



An Analysis and Survey on Multicast Routing Protocols for Mobile Ad hoc Networks

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Abstract: An ad hoc network is a dynamic wireless network with a set of cooperative nodes without a fixed infrastructure. Multicasting is used for group communication which supports the transmission of information from a sender to all the receivers in a group. Traditional Routing protocols designed for Mobile Ad hoc Networks (MANET) are not suitable for Mobile Ad hoc Networks since the number of intermediate hops needed to reach the destination may change dynamically, the resulting network topology will be changing rapidly. This paper presents a survey on recent research progress in multicast routing protocols for MANET. The routing protocols are compared according to different criteria and are categorized according to their routing strategies and relationships.

Keywords: Mobile Ad hoc Networks, Multicasting, Routing Protocols

I. Introduction

A. Multicasting in Mobile Adhoc Networks

Multicasting refers to the transmission of data from one source to multiple destinations. Multicasting is meant for group communication [1]. The group communication in MANETs is dynamic which means any host may join and may leave groups at any time. A host may be a member of multiple groups. Multicasting in MANETs is a challenging task since network is the collection of dynamic nodes where the node position will change rapidly and also the topologies of the network will change rapidly. Applications of MANETs include mobile commerce, military command and control, and intelligent transportation systems. These applications require continued connectivity, atomic transactions and secure and reliable data transmission.

B. Multicast Routing in Mobile Adhoc Networks

The advantages of Multicasting mainly expected to provide efficient bandwidth which reduces communication cost, providing efficient delivery of data taking which supports dynamic topology with unlimited mobility. The broadcasting capabilities of the radio interface are used to transmit multicast traffic in each cell. Multicast technique requires technological constraint, which is based on the capacity and specific signalling protocols which will be added into network as multicast address.

The traditional routing protocols, such as Distance Vector Multicast Routing Protocol (DVMRP), Core Based Trees (CBT), Protocol Independent Multicast (PIM), and Multicast Open Shortest Path First (MOSPF) do not perform well in MANETs. This fact is due to fragile multicast tree structure that should be reconstructive such as link state or distance vector will require frequent exchange of routing vectors or link state tables which will have continuous topology changes which will cause excessive processing overhead. Creating and maintaining upstream and downstream link status is not efficient in a wireless network.

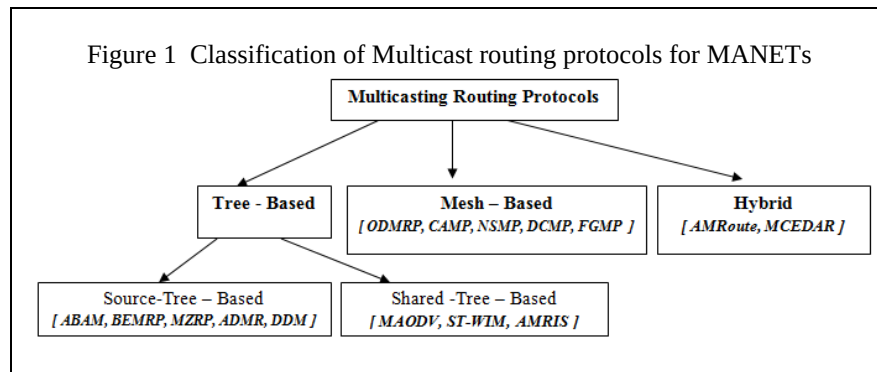
C. Classification of Multicast Routing Protocols

A primary area of concern for managing multicast group dynamics is the routing path that is built for data forwarding. Multicast routing protocols can be classified as tree-based routing protocols and mesh-based routing protocols.

In a tree-based protocol, a tree-like data forwarding path is built with the root at the source of the multicast session. The multicast tree consists of a unique path from the sender to a receiver. This can be extended to a shared-tree when multiple multicast sessions are in parallel in the network and can share some common parts of data forwarding trees with each other.

In mesh-based protocols, in contrast, multiple routes may exist between any pair of source and destination, which improves the connectivity among group members for better resilience against topology changes. A major difference between tree-based and mesh-based protocols lies in the manner in which a multicast message is relayed. In a tree-based protocol, each intermediate node on the tree has a well-defined list of next hops for a

specific multicast session. It will send a copy of the received message to only the neighbouring nodes on its next hop list.



In most mesh-based protocols, each node on the mesh will broadcast the message after its first reception of the message. Although this transmission redundancy may lead to higher overheads in many cases, it is still worth because of its resilience against dynamic topology and link quality. The Figure 1 shows the classification of Multicast Routing protocols for MANETs.

II. Related work

A Cluster based Shared Tree Wireless Multicast Protocol (ST-WIM) [7] for a multi hop wireless network was proposed by Ching Chuan Chiang [1997]. The protocol uses a Shared Tree for updating the changes in topology and membership dynamically. ST-WIM protocol appears to be reasonably efficient for low values of mobility. The performance of this protocol degrades rapidly for higher values of mobility.

Ching-Chuan Chiang [1998] proposed Forwarding Group Multicast Protocol (FGMP) for Multi-hop, Mobile Wireless Networks [27]. Without forming the multicast trees, the multicast packets are forwarded to the requesting members by a designated group of nodes. Multicast is then implemented by flooding the packets to the designated nodes. The forwarding group is periodically refreshed which will handle topological / membership changes. Multicast using forwarding group makes use of wireless broadcast transmissions which reduces the channel and storage overhead, thereby improving the performance and scalability. The key factor related to wired multicast schemes like DVMRP is the use of flags, which makes the protocol more robust to mobility. The protocol will be applied to mobile networks which has dynamic reconfiguration capability. The performance of the FGMP is evaluated using simulation. FGMP is compared with DVMRP and global flooding.

Elizabeth M. Royer [1999] proposed a Multicast Ad hoc On-Demand Distance Vector (MAODV) [3] which provides unicast, broadcast and multicast communication. In this protocol the routes are established on demand with small delays. Link breakage in active routes are efficiently repaired or re-established. This protocol offers unicast and multicast communication which has a minimum of control packet overhead. This protocol is suitable for variety of applications including conferencing, emergency search-and-rescue operations and community based networking.

C W Wu [1999] proposed Adhoc Multicast Routing protocol utilizing increasing ID Numbers (AMRIS) for Adhoc wireless networks [9]. In AMRIS each node is dynamically assigned with a unique id-number in a multicast session. The ordered id-numbers will direct the multicast flow and the sparseness among them for quick connectivity and repair. A multicast delivery tree has a special node called Sid. Sid joins the nodes participating in the multicast session. The id-numbers are increased as they radiate from the Sid in the delivery tree. The id-numbers help the nodes to leave and join a session dynamically and adapt to the changes in link connectivity. Link breakage repair messages are limited to the region where it occurs.

The Bandwidth Efficient Multicast Routing Protocol (BEMRP) [18] proposed by Tomochika Ozaki [1999] achieves low communication overhead which requires a small number of control packet transmission for route set up and maintenance. This protocol achieves high multicast efficiency by delivering multicast packets to receivers with small number of multicast transmissions. To achieve multicast efficiency with low communication overhead the protocol employs : (1) On-demand invocation of route set up and route maintenance process which will avoid periodical control packet transmissions and (2) a new route set up mechanism that allows a newly joining node to find the nearest forwarding node. In most mesh-based protocols, however, relaying transmission takes a more redundant approach: each node on minimize the number of added forwarding nodes and (3) route optimization mechanism that can detect and delete unnecessary forwarding nodes.

On-Demand Multicast Routing Protocol(ODMRP)[17] proposed by Sung-Ju Lee[1999] is a mesh based multicast routing protocol, suitable for Adhoc Wireless Networks with mobile host where bandwidth is limited, topology changes frequently and power is constrained. ODMRP is effective and efficient in dynamic environments and scales well to large number of multicast members. The limitation of ODMRP is its excessive overhead due to broadcasting of reply packets to many nodes.

Garcia et.al. [1999] proposed Core-Assisted Mesh Protocol (CAMP) [19] for multicast routing in MANETs. CAMP introduces the core-based trees for internet multicasting into multicast meshes which has much connectivity than trees. The main goal of using multicast meshes is to maintain the connectivity of multicast meshes. CAMP guarantees that within a finite time, every receiver of a multicast group has a reverse shortest path to each source of the multicast group. CAMP makes use of cores to limit the traffic for a router to join a multicast group. Packet forwarding or the process of maintaining the multicast meshes will not be affected with failure of cores.

Prasun Sinha [1999] presented Multicast Core-Extraction Distributed Ad hoc Routing (MCEDAR) multicast routing algorithm for ad hoc networks [25]. MCEDAR uses a mesh based routing infrastructure which attempts to provide increasing robustness with increase in the network mobility and uses a tree based forwarding protocol that approximates the optimal forwarding overhead in terms of the time taken for delivery of each data packet. The key issue in the MCEDAR algorithm is that of the parent child hierarchy that is maintained in an mgraph. The parent child hierarchy defines a global ordering on the join id's of the members of the mgraph.

Toh, C.K.et.al [2000] proposed Associativity-Based Ad hoc Multicast (ABAM) [20] protocol for performance evaluation of a novel multicast routing strategy, which has a dynamic topology with limited bandwidth and limited power. This protocol establishes a multicast session which uses association stability concepts which was introduced in the ABR protocol for unicasting in MANET. The performance of ABAM when compared with a flooding based multicast routing protocol results in high throughput and very low communication overhead.

Seungjoon Lee [2000] proposed Neighbour Supporting Multicast Mesh Protocol (NSMP) [13] which is an efficient mesh-based multicast routing protocol which reduces the number of control message broadcasts. A key concept is to localize control messages to a small set of mesh nodes and group neighbour nodes and minimize the frequency of network-wide flooding. This protocol attempts improves the route efficiency by taking into consideration the forwarding nodes while establishing a route. The route establishment leads to reduction in data packet transmission and further to decreased average delay due to less contention in a network. This protocol works efficiently with increasing group size and high mobility.

Kuo Chen Wang et.al. [2001] presented an Intelligent On-Demand Multicast Routing Protocol (IOD-MRP) [21] which can be applicable to dynamic network environments, such as MANET. This protocol removes the cores from Core-Assisted Mesh Protocol (CAMP). After removing the cores from CAMP, we apply an on-demand receiver-initiated procedure to establish routes and maintain multicast group membership. This protocol reduces the flooding message. Simulation results show that IOD-MRP reduces the number of control messages by 3%-13% compared to CAMP. The protocol has slightly lower packet delay and packet loss rates.

Lusheng Ji [2001] proposed Differential Destination Multicast (DDM) [23] for MANETs which has two approaches for multicast routing. Firstly, DDM implements membership control authority at the data source (i.e. senders). DDM uses differentially-encoded, variable-length destination headers are inserted in data packets which are used in combination with unicast routing tables to forward multicast packets towards multicast receivers.

DDM performs is ideally suitable for multicasting in small groups which has already unicast routing support. ODMRP is better suited for another end of MANET multicasting, multicasting to large and dense groups. The simulation results The DDM is more sensitive to network traffic level, because data packet loss has more adverse effect on protocol performance. The control information which is included in data packet will be lost due to the data packet loss.

Jorjeta G. Jetcheva [2001] introduced the Adaptive Demand-Driven Multicast Routing protocol (ADMR) [24] for multicast routing in wireless ad hoc networks. ADMR will not make use of periodic network-wide floods of control packets. It will not use periodical sensing of the neighbours, or periodical exchanges in routing table. It does not require a core. The behaviour of the protocol is based on application sending pattern, which allows for efficient detection of link breaks. The expiration of routing state is not needed. The initial performance evaluation of ADMR is compared with ODMRP, which has shown the best performance and is considered to be the best-on-demand multicast protocol for ad hoc networks. The overhead generated by ADMR is less when compared with ODMRP which delivers within 1% of the multicast data packets which is approximately equals to half to a

quarter of the overhead generated by ODMRP. The packet latency is 1.6 times lower than ODMRP due to the lower load of ADMR imposes on the network.

ADMR's overheads increase with group size and with high mobility. ADMR allows timely multicast state setup it detects mobility in the network is too high without requiring GPS or other positioning information or additional control traffic. Various Characteristics of Multicast Routing protocols for MANETs are listed in the Table1.

Table 1 Characteristics of Multicast Routing Protocols for MANETS.

S.No	Name of the Protocol	Protocol Type	Characteristic	Description
1	MAODV	Reactive	Multicasting Topology	Shared-Tree Based Routing Protocol
			Control Over Head	Minimum Control Packet overhead
			Scalability	Fair
			Initialization Approach	Receiver
			Packet Delivery Ratio	Low
			Performance in Mobility	Low
			Route Recovery	Yes, Broken links can be repaired
2	ABAM	Reactive	Multicasting Topology	Source-Tree Based Routing Protocol
			Control Over Head	Very low Control over head.
			Scalability	Not scalable
			Initialization Approach	Source
			Packet Delivery Ratio	High
			Performance in Mobility	Low
3	AMRIS	Proactive	Multicasting Topology	Shared-Tree Based Routing Protocol
			Control Over Head	Less
			Scalability	Fair
			Initialization Approach	Source
			Packet Delivery Ratio	Low with large delays
			Performance in Mobility	Low
			Route Recovery	Link breaks are repaired locally
4	BEMRP	Proactive	Bandwidth	Bandwidth is wasted due to periodically transmission of packets.
			Multicasting Topology	Source-Tree Based Routing Protocol
			Control Over Head	Low Control over head
			Packet Delivery Ratio	Low
			Route Recovery	Hard state approach applied for route recovery and repair.
5	MZRP	Proactive	Multicasting Topology	Source-Tree Based Routing Protocol
			Control Over Head	The protocol has a smaller normalized multicast Control over head.
			Scalability	The protocol is scalable to a large number of multicast senders and groups.
			Initialization Approach	Source
			Packet Delivery Ratio	High
6	ST-WIM	Reactive	Multicasting Topology	Shared-Tree Based Routing Protocol
			Performance in Mobility	For higher values of mobility performance degrades rapidly
			Routing	Cluster based routing
7	AM Route	Proactive	Multicasting Topology	Hybrid Routing Protocol
			Control Over Head	Less
			Scalability	Fair
			Initialization Approach	Source/Receiver
			Performance in Mobility	Low
8	ADMR	Reactive	Multicasting Topology	Source-Tree Based Routing Protocol
			Control Over Head	Low
			Packet Delivery Ratio	Low
			Performance in Mobility	High/Robust
9	DDM	Reactive	Multicasting Topology	Source-Tree Based Routing Protocol
			Control Over Head	More
			Scalability	Not scalable when the multicast group size increases.
			Initialization Approach	Receiver
			Security	High
			Link Breakage	Less
10	MCEDAR	Proactive	Multicasting Topology	Hybrid
			Control Over Head	More
			Performance in Mobility	Optimal
11	ODMRP	Reactive	Multicasting Topology	Mesh Based Routing Protocol
			Control Over Head	More

			Scalability	Good
			Initialization Approach	Source
			Packet Delivery Ratio	High
			Performance in Mobility	High
12	CAMP	Proactive	Multicasting Topology	Mesh Based Routing Protocol
			Control Over Head	Less
			Scalability	Good
			Initialization Approach	Receiver
			Packet Delivery Ratio	High
			Performance in Mobility	Moderate
13	NSMP	Reactive	Multicasting Topology	Mesh Based Routing Protocol
			Control Over Head	Less
			Scalability	Good
			Initialization Approach	Source
			Packet Delivery Ratio	High
			Performance in Mobility	High
14	DCMP	Reactive	Multicasting Topology	Mesh Based routing Protocol
			Control Over Head	Less
			Scalability	Good
			Initialization Approach	Source
			Packet Delivery Ratio	High
			Performance in Mobility	High
15	FGMP	Reactive	Multicasting Topology	Mesh Based Routing Protocol
			Control Over Head	More
			Initialization Approach	Receiver
			Performance in Mobility	It does not work for high mobile environments

Subir Kumar Das [2002] proposed an efficient Dynamic Core Based Multicast Routing Protocol (DCMP) for Ad hoc Wireless Networks [26]. The control overhead is reduced by dynamically classifying the sources into Active and Passive categories. The control overhead is reduced by 30% when compared to ODMRP, which contributes to the scalability of the protocol. The effectiveness of the proposed multicast routing protocol shows that the multicast efficiency is increased by 10-15% and packet delivery ratio is also improved at high network load.

Multicast Zone based Routing Protocol (MZRP) proposed by X. Zhang [2004], is a hybrid multicast extension of the unicast Zone Routing Protocol (ZRP) [5] [6] that employs a combination of proactive and reactive routing protocols. The proactive routing protocols used for intra-zone communication and reactive routing protocols used for inter-zone communication. MZRP is a Shared tree multicast routing protocol which proactively maintains the multicast tree membership for nodes' which will have local routing zones at each node while establishing multicast trees on demand. The protocol will be applied to a large number of multicast senders and groups. The data packet delivery ratio during transmission can be improved due to IP tunnel MZRP has a smaller normalized multicast routing overhead than ODMRP.

III. Conclusions and Future Work

In this paper we have investigated several multicast routing protocols for MANETs. Most of the multicast routing protocols for MANETs are either mesh-based or tree-based. Tree-based protocols can be either shared-trees or per-source based shortest trees. Mesh protocols can be either source-initiated or receiver-initiated. Tree-based protocols are efficient in data transmission whereas mesh-based protocols are robust to topology changes and are more stable than tree-based protocols. The routes chosen using tree-based protocols are fragile and require frequent reconfiguration. Each of the protocols discussed in this survey has its own advantages and disadvantages. An ideal protocol that satisfies all the requirements of MANETs is difficult to design.

The Future research would involve the development of a new and a robust dynamic source routing protocol for mobile ad hoc networks which is scalable to a larger number of multicast groups and senders, which has a smaller normalized multicast routing overhead.

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