DIAGNOSTICS OF MALFUNCTIONS OF SUBSTATIONS ELEMENTS WITH REGARD TO UNCERTAIN INFORMATION

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Introduction. During the operation of the main components of the power system, situations arise when the definition of a problem is accompanied by the condition of information uncertainty. The general majority in most cases is an element of loss of communication or ambiguous data about an object. In general, this effect is observed in powerful substations, where the number of consumers is large enough to affect the operating modes of the neighbouring network. The mechanism of Petri nets (PN) [1] with nonnegative graphs is presented as a dynamic model. Expert system techniques can be considered to implement fault detection and restoration in TPTSs. In [2,3], a power system restoration method is developed by using an expert system and a mathematical programming approach. The target system for fault restoration is formulated as a mathematical programming problem. In these expert systems, their expert knowledge is optimized and updated with the information from continuous learning systems. However, the system information may also interfere after the fault occurrence. It may affect the performance and reliability of expert systems. The paper presents an approach to determining the places of asymmetry, taking into account the uncertainty of information and the search for solutions to reconfigure the object of study.

The purpose of the work. Description of the essence of the troubleshooting approach, taking into account uncertain information.

Materials and research results. For a complete presentation of the structure of troubleshooting through the Petri nets, the main circuit was taken with two powerful substations and one power source, which has a constant component of electricity production (Fig. 1):

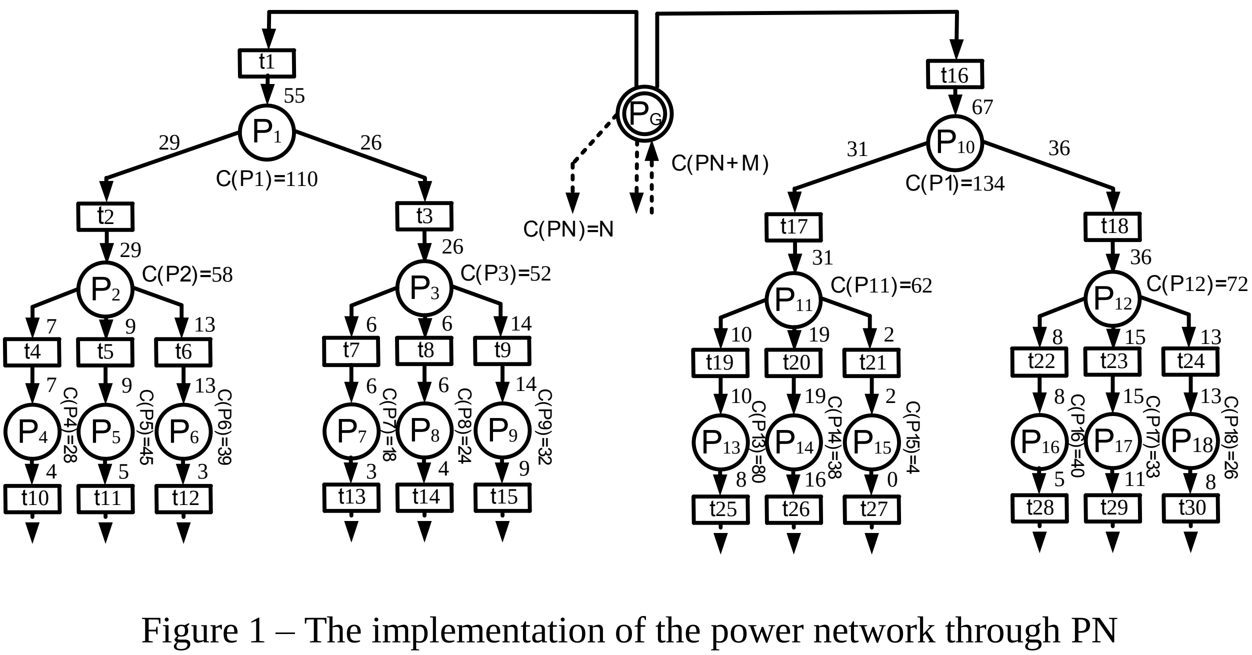

Figure 1 – The implementation of the power network through PN

The model consists of positions and transitions. The values of power flow and maximum power are shown as the start [4]. In the conditions of uncertain information, the check is carried out taking into account the conditions:

$$F_k^i = \bigcup_{t_i \epsilon p_k} \{(p_k^s, t_i)\} \; and \; F_k^j = \bigcup_{t_j \epsilon p_k} \{(t_j, p_k^s)\} \quad (1)$$

System diagnostics, taking into account certain limitations, is carried out by searching for an incorrect result or a complete failure [2]. In general, the solution to the problem of troubleshooting is reduced to the folding of PN and the evaluation of positions. For example, consider the situation with two feeders (p_4, p_{15}) and write down the decision systems for each:

$$\begin{aligned} M(p_4) &= C(p_4) - 7p_4^O = 28 - 7 * 4kW = 0kW < p_4^O \\ M(p_{15}) &= C(p_5) - 2p_{15}^O = 2 - 2 * 0kW = 2kW > p_{15}^O \end{aligned} \quad (2)$$

As you can see, the residual for the feeder 15 $(2kW > p_{15}^O)$ is greater than the input condition, so the scenario for this part of the system isn't correct and can be considered a malfunction. Tentatively, this might be due to transmission problems or improper operation of control systems or consumer protection. For this system, the condition of operation of each branch substation in normal mode should follow the condition[3]:

$$C(p_n) - M(p_n) \geq p_n^I + p_n^O \quad (3)$$

As a result, for each feeder we have such parameters (table 1):

Table 1 – The results of the analysis of operating modes

Position	$C(p_n)$	p_n^I	p_n^O	$M(p_n)$	Malfunction
4	28	7	4	0	–
5	45	9	5	0	–
6	39	13	3	0	–
7	18	6	3	0	–
8	24	6	4	0	–
9	32	14	9	-94	+ (overload)
13	80	10	8	0	–
14	38	19	16	-266	+ (overload)
15	4	2	0	2	+ (the loss)
16	40	8	5	0	–
17	33	15	11	-132	+ (overload)
18	26	13	8	-78	+ (overload)

As we can see, some connections have negative values, which means element overload or closure, which causes such a large difference in flow. Such phenomena can be effectively dealt with by redistributing power flows or by temporarily disconnecting the feeder in distorting emergency situations at a substation. In addition, there is a positive difference, which may be due to an element that has already been turned off or an increase in electrical losses [5,6]. The percentage failure characteristic is shown in Fig. 2:

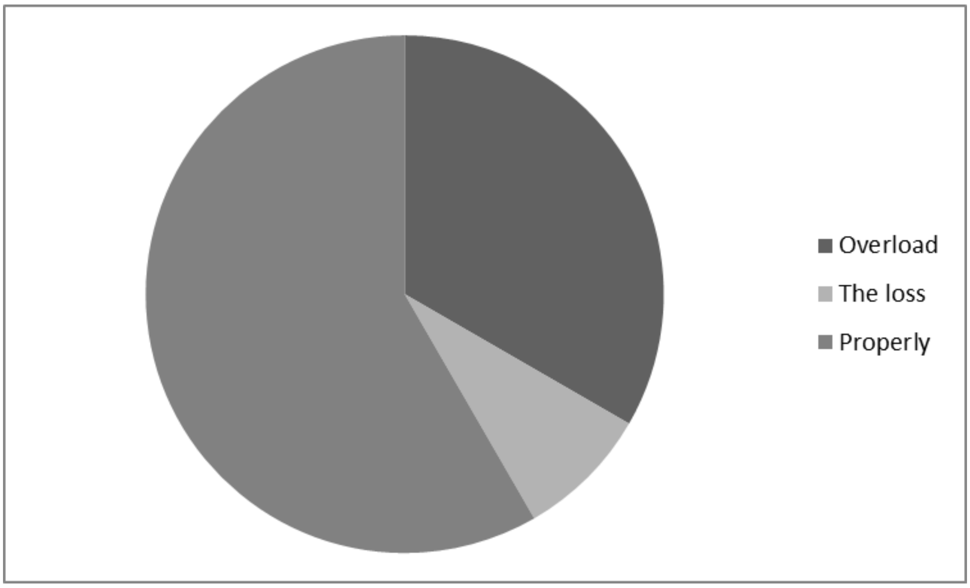

Figure 2 – Characteristic of the operating modes of the connections of two substations as a percentage

Conclusion. This approach makes it possible to find the exact cause of a malfunction at a substation in the conditions of a lack of accurate information. Thanks to the search algorithm, using Petri nets, it is possible to simulate an exact situation and determine the optimal solution for any kind of malfunction, for example, closures, a fall or an increase in the load on the feeder, and so on.

References

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