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Research paper

Ant Based Zonal Routing in Mobile Adhoc Networks

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Abstract

Mobile Ad hoc network (MANET) is a collection of moving wireless nodes which form a temporary network topology without using any pre-existing network infrastructure. One of the challenges in MANET is to identify a path between the source and the destination nodes. MANET is highly deployable, self-organizing, autonomous and self-configuring network with the ability of rapid deployment. Nodes movement imposes high challenges to routing in MANET due to dynamically changing of topologies, low transmission power and asymmetric links. So well-organized routing is very critical task due to highly dynamic environment. Route instability occurs due to node mobility and leads to frequent change in topologies; therefore routing becomes one of the core issues. Many researchers are working on the expansion of routing protocols in MANET.

Keywords: *MANET; ACO; AntHocNet; ADSR; Ant_ZRP*

1. Introduction

Wireless and mobile communication networks have allured significant interests in recent years. Moving nodes causes frequent changes in network topology between the wireless devices or wired access points (Base Station). Mobile networks can be categorized into infrastructure less (without base station), infrastructure base (fixed access point) networks and hybrid networks which combine infrastructure and infrastructure less aspects. Infrastructure less networks are also called as Mobile Ad-hoc Networks.

Each node in Mobile Ad-hoc Network (MANET) acts as a router for forwarding data packets to other nodes. A main challenge in the ad-hoc networks is the development of dynamic routing protocols that can quickly find efficient routes between two communicating nodes. Many routing protocols have been developed for MANETs [6]. These protocols have the capability to deal with typicality & limitations of ad-hoc networks which include low bandwidth, high power consumption and high error rates. Routing in MANET is classified into three types i.e. proactive (table-driven), reactive (on-demand) and hybrid (mixture of proactive & reactive). Proactive routing protocols always maintain network by using tables that store routing information or path to other nodes in network. If any change is triggered in network topology, they start propagating updates throughout the network in order to maintain a consistent network view [7]. These protocols respond to change in network topology by propagating route updates throughout the network in order to maintain a consistent network view. Reactive routing protocols are characterized by a path discovery mechanism that is initiated when an information unit needs to get to a given destination [8]. The routing creates paths when source node is in need to find route. When source node needs to discover route for destination node, it initiates the route discovery process. The process is finished when all possible routes are found. After establishment of route, the route is maintained by route maintenance procedure until it is broken by movement of intermediate nodes. Hybrid routing protocols are proposed to combine advantage of both proactive and reactive protocols. The most typical hybrid one is zone routing protocol [9].

2. Related Work

Destination-Sequenced Distance-Vector Routing protocol (DSDV) is a proactive table driven algorithm. It is mainly inspired from classic Bellman-Ford routing algorithm. In this approach every node maintains a routing table for all other nodes in the network as destinations [10]. It is maintained in the form of a table by recording information to all available destinations, the next node that need to be traversed to reach the destination, number of required hops between source and destination and sequence number. The nodes periodically exchange the routing table with all neighbors in order to maintain the topology. This creates huge network overhead [20]. A sequence number is attached to each entry in the routing by the destination node. The sequence numbers helps to identify the stale routes from new ones and thus avoid the formation of routing loops [15].

Dynamic Source Routing (DSR) is a reactive routing protocol [2]. DSR protocol is uses two types of phases: route discovery and route maintenance [3]. A route cache is maintained by each node to store recently discovered paths. Whenever source requires a route to a destination then route cache is consulted first to determine whether it has already a route to the destination. If the route is available then that route is picked otherwise a route discovery process is initiated. The route request packet (RREQ) is forwarded to every neighbor node [11]. When adjacent nodes receive RREQ packet, that node will check the cache for available route. If it does not have route to destination, then the node will add its own address to the route memory of the packet and forwards it to

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their neighbors. If any node have route to destination then a route reply packet (RREP) is generated and send back to the original source. Due to the movement of nodes any route can fail anytime. Therefore, the route maintenance process always observes the network and informs the other nodes about any failure by sending the route error packets. [15] [18].

Adhoc on Demand Distance Vector Routing Protocol (AODV) [1] is also a reactive routing protocol. AODV takes help of the properties of both DSR and DSDV. Routes are discovered in reactive manner and are maintained till their requirement. Like DSDV it also uses a sequence number which is increased each time on finding a new change in the route or topology. This sequence number helps in selecting the most recent route from different options [10]. The routing tables used by AODV store the next hop address, destination address and the destination sequence number. If any node does not receive the three consecutive HELLO packets from neighboring nodes then it assumes that link has been broken to that specific node and a route error message RERR is broadcasted to all upstream nodes [11] [13]. The source node thus receives the route error message by the neighbor nodes that are also affected by the link failure. After receiving the failure message, the source node re-initiates the route discovery process. AODV also provides fast removal of invalidated routes in response the RERR messages received due to link breakage [14] [16] [19].

Zone Routing Protocol (ZRP) is combination of proactive and reactive routing techniques. ZRP uses the concept of zones [11] [12]. In limited size zone, route maintenance became simple and numbers of routing updates are lessened. The nodes outside the zone can use reactive routing and nodes inside zone use proactive routing. Therefore, route request is not flooded to entire network but limited to the border node only [16]. The ZRP consists of four components: Intra-Zone Routing Protocol (IARP), MAC-level functions, Inter-Zone Routing Protocol (IERP) and Bordercast Routing Protocol (BRP). MAC-level helps in discovering the neighbors and uses maintenance functions. For example, when a node comes inside the zone, a notification message for the new neighbor is forwarded to IARP. Similarly is any node is disconnected due to connectivity issues, a lost connectivity message is received by IARP [4]. IARP keeps the record of all nodes inside the zone and maintain the routing table. The IERP helps maintaining the correct routes to nodes outside the zone. If IERP does not have any route to destination in its routing table then it sends route discovery to BRP [5]. BRP processes route query discovery to their border nodes because border nodes can only transmit and receive the packets. Bordercasting has important mechanism that it avoids flooding of packets to every node in the network [17] [18].

Schoonderwood et al. proposed a proactive routing algorithm named as Ant Based Control (ABC). This algorithm has the specialty of load balancing in the circuit switched networks. It is used for controlling the calls. Only one routing table is used by this algorithm whose row entries store destination, columns show neighbors. Each node maintain a routing table containing probabilities of selection of the next node [34].

Ant colony based routing algorithm (ARA) is a reactive natured routing ACO based algorithm. Route discovery and route maintenance are the two main phases of this routing protocol [22]. The source node broadcasts a forward ant to discover the route to destination and the ant is forwarded by each intermediate node until forward ant reaches the destination [26].

The Ant-AODV is swarm intelligence based routing algorithm for Mobile Ad Hoc Networks which uses artificial ants to retrieve the routes from the networks, make use of these ant agents to collect the routing information in the form of routing tables. The Ant-AODV combines the proactive nature of ACO with reactive characteristics of AODV to improve the routing performance and delay in search activities and to adapt the constantly change of network's topology [23].

Baras and Mehta proposed Probabilistic Emergent Routing Algorithm (PERA) which is ant based proactive routing algorithm. The algorithm assumes that all nodes of the network co-operate fully in data transfer process and are uses the bidirectional links inside the network. It uses the uniform forward ant and regular forward ants which are forwarded to reinforce the available routes inside the network [24].

AntHocNet is a hybrid multi-path algorithm to set up paths in the form of pheromone tables which indicates the quality of the path. The data packets are routed randomly by using the pheromone tables over various paths after the route setup [25].

HOPNET is a hybrid ant colony optimization routing algorithm. This algorithm improves scalability in network by using ant algorithms. This also uses the features of ZRP for making a zonal system and divides the network into zones. A node may be exists in multiple routing overlapping zones. Each node maintains a table for nodes inside the zone and uses the pheromone value as link quality for each neighbor node corresponding to the particular destinations [27].

Automatic Clustering inspired by Ant Dynamics (ACAD) is heuristic natured algorithm. It can involuntarily detect any number of well-separated clusters. These clusters may have any shape either convex and/or non-convex. The proposed technique can encompass both shell data as well as solid clusters. It can detect outliers from the data and is also able to identify the situation when the data do not have any natural clusters at all. It can also check whether there is any real clustering tendency in the data under test [35].

3. Methodology and Proposed Work

Ant Colony Optimization (ACO) is a swarm inspired metaheuristic introduced by Marco Dorigo [21]. This technique is inspired by the behavior of "real" ants. Ant colonies have the capability to find the shortest route between their nest and a food source by depositing a chemical trail of pheromone which help to guide the future ants in identifying the optimal paths to food [29] [32] [33]. After passing little time, the ants automatically start using the shorter path to reach the food source instead of the longer path. Ants on reaching the destination follows the same path in reverse manner to reach their nest by depositing more pheromone on shorter path. As time progresses, the pheromone on non-optimal paths evaporate while the pheromone on near-optimal paths is reinforced. The basic principles driving this system can also be applied to many combinatorial optimization problems like routing in data networks [28] [30].

After gone through the success stories of the ant based algorithm over the MANETs, we have also proposed an ant based routing algorithm for ad-hoc networks which is working similar to ZRP algorithm. The new algorithm also uses forward ants and backward ants for various phases of algorithm like route discovery, maintenance and error handling. The proposed algorithm works as follows:

Pseudo code for routing inside the zone:

Aim: To periodically maintain the routing table information

For every node in the network after a fixed period of time Send the forward ant (FAnt) & update the buffer route information

```
If TTL > time consumed check
{
        If sequence number of FAnt is greater than the sequence
        number of available routing table
        {
                Update the entries appropriately
                Increase the hop count by one
                Send the FAnt to next neighbor based on
probability
        }
}
Else
        Return with no result & send another FAnt
        If the entry of pheromone in the table is zero then dis-
card the node from the routing table entry
```

Pseudo code for routing outside the zone:
Aim: To find the route to destination for which information is not present in routing table

For every source node S in the network if the route to destination is not found in routing table send the FAnts ant to the border nodes

```
If TTL > time consumed check
{
If current node has route to the destination then
{
        Prepare route reply message via Backward ant(BAnt) and embedding the available route information with the route information collected by FAnt
        }
        If current node is equal to destination
        {
        Prepare route reply message via Backward ant(BAnt) with the route information collected by FAnt
        }
}
Else Return with no result & send another FAnt
```

Pseudo code for Backward Ant (BAnt)
Aim: When FAnt reaches the destination then prepare the BAnt and send it back along the path of FAnt by updating the pheromone information in each routing table

```
        If TTL reached
        Create the BAnt again and start the procedure
Else
{
        If BAnt reaches at node source node
        Connection established and starts sending the data packets
        else if BAnt reaches the node X
{
        Update the pheromone entry
        Fetch the next hop node from stack created by FAnt
        Increase the hop count by one
        }
}
```

Pseudo code for route maintenance
Aim: To maintain & repair the route

```
If expected next node (A) is not found
{
        Delete the entry of next node in routing table
        Broadcast repair ants to find the old route
        Save the path up to the present node
        Inform the source node
}
If repair ant reaches node B (next in series of expected node A)
{
        Send the message of path found to source node
        Check the nodes further to B in the path.
}
```

4. Simulation Work

The simulation of the mentioned protocols i.e. AODV, DSDV, DSR, ADSR and Ant_ZRP is done in network simulator NS-2 (version 2.33). All the protocols were simulated in a similar environment by using 35 node structures in which 12 active connections of constant bit rate (CBR) data packets were opened in parallel. The simulation work was compared based on various network parameters like Packet Drop (Data Packets as well Control Packets), Congestion, Number of hops traversed. Figure 1 shows the typical look of simulation window in NS-2 showing the simulation of Ant_ZRP protocol.

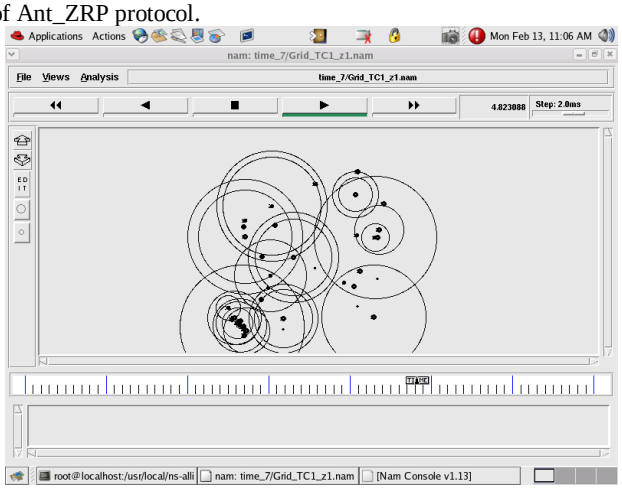


Fig. 1: Window showing simulation of Ant_ZRP

Packet Drop (Data Packets only): The results shown by table 1 and figure 2 show that minimum number of packets was dropped in Ant_ZRP. However DSR shows maximum packet drop rate.

Table 1: Data packets dropped after each second of time

Time in Seconds	AODV	DSDV	DSR	AntHocNet	Ant_ZRP
1	0	2	18	0	0
2	2	1	29	0	0
3	0	0	18	0	0
4	22	4	28	0	0
5	0	8	4	0	0
6	3	0	0	0	0
7	0	0	0	0	0
Total Packets Dropped	27	15	97	0	0

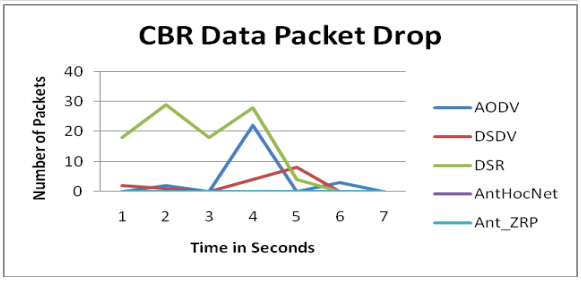


Fig. 2: Data packets dropped after each second of time

Packet Drop (Data & Control Packets): If we see the statistics of the dropped packets (data & control packets), we find that DSDV shows minimum number of packet drop rate with compared to other protocols. ZRP protocols with radius 2 shows comparative results with reference to other protocols.

Table 2: Data & Control packets dropped each second

Time in Seconds	AODV	DSDV	DSR	AntHocNet	Ant_ZRP
1	63	18	90	325	325
2	4	29	3	0	0
3	74	18	21	0	0
4	145	28	105	99	126
5	667	15	293	339	115
6	0	0	1	231	27
7	94	0	148	369	52
Total Packet Dropped	1047	108	661	1363	645

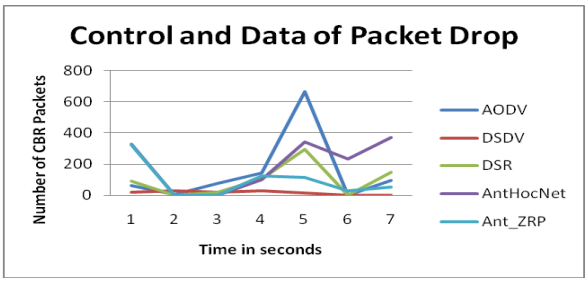


Fig. 3: Data & control packets dropped after each second of time

Received Data packets (Throughput): The simulation work was also compared based on the number of packets received by each node after every second. This basically showed the capacity of an algorithm to transmit larger number of data packets which may lead to high throughput. From the observations received we found that the Ant_ZRP has better capacity to receive data packets, so it promotes better throughput.

Table 3: Number of packets received

Time in Seconds	AODV	DSDV	DSR	AntHocNet	Ant_ZRP
1	82	110	28	28	28
2	75	120	33	28	28
3	162	238	50	36	36
4	197	202	67	55	55
5	0	128	0	4	4
6	55	121	0	0	0
7	14	14	7	0	0
Total Packets Received	585	933	185	151	151

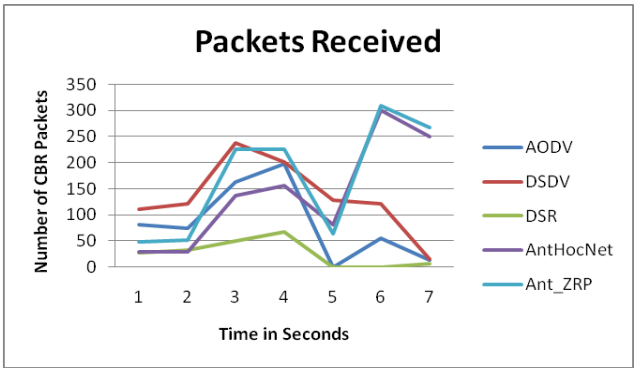


Fig. 4: Number of packets (data & control) received after each second - congestion

5. Conclusion

This paper proposes the enhancement to the ZRP routing with the help of ant colony optimization (ACO). The enhanced version of the protocol is compared with the other protocols of its category and with traditional protocols on the basis of various performance parameters like Packet Drop (Data Packets as well Control Packets), Number of packets received (Throughput) per second. It has been found that Ant_ZRP has shown the superior performance as compared to other protocols.

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