Modified Ant Colony Based Routing Algorithm in Manet

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Abstract— *In MANET, without the aid of any established infrastructure or centralized administration, a temporary network needs to be established whenever a node tries to send data to another node. Each node in MANET acts as an end system and also as a router for all other nodes in the system. In this paper we propose a new approach for routing data packets in MANET. The scheme is based on a specific criterion among the nodes, called "pheromone". Data packets are routed based on this "pheromone" value. In this paper, we have introduced modified ant colony based routing algorithm in MANET and this approach will reduce the computational overhead, end to end delay to a lot extent, increasing the packet delivery fraction rate.*

Keywords— MANET, Adhoc Routing, Ant Colony Based Routing, Heuristic approach in ant colony based routing.

I. INTRODUCTION

One of the most vibrant and active "new" fields today is that of ad hoc networks. Mobile Ad-hoc network is a set of wireless devices called wireless nodes, which dynamically connect and transfer information among them. Wireless nodes in MANET can be personal computers (desktops/laptops) with wireless LAN cards, Personal Digital Assistants (PDA), or other types of wireless or mobile communication devices.

Main problems in MANET can be classified as

1. Lack of central administration of any dedicated infrastructure
2. It is very open to attacks from both external and internal agents/ nodes.
3. Due to the dynamic nature of the network it requires to find a route each time before a new session of data transmission begins.
4. As the nodes are mobile, so finding of a route becomes more difficult when the mobility of nodes increases.

II. MOBILE ADHOC NETWORK(MANET)

As shown, the wireless node may be physically attached to a person, a vehicle, or an airplane, and should be able to enable wireless communication among them.

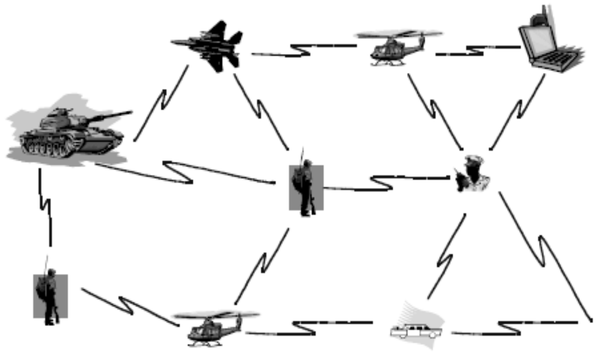

Fig. 1 BASIC STRUCTURE OF MANET

Wireless ad-hoc network have many advantages:

Low cost of deployment: Wireless Adhoc networks can be deployed on the fly; because no expensive infrastructure such as copper wires or data cables is required to build the network.

Fast deployment: Ad hoc networks are very convenient and easy to deploy since there are no cables involved. Deployment time is thus shortened.

Dynamic Configuration: Adhoc network configuration can change dynamically over time. When it is compared to configurability of LANs, it is very easy to change the network topology of a wireless network. MANET is basically a wireless network. So this is also applicable for MANET.

MANET has various potential applications. Some typical examples include emergency search rescue operations, meeting events, conferences, and battlefield communication between moving vehicles and/or soldiers.

Based on path establishment, routing protocols in ad hoc mobile wireless network can be generally divided into three groups [3].

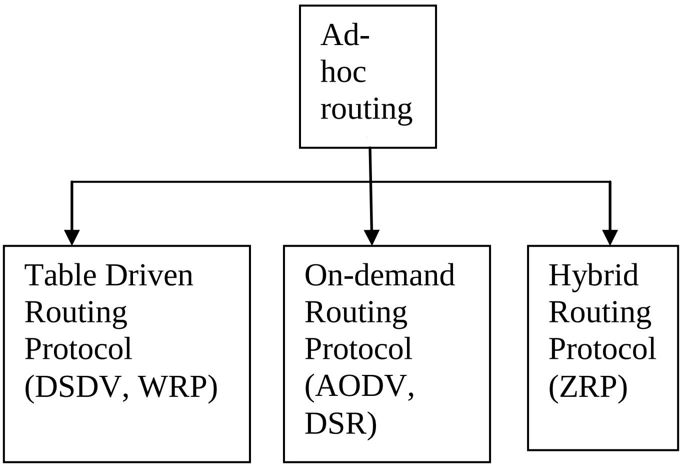

Fig.2 DIFFERENT ROUTING ALGORITHMS

Table driven protocols are also known as proactive routing protocols, in which every node in the network maintains complete routing information about the network by periodically updating the routing table. Thus, when a node needs to send data packets, there is no delay for discovering the route throughout the networks. Because the route information already exists in the node's routing table.

In **Source initiated or on demand or reactive routing protocol**, a node simply maintains routes to active destination that it needs to send data. The routes to active destination will expire after some time of inactivity, during which the network is not being used.

Hybrid routing protocols combine the features of both table driven and source initiated or demand driven routing. It requires less memory and processing power than table driven routing protocols.

III. ANT COLONY BASED ROUTING ALGORITHM

The traditional routing protocols face many problems due to the dynamic behaviour and resource constraints in MANET. To overcome this limitation, an approach based on a biologically-inspired mechanism has been applied.

The social organization of the ant is genetically evolved commitment of each individual to the survival of the colony. It is a key factor behind their success. Moreover these insect societies exhibit the fascinating property that the activities of individuals, as well as of the society as a whole, are not regulated by any explicit form of centralized control. This feature of non centralized control attracts the attention of using the principle of ant colony based algorithm as a routing algorithm in MANET.

Basic idea of the ant colony optimization meta-heuristic is taken from the food searching behaviour of real ants. When ants are on the way to search for food, they start from their nest and walk towards the food. When an ant reaches an intersection, it has to decide which branch to take next. While walking, ants deposit pheromone on the track, which marks the route taken. The concentration of pheromone on a certain path is an indication of its usage. That is, a path or route with higher pheromone concentration indicates that more ants have followed or gone through that path. With time, the concentration of pheromone decreases due to diffusion effects. This property is important because it is integrating dynamic nature into the path searching process.

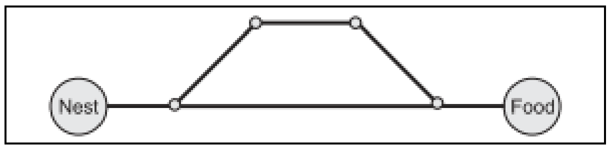

Fig.3 ALL ANTS TAKE THE SHORTEST PATH AFTER AN INITIAL SEARCHING TIME

In the above figure, a scenario with two routes from the nest to the food is shown. At the intersection, the first ant randomly selects the next branch. Since the below route is shorter than the upper one – as it has less number of intersections than the above one, the ants which take this path need to take less number of decisions while choosing a path and will reach the food place first. On their way back to the nest, the ants again have to select a path. After a short time the pheromone concentration of the smaller path is higher than on the longer path. Because the ants using the shorter route will increase pheromone concentration faster than the longer route. The shortest path will eventually be identified and all the ants will follow this route.

Ant colony optimization meta-heuristic algorithm uses the behaviour of the real ants. Every route can be represented as a graph of vertices and edges. G = (V, E) be a connected graph with n = | V | nodes. The simple ant colony optimization meta– heuristic can be used to find the shortest path between a source node v_s and a destination node v_d on the graph G. In MANET, the path length is given by the number of nodes on the path. Each edge e(i,j) connecting two nodes v_i and v_j has been associated with an artificial pheromone variable $\psi_{i,j}$ and it is modified by ants when they visit the node. To simulate the natural ant foraging process, three equations are used to depict the following three:

1> Pheromone increase,
2> Pheromone evaporation and
3> Path selection.

If an ant at node i and transitions to node j, $\psi_{i,j}$ of the edge gets modified by the below equation.

$$\psi_{i,j} = \psi_{i,j} + \Delta\psi \text{ ----- (1)}$$

Artificial pheromone gradually evaporates over time which is modelled by

$\psi_{i,j} = (1 - ג)\,\psi_{i,j}$ --------(2), this is also called global updating of pheromone.

where (1- ג) is the pheromone decrease factor. Here ג ε (0,1].

At each node the ant has to make a decision about the next hop over which to travel. An ant located in node v_i uses pheromone $\psi_{i,j}$ of node v_j ε N_i to compute the probability of node v_j as next hop, where N_i are the one step/ immediate neighbors of node v_i.

$$\boldsymbol{p}_{i,j} = \begin{cases} \dfrac{\psi_{i,j}}{\sum_{j \epsilon N_i} \psi_{i,j}} & if\ j\ \epsilon N_i \\ 0 & if\ j\ doesn't\ belong\ to\ N_i \end{cases}$$ ----

----(3)

IV. Modified Ant Colony Based Routing Algorithm

Challenges in MANET are the high change rate and in particular the limited bandwidth which conflicts with the continuous generation of ant packets.

As the bandwidth available in Wireless network is limited, routing along a single path may not provide enough bandwidth for a connection because of limited bandwidth. However, if multiple paths are used simultaneously to route data, the aggregate bandwidth of the paths may satisfy the bandwidth requirement of the application. Also since there is more bandwidth available, a smaller end-to-end delay may be achieved. In MANET, as nodes are in the wireless medium so the radio interference must be taken into consideration while designing a routing protocol.

Route Discovery Phase

Initial condition :

In MANET, initially pheromone value $\psi_{i,j}$ of each edge that is in between the sending and receiving nodes is set to 0.

1. When a packet arrives at a node, the node checks the routing table for destination v_d. In ARA, the route discovery is done either by the FANT (forward ant) flood technique [7] or FANT forward technique [8]. FANT is an agent that establishes the pheromone track to the source node.

2. a) In FANT (forward ant) flood technique, when a forward ant arrives an intermediate node, it's broadcasted to find a path to destination.

b) In FANT forwarding scheme, when a FANT reaches an intermediate node, node checks routing table to see if it has a route to destination over any of its neighbours in the routing table.

if yes,

then FANT is sent to only that neighbour

else

it's forwarded to all the neighbours.

In both the above approaches, a node receiving a FANT for the first time, will create a record in its routing table. Routing table entry at this stage should have three fields.

- destination address
- next hop
- pheromone value

3. a) When data packet is migrated from one node to another after the route setup, that is if a data packet is at node i and transitions to node j, $\psi_{i,j}$ of the connecting edge gets modified by the below equation.

$\psi_{i,j} = \psi_{i,jprev} + \Delta\psi$ ----- (1) In actual ant colony routing algorithm, it was like that. It has been modified to the following one in the proposed algorithm.

$\psi_{i,j}(t) = \rho.\ \psi_{i,j}(t\text{-}1) + (1\text{-}\rho)\ \psi_0$ --------(4) where ψ_0 = initial pheromone value.

Original equation in (1) has been modified to the above equation numbered as 4) in the proposed algorithm. Because previous equation does not consider the local-updating to make the desirability of route change dynamically: every time an ant uses an edge (edge depicts the route between the sending node to the received node) this becomes slightly less desirable than the edges which never belonged to a global best tour, for which the pheromone remains ψ_0. An interesting property of these local and global updating mechanisms is that the pheromone $\psi_{i,j}(t)$ of each edge is lower limited by ψ_0.

With this change, it gives much weightage on the last route found rather than initial pheromone track.

ρ is a parameter where $0 \le \rho \le 1$, usually it is set at 0.9. After each iteration ψ_0 changes and $\psi_0 = (n \cdot L_{nn})^{-1}$, where L_{nn} is the number of hops produced by the execution of one iteration without the pheromone component (this is equivalent to a probabilistic nearest neighbour heuristic) and n = number of iterations.

b) Artificial pheromones gradually evaporate over time which is modeled by equation 2.

c) At each node, the ant has to make a decision about the next hop over which to travel. An ant located in node v_i uses pheromone $\psi_{i,j}$ of node v_j ε N_i to compute the probability of node v_j as next hop, where N_i are the one step/ immediate neighbours of node v_i.

$$p_{i,j} = \begin{cases} \frac{\psi_{i,j}}{\sum_{j \epsilon N_i} \psi_{i,j}} & if\ j\ \epsilon N_i \\ 0 & if\ j\ doesn't\ belong\ to\ N_i \end{cases}$$

-------(3)

An ant located in node v_i uses pheromone $\psi_{i,j}$ of node v_j ε N_i to compute the probability of node v_j as next hop, where Ni are the one step/immediate neighbours of node v_i.

This probability calculation needs to be modified to include some parameters. For an ant k, the probability has to consider below two parameters.

- ✓ Attractiveness $\eta_{i,j}$ of the move, as computed by some heuristic indicating a priori desirability of that move. One way to measure ŋ is ŋ = 1/δ, δ = the inverse of number nodes between i and j.
- ✓ The trail level $\psi_{i,j}$ of the move, indicating how proficient it has been in the past to make that particular move.

An ant is a simple computational agent and it iteratively constructs a solution for the instance to solve. At the core of the ACO algorithm lies a loop, where at each iteration, each ant moves from a node to another corresponding to a more complete partial solution. That is at each step or iteration; an ant computes a set of feasible solutions to its current node and moves to one of these as per the probability computation. So the probabilistic value calculated in eq. 3 will be modified to the following.

$$p_{i,j} = \begin{cases} \frac{[\psi_{i,j}] \exp(\alpha) * [\eta_{i,j}] \exp(\beta)}{\sum_{j \epsilon N_i} [\psi_{i,j}] \exp(\alpha) * [\eta_{i,j}] \exp(\beta)} & if\ j\ \epsilon N_i \\ 0 & if\ j\ doesn't\ belong\ to\ N_i \end{cases}$$

α and β parameters specify the impact of trail and attractiveness, respectively. Or in other way, α is a parameter to control the influence of $\eta_{i,j}$. Here, α and β are user-defined parameters. 0≤ α, β ≥ 1 As per [16], optimal settings of the algorithm are α = 1, β = 5 give the optimal solutions.;

4. For each FANT (currently in node i),

do

a) Choose the neighbour node in which to move to using the equation 4. That is for which neighbour, this probability value will be more - that route/neighbour needs to be considered.

b) Add that node to neighbour pheromone table with the node, pheromone value between these two nodes until the ant has reached the destination.

end for

5. The whole process mentioned above gets repeated until the forward ant (FANT) reaches the destination node.

6. When FANT reaches the destination, it is sent back along the path it came as a Backward Ant (BANT). BANT is also an agent that establishes the pheromone track to the destination. Nodes modify their routing table information accordingly following the equation 4.

Route Maintenance

1. Once FANT and BANT have established the pheromone tracks for the source and destination nodes, data packets are sent over the route.

2. Similar to the nature established paths do not keep their initial pheromone values forever. When a node v_i sends a data packet towards the destination v_D to a neighbour node v_j, it increases the pheromone value of the entry (v_D, v_j, ψ) by Δψ. That is, the path to the destination is strengthened by the data packets.

3. In contrast, the next hop v_j increases the pheromone value of the entry (v_s, v_i, ψ) by Δψ. i.e the path to the source node is also strengthened. The evaporation process of the real pheromone is simulated by regular decreasing of the pheromone value according to equation 2.

Route Failure Handling The third and last phase of the routing algorithm handles routing failures, which are caused especially through node mobility and thus very common in mobile ad-hoc networks.

1. The modified ant colony based routing algorithm recognizes a route failure through a missing acknowledgement. If a node does not receive an acknowledgement within the time-out period, it generates a ROUTE-ERROR message for the link;
2. It first deactivates this link by setting the pheromone value to 0.
3. The node searches for an alternative link in its routing table.

a) If there exists a second link it sends the packet via this path.

b) Otherwise the node informs its neighbours, hoping that they can relay the packet.

CONCLUSIONS

The foraging behavior of the ant colonies has been extensively investigated for more than 50 years and has been explored the remarkable trail systems achieved through robust, decentralized communication. Their collective intelligence has been shown to be one of the best examples of self-organization. Early research revealed their ability to detect shortest paths in static environments, whereas recent research discovered fundamental mechanisms in the foraging systems for the dynamic systems as well. However, it requires improving the proposed algorithm to have security to fight against the different types of security attacks in MANET like Black-Hole attack, Gray-Hole attack and address spoofing. .

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