SEARCHING OF RADIAL SUBNETWORK IN MESHED NETWORK BY MODIFIED DEPTH-FIRST SEARCH ALGORITHM

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ABSTRACT

The article deals with Modified Depth-First Search (MDFS) algorithm used for creating random radial subnetworks, with roots in the feeders, in the meshed network. The outputs are applied for calculation of initial group of GA and have to fulfill the given conditions. Its functionality is verified on an example of a simple power network.

1. INRODUCTION

Nowadays, the cheapest solution, how to improve the parameters of power network, is a reconfiguration. The elements or parts of the network are disconnected and reconnected by switching of switchgears in such way which leads to improve required parameters. These problems usually do not contain only one parameter but a lot, afterward the case becomes to be a multicriterial problem. The stochastic methods are easily able to solve these types of the problems and Genetic Algorithm (GA) is one of them. The initial group of solutions is required by all optimalization technique but random generation, which is usually used for this purpose, doesn't secure that all solutions will fulfill input conditions.

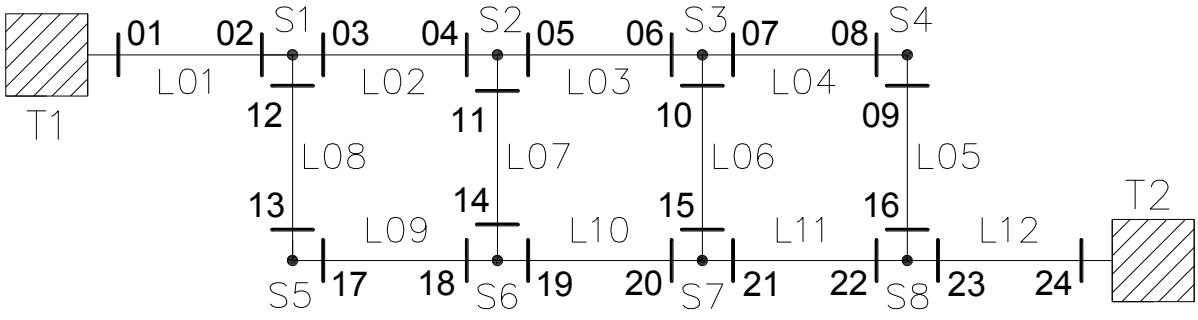

Figure 1 Scheme of network (T1 – substation, S1 – Switching station, L01 – Line, 01 -Switch)

This reconfiguration issue has several main conditions, are described in the following parts, which create the random generation of the initial solution as unsuitable. The random

generation could produce inanimateness solutions - solutions do not comply with base conditions. For small network, the quantity of non-allowed solution could not be significant but their quantity will increase with the size of the network. The large network could contain plenty useless solutions what could be problematic at next computation. Therefore in these cases, the better resolutions can be done when the appropriate function or procedure is used for the initial group generation.

2. CONDITIONS

The power network (**Figure 1**) can be described as no-oriented graph with vertices given by elements of network i.e. substations, switching stations, overhead line, and cables and so on, and switches are presented by edges (**Figure 2**). Usually for these types of problems the some of the greedy algorithm, Dijkstra, Prim-Jarnik or Boruvka algorithm, are used. The case conditions make the algorithms useless for this purpose.

The conditions are following:

- each element has to be energized – each element can be connected to consumer
- no element can be fed by more the one substation
- each subnetwork has to be fed by only one substation
- each subnetwork has to be radial – the most of distribution networks in the Czech republic is operated in this way
- the splitting of original meshed network should be unique for each generated solution

Where subnetwork means the part of network which is fed by the one substation and it is delimitated by the opened switches on the borders with other subnetworks.

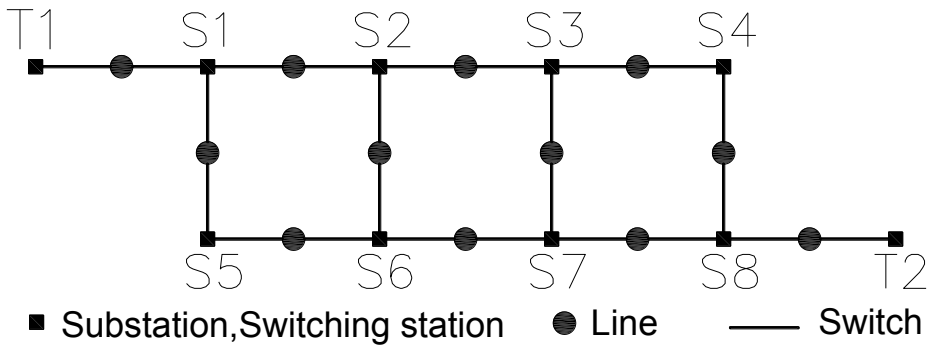

Figure 2 Graph of network

3. MODIFIED DEPTH-FIRST SEARCH ALGORITHM

Originally, Depth-first search (DFS) is an algorithm for traversing or searching a tree, tree structure, or graph. One starts at the root - at the feeder - and explores as far as possible along each branch before backtracking. DFS principle can be described following:

„Edges are exploited out of the most recently discovered vertex *v* that still has unexploited edges leaving it. When all of v's edges have been explored, the search "backtracks" to explore edges leaving the vertex from which *v* was discovered. This process continues until we have discovered all the vertices that are reachable from the origin source vertex. If any

undiscovered vertices remain, then one of them is selected as a new source and the search is repeated from that source. This entire process is repeated until all vertices are discovered“. [1]

Depth-first search algorithm had to be adapted to a current application. The modified algorithm uses same system of exploration as classical DFS but there are several changes. The first one is difference of number source vertices that is preset on the beginning. In the meshed network, source vertices are given by the outgoing feeder from substation. The graph exploration starts almost simultaneously from an each source vertex, compare to original DFS. The exploration is done by turns and one edge can be explored only from one source point in one turn. The edge exploration is not allowed automatically but with certain probability. The order of feeders is changed randomly. Every reached vertex is marked by number of feeder which was in touch. The condition specified that the vertex can be covered only if has not been reached by other source vertex. This is the third improvement of DFS. The last one is to connect with the choosing of edge or path. Original DFS chose the edge in the definite order but, in modified DFS, edge is chosen randomly.

		Label of switch																						
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Solution	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1
	2	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1
	3	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1
	4	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1
	5	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	0	1	1
	6	1	1	0	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	0	1	1
	7	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1
	8	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1
	9	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1	1
	10	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	1	1	1	1

Table 1: Generated initial solution

4. APPLICATION

The application was made in Matlab environment. The input data contains structure of network and information of elements type. At the beginning the vector of switch setup, the marking list of elements and marking matrix are created. The marking matrix has two columns which contain marks of elements before and behind switch where mark means number of feeder which feed this element. If element is without feeder the value is equal -1. On the start of computation the marking matrix is filled by -1 value only.

		Network element																						
		T1	L01	S1	L02	S2	L03	S3	L04	S4	L08	L07	L06	L05	S5	L09	S6	L10	S7	L11	S8	L12	T2
Solution	1	1	1	1	1	1	1	2	2	2	1	1	2	2	1	1	1	1	2	2	2	2	2
	2	1	1	1	1	1	2	2	2	2	1	1	2	2	1	1	1	2	2	2	2	2	2
	3	1	1	1	1	1	1	1	1	1	2	1	1	2	2	2	2	2	2	2	2	2	2
	4	1	1	1	1	1	2	2	2	2	1	1	2	2	1	1	1	1	2	2	2	2	2
	5	1	1	1	1	1	1	2	2	2	1	1	2	2	2	2	2	2	2	2	2	2	2
	6	1	1	1	2	2	2	2	2	2	1	2	1	2	1	1	1	1	1	1	2	2	2
	7	1	1	1	2	2	2	2	2	2	1	2	2	2	1	1	2	2	2	2	2	2	2
	8	1	1	1	1	2	2	2	2	2	1	2	2	2	1	1	2	2	2	2	2	2	2
	9	1	1	1	2	2	2	2	2	2	1	2	2	2	1	1	1	1	1	1	2	2	2
	10	1	1	1	2	2	2	2	2	2	1	1	2	2	1	1	1	1	2	2	2	2	2

Table 2: Generated solutions - the marking list of elements

The marking list is filled by the same way. As first step the feeders are found and the algorithm can start the first turn.

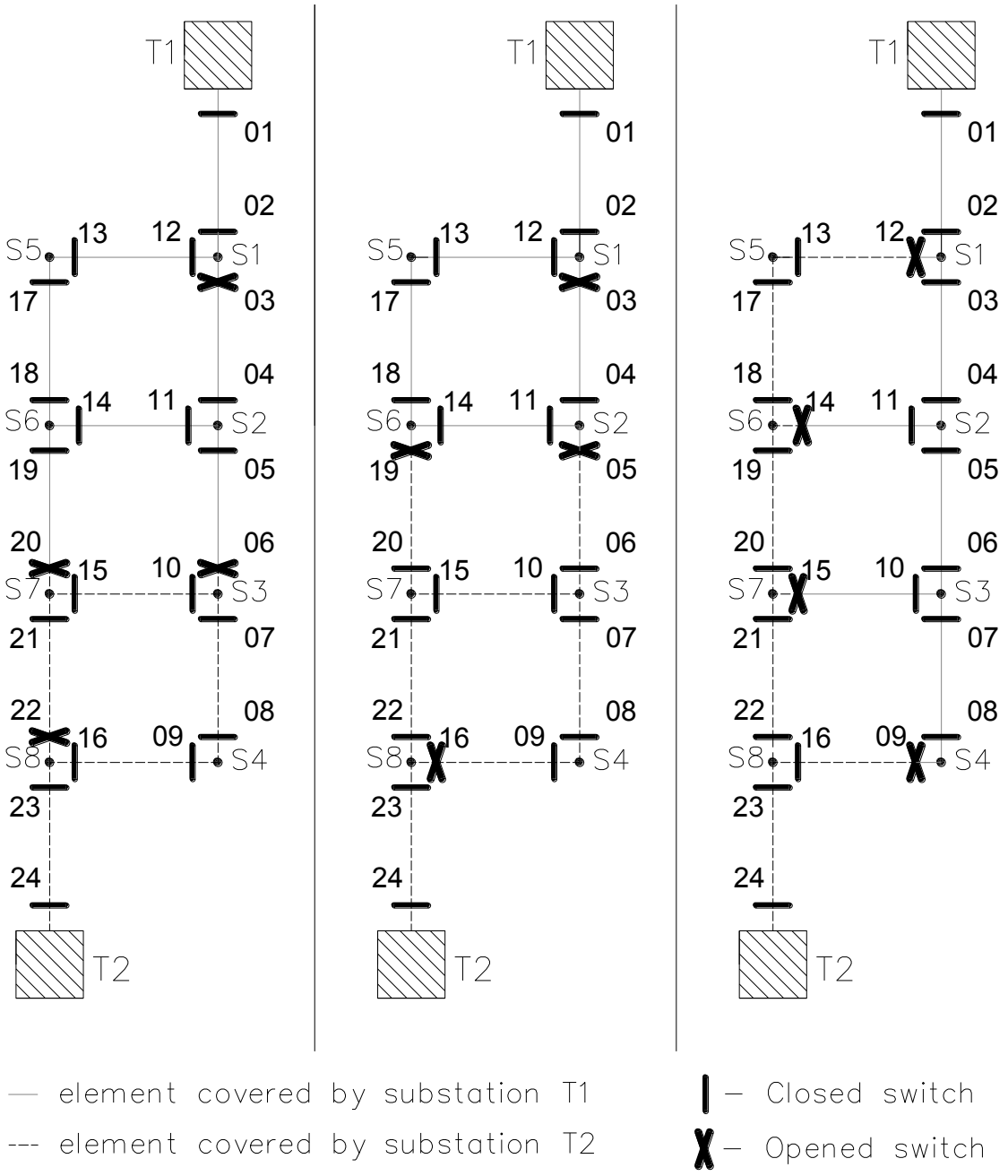

Figure 3 Generated solutions with radial subnetworks inside

The one feeder is randomly chosen and MDSF starts to explore surrounding edges (exclude the case when feeder skips the turn) and list of paths are got it. The edges that are connected to other feeders or to itself, are deleted from list of possible ways. The one path is randomly chosen, its switch is closed and element on the other side of switch is assigned to feeder in the marking matrix at all columns. The no-used edges are saved in variable which is connected with the feeder. The next steps are opening all switches where both side of them is marked but the switch is not open or close too. The opening of switches the one cycle is finished and next turn – next feeder - are starting to explore the surrounding

space. The all cycles end when no one feeder has any no-used edge or all switches are switched.

The algorithm creates such configuration of switchgears that leads to split the original network to radial parts. For each part the steady state and power losses are calculated. This information will be used for evaluation function of GA. There is no the risk that the black parts – parts without supply by any feeder – come into being as potential problem in the next calculations.

The purpose of MDSF was creating the function to production of the initial solutions of GA where splitting of the original network should be unique for each run of the algorithm. Each network contains the ultimate number of possible combination of the network splitting with the observed conditions. The small network doesn't give a high rate of combination nevertheless it can lead to create diverse initial group of solutions as can be seen on the example of simple network. **Table 1** (The list of switches) and **Table 2** (his marking element list) are showed 10 generated solutions by the algorithm and 3 of them are exhibited on the **Figure 3**. Each solution is unique, no one is repeated in the tables and all solutions are radial and fulfill given conditions.

5. CONCLUSION

The Modified Depth-First Search algorithm is used for creating random radial subnetworks in the meshed network with roots in the feeders. The outputs are applied for production initial group of GA. The solution generated by MDFS algorithm secure that it fulfill all given conditions compare to random generated solution which can lead to production plenty useless solution. Its functionality is shown on an example of a power network.

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