Performance Comparison of Multicast Routing Protocols under Variable Bit Rate Scenario for Mobile Adhoc Networks

Conference Paper · July 2010

DOI: 10.1007/978-3-642-14478-3_12 · Source: DBLP

Bhalaji Natarajan
Sri Sivasubramaniya Nadar College of Engineering

Performance comparison of Multicast Routing Protocols under Variable Bit Rate Scenario for mobile Adhoc Networks

N.Bhalaji[1], P.Gurunathan[2], Dr.A.Shanmugam[3]

[1]Research Scholar, Anna University Coimbatore
[2]School of Engineering, Vels University, Chennai
[3]Principal, Bannari Amman Institute of Technology

Abstract. An ad hoc network is formed by wireless mobile nodes (hosts) that operate as terminals as well as routers in the network, without any centralized administration. Mobile ad hoc networks (MANETs) are characterized by lack of any fixed network infrastructure. In a MANET, there is no distinction between a host and a router, since all nodes can be sources as well as forwarders of traffic. Moreover, all MANET components can be mobile. MANETs differ from traditional, fixed-infrastructure mobile networks; MANETs require fundamental changes to conventional routing and packet forwarding protocols for both unicast and multicast communication. Wireless ad-hoc networks have gained a lot of importance in wireless communications. Wireless communication is established by nodes acting as routers and transferring packets from one to another in ad-hoc networks. Routing in these networks is highly complex due to moving nodes and hence many protocols have been developed. This Paper thesis concentrate mainly on routing protocols and their functionality in Ad-hoc networks with a Variable Bit Rate (VBR) discussion being made on four selected protocols MAODV, ADMRP, ODMRP and ABAM, ending with their comparison.

Keywords: Multicast routing protocols, ADMRP, ABAM, ODMRP, Manet, Glomosim

1 Introduction

Multicasting is the transmission of datagram to a group of hosts identified by a single destination address and hence is intended for group-oriented computing [1]. In MANET, multicast can efficiently support a variety of applications that are characterized by close collaborative efforts. A multicast packet is typically delivered to all members of its destination group with the same reliability as regular unicast packets. Multicast can reduce the communication costs, the link bandwidth consumption, sender and router processing and delivery delay. In addition, it can provide a simple and robust communication mechanism when the receiver's individual addresses are unknown or changeable. Multicast routing protocols for ad hoc networks have been proposed [2] [3] [4] in order to save the network bandwidth and node resource because they are the protocols for powerful communication used in multi-hop applications, and are more efficient than the approach of sending the same information from the source to each of the receivers individually. The presence of wireless communication and mobility makes an ad hoc network unlike a traditional wired network and requires that the routing protocols used in an ad hoc network be based on new and different principles. Routing protocols for traditional wired networks are designed to support a tremendous numbers of nodes, but they assume that the relative position of the nodes will generally remain unchanged [8]. In a mobile ad hoc network, however, there may be fewer nodes among which to route, and the network topology changes can be drastic and frequent as the individual mobile nodes move.

2 Multicasting Protocols in MANET

MAODV [1, 2] protocol is the multicast extension of AODV [8] which is used for unicast traffic. It creates a group tree, shared by all sources and receivers for a multicast group. The root of each group tree is a multicast source or receiver for that group that has been designated as a group leader which is the first member of a multicast group. This leader takes the responsibility of maintaining multicast group sequence number and propagating this number to the entire group through proactive GROUP HELLO message. Members use the GROUP HELLO message to update request table, and distance (hop) to group leader.

The MAODV discovers multicast routes on demand using a broadcast route-discovery mechanism which is based on a ROUTE REQUEST and ROUTE REPLY cycle. A mobile node originates a ROUTE REQUEST message when it wishes to join a multicast group, or when it requires a route to send data to a multicast group. A member of the multicast tree with a current route to the destination responds to the ROUTE REQUEST with a ROUTE REPLY message. Non-member nodes just simply rebroadcast the ROUTE REQUEST message. Each node on receiving the ROUTE REQUEST updates its route table and records the sequence number and next hop information for the source node. This information is unicast through ROUTE REPLY message back to the source. If the source node receives multiple ROUTE REPLY message from its neighbor for its route request, it then chooses only one ROUTE REPLY message having the freshest sequence number or the least hop count. Then the MULTICAST ACTIVATION (MACT) message is sent to set up multicast state between source node and the node sending the reply. If a source node does not receive a MACT message within a certain period it broadcasts another RREQ. After a certain number of retries (RREQ RETRIES), the source assumes that there are no other members of the tree that can be reached and declares itself as the group leader. MANET multicast protocols should work efficiently with the dynamic topology changes. A tree-based protocol, e.g., MAODV (Multicast Ad hoc On demand Distance Vector), AMRoute (Adhoc Multicast Routing) [7] and AMRIS (Ad hoc Multicast Routing protocol) [6], maintains and enhances a multicast tree structure specialized in MANET scenarios. On the other hand, a mesh-based protocol such as ODMRP (On Demand Multicast Routing Protocol), and CAMP (Core-Assisted Multicast Protocol) [8] uses a multicast mesh structure that allows redundant paths between a source and a member. With a mesh structure, members can receive multicast data packets from any of their forwarding neighbor nodes. Thus, a mesh topology improves the connectivity of a network and the availability of multicast routes in the presence of dynamic topology changes.

ODMRP [1, 5], like MAODV and ADMR, is also on-demand multicast routing protocol. However, ODMRP is a mesh based rather than tree based protocol so it has multiple paths from the sender to the receivers, contrary to the MAODV or ADMR which is a tree based protocol and has only one path to the receivers. When a node has information to send but no route to the destination, a JOIN QUERY message is broadcasted. The next node that receives the JOIN QUERY updates its routing table with the appropriate node id from which the message was received for the reverse path back to the sender (backward learning). Then the node checks the value of the TTL (time to live) and if this value is greater than zero it rebroadcasts the JOIN QUERY. When a multicast group member node receives a Join Query, it broadcasts a JOIN REPLY message. A neighborhood node that receives a JOIN REPLY consults the join reply table to see if its node id is the same with any next hop node id. If it is the same then the node understands that it is on the path to the source and sets the FG_FLAG (Forwarding Group flag). ODMRP is a soft state protocol, so when a node wants to leave the multicast group it is over passing the group maintaining messages [1], [5], [7] and [8].

ADMR [1], [3], builds source-specific multicast trees, using an on-demand mechanism that only creates a tree if there is at least one source and one receiver active for the group. To join a multicast group, an ADMR receiver floods a MULTICAST SOLICITATION message throughout the network. When a source receives this message, it responds by sending a unicast KEEP-ALIVE message to that receiver, confirming that the receiver can join that source. The receiver responds to the KEEP-ALIVE by sending a RECEIVER JOIN message along the reverse path which sets up forwarding state along the shortest paths. In addition to the receiver's join mechanism, a source periodically sends a network-wide flood of a RECEIVER DISCOVERY message. Receivers that get this message respond to it with a RECEIVER JOIN if they are not already connected to the multicast tree. To detect broken links within the tree, the ADMR routing layer at a multicast source monitors the packet forwarding rate to determine when the tree has broken or the source has become silent. If a link has broken, a node can initiate a repair on its own (local repair), and if the source has stopped sending then any forwarding state is silently removed. Receivers likewise monitor the packet reception rate and can re-join the multicast tree if intermediate nodes have been unable to reconnect the tree. The receivers do a repair by broadcasting a new MULTICAST SOLICITATION message. Nodes on the multicast tree send a REPAIR NOTIFICATION message down its sub-tree to cancel the repair of downstream nodes. The most upstream node transmits a hop-limited flood of a RECONNECT message. Any forwarder receiving this message forwards the RECONNECT up the multicast tree to the source. The source in return responds to the RECONNECT by sending a RECONNECT REPLY as a unicast message that follows the path of the RECONNECT back to the repairing node. Unlike

MAODV, ADMR does not employ any periodic control packet exchanges, such as neighbor sensing or periodic flooding, and does not rely on lower layers within the protocol stack to perform such functions [3]. Thus, it performs both its route discovery and route mechanism functions on demand.

ABAM [6] is Associativity-Based Ad hoc Multicast and on-demand source-based routing protocol for mobile ad-hoc networks (MANETs). It establishes multicast sessions on demand and utilizes the association stability concept that is adopted in the ABR for mobile ad-hoc unicast routing. For each multicast session a multicast tree is established primarily based on association stability. ABAM consists of 3 phases: 1.Multicast Tree Establishment 2.Multicast Tree Reconfigurations 3.Multicast Tree Deletion**.**

3 Experimental Setup and Performance Metrics

We have used Glomosim simulator for simulation, most widely used network simulator and freely downloadable. We simulated network for simulation time of 1000 sec and area of 1000 m *1000 m. Further increase in these values increased the time taken for completing simulation, to a limit which is not feasible due to various constraints. We have used Throughput, Average Message Latency, Routing Overhead and Group Reliability as performance parameters while varying various network parameters such as Number of Nodes. To perform various operations during the simulation. The enable parameters use to configure the evaluation environment by checking its behavior. The following performance metrics that are needed to be taken into consideration in order to analyze and compare the performance of these protocols are

(a)Number of Nodes**:** Number of nodes may be varying parameter as it plays important role in performance. Various performance parameters versus No. of. Nodes. The total number of packets with different types: Sent, Received, Forwarded and Dropped, which were transmitted between mobile nodes in the period of simulation. This metric provides us with an overview of how the simulated ad-hoc network, with the defined parameters, reacts to topology changes while nodes are moving.

(b)Throughput**:** Throughput or Network throughput is the average rate of successful message delivery over a communication channel.

(c)Average Message Latency: Latency is measure from the time a request (e.g. a single packet) leaves the client to the time the response (e.g. An Acknowledgment) arrives back at the client from the serving entity. The unit of latency is time. Throughput on the other hand is the amount of data that is transferred over a period of time.

(d)Routing overhead: Routing overhead is the ratio between the numbers of control bytes transmitted to the number of data bytes received. This is the ratio of overhead bytes to delivered data bytes.

(e)Group reliability: The ratio of number of packets received by all multicast receivers to number of packets sent. Thus, for this metric, a packet is considered to be received only if it is received by every member of the multicast group.

.

4 Simulation result

Throughput The general trend we observe from Figure 1 is that, especially at high mobility, flooding performs better than ODMRP which in turn performs better than MAODV. Comparing flooding to ODMRP, we notice that at lower speeds the difference in packet delivery ratio is between 5% and 7%. However, at higher speeds the gap in packet delivery ratio starts widening. In the case of ODMRP, increased mobility requires that forwarding group members be updated more frequently. One way to address this problem is to update forwarding group members more often through more frequent Join-Queries. This of course would result in higher control overhead and possibly greater packet loss due to contention. Comparing ODMRP with MAODV, we observe that ODMRP exhibits better (by roughly 10%) packet delivery ratios. Since ODMRP maintains meshes, it has multiple redundant paths to receivers and is not affected by mobility as greatly as MAODV. Increased mobility causes frequent link changes and requires MAODV to reconfigure the multicast tree more frequently to prevent stale routing information. This in turn requires higher control traffic which can have a negative effect of increased packet loss due to contention and hidden terminals.

As a starting set of simulations we have varied the number of senders to evaluate the protocol scalability based on the number of multicast source nodes and the traffic load. We inferred from the Figure 3 that ADMR is over 37% more effective than ODMRP in throughput as the number of senders incremented from 0-15. While ABAM is over 30% more and 25% less in throughput compared to that of MAODV and ODMRP. We have also observed that both protocols have not performed well if the number of senders increased above 20.

Average Message Latency In terms of latency, overall it is shown in Figure.4 that MAODV experiences the highest latency compare to both ADMR and ODMRP. It is due to the longer paths that data packets have to follow within the shared tree. ODMRP's latency is the lowest. It is due to the frequent state discovery floods, it uses the shortest forwarding path among the three protocols. Meanwhile, though ADMR's latency is higher than ODMRP, but it is shown that its latency remarkable nearly consistent across all scenarios. In this scenario, we study the behavior of MAODV, ODMRP and ADMR as node mobility is increased from 1 m/s to 20 m/s. The number of senders and receivers is fixed to 1 and 20 respectively. We observe that, with mesh topology ODMRP is generally having a slight effect to the mobility on achieving.

The ADMR's robust performance is based on its ability to switch to flooding mode in high mobility situation. On the other hand, tree structure in MAODV is very fragile to mobility drops significantly. In terms of latency (Fig 2), ADMR and ODMRP have nearly consistent latency for all mobility scenarios. Conversely, mobility leads to higher latency for MAODV. Since MAODV proactively maintains the single shared multicast tree, the topology is very fragile to mobility. Thus, in any breaks in link that may occurs it does not have alternative paths between source and destination and requires longer times to repair the topology which in turn affect the longer delay delivering data to the receivers. Both ODMRP and MAODV protocols uses on-demand route discovery but with different routing mechanisms. In general, from Graph-4 ODMRP outperforms group reliability than the MAODV. But ODMRP hasn't had good Message Latency and Routing Overhead as the number of senders or the group size increases. Figure 4 shows the comparison of Average message latencies of all the four protocols, by this comparison we can see the decrement of the delay by 60% as that for ADMR and 20% as that for MAODV.

Routing Overhead Figure 3 plots control overhead per data byte transferred as a function of mobility. Note that flooding's overhead does not change with mobility as only data header packets contribute to overhead. In ODMRP, the Join-Query interval was fixed at 3 seconds and hence control overhead remains fairly constant with node mobility. The slight increase in overhead at higher speeds (around 55 km/hr) is due to the fact that the number of data bytes delivered decreases with increased mobility. In the case of MAODV, increased mobility causes frequent link breakages and data packet drops; link outages also generate repair messages increasing control overhead. From Figure 5 it is clear that ABAM protocol speeds up its performance better than other three protocols. ADMR and ODMRP have its routing overhead with 42 to 45 while for MAODV it is nearing 40. Thus ABAM outperforms in this case.

Group Reliability: Figure 4 plots group reliability as a function of node speed. From the Figure it can be seen that flooding is most effective in delivering packets to all group members (as expected). Moreover, flooding is able to keep group reliability fairly constant even at higher speeds. Both ODMRP and MAODV exhibit poor performance even at low mobility (group reliability lower than 50% for speeds higher than 10 km/hr). However, as expected, ODMRP exhibits better group reliability than MAODV. Although ODMRP can maintain multiple routes to receivers, the mesh connectivity is largely dependent on the number of senders and receivers. In case of 5 senders, mesh connectivity is insufficient to ensure packet delivery to all group members (especially, with node mobility) resulting in low group reliability. Since MAODV delivers packet along a multicast tree, a single packet drop upstream can prevent a large number of downstream multicast receivers from receiving the packet. The absence of redundant routes affects performance greatly as node mobility results in frequent link breakages and packet drops. From Figure 6 the reliability of the group is higher for ABAM compared to other cases. In this scenario, we study the behavior of MAODV, ABAM, ODMRP and ADMR as node number is increased from 1 to 15. We observe that, with mesh topology ODMRP is generally having a slight effect to the mobility on achieving Group Reliability. The ADMR’s robust performance is based on its ability to switch to flooding mode in high mobility situation.

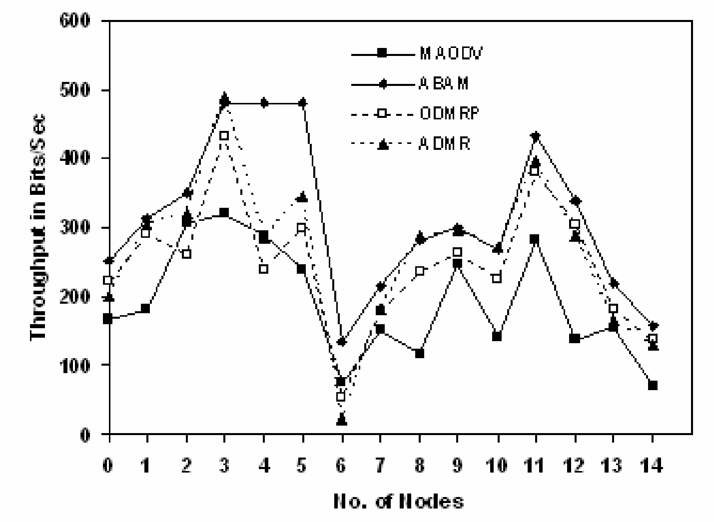

Fig.1.Throughput vs. No. of .Nodes

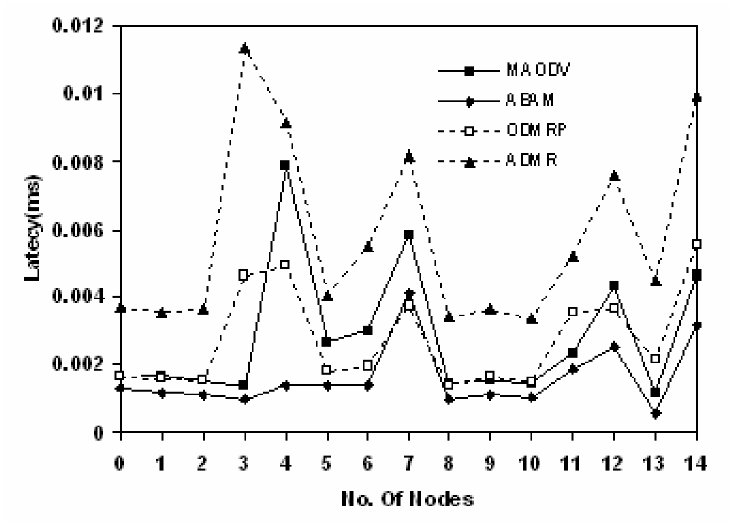

Fig.2.Message Latency vs. No. of .Nodes

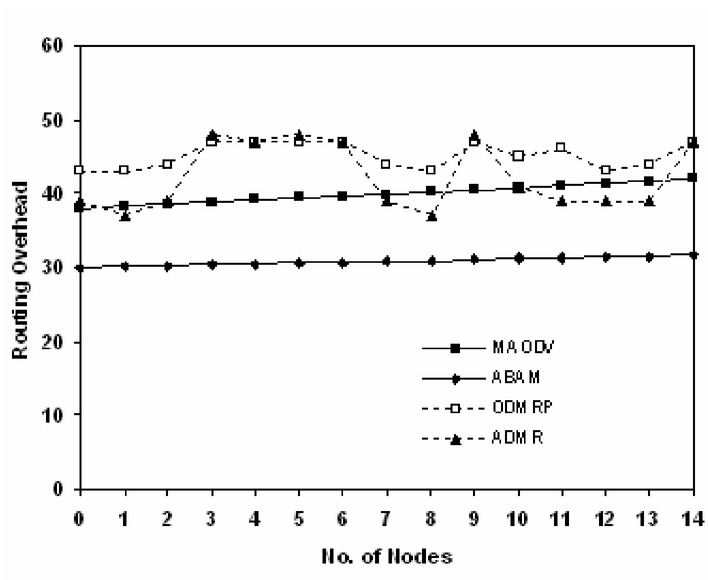

Fig.3.Routing overhead vs. No. of .Nodes

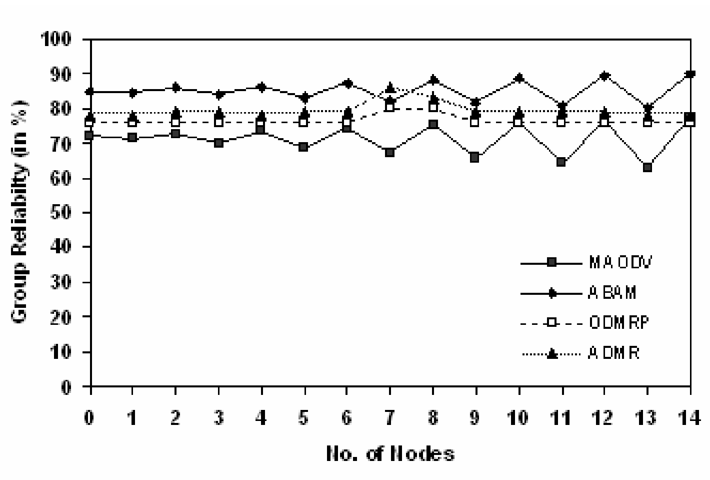

Fig.4.Group Reliability vs. No. of .Nodes

5 Conclusion and Future work

In this paper, we reported on simulation-based experiments evaluating two different approaches to multicast communication in mobile ad hoc networks (MANETs), namely mesh- and tree-based multicast. One of the chief contributions of this work is our objective analysis of these two multicast routing protocol categories in order to characterize their behavior under a wide range of MANET scenarios, including different mobility and traffic load conditions as well as multicast group characteristics (e.g., size, number of sources, multiple multicast groups, etc.). The following metrics considered for routing/multicast protocol performance evaluation (a). Throughput (b). Average Message latency (c). Routing overhead (d). Group Reliability.

We have performed a number of experiments to explore the performance nature of MAODV, ABAM, ADMR and ODMRP with respect to number nodes. As a starting set of simulations we have varied the number of senders to evaluate the protocol scalability based on the number of multicast source nodes and the traffic load. We inferred from the Figure.3 that ADMR is over 37% more effective than ODMRP in throughput as the number of senders incremented from 0-15. While ABAM is over 30% more and 25% less in throughput compared to that of MAODV and ODMRP. We have also observed that both protocols have not performed well if the number of senders increased above 20. Both ODMRP and MAODV protocols uses on-demand route discovery but with different routing mechanisms. In general, from Figure 4 ODMRP outperforms group reliability than the MAODV. But ODMRP hasn't had good Message Latency and Routing Overhead as the number of senders or the group size increases. Figure 2 shows the comparison of Average message latencies of all the four protocols, by this comparison we can see the decrement of the delay by 60% as that for ADMR and 20% as that for MAODV. From Figure 3 it is clear that ABAM protocol speeds up its performance better than other three protocols. ADMR and ODMRP have its routing overhead with 42 to 45 while for MAODV it is nearing 40. Thus ABAM outperforms in this case.

From Figure 4 the reliability of the group is higher for ABAM compared to other cases. In this scenario, we study the behavior of MAODV, ABAM, ODMRP and ADMR as node number is increased from 1 to 15. We observe that, with mesh topology ODMRP is generally having a slight effect to the mobility on achieving Group Reliability. The ADMR's robust performance is based on its ability to switch to flooding mode in high mobility situation. On the other hand, tree structure in MAODV is very fragile to mobility thus Group Reliability drops significantly. The sharp degradation of reliability is experienced by MAODV can also be explained as the cost of high control overhead generated by MAODV to adapt the increasing speed of the nodes. In terms of latency MAODV and ODMRP have nearly consistent latency for all scenarios. Thus, in any breaks in link that may occurs it does not have alternative paths between source and destination and requires longer times to repair the topology which in turn affect the longer delay delivering data to the receivers.

Our simulation results demonstrate that even though the performance of all multicast protocols degrade in terms of packet delivery and group reliability as node mobility and traffic load increases, mesh-based protocols (e.g., flooding and ODMRP) perform considerably better than tree-based protocols (e.g., MAODV). The general conclusion from the comparative analysis was that flooding, which is the simplest routing mechanism provides higher delivery guarantees than ODMRP and MAODV for most scenarios considered. ODMRP exhibits decent robustness on account of its mesh structure. MAODV did not perform as well as the other protocols in terms of packet delivery ratio and group reliability but has the lowest routing overhead among the protocols considered. One of the conclusions from our study is that given the diversity of MANETs, it is impossible for anyone routing protocol to be optimal under all scenarios and operating conditions. One possible solution would be to develop specialized multicast solutions for each type of network and the means for integrating those solutions. Our results show that ABAM, ADMR and ODMRP outperform MAODV across all scenarios which typically generate high delivery ratio with low average latency. Even in harsh environment, where the network topology changes very frequently, ABAM ADMR and ODMRP effectively delivers packets with a high Packet delivery ratio. While MAODV is scalable and effective in terms of packet delivery ratio as long as the number of senders is low. On the other hand, it does not scale well with number of multicast senders. Based on our analysis, the poor performance of MAODV is due to the shared multicast tree structure, hard state approach, requiring periodic control packet exchanges employed by the protocol. On the contrary, ABAM, ADMR is per-source tree and a soft state protocol, which attempts to reduce as much as possible any non-on-demand components. As a result, though being a tree based protocol, the performance of ABAM, ADMR is comparable to mesh-based protocol such as ODMRP which also utilize soft-state approach.

For future work, we intend to compare it with other multicast routing protocols, considering new performance metrics such as energy-based mobility and link stability metrics. We also intend to implement the protocol with different group mobility models that are suitable for multicast applications

References

1. Jaspreet Kaur and Cheng Li “Simulation and Analysis of Multicast protocols in Mobile Ad Hoc Networks using NS2” Faculty of Engineering and Applied Science, Memorial University of Newfoundland , St. John’s, Newfoundland, A1B 3X5.
2. S. Deering, “Host extensions for IP multicasting”, RFC 1112, August 1989, available at http://www.ietf.org/rfc/rfc1112.txt
3. T. Ballardie, P. Francis and J. Crowcroft, Core Based Trees (CBT) – An architecture for scalable inter-domain multicast routing, in: Proceedings of ACM SIGCOMM’93, San Francisco, CA (October 1993) pp. 85–95.
4. S.E. Deering and D.R. Cheriton, .Multicast Routing in Datagram Internetworks and Extended LANs,. ACM Transactions on Computer Systems, vol. 8, no. 2, May 1990, pp. 85-110.
5. S. Deering, D.L. Estrin, D. Farinacci, V. Jacobson, C.-G. Liu, and L.Wei, .The PIM Architecture for Wide-Area Multicast Routing,. IEEE/ACM Transactions on Networking, vol. 4, no. 2, Apr. 1996, pp. 153-162. of ACM SIGCOMM'93, San Francisco, CA, Oct. 1993, pp. 85-95.
6 J. Moy, .Multicast Routing Extensions for OSPF,. Communications of the ACM, vol. 37, no. 8, Aug. 1994, pp. 61-66, 114.
7 E. M. Royer and Charles E. Perkins. “Multicast operation of the ad-hoc on-demand distance vector routing protocol,” Proceedings Of the 5th ACM/IEEE Annual Conf. on Mobile Computing, pp. 207-218 (1999).
8. R. Bagrodia, M. Gerla, J. Hsu, W. Su, and S.-J. Lee, “A performance comparison study of ad hoc wireless multicast protocols”, Proc. Of the 19th ComSoc IEEE Conf, pp. 565 –574, (2000).
9. E.L. Madruga, and J.J. Garcia, “Scalable multicasting: the core assisted mesh protocol,” Mobile Networks and Application Journal, vol. 6, ACM/Kluwer, pp. 151-165 (2001).
10.P. Mohapatra, J. Li, C. Gui “ Multicasting in Ad Hoc Networks”, book chapter, Kluwer Press, (2004).
11.S.-J. Lee, M. Gerla, and C.-C. Chiang, ”On-demand multicast routing protocol” Proceedings of IEEE WCNC, pp. 1298-1302 (1999).
12.Thomas. Kunz, Multicasting: From fixed networks to ad-hoc networks, Handbook of Wireless Networks and Mobile Computing, John Wiley & Sons, pp. 495-507 (2002).
13. Jorjeta G. Jetcheva and David B. Johnson, “Adaptive demand-driven multicast routing in multi-hop wireless ad-hoc networks”, Proceedings of the 2nd ACM international symposium (2001).
14.C.-K. Toh. Associativity-Based Routing For Ad Hoc Mobile Networks. Wireless Personal Communications Journal: Special Issue on Mobile Networking and Computing System, Kluwer Academic Publishers, vol. 4, no. 2, March 1997, pp. 103-139.