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Solution Of Unit Commitment Problem Both In Traditional And Deregulated Environment

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1.Abstract

This project applies modified GA to the UC problem and illustrates details of the performance of Genetic Algorithm. The aim of this work is to propose the suitability of a new approach to the solution of the UC problem in both traditional and deregulated environments. In this approach, the GA maintains a population of highly fit chromosomes or strings and probabilistically modifies the population seeking a near optimal solution to the given task. A program is developed in MATLAB 6.1 for the proposed method for solving the UC problem. MATLAB 6.1 is a high-performance language for technical computing [32]. The name MATLAB stands for matrix laboratory. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

2. Introduction

The optimal fuel expense in power system generation is one of the prime research fields as fuel expenses constitute a significant part of the overall generation cost. Finding optimality in respect of fuel cost requires exhaustive search as a number of thermal units are generally involved having different characteristics and different types of fuels with distinct production cost .The scheduling problem in a power system involves the start-up and shut-down schedules of the generating units to be used to meet forecasted demand over a future short term (24-168 hours) period. The objective is to minimize the total production cost while observing a large set of operational constraints.

The resultant schedule should minimize the operating cost during the study period, while satisfying the forecasted load demands and various constraints of the system and the individual units. Mathematically the UC problem is defined as a non-linear, large-scale, mixed-integer combinatorial optimization problem, involving thousands of 0-1 as well as continuous decision variables, and a wide spectrum of equality and inequality constraints. The exact solution of such a combinatorial optimization problem can be obtained only by complete enumeration such as in the dynamic programming or integer programming methods. However these methods are impractical in terms of computational time and memory size of computers, when the system involves more units or long study periods. Various approaches, such as priority listing, modification of dynamic programming and expert systems have thus been employed to solve the UC problem. These methods suffer from the problems of sub-optimal solutions.

3. Profit Based Unit Commitment

In the deregulated environment the generation companies (GENCOs), Transmission companies (TRANSCOs) and Distribution companies (DISCOs) interact via contracts. The contract prices are determined through auction. Electricity traders make bids and offers that are matched subject to the approval of an ISO who ensures that the system is operating safely within limits. These bidding strategies might be designed to limit the traders' risk, to maximize profit, or some combination of both.

Strategies for selling power and reserve

In a restructured system, GENCO sells power in energy market and sells reserve in the reserve (ancillary) market. The amount of power and reserve sold depends on the way reserve payments are made. Given below are two examples of reserve payment method [23].

Payment for Power Delivered

In this method, reserve is paid only when reserve is actually used. Therefore, the reserve price is higher than the power (spot) price, Revenue and costs in can be calculated from

$$RV = \sum_{i=1}^{N}\sum_{t=1}^{T}\left(P_{it} \cdot SP_t\right) \cdot X_{it} + \sum_{i=1}^{N}\sum_{t=1}^{T} r \cdot RP_t \cdot R_{it} \cdot X_{it}$$

$$TC = (1-r)\sum_{i=1}^{N}\sum_{t=1}^{T} F\left(P_{it}\right) \cdot X_{it} + r\sum_{i=1}^{N}\sum_{t=1}^{T} F\left(P_{it} + R_{it}\right) \cdot X_{it} + ST \cdot X_{it}$$

Where,

SP_t forecasted spot price at hour t;

RP_t forecasted reserve price at hour t;

F_i fuel cost of generator i;

ST start-up cost

R probability that reserve is called and generated.

Payment for Reserve Allocated

In this method GENCO receives the reserve price per unit of the reserve for every time period that the reserve is allocated and not used. When reserve is used, GENCO receives the spot price for the reserve that is generated. In this method, reserve price is much lower than the spot price. Revenue and costs in (11) can be calculated from

$$RV = \sum_{i=1}^{N}\sum_{t=1}^{T}\left(P_{it} \cdot SP_t\right) \cdot X_{it} + \sum_{i=1}^{N}\sum_{t=1}^{T}(1-r)RP_t + r \cdot SP_t)R_{it} \cdot X_{it}$$

$$TC = (1-r)\sum_{i=1}^{N}\sum_{t=1}^{T} F\left(P_{it}\right) \cdot X_{it} + r\sum_{i=1}^{N}\sum_{t=1}^{T} F\left(P_{it} + R_{it}\right) \cdot X_{it} + ST \cdot X_{it}$$

In this work results are simulated for method A only i.e., payment for power delivered.

4. Solution methodology to the uc problem

Genetic algorithm is a multiple point probabilistic search technique and is characterized by the mechanism of natural selection and natural genetics. Genetic Algorithm consists of three basic operators, namely, reproduction, crossover, and mutation. The search is started from a randomly selected population of points. A genetic string called chromosome represents each of the points. The length of a genetic algorithm string is measured by a genetic string called its *fitness value*. Based on the fitness values of the population strings, two parent strings are selected probabilistically in the process of reproduction. Two child strings are then generated from the parent string by using the mechanism of crossover, where one half of the first parent string is combined with the other half of the second parent. Mutation is then applied on the child string by complementing the child string at selected bit positions, thus introducing variety in the child population. The algorithm consists of the following steps:

Generate a population of solution strings:

Set generation count=0;

Repeat, {while the number of generation$\neq$ maximum generation

Set m=0;

Repeat, {while m$\neq$ number of population/2

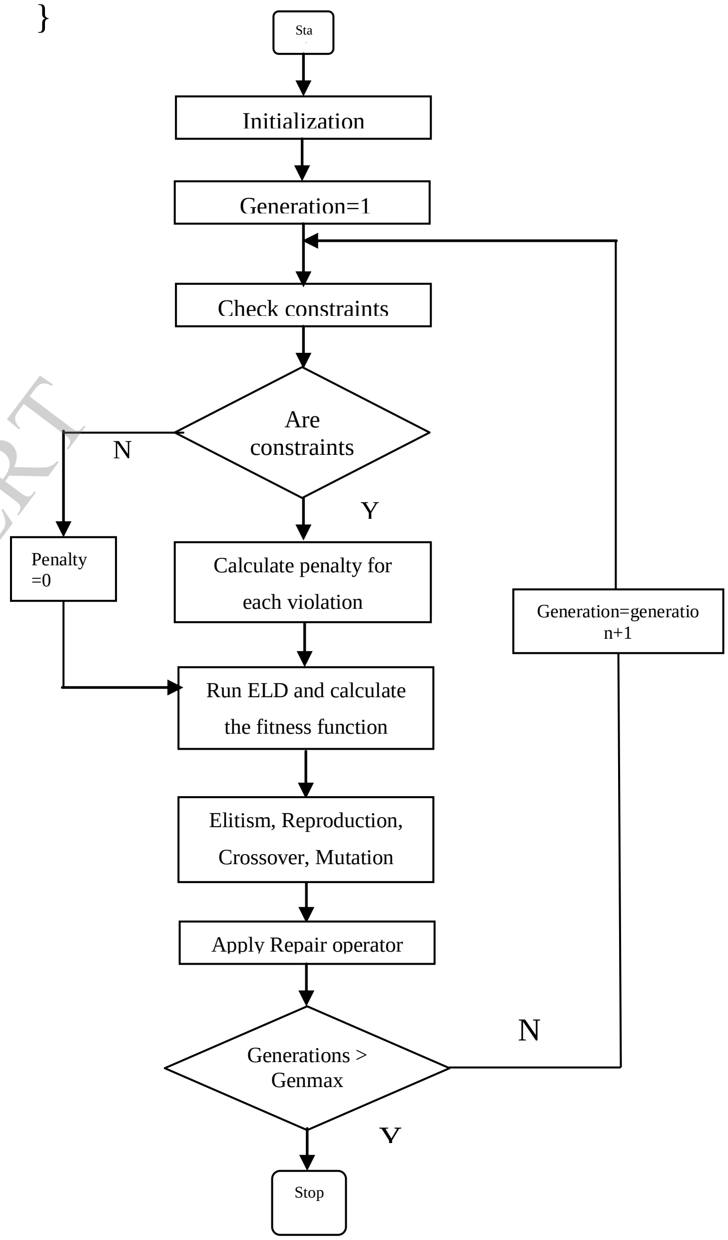
Repeat, {select two parent strings;

Generate two child strings using crossover and mutation ;}

M=m+1}

Generation count = generation count+1;

}



5. Results and Discussions

Simulations for the proposed method are carried out on a computer with following specifications:

Pentium-4 Processor, 1.8GHz

The test system is taken from [lr-ep] consisting of 3 coal-fired units and Table 5.1 shows the ranges of the unit data, minimum up time, minimum down time, start-up cost, and initial status of the units. The total installed capacity is 1200 MW. The system hourly mean load varies between 170 MW to 1100 MW. Table 5.2 gives the forecasted demand, reserve and spot prices for 3 units, 12 period system. Simulation results are shown in Table 5.3 for method A (payment for power delivered as explained in section 3.2). Here, the reserve price is fixed at triple times the spot price and the probability with which the reserve is being called and generated 'r' is taken as 0.005.From table 5.3, it can be seen that GENCO chooses to off unit 1 in all scheduling periods and to sell power and reserve below the forecasted level in some periods. It is because without regard that all demand and reserve have been met or not, running only two units (units numbers two and three in this case), provides higher profits than running all units as shown in Figs. 5.2 and 5.3

Table 5.1: Data for generating units (3 unit, 12 hr system)

	Unit 1	Unit 2	Unit 3
P^{max} (MW)	600	400	200
P^{min} (MW)	100	100	50
A($/h)	500	300	100
B($/MWh)	10	8	6
C($/MWh)	0.002	0.0025	0.005
t_{up} (h)	3	3	3
$t_{(down)}$ (h)	3	3	3
S_t($)(Start-Up)	450	400	300
Initial state (h)	-3	-3	-3

Table 5.2: Forecasted demand,reserve and spot prices(3 unit,12 hr system)

Hour	1	2	3	4	5	6	7	8	9	11	12
Demand(MW)	170	250	400	520	700	1050	1100	800	650	400	550
Reserve(MW)	20	25	40	55	70	95	100	80	65	40	55
Spot Price($/MWh)	10.55	10.35	9.00	9.45	10.00	11.25	11.30	10.65	10.35	10.75	10.60

Table 5.3: Solution for profit based UC, r=0.005

Power(MW)			Reserve(MW)			Profit($)
Unit 1	Unit 2	Unit 3	Unit 1	Unit 2	Unit 3	
0	0	170	0	0	20	531.4
0	0	200	0	0	0	570.0
0	0	200	0	0	0	300.0
0	0	200	0	0	0	390.0
0	385	200	0	15	0	210.0
0	400	200	0	0	0	1350.0
0	400	200	0	0	0	1380.0
0	400	200	0	0	0	990.0
0	400	200	0	0	0	810.0
0	129.99	200	0	35	0	818.1
0	199.99	200	0	40	0	804.6
0	349.99	200	0	50	0	929.2
Total						9173.3

The results given in Table 5.3 show that the profit obtained by the proposed GA method is higher when compared to other methods [23].

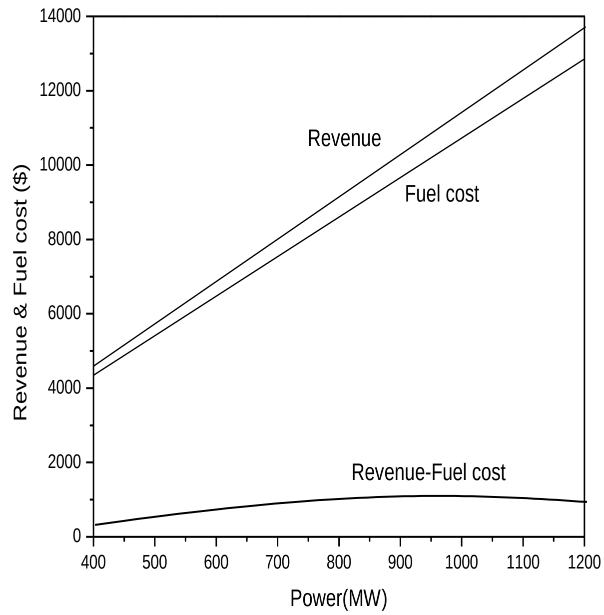


Fig. 5.2 Revenue and Fuel cost at hour-seven when all units are on

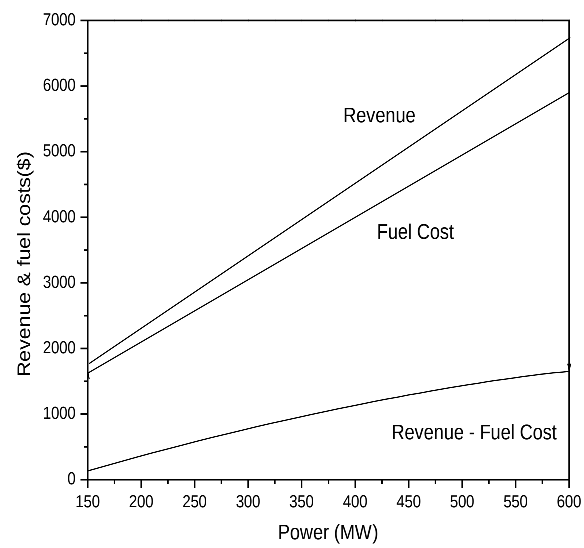


Fig. 5.3 Revenue and Fuel cost at hour seven when only units two and three are on

Figs. 5.2 and 5.3 shows the revenue received from power selling and total fuel cost at seventh hour when three units and two units are on respectively. According to Fig 5.2, the maximum profit (revenue-cost) can be received when power is served between 850 to 950 MW. In profit-based UC, GENCO can now select to sell power and reserve below the forecasted level if it gives higher profit. Fig. 5.3 shows that by running two units and selling power at 600 MW, GENCO can get maximum profit.

The marginal cost for the first hour (Third unit generating 170 MW) is 7.7$/MWh. The MinPrice calculated as per eq. 3.22 for first hour is 7.4382$/MWh. Since MinPrice is less than the marginal cost (explained in section 3.2), the bid will be placed at marginal cost i.e. 7.7$/MWh.

6.Conclusion

The Unit commitment problem in the competitive environment has been solved by using the modified Genetic Algorithm. This helps the GENCO to decide how much power it should sell. The solution of the new UC problem by modified GA has given better results when compared to other methods. As the main objective of GENCO is to maximize profit, the proposed method effectively helps the GENCO to select the most profitable schedule of generating units.

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