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Taxonomy of Mesh Based Network Layer Multicast Routing Protocols That Support QoS in MANETs

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Abstract— Mobile ad hoc network consists of a collection of nodes which independently maintain network without using the fixed network support. In MANETs, multicasting is supported through wireless network. Multicast includes one to many communication .Multicast routing protocols consist the Quality of services to increase the performance level of protocols using parameters. The main role of QoS routing protocol is to find an acceptable loop-free paths that have enough resources available from the source to the destination to satisfy the needed QoS requirements. In this paper we present Taxonomy of mesh based network layer multicast routing protocols that support QoS in MANETs.

Keywords— MANETs, QOS, Mesh, Multicast, MANETs

I. INTRODUCTION

A Mobile Ad Hoc Network (MANET) contains a collection of wireless mobile nodes, which form a temporary network without relying on existing infrastructure or centralized administration. The purpose of a routing protocol in ad hoc network is to establish routes between different nodes. Multicasting plays an important role in many applications of mobile ad hoc network. It provides communication between a single sender and multiple receivers on a network. Multicast increases the throughput of wireless link between the sender and receiver(s). It decreases data delivery delay and increases the efficiency of data transfer. Many classification criteria have already been proposed for MANETs. In this work , the mesh based protocols are considered and classified on the basis of the QOS parameter they support. This paper presents the comprehensive survey of such protocols describing the various characteristics of some prominent multicast routing protocols. The main contributions of this paper are:

- To classify network layer mesh based multicast protocols according to the type of QOS parameter they support to help researchers to analyse and compare these protocols more easily.
- To granulize the classification criteria on the basis of routing mechanism, maintenance approach and initialization approach to study the protocols more minutely.
- To identify and review typical multicast routing protocols according to the proposed classification criteria.

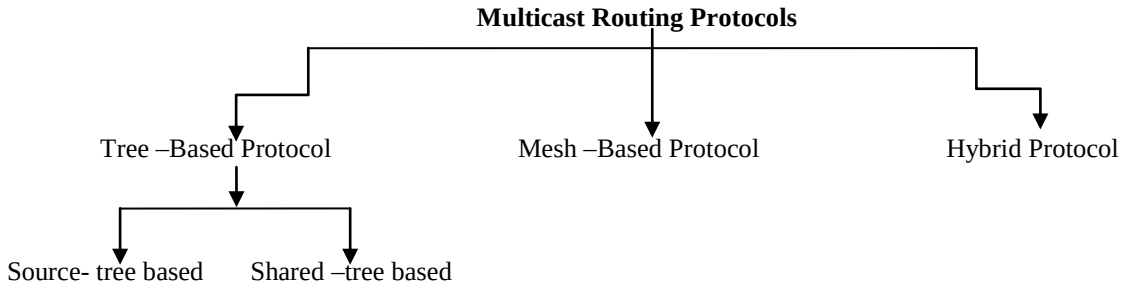

Fig. 1 Taxonomy of multicast routing protocols

The multicast routing protocols has been classified into three categories i. e tree based multicast protocol; mesh based multicast protocol and hybrid protocols, based on their multicast topologies. In tree-based multicast protocols, only one path exists between a source-receiver pair. It provide high data forwarding efficiency and low overhead but it is not robust in high mobile environments .Tree based multicast protocols are classified further into two categories: source tree based and shared tree based. In mesh based multicast protocol, more than one path may exist between a source-receiver pair. In other words, it contains multiple paths between senders and destinations. Hybrid based protocol is the combination of both tree and mesh based protocol. Multicast routing protocols that support QoS enhance one or the other quality of service parameter to increase the performance level. These parameters are bandwidth, stability, delay, jitter, control overhead etc. The main role of QoS routing protocol is to find a suitable loop-free paths that have enough resources available from the source to the destination to satisfy the desired QoS requirements. QoS includes two strategies that is used to search for routes and maintain the information state in QoS multicast routing. The first is source

routing, where a feasible route is determined locally at the source node, which is not scalable for large area networks. The second one is distributed routing, the path evaluation is distributed over the intermediate nodes which makes it more scalable than source routing. Multicast protocols can be further classified according to the following classification criteria:

A. Routing Approach

The routing scheme can be proactive or reactive. Proactive is also called table-driven and Reactive is also called on-demand. Table-driven multicast routing protocols try to maintain consistent up-to-date multicast routing information between multicast group members in the network. These protocols need each node to maintain one or more table(s) to store routing information. To maintain a consistent network view, updates to the routing information tables are driven either by events (but only if a change is recognized) or periodically. Source-Initiated On-Demand multicast routing protocols produce routes only when desired by the source node .When the source node needs multicast routes to a multicast group, it initiates a route discovery process within the network. Multicast routes and group membership are initiated, maintained, and updated on demand. A proper proactive multicast routing approach and a proper reactive multicast routing approach are located at different hierarchical levels.

B. Maintenance Approach

Due to the lack of mobility of the nodes, mobile ad hoc network suffer from frequent link breaks, which makes efficient group maintenance necessary. Maintaining the multicast group can be obtained by either the Soft-State approach or the Hard-State approach. In the Soft-State approach, the multicast group membership and related routes are refreshed periodically (proactively) by the flooding of control packets, where as in the Hard-State approach, broken links are reconfigured by two different approaches. The first is reactive, where routes are reconfigured, only when a link breaks. The second is proactive, before a link breaks, routes are reconfigured and this can be gained by using local prediction techniques based on GPS or signal strength. The proactive approach is more reliable, because it has much less packet loss, that is, it has a higher packet delivery ratio. The Hard-State approach is more efficient in terms of overhead.

C. Initialization Approach

Initialization approach describes how the session is established and terminated. This approach contains source initiated and receiver initiated. Before sends multicast data, a source node checks whether or not the desired multicast group has been established. If multicast group has it sends multicast data established, immediately otherwise, the source node first construct it.

II. QUALITY OF SERVICES PARAMETERS

Multicast routing protocols possess the Quality of services to increase the performance level of protocols using some parameters. These parameters are bandwidth, stability, delay and control overhead .The main role of QoS routing protocol is to find a suitable loop-free path that have enough resources available from the source to the destination to satisfy the desired QoS requirements. QoS include two strategies that are used to search for routes and maintain the information state in QoS multicast routing. The first is source routing, where a feasible route is determine locally at the source node, which is not scalable for large area networks. The second one is distributed routing, the path to be evaluated is distributed over the intermediate nodes which makes it more scalable than source routing.

A. Bandwidth

Bandwidth is expressed in terms of bits per second. Bandwidth defines the capacity of the connection. If the capacity is greater, then performance increases. Bandwidth also defines the maximum data transfer rate of a network.

B. Delay

The finite quantity of time it takes a packet to reach the receiving endpoint after being transmitted from the sending endpoint.

C. Stability

Stability is usually presented in the context of-node, link and route. The stability of nodes relies on the mobility. Time period of the battery and number of connection periodically being used and the data transmission rate are key factors in deciding the stability of the node. Stability decreases when the mobility increases. More is the battery life then stability is high and also number of interfaces are more than energy consume will also be more that will result to less stability.

D. Control Overhead

It includes the size and number of routing control packets that is sent by the protocol.

III. SURVEY OF MESH BASED MULTICAST ROUTING PROTOCOLS

A. Adaptive Core Multicasting Routing Protocol (ACMRP)

ACMRP [1] is known as the on-demand core based routing protocol which is of multicast type. In this multicast, a network has a number of the sources which are present in group. A main node is called a core; this core maintains the current network topology and group membership status. In this, the main working of the adaptive core is to maintain the periodic sending of a join request packet. The route of the core is updated when the node receives new request and then it

inserts the packet into the memory and then "upstream node address" changes to its own address and retransmits the packets. The receivers and sources in the multicast send a Join reply packet to their upstream node on receipt of a non duplicate JREQ packet. When on receiving the JREP the upstream node stores the group address which is then further used to forward multicast packets destined for the group. This node is known as forwarding node .It puts the group address and source address collectively into the forwarding group table. Then it sends JREP to its own upstream node .Finally, the JREP reaches the core. The backward propagations of JREPs make multicast routes between group members and the core. Finally, a multicast mesh is established. The enhanced adaptability of ACMRP gives result in the three factors: minimized score dependency, improved performance and robustness. The main drawback of the ACMRP is that the route between the sources and receivers is not optimal. It is difficult to find the core node. It should be presented with the minimum hop counts of paths towards group members.

1) *QoS parameter*: ACMRP protocol possesses the stability parameter of quality of services and provides reliability.
2) *Routing approach:* ACMRP exhibits the reactive routing approach.
3) *Maintenance approach:* Soft state maintenance approach is observed in this protocol.
4) *Initialization approach*: ACMRP is a source initiated protocol.

B. Dynamic Core Multicasting Routing Protocol (DCMRP)

ODMRP is derived from the DCMRP which tries to reduce the number of senders flooding JREQ packets by selecting specific sender as cores. It help to decrease the control overhead and also improve the efficiency of the ODMRP multicast protocol. Mesh in DCMP and ODMRP are similar .Due to this number of source flooding JREQ is reduced with the help of three type of sources- active, passive and core active. Active and Core active flood the JREQ. The number of passive sources must be limited for robust function. The distance between a passive sources and its core active node should not so much long so that the packet delivery ratio is not reduced.

1) *QoS parameter*: DCMP protocol includes the Control overhead parameter of quality of services.
2*) Routing approach*: DCMP include the Reactive routing approach.
3) *Maintenance approach*: DCMP contain the Soft state maintenance approach. The soft state is also known as Proactive.
4) *Initialization approach*: DCMP uses a Source initiated approach.

C. Forward Group Multicast Protocol (FGMP)

As multicast forwarding is based on nodes which accept multicasts packets, in these nodes directly fetch the multicast packets rather than the link on which they are forwarded. Here the nodes are known to be the group of router. FGMP [1] keep the track of this group of nodes rather than those of links on which packets are forwarded. The forwarding groups are refreshed periodically so to handle topology changes. In this protocol, it will broadcast only those packets which are not duplicate. Each multicast group G is linked with forwarding group, FG. The packets forwarded will be heard by all the neighbours, but only by those neighbours who are in FG. They will check whether it is duplicate or not and then broadcast it in return.

1) *QOS parameter*: FGMP protocol includes the Control overhead parameter of quality of services.
2) *Routing approach:* FGMP include the Reactive routing approach.
3) *Maintenance approach*: FGMP follows the Soft state maintenance approach.
4) *Initialization approach:* The initialization approach of the FGMP is receiver based.

D. Multicast for Ad hoc networks with Swarm intelligence (MANSI)

MANSI[1] uses Swarm Intelligence mechanism to the problem of multicast routing MANETs. Swarm intelligence approaches to the complex behaviours that produce from very simple individual behaviours and interactions. The concept of swarm intelligence is used to reduce the number of nodes that is used to establish multicast connectivity. However, the path between the member of multicast and forwarding set to the designated core is not always the shortest. It is used to increase redundancy by allowing packets to be forwarded over more than one path. In the multicast routing protocol, MANSI can be applied to many variations of multicast routing problems like load balancing, secure routing and energy conservation.

1) *QOS parameter*: MANSI protocol includes the Stability parameter of quality of services.
2) *Routing approach*: MANSI include the Reactive routing approach.
3) *Maintenance approach:* MANSI contain the Soft state maintenance approach.
4) *Initialization approach*: The initialization approach of the MANSI is Receiver initiated.

E. Protocol for unified Multicasting through Announcements (PUMA)

PUMA[1] creates and maintains a shared mesh for each multicast group. The receiver–initiated approach is used in PUMA. In this approach, using the address of core node, receiver joins a multicast group, without the requirement for network-wide flooding of control or data packets from all the sources of a group. PUMA chooses the first receiver of the group as the core of the group and notify each node in the network and thus uses that node to minimize data packet overhead.

1) *QOS parameter:* PUMA protocol includes the Control overhead parameter of quality of services.
2) *Routing approach*: PUMA includes the Reactive routing approach.
3) *Maintenance approach*: PUMA contain the Soft state maintenance approach. The soft state is also known as Proactive.
4) *Initialization approach*: The initialization approach of the PUMA is Receiver initiated.

F. Core Assisted Mesh Protocol (CAMP)

CAMP[9][5][2] expands the notion of core based trees (CBT) and is introduced for Internet multicasting into multicast meshes, which have much more connectivity than trees. CAMP creates and maintains a multicast mesh, which is a subpart of the network topology, which provides multiple paths between a sender-receiver pair and ensures that the shortest paths from receivers to senders are part of a group's mesh. One or multiple cores are explained per multicast group to perform in join operations; therefore, CAMP removes the need for flooding.

1) *QOS parameter*: CAMP protocol includes the Stability parameter of quality of services.
2) *Routing approach*: It includes the Proactive routing approach.
3) *Maintenance approach*: It contains the Reactive approach in hard state.
4) *Initialization approach*: It uses a receiver-initiated approach for receivers to combine a multicast group.

G. Neighbour-Supporting Multicast Protocol (NSMP)

It is an extension to ODMRP and supports a source-initiated multicast routing NSMP[2] is aimed at decreasing the flood of control packets to a subset of the whole network. It uses node locality to decrease control overhead while maintaining a high delivery ratio. NSMP supports paths with a larger number of existing forwarding nodes to reduce the total number of multicast packets transmitted.

1) *QOS parameter:* NSMP protocol includes the Control overhead parameter of quality of services.
2) *Routing approach:* NSMP include the Reactive routing approach.
3) *Maintenance approach*: NSMP contain the Proactive approach in Soft state.
4) *Initialization approach*: NSMP uses a Source-initiated approach.

H. On-Demand Multicast Routing Protocol (ODMRP)

With mobile hosts, ODMRP[2] is designed for ad-hoc networks. ODMRP is a mesh-based protocol. To build a routes in dynamically, it uses on-demand procedures and maintain multicast group representatives. ODMRP is well suited for ad hoc wireless networks where bandwidth is limited, topology changes frequently and rapidly, and power is constrained. Forwarding group concept used in ODMRP. In this a set of nodes responsible for forwarding multicast data, are used to build forwarding mesh for each multicast group. By using a mesh instead of a tree, the shortcomings of multicast trees in mobile wireless networks are handled.

1) *QOS parameter*: ODMRP protocol includes the Stability parameter of quality of services.
2) *Routing approach*: It includes the Reactive routing approach.
3) *Maintenance approach:* It contains the Proactive approach in Soft state.
4) I*nitialization approach:* ODMRP uses a Source-initiated approach.

I. Quality of Services to Ad hoc Multicast Enabled Networks (QAMNet)

The QAMNet [4]approach extends existing mesh based multicasting like ODMRP by introducing real time and best effort traffic class, distributed resource probing and admission control mechanisms to provide quality of service multicasting. The threshold rate for real-time moves is calculated and the available bandwidth is roughly calculated as the difference between the threshold rate of real time traffic and the current rate of real time traffic. To estimate the threshold rate accurately is very difficult because the threshold rate can change dynamically depending on traffic design.

1) *QOS parameter*: QAMNet protocol includes the Delay parameter of quality of services.
2) *Routing approach*: QAMNet includes the Reactive routing approach.
3) *Maintenance approach:* QAMNet contain the Proactive approach in Soft state.
4) Initialization approach: QAMNet uses a Source-initiated approach.

J. QoS aware multicast routing protocol (QMRP)

QMRP[4] protocol which calculates several node disjoint paths based on the feedback from the physical and MAC layers. QMRP modify the phases of route discovery, route selection and route maintenance which improves AODV.

1) *QOS parameter*: OMRP protocol includes Bandwidth and Delay parameters of quality of services.
2) *Routing approach*: QMRP include the Reactive routing approach.
3*) Maintenance approach*: OMRP contain the Reactive approach in Hard state.
4) *Initialization approach:* QMRP uses a Source-initiated approach.

TABLE I COMPREHENSIVE SURVEY OF MESH BASED MULTICAST ROUTING PROTOCOLS

Protocol Name	**QOS Parameters**	**RoutingApproach**	**MaintenanceApproach**	**InitializationApproach**
ACMRP	Stability	R	Soft	SI
DCMP	Control overhead	R	Soft	SI
MANSI	Stability	R	Soft	RI
FGMP	Conrol overhead	R	Soft	RI
PUMA	Conrol overhead	R	Soft	RI
CAMP	Stability	P	Hard	RI

NSMP	Conrol overhead	R	Soft	SI
ODMRP	Stability	R	Soft	SI
QAMNet	Delay	R	Soft	SI
QMRP	Bandwidth and delay	R	Hard	SI
P:-Proactive	R:-Reactive	SI:-Source Initiated	RI:-Receiver Initiated	

IV. CONCLUSIONS

Multicast routing protocols for MANET's are generally classified either tree based or mesh based. In this paper we have provided a Taxonomy of mesh based network layer multicast routing protocols that support QoS in MANETs. QoS include source and distributed routing that is used to search for routes and maintain the information state .We have discussed the parameters of quality of services like Delay, Bandwidth, Control overhead and Stability. Each of the protocols discussed in this paper has its own routing approach, maintenance approach and initialization approach. In this paper we have described working of several proposed routing schemes and the prominent multicast routing protocols are reviewed on the basis of described classification. This review can be utilized by researchers for the enhancement of theses protocols and to locate various research gaps in them. Further classification can be done on the basis of security mechanisms possessed by various multicast protocols.

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