

# Swarm Intelligence Approach for Ad-Hoc Networks

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## INTRODUCTION

Wireless ad-hoc networks are infrastructureless and they consist of nodes that come together and start communicating dynamically without requiring any backbone support. The nodes can enter and leave the network at will and can move about in the network at will.

Ad-hoc networks present the perfect test-beds for bio-inspired computing algorithms. Both ad-hoc networks and bio-inspired computing approaches are characterized by self-organization, feedback and structural and functional complexity (Toh, 2002) (deCastro & Von Zuben, 2005). Hence, bio-inspired algorithms often provide us an opportunity to solve the most complex problems of ad-hoc networks in a satisfactory manner. In this chapter, we present the works done in the field of ad-hoc networks using bio-inspired Swarm Intelligence (SI). In particular, we look at how we can use Ant Colony Optimization (ACO) technique, a SI technique, for optimal routing in ad-hoc networks.

## BACKGROUND

Most major bio-inspired algorithms have found implementations in the field of ad-hoc networks. Before delving into the details of the applications of ACO techniques for solving problems in ad-hoc networks, for contextual alignment, let us broadly review some of the applications of the different classes of bio-inspired algorithms to ad-hoc networks. Barolli, Koyama, & Shiratori (2003) presented a Genetic Algorithm to solve QoS routing for ad-hoc networks, while Di Caro, Ducatelle, & Gambardella (2004) used ACO technique to develop a nature inspired routing algorithm for ad-hoc

networks. On similar lines, Wedde & Farooq (2005) presented BeeAdHoc – a routing algorithm inspired from foraging behavior of honey-bees. Neural Networks too have been extensively used in ad-hoc networks for providing solution to the problems of routing (Vicente, Mujica, Sisalem, & Popescu-Zeletin, 2005), intrusion detection (Zhang & Lee, 2000) and clustering (Ai-bin, Zi-xing, & De-wen, 1993).

ACO is one of the most popular techniques among different bio-inspired techniques and has been extensively studied and deployed for solving problems as varied as Vehicular Routing Problem (VRP) (Toth & Vigo, 2001) to Single Machine Total Weighted Tardiness Problem (SMTWTP) (Abdul-Razaq, Potts & Van Wassenhove, 1990) to Graph Colouring Problem (Vesel & Zerovnik, 2000).

ACO was introduced by Marco Dorigo in his PhD. thesis as Ant System (AS). It was initially aimed at solving the popular Travelling Salesperson's problem. Though the solution provided by AS was suboptimal when compared with other specialized solutions, it underlined a method which models the foraging behaviour of ants to solve complex problems of computer science.

## MAIN FOCUS OF THE CHAPTER

As mentioned earlier, the primary focus of this Chapter is to illustrate the applications of bio-inspired ACO techniques in the field of ad-hoc networks. We start by introducing the concepts of SI. Then, ACO concepts and their implementations in ad-hoc networks are discussed in detail. We first present and explain properties of ant colony that can enable to find the shortest path between

the source of the food of the ants and their colony using the concept of *pheromone*. We explain the concept of artificial ants and then present the *Random Proportional Transition Rule* (Dorigo & Stützle, 2003). We, then, describe in detail, the *AntHocNet* algorithm (Di Caro, Ducatelle, & Gambardella, 2004), which uses the ACO technique for routing data in ad-hoc networks.

## SWARM INTELLIGENCE

Social insects such as ants, bees, wasps and termites and organisms such as fishes and birds rely on local communication to achieve distributed control. While insects such as ants, bees and termites rely on indirect communication through environment (also often referred to in the literature as *Stigmergy*), birds are dependent on direct but localised communication.

Nonetheless, all of these techniques aim at developing a system in which each element of the system works together to establish autonomy. The elements co-operate with each other locally to make the system much more adaptable and robust to changes and errors. Since these are the main aims of the design of ad-hoc networks, SI algorithms are effectively employed for

solving routing and Quality-of-Service (QoS) problems in ad-hoc networks.

## ACO

Natural ants have a property that they always find the shortest path to the food source from their nests. This property can be illustrated by the experiments explained in (Goss, Aron, Deneubourg, & Pasteels, 1989) and (Deneubourg, S., S., & J., 1990). The set up of the experiments is illustrated in Figure 1 and Figure 2.

In Figure 1, the path between the nest and the food source are equal. It was found that roughly 50% of the ants were using each path. On the other hand in the set up shown in Figure 2, when the paths are unequal, it was found that after some time nearly all the ants were using the smaller path. This phenomenon can be explained using the following argument.

It was found that the ants mark the path that they take by a chemical named *pheromone*, thereby guiding other ants to take that path. Its implication is that the ants choose a path on the basis of the amount of pheromone lying on that path. In Figure 2, when the first group of ants start from their nest, they choose each path with equal probability. So, about half of the ants start moving on each path. The ants using the smaller

Figure 1. Same path lengths<sup>1</sup>

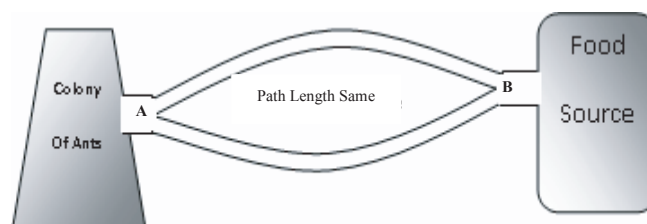
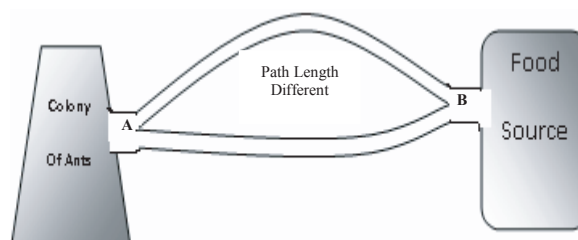


Figure 2. Different path lengths<sup>2</sup>



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