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ScienceDirect

Energy Procedia 117 (2017) 493–500

Energy Procedia

www.elsevier.com/locate/procedia

1st International Conference on Power Engineering, Computing and CONtrol, PECCON-2017, 2-4 March 2017, VIT University, Chennai Campus

Implementation of Genetic Algorithm Based Additive and Divisive Clustering Techniques for Unit Commitment

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Abstract

Saving of Fuel Cost can be done through proper commitment of available generating units. This paper presents a novel technique to solve the problem of unit commitment through sorting of units into different clusters based on Genetic Algorithm (GA). This sorting is implemented in order to decrease the overall operating cost and to assure the various constraints that involve minimum up/down. The technique of unit commitment is a significant assignment in the normal working of power systems which can actually be represented as a large scale minimization problem that involves non linear mixed integers. A new technique employing the concept of cluster algorithm called as additive and divisive hierarchical clustering has been used based on the technique of Genetic Algorithm. Proposed methodology involves two individual algorithms. Additive cluster algorithm has been employed while the load is increasing while divisive cluster algorithm has been used when the load is decreasing. The technique that has been developed has been tested on system with generating units in range of 10 to 100 and the superior performance of the technique has been reported through simulation results.

Peer-review under responsibility of the scientific committee of the 1st International Conference on Power Engineering, Computing and CONtrol.

Keywords: Unit commitment; additive clustering ; divisive clustering ; Genetic Algorithm

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Peer-review under responsibility of the scientific committee of the 1st International Conference on Power Engineering, Computing and CONtrol.
10.1016/j.egypro.2017.05.175

1. Introduction

The technique of Unit Commitment (UC) involves the calculation of levels of generation pertaining to generating units and their commitment for a certain interval of time in order to reduce the operational cost. It is actually a significant issue with very good impact on the economics. The generalized problem of UC is well known in the electric industry and definitely has the ability to save huge money each year with respect to costs of fuel and other expenses. Generally the problem of UC is a process that involves making complex decisions and it is tough to design optimization techniques that are capable of solving the system in real time. The various multiple constraints also need to be considered while determining the correct commitment schedule [1].

The most talked deterministic mathematical programming techniques include: Branch-and-Bound[2], Dynamic Programming[5,6], Priority List [3,4], Lagrange Relaxation [7-9], and Mixed- Integer methods[10]. Generally all these mathematical techniques are quite fast and are much simple to be implemented but most of them suffer from the problem of numerical convergence and have the following limitations [1]: (i) They do not guarantee the convergence to optimum point globally for non convex problems such as UC. (ii)The results also are inconsistent due to the various approximations considered while solving the constraints and objective functions which are non linear. (iii) The difficulty in reaching the solution due to the consideration of various constraints.

Therefore, research interest has been focused on heuristic search methods based on Artificial Intelligent techniques. Intelligent methods have come to be popular tool for solving many optimization problems. Recent contributions in the area of intelligent methods for UC problem include application of Expert Systems like Neural Networks , Fuzzy Logic , and Tabu Search , Basic Genetic Algorithm approach and Extended Priority List (EPL) method based on GA[11-14]. These methods seem to be promising and are still evolving. It can be observed that, the optimization problems with large number of constraints are quite difficult by solving neural networks and fuzzy logic approaches. Though the approaches have yielded attractive results, the linguistic descriptions for generating static crisp output under large number of time dependent constraints in UC may make the approaches highly complex and may even confusing. The GA approach similar to Tabu search, iteratively evaluates the best solution each time the neighborhood is updated. The method has good capability only for suboptimal search.

The novel technique of employing Genetic algorithm along with cluster algorithms has been demonstrated in this work. This technique employs both additive and Divisive algorithms. The method that has been proposed can be viewed in 3 stages. In the first stage, 4 groups are formed which are named as clusters namely base load, intermittent load, semi peak load and peak load. The generating units of the system are divided into the corresponding groups based on their various operating costs. The operating costs are obtained by GA. Based on the operating costs of units, clusters are formed and also useful for calculating the priority list. In the next stage, the solution of UC is obtained by developing Additive Cluster algorithm for increasing load pattern. Finally in the third stage a Divisive Cluster algorithm is developed for decreasing load pattern.

The paper presented is organized as follows: Section 2 deals with the formulation of the problem. The concept of Genetic Algorithm based cluster technique is explained in Section 3. The new method using clustered based GA has been explained in Section 4. Simulation results and discussions are carried out in Section 5 and some conclusions are drawn in Section 6.

Nomenclature

Based on the concept of minimization of the cost-objective function in the unit commitment problem, certain units are stated to be as 'ON' and remaining as 'OFF'. The following are the various notations considered during the implementation of the problem

N :Quantity of generating units in the system

T :Time for which the system is running in hours (h);

i :Count of Unit (i = 1,2,….., N);

t :Count of time (t = 1,2,….., T);

$I_i(t)$:status of i^{th} unit at t^{th} hour (is considered as 1, if the Unit is ON; or 0, if the unit is OFF) ;

$P_i(t)$: Power Generation of i^{th} unit at t^{th} hour;

$P_i^{\max}, P_i^{\min}$: Values corresponding to Maximum / Minimum power output (MW) of i^{th} unit;