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On the influence of the variation parameters of the ant colony optimization on the dispatch of road crews of electricity utility

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Abstract

This paper shows the application of Ant Colony Optimization algorithm for the dispatch of road crews for electric network services in an electricity utility, and the impact of varying parameters on the construction of routes. Considering the consumers' requests, the algorithm creates the routes to be taken by each road crew, selects the sequence in which the service calls will be met by the teams in the same day and the ones that will have to be postponed in order to satisfy the Company's and clients' goals.

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Keywords: Ant colony optimization, crew dispatch, service assistance

1. Introduction

The study presented on this paper is part of a Research and Development (R&D) Project of ANEEL (Brazilian Electricity Regulatory Agency), developed jointly by Electricity Company of Maranhão (CEMAR) and Daimon Engineering & Systems. CEMAR is a private-owned electricity distribution utility, located in the northern region of Brazil which supplies over 2,000,000 customers, in the state of Maranhão.

Currently, at CEMAR (and at many other Brazilian electricity companies), just a few variables are taken into account by the company's dispatchers when service assistance is needed. They make their decisions based on

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previous knowledge, usually intuitively or by ad hoc methods. Also, the decisions are not reevaluated even if the circumstances are different.

Some previous studies and projects tried to solve this kind of problem with different approaches. Projects [1] and [2], for example, do not work totally automatic. In the first one the service prioritization is implemented by the operator, whereas in the second one the dispatch is manually resolved. Other works like [3] and [4] have specific main goals. The first one wants to decrease the time spent in the service assistance and the second one tries to decrease the trajectories length, instead of other company's targets like diminishing costs. Some studies do not even take into account a prioritization system [5] and some cannot be applied at real time applications [6].

One should point out that the project presented by this paper comprises two different modules: The former uses the MACBETH (*Measuring Attractiveness by a Categorical Based Evaluation Technique*) approach, which is a multi-criteria decision method [7] for the prioritization of commercial and supply restoration services in an electricity utility [8]. The latter uses the Ant Colony Optimization (ACO) methodology [9] in order to assign the services to be met, its sequence and the route to be taken by each available crew team/road crew. There are four variations of this method and the simultaneous one was implemented in this project. The study presented on this paper will investigate the influence of some input parameters of the algorithm on the construction of the routes to be taken by each crew team. The parameters are: number of ants, pheromone evaporation and pheromone importance.

The product and the study developed offers to CEMAR, to the technical community and also to society some important solutions and tools that are not yet contemplated by the current systems, making it an original project. It is a sophisticated tool that makes the most suitable decision for crew dispatch.

This paper is organized in a way that the next section presents the theoretic bases of the project, the ACO meta-heuristic method. After, on section III, the project's methodology is described. Section IV shows and discusses the results and, finally, section V concludes the paper.

2. Ant Colony Optimization

The Ant Colony Optimization (ACO) belongs to a meta-heuristic group based on populations. This method can be used to solve the crew dispatch problem, in which there is a set of places to be visited and, in each of them, there is a prize to be taken by the visiting team. Once a team arrived at the point and received the prize, no other team can receive it. The goal is to maximize the total prize [9].

This technique was inspired by the fact that ants from a colony guide themselves by a track of pheromones, searching for the best path to their food source. Good tracks are chosen more often, making its pheromone concentration greater as well as the likelihood of it being chosen again. However, some ants can explore other possibilities trying to find paths that are even better [9].

The problem can be presented as a graph. The service locations are the vertices and the paths are the edges. In ACO algorithms, an ant represents a solution. When constructing a solution, each ant is put on a starting point and then wanders randomly from vertex to vertex in the graph. At each vertex, an ant probabilistically selects the next vertex according to a decision policy or transition rule, which depends on the pheromone trails and on the heuristic information on the edges and vertices. Also, they deposit pheromone in the edges in order to attract other ants towards the corresponding area of the search space. The pheromones can evaporate, allowing some past history to be forgotten, and helping diversify the search to new and hopefully more promising areas of the search space [9]

During the construction of a solution, an ant chooses a feasible path for each vehicle (a crew team). For the simultaneous case, at first, all the feasible vehicle-vertex pairs are considered. Then, the probability of each pair is calculated according to the pheromone tracks and the heuristic. Thus, one of these pairs is chosen respecting its probability. After, the problem constraints are verified and the set of vehicle-vertex pairs are updated. The process goes on until there are no more feasible pairs [9].

For all cases, a fixed number of ants/solutions is predefined within a cycle (the amount of cycles is also defined previously). A solution consists of a set of routes, one for each vehicle/team. In a cycle, all ants independently try to find the better routes for the vehicles. In the next cycle, its ants will be influenced by the pheromones left by the ones from the previous cycles. At the end of the process, the solution that maximizes the prize is chosen [9].