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A Survey on Multicast Routing Protocol

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***Abstract*—MANET is a type of decentralized wireless network suited for a variety of ad-hoc applications. Its nodes reconfigure themselves from continuously to perform the desired task with optimum battery power. Multicasting supports group communication by utilizing bandwidth efficiently with increased reliability and reduced delay. This requires effective management of the nodes becoming members of the multicast group. Topology-wise, there are two main types of multicast routing protocols: tree-based protocols and mesh-based protocols with both are having proactive and reactive routing alternatives. We evaluate these protocols and highlight their respective pros and cons. We also suggest the suitable places of application for excellent use of these multicast routing protocols.**

***Index Terms*– Mobile Ad-Hoc Networks, Multicast Routing Protocols, Tree-Based Protocols and Mesh-Based Protocols**

I. INTRODUCTION

A mobile ad-hoc network (MANET) is a collection of nodes communicating over wireless links without any infrastructure to facilitate their deployment. These nodes are able to interact with each other for a short period of time on temporary basis. Since the nodes are free to move randomly in any direction, the topology of the network changes from time to time. A large number of multicast routing protocols have been proposed for ad-hoc network applications. On the basis of topology considered for routing, they can be broadly categorized into tree-based and mesh-based protocols. Tree-based protocols operate on the provision of a single path for any sender-receiver pair and show greater efficiency in multicasting. Even though they exhibit high packet delivery ratio, they are not robust against dynamic topology changes and hence are not suited for environments with highly mobile nodes. This reliability issue in tree-based protocols turns us towards mesh-based protocols, which provides multiple routes between any pair of sender and receiver for reliable data transfer. This advantageous feature helps to compensate the problem of low packet delivery ratio in case of link failures. In other words, mesh-based protocols are highly robust against node mobility but yield low multicast efficiency [1].

Ad-hoc network is a network formed by wireless links between nodes, where nodes are mobile. With such dynamic features, loss of packets and packets received in error is a common thing. Reliability is a major issue due to which the problems of transmission delay and packet-loss occurs, which are overcome at the cost of higher packet delivery ratio for each transmitted packet. We can therefore say that increased reliability in multicast routing protocols is a major area of research in MANETs. Hence, error control mechanism must be included in multicast protocols to ensure reliability by deciding that who detect errors? How error messages are indicated? And how lost packets are retransmitted? Each protocol addresses the reliability issue in its own sense, as the design and operating sense of each protocol is different. Some protocols support one type of features, while other protocols go for another set of properties [2], [3].

In this paper, we have performed a detailed survey of multicast routing protocols for mobile ad-hoc networks. A comparative study of performance of various ad-hoc multicast routing protocols is presented in paper [4]. The paper [5], [6] introduces multicast protocols and discusses some existing trends. This survey has compared the working of traditional protocols with those of the newly proposed ones and by doing so, we have also mentioned their advantages and disadvantages.

The rest of the paper is organized as follows: Section II shows some tree-based protocols and mesh-based protocols, respectively with their advantages and disadvantages. Section III and Section IV explained the discussion and conclusion of the paper.

II. MULTICAST ROUTING PROTOCOLS

In recent years, the schemes of multicast routing protocols in MANETs have attained a lot of responsiveness with mesh and tree-based routing being the frequently used by the researchers. Generally, the mesh based protocol has a higher throughput, stability and resistance to link failure as compared to tree based approach, where overhead is minimized. Many surveys have been performed on MANET which focus on various routing protocols, but we explain in this survey all multicast routing protocols related to mesh based and tree-based protocols.

A) Tree-based Protocols

Multicast Ad-hoc On-demand Distance Vector: Multicast Ad-hoc On-demand Distance Vector (MAODV) [7] is a multicast version of AODV used by nodes in a mobile ad-hoc network. It responds quickly to dynamic network conditions of low data rate on links, low control information, and inefficient network utilization. This protocol provides ease of communication by forming shared multicast trees with bi-directional links facility. The senders are receivers connected by multicast trees retain these routing structures as long as they are operating within the specified region bounded by the network. In MAODV, each multicast group has a group leader which is responsible for maintaining the group by updating the group sequence number to refresh routing information propagating through the network. MAODV selects a leader within the group by flooding Hello messages. Each node has to forward Hello message by flooding it accordingly. If a node fails to reply to the Hello message, the group leader automatically learns of a broken link between the node and its neighbor. To become a member of the group, the group leader replies to a join request flooded by the node towards the group leader. Since the node is mobile, the shared routing structure may be partitioned into two or more trees temporarily resulting in multiple core nodes. This situation is countered by a group member who sends a message to its core node with a lower IP address to cease its operations as group leader. After this, the node with the highest IP address claims to be the leader of single merged tree. Figure.1 shows how MAODV works in practice.

Advantages: This protocol provides ease of communication by low data rate on links, low control information, and efficient network utilization.

Disadvantages: Due to tree-based protocol, MAODV gives more link failure in high mobility. Likewise, the merging concept of one group within the other group in MAODV make it more complicated because the node will have to find the superior core within each other, which can create unnecessary delay.

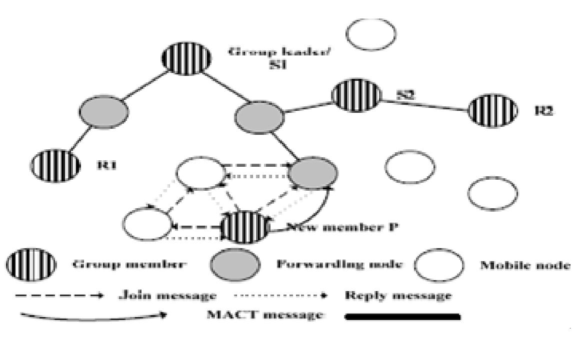

Fig. 1: Joining Procedure in MAODV

Ad-hoc Multicast Routing Protocol utilizing Increasing Id-numbers: Ad-hoc Multicast Routing Protocol utilizing Increasing Id-numbers (AMRIS) [8] is a tree-based multicast protocol, which stands for Ad-hoc Multicast Routing Protocol utilizing Increasing Id-numbers. The idea behind its operation is based on assigning each and every node participating in the multicast session with an Id number. These Id numbers increase progressively along the delivery tree, which is rooted at a special node called Sid. The Sid has Id number with the smallest numerical value, while the value of other nodes increases in ascending order as we move upstream along the tree from root node.

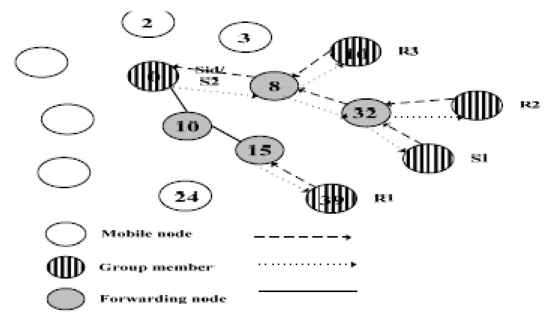

Fig. 2: Joining Procedure in AMRIS

To initiate a multicast session, a new-session message is flooded by Sid to all its neighbors so that they could prepare themselves for multicasting by generating their own Id numbers. A new node joins the session by sending a message to one of its potential parent nodes. The join request is replied to in the case the node is parent, otherwise the join message is forwarded as long as a tree is not found. In case a link failure occurs, the node with the higher Id-number is responsible for repairing the broken link between two nodes. The working principle of AMRIS is depicted in Fig. 2.

Advantages: The use of Id-numbers is very beneficial in the formation and maintenance of a multicast group tree. Due to this reason, the control overhead is significantly reduced.

Disadvantages: Due to limited amount of bandwidth, it takes time to join the nodes repeatedly. However, prioritizing the joining of nodes by periodic flooding consumes the precious bandwidth.

Bandwidth-Efficient Multicast Routing Protocol: Bandwidth-Efficient Multicast Routing Protocol (BEMRP) [9] is a source tree based hard-state routing protocol based on receiver-initiated scheme. This protocol selects the node closest to the sender instead of choosing the shortest route between the source-destination pair. This strategy is very helpful in dealing with link failures. Its main objective is to conveniently utilize bandwidth by preventing transmission of periodic control messages used for updating multicast tree. The node nearest to the sender is chosen by an optimization algorithm ignoring unwanted nodes. Its operation phases are: Tree Initialization, Tree Maintenance and Route Optimization. The benefit gained is conservation of bandwidth by using reduced number of data packet transmissions at the cost of higher probability for link failures in which there is a greater distance between source and destination. The reason for this lack of robustness is that protocol uses hard-state approach to deal with link failures as the nearest possible node strategy is used for establishing route to destination, and hence also delays the path re-establishment process.

Advantages: A higher level of multicast efficiency is obtained by removing unnecessary control information. Also, the delay caused by transmission of data packets is reduced to a significant extent.

Disadvantages: It takes considerable amount of time as well as bandwidth to connect and re-connect a node to multicast tree. Since the tree is shared-based one, its failure affects the data reception process.

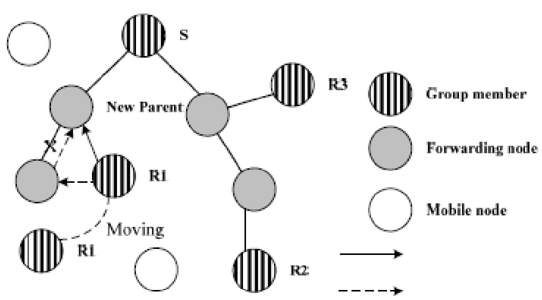

Fig. 3: Route Optimization of BEMRP

B) Mesh-based Protocols

On-Demand Multicast Routing Protocol: On-Demand Multicast Routing Protocol (ODMRP) [10] is a mesh-based soft-state protocol well suited for ad-hoc wireless network with highly dynamic nodes and arbitrary topology. This protocol uses the forwarding group technique, which is based on a set of nodes employed for the purpose of forwarding multicast data packets to their intended receivers. A soft-state approach is used for constructing and maintaining members of the mesh group, due to which the drawbacks of tree-based routing structures such as traffic congestion, unreliable connectivity, excessive reconfigurations, and sub-optimal paths in a shared tree, etc are avoided.

To establish multicast routes between a given source and destination, a join message is sent by the first sender which is then flooded within the whole network to know the updated status of the network. Any node which wants to participate in the multicast group replies to this message. Thus, a multicast mesh group shared with other senders is constructed in a predictive manner. Fig. 4 illustrates the working principles of ODMRP.

Advantages: The most reliable route is recognized among different available mesh paths for a given source-destination pair. Also, multicast paths are shared among different senders.

Disadvantages: A large amount of control overhead due to periodic flooding is experienced using this protocol. Also, the use of GPS becomes essential to locate the approximate position of nodes because of their high mobility.

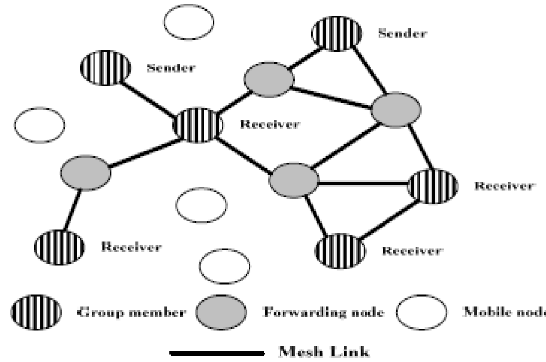

Fig. 4: Multicast Mesh in ODMRP

Dynamic Core-based Multicast Routing Protocol: To eliminate the problem of high control overhead created in ODMRP, we go for another multicast protocol known as Dynamic Core-based Multicast Routing Protocol (DCMP), short for Dynamic Core-based Multicast Routing Protocol. DCMP defines different types of senders, namely active senders, passive senders, and core senders. Active and passive senders perform the job of forming and maintaining the mesh group, while passive senders merely function as relaying nodes for delivering packets to their destinations, with core nodes acting as one of the acting senders for one or multiple passive senders. The primary task of refreshing and updating the mesh is in the hands of active and core senders, while the secondary task of data forwarding is performed by passive senders. Figure.5 graphically explains the working concept of DCMP [11].

Advantages: The control overhead is minimum, along with an increased packet delivery ratio.

Disadvantages: The stability of path is compromised, especially due to the introduction of core senders. If one core sender becomes out of order, several passive senders become unresponsive.

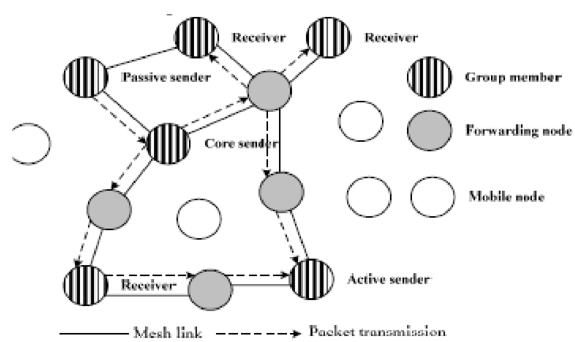

Fig. 5: Packet Transmission path in DCMP

Adaptive Core Multicast Routing Protocol: To make the core node(s) more autonomous, a protocol called Adaptive Core Multicast Routing Protocol (ACMRP) [12] is used. This protocol enables the core node behaves more intelligently in forming, maintaining and updating mesh as well as in dealing with link and node failures. The group formation process is initiated by the very first core node which starts flooding join messages in the entire network. The core node is replied with JREP messages by nodes which are interested to join the group. These messages are encapsulated in ACMRP packet, which are to be forwarded by intermediate nodes. Since there are many intermediate nodes, the forwarding of JREP messages by multiple nodes may occur.

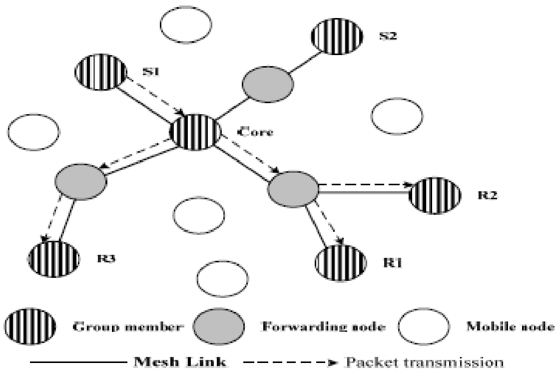

Fig. 6: Packet Transmission path in ACMRP

Advantages: The amount of control overhead generated is reduced and the overall performance is significantly improved.

Disadvantages: The task of encapsulation and de-capsulation of data packet can be performed by every node. Moreover, the calculation of hop-count is also time-consuming.

Robust and Scalable Geographic Multicast Protocol for Mobile Ad-hoc Network: Robust and Scalable Geographic Multicast Protocol for Mobile Ad-hoc Network (RSGM) [13] protocol incorporates GPS system for the sake of building several topological models to keep network information. This kind of protocol implementation has many benefits, including high robustness, increased reliability, and greater scalability in terms of group membership. Also, the communication becomes easy even in the absence of stable wireless channels due to higher node mobility. The administration of the group is performed by some virtual-location structure, while the location facility of group members is also available in the same structure. There is no need for the construction of a manual tree under this protocol, as both the data and control packets are delivered along efficient paths like those of a multicast tree, established with the help of GPS tracking.

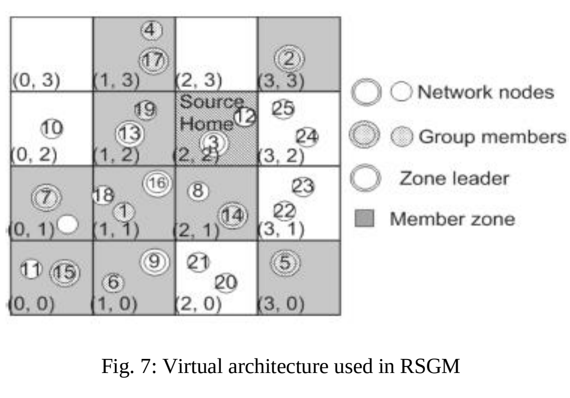

Fig. 7: Virtual architecture used in RSGM

Ease of tree management is caused by reduction in overhead while using virtual tree-based structures. Transmissions also become more efficient and robust to high dynamics than before. These network features are enhanced further with GPS-based forwarding. In order to circulate source information throughout the network by method other than flooding, some kind of efficient source tracking mechanism is introduced. After thorough qualitative analysis and extensive simulations, it is observed that RSGM performs better in terms of scalability on group and network level, and multiple multicast groups are supported efficiently by the protocol. Results show that compared to other multicast protocols, RSGM always leads in performance of packet delivery ratio tested for different values of mobility, network density, group sizes, number of groups, and network size. The control overhead and joining delay is also minimum in RSGM. Fig. 7 demonstrates the concept behind RSGM.

III. DISCUSSION

This section is concerned with discussing the features that should be considered in the design of new protocols. The factors that need to be considered in the design of a new protocol are robustness, control overhead, and multicast efficiency. The protocol developed should be able to tackle effectively the problem of link failures; otherwise it is not a good protocol for use. In this regard, mesh is the most robust of all multicast routing structures. If we design a mesh-based protocol with a single core node controlling the mesh, then such protocol is robust enough to low movements and hence duplicate transmissions are avoided. However, to support higher mobility, an adaptable mesh-based protocol should be designed.

The location of core node is equally important in deciding the level of robustness of a mesh-based protocol, since a single core node forms and updates the mesh. If the distance between the core node and other members of the group is large, the probability of link failures will be high and hence multicast efficiency will be lowered. Therefore, the selection of core node at a better location on a periodic basis becomes very important. For this reason, flooding needs to be studied carefully in order to devise an efficient core migration strategy with low overhead, since control messages are flooded on a regular basis for reelecting the core node.

Soft-state protocols only update the mesh, while hard-state protocols are used to repair link failures. Generally speaking, multicast protocols send packets through the shortest paths between senders and receivers. Though shortest paths have fewer chances of link failures and also save time in data transmission, multicast efficiency is reduced. Thus, there must be a trade-off between multicast efficiency and path lengths. At a later stage, a mesh may be partitioned due to the mobility of nodes. In such cases, the core node with highest IP address becomes the new core by uniting the separated meshes, which we think is an inefficient method of core election. According to us, the member of the group that first detects the existence of more than one mesh should become the new core, for such nodes lie in the middle of partitioned meshes.

IV. CONCLUSION

In this paper, we have discussed some of the most important multicast routing protocols used in MANETs. We divide them into two main classes: tree-based protocols and mesh-based protocols. We evaluate the performance of each protocol on the basis of its features, operation and mention its pros and cons. After that, we suggested rules to be followed in the development of a new protocol. Here we have discussed some very general multicast routing protocols. Other multicast protocols also have the availability of some special features like reliability, security, quality of service etc. Our future work will be based on investigating these types of protocols.

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