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Comprehensive Study of Multicast Routing Protocol in Ad-hoc Networks

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Abstract: A mobile ad hoc network (MANET) consist of autonomous nodes, often composed of mobile devices or other mobile devices, that can arrange themselves in various ways and operate without any central network administration. Devices in the network can change locations and configure itself on the fly. Because MANETS are mobile, they use wireless connections to connect to various networks. Multicasting is intended for group communication that supports the dissemination of information from a node to all the receivers in a group and plays a crucial role in ad hoc network. In the past couple of years, a number of multicast routing protocols have been proposed. These protocols are based on different design principles and have different functional features when they are applied to the multicast problem. Challenges in ad hoc networks are limited bandwidth, short lifetime of the nodes due to power constraints, dynamic topology caused by the mobility of nodes. In order to provide a comprehensive understanding of these multicast routing protocols designed for MANETs and pave the way for the further research, a survey of the multicast routing protocols is discussed in detail in this paper.

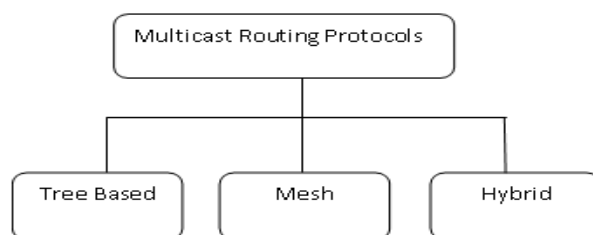
Keywords: mobile ad hoc network (MANET), multicast routing, TTL, MAODV, ADMR

I. Introduction

Mobile Ad hoc Networks are envisioned to have rapidly-changing, random, dynamic, multihop topologies that are likely composed of relatively bandwidth-constrained wireless links. These characteristics make MANETs suitable for mission-critical applications, such as disaster recovery, crowd control, search and rescue and automated battlefield communications, yet make the routing in MANETs very difficult. For these reasons, the development of routing protocols in MANET is extremely challenging. Multicast plays an important role in MANET. Many ad hoc network applications need the nodes to work as a group to carry out a given job. This kind of application is efficient due to the broadcast nature of wireless network for it can improve the efficiency of the wireless links. As a result, multicast routing has become a research focus recently, and various multicasting protocols in MANET have been proposed.

Multicasting is the transmission of packets to a group of zero or more hosts identified by a single destination address. Multicasting is intended for group-oriented computing. Typically, the membership of a host group is dynamic, that is, hosts may join and leave groups at any time. There is no restriction on the location or number of members in a host group. A host may be a member of more than one group at a time. A host does not have to be a member of a group to send packets to it. Several multicast routing protocols have been proposed for MANET, which can be classified as either tree-based or mesh-based or hybrid according to the kind of routes they create.

Figure 1 Classification of Multicast Routing Protocol



II. Multicast Routing Protocols for MANET

A. Tree based routing protocols

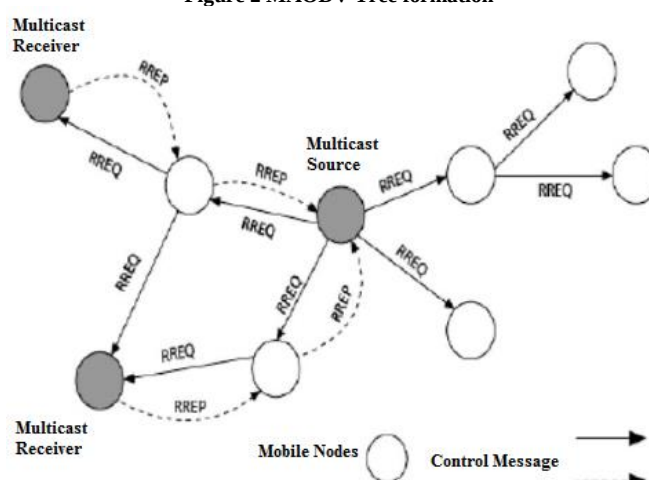
The tree based routing protocol are highly unstable in the mobile ad hoc network as it need frequent re-configuration in the dynamic network (mobility of nodes).There is only a single path between multicast source and receiver. There are various tree based protocols like multicast extension of ad-hoc on demand distance vector (MAODV) and Adaptive demand driven multicast routing protocol (ADMRP).

1. Multicast Ad Hoc On-Demand Distance Vector (MAODV)

The Multicast Ad-hoc On-demand Distance Vector (MAODV) is a reactive tree based multicast routing protocol [2]. It is an extension of Ad-hoc On-demand Distance Vector (AODV) the unicast routing protocol. Like unicast

routing operations, the sequence number is assigned to MAODV multicast group to indicate the freshness of the routing information. In every group only one leader is elected with GROUP HELLO messages throughout the MANET to maintain the sequence number [1]. When a multicast source requires a route to a multicast group, it broadcasts a Rreq packet with the join flag set and the destination address set to the multicast group address. A member of the multicast tree with a current route to the destination responds to the request with a Rrep packet. Non members rebroadcast the Rreq packet. Each node on receiving the Rreq updates its route table and records the sequence number and next hop information for the source node. This information is used to unicast the Rrep back to the source. If the source node receives multiple replies for its route request, it chooses the route having the freshest sequence number or the least hop count. It then sends a Mact which is used to activate the path from the source to the node sending the reply. If a source node does not receive a Mact message within a certain period, it broadcasts another Rreq. After a certain number of retries (Rreq-Retries), the source assumes that there are no other members of the tree that can be reached and declares itself the Group Leader. The group leader is responsible for periodically broadcasting group hello (Grp-Hello) messages to maintain group connectivity. Nodes also periodically broadcast Hello messages with time-to-live = 1 to maintain local connectivity. The route discovery process is illustrated in Figure 2.

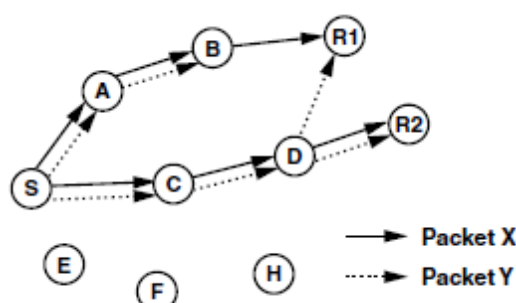
Figure 2 MAODV Tree formation



2. Adaptive Demand-Driven Multicast Routing protocol (ADMR)

ADMR is a new on-demand multicast routing protocol for wireless ad hoc networks that attempts to reduce as much as possible any non-on demand components within the protocol. In ADMR, source-based forwarding trees are created whenever there is at least one source and one receiver in the network. Each multicast packet originated by some node S for multicast group G contains a small ADMR header, including a number of fields used by the protocol in forwarding the packet and in maintaining the multicast distribution tree for S and G. The sequence number in the ADMR header uniquely identifies the packet and is generated as a count of all ADMR packets flooded in any way that originated from S. The hop count is initialized by S to 0 and is incremented by each node forwarding the packet. For a packet being forwarded, the previous hop address in the ADMR header is the MAC-layer transmitting source address from which this packet was received, copied from the MAC-layer header of the packet before forwarding it; when a packet is originated, this field is initialized to 0.

Figure 3 Multicast data packet forwarding in ADMR



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

AMRIS is an on-demand protocol which constructs a shared delivery tree to support multiple senders and receivers within a multicast session. The key idea that differentiates AMRIS from other multicast routing protocols is that each participant in the multicast session has a session-specific multicast session member id.

AMRIS consists of two main mechanisms: *Tree Initialization* and *Tree Maintenance*. *Tree Initialization* is the mechanism by which a multicast session is created and advertised to nodes within the ad hoc network. Nodes that

are interested in joining the multicast session (herein known as I-Nodes) then join in the *Initialization* phase. Nodes that are not interested in joining the multicast session are herein known as U-Nodes.

Tree initialization begins with Sid broadcasting a *NEWSESSION* message to its neighbours. The *NEW-SESSION* will contain, among other things, Sid's msm-id, multicast session id, and routing metrics. All nodes that receive the *NEWSESSION* message generate their own msm-id by computing a value that is larger and not consecutive, so that there are gaps between the msm-ids of a sender and a receiver; Information derived from the *NEWSESSION*. A random jitter is introduced between the receipt of a *NEW-SESSION* message and its subsequent rebroadcast to prevent broadcast storms. A node may receive multiple *NEW-SESSION* messages from different nodes. If it has not rebroadcast any messages yet, it will keep the message that has the best routing metrics and calculate its msm-id based on the values from that message. Otherwise the messages received are dropped. message is kept in the *Neighbour-Status* table for up to T1 seconds.

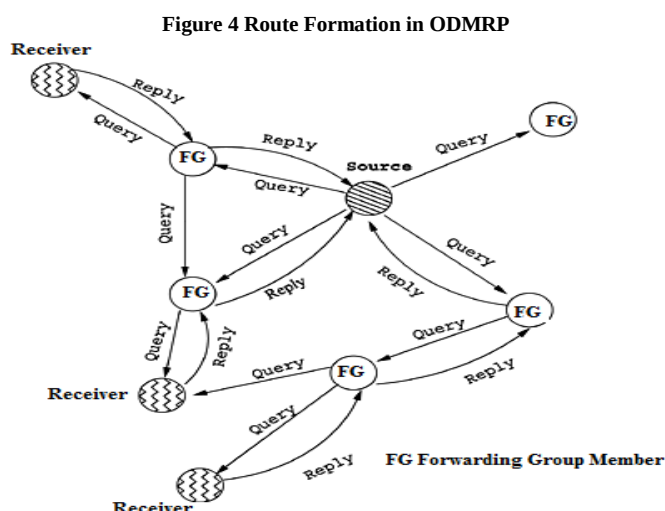
Tree Maintenance is the mechanism whereby nodes that become "detached" from the multicast delivery tree rejoin the tree to continue receiving multicast traffic, by executing a *Branch Reconstruction (BR)* routine. Nodes that did not join the multicast session during the initialization phase also make use of BR to join the tree.

AMRIS uses a soft state beacon approach to determine if a link has broken between two neighbouring nodes.

B. Mesh Based Multicast Routing Protocol

1. On Demand Multicast Routing Protocol (ODMRP)

On demand routing protocol is designed to overcome the issues with the typical tree based structure. It provide on demand routing techniques to avoid channel overhead and improve scalability. It uses the forwarding group concept to forward the multicast packet via shortest path from source to destination/receiver or between any member pair to build a forwarding mesh for each multicast group. In this approach the source establishes and maintains group membership and multicast mesh on demand if it needs to send data packets to the multicast group. A set of nodes, which is called forwarding group, participate in forwarding data packets among group members. When a source node needs the route to a multicast group, it begins to periodically broadcast a JOIN REQUEST message, which is forwarded by all the nodes in the MANET. When a group member receives such a message, it records the IP address of the node upstream to be the next hop for the source, and broadcasts a JOIN TABLE to its neighbor. On receipt of the JOIN TABLE, the neighbor node examines the table to see if it is the next hop for the source in one entry. If the answer is positive, the node sets itself to be a forwarding node and broadcasts its own JOIN TABLE to its neighbors as well. Thus the JOIN TABLE is sent back until it reaches the source [12]. At that time the forwarding group is formed and the route is built. From then on the data packets can be delivered to the receivers properly.

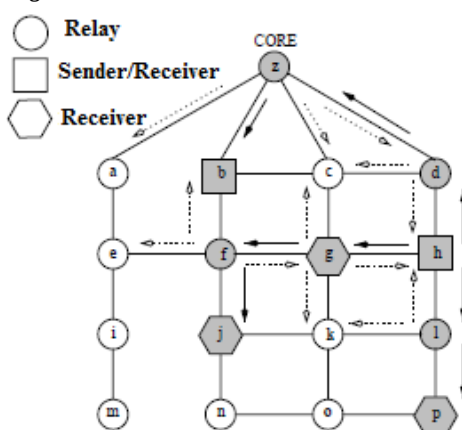


2. The core Assisted Mesh protocol (CAMP)

CAMP is designed to support multicast routing in very dynamic ad-hoc networks with broadcast links.. Each router maintains routing tableRT built with the unicast routing protocol used in conjunction with CAMP, a core to-Group Address Mapping (CAM) table, an anchor table (AT), a multicast routing table (MRT), a packet forwarding cache. At router i , the RT made available to CAMP specifies, for each destination j , the successor (s_{ij}) and the distance to the destination (D_{ij}). The packet-forwarding cache $CACHE_i$ maintains information of packets recently processed by router i . The main role of the packet forwarding cache is to avoid packet replication by keeping track of packets already received by the router.

CAMP ensures that all the reverse shortest paths between sources and receivers are part of a group's mesh by means of heartbeat and push join (PJ) messages. CAMP determines two types of push join acknowledgments — regular ACK, sent by duplex members and ACK SIMPLEX, sent by simplex members.

Figure 5 Traffic flow from router in multicast mesh



C. HYBRID ROUTING PROTOCOL

In Routing algorithm [8] the third classification is hybrid routing protocol. For more accurate metrics hybrid routing protocols use distance vectors. To find best paths to the destination networks, it uses routing information maintained by the routers, when there is any changes in the topology the router update its routing table. It allows rapid convergence but for rapid convergence it requires less processing power & memory when compared to link state routing.

1. Multicast core-extraction distributed ad hoc routing (MCEDAR)

MCEDAR [7] is source tree based hybrid routing protocol. In this protocol, mesh is created by using CEDAR [4]. CEDAR will create set that contains minimum number dominating core nodes by using core computation algorithm. Dominating core nodes are core node of senders or receivers or core node which is near to the requesting node. When a node wants to join the group the core node of that group will broadcast JoinReq (MA, JoinID). MA is the address of the group that wants to join and JoinID is the current id of the group. When a node that does not belongs to desired group receives the packet, it will broadcast to the nearby core nodes. Otherwise node will send JACK to the id that is smaller than id that is present in JoinREQ packet or it will send JACK to the node that has larger id as a replying node. mgraph contains two tables they are parent and child. Parent contains all upstream nodes and child set contains downstream nodes. Advantage is it is robust when the receiver has links to the source. Disadvantage is it doesn't work well for small groups. More control overhead will be obtained due to change of cores in a mobile environment.

2. Ad hoc Multicast Routing protocol (AMRoute)

Ad hoc Multicast Routing protocol, enables the use of IP Multicast in MANETs. Existing multicast protocols do not work well in MANETs as the frequent tree reorganization can cause excessive signaling overhead and frequent loss of datagrams. The tree reorganization in MANETs is more frequent as compared to conventional static networks, since the multicast protocols have to respond to network dynamics in addition to group dynamics. AMRoute creates a per group multicast distribution tree using unicast tunnels connecting group members. The protocol has two main components: mesh creation and tree creation. Only the logical core node initiates mesh and tree creation; however, the core can migrate dynamically according to group membership and network connectivity. Bidirectional tunnels are created between pairs of group members that are *close* together, thus forming a mesh. Using a subset of the available mesh links, the protocol periodically creates a multicast distribution tree. AMRoute uses five control messages for signaling purposes and one data message format. These are sent directly over IP. JOIN_REQ is the only message broadcast using an expanding ring search, while the other control messages are unicast between group members. The purpose of the control messages can be summarized as follows:

- JOIN_REQ. This is broadcast periodically by a logical core for detecting other group segments.
- JOIN_ACK. This is generated by a tree node in response to receiving a JOIN_REQ from a different logical core.
- JOIN_NAK. This is generated by a tree node if its application leaves the group.
- TREE_CREATE. This is generated periodically by a logical core to refresh the group spanning tree.
- TREE_CREATE_NAK. This is generated by a tree node to convert a tree link into a mesh link.
- DATA_MESSAGE. This is generated by a sender on receiving data from a multicast application.

AMRoute's simplicity is illustrated by the state diagram in figure 4, which shows the three main AMRoute states and state transitions (with causing events and resulting actions). The states can be interpreted as follows:

- NON-MEMBER – a node does not belong to the multicast group.
- CORE – a node currently recognizes itself to be a logical core.
- NON-CORE – a node is currently a non-core member in the multicast group.

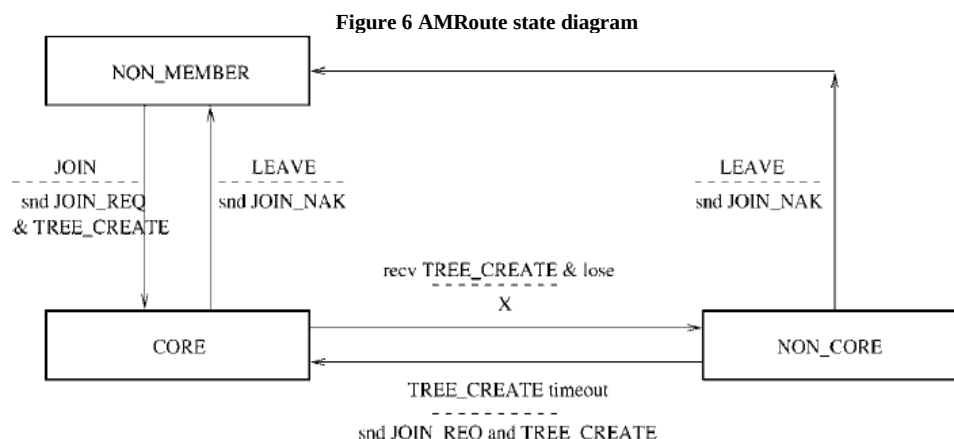


Table 1 Comparison of various Multicast Routing Protocols

Protocols	Topology	Maintenance Approach	Loop free	Unicast Protocol Dependency	Qos Support	Control Overhead	Initialization Approach	Routing Scheme
MAODV	Tree	Hard Reactive State	Yes	yes	No	Less	Receiver Initiated	Reactive
ADMR	Tree	Hard Reactive State	Yes	No	No	Less	Source Initiated	Reactive
AMRIS	Tree	Hard Reactive State	Yes	No	No	Less	Source Initiated	Reactive
ODMRP	Mesh	Soft Reactive State	Yes	No	No	Less	Source Initiated	Reactive
CAMP	Mesh	Hard Reactive State	Yes	Yes	No	More	Hybrid	Proactive
MCEDAR	Hybrid	Hard Reactive State	Yes	Yes	Yes	More	Hybrid	Proactive
AMRoute	hybrid	Hard Reactive State	No	Yes	No	More	Hybrid	Proactive

III Conclusion

A survey of the existing multicast routing protocols designed for MANETs are presented in this paper . Various classifications based on different characteristics, namely, multicast topology, initialization of multicast connectivity, routing information update mechanism, and multicast group maintenance is presented here. The major issues and challenges facing multicast routing design are also presented. These issues should be considered in the design of an efficient multicast routing protocol in MANETs. A multicast protocol can hardly satisfy all previous requirements. In other words, one size does not “fit all,” but rather each protocol is designed to provide the maximum possible requirements, according to certain required scenarios. Even if a multicast protocol meeting all the requirements is designed, it will be very complicated and need a tremendous amount of routing information to be maintained. Moreover, it will not be suitable for environments with scarce resources. Satisfying most of the requirements would provide support for reliable communication, minimize storage and resource consumption, ensure optimal paths (not necessarily as a function of the number of hops), and minimize network load.

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