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A Survey of Multicast Routing Protocols in Ad-Hoc Networks

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ABSTRACT

Multicast routing in wireless networking is the newest technology that works with network groups. Multicast routing plays an important role in point-to-point or multipoint-to-multipoint communications. Multicast routing gives wireless networks more efficient, reliable and secure than unicast routing, because the speed of the protocols and techniques that are developed or combined on multicast routing to work with wireless technology. There are a lot of multicast routing protocols, some of them works with wired networks while the others work with wireless; some protocols deal with both wired and wireless networks. In this paper, multicast routing protocols that deal with ad-hoc networks are discussed; a general overview has been given on multicast protocols, describing how they work and showing the reasons for developing these protocols. Also comparisons are made between the protocols to explain the advantages and limitations. Finally, future researches that can be made on multicast routing protocol have been also discussed.

Keyword: Multicast Routing

1. INTRODUCTION

Wireless applications, like emergency searches, rescues, and military battlefields where sharing of information is mandatory, require rapid deployable and quick reconfigurable routing protocols, because of these reasons there are needs for multicast routing protocols. Generally there are two types of multicast routing protocols in wireless networks. Tree-based multicast routing protocol, the tree-based multicast structure can be highly unstable in multicast ad-hoc routing protocols, as it needs frequent re-configuration in dynamic networks, an example for these type is Multicast extension for Ad-Hoc On-Demand Distance Vector (MAODV) [1] and Adaptive Demand- Driven Multicast Routing protocol (ADMR) [2].

The second type is mesh-based multicast protocol. Mesh-based multicast routing protocols are more than one path may exist between a source receiver pair, Core-Assisted Mesh Protocol (CAMP) [3] and On-Demand Multicast Routing Protocol (ODMRP) [4] are an example for these type of classification.

This paper is organized into four parts: Sections 2, describes the issues that should be covered when designing a multicast routing protocol. Sections 3, covered the multicast routing protocols and overviews about the protocols are given. Section 4, discusses these protocols, and gives some future research directions for multicast routing protocols.

2. DESIGNING A MULTICAST ROUTING PROTOCOL

There are many characteristics and challenges that should be taking into consideration when developing a multicast routing protocols, like: the dynamic of the network topology, the constraints energy, limitation of network scalability, and the different characteristics between wireless links and wired links such as limited bandwidth and poor security [5, 6, 7]. A good multicast routing protocol should involved characteristic as below

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Robustness: For many reasons, some data packets can be dropped In Mobile Ad-Hoc Networks (MANETs). This dropping process causes a low packet delivery ratio. Therefore, a multicast routing protocol should be robust enough to withstand the mobility of nodes and achieve a high packet delivery ratio.

Efficiency: Multicast efficiency is defined as the ratio of the total number of received packets from the receivers to the total number of transmitted data and control packets in the network

Control overhead: The limitation of bandwidth is very important in MANETs. Thus, the design of a multicast protocol should minimize the total number of control packets transmitted for maintaining the multicast group.

Quality of service: It is essential in multicast routing in most cases and the data transferred in a multicast session is time-sensitive.

Dependency on the unicast routing protocol: Sometimes multicast routing protocol needs to deals with deferent networks, then it is very difficult for the multicast protocol to work in heterogeneous networks. Therefore, the multicast routing protocol is independent of unicast routing protocol.

Resource management: In Multicast routing protocol, resource management like power management and memory usage are very important issues to make ad-hoc networks works well. To reduce the number of packet transmissions, multicast routing protocol try to minimize the power resource. To reduce memory usage, it should use minimum state information.

3. MULTICAST ROUTING PROTOCOLS IN WIRELESS NETWORKS

Wireless network consists of a set of mobile nodes that are connected to each other are wireless links. The network topology changes randomly while the nodes move on. Due to the highly dynamic topology and lack of central management, the protocols used in a traditional network to find a path from a source node to a destination node cannot be directly used in wireless networks. So a lot of routing protocols for ad-hoc networks have been developed in the recent past. Since multicast routing is a complex problem, a different multicast routing protocols classification is given in [8].

There are many classifications of multicast routing protocol; some of them are classified depending on the protocol functionality [9], while others depend on the structure. Multicast routing is continuously growing and not stable, because of that, a general overview about multicast routing protocols are given in this report.

3.1. Multicast Ad-hoc On-Demand Distance Vector Routing *Protocols, Wireless Networks, Ad-hoc Network*

Protocol (MAODV)

MAODV [1] is a multicast extension for AODV protocol. MAODV based on shared trees on-demand to connect multicast group members.

MAODV has capability of unicast, broadcast, and multicast. MAODV protocol can be route information obtained when searching for multicast; it can also increase unicast routing knowledge and vice-versa.

Using a broadcast route discovery mechanism named route request (RREQ) and route reply (RREP) messages to discover multicast routes in the network. When a node wants to join to multicast group or it has data packets but has not route to group, it first begins to send an RREQ message. In MAODV, multicast group a member could only respond to a join RREQ. If the RREQ is not a join request, other node with a newest route with a newest sequence number to the multicast group can respond. If an intermediate node receives a join RREQ for a multicast group of which it is not a member, or it receives a RREQ and does not have a route to that group retransmits the RREQ by broadcasting it to its neighbors. While RREQ is broadcast message, nodes set up pointers to establish the reverse route in their route tables.

When a node receives an RREQ, it updates its path information and saves the sequence number and the next hop information for the source node into the routing table. The reverse path entry used when the node wants to response back to the source. The node were response updates its route and multicast route tables by placing the requesting node's next hop information in the tables, then unicast an RREP message to the source node again.

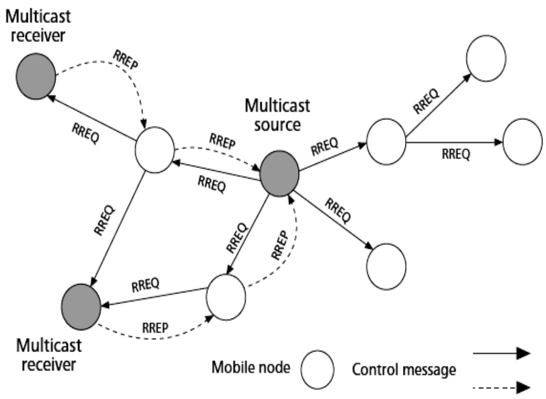


Figure 1. Route Discovery in the MAODV Protocol.

In Figure 1, when the sender node broadcasts the RREQ message, all receivers will replay the RREP message. The sender node eliminates the received routs that have smaller sequence numbers and keeps only received route that has bigger sequence number with shortest hop count to the nearest node in the multicast group for a specified time. Then, it activates the selected next hop in its multicast route table, and begins to send the activation message (MACT) by unicasting it to the selected next hop. The next hop, on receiving this message, enables the entry for the source node in its multicast routing table. If this node is a multicast tree member, it does not propagate the message.

The node keeps the best next hop for its route to the multicast group, unicasts MACT message to that next hop, and enables the corresponding entry in its multicast route table. This process continues until the last receiver is reached. The activation message ensures that the multicast tree does not have multiple paths to any tree node.

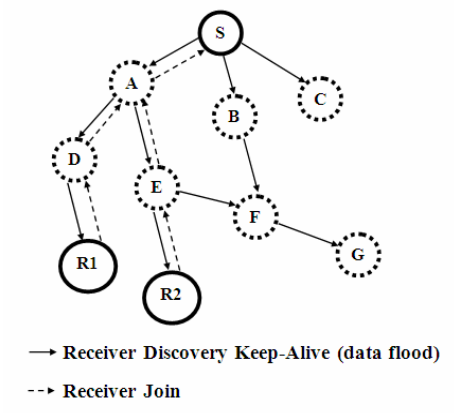
The first member, who would join to the multicast group, would become the leader of the group. The leader node in MAODV tries to maintaining the multicast group sequence number then broadcast it by sending the Group Hello message to the group. The Group Hello contains extensions that point to the multicast group IP address and sequence numbers (incremented every Group Hello) of all multicast groups for which the node is the group leader. MAODV has to actively track and react to changes in its tree. If a multicast member terminates its membership with the group, the multicast tree requires pruning. Links in the tree are monitored to detect link breakages, and the node that is farther from the multicast group leader (downstream of the break) takes the responsibility to repair the broken link. If the tree cannot be reconnected, a new leader for the disconnected downstream node is chosen as follows.

The multicast group member that will rebuild the route becomes the new multicast group leader. If the node was not the member of that group, it prunes itself from the tree by sending its next hop a prune message. All this process will continue until a group member is reached [10].

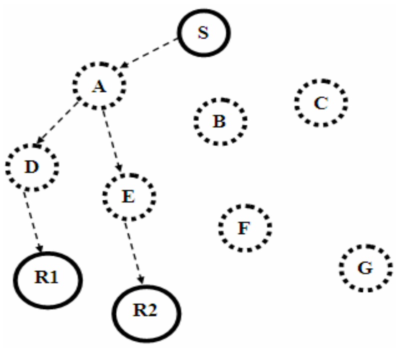
3.2. Adaptive Demand-Driven Multicast Routing Protocol (ADMR)

ADMR [2] is an on-demand source-based protocol. By using the shortest-delay path from the sender node to the receiver members, ADMR uses packet forwarding techniques by using a sequence number to uniquely identify the packets and is generated as a count of all flooded ADMR packets.

In Figure 2, when sender node wants to send data packet to the multicast group, it starts to broadcast the data packet toward the network. Then an ADMR header is added to the data packet and a *network flood flag* is set. Using this flag will make the data packet to be sent to each node in the network. Otherwise, a *tree flood flag* is set, where the packet is only sent to each node in the multicast tree. In the form of a *Receiver Join* packet, the sender node will buffer any subsequent data packets until it receives a right response, from a potential multicast receiver.



(a)



(b)

Figure 2. ADMR Protocol: (a) Route Discovery, (b) The path Selection.

When a node wants to join to the group, it establishes sending join message named *Receiver Join* to makes its way from the receiver node to the sender; intermediate routers mark in their routing tables the last hop of the *Receiver Join*. During the original network flood, nodes mark the last hop of the advertisements as their upstream node. This will give the ability to nodes to create multicast routes. Multicast sources continue to flood periodically the data packet to the specific network. When the application layer at the sender stops sending data packets, the sender sends a *Keep-Alive* message to the multicast tree. Sending a *Multicast-Solicitation* message to the entire network, receiver nodes can join a multicast group. If the node has received a lot of *Multicast-Solicitation* messages within a short period of time, group sender replies by advancing the time of the next network flood.

Otherwise, it replies by *Keep-Alive* message down the reverse path. A receiver node, receiving a reply from the sender node, responds with a

Receiver-Join message, therefore completing the three-way handshake and activating the multicast routes. This concept is responsible for controlling the forwarding tree for link breaks and fixing the breaking links. Maintenance process starts after the multicast forwarding state is configured. This process will continue as long as the sender application generates packets and there are receivers in the network interested in receiving these packets.

ADMR header is the inter-packet time at which new packets should be expected from this sender S for this group G [11]. This field in the ADMR header is initialized by S for each packet originated. This inter-packet time is used by members of the multicast forwarding tree to adaptively detect disconnection in the forwarding tree (e.g. Link Breaks), as well as inactive periods during which the source application does not send data temporarily and it will be more resource-efficient to expire the multicast state. When some node C detects broken links, it starts a local maintenance to repair the multicast forwarding tree. At the beginning node C start to sends a *Repair Notification* packet to the other nodes in the sub-tree node C in the multicast distribution tree for group G and sender S. When node sends the repair notification packet, node C will waits for a period of time to start sending REPAIR_DELAY before starting its maintenance proceeding.

3.3. Core-Assisted Mesh Protocol (CAMP)

CAMP [3] routing protocol, it is shared mesh based protocol. It is works well with the dynamic ad-hoc networks. It ensures that the shortest paths from all receivers to the sources (called reverse shortest paths) are included in the mesh of group [12].

Figure 3 illustrates how data packets are forwarded from router to the rest of the group members in CAMP and in a shared-tree multicast protocol. CAMP establishes a multicast mesh and maintains it; CAMP provides the shortest paths from receivers to senders. By using of receiver-initiated approach, any node in the network can join to multicast group. If there isn’t any node from multicast group is in his neighbors, the node will send a Join-Request message to the core, if one of the node neighbors is multicast group member it announces its membership using persistent updates.

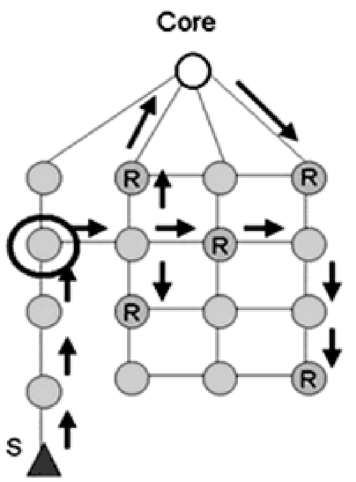


Figure 3. Core-Assisted Mesh Protocol (CAMP).

In CAMP, if the nodes detect any broken links in the path of the multicast tree, the CAMP tree will reconfigure the multicast network and start sending multicast data packets from the beginning to all nodes in the multicast tree.

3.4. On-Demand Multicast Routing Protocol (ODMRP)

ODMRP [4], is an on-demand mesh based, besides it is a multicast routing protocol, ODMRP protocol can make use of unicast technique to send multicast data packet form the sender nodes toward the receivers in the multicast group. To start sending multicast data packets, ODMRP uses two kinds of control messages: join-query and join-replay, if there is nodes wants to join to the multicast group, it uses join-query. Using of join-reply will be activated when the receiver node accept to receive the multicast data packet. In ODMRP protocol, each source floods a join request *Join-Req.* message periodically in the multicast group. A node receives the *Join-Req.* message uses store the greatest node ID in a *Routing Table*, then it will rebroadcasts the massage. The process continues until reaching the multicast receiver node. Once the receiver node received the *Join-Req.* message, it will declare its joining by broadcasting *Join-Reply* message to the multicasting group. Figure 4; show the *Join-Reply* mechanism in ODMRP protocol, *S1* and *S2* are source nodes and *R1*, *R2*, and *R3.* While broadcasting join-Reply message, if there is any exist field in the routing table, it will be updated with the new fields.

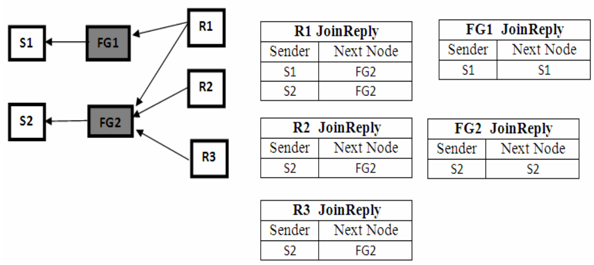


Figure 4. Join- Reply Forwarding in ODMRP.

In Figure 4, a node receiving Join-Reply checks if the next node ID in one of the table’s fields equals with its own ID, then it considers itself as a forwarding group (*FG*) node. The reply forwarding process continues until reaching the sender node using the shortest path from building mesh of *FG* nodes.

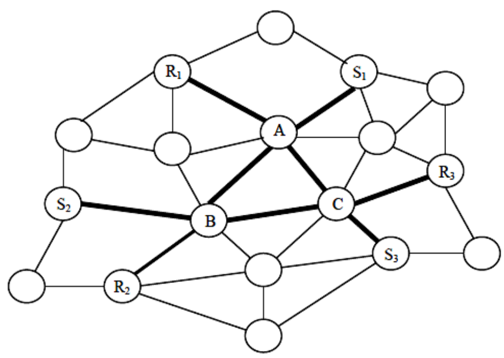


Figure 5. Mesh Configuration in ODMRP.

In Figure 5, there is data transmission between *S1* and *R3*, if node *B* moves the receiver can still receive data through another path via node *C*. ODMRP protocol uses the soft state mesh maintenance approach provides robustness. But this will cause the high expense of control overhead when the packet uses more than one path to reach the multicast receiver node [10].

3.5. Associativity-Based Multicast Routing Protocol (ABAM)

ABAM [13] routing protocol, is an On-Demand Source-based multicast routing protocol. To establish multicast process, the sender node will starts for each multicast groups based primarily on association stability techniques that introduced in ABR [14]. This technique helps the source node to select paths to receiver nodes.

The sender node starts the multicast tree configuration part by flooding a multicast broadcast query (*MBQ*) message to the network. By using node ID, each node in the network will receive the *MBQ* message. Besides, path relaying load, associatively ticks, signal strength, power life information [14], then rebroadcasts the message. Then the receiver node collects all the *MBQs* for the multicast group it is interested to join. Then it selects the most stable path, then it replay *MBQ-Reply* message to the source node of this path.

When the sender node receives a lot of *MBQ-Reply* messages from the other receivers, it determines a stable multicast tree then start broadcasting an *MC-Setup* message to start building the multicast tree in the network. When there is a new node wants to join to multicast group, the new receiver will broadcasts a Join- Query (*JQ*) message, the multicast nodes then respond by replaying a *JQ-Reply* message.

Figure 6, when a receiver node wants to disjoin from the group, it start to send a *leave* message. When a there is breaking detection in the route between nodes, where the upstream node of the break broadcasts a Localized Query (*LQ*) message, tree reconnection takes place.

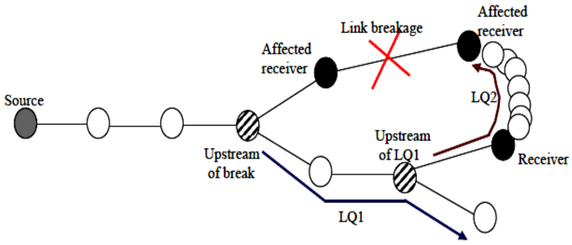


Figure 6. ABAM Tree reconnection.

ABAM routing protocol tries to reduce the number of tree reconfiguration and the control overhead. ABM routing protocol also try to increase the hop distance between the sender and the receiver node source-receiver pair. If there are many receivers of the same multicast group, it leads to congestion in the most stable routs, which leads to delay increase and a reduction in the packet delivery ratio [10].

3.6. Differential Destination Multicast (DDM)

DDM [15] routing protocol, has two deferent types: State and Stateless. In Stateless type, the sender nodes records the destination address into the DDM block of the data packet, then it start unicast the DDM block to the next neighbor. Every node receives the DDM block data packet gain the address of the next node and starts unicasting the DDM block packet again. This process will counties until the data packets reach the destination node. The other type of DDM protocol is state mode, each node that have a path in the multicast group will remembers the destination address by sorting it in the forwarding set.

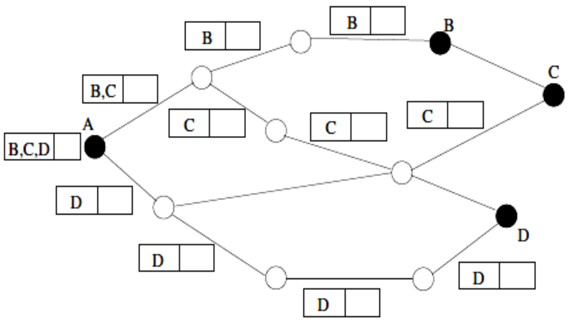


Figure 7. Transmission of DDM Packets.

DDM protocol works well with small multicast network groups. Figure 7 show packet Transmission in the DDM protocol [16].

3.7. Multicast Core Extraction Distributed Ad-hoc Routing (MCEDAR)

MCEDAR [17] is a multicast extension to the CEDAR architecture. MCEDAR has a complex structure, it is consists from combining tree-based forwarding protocols and mesh-based protocols. MCEDAR uses a mesh approach to tolerate a link breakage without rebuilt the multicast network again. To make sure that data packets will select the shortest path in the tree, MCEDAR will use a forwarding mechanism on the mesh that creates an implicit route-based forwarding tree to improve the efficiency of the network [18].

In high mobility situations, nodes in MCEDAR should changes their cores frequently; this will lead to the increasing in the control overhead.

3.8. Multicast Routing Protocol Based on Zone Routing (MZR)

MZR [19] routing protocol, it is a source-based initiated and on-demand protocol. MZR uses the concept of zone routing, and deliver the tree rooted at the sender node. The zones in the MZR protocol will be chosen by nodes neighborhood, selected by the zone radius in terms of number of hops [20]. Figure 8 shows multicast tree creation inside a zone and the Figure 9 shows Multicast Tree Extension through the entire network.

MZR protocol starts multicast transmission form the sender nodes. Sender node sends a Tree-Make packet to each node in its network zone. Each intermediate node in the network receiving the packet creates a reverse path entry in its multicast routing table with the empty list of lower set, and the upper is set to the node from which Tree-Make was received

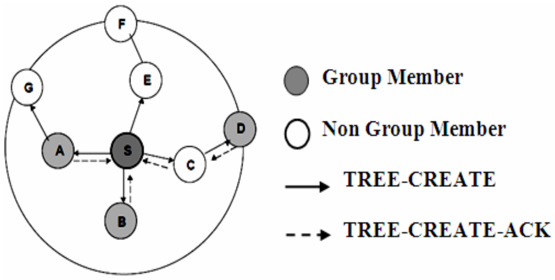


Figure 8. Multicast Tree creation inside a zone.

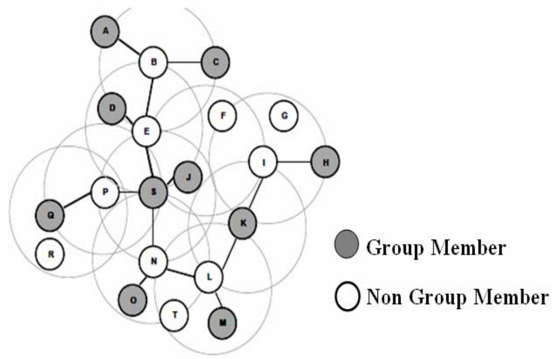


Figure 9. Multicast Tree Extension through the entire network.

Any node zone wants to joining to the session will replies by a Tree-Make-Ack using the reverse path that was created to the sender form receiver nodes to the senders. While the Ack packet is forwarding, each node on the path will refresh the fields of its routing table. This process will continuous until the sender nodes finish its zone. By sending a Tree-Propagate message to each border node of its zone, the node begins to stretch out the multicast tree to the entire network. After that, each node receiving this message creates a multicast route fields for this session and start sending Tree-Make to each node in its zone, and so on until each node gets a Tree-Make packet.

Sender nodes will start the multicast mechanism during multicast session. This mechanism lets multicast routing tree members update their information by sending a Tree-Refresh packet. MZR try to fix the broken link when it appears in the multicast tree. The lower node then starts branch reconfiguration by sending Join packets to all nodes in its zone.

In MZR protocol, every node in the multicast tree with a right route field can join to the zone by sending a Join-Ack. Otherwise, if there is no Join-Ack is received and then a Join-Propagate message is sent to the lower nodes, until a Join-Ack is received. By using PRUNE messages, nodes will have the ability to disjoin from the multicast session whenever they want.

A disadvantage of this protocol is that a far located receiver node needs to wait for a long time before it can join the multicast session, as the propagation of the Tree-Propagate message takes a considerable amount of time.

3.9. Weight Based Multicast Routing Protocol for Ad-hoc Wireless Networks (WBM)

WBM [21] routing protocol, tries to reduce high packet delivery ratio and low control overhead. The weight concept, consist of the number of newly added forwarding nodes and the distance between senders and receivers. Localized prediction scheme based on the tree maintenance scheme to improve a packet delivery ratio. The architecture of WBM protocol is illustrated in Figure 10.

The goal of WBM protocol is to find the best field point into multicast group to receiver-initiated approach. Broadcast Join-Req message and forwarding it until it is received by a node from multicast group, a node sends reply message when it wants to join to the multicast group. The reply message contains distance hop between the sender and forwarder node and between forwarder and receiver node.

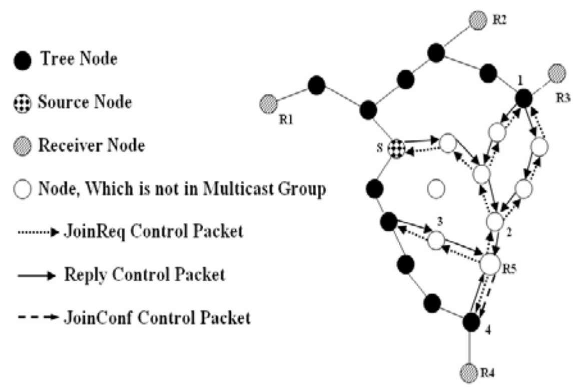


Figure 10. The architecture WBM protocol.

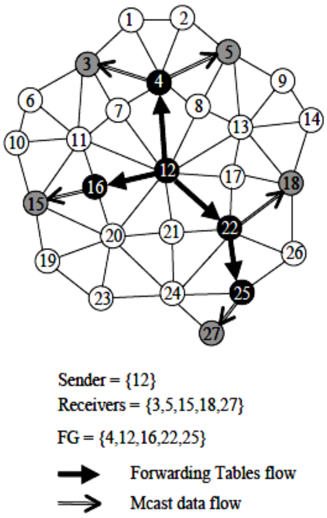
3.10. Forward Group Multicast Protocol (FGMP)

FGMP [22], it is mesh based on demand routing protocol. FGMP protocol is based on the forwarding group technique. It keeps the node group's track which participates in multicast packet forwarding. FGMP protocol controls the use of a forwarding group FG that associate with each multicast group. Any node in FG is in charge of forwarding (broadcast) multicast packets of G. When the node receives a non-duplicated packet, the forwarding node will receive a multicast packet then it will start broadcasting it to its neighbors. This broadcasting message will be received by all nodes in the neighbors, but only the nodes that are in FG will detect first whether or not it is a duplicate and then broadcast it in turn.

3.11. Forwarding Group Multicast Protocol-(Receiver-Advertising) (FGMP-RA)

FGMP-RA [23] is a mesh-based protocol which is based on the forwarding group approach. Its difference from ODMRP is that FGMP-RA is a receiver-initiated protocol while ODMRP is a source initiated protocol.

A FGMP-RA and example of multicasting forwarding tables are shown in Figure 11. Assume that node 12 is the multicast group sender. Because they are in the next hop list, the forwarding nodes will be, *FG*= {4, 12, 16, 22, 25}. Only sender nodes and internal nodes, in the example is node 12 and node 22, need to create a forwarding table (Figure 11(a), (b)) and broadcast it. Forwarding nodes 4, 16, and 25 do not need to create their forwarding tables since they are "leaves", i.e., all receiver members are immediate neighbors. The forwarding tables are created and broadcast to the neighbors only when new forwarding tables arrive. When forwarding nodes receive new forwarding tables, the forwarding time will be updated. The nodes that will be outside of updated process, the forwarding flag will automatically time out and the forwarding node is deleted from *FG*.



Forwarding Table of Node 12:

Receivers	Next hop
3	4
5	4
15	16
18	22
27	22

(a)

Forwarding Table of Node 22:

Receivers	Next hop
27	25

(b)

Figure 11. Example of forwarding tables.

3.12. Patch On-Demand Multicast Routing Protocol (PatchODMRP)

Patch ODMRP [24], it's an upper version of ODMRP protocol. Patch ODMRP works better with small networks and high mobility. Patch ODMRP uses a local patching scheme instead of frequent mesh reconfiguration, where it copes with mobility without reducing the *Join-Req* interval. This takes place through performing a local recovery scheme when some parts of the mesh are locally disconnected.

Figure 12: the official ODMRP mesh is shown in Figure 12(a), *S* node is the sender of the multicast group and *R* node is the receiver. Each *FG* node utilizes MAC layer to check for its neighbors, and comparing it with the forwarded routing table to check out if there is any unreachable node in the network. In Figure 12(b), node *K* detects that node *J* is unreachable as a result of the failure of the link *JK*. In this case, *K* node starts the patching procedure by flooding advertisement message (*ADVT*), advertising the upper loss. If *J* node

supports more than one multicast groups, then it is added in the *ADVT* message. A node receiving the *ADVT* message updates its routing table entries for the source of the *ADVT*. In Figure 12(c), a *PATCH* packet is generated as a reply on the *ADVT* and is forwarded *I* to *K* node, selecting *L* as a temporary *FG* node. If *K* receives more than one *PATCH* packet, it selects the shortest path to the multicast sender. The new mesh path is shown in Figure 12(d), *K* node marks *L* node as a new upper *FG* node [10].

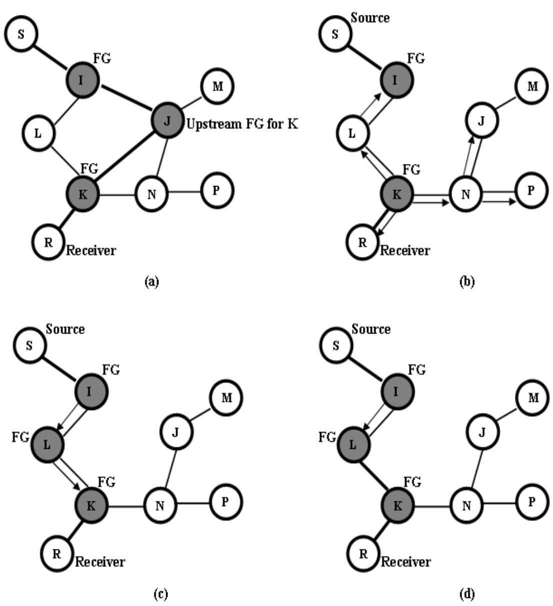


Figure 12. PatchODMRP Operation: (a) ODMRP protocol, (b) j node is not detected by node K, (c) PATCH packet from node I to node K and, (d) node K working Last FG node.

3.13. The Protocol for Unified Multicasting Through Announcements (PUMA)

PUMA [25] routing protocol, is a modern multicast routing protocol approach for MANETs. PUMA is a mesh based and uses a unique control packet called Multicast Announcement for all mesh maintenance routines.

In PUMA protocol, every sender can start sending multicast data packets toward a multicast group. By using the address of a special core node, the receivers will join the multicast group without the need for flooding of control packets from the source of the group.

Figure 13 shows an example of PUMA mesh and data forwarding within the multicast group. The parent of nodes O and Q is node N. Same case is for node P, it is marks in its multicast announcement that its parent is node K. By assuming nodes O and P are senders. Node N starts sending a data packet from node O, not from node P, because there is only one parent for node O and it is node N. Although node J is not the parent of node P, it forwards the packet when it receives it from P, because mesh members do not consult their connectivity list before forwarding a packet. As a result, receiver node I will get the packet early.

Node J does not rebroadcast the packet when it receives same packet from K due to duplicate packet checking [26].

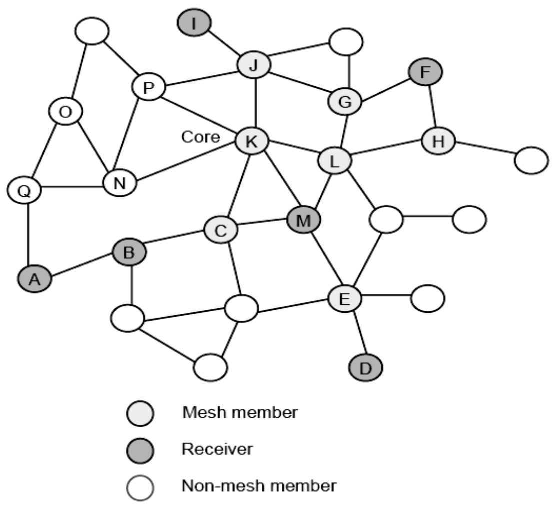


Figure 13. Mesh and data forwarding in PUMA.

3.14. Ad-Hoc Multicast Routing Protocol (AMRoute)

AMRoute [27] based on shared tree and has two faces: mesh and tree. By using mesh face, AMRoute identifies and designates certain nodes as logical cores that are responsible for initiating the signaling operation and maintaining the multicast tree to the rest of the group members. A non-core node only responds to messages from the core nodes and serves as a passive agent. The selection of a logical core in AMRoute is dynamic and can migrate to any other member node depending on network dynamics and group membership.

AMRoute does not address network dynamics and assumes the underlying unicast protocol to take care of it. The second face is a mesh, all nodes in the multicast group starts with identifying themselves as a core of the group. Then to find other group members, they start broadcasting JOIN_REQ packets with increasing time to live (TTL).

In Figure 14, core receives a JOIN_REQ packet from another core in the same multicast group. It replies with a JOIN_ACK. A new bidirectional tunnel is created between the two cores, and one of them is selected as a core after the mesh merger. When the mesh has been started up, the core starts the tree building process.

The core start to send TREE_CREATE messages to all nodes in the mesh. The TREE_CREATE messages will be received only by the multicast group nodes. Then every TREE_CREATE message receiver in the multicast group will forwards messages it received to all mesh links except his parent. Then the TREE_CREATE is discarded and TREE_CREATE_ NAK is sent back to his parent. If there is node wants to leave the group, it is try to send a JOIN_NAK message to nodes that have connection with him.

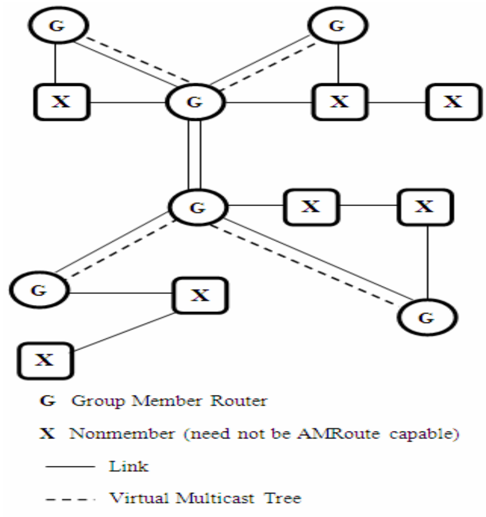


Figure 14. AMRoute virtual multicast tree.

Using the mesh links, AMRoute starts building multicast tree. If there is any change in the network, multicast tree in AMRoue tries to keep the multicast delivery tree unchanged. The main disadvantage of this protocol is that it may have temporary loops and may create non optimal trees with host mobility [18].

3.15. Ad-hoc Multicast Routing Protocol Utilizing Increasing Id-Numbers (AMRIS)

AMRIS [28], an on demand multicast routing protocol designed for mobile ad-hoc networks. A multicast delivery tree rooted at a special node called Sid joins up the nodes participating in the multicast session. This node ID makes joining and leaving multicast group easy. Besides it helps to speed the connection between the nodes inside the group.

A multicast process starts with Sid by sending *NEW-SESSION* message. The *NEW-SESSION* message includes the Sid's special ID named *msm-id*. Neighbor nodes receiving this message generate their own *msm-id*. Then these nodes start rebroadcasting their own *NEW-SESSION* message what include their own *msm-ids*. If a node wants to join to the multicast group, a node will start sending a *Join Request* (*JREQ*) message to its parent with smallest *msm-id*. If the parent is a multicast group member, it will send start sending acknowledgment information by sending a *Join Acknowledgment* (*JACK*). If the parent is not the multicast group member, the parent rebroadcast a *JREQ* message to its parent. This process will continue until the node will reach the parent that is member in the multicast group.

3.16. Source Routing-Based Multicast Protocol (SRMP)

SRMP [29] is an on-demand mesh based multicast routing protocol. SRMP tries to solve the path availability technique and higher battery life technique. SRMP depends on DSR routing mechanism [29]. Unlike other mesh based protocols, SRMP prevents the overhead of storing next hop information as well as periodical control messages, preventing channel overhead and scalability improvement.

To reduce network flooding, the Forwarding Group (FG) nodes technique [23] is used. Selecting FG nodes depends on neighborhood association stability, link signal strength, battery life, and link availability estimation [30].

3.17. Position-Based Multicast (PBM) Routing Protocol

PBM [31] routing protocol, based on the information of geographic position for the nodes to start sending the packets to the other nodes in the multicast group. PBM does not requires the maintenance of a distribution structure like other tree or a mesh based routing protocol, even there is no need resorts to flooding. PBM is a generalization of existing position-based unicast routing protocols.

PBM assume that the position of the destination nodes is known to the sender node. Using GPS systems, each node knows its own position and knows the position of its neighbors.

PBM protocol, try to solve two problems; first problem is making a multiple copies from the multicast packet in the current node to reach all destination members in the group. The second one is the recovery approach used to go out from a local optimum needs to be adapted to take multiple destinations into account.

3.18. Simple Multicast and Broadcast Protocol (SMBP)

SMBP [32], this routing protocol depends on DSR routing protocol approach to discover route mechanism in the multicast group and works well in the small networks. SMBP protocol has two faces, so it can be use as a specific multicast routing protocol, or making use of DSR routing protocol. SMBP protocol differ from other multicast routing protocol that it not need to set up multicast network when multicast group members node wants to deliver data packet to the other nodes.

When nodes wants to send a broadcast data packet uses the same route discovery approach that is exist in the DSR routing protocol by sending the *RREQ* message. After *RREQ* message flooded in the network, a multicast data packet is also flooded using the same approach with the multicast group as the *RREQ* target. When the receiver nodes receives *RREQ* message it makes a copy of the included data packet and sends it up to the data layer to forwarding it to the group. Using multicast or broadcast address for the destination member's node, *RREQ* message can be transmit all over the network as a route detection message.

SMBP protocol works like the same way of DSR routing protocol, but non propagating *RREQ* is not allowed in this protocol. Route cache should not also be consulted on behalf of the *RREQ* with multicast and broadcast targets.

3.19. The Dense Multicast Zone Routing Protocol (DMZ)

DMZ [33] based on adaptive mesh structures; it makes use of dense zone approach. A high concentration of multicast members in the specific place in the network, each dense zone has a connection to the multicast group. There are special nodes in the multicast group placed on the upper level named leader's node. This approach provides more robustness and scalability for multicast data transmission in ad-hoc networks.

3.20. Multicast Optimized Link State Routing (MOLSR) Protocol

MOLSR [34] routing protocol, it is multicast extension for OLSR routing protocol [35]. In MOLSR, multicast processes do three steps: building of multicast tree, maintenance of the tree, and the tree detachment. Any change in the network topology tree will lead to the change in the multicast tree. In Figure 15, MOLSR offers minimal connectivity between the sender nodes and the group of multicast receiver nodes when most of the nodes are multicast capable provided that multicast nodes. By broadcasting a MC_CLAIM message, multicast routers will announce themselves to the its network.

When the sender node wants to send multicast data packets to its group, it sends a SOURCE_CLAIM message activating nodes which are members of this group to detect its presence and to attach themselves to the associated multicast tree. Branches are built in a backward manner: group members who do not know yet about this source try to attach themselves to the corresponding tree. More specifically, when a group member receives a SOURCE_CLAIM message and it is not already a participant of this tree.

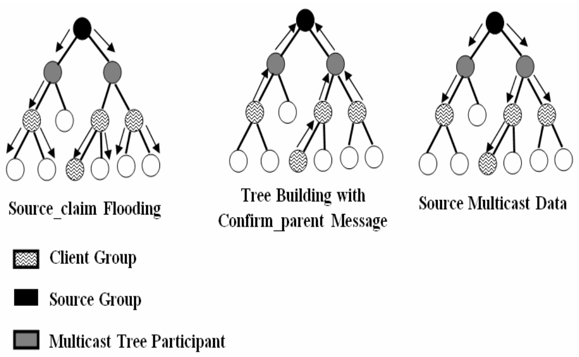


Figure 15. Tree building mechanism in MOLSR.

MOLSR looks to the multicast routing table to determine which node is the next hop that becomes node parents in the multicast tree to reach the sender node. Then it sends a CONFIRM_PARENT message to its parent node to confirm the selection of the parents. The parent node then receives confirmation message then attaches itself to the tree, if it is not already a participant to this tree. When data packet transfers hop by hop, the CONFIRM_PARENT message is will be handled by intermediate multicast routers which build the corresponding branch. By sending the SOURCE_CLAIM message and the CONFIRM_PARENT message, the multicast trees will re-update.

When a node wants to disjoin from the multicast tree and it is a leaf, it separates itself from the tree by sending a LEAVE message to its parent in this multicast tree. The LEAVE message is processed hop by hop and unused node will be deleted automatically.

4. DISCUSSION AND CONCLUSION

This paper, present multicast routing protocols in ad-hoc networks, a general view of these protocols are given. Also the main issues required in the design of an efficient ad-hoc multicast routing protocol are given. Then the aim of developing these protocols is presented, and the operation mechanisms are shown too. Summarization of these protocols is illustrated in Table 1. In addition, new protocols have been added to the table in [10].

Generally we can classify multicast routing protocols into two specific parts: tree-based and mesh-based. The tree-based multicast structure can be highly unstable in multicast ad-hoc routing protocols, as it needs frequent re-building in dynamic networks. Reestablishing the multicast group in tree-based multicast network cause to sending many control messages to the group, this means wasting in time and resources. Besides reduces the routing efficiency due to the increase in the hop distance between the source-receiver pairs. Also, a congestion of the most stable paths may occur when there are lots of receivers belonging to the same multicast group.

Table 1: the comparison between deferent multicast routing protocols

	Multicast Topology	**Loop Free**	**Dependence on Unicast Protocol**	**QoS Support**	**Periodic Message**
MAODV	Tree	Yes	Yes	No	Yes
ABAM	Tree	Yes	Yes	No	No
ADMR	Tree	Yes	No	No	Yes
DDM	Tree	Yes	No	No	Yes
MCEDAR	Hybrid	Yes	Yes	Yes	Yes
MZR	Hybrid	Yes	Yes	No	Yes
PUMA	Hybrid	Yes	Yes	No	Yes
WBM	Tree	Yes	No	No	No
FGMP	Hybrid	Yes	Yes	No	No
ODMRP	Mesh	Yes	No	No	Yes
Patch ODMRP	Mesh	Yes	No	No	Yes
FGMP-RA	Mesh	Yes	Yes	No	Yes
CAMP	Mesh	Yes	Yes	No	No
AMRoute	Hybrid	No	Yes	No	Yes
AMRIS	Tree	Yes	No	No	Yes
SRMP	Mesh	Yes	No	Yes	No
PBM	Position		Yes	Yes	
SMBP			No		
DMZ	Hybrid				Yes
MOLSR	Tree		Yes		Yes

In the mesh-based protocols provide more robustness against mobility and save the large size of control overhead used in tree maintenance. Most protocols of this type rely on frequent broadcasting, which may lead to a scalability problem when the number of sources increases.

Mesh-based protocols may form sparse mesh and unavailability of redundant paths, when the number of sources is small. Consequently, frequent reconfigurations may be required to recover link breakage increasing the control overhead, which becomes more prominent in this case.

Although the multicast topology (tree or mesh), the shortest path is widely used as a base to discover the routes to the source in multicast group. But it provides the optimal routes in ad-hoc network. In addition there is important criteria should be considered (as path stability, power efficiency, quality of links, topological changes, interference). The choice of a routing path should be agreement to the ad-hoc environment while considering these factors.

There are more issues and more protocols that are in grow stages, like mobility and QoS, there need to more studding and more researches to be done on multicast routing young research domain. Beside this, some challenges and problems are not completely finalized and analytical studies are being complex.

Finally, all multicast routing protocol tries to solve some problems, all of these routing protocols has its own advantage and disadvantages too. There is no any protocol founded yet that can be solving all ad-hoc network problems. Therefore, there are many issues in multicast routing protocol than can be discussed by researchers to develop these protocols to perform better in the coming future.

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