A Novel Algorithm to Find the Most Flexible Plan among Transmission Expansion Candidates

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1. Abstract

In this paper, a method to find the most flexible plan amongst transmission expansion candidates has been presented. The flexible plan is selected from the last generation of Genetic Algorithm (GA) based Transmission Expansion Planning (TEP) program. The flexible plan is a plan which can be converted to other suitable plan. In this paper, TEP is solved by GA. To determine the most flexible plan, 2 criteria, named *LE* and *DLN*, have been suggested. These criteria have been applied to the quasi optimal solutions of GA to determine the most flexible plan. Furthermore, another approach to generate the most flexible plan called "n+1 plan" is proposed, too. The results of TEP of Garver 6bus and Northern Brazil 87bus test systems show that *LE* criterion is suitable for large scale networks, but *DLN* is suitable for small ones.

Key words: Flexible plan, Transmission expansion planning, Uncertainty, Genetic Algorithm

2. Introduction

Several methods have been used in order to solve TEP problem. In general, these methods can be classified in two categories:

a) Mathematically Optimization and
b) Heuristic methods

One of the most serious problems that are concerned in the transmission expansion planning is uncertainty. Uncertainty means here the future evolution of relevant parameters which cannot be derived on the basis of past observation. In general, There are two methods to model the uncertainty in TEP problems. In the first group, the procedure of planning has following phases:

a) Uncertainty Modelling
b) Applying the optimization method (e.g. GA) to model
c) Presenting the final results

One of the most famous methods of this group is named scenarios method.
In second group, the procedure is as following:

a) Modelling (without uncertainty)
b) Applying the optimization method (e.g. GA) to model
c) Searching in the primary result considering the uncertainties

In this paper, The second approach has been used. This answer will be robust to the changes of designing parameters.

3. The proposed method

It is assumed that, GA is applied to TEP. Then, the last generation of program is known data. This generation is a set of best candidates among the acceptable solutions. In this step, the developed program finds a plan named "Flexible Plan", which has the highest similarity to other plans. The significant feature of this plan is its ability to be changed to any other plan, which satisfies network future conditions cost-effectively.
From the network planners point of view, the flexibility is the capability of the adaptation of the plan (generation and transmission system) to any unwanted problem which can happen during the construction [1]. The adaptation (changes) of the plan must be fast and with acceptable cost. It must be said that "Flexible Plan" is not the same as "Over-Planning".
In this method, each plan must be compared with others. The result of comparison of plan *i* with *j* is placed at the element (i,j) of similarity matrix. For example, if the result of comparison between plan 1 and plan 2 is 27, then the element (1,2) becomes 27.
The sum of all elements of row *i* (or column *j*) shows the degree of similarity of plan *i* to others. It must be mentioned that for the comparison of plans, many criteria can be suggested. In this paper, three criteria named as *LE* (Line Existence), *DLN* (Difference of Line Number) and "n+1 plan" are introduced and applied to the plans.

$$\begin{bmatrix} 0 & 27 & \mathbf{K} \\ 27 & 0 & \mathbf{K} \\ \mathbf{M} & \mathbf{M} & \mathbf{O} \end{bmatrix}$$

Fig.1: Similarity matrix

$$\begin{bmatrix} 0 & 2 & \mathbf{K} \\ 2 & 0 & \mathbf{K} \\ \mathbf{M} & \mathbf{M} & \mathbf{O} \end{bmatrix}$$

Fig-2: n+1 plan matrix

3-1 EL (Line Existence criterion) criterion
It is proposed that the *LE* criteria is equal to 1, if there is connection between bus *i* and *j*, otherwise it is equal to 0.

3-2 DLN (Difference of Line Number) criterion
In this section, the difference of line numbers in a power flow path of two plans has been proposed as a criterion named *DLN*. Finally, the sum of *DLN* of all paths shows the difference of two plans.

3-3 "n+1 plan" approach
In this method, the flexible plan is not chosen from the final results of GA. A new plan which is similar to other plans (as much as possible) is created in this approach. The start point of this approach is the last generation of GA. In this generation we have, say M solutions. The number of lines between bus *i* and *j* must be considered in all M solutions. If the *x* in the most repeated line numbers in this path, thus the element (*i,j*) of the matrix named "n+1 plan matrix" is equal to *x*. this matrix is shown in Fig-2. The all paths must be studied and this matrix must be completed.
At the end of this approach, the new plan, i.e. plan n+1, must be checked from electrical point if view.

4. Planning Results

In this article, to compare different criteria, proposed methods are applied to Garver 6bus and Northern Brazil 87bus systems.
The result in the case of Garver's 6bus system is presented in Fig-3.

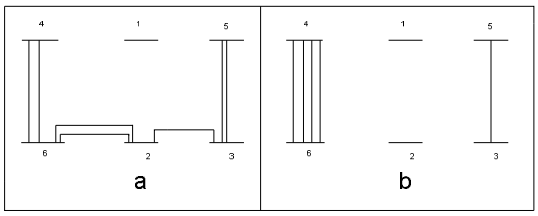

Fig-3: the results of Proposed Method
a- The most flexible expansion plan
b- Best expansion plan of genetic algorithm

5. Conclusion

In this paper, an approach has been presented to find the most flexible plans among TEP solutions. For small networks, the DLN criterion is a suitable criterion, while EL criterion is suitable for large scale networks, In other word, the result driven from DLN is more economical than the result of EL in case of small networks. It must be mentioned that, if the line construction projects are in series, i.e. one line should be constructed after finishing the other one, the "n+1 plan" approach is the best solution, Because in this case, the first line is a line which is common in most of plans. As a result, the planning should be started with this line, which is proposed by the "n+1 plan" approach. But if the line construction projects start in parallel, the output of EL criterion is suitable for small networks and the output of DLN criterion is suitable for large networks.

References

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