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MULTICAST ROUTING PROTOCOLS IN MANETS

Tanu Preet Singh
Department of CSE, ACET

Neha
Department of CSE, SIET

Vikrant Das
Department of CSE, ACET

Abstract: **Sending multiple copies of packet to different nodes is called Multicasting. Wired and infrastructure-based wireless networks are supported by many multicast routing protocols. But, applying this concept in Mobile Ad hoc wireless networks (MANETs) is a big challenge. Problems in ad hoc networks are the scarcity of bandwidth, short lifetime of the nodes due to power constraints and dynamic topology due to the mobility of nodes. These problems put in force to design a simple, scalable, robust and energy efficient routing protocol for multicast environment. In this paper we will discuss different multicasting routing protocols for mobile ad hoc networks and their deployment issues.**

Keywords: **Multicasting, Mobile Ad- Hoc Networks (MANETs), protocol, routes.**

I. INTRODUCTION

Wireless applications, like emergency searches, rescues, and military battlefields where sharing of information is mandatory, require rapid deployable and quick reconfigurable routing protocols, because of these reasons there are needs for multicast routing protocols. There are many characteristics and challenges that should be taking into consideration when developing a multicast routing protocols, like: the dynamic of the network topology, the constraints energy, limitation of network scalability, and the different characteristics between wireless links and wired links such as limited bandwidth and poor security [1, 2, 3].Generally there are two types of multicast routing protocols in wireless networks. Tree-based multicast routing protocol. In the tree-based multicasting, structure can be highly unstable in multicast ad-hoc routing protocols, as it needs frequent re-configuration in dynamic networks, an example for these type is Multicast extension for Ad-Hoc On-Demand Distance Vector (MAODV)[4] and Adaptive Demand- Driven Multicast Routing protocol (ADMR)[5]. The second type is mesh-based multicast protocol. Mesh-based multicast routing protocols are more than one path may exist between a source receiver pair, Core-Assisted Mesh Protocol (CAMP) and On-Demand Multicast Routing Protocol (ODMRP)[7] are an example for these type of classification. This paper is organized into five parts: Section 2 describes related work on some multicast routing protocols, Section 3, describes tree-based multicast routing protocols like MAODV. Sections 4, covered mesh based multicast routing protocols like ODMRP and patch ODMRP. Section 5, describes hybrid multicast routing protocol like AMRoute. Section 6, gives simulation results and finally Section 7 gives the conclusion of all these protocols.

In this paper, we will classify the protocols that tried to pose general ideas of how applying multicast concept in MANETs. The classification of these routing protocols will be mentioned under as shown in Figure 1.

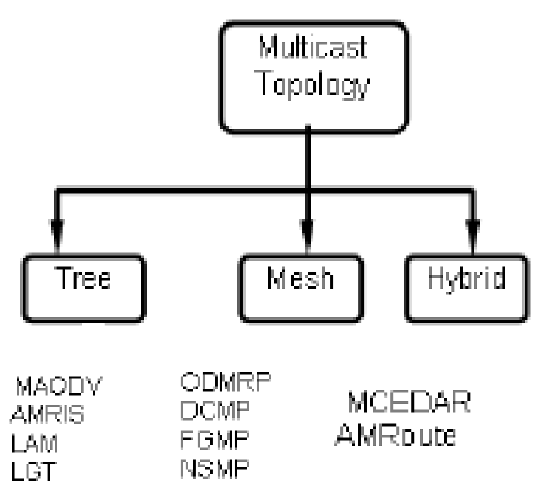

Figure 1: Multicast routing protocols in MANET

II. RELATED WORK

Multicasting consists of concurrently sending the same message from one source to multiple destinations. It plays an important role in video-conferencing, distance education, co-operative work, and video on demand, replicated database updating and querying, etc. Several multicast routing protocols have been proposed for Ad hoc networks, which are classified as either *mesh based* or *tree based*. In a mesh based multicast protocol, there may be more than one path between a pair of source and receiver, thus providing more robustness compared to tree based multicast protocols. In a tree based multicast protocol, there is only a single path between a pair of source and receiver, thus leading to higher multicast efficiency. The construction of a multicast tree can be done either from the source (*source-initiated*) or from a receiver (*receiver-initiated*). The Ad hoc environment suffers from frequent path breaks due to mobility of nodes; hence efficient multicast group maintenance is necessary. Maintaining the multicast group can be done by either *soft state approach* or *hard state approach*. In the soft state approach, the multicast group membership and associated routes are refreshed periodically which necessitate flooding of control packets. But, in the hard state approach, the routes are reconfigured only when a link breaks, thus making it a reactive scheme. Some examples of tree based multicast protocols are Ad hoc Multicast Routing (AMRoute) [6], Ad hoc Multicast Routing protocol utilizing Increasing id-numbers (AMRIS) [12], Bandwidth Efficient Multicast Protocol [13], Multicast operation of the Ad hoc On demand Distance Vector (MAODV) routing protocol , and Multicast Core- Extraction Distributed Ad hoc Routing (MCEDAR) protocol. In contrast to the tree based concept, mesh based multicast protocols may have multiple paths between any source and receiver pairs, thus providing richer connectivity among the multicast members. The ODMRP [14] protocol is a mesh based protocol which uses a forwarding group concept for multicast packet delivery. Only the members of forwarding group forward data packets. For maintaining the multicast mesh it uses soft state approach. Some of the existing other mesh based multicast protocols are Forwarded Group Multicast Protocol (FGMP) [15, 16] Core-Assisted Mesh Protocol (CAMP), Neighbor Supporting Ad hoc Multicast routing Protocol (NSMP), and Location-Based Multicast Protocols like ODMRP, FGMP [15] is also based on the forwarding group concept. But the major difference between them is that the former one is a source-initiated multicast protocol, while the latter one is receiver-initiated multicast protocol. Both FGMP and ODMRP protocols use control packets flooding to form the multicast mesh, thus resulting in considerable control overhead. In Location-Based Multicast protocol, location information is used to reduce the control overhead. To deliver the data packets to all of the nodes in the same geographical region (it is called as *member region*), a limited flooding approach is used in this protocol. Before forwarding the data packets, a source defines a *forwarding zone*. A node forwards the data packets if it belongs to the forwarding zone.

III. TREE-BASED MULTICASTING

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. A well-known example of tree-based multicast routing protocols are the Multicast Ad hoc On-demand Distance Vector routing protocol (MAODV).

A. *Multicast Ad-hoc On-Demand Distance Vector Routing Protocol (MAODV)*

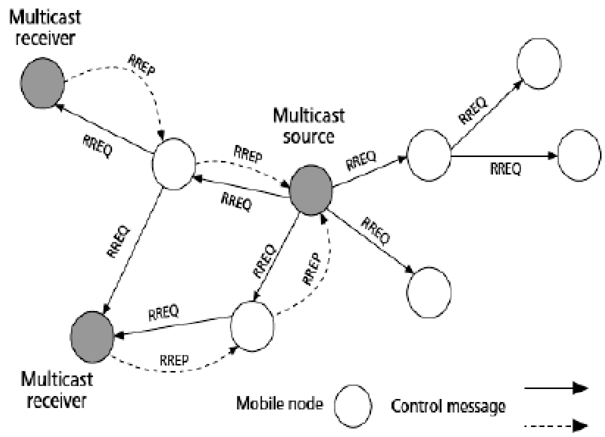

Figure 2: Path Discovery in the MAODV Protocol.

MAODV [4] is a multicast extension for AODV protocol. MAODV based on shared trees on-demand to connect multicast group members. MAODV has capability of unicast, broadcast, and multicast. MAODV protocol can be route information obtained when searching for multicast; it can also increase unicast routing knowledge and vice-versa. 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.

IV. MESH-BASED MUTICASTING

A mesh-based multicast routing protocol sustains a mesh consisting of a connected component of the network containing all the receivers of a group. Example of mesh-based multicast routing approaches is On-Demand Multicast Routing Protocol (ODMRP).

A. *On-Demand Multicast Routing Protocol(ODMRP)*

ODMRP [7], is an on-demand mesh based, besides it is a multicast routing protocol, ODMRP protocol can make use of unicast technique to send multicast data packet form the sender nodes toward the receivers in the multicasting group. 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.

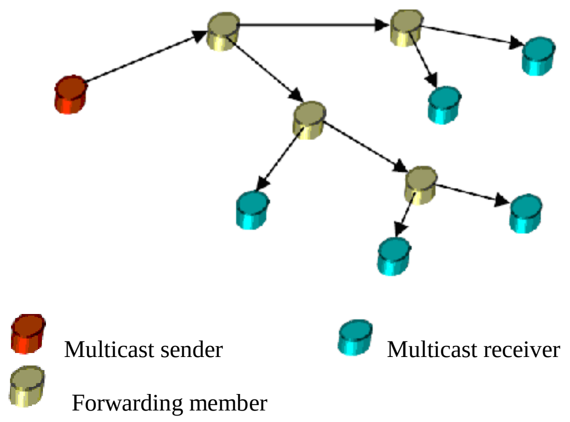

Figure 3: JOIN_DATA propagation

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. 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. A multicast table is built on each node to carry multicast data. This process either constructs or revises the routes from sources to receivers and forms a mesh.

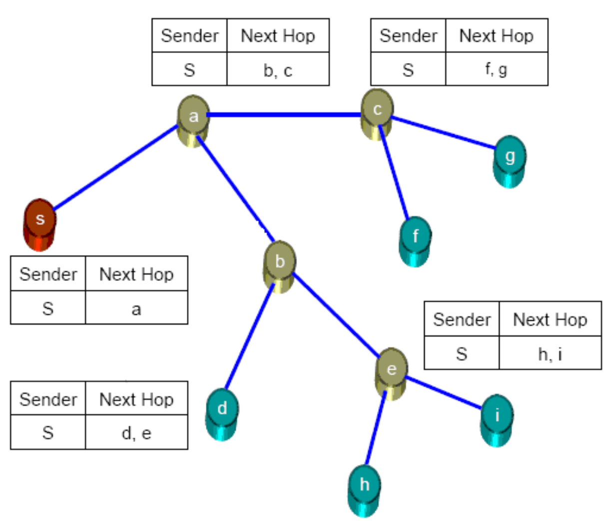

Figure 4: Multicast tables in ODMRP

B. Patch On-Demand Multicast Routing Protocol (Patch ODMRP)

Patch ODMRP [8], it's an upper version of ODMRP protocol. Patch ODMRP works better with small networks and high mobility. Patch ODMRP uses a local patching scheme instead of frequent mesh reconfiguration, where it copes with mobility without reducing the Join-Req interval.

Figure 5: the official ODMRP mesh is shown in Figure 5(a), S node is the sender of the multicast group and R node is the receiver. Each FG node utilizes MAC layer to check for its neighbors, and comparing it with the forwarded routing table to check out if there is any unreachable node in the network. In Figure 5(b), node K detects that node J is unreachable as a result of the failure of the link JK. In this case, K node starts the patching procedure by flooding advertisement message (ADVT), advertising the upper loss. If J node supports more than one multicast groups, then it is added in the ADVT message. A node receiving the ADVT message updates its routing table entries for the source of the ADVT. In Figure 5(c), a PATCH packet is generated as a reply on the ADVT and is forwarded to K node, selecting L as a temporary FG node. If K receives more than one PATCH packet, it selects the shortest path to the multicast sender. The new mesh path is shown in Figure 5(d), K node marks L node as a new upper FG node [9].

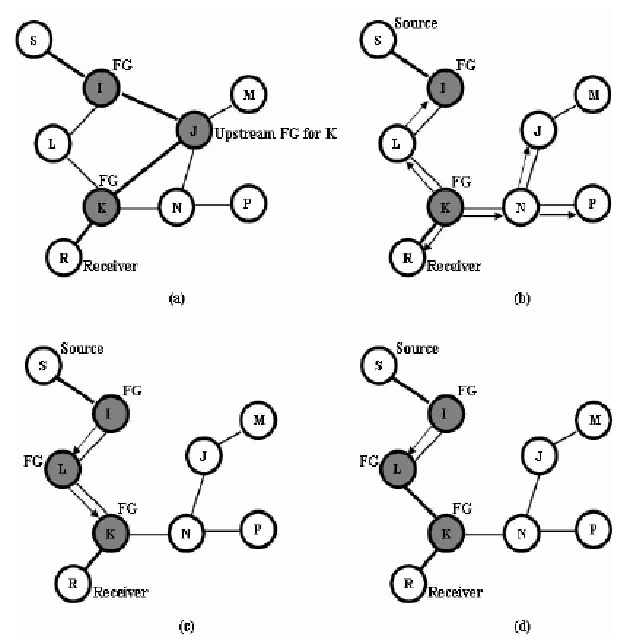

Figure 5: Patch ODMRP Process: (a) ODMRP protocol, (b) j node is not detected by node K, (c) PATCH packet from node I to node K and, (d) node K working last FG node.

V. HYBRID MULTICASTING

It is the type of protocols which have the combination of both tree-based and mesh-based multicasting routing protocols.

A. Ad-Hoc Multicast Routing Protocol

AMRoute based on shared tree and has two faces: mesh and tree. AMRoute identifies and designates certain nodes as logical cores that are responsible for initiating the signaling operation and maintaining the multicast tree to the rest of the group members. A non-core node only responds to messages. AMRoute does not address network dynamics and assumes the underlying unicast protocol to take care of it.

In Figure 6, core receives a JOIN_REQ packet from another core in the same multicast group. It replies with a JOIN_ACK. A new bidirectional tunnel is created between the two cores, and one of them is selected as a core after the mesh merger. When the mesh has been started up, the core starts the tree building process. The core start to send TREE_CREATE messages to all nodes in the mesh. The TREE_CREATE messages will be received only by the multicast group nodes. Then every TREE_CREATE message receiver in the multicast group will forwards messages it received to all mesh links except his parent. Then the TREE_CREATE is discarded and TREE_CREATE_ NAK is sent back to his parent. If there is node wants to leave the group, it is try to send a JOIN_NAK message to nodes that have connection with him.

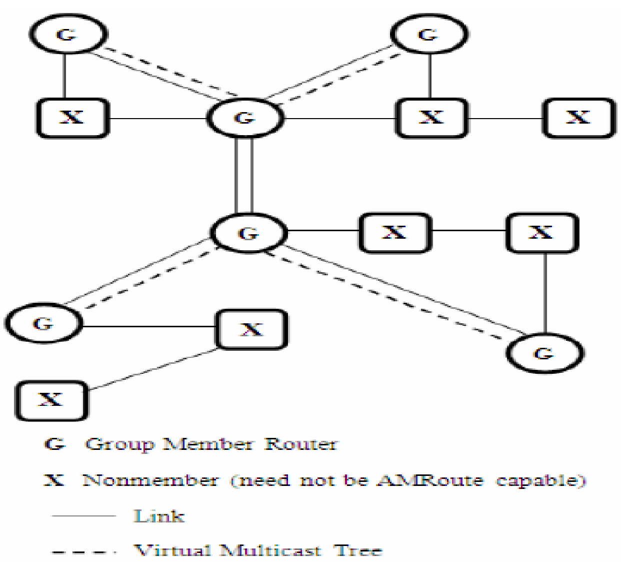

Figure 6: Virtual multicast tree formed by AMRoute

Using the mesh links, AMRoute starts building multicast tree. If there is any change in the network, multicast tree in AMRoute tries to keep the multicast delivery tree unchanged. The main disadvantage of this protocol is that it may have temporary loops and may create non optimal trees with host mobility [11].

VI. SIMULATION RESULTS

We tried to emulate scenarios to investigate the protocol performance under different network situations. We have varied the following item: mobility speed.

A. Mobility speed

A.1. Scenarios

Each node moved constantly with the predefined speed. Moving directions of each node were selected randomly, and when nodes reached the simulation terrain boundary, they bounced back and continued to move. The node movement speed was varied from 0 km/h to 72 km/h. In the mobility experiment, twenty nodes are multicast members and five sources are transmitting packets at the rate of 2 pkt/s each.

A.2. Results and analysis

Figure 7 illustrates the packet delivery ratio of the protocols under different speeds. ODMRP shows good performance even in highly dynamic situations. ODMRP provides redundant routes with a mesh topology and the chances of packet delivery to destinations remain high even when the primary routes are unavailable. The path redundancy enables ODMRP to suffer only minimal data loss and be robust to mobility. In fact, ODMRP was as effective as flooding in this experiment. AMRoute was the least effective of the protocols with mobility. Although its delivery ratio is near perfect in no mobility, it fails to deliver a significant number of packets even at low mobility speeds. The delivery ratio steadily worsens as the mobility speed is increased. One of the reasons AMRoute performs so poorly is due to the formation of loops and the creation of sub-optimal trees when mobility is present (at 72 km/h, the average hop count was nearly eight while other protocols were below four). Loops occur during the tree reconstruction phase when some nodes are forwarding data according to the stale tree and others according to the newly built tree. The existence of loops is critical in protocol performance because they cause serious congestion. At some instants, nodes had up to 13.75 packets dropped per second. The loss of packets due to buffer overflow has two consequences. First, if a data packet is dropped in the early stage of its multicast tree traversal, a large portion of tree members will not receive it. Second, if control packets (TREECREATE, JOIN-ACK, etc.) are dropped, the tree is not properly built or becomes segmented and data will not be delivered. Another reason for AMRoute ineffectiveness is its dependency on the underlying unicast protocol. AMRoute relies on the unicast protocol to set up bidirectional tunnels between group members for the multicast tree.

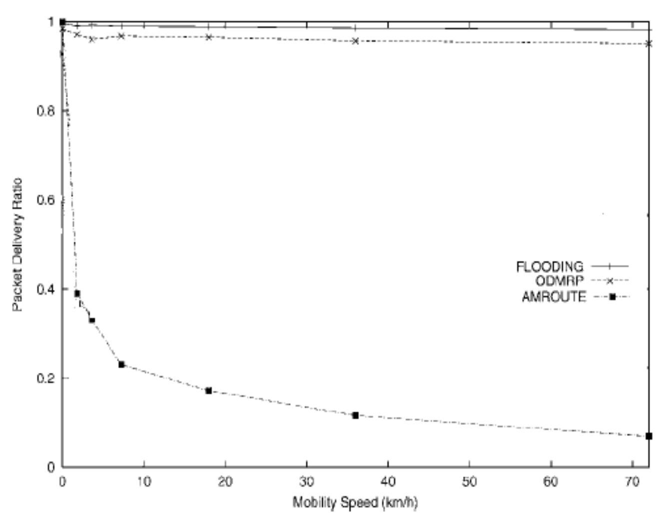

Figure 7: Packet delivery ratio as a function of mobility speed

Figure 8 shows the number of data packets transmitted per data packet delivered as a function of mobility speed. From the figure it can be seen that AMRoute has the highest number of transmissions because of loops. It can observe that protocols using mesh i.e. ODMRP transmits nearly as much data as flooding as shown in the above figure because it exploits multiple redundant routes for data delivery.

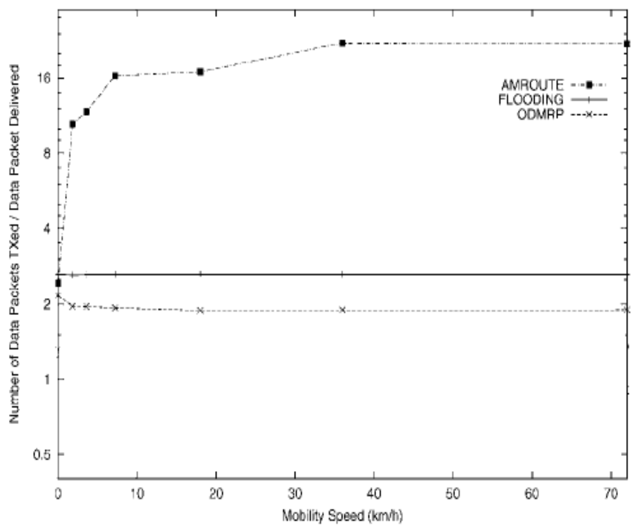

Figure 8: Number of data packets transmitted per data packet delivered as a function of mobility speed.

The control byte overhead per data byte delivered is shown in figure 9**.** Remember that data packet header is included in control overhead.

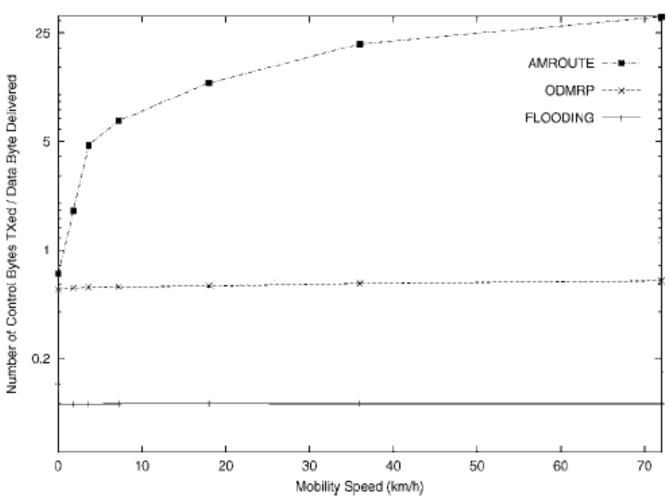

Figure 9: Number of control bytes transmitted per data byte delivered as a function of mobility speed

Flooding has no control packets. Hence, only the data header contributes to control overhead and this overhead does not increase with mobility. Other protocols generate increasing overhead as speed increases. In ODMRP, the control overhead remains relatively constant because no updates are triggered by mobility. JOIN QUERY refresh interval was set constant to three seconds and hence no additional overhead is required as mobility increases. AMRoute has the highest ratio because of the data headers that are caught in the loops. The high ratio is also due to the formation of inefficient trees. During the tree creation phase, an inefficient tree can be formed when the TREE-CREATE packets from distant mesh neighbors arrives earlier than packets from nearby nodes (e.g., due to network congestion, etc.). The non-optimal tree results in having longer hops between member nodes and increasing the number of data transmissions.

The number of all packets transmitted per data packet delivered is presented in figure 10. This shows that ODMRP transmits more data packets on redundant paths and AMRoute has the highest value number of packet transmissions because of loops.

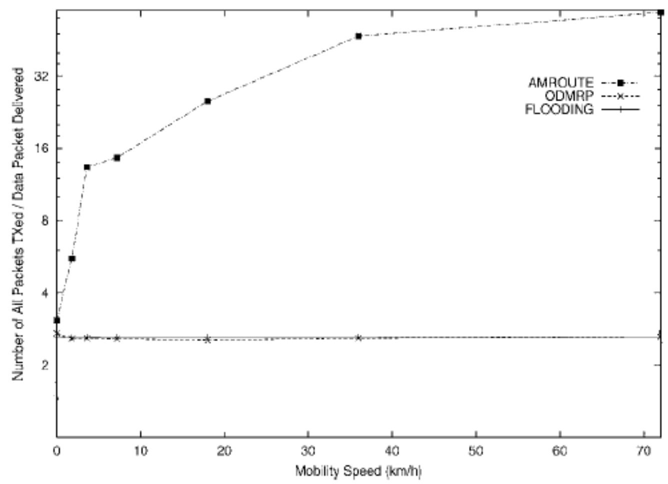

Figure 10: Number of total packets transmitted per data packet delivered as a function of mobility speed

VII. CONCLUSION

This paper, presents a general view of multicast routing protocols in ad-hoc networks. Any multicast routing protocol in MANETs tries to overcome some difficult problems which can be categorized under basic issues or considerations. All protocols have their own advantages and disadvantages. One constructs multicast trees to reduce end-to-end latency. Multicast tree-based routing protocols are efficient and satisfy scalability issue, they have several drawbacks in ad hoc wireless networks due to mobile nature of nodes that participate during multicast session. In the mesh-based protocols provide more robustness against mobility and save the large size of control overhead used in tree maintenance. Most protocols of this type rely on frequent broadcasting, which may lead to a scalability problem when the number of sources increases. Hybrid multicast provides which are tree based as well as mesh based and gives the advantage of both types. 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 develop a single protocol which can satisfy as many goals as possible in the future.

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