Research and Implementation of a Local Modification Method of Power System Topology Suitable for Large Power Grid Training Simulation System

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Abstract. This paper proposes a local topology correction method for large power grid simulation. The analysis method of the local topology corresponding to the "open" and "close" events of the power equipment and the correction method of the corresponding node admittance matrix. This method is suitable for online analysis systems such as large power grid simulation systems. Finally, this paper verifies that the local topology correction method proposed in this paper greatly improves the topology analysis speed and calculation efficiency of the large power grid training simulation system.

1. Introduction
The analysis method of power system topology is the basis of power flow calculation. Power system topology analysis is through logical analysis of the switch information of circuit breakers and disconnectors in the power system, and then forms the logical calculation point for power flow calculation of the power system, and then through the logical analysis of lines and transformer windings, it forms useful The process of tidal current calculation island for tidal current calculation.

2. Network topology analysis method
This paper defines the physical connection point of circuit breaker as a node, and defines the set of nodes connected together by closing the switch as a logical calculation point (calnode). The node is static, the change of the switch state will not affect the node, while the logic calculation point is dynamic, and the change of the switch state may change the logic calculation point. The network topology analysis consists of two steps. The first step is the connection analysis of the plant and station, which is called micro-topology analysis in this article. The traditional network topology analysis method is to use computer deep search technology, that is, starting from a node, using a stack to store nodes with intermediate branches, searching forward along a certain path, and dividing the nodes connected by closed switches into a logic Calculate the point; start from another node that has not been assigned the bus number, and use the same method to search until all the connection points are assigned the logical calculation point number. The second step is system network analysis, which is called macro topology in this paper. The logic calculation points of the entire system are connected by branches (AC lines, transformer windings) into several subsystems (flow calculation islands). In the case that the system does not split, the entire network is a subsystem.
In traditional power system simulation software, when the system has changes that affect the topological relationship, it is necessary to re-analyze the micro-topology of each station, re-form the logical calculation points, and renumber them. It is obviously not smart enough for large-scale power grids, especially the frequently operated simulation system, which causes a great waste of computing resources. Therefore, the literature [2] proposed a topology processing method to track network changes. This method saves the bus structure of the previous network topology, and locally modifies the bus number by comparing the changes of the switch states before and after. The advantage of this method is to avoid optimizing node ordering and reforming the factor table. However, it is still time-consuming to save the previous network topology results and compare the changes in the network structure to distinguish between added or removed buses. Literature [3] proposed a breadth-first fast topology search method, which speeds up the topology processing, but its local processing is searched within the range of the plant and there is still much room for improvement. The flow chart of traditional topology analysis is shown in Figure 1:

**Figure 1.** Flow chart of traditional topology analysis

### 3. Fast calculation of local network topology

The local topology modification method proposed in this paper is an improvement on the traditional topology analysis method. First, the power grid must go through the traditional power grid topology analysis to establish the relationship between calnode and node, clanode and equipment, and island and calnode.
When the power grid topology changes, the local modification of the power system topology is achieved by modifying the relationship between calnode and node, calnode and equipment, and island and calnode, and then modifying the node admittance matrix of the power grid. Changes in the topological relationship in power system analysis are caused by changes in the opening and closing states of the circuit breakers or disconnector (switches) connected to the equipment. The local topology correction mainly divides the topology relationship change into the breaker "open" event and "close" event for analysis. The specific analysis process is as follows:

3.1. Circuit breaker "Open" event
The contact points (node1, node2) at both ends of the circuit breaker, when the circuit breaker has an "open" event,
1. Perform an in-depth search on node1 to determine whether the island node2 can be searched. If the island node2 can still be searched, then it is determined that the power system does not need to do topology analysis at this time, and the local correction ends;
2. Performing a deep search on node1 but not searching the island node2, it is determined that a new logical calculation point calnode2 needs to be formed for node2;
3. Perform an in-depth search on calnode1 to see if calnode2 can be found;
4. If calnode2 can be searched, it is determined that a new logical calculation point is formed, but a new tidal current calculation island is not formed;
5. Correct the relationship between calnode1 and calnode2 and the physical contact point;
6. Amend the relationship between calnode1 and calnode2 and power equipment;
7. Add a row and a column at the end of the admittance matrix to represent the association relationship of calnode2, and increase the row and column values corresponding to calnode2;
8. Correct the row and column values corresponding to calnode1;
9. Complete the admittance matrix correction and complete the local topology correction;
10. In the third step of the search, if calnode1 is not found in the deep search of calnode2, it is determined that a new tidal current calculation island 2 and the logical calculation points;
11. Correct the relationship between the newly generated tidal current calculation island 2 and the logical calculation points;
12. Modify the original relationship between tidal current calculation island 1 and logical calculation points, that is, delete the duplicated logical calculation points in tidal current calculation island 1 and tidal current calculation island 2;
13. Modify the admittance matrix of tidal current calculation island 1;
14. If tidal current calculation island 2 is a living island, the admittance matrix of tidal current calculation island 2 is formed;
15. The partial correction is completed.

3.2. Circuit breaker "close" event
When a "close" event occurs at both ends of the circuit breaker (node1, node2), the specific analysis is as follows:
1. Determine whether node1 and node2 belong to the same logical calculation point calnode1 when there is no "combination" event;
2. If node1 and node2 belong to the same logical calculation point calnode1, there is no need to modify the admittance matrix, and the local modification ends;
3. If node1 and node2 belong to different logical calculation points calnode1 and calnode2 respectively;
4. Suppose calnode2 is to be merged into calnode1;
5. Determine whether calnode2 and calnode1 belong to the same tidal current calculation island;
6. If calnode2 and calnode1 belong to the same tidal current calculation island;
7. Delete calnode2 in the tidal current calculation island;
8. Transfer the node relationship of calnode2 to calnode1;
9. Transfer the device association relationship of calnode2 to calnode1;
10. Delete the row and column corresponding to calnode2 in the admittance matrix;
11. Modify the admittance value of the row and column corresponding to calnode1;
12. Complete local topology analysis;
13. If it is judged in step 5 that calnode1 and calnode2 do not belong to the same logical computing island;
14. Then merge the logical computing islands (in principle: merge dead islands into living islands, merge small-scale islands into large-scale islands, this article assumes that island 2 is merged into island 1);
15. Change the island association relationship of logical calculation points in island 2 except calnode2 to island 1;
16. Transfer the node relationship of calnode2 to calnode1;
17. Transfer the device association relationship of calnode2 to calnode1;
18. The increase in admittance matrix 1 corresponds to the scale;
19. Delete the rows and columns of the admittance matrix 2 corresponding to calnode2 and merge them into the admittance matrix 1;
20. Comprehend the row and column values of the new admittance matrix calnode1;
21. The partial correction ends.

4. Procedure steps
5. Conclusion
The local topology correction method implemented in this paper has been tested and verified in multiple power grids. Taking the large power grid of the National Power Distribution Center as a reference, the large power grid of the National Power Distribution Center has more than 20,000 computing nodes and 5 large power flow calculation islands after topology analysis. And several small computing islands. If the circuit breaker displacement operation occurs, the total time to re-analyze the topology is about 1s, and the admittance matrix needs to be reformed to participate in the calculation. The total time is about 1.3s. Through the local correction method implemented in this article, if there is a breaker During the displacement operation, the running test time of the program is within 1ms, and the correction time of the admittance matrix is included, which greatly reduces the calculation speed of the large power grid when the topology relationship changes.

6. References
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