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COMPARISON BETWEEN TWO OF AUTOMATIC SCHEDULING METHODS FOR MAINTENANCE OUTAGES PLAN OF TRANSMISSION SYSTEM

Fowzi Yousef Al-Somali,

National Grid $_{SA}$, Kingdom of Saudi Arabia

Sabah M. Askar,

AMA International University Kingdom of Bahrain

ABSTRACT

The main objective of this paper is to compare between two models for automatic scheduling of outages tasks for maintenances. Tabu Search is used in first model and Genetic Algorithm in the second model. The methods used to reduce maintenance outages for electrical power system with high standard of reliability. The both methods solved the maintenance outages with taking in consideration two main problems. The first is power flow constraints and contingency studies constrains. The second problem is the number of the crews. The two methods for automatic scheduling of maintenance outage tasks are compared to each other. Both methods were used in 20-bus test system.

Key Words: Artificial Intelligent, Automatic Scheduling, Contingency Analysis, Maintenance Scheduling, Outages Plan, Optimization of Maintenance Schedules, Power Flow, Tabu Search, Genetic Algorithm, Transmission System.

Introduction

THE Modern industrialized societies depend on the availability of a reliable supply of electricity to sustain their functions and standards of living. These expansions made the electric power systems and their operations the most complex systems of today's civilization, due to the highly nonlinear and computationally difficult environment involved [1]. The planning and operation of these systems should therefore be as efficient, optimal as possible, with high reliability and with low costs. For these reasons, automatic scheduling method draws a lot of attentions.

Maintenance -scheduling optimization has been studied extensively in the open literature. Most of these studies and literature have been directly about or related to generation plants/units maintenance scheduling aiming to cut the fuel costs and obtaining good maintenance schedules. However, maintenance scheduling in transmission and distribution systems is occupying a small portion of the literature. This was the motivation to study this subject.

The objective of this paper is to compare two models of automatic scheduling of outages tasks for transmission and substation maintenance using Artificial Intelligent tool such as Tabu Search and Genetic Algorithm to find the optimal solution for maintenance schedules to minimize the period of doing maintenance activity with preventing any carry-over of work activity to next week. Tabu search and Genetic Algorithm are chosen because of its ability to cross the boundaries of feasibility or local optimality, which were usually treated as barriers [2].

There are two main problems to find optimal solution for maintenance schedules. First problem is the power flow and contingency analysis. The second problem is the number of crew or the number of work groups which responsible to execute the work [3]. The number of crew (qualified crew) is very important because some time there is conflict between two or more activities in some area not because the continuity of the power (power flow) but because the crews cannot do both or all activities in same time.

This paper is organized in five chapters. First chapter is introduction flowed by chapter two which addresses the method descriptions. The chapter three is discussion. The automatic scheduling outcomes are given in chapter four. Chapter five represents the conclusions.

Method descriptions

Each division or department has one or more planners or maintenance schedulers. They are doing maintenance schedules for all equipment which related to their areas or divisions [4], [5]. The schedules are prepared weekly and consist of the starting date of the outages and the end date of the outages which include the duration of the outages. Also, the schedules contain the equipment's names, equipment's numbers and the kind of work which will be carried out. In other words, the initial schedules which requested by the planners do not contain any power flow study or contingency analysis and these schedules are sent to power dispatch [6].

The power dispatch centers receive all schedules (initial schedules or requested schedules) from all divisions so that the power dispatch planners can study these schedules from power flow point of view and contingency analysis [7], [8]. The methods solved the maintenance outages with taking in consideration two main problems. The first is power flow constraints and contingency studies constrains. The second problem is the numbers of the crews which will be execute the work. The higher priority will be executed first and the activities with less priority will be moved to another days. If some of activities cannot be done because of the shortage of the qualified man power. In this case also, the higher priority will be executed first and the activities with less priorities will be moved to another days using Tabu Search method or Genetic Algorithm [9], [10].

The methods are well documented in the literature and no need to be reviewed in this paper.

The TS Method to MS Problem

Step1: Set the initial solution (supposed to be the best solution). Tabu list is empty since it was no created any step or move.

Step 2: Enumerate candidates (moves) which consists of the neighborhood of the current solution, exception of Tabu movement. These must be moves in the neighborhood of initial solution space.

Step 3: Go to the best candidate. Add a new move to list of Tabu moves and discard the oldest move from the list of Tabu list if the list of Tabu exceeds a specified length (Tabu size list).

Step 4: Repeat steps 2 and 3 until it is satisfied the termination conditions (stop criteria) [2], [11].

The GA Method to MS Problem

Sept 1: Create random population (individuals).

Step 2: Evaluate fitness of created population.

Step 3: Select chromosomes for reproduction based on fitness.

Step 4: improved population using crossover and mutation.

Step 5: Repeat steps 2 to 4 until reach the termination condition [11], [12].

Representation of the Problem

As stated above, a chromosome is a proposed schedule in which each gene represents the start date of a task (*xi*). This means that each chromosome (string of genes) represents a possible solution, with each sub-string (gene) representing the starting date of a task. The algorithm starts from an initial population generated randomly [2].

Discussion

The 20-Bus test system demonstrated in Fig 1. It contains the following:

1. Network: 115KV, 13.8KV network
2. Network elements: 20 buses, 36 lines, 8 transformers, 7 generators.
3. Contingency study of n-1, n-2 and n-3 were applied on all of 20-bus system.
4. One week scheduling (7 day): 2012.
5. Power flow will be checked at the demand peak and off-peak time daily.

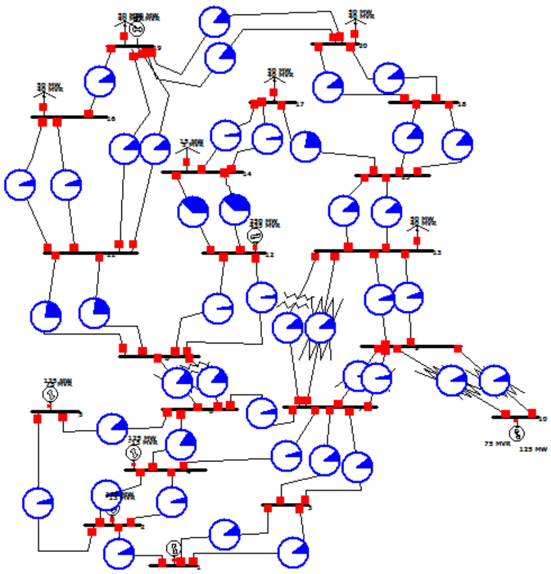

Fig. 1. Base case of the test System

Automatic scheduling outcomes

In the following, two Maintenance Schedule cases will be submitted and considered. These maintenance outage schedules were selected on the basis of possible outages of the system.

These conditions must be considered:

1. Every schedule has a maximum of six different maintenance tasks (regarded as high number of tasks for such a small system).

2. Initial configuration of the system does not have any overloaded branch.

3. Priority of maintenance outage task is given by maintenance schedulers in the initial requested schedule obtained from maintenance centers.

4. Branch outage priority relies on the sort of work involved. Priority begins at 1(highest) and ends on 6 (lowest).

5. The period of every outage is based on the work involved. The period of every outage is given by the initial requested maintenance schedule.

6. The needed manpower relies on the sort of work involved in the outage. In this work manpower is supposed to be available and enough to implement the work (no lack of manpower to prevent the extended of period of outage).

7. The start date is the starting dated of implementing the maintenance outage work. This is so important, since, it is used to determine the period of the outage.

8. Scheduling duration (T) is suggested t to be one week- seven (7) days as an example.

9. Resources (spare parts) are supposed to be available without any delay to prevent the extended of period of outage.

10. The maintenance period provided to any equipment is enough to accomplish the maintenance work.

In every following MS case, there are two schedules. The first of which represents the initial maintenance outage schedule required by local maintenance center and it points out the following:

1. The suggested starting date of each task (by maintenance units and center dispatch).
2. The priority of each task.

The second schedule is the last product of the program after running TS or GA and it points out the following:

1. The start date of every task (after violations is resolved).
2. The priority of each task.

Some of cases will be addressed to explain the methods under flowing conditions:

1. The program or the algorithm will find solution to the problem (over load or number of crew) when it occur. This means that if there is no problem in the initial schedule (requested schedule) the program will not do any change even thought this schedule is not optimal solution. In other words, this developed method finds optimal solution to the problem when it occurs.

2. The relationship between the (TS & GA) and algorithm are solutions so that it goes from one candidate solution to another one.

Maintenance scheduling for case 1 using TS:

The proposed maintenance schedule for case 1, given in table I is considered as the initial requested schedule by local maintenance centers. It has ten (10) maintenance outage tasks. The schedule proposes to maintain line 1 on Wednesday, line 2 on Friday, line 4 on Tuesday, line 5 on Friday, line 6 on Tuesday, Wednesday and Thursday, line 7 on Monday, line 8 on Saturday and Sunday, line 9 on Saturday, Sunday and Monday and line 10 on Tuesday. The program will generate the base configuration of the system. Also, it will save the given schedule as "the initial requested schedule" and will check for both constraints (overload and number of crews). Table I Shows that the schedule at Tuesday has overload between tasks 4 and 7, since, taking out line 4 and 7 at same time will generate overload on the system. First step to solve the overload by moving of starting dates. Task no. 4 has higher priority than task no. 7 so that task no.7 will move to resolve the overload problem. The program will search for optimal move between neighbor solutions. The solution (optimal solution) is given in table II.

TABLE I

INITIAL SCHEDULE OF CASE 1

Tasks	Priority	Sat	Sun	Mon	Tue	Wed	Thu	Fri
1	3					Line 1		
2	2							Line 5
3	1							
4	4				Line 4			
5	5							Line 2
6	6					Line 6		
7	7				Line 7			
8	8	Line 8						
9	9	Line 9						
10	10				Line 10			

TABLE II

FINAL SCHEULE OF CASE 1

Tasks	Priority	Sat	Sun	Mon	Tue	Wed	Thu	Fri

1	3	Line 1
2	2	Line 5
3	1	
4	4	Line 4
5	5	Line 2
6	6	Line 6
7	7	Line 7
8	8	Line 8
9	9 10	Line 9
10		Line 10

Maintenance Scheduling Case No. 2 using GA:

The proposed maintenance schedule for case no. 2 is given in Table III. It is considered as the initial requested schedule by local maintenance centers. It has ten (10) maintenance tasks. The program will generate the base configuration of the system, based on the system input data, to make sure that the base configuration has no overloaded branch or facility. The GA program will first generate the initial population, which represents possible solutions (schedules) to the problem. Then the individuals will be evaluated according to the fitness function and so on in order to reach to the final solution, which is given in Table IV.

TABLE III

INITIAL SCHEDULE OF CASE 2

Tasks	Priority	Sat	Sun	Mon	Tue	Wed	Thu	Fri
1	3					Line 1		
2	2							Line 5
3	1							
4	4				Line 4			
5	5							Line 2
6	6				Line 6			
7	7			Line 7				
8	8	Line 8						
9	9	Line 9						
10	10				Line 10			

TABLE IV

FINAL SCHEULE OF CASE 2

Tasks	Priority	Sat	Sun	Mon	Tue	Wed	Thu	Fri

1	3	Line 1
2	2	Line 5
3	1	
4	4	Line 4
5	5	Line2
6	6	Line 6
7	7	Line 7
8	8	Line 8
9	9	Line 9
10	10	Line 10

Comparison between the Tabu Search and Genetic Algorithms:

The results obtained both from the application of the TS or GA as given in previously shows that these tools are practical for the MS problem. The results obtained by TS were faster and better than the GA .This is due to the fact that the GA starts from an initial random solution which slows the convergence. The GA depends largely on the initialization, which controls the performance of the program and the final solution. Also, the GA will need more time to evaluate the fitness function for every individual in the population. Table V shows the date deviations between the requested and the obtained schedules [2], [13].

TABLE V

FINAL SCHEULE OF CASE 2

MS Case	**TS**	**GA**
MS Case # 1	1	9
MS Case # 2	1	6
MS Case # 3	1	5
MS Case # 4	0	3
MS Case # 5	2	3
MS Case # 6	3	7

Conclusion

The developed scheduling methods were applied to 20-Bus test system and from the results, it shows the following:

1. The results obtained by TS were faster and better than the GA.
2. It is confirmed that the methods are useful and practical as scheduling tools.
3. The works progress is maximized in the scheduling period while minimized the carry-over work to the next scheduling period.
4. The deviation of date work (starting of the work) which could be requested from local maintenance centers is minimized.
5. The results have been obtained in low execution times.
6. It shows a good performance for functions having small number of variables.
7. Easy to implement.

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BIOGRAPHIES

Fowzi Al-Somalia was born in Saudi Arabia, on December 20, 1981. He received the B.Eng. degree in electrical engineering from the KFUPM, Dhahran, in 2005 and the M.Sc. degree in engineering science from the Gulf University, Bahrain, in 2012. He is currently a senior transmission engineer in National Grid$_{SA.}$

Sabah Mansour Askar Al-Jubouri was born in Mosul, Iraq; in1956.He received his BSc, MSc, and PhD in Electrical Engineering from Mosul University, Mosul, Iraq in 1978, 1995 and 2006, respectively. In 1980 he joined the State Organization of Electricity as electrical engineer, manager of Mosul power station, chief of research and development department in North Region and Expert Engineer of power system up to 2006. Faculty Member of Alhadbaa University College, Mosul, Iraq at 2007. Faculty Member of Shinas College of Technology at Sultanate of Oman (2008- 2009). He was Assistant professor of Electrical power engineering and Dean of College of Computer Engineering and Sciences at Gulf University, Kingdom of Bahrain(2010-2015).Recently, He is Assistant Professor of Electrical Engineering at AMA International University-Bahrain. His research interests include power system operation and control and power system management and Economics.