International Journal of Advance Research in Science and Engineering
Volume No. 10, Issue No. 12, December 2021
www.ijarse.com
IJARSE
ISSN 2319 - 8354

A STUDY OF MULTICAST ROUTING PROTOCOLS WITH RELIABLE DATA DELIVERY IN MANET

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ABSTRACT

Mobile Adhoc Networks (MANET) are widely used in group oriented communication which may have limited bandwidth, energy sources and limited memory and processing capabilities. In such networks with varying topology, multicast routing plays a major role in energy efficient data delivery among the nodes. In this paper, multicast routing protocols are classified into four categories such as tree based, mesh based, hybrid and stateless multicast routing protocols. This survey summarizes some of the protocols belongs to each of the category and analyzed their merits, demerits and performance based on some of the Qos parameters.

Keywords: Data delivery, Energy Efficiency, MANET, Multicast Routing Protocols.

I. INTRODUCTION

MANET is a self-configuring, infrastructure less network of portable mobile devices connected through wireless links to exchange information. This type of networks are deployed anywhere temporarily and dismantled easily. Nodes in MANET moves randomly in any direction causes frequent and unpredictable change in network structure contrary to fixed network infrastructure. Due to dynamically changing topology, routing protocols reliable and successful data delivery is a challenging issue to be considered. MANETs are widely adopted in dynamic environments like military battlefields, extreme weather condition, disaster recovery emergency and rescue operations and communication in remote environments. This kind of application requires multicasting capability to enable communication among several nodes.

Multicasting is an efficient technique used to transmit same stream of data from one or more source node to group of recipient nodes concurrently with the utilization of limited resources and minimum communication cost. The benefits of using multicasting are simultaneous delivery of message to destinations; delivering the message only once through each link and only copy of the message is created when links to destination splits.

The designs of multicast protocols are significantly complex because of the wireless nature, changing topology, available bandwidth and battery power as well. The group of destination nodes are called multicast group which is identified by a single destination address called multicast address. Multicast address belongs to class D addressing scheme in which multicasting is allocated from 224.0.0.0 to 239.255.255.255.

Multicasting requires the creation of multicast trees. Multicast group consist of set of host. The host can join the group or leave the group any time. To manage the multicast groups several control message must be transferred, this involves high consumption of mobile nodes battery power and other network resources. Automatically longitivity of MANET is reduced. Therefore, the main objective of multicast routing protocol is energy efficient, reliable data delivery with reduce delay and bandwidth particularly in low or limited energy scenarios. Consequently, MANET has group of nodes in which multicast routing protocols are used for data delivery. Reliable data delivery ensures three important factors.

Reliability – The data sent from the source node to destination node will be delivered.

Scalability - The size of the network increases or decreases

Longitivity – Lifetime of the network depends on efficient utilization of energy.

Multicasting guarantees that reduced utilization of nodes battery power and network bandwidth.The major issues in multicast routing protocol are

Efficiency: It should take minimum number of transmission to deliver the packets to the group members.

Robustness: When link break occurs, it must be able to reconfigure and recover immediately. So that , it can be useful in dynamic environment.

Quality of service: Though MANET deals with time sensitive data, multicast routing must ensure quality of service requirements such as throughput, delay, jitter, loss rate, energy utilization, etc.,

Scalability: It should provide service to both small and large networks.

Security: MANETs are vulnerable to security attacks due to its wireless and broadcast nature. It is obvious to authenticate session members and prevent unauthorized session members to access information.

Energy efficiency: Multicast routing aims to minimize the energy consumption by mobile nodes in the multicast group. Obviously, this will maximize the life span of multicasting.

Multicasting is applied to many envisioned real time applications like teleconferencing, news dissemination, sports events, disaster situations(earthquake, fire, flood) and distance learning, etc.,. It is also used in multimedia data like audio video conference and live streaming.

II. CLASSIFICATION

In MANET, multicast routing protocols are classified into several types such as application dependent , application independent, based on topology, based on initialization approach(source initiated, receiver initiated, hybrid approach), based on routing scheme(proactive, reactive, hybrid approach), based on route maintenance (soft state approach, hard state approach).

Based on the routing topology or route construction approach used for delivery of data, the multicast routing protocols are classified into four categories.

A.Tree based multicast routing protocols

In this method, a shared multicast routing tree is created and maintained among the group members to deliver data from source to destination of a multicast group. Multicast tree is constructed with a unique path from source node (root) to all other receivers. Tree based multicast routing protocols are not suitable for dynamic networks and it is efficient on terms of data delivery. Some examples of tree based multicast routing protocols MAOCV, DDM, BEMRP, MOLSR and AMRIS.

Tree based multicast routing protocols are classified in to two types based on number of trees in multicast group.

1. Source based tree:

In this approach, both source and group determines the tree. Each router have shortest path tree to each group. For each source node, a multicast tree is constructed among all member nodes. Source node knows the address of all the recipients in the multicast group and also the topology information. In this approach, the traffic is distributed throughout the network leads to better throughput and less scalability problems

2. Group shared tree:

Only one multicast tree is constructed for a multicast group. Group determines the tree and minimum cost spanning tree is constructed. The core router alone involved in multicasting. Including several source node, only one multicast tree is constructed for multicast group. It is less efficient than source based multicast.

B. Mesh based routing protocols

Route failure is common in MANET. In this method multiple or redundant data transmission paths exist between source to destination. If route failure occurs, this redundant paths are used thus it provides high packet delivery. It uses broadcasting for route discovery. Mesh based routing methods achieves good packet delivery ratio with the elimination of link failure. But it suffers from power wastage and dismissal of packets. As a result, mesh based approach is more suitable for MANET compared to tree based approach.

Example: ODMRP, DCMP, FGMP, CAMP,NSMP, etc.,

C. Hybrid multicast routing protocols

It combines the advantage of robustness of mesh based and low overhead of tree based multicast routing protocols. In this method, multiple routing paths are created and duplicate messages are send to the receivers through multiple paths. Non optimal trees are created in these schemes due to node mobility. Example: AMRoute, MCEDAR, MZRP, etc.,

D. Stateless multicast routing protocols

It is suitable for small multicast group. The source node maintains the protocol state and mention the list of destination nodes not by other nodes. The forwarding state information's are included in the header. Using the information in the header, the intermediate node understands how to duplicate and forward the packets. However the inclusion of routing information in the header increases the packet size, the control overhead is reduced.

It is an optimal method and it evades overhead caused during mesh or tree construction. Example: DDM, LGT, RDG, etc.,

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III.PROTOCOL DESCRIPTION

MAODV (Multicast Ad hoc on demand Distance Vector)

MAODV is an extension of AODV which is unicast routing protocol. It handles unicast, multicast and broadcast. It is a hard state reactive tree based routing method and it finds the route on demand using broadcast route discovery mechanism. It works in two phases: route discovery and route maintenance.

It constructs a multicast tree to transmit data between multiple senders and receivers during the multicast session. When a source wants to send data to multicast group, it broadcasts route request message to the group. Upon the receival of RREQ, Multicast group members send unicast RREP packets and reverse route details to the source. The source node receives multiple RREP packets from which it selects the packet with smallest hop count. Each node maintains three tables such as Routing table, Multicast routing table and Request table. The group leader node is responsible for maintaining the multicast group. The MAODV exhibits poor packet delivery ratio in especially in high mobility network. It has low control overhead.

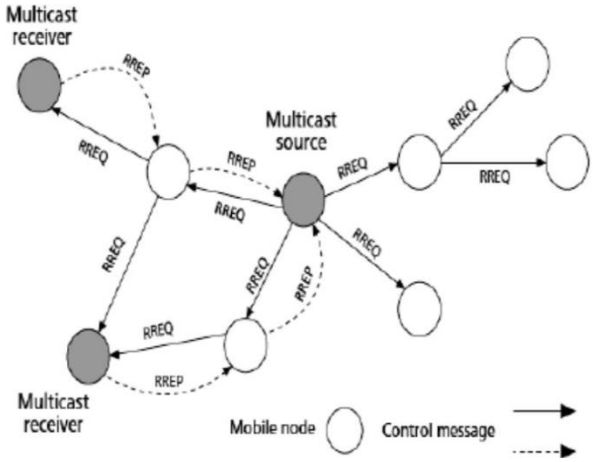

Fig.1 Path discovery in MAODV

DVMRP (Distance Vector Multicast Routing Protocol)

In this method, a source based multicast tree is constructed using reverse path algorithm. DVMRP works in two phases: Advertising and Pruning. In former, the source node broadcast the advertise message. Every node receives this message sends the shortest path back to the source. The later, the nonmember node which receives the advertise message sends prune message back to its parent. The parent who receives the prune message deletes the nodes entry in the route table.

AMRIS (Adhoc on demand multicast routing protocols utilizing increasing Id numbers)

AMRIS is based on shared tree based multicast routing. It facilitates communication between sender and receiver by constructing shared multicast distribution tree. This protocol dynamically distributes Id to each node involved in multicast transmission. The root node has minimum id and based on the Id, multicast tree is built. AMRIS works in two phases. Initializing multi cast tree: The source node contains SId starts broadcasting. When the multicast group

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Volume No. 10, Issue No. 12, December 2021
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IJARSE
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contains only one sender, Sid is given to the sender. If more than one sender exists in the multicast group, the SId is given to the sender which has larger network address.

The node contains the SId broadcast the new session message to the nearest nodes. This message contains node id, multicast id and route details. The node which receives the session message changes the id number and routing details and rebroadcast the message until it reaches all the nodes. During maintenance node wants to join multicast group, it has to execute branch reconstruction algorithm; AMRIS sends a control message periodically to the nearest node to check the link stability.

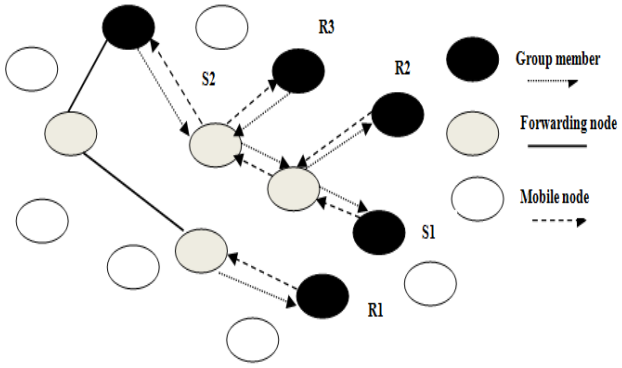

Fig.2 Joining to AMRIS

ODMRP (On demand Multicast Routing Protocol)

ODMRP creates mesh topology rooted from source node. It uses forwarding node approach to build the mesh and updates the mesh by mobility prediction scheme. It selects few nodes as forwarding node from the entire network. Only these nodes can forward multicast packets. The source establishes the route by broadcasting by join message. This message is periodically flooded to refresh the membership and update the route information. Each member receives join data message, broadcast join table message to its neighbor nodes. In this way, the mesh is built. ODMRP uses two multicast messages such as Join Query and Join Reply.

ODMRP performs better in high mobility network. But it creates high routing overhead due to redundant links. This overhead is highly destructive to energy constraint MANETs.

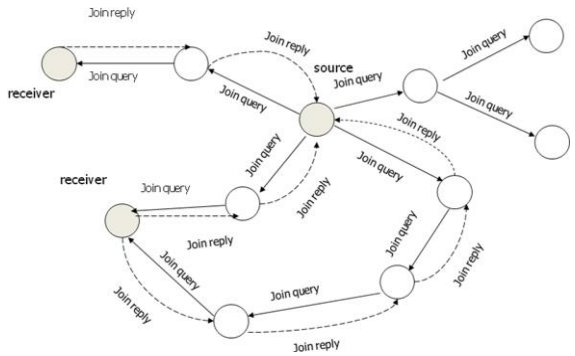

Fig.3 Mesh building in ODMRP

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www.ijarse.com
IJARSE
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CAMP (Core Assisted Mesh Protocol)

This protocol builds multicast mesh for each multicast group. It provides multiple paths between source and receiver. The receiver join the multicast group by sending join message to the core of the group.(receiver initiated approach).Each multicast group defines one or more core to support join operation. The core node limits the traffic and helps the receiver to join the multicast group. If neighbor nodes are not the member of the group, a node sends JREQ message to the core. Else it announces its membership by periodical updates. If the core is not reachable for the node to join a group, it broadcast the JREQ or it uses simplex mode to reach some group member. If a node wants to leave the group, it broadcasts the change of group membership message to its neighbor.

MCEDAR (Multicast Core Extension Distributed Adhoc Routing)

It is the extension of CEDAR which combines the robustness of mesh and efficiency of tree structure. It uses mesh based model to sustain with link breakage without rebuilding the multicast structure. It uses route based forwarding tree to transmit packets. It selects the shortest path to improve the efficiency of the network. In high mobility networks, nodes must change their core frequently, this increases the control overhead. It is suitable for MANETs with multiple groups coexist. MCEDAR divides the network into several disjoint clusters. Each node sends a special beacon message to choose the dominator. The dominator then becomes the core node and send message to the nearby core node to form a virtual link among them. This is called core graph. A sub graph of core graph is mgraph which is formed by the core nodes belongs to same group. When a packet reaches the mgraph member, it forwards the packet to the nearby core node.

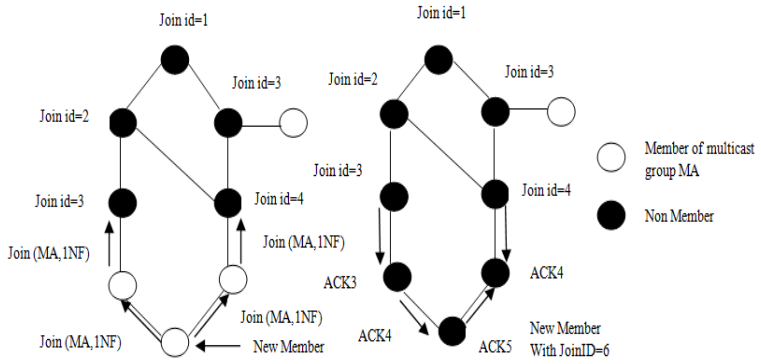

Fig.4 Join procedure

In MMHR, a mesh structure is created for multicast routing and it uses source based tree to forward multicast packets.

AMRoute (Adhoc Muticast Routing Protocol)

AmRoute constructs a bidirectional user multicast distribution tree over the mesh. The group members are connected and forward data using unicast tunnels. The core node initiates the tree and mesh creation. The mesh is formed by connecting group members which are nearby using bidirectional tunnels. The tree nodes are only the

sender and receiver. It depends upon any underlying routing protocol to maintain the member connectivity. There are five control messages are used in AMRoute which are Join Req, JoinAck, Join Ask, Tree create,, Tree Create Nak and Data Message.

Multicast routing involves several issues and challenges like management of resources, link failure, control overhead, efficiency, reliability, wireless nature, security issues. All the nodes in MANETs collaborate themselves to manage resources, communication among nodes and routes.

DDM (Differential Destination Multicast Protocol)

It uses source based tree approach and is applicable to small multicast groups with short distance. In this protocol, the sender has the authority to control group members. It uses data packet and control packets. It also contains packet with variable length header. It uses unicast routing table to forward multicast packet to multicast receivers. During the transmission, the source node adds a list of destination address in the header of each data packet. When a node receives this packet, its DDM agent asks the unicast routing protocol about where to send the packet to reach the destination. It has four types of control packets such as Join, Ack, Leave and Rsync. The main advantage of this protocol is less link break and it saves storage space. It suffers from more control overhead and it is less when number of receiver increases. It is suitable for horizontal scalability (small group). When the group size becomes large, it enforce heavy burden to the supporting unicast protocol.

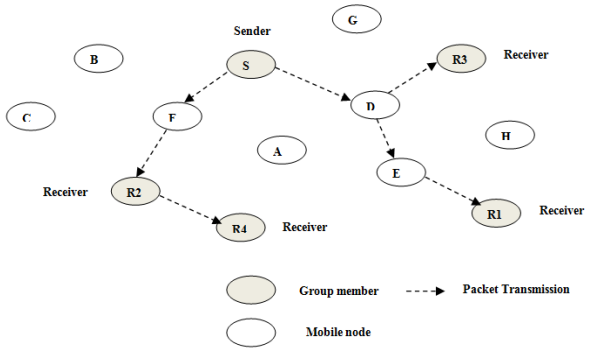

Fig.5 Mesh building in ODMRP

LGT (Location Guided Tree Construction Algorithm)

This protocol uses packet encapsulation technique and it is widely used for small multicast groups. It constructs an overlay packet delivery tree using the location information of the multicast group member nodes without considering the network topology. It uses unicast packet to transmit multicast data to group members. The unicast packet contains destination list and the nodes in the list forwards packet using location guided k-array (LGK) and location guided stenier (LGS) algorithms. It uses route buffer to optimize tree structure and updates the location and

member using hybrid mechanism. This protocol stores the existing routing information in cache which reduces the information storage and increases the speed of routing.

RDG (Route Driven Gossip)

It uses probabilistically controlled flooding technique called gossiping to transmit packet to all the multicast group members. It uses unicast routing protocol DSR to provide routing information which guides gossip process. Each nose contains a buffer and a view. The buffer stores all received data packets. There are two views. The active view maintains the list of member Ids to which at least one route exist. Passive view contains a list of member Ids to which no route is currently available. A node wants to join a multicast group broadcasts group request message. The members receiving request message returns group reply to the initiator and update their active view. Each member node periodically generate gossip message which contains data buffer and sequence number of the missing packet and gossip with some nodes in active view. If the node receives the gossip message contains the missing data packet will unicast the data to the initiator.

IV. PERFORMANCE ANALYSIS

The performance of MAODV, ODMRP, PIM, OSPF is compared under different multicast group size, mobility condition and number energy sources. The packet delivery ratio of MAODV is higher than other three but the average end to end delay of PIM and OSPF is very low compared to MAODV and ODMRP. PIM performs well when number of energy sources increases. On an average, ODMRP outperforms than other multicast routing protocols.

The CAMP protocol consumes more bandwidth than ODMRP, AMRIs and MAODV. In AMRIS, the joining and rejoining of node to multicast group involves more time results in wastage of bandwidth. It also uses periodic beacons which takes more bandwidth. In ODMRP, duplicate transmission of packets in low mobility scenarios and the increase in number of sender causes more flooding which leads to bandwidth wastage.

Generally, link failure occurs in MANET due to node mobility which results in low packet delivery ratio. The mesh based multicast routing protocols provides better packet delivery ratio compared to tree based protocols because it uses alternative paths for data transmission during link failure. The packet delivery ratio of MAODV is low compared to ODMRP. In AMRIS, packet delivery ratio decreases with increase in node mobility. CAMP and MAODV support scalability than ODMRP. The performance of MAODV degrades when single point of failure occurs. The performance of MAODV is increased by reducing control overhead by self pruning the network

The end to end delay of mesh based multicast routing protocols are better than tree based protocols. ODMRP has more delay than CAMP. MAODV has higher end to end delay .So it is not suitable for transmitting multimedia and web related data's. ODMRP possess lesser end to end delay than MAODV which is used in video streaming applications. But ODMRP has high control overhead leads to excessive bandwidth utilization.

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www.ijarse.com
IJARSE
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Scheme	Protocol	Energy Efficiency	Delivery Ratio	Merits	Demerits
Tree Based	MAODV	Yes	Low	• Quick and efficient construction of multicast tree • Low control overhead • Good for small groups	• Not suitable for high mobility networks and high traffic • Frequent link breaks • Long delay
	AMRIS	No	Low	• Simple topology • Low overhead • No need to store global information	• High bandwidth consumption and network resources • Creation of additional routes • Must send periodic becons to indicates its presence to the neighbor node • Performance degrades when mobility increases
Mesh based	CAMP	No	Better	• Good control traffic when multicast group size increases	• Depends on underlying unicast routing protocol • Considerable overhead occurs
	ODMRP	No	High	• Suitable for high mobility networks • Robustness to host mobility • Does not depends upon specific unicast routing protocol.	• Topology is complex • High control overhead occurs to maintain forwarder group • Reduced multicast efficiency • Suffers from scalability problem
Hybrid	MCEDAR	No	Low	• Robust • Independent of underlying protocol	• Increases control overhead • Complex
	AMRoute	Yes	Low	• Multicast trees are established using virtual mesh links • Operates upon any unicast routing protocol	• Creation of non-optimal trees • Temporary loop exist • High overhead
Stateless	LGT	No	High	• Small group • High transmitting efficiency • Improves routing speed	• Robustness is not good • Low bandwidth is utilized. • Used in less mobility environment
	RDG	Yes	Moderate	• Achieves probabilistic reliability • Reduce the burden at source for retransmission	• Modest degradation in performance when mobility and scalability increases • Lacks full delivery of all packets to all the receivers

Table 1: Merits and Demerits of Multicast Routing Protocols

V.OPEN ISSUES

The main objective of multicast routing protocol is to transmit the information to the indented recipients in an optimal way with minimal duplication. The tree based multicast routing protocols establishes a unique path between sender and receiver. The bandwidth requirement for initialing multicast tree is less compared to other structure. If any node moves out of the communication range cause division of multicast tree into more sub trees results in difficulty in communication among all nodes. Compared to other protocols, the control overhead is relatively high when maintaining the multicast tree. The main advantage of tree based multicast routing protocols are its high packet forwarding efficiency and simplicity. Their drawback is when the node moves out, the packets are possibly dropped before the reconstruction of the tree.

Mesh based routing creates multiple redundant path which guarantees robustness during link failure. It is suitable for harsh environment with frequent change in topology. The resource requirement for mesh based routing protocols is much higher than tree based protocols. These protocols suffer from routing loop problem which results in additional overhead in the entire communication system. Some measures must be taken to avoid this problem. Mesh construction and mesh refreshment is done by one core node. If the core node is far away from the group member reduces multicast efficiency than tree based multicasting. Thus core selection is considered to be an important issue. Hybrid routing protocols are tree based or mesh based which gains the advantage of both of these and suitable for moderate mobility environment.

The stateless multicast routing protocols avoids overhead caused by tree and mesh construction and it shows optimal behavior. But, it is suitable only for small multicast group because it is not scalable and stable.

VI. CONCLUSION AND FUTURE SCOPE

The advancements in mobile communication technology have broadened the application of multicasting in MANET. Multicast routing is an efficient technique to provide group communication and also it necessitate the design of energy efficient data forwarding schemes. This study analyses the performance of several existing multicast routing methods and it reveals that each and every multicasting protocol has their unique feature to improve the network performance in terms of Qos parameter. Depends upon the application Nature, availability of resources and network requirement, the user can select multicast routing protocol for data transmission. In future, there is an ample scope for research in designing multicast data forwarding techniques that will focus on various factors of evolving applications in MANET.

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