ISSN:0975-9646

Sagar P. Latake et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 4 (3) , 2013, 485-488

Tree, Mesh Structure Based and Stateless Multicast Routing Protocols in Wireless Networks

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***Abstract*— Multicasting is the transmission of one packet to a group of nodes identified by single source. In multicasting multiple copies of one packet are delivered to the group of destinations. A single host may be the member of more than one multicast group. In this paper we will discuss the classification of multicast routing protocols depending upon path distribution among the multicast member and how the routing information is exchanged by multicast members in wireless network. In this paper we have discussed the tree and mesh structure based and stateless solution for multicasting in wireless network. Lastly we have compared multicast routing protocol based on the set of parameters.**

***Keywords*— Wireless network, multicasting, tree, mesh, stateless.**

I. INTRODUCTION

In present, numbers of protocols are in existence for multicast routing in wireless network. But most of the protocols are not suitable due to limited bandwidth and memory as well as limited computational power. Multicast packet is delivered to all members of multicast destination group. Multicast routing protocols have been proposed such as AMRoute [1], AMRIS [2], CAMP [3], and ODMRP [4] in order to save network bandwidth and node resource because they are the protocols used for powerful communication in multihop wireless application. In this paper we discussed the multicast routing protocols based on tree structure and mesh structure for connecting the multicast group members. These protocols need to maintain the state information for packet forwarding. As well as we discussed the stateless protocols which do not needs to maintain the state information for routing packets.

In section II we have discussed the classification of protocols, in section III we have discussed different multicast routing protocols, in last section we have compared the performance of the these protocols.

II. PROTOCOL CLASSIFICATION

We classify multicast routing protocols in following ways

A. Based on path distribution

Classification of multicast routing protocols in wireless network can be done using an idea of path distribution among the group members. By using this idea, in MANET multicast routing protocols are divided into following categories

- Tree based routing protocol.
- Mesh based routing protocol.
- Hybrid 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. Further tree based protocols are classified into two categories

- Source rooted tree multicast routing protocol.
- Core rooted tree multicast routing protocol.

In a source rooted tree based multicast protocols source nodes are roots of trees and executes the algorithms for distribution tree construction and maintenance. Source must be aware of topology information and addresses of all receiving nodes. In core rooted tree multicast routing protocol core nodes are with special functions such as data distribution and membership management.

In mesh based multicast routing protocols, packets are distributed along the interconnected mesh structure. Mesh based protocols provides robust performance due to redundant path availability. Hybrid multicast routing protocols combine the advantages of both tree based and mesh based protocols and offers efficiency and robustness.

B. Based on Exchange of routing information

Another idea of classifying the multicast routing protocol is based on the idea of how routing information acquired and maintained by nodes in the network. With this idea routing protocols are divided into two categories.

- Proactive multicast routing.
- Reactive multicast routing protocol.

“Table-driven” multicast routing protocols are called as proactive routing protocols. To represent topology of network a proactive multicast routing protocol uses one or more tables. Every node in the network updates these tables on regular basis in order to update routing information.

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 routing protocols are scalable as compared to proactive routing protocols. Reactive multicast routing protocols may suffer from long delays due to route searching before data packets are forwarded.

III. Multicast Routing Protocols

A. Ad-hoc Multicast Routing (AMRoute)

AMRoute [1] is a tree based proactive multicast routing protocol. It connects multicast group members by using unicast tunnels. There is at least one core in each multicast group. At initial state each member from group declares itself as a core. Disjoint partitions are discovered by broadcasting JOIN-REQ periodically. Members from different partitions upon receiving JOIN-REQ respond with JOIN-ACK and mark that node as neighbour. The node which receives a JOIN-ACK also marks the sender of the JOIN-ACK as its neighbour. A member which wants to leave multicast group sends JOIN-NACK to its neighbours. After sending JOIN-ACK to neighbours, it stops forwarding packets to group members. As long as routes are available between the group members through mesh, tree can be formed even after the topology change. Protocol is dependent on unicast protocol for maintaining tunnels among the group members. AMRoute offers good throughput.

B. Ad hoc Multicast Routing protocol utilizing Increasing id-numberS (AMRIS).

AMRIS [2] is also a tree based proactive protocol. The main idea in AMRIS is each node is tagged with a multicast session member ID (msm-ID). Source tagged with msm-ID is called as Sid. When new multicast session begins Sid broadcasts NEW-SESSION message including Sid's msm-ID. When neighbour receives non-duplicate NEW-SESSION message node increases msm-ID by one than specified in message, and then rebroadcast the NEW-SESSION message with its own msm-IDs. To join the session a node sends unicast JOIN-REQ, which travels along the route to corresponding parent having smaller msm-ID. If a group member is met, the member sends back a JOIN-ACK to form a registered parent child relationship. If JOIN-ACK is not received, then node broadcasts JOIN-REQ for other potential parents. AMRIS uses beaconing mechanism to detect link disconnection.

C. Core-Assisted Mesh Protocol (CAMP)

CAMP [3] is a mesh based proactive multicast protocol. A node who wants to join multicast group has to search for the neighbours which are already mesh members. If so, the node uses CAMP update message to announce its membership. In other cases node broadcasts request and try to reach the mesh members or sends join request to one of the core. CAMP has two types of mesh members

- Duplex member and
- Simplex member.

A duplex member is capable to send and receive multicast data and simplex member can only send out data multicast data packets. If any node in the network sends a join request then only duplex member can reply with join acknowledgement. A heartbeat message along the new shortest path is sent to the source. If nodes on the path are not the member of mesh then push-join message adds them to mesh. To get the correct distances to all destinations, this protocol is dependent on unicast routing protocol.

D. ODMRP (On-demand Multicast Routing Protocol)

It [4] is a mesh-based reactive multicast protocol. ODMRP construct route between members using forwarding group proposed in FGMP [11]. When source wants to send a packet to a node whose routing information is not maintained then it broadcasts Join-Query message periodically, when the multicast receiver is reached then it sends back Join-Reply. Join-Reply message contains currently known routes to the sender as well as next hop of each route. Upon receiving Join-Reply each node checks that whether it is present on a route to the source by matching own ID with next hop ID from the join-Reply. ODMRP gives robust performance due to multiple paths available in mesh structure. ODMRP does not need any explicit control message to join or leave the group.

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

MAODV [5] is tree based reactive multicast routing protocol. It uses shared bi-directional tree to connect multicast group members. MAODV supports unicast, multicast and broadcast. If a node is having data to be sent to the node which is not a member of group or it does not have path to that node then it creates route on-demand. To discover route it sends route request (RREQ) message and only the members of that multicast group respond to RREQ. When a node receives Join RREQ for a group of which it is not a member or it receives a route RREQ to the group for which does not have a route, then it broadcast that request. But if request is not Join request then any node from that group may reply to that request.

F. MCEDAR (Multicast Core Extraction Distributed Ad hoc Routing)

MCEDAR [6] uses a new mesh structure for multicast routing called as mgraph. It reduces number of node involved in routing structure by allowing only core nodes to become the member of mgraph. Each member of mgraph maintains information about its neighbouring node belonging to same mgraph. This information is used in data forwarding. When node wish to join mgraph, then dominating core needs to join the mgraph first and then dominating core performs the join operation. Members of mgraph also maintain the ordering information among themselves to avoid the loop formation. JoinID value is assigned to each member of mgraph. Initially JoinID value is infinity for all members and it is updated during the mgraph construction. The newly joining core broadcasts the JOIN request, when group member receives the join request then it reply with JOIN-ACK if its joinID is less than the joinID field of the arriving join request. If the relayed JOIN-ACK has lower value then intermediate core updates its own joinID. Otherwise intermediate core updates joinID field of the JOIN-ACK packet.

G. Node State Multicasting protocol (NSM)

Node state multicasting (NSM) [7] is built directly on top of node state routing (NSR) . NSR uses two different routing construct called as node and wormhole. Node construct is modeled as point in space and wormhole as directed path. NSR also requires two capabilities

- Location awareness and
- Ability to measure signal strength,

These two capabilities are used to create pathloss map which is used as measure of connectivity for topology determination. If the pathloss is below some threshold, a connection is inferred. NSR consists of three processes

- Propagation map discovery.
- Node state dissemination.
- Route calculation.

On periodic basis each node transmits node state update packet, which is used to discover propagation condition and topology determination. NSM supports both multicasting approaches where destination subscribe to multicast address and other in which source specifies destinations. Multicasting in NSM is accomplished with following features i) Mapping IP address to MAC address which eliminates need of address resolution protocol and provides a means to join multicast group. Node joins multicast group by adding its address to their states. ii) Special multicasting packet formats which contain source address, next hop address and destination address list. It offers specialized packet formats for geographical multicasting. iii) Forming and routing packets, a typical NSR routing table contains an entry of next hop, previous hop for each destination. NSM provides different multicast packet headers for reliable and unreliable MAC multicast.

H. Robust and Scalable Geographic Multicast Protocol (RSGM)

RSGM can scale up to a large group size and network size. It provides robust packet transmission in a dynamic MANET. Protocol uses several virtual architectures for more robust and scalable membership management and packet forwarding in unstable wireless network. Membership management is done using virtual zone based structure. Data and control packets will be transmitted along efficient tree like path. This protocol is different from other tree based protocol. In this protocol there is no need to create and maintain tree structure. Stateless virtual tree based structure reduces tree management overhead and supports efficient packet transmission. Geographic forwarding is used to increase the scalability and robustness. The efficient source tracking mechanism is used to avoid the periodic flooding of the source information in the network. RSGM can scale to large group and network size over existing protocol ODMRP. It also increase the delivery ratio under all circumstances such as node speed, node density etc. This protocol is having minimum control overhead and joining delay.

IV. PROTOCOL ANALYSIS

AMRoute uses unicast tunnel to connect multicast group members which allows tree formation even after topology changes if route exists between members via mesh. In AMRoute the tree formation is inefficient due to mobility of the nodes in the network. Packet delivery to the destination is not reliable due to unidirectional links. Also loops may get formed.

ODMRP gives robust performance because of redundant paths availability by forming the mesh structure. It out performs in packet delivery ratio than MAODV. ODMRP suffers from route acquisition delay while offering reduced network traffic. It does not lead to extra overheads because link breaks does not generate control packets. Protocol does not support the large number of multicast sender which leads to extra overhead. It does not support scalability.

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. Multicast beaconing mechanism is used to detect link failure which in turn results into extra overhead. Packet delivery ratio drops with increasing mobility of nodes. In AMRIS routing overhead increases with smaller beaconing interval. Nodes closer to the source have less end-to-end delay than nodes further away.

CAMP supports the increasing multicast group size. CAMP does not incur the overhead on addition of nodes to multicast group. CAMP may give the better performance if it is modified to work with on-demand routing protocols. It offers less control packet overhead and quick response to the mobility. CAMP offers less delay than ODMRP. CAMP gives better performance and supports scalability in comparison with the ODMRP.

MAODV performs average as compared to ODMRP in packet delivery ratio. But MAODV supports scalability as the group size increase which is not supported in ODMRP. Self pruning decreases the control overhead in network. MAODV offers poor delivery ratio due to fragileness of the bi-directional shared link. The performance of MAODV can be improved by reducing the overhead.

MCEDAR multicast routing protocol uses the mesh based structure to increase the robustness with increase in network mobility. It reduces overheads in terms of time taken to deliver a single packet. By separating the control structure from forwarding structure it minimizes control overhead and maximizes efficiency.

Almost all of the protocols provide stateful solutions for the multicasting in wireless network. Members of wireless network needs the frequent exchange of control information due to small topology time. In this scenario overheads increases with network size. But NSM provides stateless solution that uses network state information which is already disseminated as a part of the node state routing protocol. It provides better throughput and optimum delay service. This approach gives limited scalability support as the destinations are added to the packet header.

Most of the protocols [1], [2], [3], [4], [6] rely on tree based or mesh based structure and hence intermediate nodes needs to maintain tree states or routing states for packet delivery. RBMulticast [7] stores the destination information into packet header, thus there is no need of multicast tree and therefore it does not need to maintain tree states at intermediate nodes in the network. Sender does not need create and maintain the routing table or neighbour table to forward packets. Thus the stateless protocols perform better than any existing routing protocol in wireless network in terms of number of transmissions, throughput and routing overheads. It supports scalability.

TABLE I
COMPARISON OF MULTICAST ROUTING PROTOCOLS

Protocols	AM-Route	AMRIS	ODMRP	CAMP	MAODV	MCEDAR	NSM	RB-Multicast
Configuration	Tree based	Tree based	Mesh based	Mesh based	Mesh based	Mesh based	Stateless	Stateless
Proactive or Reactive	Proactive	Proactive	Proactive	Proactive	Reactive	Proactive	Proactive	Reactive
Control Packets	Required	Required	Required	Not Required	Required	Required	Required	Required
Loops free	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Perfor-mance	Good	Decreases with overheads	Good	Better	Average	Better	Better	Better
Unicast Protocol Dependency	Yes	No	No	Yes	Yes	Yes	No	No
Scalability Support	No	No	No	Yes	Yes	No	Limited	Yes

ACKNOWLEDGMENT

Authors are thankful to N.B. Pokale for his continuous guidance and support.

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