Biologically Inspired Ant-Based Routing In Mobile Ad hoc Networks (MANET): A Survey

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Abstract **– This paper presents the state of the art in biologically inspired ant based routing in wireless Mobile Ad hoc NETworks (MANET). The motivation for using ant-like mobile agents for providing routing information to mobile hosts in MANETs stems from the fact that ant-like mobile agents do not require high bandwidth overhead compared to MANET proactive routing protocols for disseminating the topology information in the network. The increased connectivity information provided by the ants can be used to for making better routing decisions which can improve the network performance without causing high overhead.**

1. Introduction

A Mobile Ad Hoc networks (MANET) [1] is a network formed when wireless mobile nodes such as PDAs & laptops have wireless communication capability come together and dynamically form a temporary network, without using any existing network infrastructure. In such networks, when two nodes that wish to communicate and are not within direct wireless range of each other, they make use of multi-hop communication, wherein intermediate nodes relay the packets from the source to the destination node. Figure 1 shows an example of a MANET. MANETs have many applications ranging from battlefields [2], rescue and disaster relief scenarios [3], sensor networks [4], campus [5] & office networks to satellite sensor web [6].

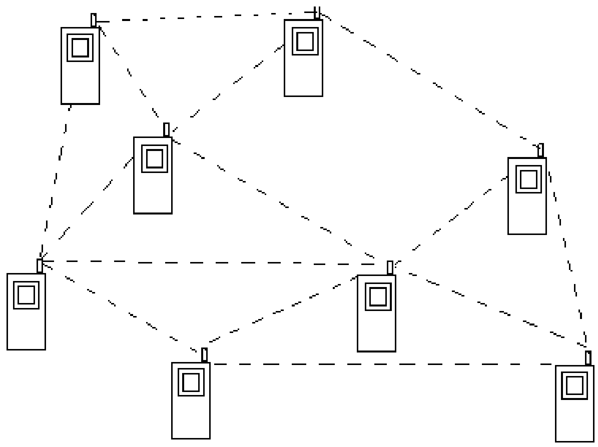


Fig. 1: Example of a Mobile Ad Hoc Network

Conventional MANET routing protocols have some drawbacks [11]. Proactive routing schemes such as Destination Sequenced Distance Vector (DSDV) [7] exchange routing tables which leads to high overhead as the network topology is dynamic in MANETs. Reactive routing protocols such as Ad Hoc On Demand Distance Vector (AODV) [8] and Dynamic Source routing [9] on the other hand search for routes as and when they are needed. This may lead to a long delay before starting a communication session if the network size is large and may not be suitable for communication scenarios requiring faster connection establishment times.

MANET routing can benefit from Mobile agents similar to ants [10, 11, 12] which can be used to discover and disseminate the network topology information to the mobile nodes and discover routes without much control overhead compared to proactive MANET routing schemes. Mobile software agents have been used in telecommunications networks for a long time now [13, 14, 15].

2. Background on Routing in Mobile Ad hoc Networks

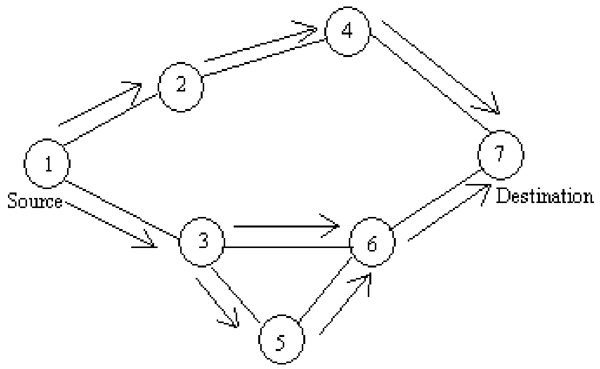
This section presents the basic background to wireless Mobile Ad hoc Networks (MANETs) routing using the two main MANET protocols: (i) Ad hoc On-demand Distance Vector (AODV) routing protocol and; (ii) Destination Sequenced Distance Vector Routing (DSDV) routing protocol.

2.1 Destination Sequenced Distance Vector routing

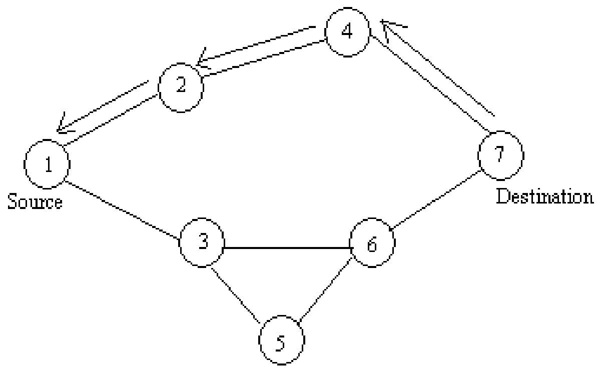
Destination Sequenced Distance Vector (DSDV) [7] routing protocol for MANETs is based on Bellman-Ford Routing Algorithm [18] with few changes [7]. Using DSDV, every mobile node in the MANET network maintains a routing table. This routing table contains the lists of all the destination nodes in the network, the number of hops to reach those destinations and the sequence number assigned by the destination node. With the help of destination sequence numbers, a source or intermediate node in the network can distinguish old and unusable routes from new ones. The nodes in the network running the DSDV protocol periodically exchange routing tables with their neighbours. A unique sequence number is also used in each route update. A node receiving route updates for the same route will use the route with the highest sequence number, which is the most recent one. In case the sequence number of two routes is the same, then the node will select the route with the shortest hop count.

2.2. Ad hoc On-Demand Distance Vector routing protocol

If a node is using Ad hoc On-demand Distance Vector (AODV) [8] routing protocol and it does not have a route to the destination it wants to communicate with, then that node initiates a route discovery to locate the destination node. During the route discovery process, the source node broadcasts a route request (RREQ) packet to all of its neighbours as shown in figure 2 (a). When a node receives an RREQ packet, it forwards the same to its neighbours until either the destination node or an intermediate node with a route to the destination is reached.



(a) Propogation of RREQ Packet



(b) Propogation of RREP Packet

Figure 2. Route discovery in AODV

When the destination node or an intermediate node having a route to the destination receives the RREQ message, it responds by sending a route reply (RREP) packet to the source node as shown in figure 2 (b). Sequence numbers are also used in AODV to ensure that the routes are loop free.

3. Routing in Communication Networks using Ant-like agents

Many routing protocols for MANETs have been proposed which employ ant-like mobile agents. This section presents some of the most important contributions.

3.1 Mobile Agents for MANET Topology Discovery

Chaudhary et. at. [11] have proposed an Ant based protocol for discovering the topology of the MANET networks for routing purpose. [11] uses ant-like agents moving from one node to the other in the MANET. As these agent visit a node, they update the routing tables of the visited node with the topology information they have gathered in their traversal so far. This is as shown in figure 3. Ant agents store information of nodes visited by them in a list. This information is passed to the nodes when an ant agent arrives at that node.

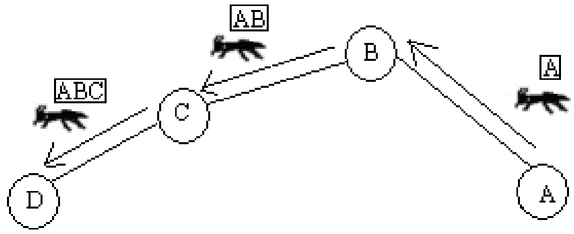


Fig. 3. Ant traversing the network and providing routing information to the nodes.

3.2 AntNet

AntNet [19] uses ant agents for routing in the network. Using AntNet [19], nodes in the network frequently send ant agents to randomly selected destinations in the network. After reaching the destination, the ant agent traverses the same path going back to the original source node. On the way back to the Source node, the ant agents update the routing table of the nodes.

Launching ant-agents continuously increases the control overhead even more. In a dynamic network such as MANETs, by the time, the ant agent reaches the source node; the routing information may have changed.

3.3 Ant-like Agents for Load Balancing

In order to overcome the overhead of the backward ants, Schoonderwoerd et. al. [13] propose the use of the ant's trail laying characteristic, in which just the forward ants leave update the routing table at each node that they visit as they traverses from the source towards the destination node. The nodes can select the path presented to them by the ants which is shortest.

This scheme may lead to the problem that some routes created by the forward ants may be unidirectional. This is especially true in the case of wireless networks.

3.4 Ant-Colony Based Routing Algorithm for MANETs

In Ant Colony Based Routing Algorithm (ARA) [20] the source node in a MANET wishing to communicate with a destination node, broadcasts a forward ant destined towards the destination node, which is similar to AODV's RREQ packets [8]. These forward ants create backward routes at each visited intermediate node towards the source node which originated the forward ant. When the forward ants reach the destination node, backwards ants are created and sent towards the source node similar to [19].

Once the communication session has started, data packets maintain pheromone values on the path. Pheromone value is incremented for every data packet relayed and at the same time the pheromone value is also evaporated or decreased periodically.

When a route fails, due to mobility of an intermediate node of an ongoing session, the upstream node generates a notification and sends it towards the source node. When an upstream node receives the route failure notification, it checks if it has an alternate route and if so, the data packets are sent on that path. If the upstream intermediate node does not have an alternate path to the destination node, it checks with its neighbours if they could forward the data packets to the destination. Finally if none of this works, the route failure notification is propagated back to the source node, which then broadcasts another set of forward ants towards the source.

3.4 Efficient Ant-based Routing Algorithm for MANETs

Woo et. al. [21] also propose an ant based routing scheme for MANETs similar to [20], however with a few differences. In [21] once the path has been found by the forward ants from the source to the destination, the source node periodically sends forward ants to probe established paths or to find better alternate paths. Furthermore, when a route fails, the route failure notification is sent to all the concerned nodes which have used that link for relaying their data packets. Lastly, the intermediate nodes upon detecting a route failure are also capable of launching a reactive route discovery using forward ants.

4. Conclusion

This paper presents the algorithms being proposed which utilise distributed cooperative Mobile Agents for routing in Dynamic Networks such as MANETs. It is evident from this review that by utilising ant-like mobile agents in MANETs, the network topological information can be disseminated to the nodes in the network without incurring high control overhead compared to proactive routing schemes. With the enhanced topological information available at the nodes in the network, better routing decisions can be made to reduce the end-to-end packet delays and route discovery latency.

6. Acknowledgements

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