Journal of Network and Computer Applications 35 (2012) 1964–1972

Contents lists available at SciVerse ScienceDirect

Journal of Network and Computer Applications

journal homepage: www.elsevier.com/locate/jnca

Ant colony algorithms in MANETs: A review

Gurpreet Singh [a], Neeraj Kumar [b,*], Anil Kumar Verma [b]

[a] Department of Computer Science and Engineering, YIET, Gadholi (Yamuna Nagar), Haryana, India
[b] Department of Computer Science and Engineering, Thapar University, Patiala (Punjab), India

ARTICLE INFO

Article history:
Received 11 April 2012
Accepted 31 July 2012
Available online 14 August 2012

Keywords:
Mobile ad hoc networks
Ant colony optimization
Routing

ABSTRACT

Mobile ad-hoc networks (MANETs) consist of special kind of wireless mobile nodes which form a temporary network without using any infrastructure or centralized administration. MANETs can be used in wide range of future applications as they have the capability to establish networks at anytime, anywhere without aid of any established infrastructure. It is a challenging task to find most efficient routing due to the changing topology and the dynamic behavior of the nodes in MANET. It has been found that ant colony optimization (ACO) algorithms can give better results as they are having characterization of Swarm Intelligence (SI) which is highly suitable for finding the adaptive routing for such type of volatile network. ACO algorithms are inspired by a foraging behavior of group of ants which are able to find optimal path based upon some defined metric which is evaluated during the motion of ants. ACO routing algorithms use simple agents called artificial ants which establish optimum paths between source and destination that communicate indirectly with each other by means of stigmergy. Keeping in view of the above, in this paper we provide a taxonomy of various ant colony algorithms with advantages and disadvantages of each others with respect to various metrics.

1. Introduction

Mobile ad-hoc networks (MANETs) are special kind of networks in which the mobility of the nodes is quite high. Nodes can join or leave the network at any time as there is no fixed infrastructure and centralized control in MANETs. All nodes are supposed to be equal in processing power. The network is required to have self configuration by means of the cooperation among the mobile devices: all nodes operate as routers and are capable of discovering and maintaining routes to propagate packets to their destinations. The movement of mobile nodes requires the aid of quite complex routing algorithms, as routes are not stable and need to be updated continuously (Toh, 2002; Das et al., 2000).

Due to the dynamic nature of MANETs, route maintenance is quite difficult task. Basically, Routing is the process of choosing paths in a network along which the source can send data packets towards destination. Routing is an important aspect of network communication because the characteristics like throughput, reliability and congestion depends upon the routing information. An ideal routing algorithm is one which is able to deliver the packet to its destination with minimum amount of delay and network overhead. The nodes update the routing tables by exchanging routing information between the other nodes in the network.

Routing protocols for MANETs are classified into three different categories: proactive, reactive and hybrid protocols (Deepalakshmi and Radhakrishnan, 2011; Sampath et al., 2011). The proactive protocols are derived from the static networks and require periodic advertisement and global dissemination of routing information for operation which leads to frequent system-wide broadcasts. These are also called as table-driven protocols which indicate that they maintain a routing entry for every possible destination in the network. The reactive routing protocols create routes only when the source node wants to communicate with the other nodes in the network. When a node requires a route to a destination, it initiates a route discovery process within the network. Once a route has been established, it is maintained by a route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired. Hybrid routing protocols uses the combination of both proactive and reactive protocols (Khosrowshahi-asl et al., 2011).

Ant colony optimization (ACO) is a population-based meta-heuristic approach introduced by Marco (1992). As the name suggests the technique was inspired by the behavior of ‘‘real’’ ants (Bonabeau et al., 1999; Gudakahriz et al., 2011; Pavani et al., 2008). Ant colonies are able to find the shortest path between their nest and a food source by depositing and reacting to the trail of pheromone which provide help to future ants towards optimal paths to food (Paramasiven, 2011; Wankhade and Ali, 2011; Pankajavalli and Arumugam, 2011). Figure 1(a) and (b) illustrates how, after some time, the ants on the shorter path reach the food source earlier as compare to the ants on the longer path. Ants on reaching the destination; start a new route backward towards the source nest by following the same path and biases the path by

* Corresponding author. Tel.: +91 8872540189.
E-mail addresses: gps_ynr@yahoo.com (G. Singh), nehra04@yahoo.co.in (N. Kumar), akverma@thapar.edu (A. Kumar Verma).

1084-8045/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jnca.2012.07.018

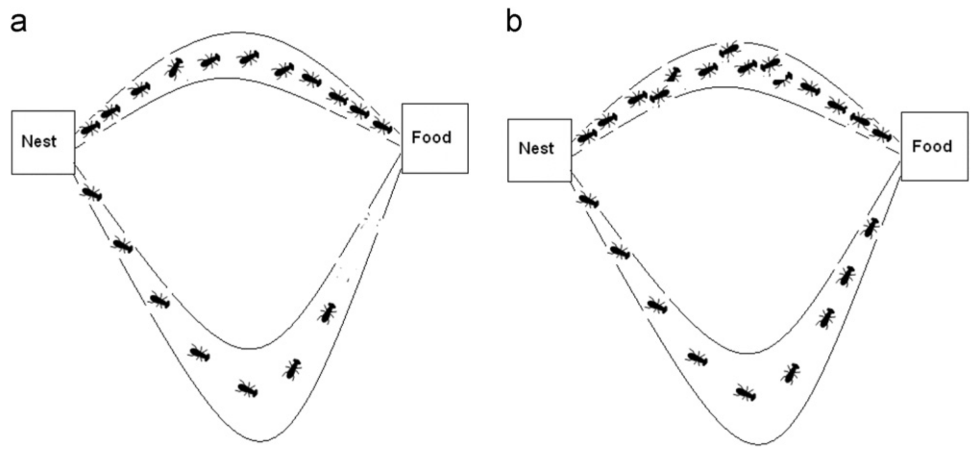

Fig. 1. (a) Double bridge experiment—ants on shorter path reaches to food source earlier. (b) Ants on the shorter path return to nest before the ants on longer path.

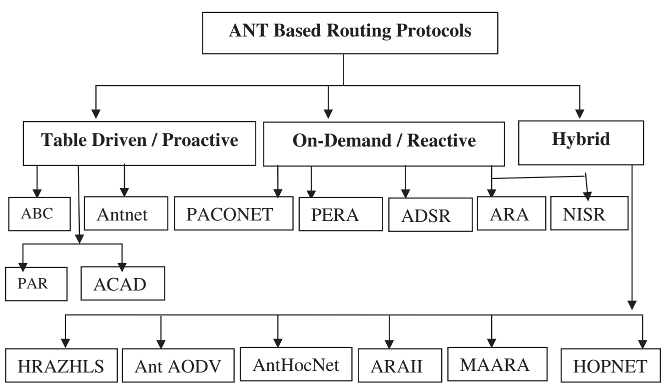

Fig. 2. Categorization of ant based routing protocols for MANETs.

depositing more pheromone on the shorter path. As time progresses, the pheromone on non-optimal paths evaporate while the pheromone on near-optimal paths is reinforced. The basic principle of ACO algorithms can also be applied to many other combinatorial optimization problems (Al-Zurba et al., 2011; Roy et al., 2011; Poojary and Renuka, 2011).

Rest of the paper is organized as follows. Section 2 provides the categorization of various ACO based routing algorithms. Section 3 describes table driven algorithms. Section 4 describes the on demand algorithms. Section 5 describes the hybrid algorithms. Section 6 provides the detailed analysis and comparison of all the schemes with respect to various metrics. Finally Section 7 concludes the article Fig. 2.

2. Categorization of various ACO routing algorithms

The ant colony optimization due its nature can be applied to the various problems of MANETs. As the MANETs can be classified into Proactive, Reactive and Hybrid categories, over MANETs can also be categorized into similar categories based upon various performance metrics as follows:

3. Table driven/proactive ant based routing protocols

3.1. Ant based control (ABC)

Ant-based control (ABC) schemes for routing in telephone networks have been proposed by various researchers (Schoonderwoerd et al., 1997; Stojmenovic, 2005; Sharma and Kotecha, 2011). The algorithms proposed are purely proactive in nature and are suitable for MANETs due to their decentralized nature, high robustness to node failures, load balancing and adaptability to highly dynamic environments (Biskupski et al., 2007). In the ABC routing scheme, following procedure is adopted by the ants (Ladhake and Thakare, 2012): groups of exploratory ants make probabilistic decisions about selection of path by making the deterministic decisions, i.e., by choosing the link with the most pheromone in the column corresponding to the destination. Exploratory ants are used for source updates. Each source node S issues a group of exploratory ants. Each of these ants goes toward a randomly selected destination *D*. The routing table at each node contains neighbours as rows and all possible destinations as columns, and each entry corresponds to the amount of pheromone on the link towards a particular neighbour for a particular destination. These amounts are normalized in each column to value equal to one, so that they can be used as probabilities for selecting the best link. At each current (C) node, the entry in the routing table at C corresponding to the source node S is updated. Exploratory ants make the next node choice by generating a random number and using it to select a link based on their probabilities in the routing table. The amount of pheromone left on a trail depends on how well the ant performs. Two new aspects introduced in the ABC algorithm are the aging and delaying of ants. Thus, the authors proposed a scheme in which ants find the shortest paths, and to prevent the agents from visiting heavily congested nodes. Aging is also used to measure performance. At each hop, the delay depends on the amount of spare capacity of the node, and is added to the age. Both ants and calls travel on the same queue. Calls make a deterministic choice of a link with the highest probability, but do not leave any pheromone. The second objective is obtained by adding an artificial delay to the ants when passing congested nodes. This additional delay is related to the degree of congestion and tries to normalize the situation by the following effects (Schoonderwoerd et al., 1997):

- Delaying the ant forwarding from a congested node leads to a reduced flow rate of agents to its neighbors, which thereby prevents the ants from positively reinforcing the path towards the congested node. This allows other ants arriving from different nodes to find alternative routes around the obstacle and to reinforce them.
- The additional delay also increases the age of the ants when they arrive at the neighboring node. Therefore, this mechanism has less impact on the updated probability value.

The proposed ant based algorithm was compared with other well known algorithms for shortest path like dijkstra's algorithm