Application of ant colony optimization for Multicasting in MANET

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Abstract- The advent of ubiquitous computing and the proliferation of portable computing devices have raised the importance of mobile and wireless networking. at the same time ,the popularity of group-oriented computing has grown tremendously .However, little has been accomplished to–date in bringing together the technologies for group-oriented communication and mobile networking. In particular, most modern wireless/mobile and ad hoc networks do not provide support for multicast communication. A major challenge lies in adapting multicast communication to environments where mobility is unlimited and outages/failures are frequent. Ant colony optimization (ACO) algorithm is a novel population-based meta-heuristic search Algorithm for solving difficult discrete optimization problems, inspired by the foraging behavior of real ant colonies .it has been applied to TSP, QAP, Scheduling and graph coloring etc. In this paper we develop an efficient heuristic ant colony algorithm for multicast routing; this algorithm can find optimal solution quickly and has a good scalability.

Index Terms-ACO, CBT, MANET, Multicast Routing, PUMA, QoS, TSP.

1. INTRODUCTION

A mobile ad hoc network (MANET) is a collection of wireless mobile nodes that forms a temporary network without a centralized administration and wired infrastructure. Mobile nodes communicate with each other over multi-hop wireless links. Design considerations of MANET routing protocols differ from wired network routing protocols, since a MANET is characterized by node mobility, ad hoc nodes, node/link unreliability, limited bandwidth, high error rates, security risk, etc. The primary goal of a MANET routing protocol is to establish an efficient route between the communicating nodes to achieve the following: timely delivery of messages; reduce packet losses; provide more stable connectivity and reduce routing control overheads.

Multicasting is the ability of a communication network to accept a single message from an application and deliver copies of this message to multiple recipients at different locations [1]. With the rapid development of the commercial use in internet, multimedia multicast application that satisfies the QOS Constraints attracts more and more research attention. In order to support multicast, efficient multicast routing is crucial. For delay-sensitive multimedia applications, such as real-time teleconferencing, etc.it seems more important to find a delay-constrained minimum-cost multicast tree, which has been proven to be a NP-complete problem [2]. Currently many heuristics algorithms have been proposed, most of which are centralized or centralized in nature such as BSMA (bound shortest multicast algorithm) [3], KMB[4] and CBT [5], etc.Recently, some algorithms based on genetic algorithm are also proposed [6,7,10], which are centralized algorithms, too.the research on distribution algorithms is relatively less.

Ant colony optimization (ACO) is an agent-based heuristics algorithm inspired by the behavior of real ants finding food [8]. The ACO has the distributed and adaptive characteristics, which endow it with excellent performance in solving the NP-hard problems.

This paper presents a novel multicast routing scheme using ant colony optimization. The scheme tries to construct the minimum-cost tree using the local information in the case that the source node does not possess the whole network information. Combined the characteristics of multicast routing, the algorithm was improved, which accelerated the convergence speed and obtained better result.

2. RELATED WORK:

Several algorithms based on ACO consider the multicast routing as a mono-objective problem, minimizing the cost of the tree under multiple constraints. In Liu and Wu propose the construction of a multicast tree, where only the cost of the tree is minimized using a degree constraints. On the other hand,Gu et al. considered multiple parameters of QOS as constraints, minimizing just the cost of the tree .it can be clearly noticed that previous algorithms treat the multicast traffic engineering problem as a mono-objective problem with several constraints. Then main disadvantage of these approaches is the necessity of an a priori predefined upper bound that can exclude good practical solutions.

Hiroshi Matsuo et al. [11] Accelerated Ants-Routing which increase convergence speed and obtain good routing path is discussed. Experiments on dynamic network showed that accelerated Ants-routing learns the optimum routing in terms of convergence speed and average packet latency.

Ravindra Vaishampayan et al. [12] proposed the protocol for unified multicast through announcements (PUMA) in ad-hoc networks, which establishes and maintains a shared mesh for each multicast group, without requiring a unicast routing protocol or the pre-assignment of cores to groups. PUMA achieves a high data delivery ratio with very limited control overhead, which is almost constant for a wide range of network conditions.

3. ANT COLONY ALGORITHM:

Ants are capable of finding the shortest path from a food source to their nest, and are adaptive to change in the environment for finding a new shortest path once the old path is no longer feasible. on the way ants deposit pheromone, a kind of cumarin which ants are able to smell by which they marks the route taken. the concentration of pheromone on a certain path is an indication and with time the concentration of pheromone decreases due to diffusion effects. This behavior explains how they can find the shortest path.

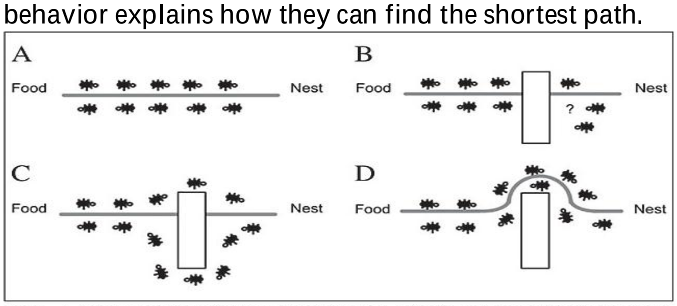


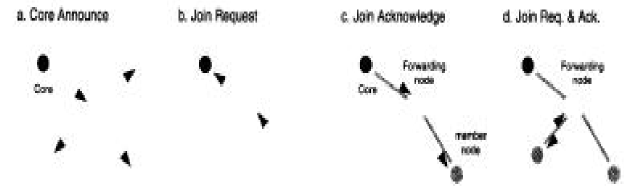
Figure A. Ants in a pheromone trail between nest and food; B. an obstacle interrupts the trail; C. ants find two paths to go around the obstacle; D. a new pheromone trail is formed along the shorter path.

Fig 1. Ants Finding Shortest Path

Figure 1 shows the ANT colony optimization Meta-heuristics with two routes from the source (nest) to destination (food).At the intersection (node B) ant's select different branch. Since the below route is shorter than the upper one, the ants which take this path will reach the destination (food) first. After a short time the pheromone concentration on the shorter path will be higher than on the other path, because the ants using the shorter path will increase the pheromone concentration faster. Thus the shortest path will be identified.

3.1 PROPOSED ALGORITHM:

3.1.1 Group Construction:



Core Announce:

Initialize: Source=Core; Announce itself as the core by flooding the announce message. Core accepts the join requests from the other node in the network and regularly floods the core announce message to announce group existence. A sender (Source) plays the role of the core.

Join Request:

If a node wants to join the currently existing group, the node forwards the Join request message to a selected node of its neighboring nodes. If the selected node is not the core, the selected node again forwards the message to the one of its neighbor's nodes. If the selected node is the core, then it forwards join acknowledge message to accept the join request.

Join Acknowledge:

If a node receives the join request message, it sends the join acknowledge message. The message moves along the opposite direction by which the join request Message has been delivered. If a node which received a join request message is not a member of the Multicast group maintained by the core, the node is included as one of forwarding node in the group.

Join request and Ack:

If the message is delivered finally to the node that sent the join request Message, the node becomes the member of the group. Any node including the core in a multicasting group can accept the join Requests made by the other nodes in the group.

3.1.2 *Multicast Route construction*:

1. Let N= {1,….,N} be a finite set of nodes in the current ad-hoc Network. For each node i belong to N, we define Ni as the set of the Neighboring nodes. A node j is in Ni if j is in the propagation range of i. The Pheromone τ of each node (ant) consists of two components for a given node I belongs to N:

a) Di denotes how far i is located from the core in terms of number of hops.

b.) Si signifies how "safe" the path from i to core is. This is calculated from the pheromones of the neighbor's nodes and the node's "communication time" with its neighbor nodes.

2. Distance updates (Di):

The distance measure Di for a non-core node I is updated as Follows:

$$D_i = \min_{j \in N_i} \tau_{j \to i}(D_j) + 1. \qquad (1)$$

If i is the core, Di is set to 0.

3. Safe Path Update (Si):

Let t be the current time and tij be the time when the nodes I and j .Started their communication or the time the node j was registered As a neighbor node of i.

a) If i is the core, set Si to an arbitrary chosen constant.

b) For a non-core node i, Si is updated(after Di is updated) as:

$$S_i = \sum_{j \in N_i^*} \tau_{j \to i}(S_j) \cdot (1-\mu)^{(\Delta t_{ij} - \Delta t_i)^+}, \qquad (2)$$

4. Re-evaluation of Node Safety:

$$(1-\mu)^{(\Delta t_{ij} - \Delta t_i)^+} \in (0,1) \qquad (3)$$

An approximate probability that one of the links along the path. Between the nodes i to the source do not go down.

5. Join Request: The node i decide to which neighbor node to send its join request

Message from Ii component as follows:

$$\arg\max_{j \in N_i - V_i} S_i(j) \cdot \alpha^{\tau_{j \to i}(D_j) - D_i + 1}, \alpha \in (0,1), \qquad (4)$$

Where Vi is the set of the nodes that a Join Request sent to i from a node in N had already visited, and α controls the degree of emphasis on the relative distance difference. For the smaller α, the node whose distance is shorter than the node i's is Emphasized more.

a) Eliminating the nodes in Vi in eqn(4) ensures no looping of the Join request message.

b) If Ni = Vi, the node i retries after some interval.

6. ACO and multicasting route construction method: The pheromone is evaporated with a given evaporation factor Similar to the usage of µ in eqn.(2).the probabilistic rule that Determines the probability of moving from a vertex i to j, Pij in The solution graph at step k of ACO is updated by:

$$P_{ij}(k) = \frac{\phi_{ij}(k)^{\delta} \eta_{ij}(k)^{\theta}}{\sum_{l \in N_i} \phi_{il}(k)^{\delta} \eta_{il}(k)^{\theta}}, \delta, \theta \geq 0, \qquad (5)$$

Where ϕij is the merged pheromone for the edge (i,j) in the Solution graph and ηij is called visibility value that is used for Heuristic evaluation for the edge (i.j) and δ and θ are control Parameters

3.1.3 *Multicast Group Maintenance:*

Pheromone Update: The algorithm applies the methodology of CBT for detecting the breaks of multicasting routes with some adaptation for MANET. By using Pheromone message (Hello) the breaks are detected and by Flush Tree message the roots are reconfigured. Each node sends regularly it's Hello message to it's neighbor Nodes to announce its existence. If for a certain period the Hello message from a node is not received, the node is regarded as dead. Once a node receives a Pheromone Update message, the node Updates its pheromone components and sends its pheromone to it's neighbor nodes by it's pheromone Update message.

Group construction Phase: If node i sends Join acknowledge message to node j, i becomes a Parent node of j and j becomes a child node of I. If for a certain period a node did not receive Hello or Pheromone Update message from its parent node, it detects a route break and Sends a Flush Tree message to it's nodes to report break. Every node which receives a Flush Tree message from its parent node needs to forward the message to it's child nodes. If a member node receives the Flush Tree message from it's parent node, the node sends it's Join Request message again to reconfigure it's multicasting routes

Core announce message: The core floods the Core Announce message every core Announce Interval. If a non-core node does not receive the message during this interval, the node regards the group as being lost and deletes the group information. Every node except the core node sends its Join Request message again if the amount time in Join Request Interval passes. If every node in a multicasting group does not receive a Join Request message during the interval from its child node, the child node is eliminated from its child node set. If forwarding node does not receive the message during the interval, the node withdraws from the forwarding node.

4. SIMULATION SCENARIO

The goal of the simulation is to evaluate the performance of MAODV with ANT Colony Algorithm under a range of various scenarios. The simulation model was built in NS-2, a network simulator that provides support for multicasting multi-hop wireless networks.

The simulations were carried out using a wireless ad-hoc environment consisting of 50 wireless mobile nodes roaming over a simulation area of 1000 meters x 1000 meters flat space operating for 600 seconds of simulation time with a radio transmission range of 250 meters. Constant Bit Rate model is used for data flow and each data packet size is taken to be 512 Bytes, with maximum speed from 0 m/s to 20 m/s. each node starts its journey from a random location to a random destination with a randomly chosen speed.

The pause time is taken as 10 seconds. The network traffic load is kept at 10 packets per seconds through out the simulation. For fairness, identical mobility and traffic scenarios are used across the compared protocols. only one multicast group was used for all the experiments.

Packet Delivery Ratio

Packet Delivery ratio is defined as the percentage of data packets received by the receivers. This ratio represents the routing effectiveness of the multicast protocol. To evaluate the effects of mobility the speed is varied from 0 m/s to 20 m/s.it shows that packet delivery ratio of the protocols slightly decreases with the increase in speed.

Fig. 2 Analysis of Packet Delivery Ratio

Figure 2 shows the analysis of packet delivery ratio as a function of mobility. It was observed that the packet delivery ratio of ANT Colony Algorithm is improved than that of MAODV.

Control overhead

Control packet overhead is defined as the ratio of number of control packets transmitted per data packets delivered. Figure 3 shows the performance analysis of control overheads for ANT Colony Algorithm and MAODV.It was analyzed that the control overhead is reduced for ANT Colony Algorithm than that of MAODV.

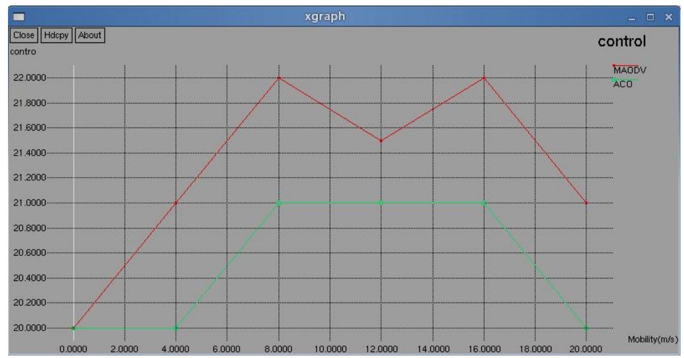


Fig 3 Analysis of Control Overhead

Group Reliability

Group reliability decreases with increase in mobility. ACO shows better group reliability than MAODV. Reduction in group reliability takes place at higher speeds due to either a group member moving out of range of reliable node or change of reliable nodes and intermediate nodes.

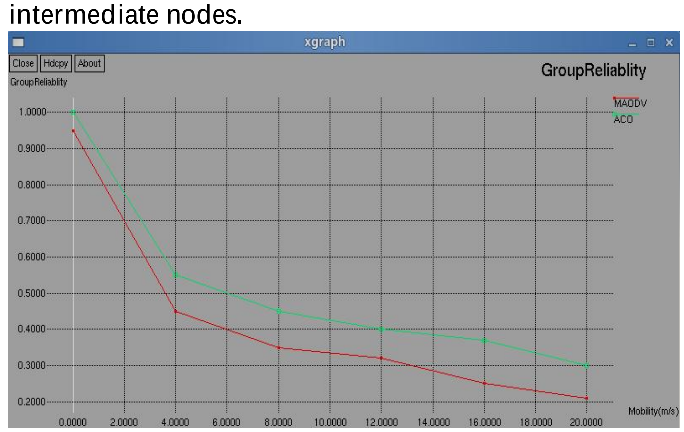


Fig 4 Analysis of Group Reliability

Packet Latency

Latency is an expression of how much time it takes for a packet of data to get from one designated point to another. In some usages latency is measured by sending a packet that is returned to the sender and the round-trip time is considered the latency. Packet latency value of MAODV is much higher than that of ACO. Owing to reliable node selection in backbone, ACO is efficient in packet delivery for groups with larger size.

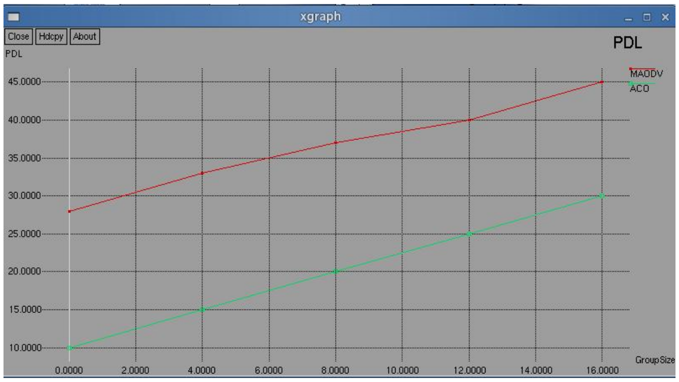


Fig 5 Analysis of Packet Latency

Route Discovery Time

Route discovery time is defined as the total time taken to find route from source to all members of the multicast group. Route discovery time varies with backward load and mobility. Route discovery time is more for ACO as compared to MAODV protocol due to multiple core selection.

Fig 6 Analysis of Route Discovery time

Routing Load

The normalized routing load is the ratio of no. of routing packets and the total no. of packet received. The routing load of ACO is signify-cantly less as compared to the MAODV routing protocol.

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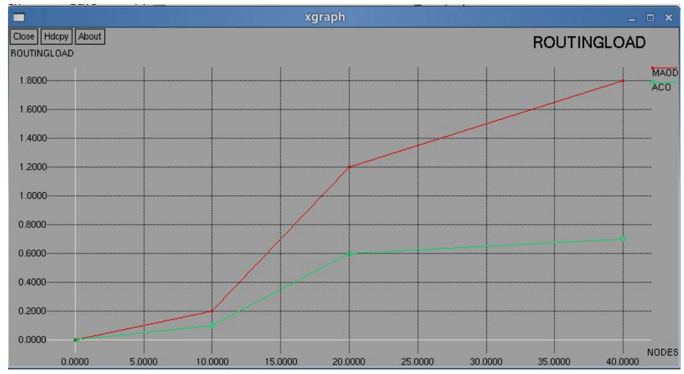

Fig 7 Analysis of Routing Load

CONCLUSION

The availability of alternate route in ANT colony based provides less robustness to mobility. Simulation results show that ANT colony based algorithm is better than MAODV for packet delivery ratio. And while looking at the control overhead ANT colony based Algorithm is better than MAODV.It was suggested that in future multicast protocol evolutions need to be more comprehensive. Evolutions should consider a range of realistic mobility models and should include special cases, such as high density and high traffic rates.

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