Optimization Method for Service Restoration in Sub-transmission Systems

Background

Sub-transmission systems are usually operated in a radial network configuration, but possess a kind of meshed structure that allows for several operating configurations. When a fault occurs, in order to restore as many loads as possible, the areas isolated by the fault should be supplied by adjacent networks through network switching operation. This procedure is called service restoration and the authors have already proposed an optimization method of network switching to minimize unserved energy. To apply the method to actual restoration procedure in sub-transmission systems, it is important to consider various operational restrictions, such as the restoration that ensures supply margin from adjacent networks beforehand.

Objectives

The objective of the research is to develop an optimization method that ensures supply margin from adjacent networks in the case of service restoration in sub-transmission systems.

Principal Results

1. Development of an optimization method for service restoration in sub-transmission systems

The authors have proposed an optimization method based on a genetic algorithm (GA) to minimize energy not supplied (ENS) during the restoration process. In the proposed method, an optimal service restoration can be obtained by integrating the following two search procedures and optimizing it repeatedly (Fig.1).

(1) Search for the final network configuration;
Radial network configurations are created by GA as the candidates for the final configuration. To find promising final radial configurations earlier, all the candidates for final configuration obtained by GA are applied with a local search procedure to minimize power not supplied (PNS) after completing restoration.

(2) Search for the sequence of switching operations;
To find the optimal sequence of switching operations that minimizes ENS for each final configuration created in (1), a greedy algorithm that sequentially selects the switching operation with the smallest PNS is used. Moreover, the algorithm excludes the switching operation that causes the overflow from possible operations in order to ensure supply margin from adjacent networks beforehand (Fig.2).

2. Verification of effectiveness of the proposed method

In order to verify the effectiveness of the proposed method, we conducted numerical experiments with a test sub-transmission system shown in Fig.2. As shown in Table 1, the results show that the proposed method can find the optimal sequence of switching operation for each fault case. From the result of the experiments, we confirmed that the proposed method can obtain practical switching operations, such as the restoration that ensures supply margin from adjacent networks beforehand.

Future Developments

To apply the proposed method to actual restoration procedure in sub-transmission systems, we will enhance the method to consider various operational restrictions.

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Reference

Isamu Watanabe, et al., 2006, “Optimal service restoration in sub-transmission systems with ensuring supply margin from adjacent networks”, CRIEPI Report R05023 (in Japanese)

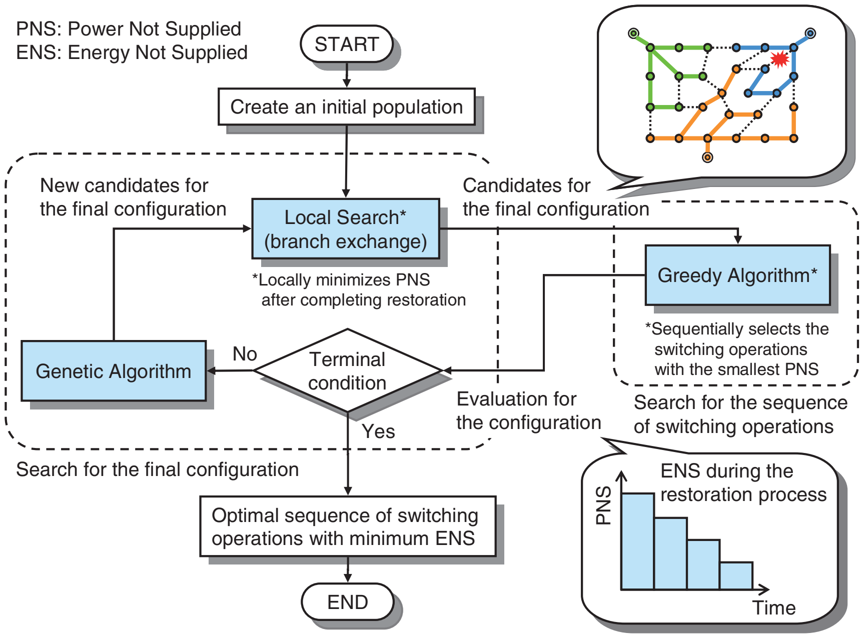

Fig.1 Optimization method for service restoration in sub-transmission systems

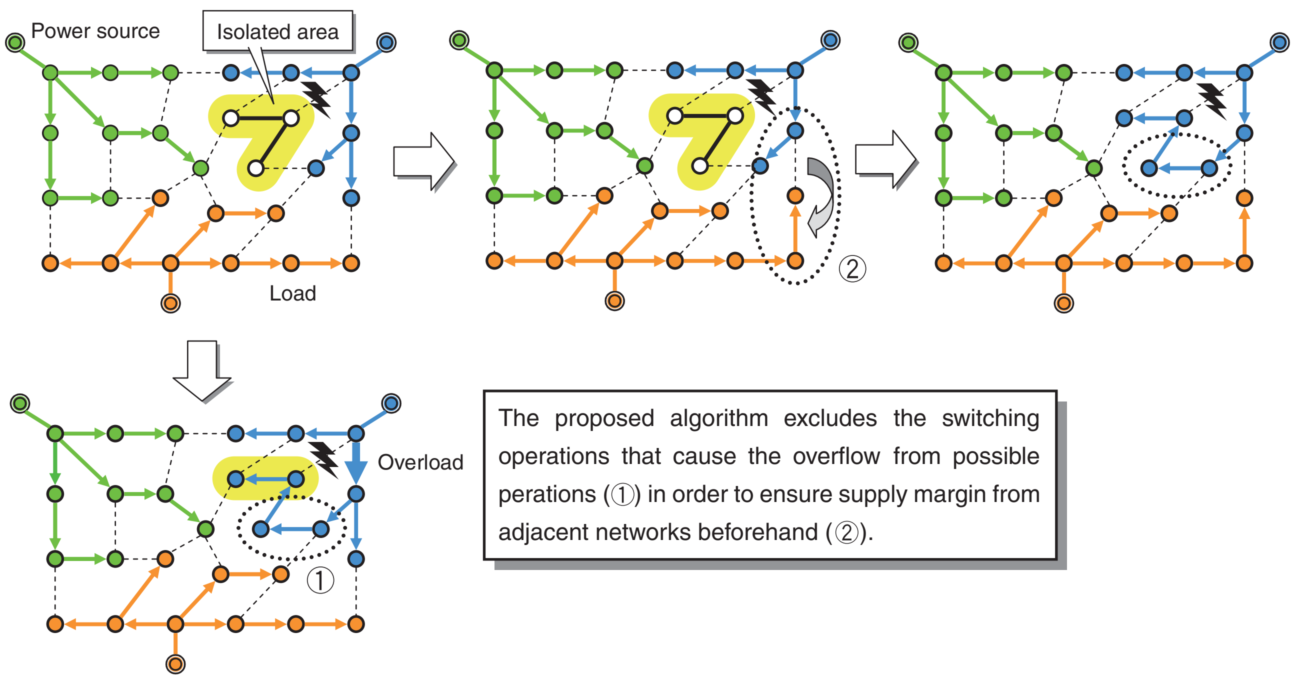

Fig.2 Sequence of switching operations with ensuring supply margin from adjacent networks

Table 1 Computational results with a test sub-transmission system (100 trials)

Fault Case	ENS (MW-min)		Computation Time (s)	Success (%)	Fault Case	ENS (MW-min)		Computation Time (s)	Success (%)
	Optimal	Mean*				Optimal	Mean*		
1	189	189.0	0.21	100	4	30	30.0	0.03	100
2	68	68.0	0.09	100	5	33	33.0	0.04	100
3	122	122.0	0.07	100	6	85	85.0	0.07	100

* The solution obtained by the genetic algorithm (GA) varies. Thus, we ran the algorithm 100 times.
** This table shows only six results of 22 fault cases.