Evolving ant colony optimization based unit commitment

K. Vaisakh\textsuperscript{a,}\textsuperscript{*}, L.R. Srinivasa\textsuperscript{b}

\textsuperscript{a} Department of Electrical Engineering, AU College of Engineering, Andhra University, Visakhapatnam 530003, AP, India
\textsuperscript{b} Department of Electrical and Electronics Engineering, S.R.K.R. Engineering College, Bhimavaram 534204, AP, India

\textbf{A B S T R A C T}

Ant colony optimization (ACO) was inspired by the observation of natural behavior of real ants’ pheromone trail formation and foraging. Ant colony optimization is more suitable for combinatorial optimization problems. ACO is successfully applied to the traveling salesman problem. Multistage decision making of ACO gives an edge over other conventional methods. This paper proposes 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, startup cost, spinning reserve, and generation limit constraints. The feasibility of the proposed approach is demonstrated on two different systems. The test results are encouraging and compared with those obtained by other methods.

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\section{1. Introduction}

Unit commitment (UC) is used to schedule 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 [1]. Up to now, many methods have been developed for solving the UC problem such as priority list methods [2,3], integer programming [4,5], dynamic programming (DP) [6–8], branch-and-bound methods [9], mixed-integer programming [10] and Lagrangian relaxation (LR) [11–13].

These methods have only been applied to small UC problems and have required major assumptions which limit the solution space [14,15]. Lagrange relaxation for UC problem was superior to dynamic programming 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 [16].

Ant colony optimization (ACO) was proposed by Dorigo et al. to solve 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 [17–20]. In ACO, the ants’ behavior is simulated to solve combinatorial problems such as traveling salesman problem and quadratic assignment problem [19,20]. Artificial ant colony search algorithm is applied to solve large-scale economic dispatch problem in Ref. [21]. In Ref. [22], economic dispatch of power systems was solved by generalized ant colony optimization. Ant colony search algorithm is applied to distribution network reconfiguration for loss reduction in Ref. [23].

This paper proposes a new method, evolving ant colony optimization (EACO) for solving UC problem for a period of 24 h. 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-h schedule. To illustrate the effectiveness of the proposed method, it is tested on two different systems one with 10 and 20 units and the other with 10 units. Simulation results are presented and compared with other methods.

\section{2. Problem formulation}

The objective of unit commitment problem is to minimize the production cost over the scheduled time horizon (24 h) under the generator operational and spinning reserve constraints. The objec-
The active function to be minimized is
\[
F(P_i, U_{i,t}) = \sum_{t=1}^{T} \sum_{i=1}^{N} [F(P_i^t) + ST_{i,t}(1 - U_{i,t-1})]U_{i,t}
\]  
subject to the following constraints:

1. Power balance constraint
\[
\sum_{i=1}^{N} P_i^t U_{i,t} = P_D^t
\]

2. Spinning reserve constraint
\[
\sum_{i=1}^{N} P_{i,\text{max}} U_{i,t} \geq P_D^t + R_i
\]

3. Generator limit constraints
\[
P_{i,\text{min}} U_{i,t} \leq P_i^t \leq P_{i,\text{max}} U_{i,t}, \quad i = 1, \ldots, N
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