ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 5, Issue 7, July 2016

Survey on Multicast Routing Protocols in MANETs

A Viswanath, Dept of CSE, Sree Vidyanikethan Engineering College, Tirupati, AP, India.
N Papanna, M.Tech, Assistant Professor, Sree Vidyanikethan Engineering College, Tirupati, AP, India

Abstract:
The mobile Ad-hoc network (MANETs) defined as a collection of wireless nodes that are able to communicate each other without need of established infrastructure. MANETs follows multi hop routing from source to destination node or nodes. These networks have quite as many constraints because of uncertainty of radio interface and its limitations. The nodes in Ad hoc networks are battery operated with limited energy resources. A routing protocol uses routing algorithm for optimal network data transfer and communication between network nodes. Routing protocol facilitates router communication and overall network topology understanding. Each node in the network acts as a router and host and makes decision in forwarding packets from one node to another node. Sending the multiple copies of packet to different nodes is called multicasting. Wired and infrastructure based wireless networks are supported by multicasting protocols. But applying this concept in mobile Ad-hoc networks (MANETs) is a big challenge. Problems in Ad-hoc networks are scarcity of bandwidth, short life time of the nodes due to power constraints and dynamic topology due to mobility of nodes. These problems put forth to design a simple, scalable, robust and energy efficiency routing protocol for multicast environment. In this work multicast routing algorithms for MANETs are surveyed and categorized on the basis of metrics used for multicasting. These algorithms are analyzed in highlighting their strengths and deficiencies.

Keywords — MANETs, Multicast, Routing, Nodes.

1. Introduction

An Ad hoc network is a dynamically reconfigurable wireless network with no fixed infrastructure. Because of lack of infrastructure, centralized administration is not possible in ad hoc networks. Mobile ad hoc networks are self organizing and self-configuring multi-hop wireless networks where, the structure of network changes dynamically.

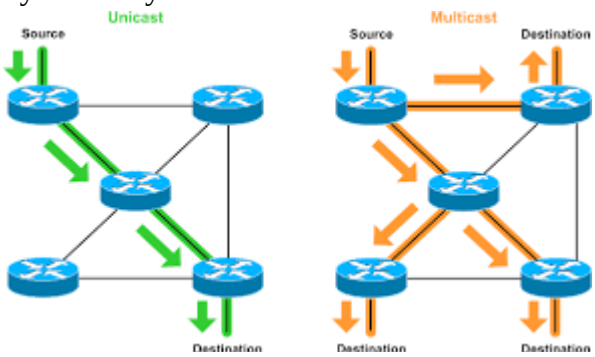

Fig. 1.1 Example of unicast and multicast Ad hoc networks

Communication among mobile nodes in an ad hoc network requires routing over multi-hop wireless paths. In MANETs all the mobile nodes play the role of a router. Even if the source and the destination mobile nodes are not within the communication range of each other, data packets are forwarded to the destination mobile node by relaying the transmission through intermediary mobile nodes.

Each device in a MANET is free to move independently in any direction, and will therefore changes its links to other direction of the devices frequently. Because of the limited transmission range of the nodes, multi-hops may be needed to reach each other nodes. Nodes in the networks utilize the same random access wireless channel and cooperating in a friendly manner to engaging themselves in multi-hop forwarding.

The primary responsibility of a routing protocol is exchanging the routing information by finding a feasible path to destination based on criteria such as minimum power required ,hop length and the life time of wireless link based on information about path breaks, processing power and bandwidth.

The primary purpose of multicasting is to carry out certain tasks that require point-to-multipoint, multipoint-to-multipoint voice and Data communication to a group of nodes.

Non-restricted easy deployment and mobility characteristics of MANETs make them very popular and highly suitable for various applications like emergencies, natural disasters, collaborative and distributed computing, military operations, civilian environments, commercial, wireless sensor networks, wireless Mesh networks, and hybrid wireless networks.

There are various protocols designed to minimize the design issues in mobile ad hoc wireless networks. All design areas can have some features and requirements for protocols in common. Uniqueness in the characteristics of an ad hoc network has several requirements for the routing protocol design. Ad-hoc routing must be simple, robust and minimize control message exchanges.

Protocols can be assumed to be operating at unicast, multicast, geocast, broadcast situations. In unicast routing protocols, one source transmits messages or data packets to destination.

Multicasting is a communication process in which the transmission of message (packets) is initiated by a single user and the message is received by one or more end users of the network.

Broadcast is a unique case of multicast, where all the nodes in the network should get broadcast message.

The purposes of geo cast protocols are to deliver data packets for a group of nodes which are situated on at specified geographical area. Unicast is a special form of multicast and some multicast routing protocols supports both unicast and multicast routing.

2. Literature Survey

A mobile ad hoc network is a (MANET) is a collection of autonomous mobile nodes that formin a temporary network without aid of any stand alone infrastructure or centralized administration. Ad hoc wireless network uses shared radio channel and distributed routing fashion for communication in the network.

To send the data to a group of nodes in the ad-hoc network using unicast operation is very difficult. To avoid the difficulty multicast operation is required. There are several multicast protocols which will play a key role in data transfer among the group of nodes.

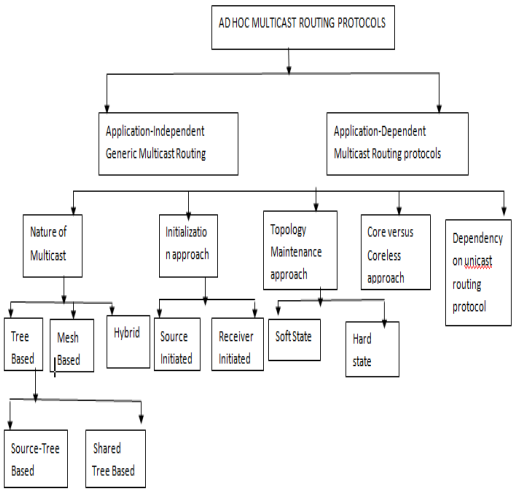

Fig 2.1: Classification of Multicast Routing Protocols over MANETs.

Multicast routing protocols which are used in static networks such as distance vector multicast routing protocol (DVMRP) do not perform well in ad hoc networks.

Generally in wireless networks multicast routing protocols are classified into two categories: tree based multicast routing protocols and mesh-based multicast routing protocols. In tree based multicast routing protocols, there exist a single path between any sender-receiver pair.

In Mesh based multicast routing protocols there may exist more than one path between a source-receiver pair. Mesh based protocols provide redundant (more than one) routes for maintaining connectivity to group members. However, tree-based protocols are not robust against frequent topology changes and the packet delivery ratio (defined as the ratio of number of data packets delivered to all the receivers to the number of data packets received by all the receivers) drops at high mobility.

Ad-hoc wireless networks multicast protocols are classified into two types based on the type of operation: source initiated protocols and receiver initiated protocols. In source initiated routing protocols the packet transmission is initiated by the sender. This is a 2 pass protocol (join REQ and join REP) for establishing the tree (mesh). In receiver initiated multicasting protocols, the receiver uses flooding operation to search for paths to the sources of multicast groups to which it belongs. The tree or mesh construction is a 3 phase process (join REQ, join REP, join ACK).

2.1 Multicast topology classification

Ad hoc wireless networks multicast routing protocols can be broadly classified into two types: Application-independent/Generic-multicast protocols and Application dependent multicast protocols.

Application-independent multicast protocols are used for conventional multicasting and application dependent multicast protocols are meant only for specific applications for which they are designed. Application-independent multicast protocols can be classified along different dimensions.

1. Based on topology
2. Based on initialization of the multicast session
3. Based on the topology maintenance mechanism
4. Based on the core versus core less approach
5. Base on the dependency on unicast routing protocols

2.1.1 Based On Topology:

Topology is defined as how nodes are arranged to form a network. Based on the multicast topology current approaches used for ad-hoc multicast routing protocols

can be classified into two types: tree-based and mesh-based.

Only a single path exists between a source receiver pair in tree-based multicast routing protocols and more than one path may exists between a source receiver pair in mesh-based multicast routing protocols.

Tree-based multicast protocols are more efficient compared to mesh-based multicast protocols, but mesh-based multicast protocols are robust due to the availability of multiple paths between the source and receiver. Tree-based multicast protocols can be further divided into two types: source-tree-based and shared-tree-based.

Generally, a sender initially performs flooding operation as a join message to all nodes in the network. The nodes which are interested can reply to the sender via the reverse path. After arriving all reply messages at the sender, a multicast tree rooted at the sender is formed. This type of tree construction is called sender-tree-based multicast protocols. Usually a multicast group has several senders and thus which costs high for each sender to build its own tree. Some kind of protocols select a single sender to build a multicast tree that is shared with other senders. This type of tree construction is called shared-tree-based multicast protocols and the selected sender is called the core node (group leader). Other senders first transmit data packets to the core node and the core node then relays the packets downward the shared tree to all receivers. The type of initialization approach for tree construction by one or more senders is called a sender-initiated scheme. The receiver-initiated scheme requires the receivers to initiate the tree construction, and it is often used for the shared-tree structure.

2.1.2 Based on Initialization of the Multicast Session

The multicast group formation can be initiated by either the source or the receivers. If the group formation is initiated only by the source node in a multicast routing, then it is called a source-initiated multicast routing protocol, and when it is initiated by the receivers of the multicast group, then it is called a receiver-initiated multicast routing protocol. The multicast protocols which do not distinguish between source and receiver for initialization of the multicast group are called as source-or-receiver initiated multicast routing protocols.

2.1.3 Based on the Topology Maintenance Mechanism

Due to mobility of node, the routing structure requires reconfiguration. If a broken link is repaired by periodic flood packets issued by a sender, this kind of protocol is called soft-state maintenance. Periodic flooding packets also helps new members join the group.

If a link failure is repaired by a node on the link, this kind of protocol is called hard-state maintenance. Since no periodic flooding packets are issued in hard state protocols, new members usually join the group by using expanded ring searches (iteratively expands the flood range). A group member usually leaves the group by sending a message to inform its parent of its departure. In addition to link failures, mobility of node may cause partition of the routing structure. For successfully delivering

data packets to all group members' partition must be merged. Each sender builds its own tree because sender tree- based protocols incur higher control overhead than shared-tree-based protocols. Shared-tree-based protocols have two main disadvantages: sub-optimal multicast paths and single point of failure of the group leader. The group leader may locate in a bad position which further decreases multicast efficiency and increases packet latency. The mesh structure is robust against topological changes, but multicast efficiency is reduced. A new member cannot join a group as soon as it wishes in soft state protocol and hence it may miss interested packets for a while.

2.1.4 Based on the Core versus Core Less Approach:

Core-based approach can be classified into two different approaches. They are dynamic core and static core approaches. If the current core node is failed then the member nodes of a multicast session elect or search for another one to be a new core then it is called dynamic core approach. Static core approach differs from the dynamic core concept. A group of nodes or just one node controls all network tasks in static core approach. Network will be dropped due to any kind of failure of these core nodes. Generally, core based routing protocols are used to reduce control overhead messages and to make a best utilization of bandwidth. However; they have a risk of a single point of node failure. Coreless based protocols solve the last problem but large overheads resulting of periodic announcements.

2.1.5 Based on the dependency on unicast routing protocols:

Multicast routing protocol had the ability to work as a multicast or a unicast protocol. Separating unicast and multicast approaches has many disadvantages. It increases separated, redundant control overhead packets and it causes consequently wastage of bandwidth, decrease in overall efficiency of all the systems. Also, a complex problem is established when a unicast session need to be converted into a multicast session at any time. Above all of these cons, it is a challenge for multicast protocol that relay on unicast one can work in heterogeneous networks.

2.2 Tree-based Multicast Routing Protocols

Tree-based multicasting is a concept used in several wired multicast protocols to achieve high multicast efficiency. There is only one path between a source receiver pair in tree based routing protocols. This tree based protocols are not robust enough to operate in high mobility environments.

Tree-based multicast protocols can be categorized into two types: source-tree-based multicast routing protocols and shared-tree- based multicast routing protocols. A single multicast tree is maintained per source in sourced tree based multicast routing, where as a single tree is shared by all the sources in the multicast group in a shared-tree- based multicast routing. Shared-tree-based multicast protocols are more scalable than source-tree-based multicast protocols.

Advantages:

- With the unicast route information, the multicast tree can be constructed more quickly and efficiently.

- It may incur very low overhead for a node to join or rejoin the session.
- It achieves higher multicast efficiency
- The path optimization process eliminates redundant paths gradually that leads to higher efficiency with lower packet transfer delay.
- It incurs low control overhead at low mobility.
- It can adapt to the change of mobility

Disadvantages:

- Tree reconstruction delay and traffic concentration.
- Ease of tree structure fragile because of unpredictable topology changes due to mobility of nodes.
- Flooding Group Hello messages even if no sender for the group exists.
- Joining and rejoining of a node may take long time and waste much bandwidth since each node tries potential parent nodes arbitrarily.
- The usage of periodic beacons consumes bandwidth.
- The failure of a shared link affects several receivers.
- If there are many receivers of the same multicast group, it leads to congestion in the most stable routes, which leads to increase in delay and a reduction in the packet delivery ratio.
- The occasional flooding of multicast packets is an overhead.
- The usage of periodic beacons consumes bandwidth.
- The failure of a shared link affects several receivers.

2.3 Mesh based Multicast Routing Protocols

In ad hoc wireless networks, wireless channel breaks due to the mobility of the nodes. In case of multicast routing protocols, the path between a source and receiver suffers very much due to link breaks, which consists of multiple wireless hops. The protocols which provide multiple paths between a source receiver pair are classified as mesh-based multicast routing protocols. Multiple paths in the network adds to the robustness of the mesh-based protocols at the cost of multicast efficiency.

Generally mesh-based multicast routing protocols robust due to the penalty of multiple paths between different nodes. But many of these proposals suffer from excessive control overhead which will affect on scalability and utilization of limited bandwidth, while others that apply core-based approach try to collect both robustness and efficiency from mesh and tree multicast approaches.

Advantages:

- Reduces data delivery latency during shortest paths.
- Lowers control overhead at mobility.
- Less control overhead with high packet delivery ratio.
- With correct routing information, shortest paths are included in the mesh and the joining procedure incurs very low overhead.
- Maintains a balance between routing efficiency and path robustness.

Disadvantages:

- Suffers from excessive flooding if there are a large number of senders.

- The duplicate transmissions waste bandwidth at low mobility.
- The failure of a core node affects several passive senders.
- High storage overhead is incurred for each node due to several maintained data structures.
- The periodic message exchanges among cores are a high overhead.
- Each member in the network waits for a period to select the best path which leads to take long time on mesh maintenance.

2.4 Hybrid Multicast Routing Protocols

The Hybrid based multicast routing combines both the Mesh-based and the Tree-based routing approaches in order to achieve both robustness and efficiency.

Table 1: Comparison of routing protocols in unicast and multicast approaches

Protocol	Routing Approach	Unicast routing protocol	Loop-free	Route acquisition latency	Control packet flooding	Periodic control message	QoS support	Multicast Control Overhead
MAODV	Flat	Unicast-based (AODV)	Yes	High	Yes	Yes	No	Low
AMRIS	Flat	Autonomous	Yes	High	Yes	Yes	No	Low
BEMRP	Flat	Autonomous	Yes	High	Yes	No	No	Low
MZRP	Hierarchy	Unicast-based (ZRP)	Yes	High	Yes	Yes	No	Low
ABAM	Flat	Autonomous	Yes	High	No	No	No	Low
DDM	Flat	Dependent	Yes	High	Yes	Yes	No	Low
WBM	Flat	Autonomous	Yes	Low	Yes	No	No	Low
ADMR	Flat	Autonomous	Yes	High	No	No	No	Low
MCEDAR	Hierarchy	Unicast-based (CEDAR)	Yes	Low	Yes	No	Yes	High
PLBM	Flat	Unicast-based (PLBR)	Yes	Low	No	Yes	No	High
ASTM	Hierarchy	Dependent	Yes	Low	Yes	Yes	No	High
AMRoute	Flat	Dependent	No	Low	Yes	Yes	No	High
ODMRP	Flat	Autonomous	Yes	High	Yes	Yes	No	Low
DCMP	Flat	Autonomous	Yes	High	Yes	Yes	No	Low
CAMP)	Flat	Dependent (any Proactive)	Yes	Low	No	Yes	No	High
NSMP	Flat	Autonomous	Yes	High	Yes	Yes	No	Low
CAMP	Flat	Dependent (anyproactive)	Yes	Low	No	Yes	No	High
SRMP	Flat	Unicast-based (DSR)	Yes	High	No	No	Yes	Low

3. Motivations

During the routing time Ad-hoc Networks have to suffer from many challenges. Dynamically changing topology

and lack of centralized infrastructure are the biggest challenges in the designing of an ad-hoc network. The position of nodes in ad-hoc network continuously varies due to mobility. We can't say that which particular protocol will give best performance in each and every case of topology variations very frequently. So we have to select a protocol which dynamically adapts to the ever changing topology very easily.

Another challenge in MANET is limited bandwidth. If we compare the wired network to the wireless network, wireless network has less and more varying bandwidth, so bandwidth efficiency is also a major concern in ad-hoc network protocols.

Limited power supply is the biggest challenge of an ad-hoc network so if we want to increase network life time (time duration when the first node of the network runs out of energy) as well the node life time then we must have an efficient energy management protocol.

Rapid increase in Ad-hoc network technology, wide deployment for several applications and the challenges that are facing in MANETs while packet transmissions in the network are the motivations to improve the performance in every case.

4. Open Issues and Problems

Error-prone shared broadcast channel, limited bandwidth resource availability, limited energy resources with mobility of nodes, the hidden terminal problem and limited security make the design of a multicast routing protocol for ad hoc networks a challenging.

The current open issues and problems in ad-hoc networks are as follows:

- Energy saving
- Limited range in the wireless transmission
- Broadcast nature in the wireless transmission medium
- Packet loss due to transmission errors
- Route changes in the network due to mobility induced
- Mobility-induced packet loss
- Battery constraints
- Frequent potential network partitions
- Ease of snooping on wireless transmissions
- Limited power supply

Information Storage:

- To store as less information as possible in the hosts.
- High storage overhead is incurred for each node due to several maintained data structures
- Suffers from excessive flooding when there is a large number of senders in the network

Messages Exchanged:

- Because the networks are bandwidth constrained, less exchange of information or messages between the nodes.
- Duplicate transmissions waste bandwidth at low mobility

Active Adaptability:

- The nodes should adapt themselves to mobility, power considerations, environmental conditions, etc.

Local Effect of Link Breakages:

- Network partitions or rapid movement in the mobile node.

- Unpredictable topology changes due to mobility of nodes.

Delay:

- Tree reconstruction delay and traffic concentration.
- Takes long time on mesh maintenance since each member waits for a period to select the best path.

5. Conclusion and Future Work

In this work, broad range of multicast routing protocols designed for MANETs is reviewed and classified all multicast routing protocols into two categories: tree-based protocols and mesh-based protocols. For each protocol, there are the properties, operations, strengths and weaknesses. In this work more focus is only on general multicast routing protocols for ad hoc networks there are other multicast routing protocols that aim at providing reliability, QoS (Quality of Service) guarantees, security, and so on. Further investigation of these protocols and survey make more complete in future work to design a routing protocol with high packet delivery ratio, effective throughput, minimum delay with minimize at ion of energy consumption levels.

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