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

***Abstract*—In this paper, a centralized algorithm on the basis of ant colony optimization (ACO) is suggested for channel assignment in cluster-based MANETs. The suggested method is a new channel assignment method and its objective is minimizing the number of used channels while satisfying the co-channel interference constraints. The suggested algorithm is examined for several scenarios and the obtained results are compared with the results of using a grouping genetic algorithm.**

***Index Terms*—Ant Colony Optimization, Channel Assignment Problem, 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 scheme has been classified as the channel allocation problem [1] that was early defined as a frequency assignment problem in cellular communication systems [2]-[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 [2]-[4].

For different types of wireless network architectures, a large number of heuristic methods have been proposed for solving this problem that has been identified as an NP-hard problem [5]-[6]. This paper suggests the use of meta-heuristics methods for solving the channel assignment problem in cluster-based MANETs. The methods are based on ant colony optimization (ACO) and grouping genetic algorithm (GGA). We apply them to maximize spectral efficiency while avoiding the co-channel interference between clusters.

II. Meta-heuristic methods

Recent researches have shown that the meta-heuristic methods that are bio-inspired algorithms are more suitable than the classical optimization methods (e.g., branch and bound) to solve NP-hard problems. Genetic algorithm and ant colony optimization are two type of meta-heuristic methods that have been applied in this paper.

A. Grouping Genetic Algorithms

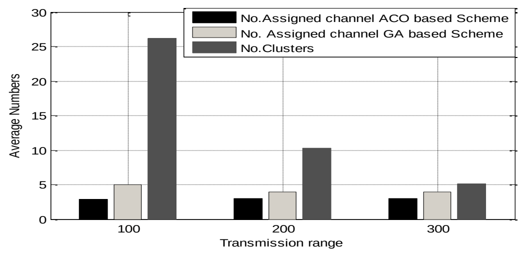
The standard genetic algorithm is a stochastic search that finds a near optimal solution among the potential solutions, which are represented as chromosomes. Each chromosome consists of genes, one for each dimension, to cover the search space. The grouping genetic algorithm (GGA) that has been proposed for combinatorial optimization problems [7] is different from standard genetic algorithm (SGA) in terms of chromosome representation and genetic operators. In GGA, each chromosome that consists of two parts: the object part and the group part and three genetic operations are defined: crossover, mutation and inversion that are applied on the group part [7].

B. Ant Colony Optimization

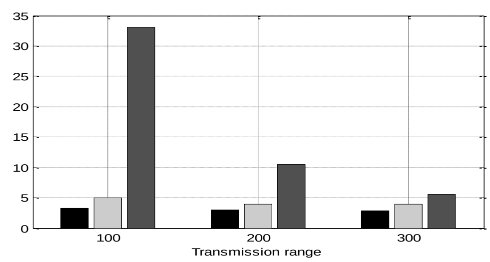
Ant colony optimization has been inspired from the behavior of real ants to construct the shortest path from the source node to the destination node. To solve an optimization problem using ACO-based algorithms, the problem is represented by a graph; while a feasible solution is a sequence of graph nodes with minimum cost function that is constructed by a best ant. This algorithm stars with a population of ants that are randomly paced on the graph nodes. Each ant chooses the next node and path using a 'probabilistic transition rule' [8] that is defined on the basis of heuristic function and pheromone intensity. The heuristic function is problem independent function and shows the desirability of selected node, while pheromone intensity represents the desirability of the selected path. A cost function that is assigned to each complete path, the cost indicates how profitable the path is. In cluster-based channel allocation problem, the graph of problem $G'=(V',E')$ consists of nodes, V', that represent the cluster heads and links, E', that represent that the two cluster heads are neighbors, i.e., they have a common cluster member node (gateway node). For finding a solution, ants should traverse this graph and choose different channels for neighbor mobile nodes. For finding a desirable channel assignment, we define two transition rules, two feasible sets, two heuristic functions and two pheromone updated rules.

III. Simulation Results

We use the meta-heuristic methods for different simulated scenarios using MATLAB under the following assumptions: 1) A centralized based station senses available channels and decides a channel assignment e. 2) In arrival time of a demand for channel assignment, a channel assignment is provided on the basis of the available channels. 3) During channel allocation the topology of network has no change. 4) All of nodes of network have the same transmission power that is fixed during executing of algorithm. 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) is 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 [0, 1000]. The number of allocated channels to the MANETs with different clusters is depicted in Figure 1. Obviously, the number of required channels is dependent upon the number of clusters and the topology of the network. However, for the same topology, the number of assigned channels by ACO is smaller than GGA. (See Figure 1 the black and grey bars). It also can be seen that the number of assigned channels has no significant change when the size of the network (number of clusters) increases. It shows that the methods might be scalable for a large sized MANET.



(a)



(b)

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 by applying GGA and ACO for channel assignment. The simulated MANET has 100 nodes and the transmission range and interference range are assumed to be100 and 250 meters, respectively. The convergence characteristics of GGA and ACO algorithms are depicted in Figure 2. It can be observed that ACO converges after approx. 50 iterations, while the GGA converges after 60 iterations. However, the average and minimum values of objective functions using GGA differs to a large extent and it converges much slower to reach a minimum of the objective. .

IV. Conclusion

In this paper, cluster-based channel assignment schemes on the basis of ant colony optimization methods and group genetic algorithm (GGA) are proposed and examined by two scenarios. 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 MANETs, e.g., the number of clusters in MANETs. 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.

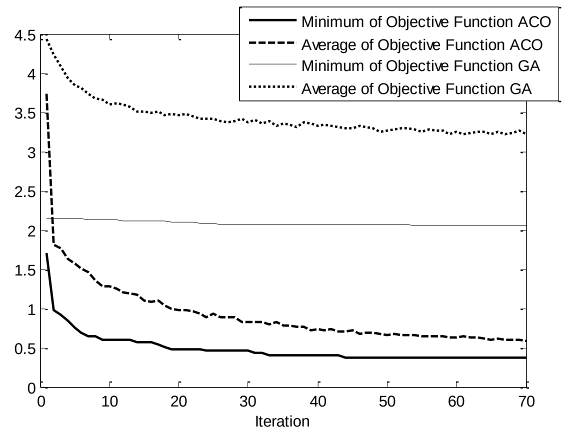


Figure 2. The minimum and mean values versus the number of iterations for GGA and ACO.

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