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Critical Analysis and Performance Comparison of Multicast Routing Protocol in Mobile Ad-hoc Network

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ABSTRACT

Mobile ad-hoc network (MANET) is a collection of mobile nodes and they can communicate via the radio signals. Multicasting plays significant role in MANET. There are so many protocol was developed for multicasting in MANET in last few years. Here we present comparative performance of five multicast routing protocol those are used in mobile ad-hoc network environment: MAODV, AMRIS, CAMP, ODMRP and MZRP.

Keywords : MAODV, AMRIS, CAMP, ODMRP, MZRP, MANET, Multicasting.

I. INTRODUCTION

Wireless network is very much popular day by day because of its advances and benefits. There are two types of Wireless network, one is infrastructured wireless network, where nodes (devices) can communicate via centralized administrator and other is infrastructureless wireless network which is also called mobile ad-hoc network (MANET). In MANET nodes are mobile and topology changes frequently. Because of this decentralized nature, it is not possible to use access point or router in MANET environment, so mobile nodes can act as a router as well as host and they can make direct communication between them. Here if receiver is unreachable from source using single hop it can use multiple hop. The characteristics of MANET are limited bandwidth due to radio waves, limited battery power and dynamic. Multicasting is a major challenge of mobile ad-hoc network. Multicasting means sending same packets from group of one or more sender to group of one or more receiver. It can minimize transmission cost while transmitting same packet from single sender to multiple receiver and also minimizes link bandwidth and reducing the power consumption. Multicasting is used in video/audio conferencing, battlefield, and search and rescue operation for sharing information among mobile nodes. In MANET there may be the possibility of packet loss during multicast routing because of higher mobility of nodes. So using an efficient routing protocol is also another challenging task in MANET environment. There are so many protocol were developed for wired network like Distance Vector Multicast Routing Protocol(DSMRP), Multicast Open Shortest Path First(MOSPF), Core Based Tree(CBT) etc. but they are not suitable for Mobile ad-hoc network. So here we present some protocol that can be used in MANET. Depending on when the route is computed, multicast routing protocol in MANET can be divided into three categories, Proactive, Reactive and Hybrid. In proactive routing protocol, route to destination from source must be exists in advance but in case of reactive (also called on demand) routing protocol route to the destination is only created when route discovery process initiates the route request. Hybrid protocol is a combination of proactive and reactive protocol. Multicast routing protocols are also classified based on topology of network like, tree-based and mesh-based. Tree based protocols uses single path between source and destination and mesh based protocols there are more than one route in

between source and destination. This paper organized as follows. Operations of five multicast routing protocols we summarized in section II. Section III gives the comparison among routing protocols. Section IV presents conclusion.

II. PROTOCOL DESCRIPTION

A. Multicast extension for Ad-hoc On-demand Distance Vector (MAODV)

MAODV uses two processes, route discovery and route maintenance.

Route discovery process use route request (RREQ) and route reply (RREP) query. When a node wishes to join the multicast tree or if it has data to send to the node it broadcasts RREQ packet across the network. If a node is sending the join query then only the member of the multicast group will respond otherwise any node of the multicast tree can respond. After receiving the RREQ packet by a node, it can send the RREP packet to the source of the RREQ packet, if it is either the destination or it has the route to the destination with corresponding sequence number greater than or equal to that contained in the RREQ. If the message received by the intermediate node it rebroadcast the RREQ message to its neighbor. When a node receives RREQ message it update their information for the source node and creates the backward pointer to the source node in the routing table. A node can receive multiple RREP message, it can find out the route with greatest sequence number and shortest route to the member of the multicast group. Source node can send data packet to all the destination nodes after receiving the RREP packet.

For route maintenance purpose MAODV uses Group leader. When a node broadcast RREQ message it waits for RREP message and if it does not receive the RREP message, automatically send RREQ for second time and if it still does not get RREP message it act as group leader. Group leader is responsible for maintain the group tree by periodically sending hello message containing group sequence number for the multicast group and this hello message refresh the routing table. When a node wants to terminate from group membership, if it is the leaf node it can easily terminate otherwise it must remain in the tree as a non group multicast group member.

B. Ad Hoc Multicast Routing Protocol Utilizing Increasing ID Numbers (AMRIS)

AMRIS protocol uses two mechanisms, Tree initialization and Tree Maintenance. In Tree Initialization, all participant established their initial msm-ids (multicast session member id), which is initialized by Sid (source id). In single sender and multiple receivers, Sid is the single sender. But if there multiple sender and multiple receiver, Sid is elected among multiple sources. Sid broadcast NEW-SESSION message and after receiving the message by its neighbor calculate their msm-id which is larger than Sid's msm-id. These neighbor nodes again rebroadcast NEW_SESSION message by replacing the previous msm-id by its own msm-id. Msm-id of a node increase its numerical value as it radiate away from the source. If a node is interested to join multicast session, it can join during Tree Initialization phase. The nodes that are not interested joining multicast session but it become a part of multicast session by acting as an intermediate node are called U-node. When a node A wants to join multicast session it send NEW_SESSION message to its all neighbor nodes and they form the set of potential parent node. Then node A send a unicast JOIN_REQ to one of the potential parent nodes B and checks the presence of B in the delivery tree. If so, it send JOIN-ACK message to A. Otherwise it initializes Tree Maintenance mechanism to find out the potential parent for itself by executing Branch Reconstruction (BR) process. BR has two subroutines:BR1, BR2. BR1 executes when a node has neighbor potential parent to join. If requesting node does not have any neighboring node that can be potential node, BR2 will work. In BR2 instead of using unicast JOIN_REQ message, requesting node broadcast JOIN-REQ.

C. Core Assisted Mesh Protocol (CAMP)

CAMP has two types of mesh member: simplex member and duplex member. Simplex member can send out multicast data but duplex member can capable of both sending and receiving multicast data. When a node wishes to join multicast group, only duplex member can reply with join acknowledgement. When a node wants to join multicast group, it forward join request to neighbor node, if neighbor node is a member of multicast group. Otherwise send the join request to the core node. Core node may not be the part of the mesh of multicast group but it can limit the control traffic needed for receiver to join multicast meshes. When core node is unreachable from the node that needs to join the group, the node broadcast the message using *expanding ring search* which eventually reaches some of the group member. CAMP ensures the shortest path from each source to each destination, the part of the multicast mesh. A node keeps the cache of the identifier of packet that it has recently forwarded, and node forward the multicast packet if packet identifier is not in the node's cache. A node can easily leave from the group if no other node is dependent on it simply advertizing the change of group membership to their neighbors.

D. On- Demand Multicast Routing protocol (ODMRP)

ODMRP uses Route Request and Route Reply process. When source node can have data packet to send but it has no knowledge about the group membership in a network then it broadcasts Join-Query message to entire network. After receiving the non-duplicate Join-query message the node store the information of upstream node and rebroadcast the message again. When the message received by the receiver it creates a Join-table and forward to its neighbor. When a node receive Join-table it checks whether next node Id from one of the entries match with its own Id. If yes then it means that this is the path to the source nodes and this node is a part of forward group. It then broadcast its own Join table to its neighbor. This process continues until it reaches to source nodes via shortest path. Routes from sources to receivers build the mesh of nodes called forward group. In ODMRP source node periodically send Join-Query message to refresh the multicast route information between source and receiver node.

E. Multicast Zone Routing Protocol (MZRP)

MZRP divides the entire network into some overlapping network zone of variable size. It is composed of Multicast InrAzone Routing Protocol(MIARP), and Multicast InteRzone Routing Protocol (MIERP). MIARP is able to keep track of group information in each node's local routing zone and MIERP is able to construct the shared tree for a multicast group.

In multicast tree there are two kinds of nodes: multicast group member and multicast forwarding members. When a node wants to join the multicast group and if it the forwarding node it change its status from forwarding node to a multicast group member. If a node has data to send to the multicast group and it does not have the route to that group it uses Multicast Route Request (MRREQ) message. There are two types of MRREQ based on the information of the source has. If the source has valid route the multicast tree it sends unicast MRREQ along the route to the multicast tree. Otherwise it initiates bordercast MRREQ. Bordercast MRREQ is sent via the bordercast tree of the source node and when this message is received by the peripheral nodes it checks whether it has the valid route to the group or group leader, if yes then it uses unicast MRREQ instead of bordercast MRREQ, otherwise bordercast MRREQ is sent via the bordercast tree of the peripheral nodes and so on. In all the above cases after sending MRREQ message source node waits for MRREP for finite period of time. After sending MRREP to the source and destination nodes waits for the multicast route activation (MRACT) message from the source node to activate the new branch of the multicast tree. If no reply message received by the source node it elect itself as a group leader and it becomes the group leader until it decides to leave that group or until two partitions of the multicast tree merge.

When a node wants to leave the multicast group and if it a leave node it can leave by sending prune message to its upstream node and upstream node remove the node from its downstream list. If the downstream list of an intermediate node becomes empty then it sends a TREE-PRUNE to its upstream node.

III. Comparison of Multicast Routing Protocol

A. Here we mentioned some comparison of the above protocols based on their performance.

1) Bandwidth

Bandwidth means the amount of data that can be carried from one point to another in a given time period (usually a second). Network bandwidth is usually expressed in bits per second (bps).

Proactive protocol (CAMP) consumes more bandwidth than reactive routing protocol (ODMRP, MAODV and AMRIS) since it periodically keeps track of up to date information of routes from source to receiver. ODMRP suffers from excessive flooding when there are a large number of senders and the duplicate transmissions waste bandwidth at low mobility. In AMRIS Joining and rejoining of a node may take long time and waste much bandwidth since each tries potential parent nodes arbitrarily. Also the usage of periodic beacons consumes bandwidth. MZRP also reduces the wastage of bandwidth.

2) Controlling packet

MAODV, AMRIS and ODMRP all are required packet control. But CAMP constructs a mesh without control packet flooding. It offers less control packet overhead and quick response to the mobility. MZRP reduces the control traffic produced by periodic flooding of routing information packets (proactive scheme).

3) Control overhead

Control overhead is a basic criterion on which highly reliable networks are made up and operated. The optimization of control overhead during the design phase of a network gives high throughput and performance for the network. Controlling of overhead is a matter of concern in multicast networks. For the minimal overhead on demand routing protocols such as MAODV, AMRIS, MZRP and ODMRP can be best fit since they provide creation of mesh networks based on the need of the nodes that wants to join the group and thus the overhead can be balanced to a great extend.

ODMRP does not lead to extra overheads because link breaks does not generate control packets. ODMRP protocol does not support the large number of multicast sender which leads to extra routing overhead. In AMRIS, multicast beaconing mechanism is used to detect link failure which in turn results into extra overhead but it may incur very low overhead for a node to join or rejoin the session if it chooses a potential parent node which happens to be a tree node. In AMRIS routing overhead increases with smaller beaconing interval. In CAMP With correct routing information, shortest paths are included in the mesh and the joining procedure incurs very low overhead. It does not incur the overhead on addition of nodes to multicast group. But in CAMP, the periodic message exchanges among cores are a high overhead. MZRP reduces control overhead compared to reactive schemes.

4) Packet delivery ratio

Packet delivery ratio means number of data packet delivered to multicast receivers over the number of data packets supposed to be delivered to multicast receivers.

Since all the above protocols are used in MANET, so due to the mobility of nodes link is broken at any time which leads low packet delivery ratio. But mesh-based protocol provides better performance than tree-based protocol since they have alternate path in between source and receiver for packet transmission.

MAODV performs average as compared to ODMRP in packet delivery ratio. MAODV offers poor delivery ratio due to fragileness of the bi-directional shared link. In AMRIS Packet delivery ratio drops

with increasing mobility of nodes. MZRP has more states at nodes involved in many groups, each having multiple sources. But due to IP tunnel used in data packet transmission, the data packet delivery ratio has improved.

5) Performance

In MAODV, multicast tree can be constructed more quickly and efficiently with the information of unicast route. But this protocol also has a disadvantage since the group leader continues flooding Group Hello messages even if no sender for the group exists. It uses shared tree approach which degrades the performance when single point of failure occurs. In AMRIS, the concept of increasing id-numbers is useful for constructing and maintaining a multicast tree. AMRIS results in poor performance due to number of transmissions and size of beacons. AMRIS can offer better performance by sending the beacon when no packets are being transmitted in given interval. CAMP gives better performance and supports scalability in comparison with the ODMRP. CAMP supports the increasing multicast group size. CAMP may give the better performance if it is modified to work with on-demand routing protocols. ODMRP does not support scalability. MAODV supports scalability as the group size increase which is not supported in ODMRP. MAODV uses shared tree approach which degrades the performance when single point of failure occurs. The performance of MAODV can be improved by reducing the overhead and controlling overhead can be done by using self pruning in network.

6) End-to-End Delay

End-to-end delay refers to the time taken for a packet to be transmitted across a network from source to destination.

Here also mesh-based protocol better than tree based protocol. ODMRP proposes the concept of "forwarding group". The offering of shortest paths reduces data delivery latency. ODMRP suffers from route acquisition delay while offering reduced network traffic. In AMRIS, nodes closer to the source have less end-to-end delay than nodes further away. CAMP offers less delay than ODMRP.

B. Here we compare protocols based on their characteristics.

1) Topology

Topology that can be used by the multicast routing protocols is either tree-based or mesh-based. MAODV, AMRIS and MZRP are tree based protocol and ODMRP and CAMP are mesh based protocol. If a protocol uses mesh topology, there are redundant path in between source and receiver, so failure of one link it can use another one for packet transmission. But on the other-hand in tree based protocols there is only single path in between source and receiver. Tree based protocols are simple but in MANET, packets are dropped until tree is reconstructed after the movement of a node.

2) Proactive/Reactive/Hybrid Protocol

CAMP is a proactive routing protocol. Proactive routing protocol is also known as Table-driven protocol, as routes to all destinations are assumed to exist in the form table, and it keeps the up to date information. Each nodes periodically update their information wherever topology changes. But MAODV, AMRIS and ODMRP all are reactive routing protocol. Reactive multicast routing protocols set up routes on demand. If a node wants to have communication with a node, to which it has no route, reactive protocols set up such route. Reactive protocols perform better for ad-hoc wireless network. MZRP is a hybrid protocol. Hybrid protocol takes the advantages of both proactive and reactive routing protocol. In MZRP routing is proactive inside the zone and reactive between the zones.

3) Initialization approach

In multicast routing protocol routes are initialized either by the source node or receiver node. A protocol is using source-initiated approach means multicast routes are initialized at source node. MAODV, AMRIS, ODMRP, CAMP and MZRP all are using source-initiated approach. But CAMP also uses receiver-initiated approach with the benefit that it ensures shortest path from receiver to source.

4) Unicast routing protocol dependency

Using unicast routing protocol provides the information of availability of route. Unicast protocol is also used to work correctly in presence of router failure and network partition. To get correct distance to all destinations CAMP and MAODV both depends on unicast routing protocol but other protocols (AMRIS, ODMRP and MZRP) are not.

5) Periodic message

All the protocols discussed here use periodic message to get the information of presence of number of nodes, because in MANET at any time can join or leave the multicast group and topology can changes frequently.

6) Maintenance approach

Multicast topology formed is maintained either by soft state approach or hard state approach. In soft state approach the link between the nodes is maintained by sending refreshing control packets periodically thus resulting in high packet delivery with more control overheads. AMRIS and ODMRP use soft state approach. But in hard state approach control packets are flooded only when link failure is detected thus minimizes the cost of overhead which leads to low packet delivery ratio. MAODV, CAMP and MZRP use hard state approach.

Table for comparison of Multicast routing protocol in MANET

Routing protocol	**MAODV**	**AMRIS**	**CAMP**	**ODMRP**	**MZRP**
Configuration	Tree based	Tree based	Mesh based	Mesh based	Tree based
Proactive/Reactive/ Hybrid	Reactive	Reactive	Proactive	Reactive	Hybrid
Loop free	Yes	Yes	Yes	Yes	Yes
Unicast Protocol dependency	Yes	No	yes	no	No
Packet control	Required	Required	Not required	Required	Required
Performance	Average	Decrease with overhead	Better	Good	Better
Periodic message	Yes	Yes	Yes	Yes	Yes
Initialization approach by	Source	Source	Source & Receiver	Source	Source
Maintenance approach	Hard State	Soft State	Hard State	Soft State	Both hard state and soft state

IV.CONCLUSION

The general conclusion of this paper is that mesh-based routing protocols are out performed better than tree-based routing protocol. Tree based protocols gives the high data forwarding efficiency and low robustness. Tree based protocols are simple but in MANET packets are dropped until tree is reconstructed after the movement of a node. Mesh based protocols provides robust performance due to redundant path availability.

Proactive routing protocol is also known as Table-driven protocol, as routes to all destinations are assumed to exist in the form table, and it keeps the up to date information. Each nodes periodically update their information wherever topology changes. Advantages of this protocol are that, it consumes

bandwidth to keep routes up-to-date and little or no delay for route determination. Disadvantage is that it maintains routes that never be used. Reactive protocols perform better for ad-hoc wireless network as it causes lower overhead since routes are determined on demand. While network is divided into zones hybrid protocol is used. Each zone is a collection of nodes. Within the zone proactive protocol is used for routing and routing between the zones can be done using reactive routing protocol.

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