Reliability Modeling and Evaluation of Electrical Power Generation using Genetic Algorithm

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ABSTRACT: *Reliability modeling for electrical power Generation is important tasks which can be evaluated using genetic algorithm [1].The genetic algorithm approach have significant advantages over the conventional methods [2]. Electrical Power generation modeling is essential to predict available capacity of the plant. Capacity outage probability table is one of the Techniques to evaluate the generating station availability, unavailability and generation level for different mode of failure of units [4]. Conventional approaches use a considerable mathematical modeling of the generating units. This process requires a huge time and it includes least occurrence states also, which may not occur in practically. This paper proposes a Genetic Algorithm (GA) technique to obtain   the COPT (Capacity Outage Probability Table) with most occurrence states of a generating system. The proposed technique gave an effective approach to construct COPT for the generation model.*

1. INTRODUCTION

Electrical power Generating capacity modeling is an important aspect of power system planning [5]. In order to meet the load demand with required level of reserve capacity and to maintain a desired reliability, generation model is highly preferable. The generation model can be evaluated using a capacity .outage probability table which includes the down or up state of units with their corresponding probabilities. The COPT has been evaluated using different approaches these approaches can be divided into two main types conventional and Genetic algorithm approach. Conventional approach certainly it includes all states which may not occurs practically, so to avoid computation time to evaluate the COPT , Genetic algorithm approach is used it give the most occurrence state and its corresponding Capacities and Probabilities[6].

In GA approach the process starts with a random population of strings of ones and zeros. This is similar to selection of the players in team. Some basic operations are to be performed to find the new generation, then it goes through a number of iterations in which the population at the beginning each iteration is replaced by another population. The population produced at each step is called a generation. The chromosomes of each new generation are produced by the reproduction process. Reproduction of the new generation involves three operations applied to the current generation [6-9]. These operations are selection, crossover and mutation. This paper presents the implementation of the GA as a technique to evaluate the most effective capacity states for the COPT.

2. CONVENTIONAL METHODOLOGY

In conventional approach all occurrence states have been considered. The most important information required for generation model for reliability analysis are the capacity and the failure probabilities of individual generating units. For a simple two state model, its failure probability is given by its unavailability U, which can be expressed in terms of the unit failure rate λ and repair rate μ

$$U=\frac{\lambda}{\lambda+\mu}\text{------------------- (2)}$$

Where, λ = unit failure rate,μ = unit repair rate. U = unit unavailability
Unit unavailability is also known as FOR(Forced outage rate)
For n unit generation system total no of units=2^n
C_i=i^{ts} state available capacity.----------------(3)
$C1_i$=ith state unavailable capacity------------(4)
.P_i=ith state probability---------------------------(5)
Above 1,2 ,3 and 4 equations are used to calculate the availability, Unavailability capacity and its probability. In conventional approach all 2^n state values are evaluated.

3 GA METHODOLGOY

The GA is used to obtain occurrence of the different states of generating station to develop the generation model. The GA approach evaluates the system states represented as a string of ones and zeros. Cumulative probability is taken as a fitness function for construction of COPT. For a system with n generating units which can be either "up state" or "down state", the total number of system states is 2^n. The cumulative arability i.e sum occurrence of all states probabilities is equal to 1.0. If all the states are considered, cumulative probability is exactly equal to 1. However, for practical systems, all the states may not occur. The states which may not occur have least probability of occurrence. There is no impact of such states on the evaluation of reliability generation model. For each sample total availability capacity and outage capacity and corresponding probability of occurrence are evaluated which are mentioned in COPT table. Procedure for GA approach is explained with the help of flow chart, it starts with e initial population. This procedure first evaluates the first generation states and corresponding capacity values and probability of occurrences.

The following flow chart illustrate the procedure
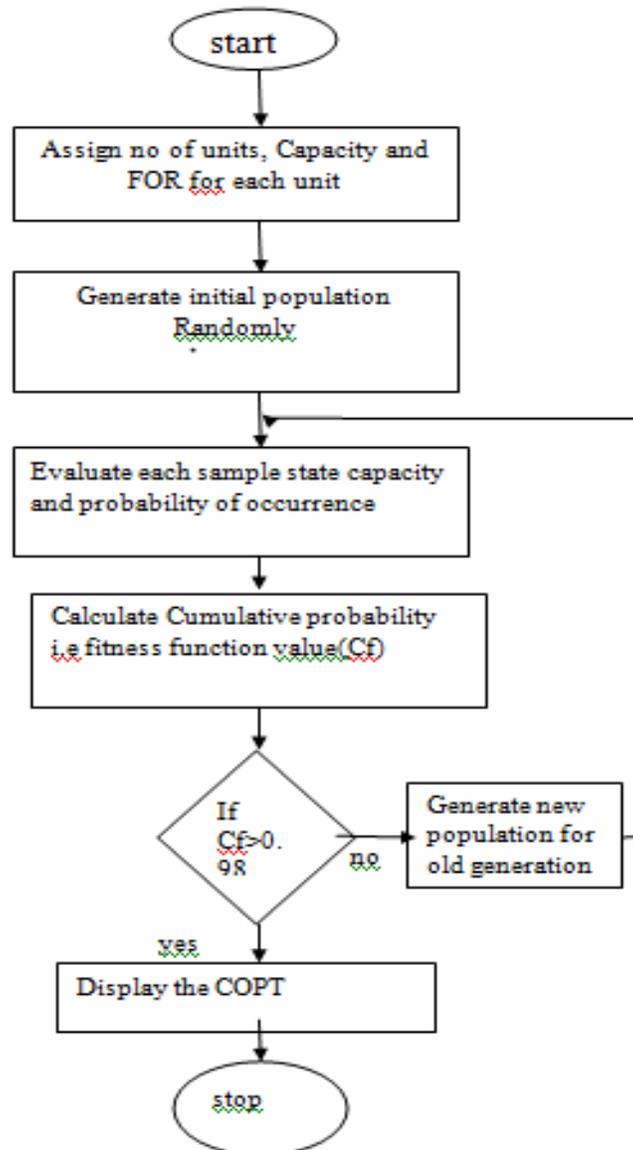
To implement conventional and GA approach a test system is to be considered with source generating units. For generation model load data is not required, for the assessment of loss of load expectation (LOLE), Loss of load probability (LOLP) load is essential..

4.CASE STUDY
Table 1:Test system

Unit NO	Capj (MW)	FORj
Unit 1	25	0.02
Unit 2	50	0.04
Unit 3	75	0.01
Unit 4	100	0.03

The total number of states N=24=16
Since this system is very small then all of the states will be recovered by In GA search a population size of 8 is considered,
Which is initial population generated randomly shown in table 2

Table 2. Initial population for the test system

S.No	Unit-1	Unit-2	Unit-3	Unit-4
1	1	1	1	1
2	1	1	0	1
3	0	1	1	1
4	0	1	1	0
5	0	1	0	1
6	0	1	0	0
7	0	0	1	1
8	0	0	1	0

.
Table 3:Initial population and its state probabilities

Unit-1	Unit-2	Unit-3	Unit-4	Capacity Availability	Occurrence of Probability
1	1	1	1	250.00	0.00
1	1	0	1	175.00	75.00
0	1	1	1	225.00	25.00
0	1	1	0	125.00	125.00
0	1	0	1	150.00	100.00
0	1	0	0	50.00	200.00
0	0	1	1	175.00	75.00
0	0	1	0	75.00	175.00

Table 4: Second generation population for the test system

S.No	Unit-1	Unit-2	Unit-3	Unit-4
1	1	1	1	1
2	1	1	0	1
3	0	1	1	1
4	0	1	1	0
5	0	1	0	1
6	0	1	0	0
7	0	0	1	1
8	0	0	0	0

Table 5. COPT Table after second generation.

Unit-1	Unit-2	Unit-3	Unit-4	Capacity Availability	Occurrence Of probability
1	1	1	1	250.00	0.00
1	1	0	1	175.00	75.00
0	1	1	1	225.00	25.00
0	1	1	0	125.00	125.00
0	1	0	1	150.00	100.00
0	1	0	0	50.00	200.00
0	0	1	1	175.00	75.00
0	0	1	0	75.00	175.00
0	0	0	0	0.00	0.00000024

similar procedure is applied to obtain the complete system states with fitness value is equal to 1 or least occurrence states can be eliminated by reducing fineness values(Cumulative probability).

Table 6.Complete COPT Table without combining similar states

S.No	U-1	U-2	U-3	U-4	Available Capacity	Unavailable Capacity	Probability
1	1	1	1	1	250.0	0.00	0.9034
2	1	1	1	0	150.0	100.00	0.0279
3	1	1	0	1	175.0	75.00	0.00536
4	1	1	0	0	75.00	175.00	0.00028224
5	1	0	1	1	200.0	50.00	0.03764
6	1	0	1	0	100.0	150.00	0.001164
7	1	0	0	1	125.0	125.00	0.00038
8	1	0	0	0	25.00	225.00	0.00001176
9	0	1	1	1	225.0	25.00	0.01843
10	0	1	1	0	125.0	125.00	0.0005702
11	0	1	0	1	150.0	100.00	0.000186
12	0	1	0	0	50.00	200.00	0.000576
13	0	0	1	1	175.0	75.00	0.000768
14	0	0	1	0	75.00	175.00	0.00002376
15	0	0	0	1	100.0	150.00	0.00000776
16	0	0	0	0	0.00	250.00	0.00000024

Table 7.Complete COPT Table with combining similar states

S.No	Available Capacity	Unavailable Capacity	Probability
1	250	0	0.9034
2	225	25	0.01843
3	200	50	0.03764
4	175	75	0.000306
5	150	100	0.028086

6	125	125	0.0009502
7	75	175	0.000306
8	50	200	0.000576
9	25	225	0.00001176
10	0	250	0.00000024
Cumulative Probability			0.98923

5.CONCLUSION

Generation system reliability is an important aspect of planning for the future expansion of capacity to main the future demand with reliable power. In this paper a generation system reliability model and calculation was done with GA approach.

6.FUTURE SCOPE OF WORK

The presented work can be extended in following area, Evaluation of LOLP, LOLE and other reliability indices. Security analysis of generation system. Modes of failure of units. Reliability of system with Tie line connection.

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