Survey Paper on Multicast Routing in Mobile Ad-hoc Networks

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***Abstract*— This paper surveys the various multicast routing protocols proposed for mobile ad-hoc networks. Some of the protocols use tree based approaches for creating multicast routes, some use graphs to construct multicast trees for routing, some protocol use the flooding approach to send multicast packets. This paper makes a detailed analysis and talks about the merits and demerits of various multicast protocols for mobile ad-hoc networks. The paper focuses on the number of control messages used in every protocol, the data structures used to maintain information, the merits of the protocol, the demerits and overhead involved during routing, the bandwidth utilized due to these message overheads. Also this paper studies the advantages and disadvantages of using trees, graphs and flooding for routing.**

Keywords—ad hoc networks, routing protocols, multicasting, wireless networks.

I. Introduction

Ad-hoc networks are dynamically changing networks, where routes have to be reconfigured due to the mobility of the nodes. Since there is not much radio propagation range for wireless devices, routes chosen will be often multihop [1], [2], [3]. Adhoc networks are mainly used for rescue operations and they are also used in battle fields. There is a change in the topology of ad-hoc networks due to constant mobility of nodes. Moreover, ad-hoc networks have limited bandwidth and battery power. So we need to constantly recompute the routes for forwarding packets to the destination [8], [9], [11]. The constantly changing network topology makes routing in ad-hoc networks a very challenging one. Since multicasting deals with forwarding packets to a set of destinations, we need to compute routes to the various destinations, taking into account the node mobility and the available bandwidth. Also careful precautions must be taken while choosing routes, as ad-hoc networks works on battery. There are several multicast protocols proposed for ad-hoc networks, we analyze a few of them. The various protocols surveyed in this paper are AM-Route [1], ODMRP [4], AMRIS [5], [10], Location Based Multicast in Mobile Adhoc Networks [6], Scalable Team Multicast in Wireless Ad-hoc networks exploring Coordinated Motion [7], and flooding. The rest of the paper is organized as follows. Section II presents an overview of the various multicast protocols, and the various merits and demerits of all these protocols. The protocols are compared on basis of the number of messages used for communication, the data structures used to maintain the nodes information, and the bandwidth constraints. Concluding remarks are made in Section III.

II. Multicast Protocols Review

A. Adhoc Multicast Routing (AMRoute)

This protocol uses a shared multicast tree approach. It runs over an underlying unicast channel. Dynamic core migration is allowed based on group membership and network configuration. The disadvantage of AMRoute [1], [10] is that it suffers from unbalanced traffic and vulnerability of the core. All multicast tree structures are fragile and must be re adjusted continuously as connectivity changes. And more over typical multicast trees need a global routing sub structure such as link state or distance vector, and frequent exchanges of these routing vectors or link state tables, due to constant topology change, causes excessive channel and computational overhead. As a result, most of the bandwidth is utilized for this purpose.

In AMRoute any group must have at least one logical core that maintains the multicast structure and the members. During the start each member assumes that they are the core of their own group, and the group size is one. Now the core periodically floods a join request to discover other mesh segments. When a node receives the message from a core of the same group but from a different mesh segment, it replies with a join-ack, and marks it as it meshes neighbor. Once the mesh is created each core sends a Tree-create packet periodically to its mesh neighbors for building the shared multicast tree. Members forward the non-duplicate create tree packets to others, which they have received from one of their mesh links. If a duplicate multicast tree create is received, then the node receiving the packet send a tree-createnak, along the incoming link. Any node wants to leave the multicast group sends a joinnak to their neighbors, and they stop forwarding any data for the group. The AMRoute protocol uses virtual mesh links to create the shared multicast tree, so as long as routes between multicast tree members exist through mesh links, the tree need not be re adjusted when there is a network topology change. So processing overhead is incurred only by the nodes that form the tree.

Since there are loops present a non-optimal tree is created when there is node mobility. Various messages used in AMRoute are: Join Request, Join Reply, Tree Create, Tree Create NAK, and Join NAK.

There are various points to be noted There is a channel overhead when sending the Tree Create NAK is used, to suppress the duplicates. With limited bandwidth available for ad-hoc networks this overhead needs to be avoided. The node that received a duplicate packet could have just ignored the packet. Join NAK, also increases the processing and channel overhead. A more efficient solution could be using a time out procedure, i.e. if a node wishes to leave the group issues no more join requests; as a result, the source or the logical core can remove this node from its routing table.

B. On-Demand Multicast Routing Protocol (ODMRP)

The second protocol this paper focuses on is ODMRP [4], [10], [12], This is a mesh based protocol, i.e. it uses a mesh of nodes which forward multicast packets through flooding within the mesh. This is an on demand routing protocol, and route information will not be saved permanently. Unlike AMRoute this protocol does not require the nodes to send explicit leave group messages. The multicast route information is established and maintained by source on demand.

This protocol has two phases a request phase and reply phase. Once a source has some multicast data to be transmitted, at that instant it does not have a routing table or the member information. All the routes and the member information created on demand. Instead the source floods a JOIN-DATA packet. When a node receives a non-duplicate packet, it stores the upstream node ID (used for backward learning) and re broadcasts the packet. When the packet reaches the receiver, the receiver creates a JOIN TABLE and broadcasts to its neighbors. When a neighbor receives this packet, it checks if the next node ID column, matches its own ID, if so it realizes that it is on the path to the source, i.e. it has to act as a forwarding node. As a consequence, a forwarding group is created from the source to the destination. Data is forwarded by a node if it is a forwarding node and the packet they receive is not a duplicate. Advantages of ODMRP are that it does not depend on an underlying unicast routing protocol. Moreover, in the case of link failures or signal loss, routes need not be re computed, as there is a redundancy of routes already, and an alternate route can be chosen to the destination. This protocol also allows scalability. The primary disadvantage is that, there are redundant routes in the network, and this consumes some amount of bandwidth. And if there are more nodes in the network, due to this high redundancy while computing routes, yields a poor performance. The various messages used in ODMRP are: Join Data and Join Table.

Data Structures used are: Member Table: Each Multicast receiver stores the source information in this table. Source ID and the time when the last JOIN Request was received from the source are recorded. Routing Table: It is created on demand and maintained by each node. The node stores destination (i.e. source of JOIN Request) and the next hop destination. Forwarding Group Table: When node is a forwarding node it maintains the group information. Message Cache: Maintained by each node to detect duplicates.

C. Ad hoc Multicast Routing protocol utilizing Increasing id numbers (AMRIS)

AMRIS [5], [10], [12], like AMRoute uses a shared tree for multicast data forwarding. Each node in the multicast session is assigned a multicast session member id (msm-id). The key idea in using msm id is to denote the logical height of the node at that particular instant in the shared multicast tree. It does not rely on an underlying unicast routing protocol like ODMRP. Like ODMRP, AMRIS has two mechanisms they are the Tree Maintenance and Tree Initialization. Nodes interested to join the Periodic beacon signals are sent to find out the existence of a neighbor. Initially a special node with id Sid broadcasts a NEW SESSION packet. The relation between Sid and msm id is that msm ids increase in value as they radiate away from Sid. This (NEW SESSION) packet includes the Sid's msm id. The neighbors upon receiving this packet calculate their own msm-ids and re broadcast the packet. The msm ids computed are not consecutive; this is to bridge the gap in case of link failures. Information derived from the NEW Session message is kept in the neighbor status table for up to t1 seconds. Random jitter is introduced before the New Session packet is re broadcast. A node joins the session by determining its parent, i.e. the neighboring nodes that have smaller msm ids. A unicast join is then sent to the potential parent, i.e. Join Req is sent and if the parent is in the delivery tree then it sends a Join ACK message, or that node will try to locate a potential parent for it. And a join ack is sent back through the reverse path, thereby drafting a branch to the node. The node receives all data through this branch. If no parent is found by unicast request to neighboring nodes, then a broadcast message is sent to locate a parent. If node is unable to locate a parent, then a BR (Branch Reconstruction) process is carried out.

The Tree maintenance mechanism operates in parallel in the back ground. When some link failure occurs, the node with higher msm id i.e. the child is responsible for re-construction of link. BR has two sub routines, BR1 and BR2, where BR1 is execute when the node has neighboring potential parent and BR2 when no neighboring potential parent is present. In BR1 a node sends a unicast message to neighbor parent, and the node sends a JOIN ACK, this process happens if the neighboring parent is on the multicast tree or else it sends JOIN NACK. Now BR2 is executed where a broadcast message is sent, and there is a restriction on the number of hops. If the node succeeds to find a parent, then it receives a JOIN-CONF. The control messages used are: JOIN REQ, JOIN ACK, JOIN NACK, JOIN CONF, NEW SESSION, and BEACON.

The data structures used are: Neighbor-Status Table: Maintains a list of neighbor and their msm id. Considerable points that require attention in AMRIS are: Flooding of packets must be done in r hops, where r is chosen arbitrarily based on the network topology and the battery power. Signal strength must be considered while choosing potential parents

D. Location Based Multicast in Mobile Adhoc Networks.

Location Based Multicast in Mobile Adhoc Networks use GPS (Global Positioning Systems) for identifying the nodes position [10]. The protocol defines a set of nodes residing in a geographical multicast region, i.e. if a host resides in a specific area at a given time, it will automatically be a member of a multicast region, and all the hosts in the region must receive the multicast packet, as a result there may be nodes that receive packets even though they might not be interested in receiving them. This protocol uses a technique similar to packet flooding; it does not compute a multicast tree or graph, since the overhead involved in re computing data structures for routing increases with rapidly changing network topology.

Concept of a multicast region and forwarding zone forms the back bone for this protocol. If a node needs to multicast data to all nodes that are currently located within a certain geo graphical region and this is called a multicast regions and it is represented by some closed polygon such as a circle or rectangle. Forwarding zone is defined so that the overhead in flooding is reduced. Here the packets are forwarded only if the belong to the forwarding region. This is a modification to flooding. In flooding we send packets to all destinations, but here packets are flooded only to destinations which belong to the forwarding zone. The membership of a forwarding zone is done using two schemes. In scheme 1 the source node is a rectangular region, and it is defined as the smallest region that includes current location of source and the multicast region. The source sends the co-ordinates of the forwarding zone in the multicast packet. In scheme 2, source send three parameters (a) the geographical center of the multicast region, (b)multicast region specification, (c) co-ordinates of source. When some node X receives this packet it checks whether it belongs to the multicast region or not.

E. *Scalable Team Multicast in Wireless Ad-hoc networks exploring Coordinated Motion*

Scalable Team Multicast in Wireless Ad-hoc networks exploring Coordinated Motion [7], [10] uses a new multicast paradigm called team multicast that is used for large scale ad hoc networks. Here the whole concept of multicasting is done as a team; no more individual receivers are there. All multicast packets are sent to a team instead of an individual. Again the basic assumption here is that the whole team is interested in the multicast session. This paper exploits the motion affinity which is present if a set of nodes have common interest. The protocol M-LANMAR uses tunneling from multicast sources to each landmark of the subscribed team and restricted flooding within the group. One more assumption made here is that multicast dynamics are on a per time basis, that is either join as a team or withdraw as a team from a multicast group. Also two or more teams can merge into a big one or one team can split into two sub teams.

A landmark for each team is first elected dynamically for a subnet. A subnet is a logical team which has a subnet address. There are two complementary routing schemes followed in LANMAR. One uses a myopic proactive routing scheme operating within limited scope centered at each node and exchanging route information about nodes up to only a few hops. The other long haul distance vector routing that propagates the elected landmark of each subnet and the path to it into the whole network. There are two routing tables one is the local routing table that maintains the direct routes to nearby destinations and the other is the land mark table that maintains routes to all landmarks from the source. Landmark nodes are elected on a threshold based mechanism. Here the land mark is elected if it knows more than n neighbors. In case of a tie, a node who knows the largest number of neighbors wins the election. The basic activities involved here are Join Multicast group, leave multicast group, data propagation.

Join Multicast group: Here each node keeps fresh routes to all landmarks in the network by periodic landmark updates. Using this landmark updates, a team maintains its membership to the multicast group(s). A join request is advertised by piggy backing the targeting group ID (address) on the landmark broadcast packet. These requests are propagated into the source with a few table exchanges. Memberships are constantly refreshed as each land mark includes subscribed multicast addresses to all outgoing land mark updates. Leave Multicast Group: When the multicast group wants to leave, its landmark removes the ID of that multicast group from its subscribed multicast group list. Thus the land mark will stop advertising the group. The landmarks entry will be updated at other nodes accordingly. Data Propagation: First the source node looks up the land mark table to find the subscribed land mark address(es). For the subscribed land mark a virtual link i.e. a tunnel, to the landmark and sends encapsulated multicast data. On receipt of this data the landmark floods packets with in the subnet so that each member receives the data.

Data Structures used are: Neighbor table for subnet Landmark table. Control Messages Exchanged: Join Request, Periodic messages to find neighbors, and Broadcast of landmark address to other subnets.

F. *Flooding*

It is the simplest scheme used for multicast routing. It can be used to deliver data packets within a group or to a set of receivers. Since packets are sent to all nodes, and nodes which are interested in the multicast session alone will accept the packets. This scheme is not used separately but they are used within certain multicast protocols.

III. CONCLUSION

AMRoute depends entirely on the underlying MANET unicast protocol. If the unicast protocol fails, then AMRoute fails. More over since it uses a shared tree approach, the core can be become congested and this may lead to failure of the core. In ODMRP the amount of control over head is less when compared to AMRoute, where we use 5 control messages where as ODMRP uses only 2. Though there is a sizeable performance improvement in terms of bandwidth usage, but still redundant routes cause a performance. As in AMRoute, AMRIS also suffers from congestion of the tree. And moreover due to the number of control message, lot of overhead is involved. Also over head is involved in calculation of msm ids. Also there is a potential problem, if we choose a smaller msm id as our parent, it could be such that, that node may be far away from us, thereby we have decreased signal strength, and the number of hops to the parent also increases, wasting the battery of intermediate forwarding ad-hoc nodes. Location Based protocol seems to better than other discussed so far, but frequent computation of position using GPS involves a lot of overhead. And more over nodes which are not interested to receive the packets are also forced to receive the packets. With certain modifications this protocol suite the changing ad-hoc environment. And the data structures used are to maintain the information of co-ordinates only, thereby the control overhead is reduced. In Scalable Team Multicast the number of control messages exchanged for multicast are far very less when compared to other protocols. But the protocol suffers from the fact that all team members will receive packets, because it makes an assumption that all team members are interested in the multicast session. And more over the way how teams are formed does not take into account that all members in team have same interest. It is just based on the number of hops, and more over if the team size increases, there will be congestion, and the overhead of marinating tables will be high. In flooding there are a lot of overhead involved if the number of receivers is more. Flooding can also cause channel overhead and congestion. Therefore, proposing new routing protocol is needed.

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