A Novel Approach for Route Determining by Integrating Three Routing Techniques

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ABSTRACT
Mobile Ad Hoc Networks (MANET) is an autonomous collection of mobile users that communicate over relatively bandwidth constrained wireless links. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. The network is decentralized, where all network activity including discovering the topology and delivering messages must be executed by the nodes themselves, i.e., routing functionality will be incorporated into mobile nodes. The routing algorithms can be classified into Reactive and Proactive. A Hybrid algorithm combines the basic properties of reactive and proactive into one. The proposed approach is a novel and hybrid (integrated) approach, integrates three different algorithms together and helps to get optimum routes for a particular radio range. The approaches used here are Ant Colony Optimization (ACO), Multi Agent System (MAS) and Position based routing approach. The proposed integrated approach has a relatively short route establishment time while using a small number of control messages which makes it a scalable routing approach. The overhead of this routing approach is inexpensive and also enables to have an alternate route during route failure.

General Terms
Algorithm, Optimum, Routing, Topology and Wireless.

Keywords
Mobile Ad Hoc Networks, Ant Colony Optimization, Multi Agent System, Position based routing and control messages.

1. INTRODUCTION
A mobile ad-hoc network (MANET) is a self-configuring infrastructure-less network of mobile devices connected by wireless. Ad hoc is Latin and means "for this purpose"[1]. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET (*See figure 1*) is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet.

MANETs [1] are a kind of wireless ad hoc networks that usually has a routable networking environment on top of a Link Layer ad hoc network. In order to reach a destination, a message must pass through some intermediary nodes; therefore these networks are also called multi-hop networks.

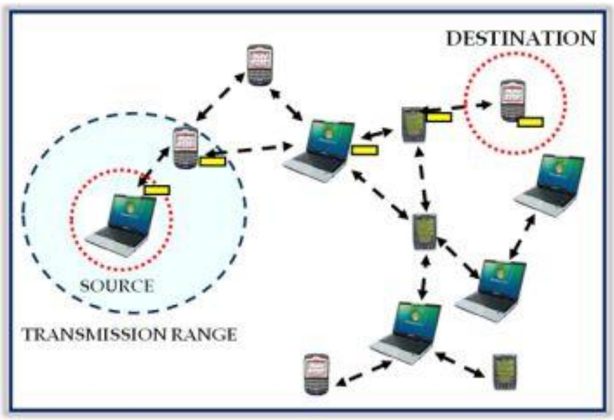

Fig 1: Mobile Ad Hoc Network

The availability of cheap instruments like GPS receivers for estimating the position of nodes in a network motivated to propose position based routing schemes [2] [14]. In position-based routing schemes it is assumed that a node is aware of its position, the position of its neighbors, and the position of the destination. Another family of routing method for mobile Ad-hoc networks [1] [9] is based on Ant Colony Optimization (ACO) [4] [5] [6]. They have a very high delivery rate and find routes whose lengths are very close to the length of the shortest path.

The drawback of ACO [4] [5] [6] [17] is the number of routing messages that needs to be sent in the network for establishing routes to the destination are more and the time needed before a system of paths between the nodes of the network is established. This is referred to as the convergence time. A long convergence time is a significant drawback. The MAS [3] [10] acts sending agents (broadcasting) to the neighborhoods, and it waits for successful information and it forms alliances.

In Routing, protocols for mobile ad-hoc networks can be classified into two main categories:

- Proactive or table-driven routing techniques
- Reactive or on-demand routing techniques
- Hybrid (Integrated) routing technique

1.1 Proactive Routing Techniques

In table-driven routing protocols [7] [9] [16], each node maintains one or more tables containing routing information to every other node in the network. All nodes update these tables to maintain a consistent and up-to-date view of the network. When the network topology changes the nodes propagate the updated messages throughout the network in order to maintain consistent and up-to-date routing information about the whole network.

1.2 Reactive Routing Techniques

These protocols take a lazy approach to routing. In contrast to table-driven routing protocols not all up-to-date routes are maintained at every node, instead the routes are created as and when required. When a source wants to send to a destination, it invokes the route discovery [7] [9] [16] mechanisms to find the path to the destination. The route remains valid until the destination is reachable or until the route is no longer needed.

1.3 Integrated Routing Technique

Due to the advantages and disadvantages of each kind of routing algorithm, we can consider the usage of hybrid routing approach. Hence we propose novel approach for route determining by integrating three routing techniques. Hybrid Protocols try to profit the advantages of both reactive and proactive protocols [7] [9] [16] and combine their basic properties into one. These protocols have the potential to provide higher scalability than pure reactive or proactive protocols.

The rest of the paper is organized as follows: Section II presents an Overview of Position based Route Determining approach [2] [14], ACO [4] [5] [6] approach and ACO [4] [5] [6] integrated with MAS [3] [10] approach. In section III, we present our Novel and Integrated Route Determining Technique with better performance and failure recovery. Finally, Section IV concludes the paper and describes the future work of our paper.

2. THREE ROUTING TECHNIQUES

2.1 Position based Route Determining

GPSR [11] and Compass routing are examples of position based routing schemes [2] [14] in which a routing decision is made locally in each node that is reached in the routing process (See *figure 3*). In Compass routing (Also known as DIR]) a node S that receives a packet for destination D, calculates for every neighboring node N the angle between the line segments from S to D and S to N.

The packet is forwarded to the neighbor of S for which this angle is the smallest. In GPSR [11] method, a packet can have two different modes, greedy- mode and perimeter-mode. Upon receiving a greedy-mode packet, a node searches its neighbors to see if there is a neighbor with a positive progress. If such a neighbor exists, it will forward the packet to the neighbor that is closest to the destination; otherwise the packet will be changed into perimeter-mode. GPSR [14] uses a graph traversal method to forward perimeter-mode packets. When a packet enters perimeter mode at node S for destination D, it will be forwarded on progressively closer faces of the graph which are crossed by line SD.

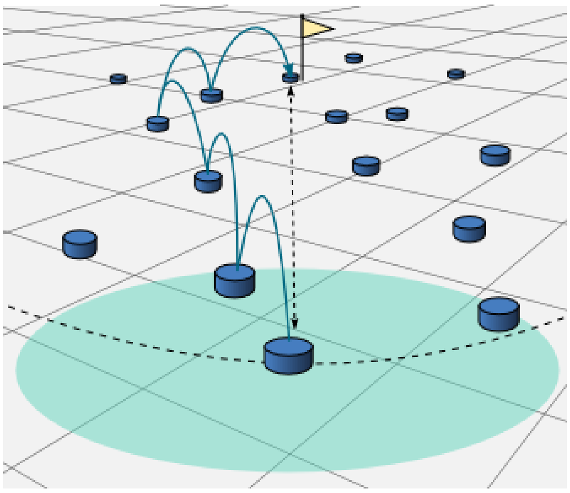

Fig 2: Position based Route Determining Approach

When a perimeter-mode packet enters a node which is closer to D than S, its mode will be changed into greedy again. This scheme does not guarantee to find a shortest path to the destination. This scheme has some useful characteristics: They don't need to use memory in the intermediate nodes since they don't have any routing table [12] and there is no need to keep the traffic history of packets. Also no control packet needs to be exchanged. It makes them very simple to implement with little overhead of routing. This is a Reactive routing algorithm [2] [7] [9] [16].

2.2 Ant Colony Optimization

Ant colony optimization (ACO) [4] [5] [6] takes inspiration from the foraging behavior of some ant species (*See figure 3*). These ants deposit pheromone on the ground in order to mark some favorable path that should be followed by other members of the colony. Ant colony optimization exploits a similar mechanism for solving optimization problems. Ant colony optimization (ACO) [4] [5] [6] has proved its success as a meta-heuristic optimization in several network applications such as routing and load balancing.

Ants [18] can construct the shortest path from their nest to the source of food, through the use of pheromone trails. The ant leaves some quantities of pheromone on the ground while it walks. The next one will sense it, and based on a probability proportional to the amount of pheromone, it will choose its path].However, artificial ants have some major differences with real ones: First, ants have a memory. Second, ants are not completely blind; finally, the time of artificial ants is discrete [17]. The collective activities of social insects are self-organizing, meaning that complex group behavior emerges from the simple interactions of individuals. The results of self-organization are of global nature, but come basically from local information and interactions [17]. The interaction within a society of insects can take one of the two forms: direct and indirect. Direct interactions can take the form of bodily contact, visual contact, and food exchange. Indirect interaction is also important, it can occur when agents exchange information through the environment in which they exist. Thus the storage of information occurs at the colony level as well as individual level. This cooperation through modification is called stigmergy.

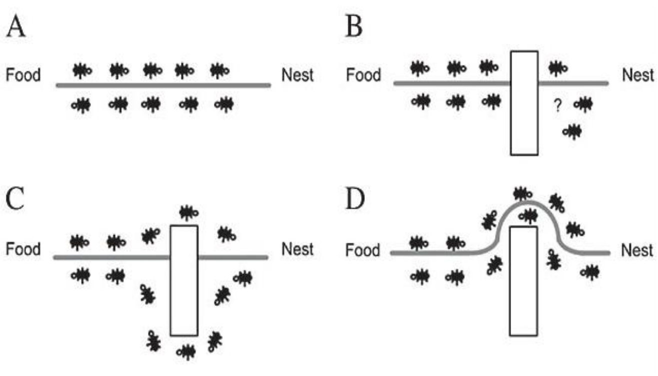

Fig 3: Food Searching behavior of Ants

ACO [4] [5] [6] routing methods guarantee message delivery. Since ACO launches ant at regular intervals. The more the number of ants needed to converge to a route, the more the time elapsed since the start of the scheme. Hence ACO [17] has a long convergence time. Also broadcasting ants causes a large overhead on the network especially when the size of the network is too big.

2.3 ACO integrated with MAS

This Multi Agent System combined with ACO [4] [5] [6] is composed of three main data structures in each node: the Routing Table (RT) [12], the Historical Path Table (HPT) and the Alliance Formation Table (AFT). The RTi in node i contain for each destination d and each possible next hop n a value Pdn (pheromone) that represents the probability of choosing n as next hop to reach destination d when a data session in node source S needs it [3] [8] [10] [15]. This pheromone tables in different nodes indicate multiple paths between s and d, and data packets can be sent from node to node until they reach their destination.

Using HPT alternative route can be obtained during a route failure. To update the pheromone tables, initially, this Scheme (in fact, the MAS [3] [8] [10] [15]) has a reactive behavior when a data session is started at node s with destination d, and it does not find up-to-date routing information to reach d. The MAS acts sending agents (broadcasting) to the neighborhoods, and it waits for successful information represented by the initial AFT in node i. This AFT is inspired by previous works related to Alliance Formation for Agents. This AFTi represents node alliances for node i and contains information related to the degree of trust existing between node i and its neighbors to reach destination d. If the degree of trust related to node n (possible next hop) to reach destination d is high, then the pheromone Pdn in RTi will be high, or vice versa[18].

The MAS [3] [15] always acts when a reactive behavior is needed. As an Alliance Diameter Control (ADC), there is a hop-count field that would decide the number of hops to which the advertisement of trust may be propagated by receiving platforms. In a highly dynamic environment, such as MANETs, a small diameter of an alliance is more desirable. This is because, if the diameter is large, stability of a system in an alliance would be less. To maintain and explore routes in a proactive way, the proposed scheme (in fact, the ACO [3] [4] [5] [6]) acts sending out routing packets (forward ants) according to the data sending rate while a data session is running. Ants follow and actualize the pheromone values in the routing table [12] in order to maintain the existing routes, and they also have a small probability of being broadcasted, in order to have the possibility of finding new routes.

Like in the traditional ACO [17], when a forward ant finds a destination, a backward ant is generated to go back from the destination to the source with the goal of maintaining up-to-date the estimates of this path, and to update the pheromone values related to this path. If at any point the forward ant is broadcasted, it will explore new paths and leave a pheromone trail.

As it is shown in *Figure 5*, the ACO [3] has two main aims, first to update the RT and second to maintain the HPT in order to have possible backup paths. The HPT contains information about the last five paths traversed, and their respective delay statistics. The MAS [3] [8] enhances the decisions of the ACO [17] by using an AFT and updating the RT. Finally, when a data session arrives, it follows the Pdn pheromone to reach their destination d.

3. NOVEL AND INTEGRATED ROUTE DETERMINING TECHNIQUE

Consider a destination node D and a network graph G. For each node S (i.e. S is not necessarily the source node) we partition its neighbors into 3 zones called zone1, zone2 and zone3. Consider a line segment between S to D.

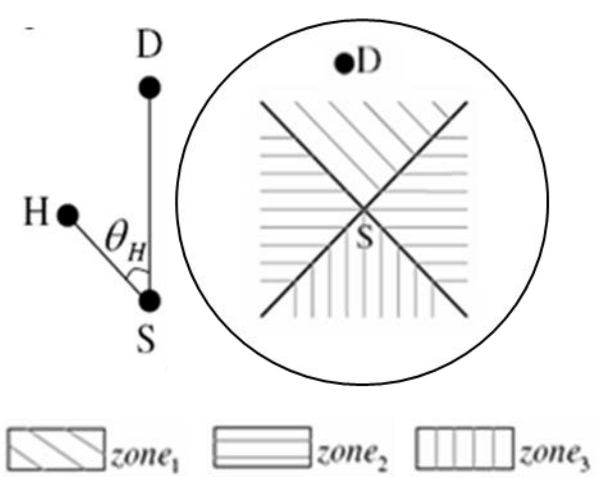

Fig 4: Network Graph of the proposed novel approach (S- Source, H- Next Hop and D- Destination)

For a neighbor H of S, angle θH is defined as the angle between line segments SH and SD. Node H belongs to zone1 if $\theta H \le \pi/4$, zone2 if $\pi/4 < \theta H < 3\pi/4$, and zone3 if $3\pi/4 \le \theta H \le \pi$ (*See figure 4*). Three different algorithms [18] namely Proactive Ant Colony Optimization (ACO), Reactive Multi Agent System (MAS) [3] and Reactive Position based routing scheme [2] are combined to form a Hybrid (combined or integrated) Routing Scheme (*See Figure 5*).

The hybrid combination of ACO and MAS offers [18] good solution [3] for the existing problems in MANET. Hence the combined form of ACO and MAS is again combined with another algorithm called Position based routing algorithm [2]. Here the nodes are identified based on the position as the communication range is divided into zones.

These divisions are made to trace the node's location easily. The MAS form alliances by broadcasting agents. The ACO does define a route by using the forward ant and backward ant [3]. Using Position based routing scheme [2] unnecessary exchange of control messages can be reduced.

The location information and alliance formation helps to trace and locate the nodes' appropriately which is the major issue in MANET. Therefore this proposed scheme enables to have an optimum route. Previous approaches may fail to find a route from a source to a destination in some types of ad-hoc networks and if they find a route, it may be much longer than the shortest path. On the other hand, routing schemes which are based on ant colony optimization [2] [3] [18] find routing paths that are close in length to the shortest paths.

The use of location information as a heuristic parameter can result in a significant reduction of the time needed to establish routes from a source to a destination [18]. In addition to having a short route establishment time, it can also reduce greatly the number of generated control messages, unlike some ACO routing methods. Hence a robust and efficient hybrid scheme can be expected.

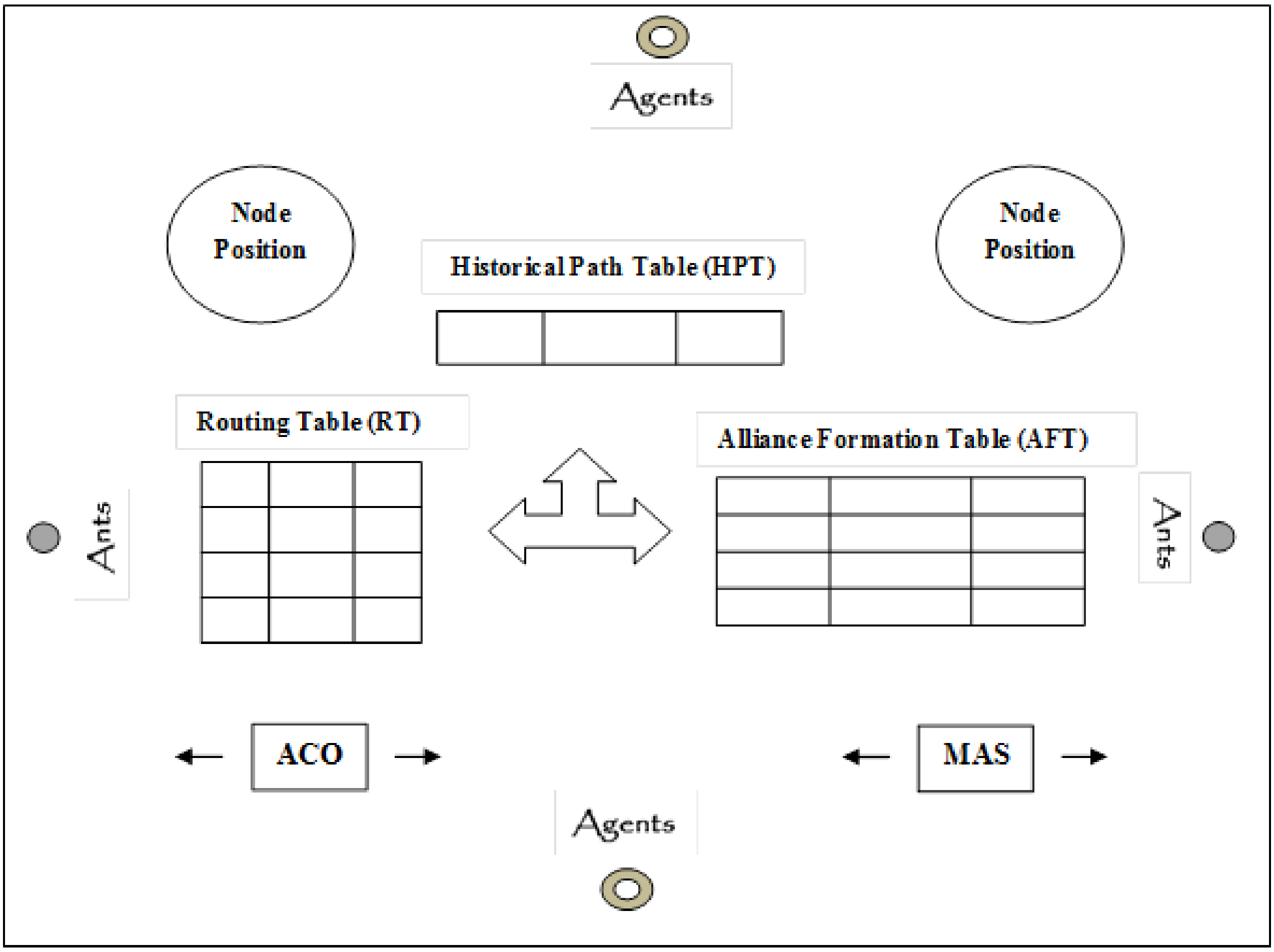

Fig 5: Working of Novel and Integrated Route Determining Technique

4. CONCLUSION

Each earlier proposed protocol has their own merits and demerits, none of them can be claimed as absolutely better than others can. This paper compared the three ad-hoc routing protocols and proposes a better routing algorithm with historical monitoring of the network and failure recovery to facilitate reliable transmission of data packet over the wireless network. The future aspect of the system involves the improvement of this scheme that facilitates more efficient in sending data packets for a large communication range.

This proposal is an initial step of our project. Now we have combined three different ad hoc routing schemes and made an analysis on this combination. We will extend our proposal by producing experiments and results in future. Above all, hybrid routing protocols have 'the potential' to provide higher scalability than pure reactive or proactive protocols, and moreover to maintain routing information much longer because of the collaboration between nodes.

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