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INTELLIGENT TECHNIQUES FOR SOLVING UNIT COMMITMENT PROBLEM – A REVIEW

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ABSTRACT

Unit Commitment is one of the challenging tasks in the operation of power systems for scheduling the units over a scheduled time horizon. The objective is to determine the on/off status of thermal generating units and its power generation. Several methods have been proposed to solve the UC Problem. These include mathematical and non-mathematical approaches. The limitations with the mathematical approach are that they suffer from the dimensionality problem. Computationally intelligent algorithms are able to handle these complex non-linear optimization problem producing high quality of solution. In this paper various intelligent methods are analyzed to solve the unit commitment problem.

Index Terms— Optimization, Unit Commitment, Simulated Annealing, Genetic Algorithm, PSO, Tabu Search

I. INTRODUCTION

UNIT COMMITMENT is a complex decision making process which involves the determination of on/off status of generating units over a scheduled time horizon[1].The overall problem can be divided into two sub problems namely Economic Dispatch and Unit Commitment. The objective is to satisfy the power balance constraints at minimum operating cost. The exact solution to the UC problem can be obtained by complete enumeration which is quite time consuming. Therefore several solution methods have been proposed to solve the unit commitment problem. This includes deterministic and stochastic approaches. Deterministic approaches include priority list method[2], dynamic programming [3],[4] Lagrangian relaxation[5], Bender's Decomposition methods[6]. Priority list method is simple and very fast but they are highly heuristic and give schedules with relatively high production costs. In dynamic programming, it is relatively easy to add constraints that affect the power balance constraints since these constraints mainly affect the economic dispatch. Dynamic Programming is very accurate but suffers from the curse of dimenionality because the problem grows rapidly as the number of generating units increases. Hence, it is required to limit the commitments considered at any hour through some simplification techniques such as truncation and fixed priority ordering. Obviously this leads to the sub-optimal solution. Lagrangian Relaxation method is more flexible in dealing with constraints. A lagrangian multiplier is defined for each constraint for each time period and the constraints are adjoined into the objective function of the relaxed problem. Major weakness of the method is the dual optimal solution which never satisfies the once relaxed coupling constraints. However, the degree of suboptimality decreases as the number of units increases. This simplification, particularly for large scale systems, can lead to suboptimal schedules. Bender's Decomposition the UC problem is decomposed into Master problem involving only the discrete commitment variables and a subproblem involving the continuous generation variables. The master problem and the economic dispatch subproblem are solved iteratively until the solution converges. The major difficulty in Benders decomposition approach is the determination of the solution of the master problem, which is still regarded as a large scale integer optimization problem. The drawback is its inability to handle the inequality constraints. Although the deterministic approaches are fast and simple yet they suffer from numerical convergence resulting in suboptimal solution. This is overcome by the stochastic search algorithms such as Artificial Neural Networks, Genetic Algorithm, Simulated Annealing, Particle Swarm Optimization , and Tabu Search . This paper summarizes the various stochastic methods used in the UC problem-solving technique.

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I. UNIT COMMITMENT PROBLEM FORMULATION

The objective of the UC problem is to minimize the total production cost over a scheduled time period. The total cost includes the fuel cost, start-up and shut-down cost. Fuel cost is calculated based on the unit heat rate and start-up costs are expressed as the function of number of hours the unit has been down. Shut-down cost are fixed for the units. The constraints that need to be satisfied are power balance constraints, reserve constraint, unit initial status, unit minimum and maximum limit, minimum up time and minimum down time, unit status restrictions, unit ramp limits and crew constraints. Equality constraint and reserve constraint are the coupling constraints which need to be satisfied for the system optimization.

II. STOCHASTIC METHODS - REVIEW

A) ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks imitate the behavior of the biological network of neurons. The original hope for the development of ANNs is intended to take advantage of par- allel processors computing than traditional serial computation. Over the years, several models of ANNs and the learning algo- rithms that are associated with networks have been developed [7],[8]. The sigmoid characteristics of the Artificial Neural Networks can handle both equality and inequality constraints. Hopfield neural network (HNN) [9] can handle the stochastic nature of UCP. If the solution with ANN is not feasible then it is used as an initial point for the near optimal solution . Sasaki et al [10] scrutinized the possibility of solving optimization problems, in particular in UC by applying the Hopfield NN. With an intelligent system such as ANN, the available scheduling information regarding a generating system can be stored and retrieved as part of the new solution process. With artificial neural network computing, the majority of time is spend on off-line training the network as ANN accumulates knowledge during off-line training from the given input/pattern data pairs. Once the network is completely trained, the on-line operation would involve a chain of simple arithmetic operations for which the processing time is very short as compared with analytical programming techniques.

B) GENETIC ALGORITHM

A genetic algorithm is a global search technique based on principles inspired from the genetic and evolution mechanisms observed in natural systems and populations of living beings i.e. natural selection, mutation, and recombination [11]. GAs differ than other conventional optimization techniques in many ways. They use the objective function itself and not the gradient; they search from a population of strings and not single point; and they work with a coding of the parameter set, not with the parameter themselves. Because of these reasons, and others, GAs are considered as an attractive alternative optimization technique. The GA is a simple algorithm that starts with random generation of a population. A population consists of a set of strings. Usually, the string size ranges between 50 and 1,000. The population may be of any size according to the accuracy required. The population size remains constant throughout the whole process. Each string in GAs may be divided into a number of sub-strings. The number of sub-strings, usually, equal s to the number of the problem variables. The problem variables are coded using suitable coding system. In this study binary coding system is used. In addition to coding and fitness evaluation, the simple GA comprises another three basic operations: reproduction, crossover and mutation. Each string of the old population goes through these three steps before a new population is generated. For the application of GAs to the unit commitment problem a simple binary alphabet was chosen to encode a solution. If N represents the number of units and H the scheduling period in hours, then with the assumption that at every hour a certain unit can be either ON or OFF, an H-bit string is needed to describe the operation schedule of a single unit. In such a string, a '1' at a certain location indicates that the unit is ON at this particular hour while a '0' indicates that the unit is OFF. The main feature of the GA approach for solving the UC problem [13]-[15] is the continuous encoded string chromosome, consisting of 24 state variables (one for each hour of the 24h time horizon) for N thermal power units. Each variable considered represents the number of power generating units to be committed at hour t of the 24h time horizon, according to the list of strict priority order.

During the search process, constraints are being observed in following order: minimum up time and down time and output limits and ramp-rate limits respectively. If any of the proposed variables does not meet the given constraints, a penalty factor is being added to corresponding value of the performance function, making the solution candidate extremely unfavorable, thus reducing the probability of that individual's contribution to new generation solutions. An evaluation of the fitness function takes place during the process of economic dispatch problem decision making, and is performed over a set of operating units proposed by the GA[16]. The whole procedure is being repeated in a number of loops, where the algorithm is always given a new initial chromosome, if that solution is better then the one obtained before. The main advantages of this approach are low computational time and storage requirements.

C) SIMULATED ANNEALING

Simulated Annealing technique was proposed by Kirkpatrick, Gelatt and Vecchi in 1983 [17]. It takes the advantage of analogy between the minimization of a cost function and gradually cooling a metal until it reaches its freezing point, where the energy of the system acquires a

global minimum [18] The algorithm proposed by Metopolis et al [19], [20] are based on the iterative procedure, which simulates the transition of atoms in equilibrium at a given temperature. Simopoulos et al proposed SA algorithm combined with a dynamic economic dispatch for the solution of the UC problem with ramp rate constraints. Based on the solution schedule provided by the SA algorithm, the inclusion of ramp rate is achieved with the modification of limits either by a backward or a forward sequence of conventional economic dispatch. The application of SA for unit commitment was reported by Zhuang and Galiana in 1990 [21]. They have compared the SA algorithm with Lagrangian relaxation and iterative improvement algorithms and have shown that SA is easily adaptable to problems with complicated constraints.

D) PARTICLE SWARM OPTIMISATION

Particle swarm optimization (PSO) was first proposed by Kennedy and Eberhart [22] in 1995. PSO is a population based searching algorithm. This approach simulates the simplified social system such as fish schooling and birds flocking. PSO is initialized by a population of potential solutions called particles. Each particle flies in the search space with a certain velocity. The particle's flight is influenced by cognitive and social information attained during its exploration. It has very few tunable parameters and the evolutionary process is very simple. It has been successfully applied to solve nonlinear, combinatorial, multimodal and multi-objective problems. It is capable of providing quality solutions to many complex power system problems. In ref [23]binary coded PSO algorithm using tanh function is proposed to solve the UCP and the real-coded PSO algorithm is used to solve the EDP. From [23] Because of the intrinsic nature of updates of positions and velocities it generates better solutions. The second reason is the introduction of tanh function in UCP increase the probability of flipping the status of the binary variable thereby improving the performance of the binary PSO and determines the optimal status.

E) TABU SEARCH

Tabu Search (TS) is a powerful optimization procedure that has been successfully applied to a number of combinatorial optimization problems [24]-[27]. It has the ability to avoid entrapment in local minima by employing a flexible memory system. In [28] a simple TS algorithm based on short-term memory has been proposed for solving the UCP. TS is used to solve the combinatorial optimization, and the nonlinear optimization is solved via a quadratic programming routine . The algorithm contains three major steps generating randomly feasible trail solutions, calculating the objective function of the given solution by solving the EDP and applying the TS procedures to accept or reject the solution in hand. Long-term hydroscheduling and UC problems are solved very efficiently using tabu search algorithms.

III. CONCLUSION

Stochastic approaches have been extensively applied to unit commitment problem and a plenty of research publications in this research area have come. In this paper, an attempt has been made to identify a detailed survey of the application of intelligent techniques in the field of unit commitment problem. The inference from the survey is that the combination of different intelligent techniques produce the best optimal solution in solving the unit commitment problem. In order to be feasible, the method to be developed must be flexible, efficient and reliable.

REFERENCES

[1] A.J. Wood and B.F. Wollenberg, Power Generation Operation and Control, 1984, John Wiley, New York.

[2] S.K. Tong, Shahidehpour, Z. Ouyang, A heuristic short term unit commitment, IEEE Trans Power Apparatus Syst. 6 (August) (1991) 1210–1216.

[3] R.E.Bellman, "Dynamic Programming" book. Princeton, New Jersey, Princeton University Press, 1957

[4] W.L.Snyder, H.D.Powel and J.C.Rayburn,"Dynamic Programming Approach to Unit Commitment", *IEEE Transactions on Power Systems*, Vol 2, No.2, 1987, pp 339-350.

[5] A.Merlin and P.Sandrin, " A new method for unit commitment at electricite de France,"IEEE Trans. Power Apparatus Syst. Vol PAS-102, pp.1218-1225, May 1983

[6] Cong Liu ; Shahidehpour, M. ; Lei Wu, "Extended Benders Decomposition for Two-Stage SCUC," IEEE Transactions on Power Systems,Vol 25, pp:1192-1194, 2010

[7] H. Sasaki, M. Watanabe, J. Kubokawa, N. Yorina, and R. Yokoyama, "A solution method of unit commitment by artificial neural network," in Proc. IEEE Power Eng. Soc. Summer Meeting, 1991.
[8] H. Sasaki, M. Watanabe, and R. Yokoyama, "A solution method of unit commitment by artificial neural networks," IEEE Trans. Power Syst., vol. 7, pp. 974–981, Aug. 1992.
[9]] M. P. Walsh and M. J. O. Malley, "Augmented Hopfield network for unit commitment and economic dispatch," IEEE Trans. Power Syst., vol. 12, pp. 1765–1774, Nov. 1997.
[10] V. B. A. Kasangaki, H. M. Sendaula, and S. K. Biswas, "Stochastic Hopfield artificial neural network for electric power production costing." IEEE Transactions on Power Systems, 1995, 10(3), 1525- 1533.
[11] Lawrence Davis, Handbook of Genetic Algorithms, International Thomson Computer Press, London
[12] Grzegorz Dudek, "Unit commitment by genetic algorithm with specialized search operators." Electric Power Systems Research, Volume 72, Issue 3, 15 December 2004, Pages 299-308.
[13] S.A.Kazarlis, A.G.Bakirtzis, V.Petridis," A Genetic Algorithm Solution to the Unit Commitment Problem", *IEEE Transactions on Power Systems*, Vol 11, No.1, pp 83-92, Feb 1996
[14] K.S.Swarup, S.Yamashiro,"Unit Commitment Solution Methodology Using Genetic Algorithm", *IEEE Transactions on Power Systems*, Vol 17, No.1, Feb 2002
[15]] A. H. Mantawy, Youssef L. Abdel-Magid, Shokri Z. Selim, "A new genetic-based tabu search algorithm for unit commitment Problem", Electric Power Systems Research, Volume 49, Issue 2, 1 March 1999, Pages 71-78.
[16] V. Petridis and S. Kazarlis "Varying Quality Function in Genetic Algorithms and the Cutting Problem" to be published in the WCCI-94 (Evolutionary. Computation) Proceedings.
[17] S. Kirkpatrick, C. D. Gelatt, Jr., and M. P. Vecchi, "Optimization by simulated annealing," Science, vol. 220, pp. 671-680, May 1983
[29] No. 1, January 1998, pp. 56-64
[18] P. J. M. Van Laarhoven and E. H. L. Aarts, "Simulated Annealing: Theory and Applications." The Netherlands: Kluwer Academic Publishers, 1987, p. 185
[19] N. Metropolis, A. W. Rosenbluth, M. N. Rosenbluth, A. H. Teller, and E. Teller, "Equations of state calculations by fast computing machines," Journal of Chemical Physics, vol. 21, pp. 1087-1092, June 1953
[20] D. Simopoulos, S. Kavatza, "Consideration of Ramp Rate Constraints in Unit Commitment Using Simulated Annealing", Power Tech, 2005 IEEE Russia27-30 June 2005 Page(s):1 – 7.
[21] F. Zhuang and F. D. Galiana, "Toward a more rigorous and practical unit commitment by Lagrangian Relaxation," IEEE Trans. Power Syst., vol. 3, pp. 763–773, May 1988.
[22] J. Kennedy and R. C. Eberhart, "Particle swarm optimization," in Proc. IEEE Int. Conf. Neural Networks (ICNN'95), Perth, Australia, 1995, vol. IV, pp. 1942–1948.
[23] Binary/Real Coded Particle Swarm Optimization for Unit Commitment Problem K.Chandrasekaran, Sishaj P Simon, IEEE conference proceedings,
[24] B. Awadh, N. Sepehri, and 0. Hawaleshka, " A Computer-Aided Process Planning Model Based on Genetic Algorithms", Computer Ops. Res,, Vol. 22, No. 8, 1995, pp. 841-856. & 12315.
[25] F. Glover, " A User's Guide to Tabu Search ", Annals of Oper. Reas. 41(1993) 3-28 [25]F. Glover, "Artificial Intelligence, Heuristic Frameworks and Tabu Search", Managerial and Decision Economics, Vol. 11,365-375 (1990).
[26] F. Glover , H. J. Greenberg, " New Approach for Heuristic Search: A Bilateral Linkage with Artificial Intelligence", European Journal of Operational Research 39 (1989) 119-130.
[27] F. Glover, "Future Paths for Integer Programming and Links to Artificial Intelligence", Comput. & Ops. Res. Vol. 13, NO. 5, pp. 533-549, 1986.
[28] A. H. Mantawy, Youssef L. Abdel-Magid, and Shokri Z. Selim, "Unit Commitment by Tabu Search ", IEE proceedings -Generation, Transmission and Distribution, Vol. 145,