

Reconstruction of Distribution Network Based on Parallel Tabu Search Algorithm

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Abstract. In order to achieve the reconstruction of distribution network, the partition method and the parallel tabu search algorithm were introduced. Distribution network was simplified as ring network which only contained branch-groups, and the necessary conditions for the reconstruction of the distribution network was put forward. In the solving process, First step chose the broken branch-groups, father and son linked list which was formed by depth first search was used to judge network structure. Then, partition theory which could reduce complexity was introduced to decompose the solution neighborhood of TS into subneighborhood, then different tabu lengths made solution more diverse, then processors were used to parallel search. The simulation results verified the validity of the improved method.

Introduction

Distribution network reconstruction is a control method which achieves optimal operation of the distribution network, and is an important part of the study of automation. Under normal operating conditions, the distribution dispatchers according to the operation requirements adjust the distribution network structure through the switch operation, on the one hand, load balancing, eliminating overload[1,3] to improve the quality of power supply; On the other hand, decreasing network loss [2], improving the system stability. When the system is failure, power dispatchers should quickly isolate faults, reduce the blackout range, and rapidly restore the electricity. Distribution Network Reconfiguration used in power distribution networks can improve the security, economy and reliability of the distribution network. Therefore, the study of distribution network reconfiguration problem has important practical significance.

The reconstruction of the distribution network is a multi-constrained multi-objective nonlinear combinatorial optimization problems[4], the present solution algorithm can be roughly divided into the following categories:

1) Traditional mathematical optimization algorithm[5-7], namely, direct use of the existing mathematical optimization principle for reconstruction. Such methods are "greedy" search algorithm difficult to apply the large-scale network.

2) Heuristic algorithms, including the branch exchange method[8-10] and the optimal flow pattern method[11-12], although the combination of the physicalAfter the power flow system's operation mode is adjusted (such as modified power generation, load, network topology, etc), the system's power flow may not keep balance.

characteristics of distribution network reconfiguration, but each time optimization search is only part of the sub-space, lack of global optimization in the mathematical sense.

3) Artificial intelligence algorithms, including simulated annealing^[13], genetic algorithm^[14], tabu search (Tabu Search, TS)^[15], particle swarm optimization algorithm. These methods obtained the global optimal solution with very good results, but some methods were influenced by the network size, the initial solution and other factors, and increased the computing time. So improving the computational efficiency of the algorithm will have high utility.

In order to obtain the optimal solution and to shorten the calculation time, simulated annealing and genetic algorithms were respectively developed parallel simulated annealing algorithm^[16] and parallel genetic algorithm^[17], but because of its random algorithm, the efficiency of application of

the actual large-scale distribution network has not been improved significantly.

TS algorithm which is introduced into the tabu list can escape from local optimal solution and has a strong ability of global optimization, parallel tabu search algorithm (parallel TABU search, the PTS)^[18] has the following characteristics: 1) According to the partition ideological decomposition of the neighborhood; 2) multiple processors at the same time used to search, and set a variety of tabu length. PTS based on the idea of partition method, broke down the solution space into multiple sub-space, then search in parallel by multiple processors. Therefore, PTS can significantly improve the calculation efficiency; At the same time using several tabu list, which means that we adopt different tabu length, tabu length control search direction, so different tabu length can expand the search scope, help the search to obtain the global optimal solution.

The mathematical model of distribution network reconfiguration

Distribution network reconstruction which meets the constraints of the distribution network operation conditions, by changing the combination state of the switch, make a or a few goals are the best. This article is loss (PL) minimum as objective function:

$$\min P_L = \sum_{i=1}^{N_b} R_i (P_i^2 + Q_i^2) / U_i^2 \quad (1)$$

end of the branch.

Distribution network reconfiguration is required to meet the following constraints:

1) The distribution network load flow equations.

Distribution Network Reconfiguration must satisfy the flow equations, generally use the forward and backward substitution or rapid decomposition algorithm to calculate the distribution power flow.

2) Branch current constraints.

$$I_i < I_{i,\max}, \quad i = 1, 2, \dots, q \quad (2)$$

Where, n is the total number of system nodes; I_i is the current flow through the branch b_i ; $I_{i,\max}$ is the maximum current which is allowed to flow through the branch b_i .

3) Node voltage constraints

$$U_{i,\min} < U_i < U_{i,\max}, \quad i = 1, 2, \dots, q \quad (3)$$

Where, U_i is the node voltage; $U_{i,\min}, U_{i,\max}$ is respectively to allow the voltage lower and upper limits on node i .

4) Supply constraints.

Distribution network must meet the requirements of the load, meanwhile the network does not allow isolated nodes.

Example analysis

Based on the IEEE 69 nodes^[21] system as an example to verify the effectiveness of the method presented in this paper, the system has 73 lines, 5 contact switches, and the total load is 3 802.19 kW; 2 694.60 kvar, choose the current state of the network for initial condition.

The reconstruction results of the proposed algorithm, fuzzy genetic algorithm^[22], the immune algorithm^[23] and the family eugenics algorithm^[24] are shown in Table 2. Table 2 showed that the reconstruction loss of the proposed algorithm was lower than the other algorithms, the lowest node voltage was higher than the other methods, thus the proposed algorithm could guarantee the search for the global optimal solution.

Table 1. TABLE II. RESULTS OF COMPARISON OF SEVERAL ALGORITHMS

Algorithm	Network loss after reconstructed /kW	the lowest node voltage /pu
The proposed algorithm	99.15	0.973
Fuzzy genetic algorithm	100.81	0.933
Immune algorithm	101.10	0.931
Family eugenics algorithm	101.01	0.927

Conclusion

This paper, in order to reduce network losses of the distribution network reconstruction, proposed parallel tabu search algorithm. Partition thought would be disconnect the branch group as the solution space, each sub-space set different tabu list, expanded the scope of the search, multi-processors conducted parallel tabu search, parallel processing computing time was the $1/m$ of original, The combination of Partition thoughts and parallel computing reduced the computational time, improved the efficiency of reconstruction. This method in distribution network reconstruction would not produce infeasible solution, complexity was decreased, calculation efficiency was improved, and could search to the global optimal solution.

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