Chapter 12

Unit Commitment by Evolving Ant Colony Optimization

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ABSTRACT

Ant Colony Optimization is more suitable for combinatorial optimization problems. ACO is successfully applied to the traveling salesman problem, and multistage decision making of ACO has an edge over other conventional methods. In this paper, the authors propose the Evolving Ant Colony Optimization (EACO) method for solving unit commitment (UC) problem. The EACO employs Genetic Algorithm (GA) for finding optimal set of ACO parameters, while ACO solves the UC problem. Problem formulation takes into consideration the minimum up and down time constraints, start up cost, spinning reserve, and generation limit constraints. The feasibility of the proposed approach is demonstrated on the systems with number of generating units in the range of 10 to 60. The test results are encouraging and compared with those obtained by other methods.

INTRODUCTION

The task of unit commitment (UC) involves scheduling of the generating units for minimizing the overall cost of the power generation over the scheduled time horizon while satisfying a set of system constraints. UC problem is a nonlinear, combinatorial optimization problem. The global optimal solution can be obtained by complete enumeration, which is not applicable to large power systems due to its excessive computational time requirements (Wood & Wollenberg, 1996). So far many methods have been developed for solving the UC problem such as priority list methods (Burns & Gibson, 1975; Sheble, 1990), integer programming (Dillon, Edwin, Kochs, & Taud, 1978; Garver, 1963), dynamic programming (DP) (Lowery, 1983; Ouyang & Shahidepour, 1991;
Snyder, Powel, & Rayburn, 1987), branch-and-bound methods (Cohen & Yoshimura, 1983), mixed-integer programming (Muckstadt & Wilson, 1986). These methods have only been applied to small UC problems and have required major assumptions which limit the solution space (Sen & Kothari, 1998; Sheble & Fahd, 1994). Lagrangian Relaxation (LR) (Fisher, 1981; Merlin & Sandrin, 1983; Zhuang & Galiana, 1988) can be applied to large UC problems due to its faster computational time. However, it suffers from numerical convergence and solution quality problems in the presence of identical units. Furthermore, solution quality of LR depends on the method to initialize and update Lagrange multipliers (Dekrajangpetch, Sheble, & Conejo, 1999).

In addition to the above methods, there is another class of numerical techniques applied to the UC problem. These are (GA) (Kazarlis, Bakirtzis, & Petridis, 1996), evolutionary programming (EP) (Juste, Kita, Tanaka, & Hasegawa, 1999) and simulated annealing (SA) (Zhuang & Galiana, 1990). These are general-purpose searching techniques based on principles inspired from natural systems. These methods have the advantage of accommodating more complicated constraints and are claimed to have better solution quality.

Ant colony optimization (ACO) was proposed by M. Dorigo et al to solve the difficult combinatorial optimization problems. ACO is a random stochastic population based algorithm that simulates the behavior of ants for cooperation and learning in finding shortest paths between food sources and their nest (Bonabeau, Dorigo, & Theraulaz, 1999; Dorigo, Mahiezzo, & Colorni, 1996; Dorigo & Gambardella, 1997; Dorigo, Di Caro, & Gambardella, 1999). In ACO, the ants’ behavior is simulated to solve the combinatorial problems such as traveling salesman problem and quadratic assignment problem (Dorigo, Mahiezzo, & Colorni, 1996; Dorigo & Gambardella, 1997). The ACO is applied to solve the UC problem by Simon, Padhy, and Anand (2006) and Yu, Chou, and Song, 1998).

This paper proposes a new method, Evolving Ant Colony optimization (EACO) for solving UC problem for a period of 24 hours. In this approach, the ACO is used to obtain the unit commitment schedule and genetic algorithm technique is used to find optimal set of parameters required for ACO. The Lagrangian multiplier method is applied to obtain the economic dispatch for the 24-hour schedule. The proposed method is tested on systems having 10 to 60 generating units to illustrate its effectiveness and simulation results are presented and compared with other methods.

**PROBLEM FORMULATION**

The objective of unit commitment problem is to minimize the production cost over the scheduled time horizon (24 hours) under the generator operational and spinning reserve constraints. The objective function to be minimized is

\[ F(P_i, U_{i,t}) = \sum_{i=1}^{N} \sum_{t=1}^{T} [F_i(P_i) + ST_i(1 - U_{i,t-1})]U_{i,t} \]  

(1)

subject to the following constraints:

Power balance constraint

\[ \sum_{i=1}^{N} P_i U_{i,t} = P_{d,t} \]  

(2)

Spinning reserve constraint

\[ \sum_{i=1}^{N} P_{i,max} U_{i,t} \geq P_{d,t} + R' \]  

(3)

Generator limit constraints

\[ P_{i,min} U_{i,t} \leq P_{d,t} \leq P_{i,max} U_{i,t}, \quad i = 1, \ldots, N \]  

(4)