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Multicasting in Ad Hoc Networks

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Abstract *– An ad hoc network is a dynamic wireless network with the engagement of cooperative nodes without a fixed infrastructure. Multicasting is intended for group communication that supports the dissemination of information from a sender to all the receivers in a group. Problems in ad hoc networks are the scarcity of bandwidth, short lifetime of the nodes due to power constraints, dynamic topology caused by the mobility of nodes. These problems put in force to design a simple, scalable, robust and energy efficient routing protocols for multicast environment. In this project I discuss different multicasting protocols, their deployment issues and provide some guidelines for the researchers in this field.*

Keywords *– Ad hoc network, multicasting, performance.*

I. INTRODUCTION

MANET applications, such as emergency searches, rescues, and military battlefields where sharing of information is mandatory, require rapid deployable and quick reconfigurable routing protocols. I literature, there are two types of overlay structure for multicasting in ad hoc networks. A tree-based multicast routing protocol establishes and maintains a shared multicast routing tree to deliver data from a source to receivers of a multicast group. Two well-known examples of tree-based multicast routing protocols are the Multicast Ad hoc On-demand Distance Vector routing protocol (MAODV), and the Adaptive Demand-driven Multicast Routing protocol (ADMR). But a mesh-based multicast routing protocol sustains a mesh consisting of a connected component of the network containing all the receivers of a group. Examples of mesh-based multicast routing approaches are the Core Assisted Mesh protocol (CAMP) and the On-Demand Multicast Routing Protocol (ODMRP). Former structure is vulnerable to high mobility, high load and large multicast group. Later one faces the problem of excessive control messages over the network. Some other multicasting protocols aim to restrict flood of control packets over the multicast network. Position-Based Multicast (PBM) routing protocol ignores the maintenance of distribution structure (e.g. tree or mesh). It assumes that sender knows the location of destinations and each node has the position knowledge of its direct neighbors and its own as well. Multicast for Ad Hoc Networks with Swarm Intelligence (MANSI) is a biologically inspired protocol that adopts swarm intelligence to reduce number of nodes to construct the overlay structure. This report is organized into three groups according to the importance. In the following sections I cover these parts (I-III) in sections II, III and IV respectively, and finally I draw the conclusion at section V.

II. AD HOC MULTICASTING: PART-I

In this section some ad hoc multicast routing protocols are discussed. The objective and the way of multicasting of these algorithms are quite different from each other. The Multicast Ad hoc On-demand Distance Vector (AODV) and On Demand Multicast Routing Protocol (ODMRP) are explained as these are the state of the art in this field. Moreover one constructs tree and other builds mesh in order to disseminate packets among the multicast group members. Position Based Multicast (PBM) protocol that neither constructs a tree nor a mesh is also explained. It tries to adapt existing greedy and perimeter routing in multicast environment. An overlay multicast routing protocol namely Progressively Adapted Sub-Tree in Dynamic Mesh (PAST-DM) that builds a virtual mesh spanning all the members of a multicast group is highlighted in this section. Finally I conclude this section with an energy efficient multicast routing protocol, named L-REMiT that aims to increase the lifetime of the multicast tree and followed by The Protocol for Unified Multicasting through Announcement (PUMA) which uses core to support multicasting.

A. Multicast Ad hoc On-demand Distance Vector- MAODV

Royer and Perkins proposed MAODV in 1999 [1]. Here protocol discovers multicast routes on demand using a broadcast route discovery mechanism. When a node wishes to join a multicast group or it has data to send to the group but does not has a route to that group, it originates a route request (RREQ) message. Only the members of the multicast group respond to the join RREQ. If an intermediate node receives a join RREQ for a multicast group of which it is not a member or it receives a route RREQ and it does not have a route to that group, it rebroadcast the RREQ to its neighbors. But if the RREQ is not a join request any node of the multicast group may respond. Figure 1 depicts the propagation of RREQ.

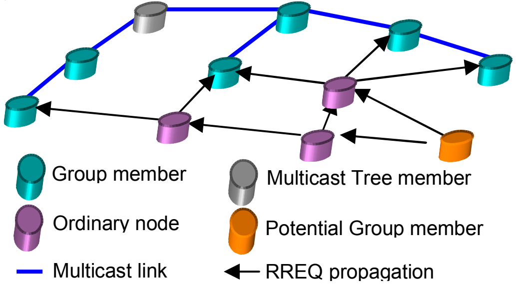


Figure 1: RREQ propagation

Every node sets up pointers to determine the reverse route in its routing table upon receiving a RREQ. This entry may later be used to relay a response back to the route requester. This entry is not activated until or unless it gets multicast activation message from the requester. The responding node unicasts the route response RREP (figure 2) back to the route requester after the completion of necessary updates on it routing table.

A node may receive multiple route reply for a route request. Usually node selects a route with the greatest sequence number and the shortest hop distance to the member of the multicast group and discards other routes. After that, node enables the selected next hop in it routing table and unicasts an activation message to that node. Upon receiving this message it activates the entry for that node in its multicast routing table. It does not forward the message further if it is a member of the multicast group otherwise it does. On the other hand, if it is not a member of the multicast group it may have multiple options to forward this activation message due to multiple route responses. It chooses best next hop and unicasts this activation message to the next hop. This process continues until activation message reached to the source of the route responder. Figure 3 represents the final multicast tree (other nodes are not shown in the figure).

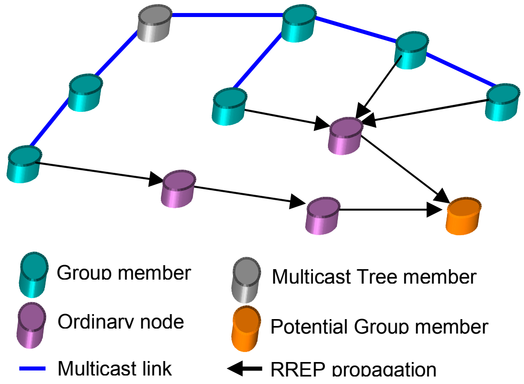


Figure 2: RREP propagation

For maintenance purpose multicast AODV uses group leader. The member who joins the multicast group first becomes the leader of that group. It periodically broadcasts hello message containing group sequence number to the multicast group. Using this hello message nodes refresh their routing tables.

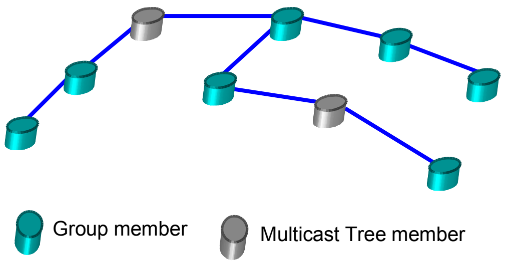


Figure 3: Multicast tree formed by MAODV protocol

Multicast AODV routing protocol requires to actively follow and respond to the changes in the multicast tree as it maintains hard state in its routing table. In order to terminate from the multicast group multicast AODV requires pruning. It allows a node to quit from the group if it is a leaf node in the tree otherwise it must remain in the tree as a non group multicast member. Links are checked to detect link failures. When link failure is detected, downstream node is responsible for repairing the link.

B. On-Demand Multicast Routing Protocol - ODMRP

In 2000, Bae et al. proposed a mesh based, rather than a conventional tree based, multicasting routing protocol, named On-Demand Multicast Routing Protocol (ODMRP) [2]. To carry multicast data via scoped flooding it uses forwarding group concept.

The source, in ODMRP, establishes and maintains group membership. If source wishes to send packet to a multicast group but has no route to that group, it simply broadcasts JOIN_DATA control packet to the entire network. When an intermediate node receives the JOIN_DATA packet it stores source address and sequence number in its cache to detect duplicate. It performs necessary routing table updates for reverse path back to the source. Non duplicate message is re broadcasted if TTL value is greater than zero (figure 4).

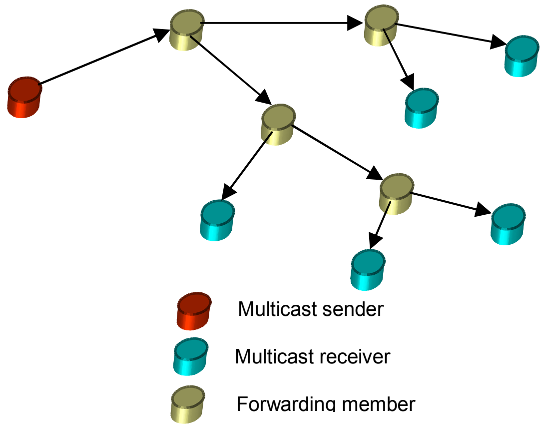


Figure 4: Non duplicate JOIN_DATA propagation

A multicast receiver constructs a JOIN_TABLE upon getting JOIN_DATA packet and broadcasts it to its neighbors. When a node receives a JOIN_TABLE, it resolves whether it is on the way to the source by consulting earlier cached data. If it realizes it is the part of forwarding group it sets FG_FLAG.

Considering the matched entry this node builds new join table and broadcasts it. In this way JOIN_TABLE is propagated with the help of forwarding group members and ultimately it reaches to the multicast source (figure 5). A multicast table is built on each node to carry multicast data (figure 6). This process either constructs or revises the routes from sources to receivers and forms a mesh.

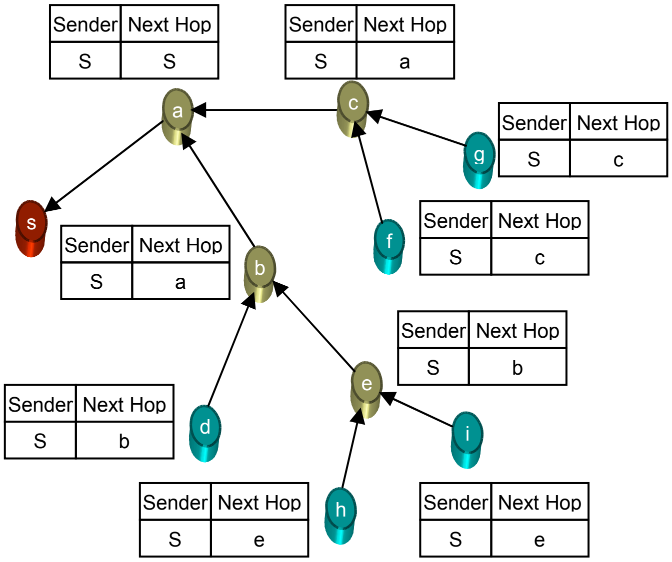


Figure 5: JOIN_TABLE propagation

Group maintenance in ODMRP is quite simple as it uses soft state approach. No explicit control packets are required to join or leave the group. If a multicast source wishes to leave the group, it simply stops sending JOIN_DATA packets. On the other hand if a multicast receiver wants to escape from the group it just stops responding to the join reply.

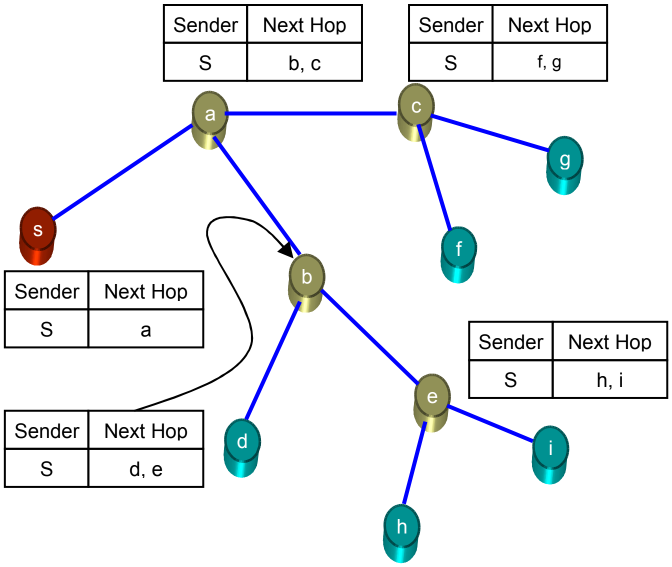


Figure 6: Multicast table formed by ODMRP

The robustness of mesh configuration is in depicted in the figure 7. Let, three multicast sources, S_1, S_2, and S_3, are sending multicast packets to the receivers, R_1, R_2 and R_3. In doing the transportation there are three forwarding group members namely, A, B and C. In a tree configuration if a link fails between any path between sender to receiver, data forwarding is stopped instantly until tree is reconfigured. But in this mesh configuration there may be some redundant paths between senders to receivers. And hence ensures some sorts of robustness by exploiting redundant paths.

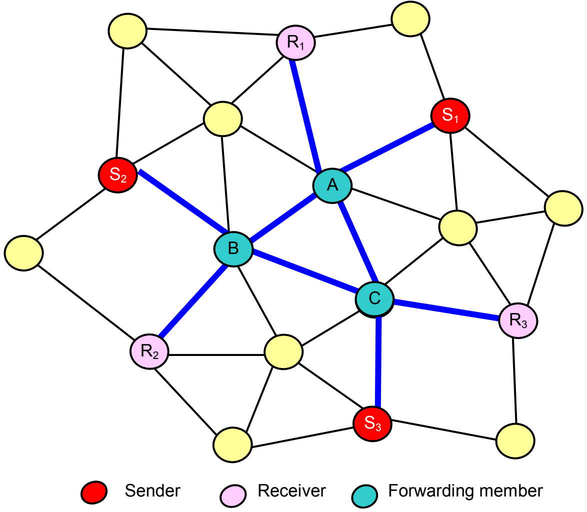


Figure 7: Multiple path in ODMRP

C. Position Based Multicast Routing

Position Based Multicast (PBM) routing protocol uses geographical position of the nodes to make forwarding decision [3]. One of the key features of PBM approach is that it neither requires to maintain a data distribution structure such as tree or mesh nor resorts the flooding. Actually it is a generalization of existing position based unicast routing protocol such as Greedy Perimeter Stateless Routing (GPSR) or Face.

The protocol assumes the position of the destinations are known to the sender by means of location service, the position of its own by the use of GPS and the position of its direct neighbor through periodic beacons. Two key problems have to be solved to adapt PBM unicast routing to multicast routing. On of them is to decide when and where at a particular node and a particular multicast packet has to split into multiple copies to reach all the destinations. Another is the recovery strategy used to escape from a local optimum to reach multiple destinations.

In multicasting two conflicting design goals are:

- The length of the paths (usually in terms hops) to the individual destinations should be minimum, and
- The total number of hops to forward the packet to all the destinations should be as small as possible.

PBM uses local information available to approximate these two conflicting goals.

Two distinct cases can occur when forwarding node selects the next hop nodes. In the first case, for each destination there is at least one neighbor exists that is closer to the destination than the current forwarding node itself. Greedy multicasting is used in this case. Otherwise perimeter multicasting is deployed.

A forwarding node optimizes following equation in order to determine next hop nodes, where first part denotes the number of neighbors that the packet is transmitted to and the second part calculates the remaining distance to all the destinations.

$$f(w) = \lambda \frac{|w|}{|N|} + (1-\lambda) \frac{\sum_{z\in Z} \min_{m\in w} d(m,z)}{\sum_{z\in Z} d(k,z)} \qquad (1)$$

In the above equation symbols have following meaning:

k : Current forwarding node
N : The set of all neighbors of k
W : The set of all subsets of N
Z : The set of all destinations, and
$d(x,y)$: A function that measures the distance between nodes x and y.

Given a set of next hop nodes $w \in W$, the normalized number of next hop nodes is determined in first part and while in second part the overall distance to all the destinations is normalized to the distance from the current node to all the destinations. These values are linearly combined using a parameter $\lambda \in [0,1]$. Multicast packet will split early if λ is closer to 0.

In greedy multicast forwarding, there may be a situation where a packet arrives at a node that does not have neighbors offering progress to one or more destinations. This situation can be handled by applying a modification of the right hand rule, e.g. Face routing. The key idea is to traverse the boundaries of the gap until greedy can be resumed.

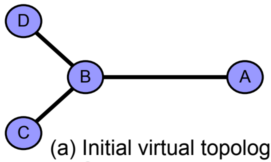
D. Overlay Multicast – PAST-DM

Progressively Adapted Sub-Tree in Dynamic Mesh (PAST-DM) is an overlay multicast routing protocol that builds a virtual mesh spanning all the members of a multicast group [4]. In order to carry packets it uses unicast routing protocol. But this algorithm gradually adapts to the changes of the physical topology in a distributed manner. The advantages of this approach are the robustness and the low overhead.

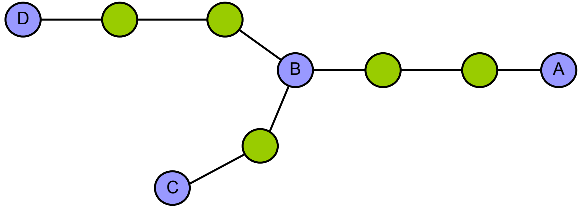
The advantages of overlay multicast are at the cost of low efficiency of packet delivery and long delay. When constructing the virtual topology, it is very hard to prevent different unicast tunnels from sharing physical links, which results in redundant traffic on the physical links. Figure 8 is an example of such a scenario.

A multicast session begins with the formation of a virtual mesh spanning all group members. Each member node makes the use of expanded ring search (ERS) technique to discover neighbors. When a node I receives a group request message from node J, along with the hop distance to node J, node I records node J as its neighbor in the virtual mesh and then sends back a group response message to J, so that node J will record the same. This virtual topology has a maximum degree for each node. The node stops the neighbor discovery phase when the number of virtual neighbors of a node reaches the upper limit. If a node fails to discover any neighbor using the expanded ring search technique, in that case it can use flooding to locate neighbors.

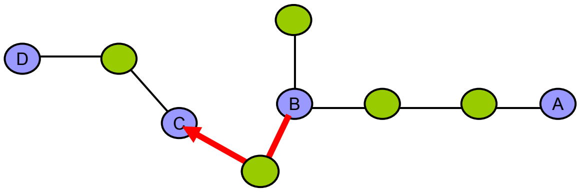
By exploiting unicast routing table each node keeps the track of other nodes in its locality. Each node records its virtual neighbors as a virtual link. Topology map is represented as a link state table. The entries are the link state information of all group nodes obtained from virtual neighbors. Every node periodically exchanges this link state table with its virtual neighbor nodes only. Through this link state table node has a local view of the entire virtual topology.



(a) Initial virtual topology



(b) Initial physical topology



(c) Change in physical topology introduces redundant data delivery over the same link

Figure 8: Side effect of overlay multicast

Source-based tree is more efficient for data delivery as compared to shared tree. By exploiting link state table each source node, in PAST-DM, constructs its own data delivery tree. The source builds a Steiner tree for the virtual mesh to minimize total cost of the multicast tree. For a virtual link (n_1,n_2), its hop distance to the source node is defined by following expression:

$$ds(n_1,n_2) = \min[ds(n_1), ds(n_2)]$$

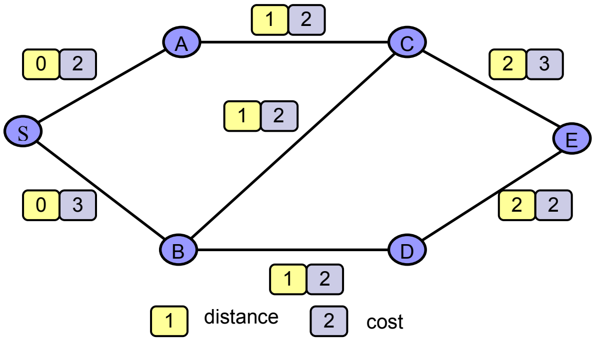
Where $ds(n)$ denote the hop distance of n from the source node. Let, $c(n_1,n_2)$ denote the cost of the virtual link (n_1,n_2). PAST-DM defines adapted cost of a link by simply multiplying its cost by the distance to the source.

$$ac(n_1,n_2) = ds(n_1,n_2) \times c(n_1,n_2)$$

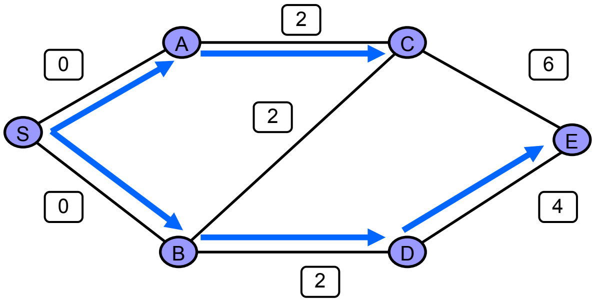
By applying the Source-Based Steiner tree algorithm, the source marks all its neighbors as its children in the multicast tree and partitions the remaining nodes into subgroups. Each subgroup forms a sub-tree rooted at one of the first-level children. The source node does not need to compute the whole multicast tree. It puts each subgroup into a packet header, combines the header with a copy of the data packet, and unicast the packet to the corresponding children. Each child is responsible of forwarding the data packet to all nodes in its subgroup. It does so by repeating the Source-Based

Steiner tree algorithm. This process continues until the sub-group is empty or it has only one member in the sub-group. In the later case it unicasts the packet to the receiver. Multicast tree data delivery process through PAST-DM is given in the figure 9.

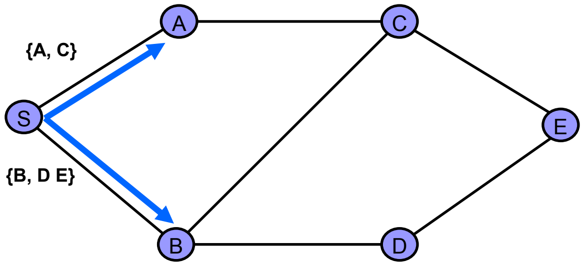
A new member starts off receiving packets right after uncovering of virtual neighbors even though source is still unaware of the new member at that time. To leave the group node only needs to send group leave message to all of its virtual neighbors. This ultimately stops exchanging link state packets with its virtual neighbors.



(a) Distance and cost of each link



(b) Adapted cost of each link and source based Steiner tree



(c) Head of the packet contains receiver list

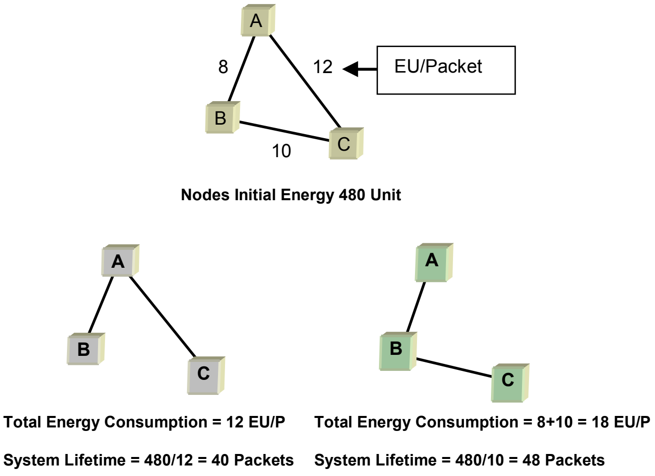
Figure 9: Data delivery tree formed by PAST-DM

E. Lifetime Aware Multicast – L-REMiT

Lifetime of a multicast tree in terms of energy is the duration of multicast service until a node fails due its lack of energy. In 2003, Ben et al. presented lifetime aware multicast routing protocol named L-REMiT (Lifetime-Refining Energy efficient of Multicast Trees) [5].

There are two conflicting goals in designing multicast routing protocols in terms of energy. Some protocols target to optimize (minimizes) total energy consumption of the multicast tree while other protocols aim to optimize (maximize) the life time of the multicast tree. In literature these are called minimum energy multicast tree and maximum lifetime multicast tree, respectively. Consider the figure 10, assuming each node initially has 480 energy units, results in two different multicast trees based on two different optimization goals.

Let d_i be i's maximum distance with its neighbors. The energy cost of a node i in a multicast tree T depends on its position in the tree. If it is a source node it will lose energy only through transmission, e.g. $E_{elec} + Kd_i^{\alpha}$, if it is a leaf node it loses energy only due to packet reception, e.g. E_{recv}, otherwise node loses energy by both packet reception and packet re-transmission, e.g. $E_{elec} + Kd_i^{\alpha} + E_{recv}$.



(a) Minimum Energy (b) Maximum Lifetime

Figure 10: Multicast trees based on energy

The lifetime of a node in a multicast is the total number of multicast packets that may be transmitted or forwarded by the node for a given initial energy, assuming that it does not participate in either forwarding or transmitting of any other packets. Thus maximum number of packets that a node i can transmit is $R_i / E(T,i)$, here R_i is the residual energy of node i. Say $LT(T,i)$ denote the life time of node i, hence

$$LT(T,i) = \frac{R_i}{E(T,i)}$$

Thus the lifetime of the multicast tree is the maximum number of packets that may be transmitted over the multicast tree that is the minimal among the all $LT(T,i)$. Mathematically, the multicast lifetime $LT(T)$ be,

$$LT(T) = \min_{\forall_i \in T} LT(T,i)$$

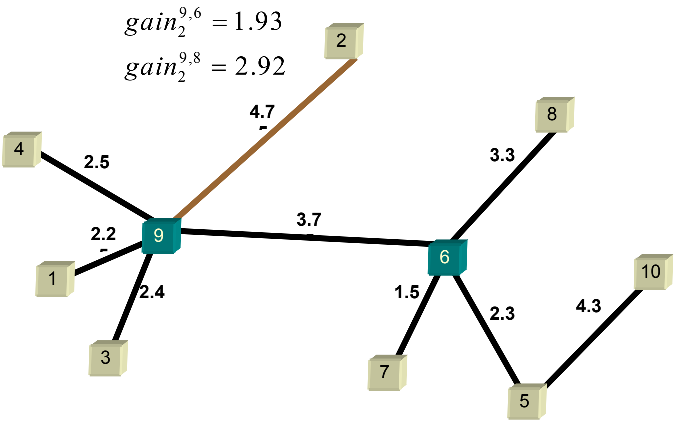
$$= \min_{\forall_i \in T} \frac{R_i}{E(T,i)}$$

The node for which lifetime is minimum is called bottleneck node. The key concept of the algorithm L-REMiT is to figure out the bottleneck node and the change the parent of the node (farthest neighbor of the bottleneck node) for which bottleneck node is losing too much energy.

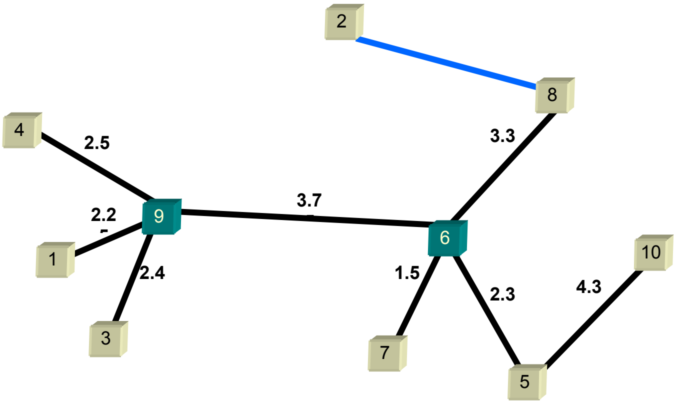
Let the notion $Change_i^{x,y}$ refers to change of i's parent x to y. Authors named it refinement operation. Let T and T' are the multicast tree before and after the refinement operation, e.g. $Change_i^{x,y}$. After refinement operation gain is calculated using the following formula,

$$gain = LT(T') - LT(T)$$

L-REMiT uses gain as the criteria for changing the parent of a node. If gain is positive refinement operation is carried out. Figure 11 is an example of refinement operation.



Multicast tree before refinement



Multicast tree after refinement

Figure 11: Refinement operation in L-REMiT

The following two lemma guarantees that T' is a tree and identify which nodes lifetime due to refinement.

Lemma 1: If node y is not a descendant of node i in tree T, then the tree remains connected after $Change_i^{x,y}$.

Lemma 2: Nodes x and y are the only nodes in the tree whose multicast lifetime may be affected by $Change_i^{x,y}$.

L-REMiT is a distributed algorithm that tries to optimize the lifetime of a multicast tree through refinement operation. This refinement operation goes in rounds coordinated by the source node.

F. Protocol for Unified Multicasting through Announcements

The objective of a multicast routing protocol for ad hoc environment is to support the transportation of information from a sender to multiple receivers in a group while trying to use the available bandwidth efficiently in the presence of frequent topology changes. The Protocol for Unified Multicasting through Accouchements (PUMA) establishes and maintains a shared mesh for each multicast group without depending upon a unicast routing protocol [6].

In PUMA, any source can send multicast data to a multicast group without having to knowing the constituent members of the group. Moreover source does not require joining the group to dispatch the data. PUMA is a receiver initiative approach where receivers join the multicast group using the address of a special core node without the need for flooding of control packets from the source of the group. It makes the use of dynamic cores (not pre-assigned).

When a receiver wishes to join a multicast group, it first determines whether it has received a multicast announcement for that group before. If the node knows the core, it starts transmitting multicast announcements and specifies the same core for the group. Otherwise it considers itself the core of the group and starts transmitting multicast announcements periodically to its neighbors stating itself as the core of the group. Node propagates multicast announcements based on the best multicast announcements it receives from its neighbors. A multicast announcement with higher core ID nullifies the announcement of a lower core ID. So, each connected component has only one core. If more than one receiver joins the group simultaneously, then the one with the highest ID becomes the core of the group.

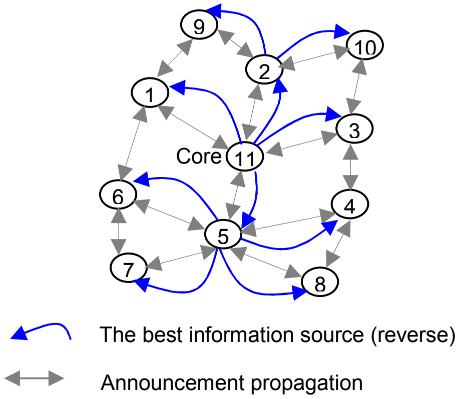


Figure 12: Dissemination of multicast announcements

When multicast announcement propagates through the network it establishes a connectivity list at every node in the network and helps nodes to build the mesh (Table 1). Each node uses core ID, group ID, sequence number, distance to core, parent as fields in multicast announcement. There may be multiple routes to the core. But if core is changed, all nodes have to rebuild their connectivity lists. Figure 12 represents the propagation of multicast announcement.

Table 1: Connectivity list

Connectivity list of node 6
Core ID = 11, Group ID=224.0.0.1, Seq. No = 79

Neighbor	Multicast Announcement		Time
	Distance to Core	Parent	
5	1	11	12152
1	1	11	12180
7	2	5	12260

At the beginning only the multicast receiver considers itself as a mesh member and send multicast announcement. Non-receivers consider themselves mesh-members if they have at least one mesh child in their connectivity list. A neighbor in the connectivity list is a mesh child if (a) its mesh member flag is set, (b) the distance to core of the neighbor is larger than the nodes own distance to core and (c) the multicast announcement corresponding to this entry was received in within a time period equal to two multicast announcement intervals. If a node has a mesh child means a mesh member. Hence it lies on a shortest path from a receiver to the core.

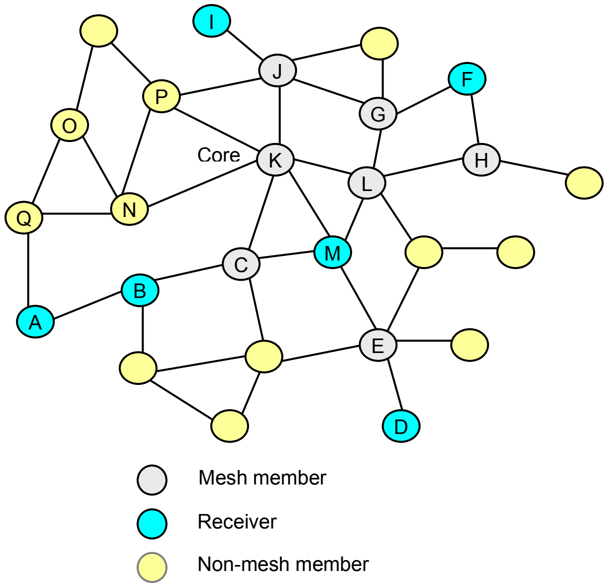


Figure 13: Mesh and data forwarding in PUMA

A node forwards a multicast data packet it receives from its neighbor if the parent for the neighbor is the node itself. Hence, multicast data packets move hop by hop, until they reach mesh members. The packets are then flooded within the mesh, and group members use a packet ID cache to detect and discard packet duplicates. Figure 13 is an example of PUMA mesh and data forwarding within the multicast group. Nodes O and Q marks in the multicast announcements that their parent is node N. Similarly, node P marks in its multicast announcement that its parent is K. Let nodes O and P are senders. Node N forwards a data packet from O, but not from P, because only O has informed N that it considers N as its parent. Although node J is not the parent of P, it forwards the packet when it receives it from P, because mesh members do not consult their connectivity list before forwarding a packet. As a result, receiver node I will get the packet early. Node J does not rebroadcast the packet when it receives same packet from K due to duplicate packet checking.

III. AD HOC MULTICASTING: PART-II

A. Neighbor Supporting Ad Hoc Multicast Routing Protocol

Neighbor Supporting Multicasting Protocol (NSMP) adopts a mesh structure to enhance the resilience against nodes mobility [7]. It operates independent of unicast routing algorithm. A soft state approach is used and routes are built and maintained with route discovery and with reply messages. NSMP reduces routing overhead as it exploits localized route discovery and maintenance operations.

In NSMP, two types of route discovery methods are mentioned, namely flooding route discovery and local route discovery. In order to build initial route or to recover from network partition NSMP uses flooding while for maintenance purposes it makes the use of local route discovery approach.

NSMP attempts to achieve the route efficiency of multicast tree while confirming the robustness by the use of multicast mesh. In selecting a route, NSMP prefers a path that contains existing forwarding nodes to reduce the number of forwarding nodes. This enhances route efficiency, leading to less contention and further to lower end to end delay [7]. Let, node 17 becomes a new receiver and gets two route discovery packets: one from the path 4-5-9-13-17 and other from the path 48-12-16-17. Here both paths have the same length but first one uses existing path while later one requires three new forwarding nodes. Usually NSMP gives preference to a path that has more existing forwarding nodes to other paths.

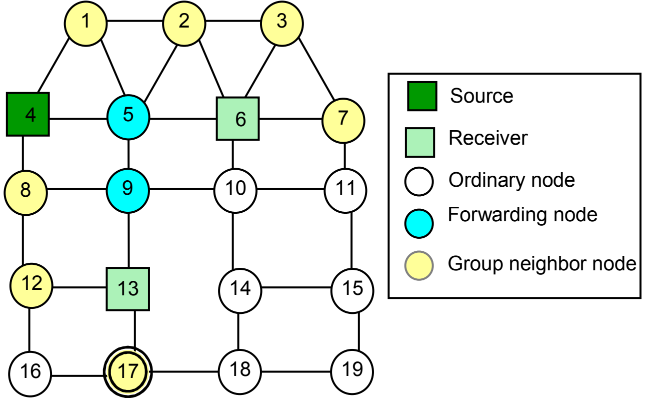


Figure14: Multicast mesh and path preferences

B. A Dynamic Core Based Multicast Routing Protocol

Dynamic Core based Multicast routing Protocol (DCMP) builds and maintains a shared mesh formed by a group of core based trees [8]. By exploiting the advantage of core based trees, it improves the scalability of the protocol. DCMP is a source initiative multicast protocol.

DCMP classifies its sources in three classes: active source, core active source and passive source. Active source periodically floods join request like the source of ODMRP. But core active source is active source that act as a core for one or more passive sources. These core active sources are responsible for creating shared mesh for passive sources and are dynamic in nature. So here, passive sources are depend on the cores to transmit their packets and core takes care of their packets.

C. Physical Hierarchic Ad Hoc Multicast

Physical Hierarchy-driven Ad hoc Multicast (PHAM) builds a multicast structure at each level of the hierarchy for efficient and scalable multicast message delivery [9]. It considers the heterogeneity of the mobile devices in terms of networking resources and computing power. PHAM assumes each physical group or cluster consists of a super node and communication between different physical groups carry on through super nodes. So the main challenges are in the way to communicate within the group and among the groups.

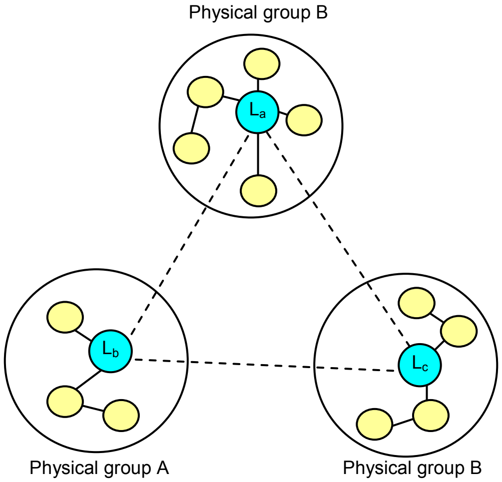


Figure15: Physical hierarchy in PHAM

When all the nodes are in the same physical group, message delivery is performed locally between the super node and with all the nodes in that group. It can apply any existing multicast algorithms such as ODMRP, ADMR within a physical group. Super node to super node communication is handled through unicast routing. Figure 15 illustrates the concept of PHAM.

D. Physical Hierarchic Ad Hoc Multicast

Swarm intelligence refers to complicated activities that occur from very simple individual behaviors and interactions, which is often observed in nature, such as in ant's community. Multicast for Ad hoc Networks with Swarm Intelligence (MANSI) is a biologically inspired metaphor to the multicast routing problem in mobile ad hoc networks [10]. It uses a core-based technique that establishes multicast connectivity among members. An initial multicast connection can be quickly setup through the core by flooding the network with an announcement so that nodes on the reverse paths to the core will be requested by group members to serve as forwarding nodes.

However, each member, other than the core, periodically deploys a small packet that behaves like an ant to intelligently discover different paths to the core. This searching mechanism may enable the nodes to discover new forwarding nodes that yield lower total forwarding costs.

IV. AD HOC MULTICASTING: PART-III

Sequence and Topology encoding for Multicast Protocol (STMP) provided multicast routing representation using fuzzy Petri net model with the concept of immediately reachable set in wireless ad hoc networks where all nodes equipped with GPS unit [11]. It uses a structured representation of network topology, and apply fuzzy reasoning algorithm in order to construct multicast tree and improves the efficiency of routing protocol. Its main objective is to reduce the size of the multicast tree.

In Adaptive Demand Driven Multicast Routing (ADMR), senders and receivers cooperate to establish and maintain forwarding states in the network to allow multicast communication [12]. It adaptively monitors the proper execution of forwarding states and maintains it connected when one or more forwarding nodes or receivers become disconnected.

Lifetime-aware Multicast Tree (LMT) routing algorithm maximizes multicast lifetime by finding routing solutions that minimizes the variance of the remaining energies of the nodes in the network [13].

Prioritized Overlay Multicast (POM) aims to improve the efficiency and robustness of the overlay multicast in MANET by building multiple role-based prioritized trees [14]. Usually it takes the benefits of location information.

V. CONCLUSION

A MANET consists of dynamic collection of low power nodes with quickly changing multi-hop topologies that usually composed of relatively low bandwidth wireless link. These constraints make multicasting in mobile ad hoc networks challenging. The general solutions to solve these problems are to avoid global flooding and advertising, construction of routes on demand and dynamically maintain memberships, etc. All protocols have their own advantages and disadvantages. One constructs multicast trees to reduce end-to-end latency while other builds mesh to ensure robustness. Some protocols create overlay networks and use unicast routing to forward packets. Energy aware multicast protocols optimize either total energy consumption or system lifetime of the multicast tree. It is really difficult to design a multicast routing protocol considering all the above mentioned issues. Still it is an open problem for researchers to satisfy as many goals as possible in a single protocol.

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