An Improved Ant Colony Otimization (IACO) Based Multicasting in MANET

Deepender Dhull, Swati Dhull

Abstract— A Mobile Ad hoc Network (MANET) is one of the challenging environments for multicast. Since the associated overhead is more, the existing studies illustrate that tree-based and mesh-based on-demand protocols are not the best choice. The costs of the tree under multiple constraints are reduced by the several algorithms which are based on the Ant Colony Optimization (ACO) approach. The traffic-engineering multicast problem is treated as a single-purpose problem with several constraints with the help of these algorithms. The main disadvantage of this approach is the need of a predefined upper bound that can isolate good trees from the final solution. In order to solve the traffic engineering multicast problem which optimizes many objectives simultaneously this study offers a design on Ant Based Multicast Routing (AMR) algorithm for multicast routing in mobile ad hoc networks. Apart from the existing constraints such as distance, delay and bandwidth, the algorithm calculates one more additional constraint in the cost metric which is the product of average-delay and the maximum depth of the multicast tree. Moreover it also attempts to reduce the combined cost metric. By reducing the number of group members that participate in the construction of the multicast structure and by providing robustness to mobility by performing broadcasts in densely clustered local regions, the proposed protocol achieves packet delivery statistics that are comparable to that with a pure multicast protocol but with significantly lower overheads. By this protocol we achieve increased Packet Delivery Fraction (PDF) with reduced overhead and routing load. By simulation results, it is clear that our proposed algorithm surpasses all the previous algorithms by developing multicast trees with different sizes.

Keywords— ACO, AMR, APPMULTICAST, MANET

I. INTRODUCTION

A Mobile Ad Hoc Network (MANET) is a kind of wireless ad hoc network and is a self-configuring network of mobile routers (and associated hosts) connected by wireless links-the union of which forms an arbitrary topology. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet. Mobile ad hoc networks became a popular subject for research as laptops and 802.11/Wi-Fi wireless networking became widespread in the mid to late 1990s.

A Mobile Ad hoc Network (MANET) is a set of mobile nodes which communicate over radio and do not need any infrastructure . This kind of networks are very flexible and suitable for several situations and applications, thus they allow the establishing of temporary communication without pre-installed infrastructure. The interfaces exhibit limited transmission range to facilitate communication between two nodes. Many intermediate nodes have been involved to relay communication traffic. Therefore, this kind of networks is also called mobile multi-hop ad-hoc networks.

In order transmit data to a subset of destination nodes in a computer network multicast consists of simultaneous data transmission from a source node. Multicast routing algorithms are used in radio and TV transmission, on demand video and teleconference. End-to-end delay, minimum bandwidth resources and cost of the tree are the main QoS parameters which are included in the multicasting. Thus the traffic engineering multicast problem should be treated as a multi-objective problem. In this study, an Ant Based Multicast Routing (AMR) algorithm for multicast routing in mobile ad hoc networks has been proposed to solve the Traffic Engineering Multicast problem that optimizes several objectives simultaneously. This algorithm calculates one more additional constraint in the costs metric which is the product of average-delay and the maximum depth of the multicast tree and tries to minimize this combined cost metric.

1.1 Multicasting:

Multicasting is the transmission of data grams to a group of hosts identified by a single destination address Multicasting is intended for group-oriented computing. There are more and more applications where one-to-many dissemination is necessary. The multicast service is critical in applications characterized by the close collaboration of teams (e.g. rescue patrol, battalion, scientists, etc) with requirements for audio and video conferencing and sharing of text and images. The use of multicasting within a network has many benefits. Multicasting reduces the communication costs for applications that send the same data to multiple recipients Instead of sending via multiple unicasts, multicasting minimizes the link bandwidth consumption, sender and router processing, and delivery delay.

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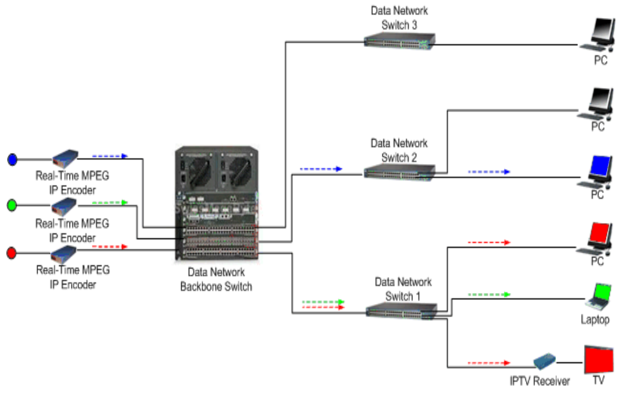

Fig. Multicasting

Maintaining group membership information and building optimal multicast trees is challenging even in wired networks However, nodes are increasingly mobile. One particularly challenging environment for multicast is a mobile ad-hoc network MANET.

A MANET consists of a dynamic collection of nodes with sometimes rapidly changing multi-hop topologies that is composed of relatively low-bandwidth wireless links. Since each node has a limited transmission range, not all messages may reach all the intended hosts. To provide communication through the whole network, a source-to-destination path could pass through several intermediate neighbor nodes. Unlike typical wire line routing protocols, ad hoc routing protocols must address a diverse range of issues. The network topology can change randomly and rapidly, at unpredictable times.

Since wireless links generally have lower capacity, congestion is typically the norm rather than the exception. It is observed that typical multicast protocols are geared toward and optimized for particular scenarios. Therefore, when they are deployed in different scenarios, their performance may vary significantly. Furthermore, they may incur unreasonable amounts of overheads in certain scenarios. The creation and maintenance of the multicast structure could be heavyweight as their operations require control messages to be exchanged among the constituent nodes in the network. In cases of high mobility, wherein the constructed multicast structure tends to stale fairly quickly, there is a need for the periodic invocation of control messages with high frequency.

Broadcasting provides several basic advantages. First, it does not require the creation of any delivery structure. Second, there is a natural redundancy in broadcasting due to multiple rebroadcast nodes. This redundancy provides extra robustness in conditions of mobility. Therefore, broadcasting is preferable for use in the scenarios with large group members or in case of high mobility. On the negative side, broadcasting would attempt to deliver the packet to all the nodes in the network regardless of who the intended recipients are. This property of broadcasting leads to many redundant data transmissions and renders it an unsuitable choice in scenarios with a small number of group members.

Ant agent based adaptive, multicast protocol that exploits group members' desire to simplify multicast routing and invoke broadcast operations in appropriate localized regimes has been proposed. By reducing the number of group members that participate in the construction of the multicast structure and by providing robustness to mobility by performing broadcasts in densely clustered local regions, the proposed protocol achieves packet delivery statistics that are comparable to that with a pure multicast protocol but with significantly lower overheads.

1.2 Some other MANET Multicast Routing Algorithms

Existing MANET multicast routing algorithms use a hybrid of link state and distance vector algorithms to create a source tree. As mentioned before, multicast is a relatively new topic in the field of MANETs, and only a few algorithms have been proposed. Examples of some MANET multicast algorithms are

1.2.1 Position-Based Multicast (PBM)

PBM a forwarding node uses information about the positions of the destinations and its own neighbors to determine the next hops that the packet should be forwarded to. It is thus very well suited for highly dynamic networks.

1.2.2 Application Layer Multicast with Network Layer Support (APPMULTICAST)

APPMULTICAST is an efficient application layer multicast solution suitable for medium mobility applications in MANET environment. We use network layer support to build the overlay topology closer to the actual network topology.

1.2.3 Robust Demand-driven Video Multicast Routing (RDVMR)

Our protocol uses a novel path based Steiner tree heuristic to reduce the number of forwarders in each tree, and constructs multiple trees in parallel with reduced number of common nodes among them.

1.3 Multicast Tree Algorithm

The algorithm utilizes shortest path information, which can be obtained from unicast routing tables for fully distributed implementation.

Progressively Adapted Sub-Tree in Dynamic Mesh (PAST-DM)

In PAST-DM the virtual mesh topology gradually adapts to the changes of underlying network topology in a fully distributed manner with minimum control cost. The multicast tree for packet delivery is also progressively adjusted according to the current topology.

Multicast AODV (MAODV)

In MAODV, control of the multicast tree is distributed so that there is no single point of failure.

On-Demand Multicast Routing Protocol (ODMRP)

ODMRP applies on-demand routing techniques to avoid channel overhead and improve scalability. It uses the concept of forwarding group, a set of nodes responsible for forwarding multicast data on shortest paths between any member pairs, to build a forwarding mesh for each multicast group

1.4 Problem Identification and Description

There are two threats posed by a compromised router: the attacker may attack by means of the routing protocol (for example, by sending false advertisements) or by having the router violate the forwarding decisions it should make based on its routing tables. The first situation is often referred to as an attack on the control plane, while the second is termed an attack on the data plane. These threats have a major impact on QoS. Previous approaches to dealing with router misbehavior have primarily focused on protecting routers within a single autonomous system. Perlman suggested the use of hop-by-hop acknowledgements to expose misbehavior. However, this adds considerable overhead for each router along the path and significantly increases traffic in the Internet with all of the extra acknowledgments that must be sent. Another method proposed involves route tracing, but an intelligently misbehaving router would be able to identify a test packet and thereby avoid detection. A more sophisticated approach for identifying router misbehavior was proposed by Bradley et al. While his approach is attractive for monitoring misbehavior within a small autonomous system, the state requirements for each router are prohibitive in a larger network setting such as the Internet.

II. PROPOSED MODEL DESCRIPTION

We improve the QoS of an Ant System Based Multicasting in Mobile Ad Hoc Network by introducing IACOR which is an improvement to the ACO algorithm introduced by Marco Dorigo for Wireless networks. AntNet is a routing protocol for packet switched networks, invented by M. Dorigo and G. Di Caro. It is an alternative routing algorithm for the well-known OSPF protocol, based on Ant Colony Optimization (ACO). ACO studies the behavior of ants in a colony and mimics this behavior in software. The problem to be solved is represented by a graph. Artificial agents, i.e. software ants, gradually construct paths in this graph. This phase is repeated until an optimal (or in some cases a sub-optimal) solution is found. ACO has been applied to many domains, e.g. the Traveling Salesmen Problem, manufacturing control systems, etc. A good overview of the ACO meta-heuristic and a number of applications can be found in ACO itself is a metaheuristic. When combined with an actual problem area, it can lead to several heuristics. AntNet is a result of the application of ACO on the problem of Internet routing. Intelligent agents, ants for short, are sent over the network. They communicate indirectly by information they leave behind in the routers on their path. Over time, this information leads to optimal routing paths between the routers in the network.

2.1 AntNet Algorithm

The operation of AntNet is based on two types of agents:

1. Forward Ants who gather information about the state of the network, and
2. Backward Ants who use the collected information to adapt the routing tables of routers on their path.

An AntNet router contains a special routing table where each destination is associated to all interfaces and each interface has a certain probability. This probability indicates whether or not it is interesting to follow that link in the current circumstances. The router also contains a statistical model to store the mean and variance values of the trip times to all destinations in the routing table. These are used as reference values. On a regular time base, every router sends a Forward Ant with random destination over the network. The task of the Forward Ants is collecting information about the state of the network. In each router they pass, the elapsed time since the start is stored on an internal stack together with the identifier of the router. Then the next hop is determined. Normally this is based on the probabilities in the routing table. There is however a small chance (exploration probability) that the next hop is randomly chosen. This is necessary to constantly explore the network and to be able to react fast to network changes like link failures or congestion. When the Forward Ant reaches its final destination again the elapsed time since the start and the identifier of the router Open Shortest Path First (OSPF), a distance-vector routing protocol, based on the Dijkstra algorithm, are stored on the stack of the ant. The Forward Ant is transformed into a Backward Ant. This Backward Ant will follow exactly the same path as the Forward Ant but in the opposite direction. The Backward Ants use the information collected by the Forward Ants to update the different data structures in each router along their path. The time information on the stack is compared with the model in the router and based on these comparisons, the probabilities in the routing table are updated. When the Backward Ant arrives in the start router, it dies. Backward Ants have a higher priority than data packets, so that they are processed as fast as possible making the algorithm more adaptive. Forward Ants have the same priority as data packets, to suffer the same delays so that the algorithm can react to network congestion. A trip time better than the mean value will boost the probability on that interface, while a bad trip time will only slightly increase the probability. The variance value is an indication for the stability of the network. A relatively large value indicates an unstable network state; a small value indicates a stable state. In an unstable state the effects on the probabilities are weakened as it is unsure that bad trip time indicates a long path.

2.2 Ant Colony Optimization System

The basic ideas of ACO are from the social search behavior of biological ant colonies. In nature, ants move around in their environment in a rather random way, but they have certain tendency to follow the walk of other ants. They can recognize these walks because, while moving, each ant leaves a chemical substance called pheromone on the ground. Sensing pheromone on a path increases the probability of an ant to follow it, which further reinforces this path. This mechanism has the effect that short paths between a starting point and a goal point are favored, leading to a kind of heuristic optimization behavior.

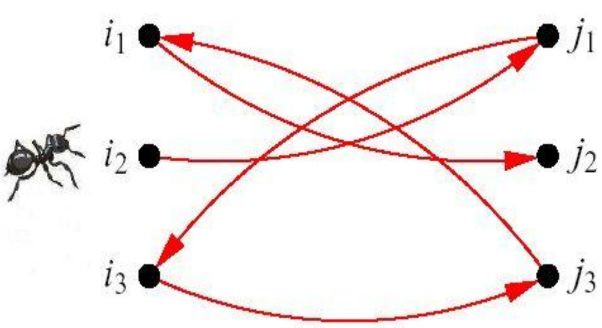

Fig. Ant Colony

The described principle is exploited for optimizing an arbitrary objective function of a combinatorial problem by simulating the walks of conceptual ants and by doing the re-enforcement of good walks based on a post-hoc evaluation of the objective. In the graph-based ant system [GutjahrOO], a directed graph (called "construction graph") is used as the basic structure on which the walks take place. The feasible solutions of the combinatorial optimization problem are encoded as paths on this graph. In each iteration, several ants are first positioned at the same node of the graph. Then, in successive steps, each ant chooses randomly a successor node of the node where it is currently located. The probabilities for the successor nodes are computed from "pheromone values" assigned to the arcs of the graph (and additionally from "visibility values," which are pre-evaluations of the suitability of possible continuations). After all ants have finished their walks, the walks are decoded as problem solutions and evaluated. The arcs on "promising" walks are then reinforced by pheromone increments. This process is iterated.

We exploit ACO in designing a method of multicasting route construction. An ant in ANMAS, unlike in ACO, is a node in MANET (not moving around the graph). It is the messages for multicasting that move around the "network graph." Based on the message information (pheromone), each node updates a deterministic (rather probabilistic) rule that determines where to send its join request message.

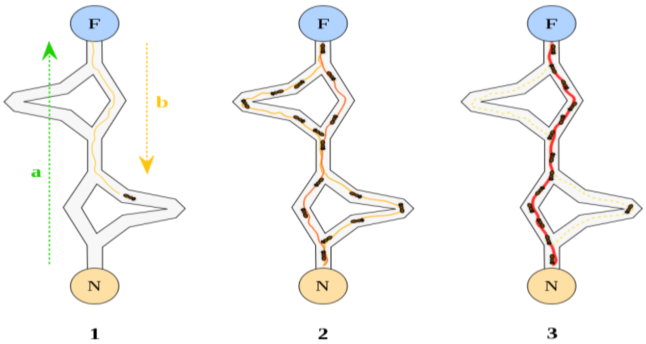

Fig. Ant Colony Optimization

III. ANT-SYSTEM-BASED QOS MULTICASTING ALGORITHM:

Multicast algorithm:

Step1: Backup-paths-set: For each destination node $m_i \in M$, Dijkstra K shortest path algorithm is used to compute the least-cost paths from s to m to construct backup-paths set. Let P_i be paths set for destination node i:

$$P_i = \{P_i^1, \ldots\ldots P_i^j, \ldots\ldots P_i^k\}$$

Where, P_i^j is the jth path for destination node i.

If the delay constraint is violated by some of the trees, then the cost is to be increased, so that it is likely to be rejected.

Step 2: Tree formation: In this algorithm, a multicast tree T is represented as an array of m elements:

$$T = \{P_1, P_2, \ldots\ldots P_m\} \qquad (2)$$

Where:

$P_i = P(s, m_i)$ = the path set selected from (1)

S = the source and m_i is the destination

Step 3: Path selection: When an ant moves from the node i to the next node j, the probability function of the ant choosing node j as the next node as follows:

$$f_{ij} = \begin{cases} \dfrac{[T_{ij}]^{\alpha}[\eta_{ij}]^{\beta}}{\sum u \in N_h(t)^{[T_{iu}]\alpha[\eta_{iu}]^{\beta}}} & \text{if } j \in N_h(i) \\ 0 & \text{otherwise} \end{cases} \qquad (3)$$

α and β are the relative importance of pheromone strength and the distance between nodes that affect an ant's judgment when choosing the next node to select.

Step 4: Pheromone update: The pheromone trail associated to every edge is evaporated by reducing all pheromones by a constant factor:

$$\tau_{ij} \leftarrow (1-P)\ \tau_{ij} \qquad (4)$$

Where, p ∈ (0, 1) is the evaporation rate. Next, each ant retracts the path it has followed and deposits an amount of pheromone $\Delta^{\tau ijth}$ on each traversed connection:

$$\tau_{ij} \leftarrow \tau_{ij} + \Delta\tau_{ij}^{h}, \quad \alpha_{ij} \in Sh \qquad (5)$$

The pheromone on a connective path (i,j) left by the m^{th} ant is the inverse of the total length traveled by the ant in a particular cycle. The formula is as follows:

$$\tau_{ij}^{h} = Q / Lm$$

In the above formula:

Q = A constant

Lm = $(C_j - C_i)$

Where:

C_i = cost of sub multicast tree node i

C_j = cost of sub multicast tree node j

To avoid the situation of Ci = Cj compute:

$$Lm = (C_j - C_i)^2 + 1 \qquad (6)$$

Step 5: Stopping criterion: The stopping criterion of the algorithm could be specified by a maximum number of iterations or a specified CPU time limit.

Problem formulation: The multicast tree will be determined on a particular set of nodes in which the delay can be measured between all nodes. A graph representation is considered as G = (V, E). V is the set of all vertices (end systems in the network) and E is the set of weighted, undirected edges between all nodes. Let us consider only networks in which all nodes are subscribers of the multicast group or one in which non-subscribers can be ignored. Edges are assigned weights corresponding to the bandwidth and delay between the nodes they connect:

- Cost of the tree (C)
- Average end-to-end delay (d)
- Maximum Depth (D)

We will compute the normalized product:

P = C*d*D

A multicast routing problem tries to find the multicast tree T that minimizes P. Bounding the maximum depth of the tree and therefore bounding the maximum hops, is a meaningful

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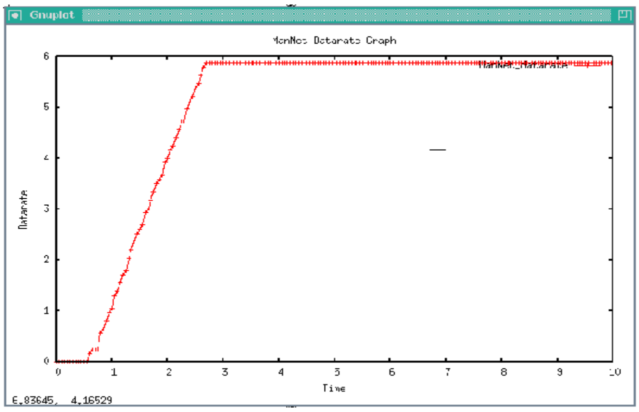
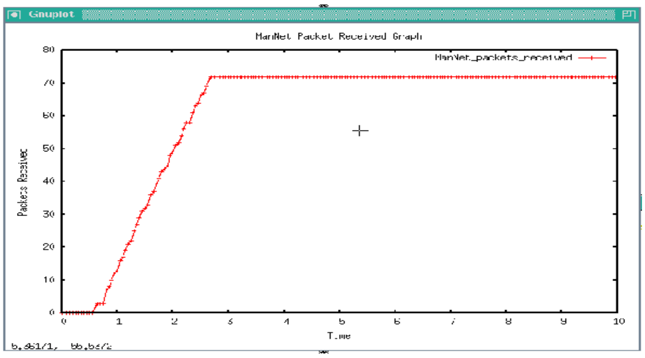
metric for networks in which Time to Live (TTL) is a parameter on messages. Reducing the number of hops between the root and the leaves reduces the number of failure points along any given root to leaf path.

IV. SIMULATION AND RESULTS

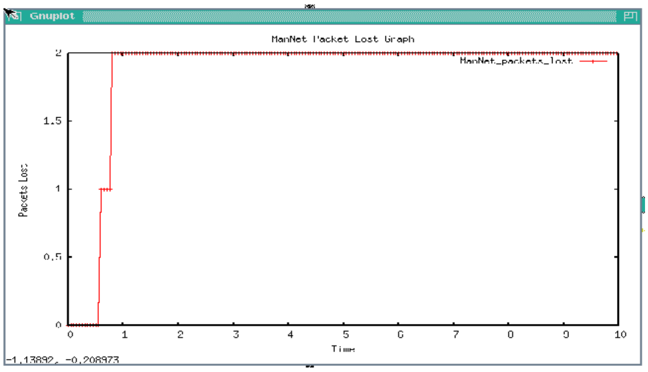
Data Rate



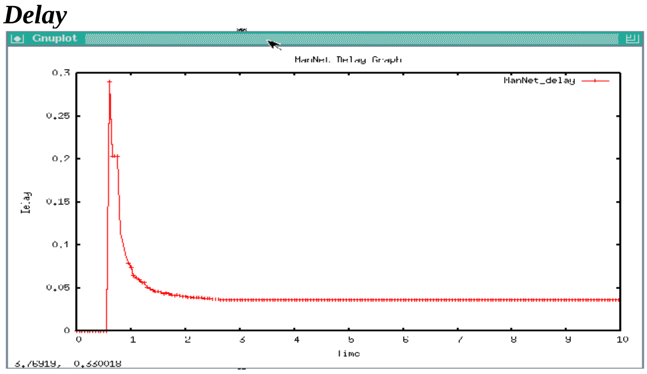
Packet Received



Packet Lost



Delay



V. FUTURE SCOPE AND CONCLUSION

In our work, we have used an efficient AntNet algorithm to detect the existence of compromise router with packet loss. Our approach makes use of the data structure used the mobile agents, where each agent collects local traffic information. We believe that our algorithm can improve the QoS of an Ant System Based Multicasting in Mobile Ad Hoc Network than the previous methods. The simulation is done in NS2, and the simulation results in the form of graph are given in the Simulation Result session such as data rate, packet received, packet lost and delay.

The purpose of the new method viz. Improved Ant Colony Optimization for Routing Algorithms was effectively implemented in the NS2 Environment and the Quality Of Service (QOS) parameters can be compared with the existing scenario and the improved representation can be shown as graphical analysis. The Performance Analysis and the Simulation Results were analyzed based on the Routing Algorithms.

Though ad-hoc networks are currently studied, more research has to be done to deploy this technology in a large scale to the market. Not only about routing issues, but also about security risks, social acceptance, and selfishness. If a user declines to route packets for other hosts, and he only wants to use the network as transport for himself, other hosts will not get service. Research should be done to avoid this. Furthermore, security risks should be taken in account. For instance, a host, like a laptop or a PDA, can be compromised by malware; thus affecting communications between nodes. Due to the distributed routing, a node failure will not be critical, but has to be studied. We think that perhaps AODV, already implemented in the Linux kernel, is a great candidate to act as a routing agent. However, real experiments should be done with real laptops and PDAs devices. Further simulations could also be done using another simulator. Both OPNET and QualNet are good candidates and have commercial support.

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