A Meta-heuristic Method for Cluster-based Channel Assignment in a Mobile Ad Hoc Network

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Abstract—In this paper, a centralized algorithm on the basis of ant colony optimization (ACO), a well-known bio-inspired model is suggested as a channel assignment scheme. The suggested method is applied for a cluster-based MANET and aims at minimizing the number of used channels while satisfying the co-channel interference constraints. The suggested algorithm is examined for two scenarios and the obtained results are compared with a GA-based (genetic algorithm) scheme.

Index Terms—Ant Colony Optimization, Channel Assignment Problem in MANET, Co-channel Interference, Spectral Efficiency.

I. Introduction

Next generation military wireless communication systems at the tactical edge will be based on mobile ad hoc networks (MANETs). In the case of large military endeavors extremely high channels utilization is necessary and this can only be achieved if efficient spatial channels reuse is possible. Finding an efficient channel reuse has been classified as the channel assignment problem [1] that was early defined as a frequency assignment problem in cellular communication systems [1]-[4]. In frequency assignment problem, a feasible scheme should maximize spatial channels reused while satisfying interference constraints (e.g. co-channels interference constraint). It should also address several issues, such as: stability, throughput, connectivity and fault tolerance [1]-[4].

For different types of wireless network architectures, numerous heuristic methods have been proposed for solving channel assignment problem that has been identified as an NP-hard problem [5]-[8]. This paper suggests the use of ant colony optimization (ACO) that is a meta-heuristics method and has been inspired by ants’ behavior. The rest of the paper is organized as follows: Section II reviews the ant colony optimization method. Section III describes the obtained results of applying an ACO-based channel assignment scheme for three MANETs. Section IV presents some significant notes and explains about the future works.

II. Ant Colony Optimization: A Meta-heuristic Methods

Recent researches have shown that the meta-heuristic methods are more efficient than the classical optimization methods (e.g., branch and bound) to solve NP-hard problems. Ant colony optimization is a well-known meta-heuristic method that has been shown excellent performance on solving NP-hard problem. Ant colony optimization has been inspired from the behavior of real ants to construct the shortest path from the nest to the source of food. To solve an optimization problem using an ACO-based algorithm, the problem is represented by a graph. A best solution is a sequence of the graph nodes with minimum cost function. This algorithm starts with a population of ants that are randomly placed on the graph nodes. To traverse the graph, each ant chooses the next node using a ‘probabilistic transition rule’ [9],[10] that consists of two components: a heuristic function and pheromone intensity. The heuristic function is a problem independent function and shows the desirability of the next node, while pheromone intensity represents the desirability of the next path from the perspective of the best ant (the ant that finds the path between the source and destination with a minimum cost function). The cost function is assigned to each complete path between the source and destination node and indicates how profitable the path is. In channel assignment problem for a clustered MANET, the graph of problem $G'' = (V'', E'')$ consists of nodes, $V''$, that represent the cluster heads and links, $E''$, that represent that the two clusters are neighbors, i.e., they have a common node (gateway node). For finding a solution, ants should traverse this graph and choose different channels for neighbor cluster heads.

III. Simulation Results

We use the ACO-based method for solving the channel assignment problem in two simulated scenarios using MATLAB. The results are compared with the results of a GA-based method that is proposed in [11]. We have taken the following assumptions: 1) A centralized base station senses the available channels and decides for a channel assignment scheme. 2) In the arrival time of demands for channels, an assignment scheme is provided on the basis of the available channels. 3) The topology of network and the transmission power of nodes are assumed to be static.
during the execution of the channel assignment algorithm.
4) All of nodes of network are assumed to have same
transmission power. In the first scenario, a MANETs with
N nodes (i.e., N=50 and 100) and different transmission
ranges (i.e., TR=100, 200 and 300 meters) are simulated.
Lowest ID (LID) clustering is applied to form the clustered
network structure. The nodes are placed in a 1000 x 1000
meter square and the position of each individual node has
two coordinates, \( x \) and \( y \), that are drawn from a uniform
distribution. The number of used channels to the MANETs
with different nodes is depicted in Figure 1. Obviously, the
number of required channels is dependent upon the number
of nodes and the topology of the network. However, for the
same topology, the number of assigned channels by an
ACO-based method is smaller than a GA-based method.
(See Figure 1 the black and grey bars). It can also be
observed using ACO-based method the number of assigned
channels has no significant change when the size of the
network (the number of clusters) increases. Thus, the
methods might be scalable for a large sized MANET.

![Figure 1](image1.png)

**Figure 1.** The average number of assigned channels and clusters. (a) for a network with 50 nodes. (b) for a network with 100 nodes.

For the second scenario, a clustered MANET with 20
clusters is examined. The simulated MANET has 100 nodes
and the transmission range and interference range are
assumed to be 100 and 250 meters, respectively. The
convergence characteristics of the ACO and GA algorithms
are depicted in Figure 2. It can be observed that ACO-based
method converges after approx. 50 iterations, while the GA-
based algorithm converges after 60 iterations. However, the
average and minimum values of objective functions using
GA differs to a large extent and it converges much slower to
reach a minimum of the objective.

**IV. Conclusion**

In this paper, a cluster-based channel assignment scheme
on the basis of ant colony optimization method is proposed
and examined by two scenarios. We also compare its results
with the obtained results from a GA-based scheme. The
obtained results show that the proposed ACO has the
capability to approximate the solution to minimize the
average level of assigned channels. The results also
indicate that the performance of an ACO-based channel
allocation scheme is not dependent on the size of MANET,
e.g., the number of clusters in MANET. Thus, it provides a
stable and scalable scheme. In future, we will develop a
distributed clustered-based scheme on the basis of ACO
and replace the present lowest ID clustering algorithm with
an ACO-based clustering method to effectively address the
channel assignment problem.

![Figure 2](image2.png)

**Figure 2.** The minimum and mean values of cost function versus the number of iterations for GGA and ACO.

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