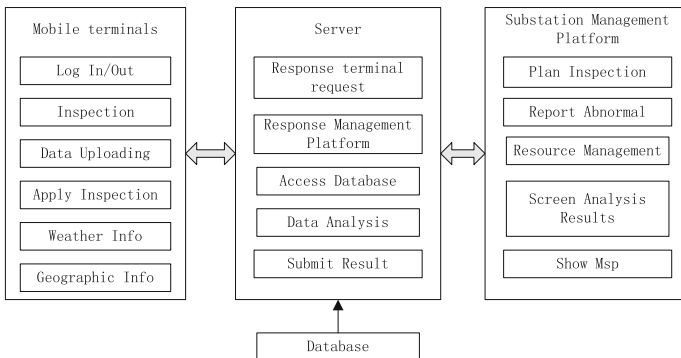**Fig. 1.** The system block diagram

Fig. 2. The system function block diagram

The mobile terminals are handheld devices for inspection officers, who are responsible for the inspection of substation equipment. They can ill inspection report or put forward inspection application [3]. These terminals are data capture terminals. The mobile terminals interact with the server in the form of 3G network generally. The mobile terminal subsystem includes log in and out function, inspection function, Data uploading function, apply inspection function, weather Information function and geographic information function. The most important ones are the inspection and data upload functions which include filling weather information, preparing tools, confirming the danger points, filling inspection results, taking pictures of evidence and uploading inspection results (Fig. 2).

The log in and out function provides an authentication mechanism to ensure that just the users who are accepted by system are allowed to log in. It also provides a convenient way to send worksheets to the correct staff.

The inspection and data uploading function is the most important function of the mobile terminal. Inspection staffs complete the inspection task through the mobile terminal. They fill weather information, prepare tools, confirm the danger point, fill in the inspection results and take photo of evidences. Then they send the inspection results to the server.

The inspection task application function makes the inspection staff be able to ask for a new inspection task by the actual situation. But they must offer the inspection date, type, substation and reasons.

The weather information function means the mobile terminal system can determine its location based on the GPS information to get the locate weather information which can be used to help inspection officers to make plans of inspection tasks.

The geographic information acquisition function is used to track terminal trajectory Real-time by sending its GPS information to the server every once in a while.

Platform server is responsible for responding mobile terminals and management platform requests and responds on the one hand. And it is responsible to store and retrieve database to analysis data on the other hand. Platform server gets the analysis results and submits the results to management platform [4]. Its main features include responding terminal request, responding management platform, accessing database, analyzing data and submitting results.

The responding to mobile terminals' requests function is designed for mobile terminals applying inspection tasks and uploading inspection results and geographic information.

The responding to management platforms' requests function is used to accept requesting of issuing worksheets, get terminal inspection result data and geographic information data.

The accessing database function refers to the platform to access the database. It includes database CRUD operations.

The results submitting function is used to feedback data analysis results. Database is responsible for various types of data. Management Platform is used to develop inspection plans, report abnormalities, manage resource, screen Analysis Results and show Maps.

The inspection plan management function contains making, reviewing, modifying, deleting and approving plans. And the data analysis results can be used in plan making.

3   Data Analysis Method of Mobile Inspection Substation Platform

3.1   Data Mining Algorithm and Association Rules

Association rules are mainly used in finding associations of transaction database items or attributes. It focuses on identifying the set of attributes frequent and frequent itemset from data. Then it uses these to create the association rules. Association rules are not based on the intrinsic properties of the data itself. It is based on characters of the simultaneous occurrence of the data items. Association rules are succinct and understandable.

The basic model of association rules is as follows. The problem of association rule mining is defined as: Let $I = \{i1, i2,…, in\}$ be a set of n binary attributes called items. Let D be a set of transactions called the database. Each transaction in D has a unique transaction ID and contains a subset of the items in I. A rule is defined as an implication of the form $X \Rightarrow Y$ where $X \subseteq I$, $Y \subseteq I$ and $X \cap Y = \emptyset$ [2]. The sets of items (for short itemsets) X and Y are called antecedent and consequent of the rule respectively.

To select interesting rules from the set of all possible rules, constraints on various measures of significance and interest can be used. The best-known constraints are minimum thresholds on support and confidence. The support $supp(X)$ of an itemset X is defined as the proportion of transactions in the data set which contain the itemset. The confidence of a rule is defined $conf(X \Rightarrow Y) = supp(X \cup Y) / supp(X)$. The association rules algorithm follows the general process.

Among so many association rules algorithms, Apriori algorithm, which was proposed in 1993 by R. Agrawal is one of the most influential ones. Apriori is designed to operate on databases containing transactions. Apriori Association rules consist of the following steps [5] (Fig. 3).
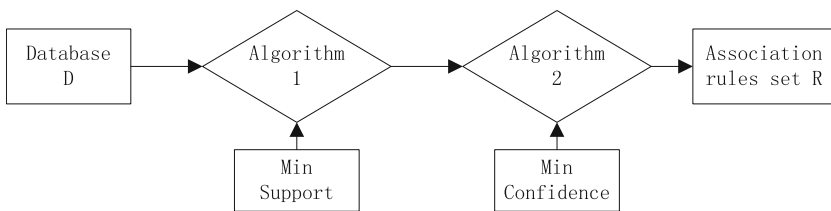

Fig. 3. The general process of association rules algorithm

Step 1, According to user-set minimum support frequent item sets, priori iterates to identify all frequent item sets. Step 2, It gets strong association rules by the minimum degree of confidence. The process of Apriori algorithm is as Fig. 4.

Apriori algorithm has its fatal deficiencies. First, when each element needs to decide whether to join frequent item sets by verifying, it cause the algorithm to scan the database multiple times, which will cause excessive I/O operations. This reduces the efficiency
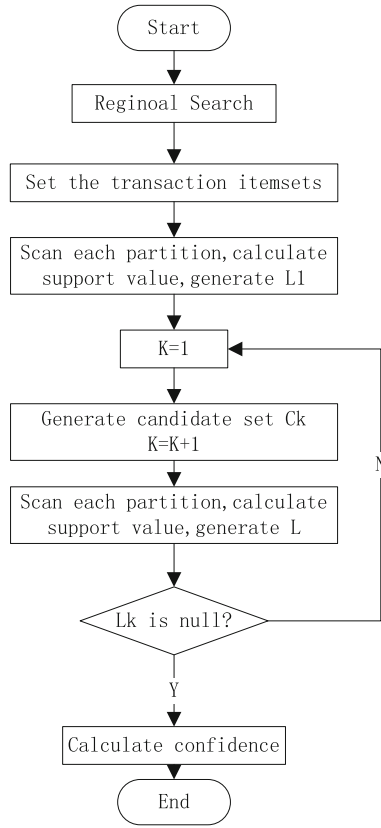
Fig. 4. The process of Apriori algorithm

of the algorithm. Second, when the project set has a larger scale, the project will have a huge set of candidate. This will greatly consume system's CPU and memory capacity [6].

It cannot be directly used for mining association rules relational databases. This association rules do not apply to massive data mining environment too. So, the Apriori algorithm needs to be improved.

3.2   Improved Apriori Algorithm Analysis

Currently, there are a lot of association rule algorithms. The vast majority are based on Apriori algorithm as a basis for optimization improvements. They reduce I/O operations by reducing the number of scanning database to improve the efficiency of the algorithm.

By combines Sampling algorithm proposed by H. Toivonen and DIC algorithm proposed by S. Brin et al., we subdivide substation database, and then sample it to improve the efficiency of obtaining frequent item sets [7].

Substation operation information data distinguish in accordance with the substation node. Any association rules are only valid within the same substation. This is consistent

with DIC algorithm which demands for data partitioning [8]. The process of Improved Apriori algorithm is as follows (Fig. 5).
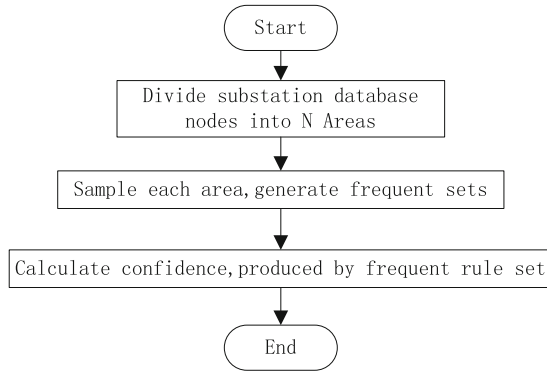

Fig. 5. The process of improved Apriori algorithm

The improved Apriori association rules proposed by this paper require a combination of experience of substation staffs. This mining that the accuracy requirements of this algorithm can be slightly reduced [10].

4   Conclusion

In this paper, the design of data analysis system based on mobile inspection substation platform is studied. And the association rules data mining technology is introduced into substation data analysis which based on the data characteristics of mobile inspection substation platform. We apply the improved Apriori association rules algorithm to substation data analysis. A smart substation data analysis system has been established. With the rapid development of smart grid, in particular, the promotion and construction of substation integrated digital technology, this system will providing a wide application platform for growing amounts of substation data.

References

1. Zhang, P., Gao, X.: Mobile inspection substation platform. Electr. Technol. **2010**(08), 31–40 (2010)
2. Berzal, F., Cubero, J.-C.: An efficient method for association rule mining in relational databases. Data Knowl. Eng. **37**, 47–64 (2001)
3. Chen, F., Deng, P.: A survey of device collaboration technology and system software. Acta Electronica Sinica **39**(1), 440–447 (2011)
4. McKinsey & Company. Big data: The next frontier for innovation, competition, and productivity, vol. 37(1), pp. 1–28. McKinsey Global Institute, New York (2011)

5. Abdrabou, A., Gaouda, A.M.: Understanding power system behavior through mining archived operational data considerations for packet delivery reliability over polling-based wireless networks in smart grids. Comput. Electr. Eng. **18**(20), 118–119 (2015)
6. Wu, X., Zhu, X., Wu, G., et al.: Data mining with big data. IEEE Trans. Knowl. Data Eng. **26**(1), 97–107 (2014)
7. Shin, S.-J., Woo, J., Rachuri, S.: Predictive analytics model for power consumption in manufacturing. Procedia CIRP **29**(30), 191–194 (2014)
8. Lin, S.: Grid integrated electrical equipment on-line monitoring platform based on the design of data acquisition system. Power Electr. **29**(2), 29–31 (2009)
9. Wang, D.: Center infrastructure and key technologies based on the power of cloud computing data. Autom. Electr. Power Syst. **10**(11), 146–169 (2012)
10. Divyakant, A., Philip, B., Elisa, B., et al.: Challenges and opportunities with big data. Proc. VLDB Endowment **5**(12), 2032–2033 (2012)