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Power Systems Observability Analysis Based on Parallel Gaussian Belief Propagation

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Introduction

A necessary condition for a power system state estimate (SE) to have a solution is that the power system is observable. Observability analysis is thus critical for SE. When the results of the observability analysis find that the overall network is unobservable, the overall network structure will be divided into observable islands according to the observable parts, and the observable islands will be connected to each other by adding pseudo-measurements, making the overall network observable. As power systems are constructed and developed, the grid structure becomes increasingly large and complex, which poses current challenges for efficient observability analysis.

Methods

We present a parallel observability analysis algorithm based on GBP, which is named PGBP-based observability analysis. Specifically, the main implementation is to split the GBP computation process into multi-core and multi-thread parallel computations. Compared with the traditional BGP method, we added a parallel computing method to optimize the BGP computation process for a more efficient observability analysis process. The key step in parallel computing is to decompose the task. During the GBP calculation, there are three main tasks that can be decomposed.

1) Variable nodes propagate variance information to factor nodes in parallel as shown in Fig.1.

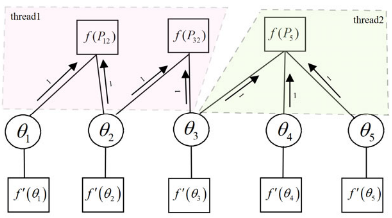

Fig. 1. Two threads parallel computing realize the propagation of variance from variable nodes to factor nodes

2) Factor node propagates variance information to variable node in parallel as shown in Fig.2.

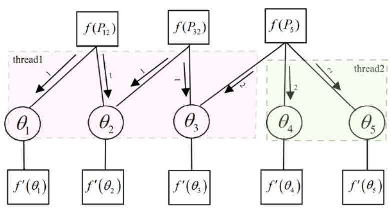

Fig. 2. Two threads parallel computing realizes the propagation of variance information from factor nodes to variable nodes

3) Calculate the marginal variance of each variable node in parallel as shown in Fig.3.

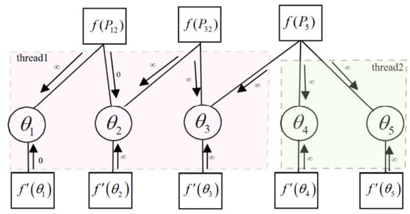

Fig. 3. Two threads compute the marginal variance on each variable node in parallel

Result and discussion

The simulation calculation in this paper uses three large-scale power system cases in the MATPOWER package. In order to verify the effectiveness of the observability analysis algorithm proposed in this paper, we compared it with recent research works, including the topological method (TM) and GBP-based method. The results of a test sample from one of the three large power systems are shown in Fig.4.

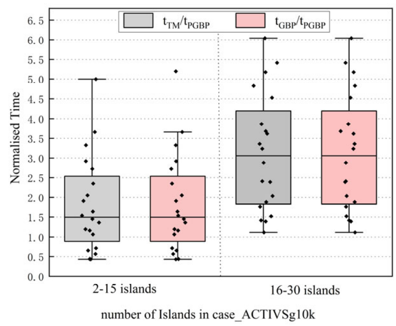

Fig. 4. Time-consuming calculation of TP, GBP and PGBP standardization under the case_ACTIVSg10k instance system

Fig.4 shows that the ratios of standardized time t_{GBP}/t_{PGBP} and t_{TM}/t_{PGBP} are mostly greater than 1, indicating that the PGBP-based observability analysis algorithm proposed in this paper significantly improves the efficiency of observability analysis.

Conclusion

In order to improve the computational efficiency of the observability analysis. We proposed a novel PGBP-based observability analysis algorithm. By applying multi-thread parallel computing technology to optimize the GBP process, the GBP algorithm process is optimized to shorten the computational time of observability analysis. Compared with the latest research, the efficiency of the proposed algorithm is verified, and it provides a reliable guarantee for the realization of real-time state estimation.