Polymorphic accident inversion method in on-line monitoring system of power transmission and transformation equipment

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Abstract. Most of the equipment on-line monitoring system does not have the function of accident inversion or weak function. Even if it has the function of inversion, it only records the real-time steady-state information of a specific type within a period of time before and after the time of the accident, which cannot meet the actual needs of customers. This paper proposes a polymorphic accident inversion method based on time series database, equipment on-line monitoring of the site of all collected data by time sequence database for high-speed storage, reappear in the inversion environment equipment failure accident system before and after all of the conditions and for the whole process of continuous play, for the analysis of status evaluation for power grid provides a simulation environment of inversion and effective data to support. Based on the design idea of polymorphism, the user accident inversion requirements under different scenarios are satisfied.

1. Introduction

With the rapid development of power construction, the scale of power grid is expanding, and the task of inspection and maintenance of power grid equipment increases sharply. The on-line monitoring system of power transmission and transformation equipment builds the state monitoring center of power transmission and transformation equipment by accessing real-time data monitored by various on-line monitoring devices of power transmission and transformation equipment, realizing real-time monitoring of equipment state and providing efficient and reliable data support for equipment state diagnosis and maintenance [1-4]. Equipment status monitoring information is sent to management departments at all levels through SMS and email, which is of great significance for operation and maintenance personnel to improve maintenance efficiency, reduce operation and maintenance cost and ensure the stability and reliability of power grid operation.

The advantage of on-line monitoring is that it can monitor the health status of electrical equipment in real time. However, it is equally important to extract historical indexes of the equipment, conduct accident inversion and carry out comprehensive operation analysis of the equipment [5-7]. Manual intervention is carried out based on the conclusion of status assessment and risk warning of the inversion results to correct the automatic judgment results of the system and improve the accuracy and credibility of the system decision-making.

Most on-line monitoring systems of equipment do not have the function of accident inversion or have weak functions. Systems with the function of accident inversion can only record the real-time steady-state information of a specific type within a certain period of time before and after the time of accident. This method lacks continuity in time selection of accident traceability, information is not comprehensive, and real operation scene simulation is not available. If the latest power grid model and
graph are used for inversion, it cannot be matched with the section data and model at the time of the accident. Operation and maintenance personnel hope to provide a simulated scene for training and learning through accident inversion without operating on-site equipment [8]. In this paper, a polymorphic accident inversion method based on time series database is proposed. The time series database satisfies the high-speed continuous storage of the collected data and the polymorphism satisfies the user accident inversion requirements under different scenarios.

2. Time series database

Time series database is used for the collection and analysis of process data. It can store the monitoring data of on-line monitoring device for a long time and can meet the needs of data collection, storage and query quickly and efficiently. The mainstream products include time series databases such as HighSoon, PI and eDNA. In this paper, pcs-9000 time series database developed by ourselves is adopted, which is composed of four parts: object registration service, data processing service, naming service and data access service. The data processing service can receive, compress and store the sequential data. Naming service completes service name conversion and authorization control; The data access service provides a client query interface to access any professional data stored in a high-speed database. The description of the client query service interface is as follows:

1) establish and close the database connection;
2) single-point time-series query of data;
3) data multi-section query;
4) query data at any time period;
5) query the data at any step size;
6) data point model configuration information query.

The most basic concept of PCS9000 time series database is point, which is the unique representation of different data streams. Any measurable equipment properties can be defined as points, such as gas content of various components of oil chromatography monitoring device, dielectric loss, leakage current, equivalent capacitance, etc. of capacitive equipment insulation on-line monitoring device. Each data record of each point is composed of four parts, including PtID, Timestamp, Value and Flag. Where, the encoding is represented by an unsigned integer (4 bytes); The time scale is represented by two 4-byte integers (hours and usecs), in which hours refers to the number of hours from the current time to the first year of the Christian era, and usecs refers to the number of microseconds from the current time to the last hour. The precision of the time scale is 1 delicate, and the time range can be expressed is from the first year of the Christian era to 490,000 years after the Christian era. Data values are represented by a single precision floating-point number or by an association of signed integers (4 bytes); The quality flag is represented by a 4-byte signed integer. A complete event point occupies 20 bytes of storage space, as shown in figure 1 below:

![Figure 1. Time series database data record composition](image)

3. Polymorphic

Polymorphic, also known as multi-scene, is a multi-scene model established for the on-line monitoring system of equipment in different application stages and states, which can be divided into real tense, historical state, research state and so on.

1) Real tense: the scene in which the system is actually running. You can only have one of these states in the system;
2) Historical state: the scene created by the system at a certain historical moment. Depending on the situation, you can have multiple states like this, each with a different start and end time;
3) Research status: the scene created by the system at any time according to the research needs. You can have multiple states like this.
   When other scenarios need to be created in the system, the current real tense is used as the master, similar to making a mirror image of it, and the main data includes model, graphics and system parameters, etc.. After the scene is created, the data of each scene is private and will not interfere with each other in the future. Applications can also run in various states without interfering with each other.

4. Accident inversion
Accident inversion includes two functions: accident trigger and accident inversion demonstration, as shown in figure 2:

4.1 Accident inversion sampling trigger service
The system adopts time series database sampling and has the ability of accident inversion with all collected data. It can record and save the state of power grid accidents in an all-round way, and can truly and completely invert the accident process. An incident data sampling service can be triggered by a trigger source.

There are a variety of trigger sources:
* The logical operation result of any event or several events can be defined as the trigger source of the accident;
* Operation and maintenance personnel start manually on the screen;
* Application module issues corresponding incident inversion events;
* Multiple triggers: when multiple accidents are recorded, the record storage time of accident inversion will be postponed accordingly.

Accident data sampling services received trigger source, according to the specified before the accident and recall the time period after the accident, will immediately begin to save for a period of time before and after the accident, accident record multiple storage cycle (Nmin until after the last accident Nmin full, polymorphism, accident data will preserve the historical data to the corresponding scene list.

4.2 Accident inversion demonstration

4.2.1 Establish the inversion environment. Accident inversion can be carried out in any workstation, and two ways can be considered: select the application research state of single-machine accident inversion for the local demonstration; The running state of multi-machine accident inversion application is selected for joint demonstration.
When the user selects the inversion start time and end time, the following contents matching the
start time need to be obtained:
* On-line monitoring application database, including analog value, state value, cumulative value, etc.
* Alarm events, such as accident displacement, remote signal displacement, telemetry over the
  limit, manual start;
* On-line monitoring of historical models, historical versions of graphic images;
* On-line monitoring application database measuring point and its corresponding time series
database correlation;
* The incident inversion application checks whether the on-line monitoring application database
  changes between the start time and the end time. If so, modify the end time to before the change, and
  then use it as a new inversion process;
* When it is discovered that the user's choice of accident does not belong to the current scenario,
  the prompt is given. The incident inversion application ensure that users can invert the accidents
  covered by them under appropriate scenarios, make the accident data consistent with the power grid
  model and graphics at that time, and truly reproduce the power grid operation state in a period of time
  before and after the accident.

4.2.2 The operation tool of inversion. 1) Inversion includes single step and continuous mode
* Single step mode: inverse single step length indicates the number of seconds after the pause, waiting
to press the start button to go on a single step length;
  * Continuous pattern: the inversion process continues until manual intervention.

In the single-step mode, the control unit of inversion is the step length, and the time unit of a step
length is the second.

2) Manual setting changes the inversion speed
The greater the positive value is, the faster the inversion will be; otherwise, the greater the negative
value is, the slower the inversion speed will be (but the maximum and minimum values have upper
and lower limits). For example, if the user sets the single step length as 10 seconds and selects the
speed value as 5, the actual time used for a single step length is 10/5=2 seconds. The same is true for
continuous mode.

3) Control keys of inversion
* The start button(●): start inverting;
* Pause button(■): halts the inversion (at the current time);
* Stop button(■): stop the inversion;
* Fast forward button(▶): the number of seconds indicated by the forward single step length when
  clicked once;
* Fast back button(◀): click once to go back the number of seconds indicated by the single step
  length;
* Drag bar(●): can drag any, forward or backward drag bar displayed proportion of the time value,
  the beginning and end of the sliding control bar corresponding to the user set the inverse start time and
  end time, drag the slider resolution accuracy of 1 second.

4) Inversion switching
In the inversion process can be arbitrarily transformed into a single step or continuous mode, from
a single step into a continuous, if in the pause process, press the start button to continue the inversion.

4.2.3 Inversion screen design. The demonstration can be carried out by many ways, such as station
map, power flow chart or curve in the inversion information display directory. In the inversion process,
the topology of the network can be dynamically colored, and the change process of the network
structure can be dynamically displayed on the single-line graph. A certain section in the inversion
process can be used for equipment state comprehensive operation analysis, PAS analysis, and DTS
simulation research.
5. Summary
Polymorphic accident inversion method based on time series database, time series database meets the requirements of high-speed continuous storage of collected data, and the whole process data presentation in terms of inversion granularity reaches us level. Polymorphism meets the needs of user accident inversion under different scenarios and solves the drawbacks of traditional accident inversion functions. The accident inversion and analysis tools of this method have been used in several on-line monitoring systems of large power transmission and transformation equipment. By means of this tool, the working scene at the time of occurrence of the accident is reproduced realistically, multiple accidents are successfully analyzed, the fault processing time is greatly shortened, convenient data and tool support are provided for equipment fault diagnosis and state evaluation, and the automation level and practical degree of power grid equipment operation and maintenance are promoted to a certain extent.

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