

A Comparative Analysis of Multicasting Routing Protocols in MANET under various Placement Models

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Abstract— Multicast routing is a key technology for modern communication networks. In multicasting, a single copy of message is sent by the source to multiple receivers on a shared channel. This is especially appropriate in wireless networks where bandwidth is scarce and many users are sharing the same wireless channels. Wired and infrastructure based wireless networks are supported by many multicast routing protocols. But one particularly challenging environment for multicasting is MANETs (Mobile Ad-hoc Networks). MANET is a collection of mobile nodes connected by wireless links forming a dynamic topology without any network infrastructure such as routers, servers, access points/cables or centralized administration. In MANET, each node can act as both host and router. This paper presents the simulation and analysis of three existing multicast routing protocols for MANETs namely On-demand Multicast Routing Protocol (ODMRP), Multicast Open Shortest Path First (MOSPF) an Distance Vector Multicast Routing Protocol (DVMRP). Qualnet 5.2 is used as simulation tool for carrying out simulations.

Key words: MANET, Multicasting Routing Protocols

I. INTRODUCTION

The origin of MANETs [1] begins in the 70's for the military necessity of the interconnection of different hosts. This type of networks was implanted to avoid the need of a central base of communications. Mobile Ad-hoc Networks (MANETs), which does not require any centralized control and fixed infrastructure, is a self-configuration wireless communication network. The network may operate in an isolated manner, or be connected to a fixed network (such as the Internet) through gateways. The majority of applications of MANET are in areas where rapid deployment and dynamic reconfiguration are necessary and wired network is not available. These include military battlefields, emergency search, rescue sites, classrooms and conventions etc.

In this paper authors presented a general view of multicasting routing protocols in ad-hoc networks. Multicast tree-based routing protocols are efficient and satisfy scalability issue, they have several drawbacks in ad hoc wireless networks due to mobile nature of nodes that participate during multicast session. In the mesh-based protocols provide more robustness against mobility and save the large size of control overhead used in tree maintenance. Hybrid multicast provides which are tree based as well as mesh based and gives the advantage of both types. All three types of protocols are compared under various mobility scenarios. [1]

In this paper author has implemented the dense mode and Core-Based Tree Multicast routing protocols, in tool command language and integrated the module in the ns-2 Simulator. The performance of the protocols were measured with respect to metrics like Packet delivery ratio,

end – end delay etc. Comparison of performance and quality of services (QoS)of the protocols has been made. Simulations were carried out with identical networks and running different protocols on the mobile node. The results of the simulation indicate that performance and QoS of the Core-based tree mode multicasting routing protocol is better than the dense mode multicasting routing protocol. [2]

In this paper authors have investigated and analyzed the performance of ODMRP, DVMRP and PIM-DM. From the investigation, it can be concluded that proactive multicast routing protocols are not suitable for mobile ad hoc networks (MANETs), because of their huge routing overheads. Among the other two reactive routing protocols, mesh based (ODMRP) shows better performance than tree based routing protocol. ODMRP has low packet loss, high packet delivery ratio (PDR), less average end to end delay (ETED) high throughput as compared to other tree-based routing protocols. It was concluded that there is a trade-off between number of dropped packet and delay. If the number of dropped packets was decreased with the help of buffer, then average end-to-end delay will increase. ODMRP uses a forwarding group, to forward packets to receiver via scoped flooding. Topology, number of network nodes and node mobility are important parameters that can significantly affect the performance of the protocols being. [3]

In this paper, author presented a comparative performance of three multicast protocols for Mobile Ad hoc Networks – ODMRP, AMRIS and MAODV focusing on the effects of changes such as the increasing number of receivers or sources and increasing the number of nodes. A systematic performance evaluation of these protocols is done by performing certain simulations under NS-2. The applicability of multicast protocols to diverse situation are also studied and discussed. A general conclusion is that, in a mobile scenario, mesh-based protocols out performed tree-based protocols. The availability of alternate routes provided robustness to mobility. AMRIS was effective in a light traffic environment with no mobility, but its performance was susceptible to traffic load and mobility. ODMRP was very effective and efficient in most of simulation scenarios. [4]

II. MULTICAST ROUTING TECHNIQUES

Multicasting is transmission of packets to a group of multiple hosts identified by a single destination address. Multicasting is intended for group oriented communication services such as video conferencing etc. Many different routing protocols for multicasting have been proposed in recent years. Classification of multicast routing protocols can be done in many ways. Multicast routing protocols can be classified as proactive and reactive protocols based on how routing information is acquired and maintained by

mobile nodes. They can also be classified as tree and mesh protocols based on how distribution paths among group members are constructed. Classification of multicast routing protocols is shown in Fig. 1

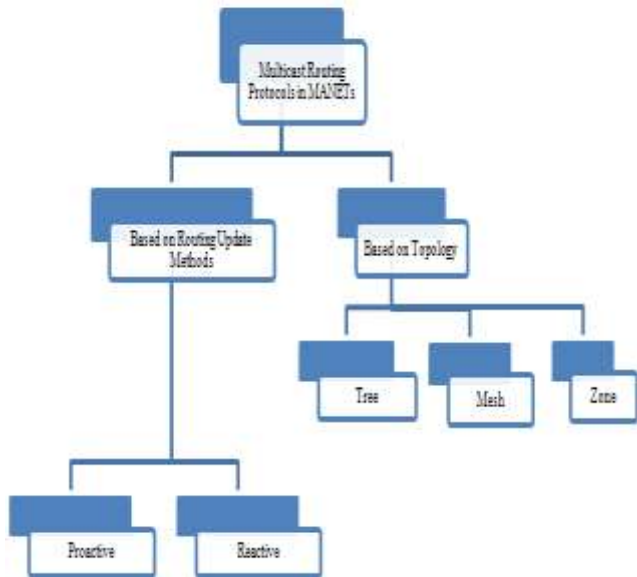


Fig. 1: Classification of multicasting routing protocols in MANETs

A. Based on Routing Update Methods

In this classification strategy, routing protocols are classified based on how routing information is acquired and maintained by mobile nodes. Using this method, multicasting protocols can be divided into proactive and reactive protocols.

1) Proactive Protocols

A proactive multicast routing protocol is called “table driven” multicast routing protocol. In a network utilizing a proactive routing protocol, every node maintains one or more tables representing entire topology of the network. These tables are updated regularly in order to maintain up-to-date routing information from each node to every other node. To maintain up-to-date routing information, topology information needs to be exchanged between the nodes on a regular basis, leading to relatively high overhead on the network. On the other hand, routes will always be available on request in proactive protocols. Unfortunately, proactive protocols often suffer from excessive control overhead due to frequent updates when network mobility is high. There are some typical proactive multicast routing protocols, such as CAMP, LGT and AMRIS.

2) Reactive Protocols

A reactive multicast routing protocol is also called “on-demand” multicast routing protocol. Reactive protocols seek to set up routes on-demand. If a node wants to initiate communication with a node to which it has no route, the routing protocol will try to establish such a route. Reactive multicast routing protocols have better scalability than proactive multicast routing protocols. However, when using reactive multicast routing protocols, source nodes may suffer from long delays for route searching before they can forward data packets. ACMP and CQMP are examples for reactive routing protocols for MANETs.

3) Based on Topology

In this classification strategy, routing protocols are classified based on how distribution paths among group members are constructed. Using this classification, routing protocols are classified as tree-based, mesh-based and zone routing protocols.

4) Tree based Protocols

Tree-based multicast routing protocols can be further divided into source-rooted and core-rooted schemes according to the roots of the multicast trees.

In a source-rooted tree-based multicast routing protocol, source nodes are roots of multicast trees and execute algorithms for distribution tree construction and maintenance. This requires a source to be aware of the topology information and addresses of all its receivers in the multicast group. Therefore, source-rooted tree-based multicast routing protocols suffer from high traffic overhead when used for dynamic networks. AMRoute is an example for source-rooted tree multicast routing protocol.

In a core-rooted tree multicast routing protocol, cores are nodes with special functions such as multicast data distribution and membership management. Some core-rooted multicast routing protocols utilize tree structures. But unlike source-rooted tree-based multicast routing, multicast trees are only rooted at core nodes. For different source-rooted multicast routing protocols, core nodes may perform various routing and management functions. Shared Tree Ad-hoc Multicast Protocol (STAMP) and Adaptive Core-based Multicast Routing protocol (ACMP) are core-based multicast routing protocols proposed for MANETs.

Tree-based protocols provide high data forwarding efficiency at the expense of low robustness. Their advantage is their simplicity. Their disadvantage is that until the tree is reconstructed after movement of a node, packets possibly have to be dropped.

5) Mesh based Protocols

In a mesh-based multicast routing protocol, packets are distributed along mesh structures that are a set of interconnected nodes. Route discovery and mesh building are accomplished in two ways: by using broadcasting to discover routes or by using core or central points for mesh building. Mesh-based protocols perform better in high mobility situation as they provide redundant paths from source to destinations while forwarding data packets. However, mesh-based approaches sacrifice multicast efficiency in comparison to tree-based approach.

Mesh-based Multicast Routing Protocol with Consolidated Query Packets (CQMP), Enhanced On-Demand Multicast Routing Protocol (E-ODMRP) and Bandwidth Optimized and Delay Sensitive (BODS) are the mesh-based multicast routing protocols proposed for MANETs.

6) Zone based Protocols

Zone based multicast routing mechanisms are basically used to form the clusters of nodes to make multicast routing decisions simple and efficient. Every cluster has a cluster head to which all the nodes within that cluster are connected. The nodes within a cluster are connected to a cluster head either by a single hop or by multiple hops. Different routing strategies are used to establish connections within a cluster (intra-cluster) and among clusters (inter-

cluster). Both intra-cluster and inter-cluster routing mechanisms are designed with various mechanisms.

Dynamic Core based Multicast Routing Protocol (DCMRP), Multicast Zone Routing Protocol (MZRP) are some examples of zone-based multicasting routing protocols proposed for MANETs.

III. DESCRIPTION OF PROTOCOLS

In this paper, three multicast routing protocols namely ODMRP, DVMRP and MOSPF are analyzed by simulating various MANET scenarios. In this section working of these three protocols is explained in detail.

A. On-demand Multicast Routing Protocol (ODMRP)

ODMRP [5] is an on-demand mesh based protocol where a mesh is formed by a group of nodes known as forwarding nodes. These nodes forward the data packets between the source and destinations, and keep a message cache which helps in the detection of duplicate data and control packets.

As shown in Fig. 2, in the Mesh establishing phase between the source and receivers, a JoinQuery control packet is flooded by the sender periodically for the creation of mesh. The receivers respond to the request by sending a JoinReply through the shortest re-verse path. Each intermediate node that receives the JoinQuery packet stores the upstream node Identity before broadcasting the packet.

The Join Reply packet consists of the Source Id and the Next Node ID. An intermediate node on the receipt of a Join Reply packet sets a forwarding flag thus becoming a member of the forwarding group of that multicast group.

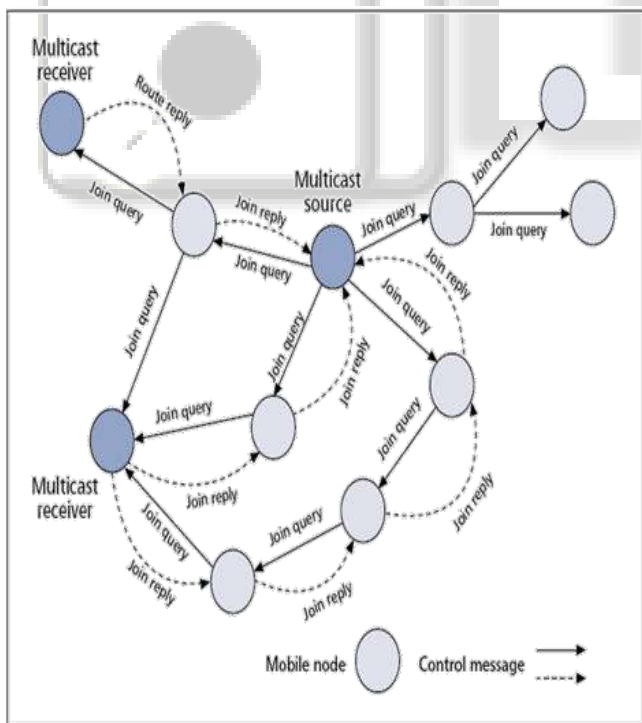


Fig. 2: ODMRP mesh creation

Mesh Maintenance is carried out by soft state approach, in which routes are reestablished between the source and destination by the sending of periodic Join Query packet by the source. This protocol is resistant to link and a node failure since it has a forwarding group which is in fact a merit of mesh-based protocols.

B. Multicast Open Shortest Path First (MOSPF)

The Multicast extension to OSPF (MOSPF) [6] is built on the top of Open Shortest Path First (OSPF) Version 2. MOSPF uses the group membership information obtained through IGMP and with the help of OSPF database builds multicast delivery trees. These trees are Shortest-Path Trees constructed (on demand) for each (source, group) pair. MOSPF supports hierarchical routing. All hosts in the Internet are partitioned in to some “Autonomous System” (AS). Each AS is further divided in to subgroups called “areas”. In OSPF, each router with in a routing domain keeps state and topological information of this domain; this is achieved by link-state advertisement (LSA) flooding. A shortest path tree rooted at the source using Dijkstra’s algorithm is built by MOSPF router. After the building of tree, group membership information is used for pruning for those branches that do not lead to sub networks with group members, resulting in a pruned Shortest-path tree in which source as a route. The MOSPF router creates a forwarding table and then determines its position in the shortest-path tree. The forwarding table is not changing after a fixed interval but when the network topology or group membership have changed the forwarding table has also changed.

C. Distance Vector Multicast Routing Protocol (DVMRP)

DVMRP [7] is a distance-vector routing protocol designed to support the forwarding of multicast datagrams through an internetwork. This is one of the most widely used multicast routing protocol in internet. DVMRP constructs source-rooted multicast delivery trees using variants of the Reverse Path Broadcasting (RPB) algorithm. It is a source-based tree protocol.

DVMRP implements the Reverse Path Multicasting (RPM) algorithm. According to RPM, the first datagram for any (source, group) pair is forwarded across the entire internetwork, providing that the packet’s TTL and router interface thresholds permit. The initial datagram is delivered to all leaf routers, which transmit prune messages back toward the source if there are no group members on their directly attached leaf sub-networks. The prune messages result in the removal of branches from the tree that do not lead to group members, thus creating a source-specific shortest path tree with all leaves having group members. After a period of time, the pruned branches grow back and the next datagram for the (source, group) pair is forwarded across the entire internetwork, resulting in a new set of prune messages.

DVMRP implements a mechanism to quickly “graft” back a previously pruned branch of a group’s delivery tree. If a router that previously sent a prune message for a (source, group) pair discovers new group members on a leaf network, it sends a graft message to the group’s previous-hop router. When an upstream router receives a graft message, it cancels out the previously received prune message. Graft messages may cascade back toward the source allowing previously pruned branches to be restored as part of the multicast delivery tree.

IV. SIMULATION SETUP

QualNet 5.2 is used to simulate the chosen protocols under various MANET scenarios by varying no. of nodes, node

speed and multicast group size. The network size is 1500m X 1500m area for scenario simulation. There is no network partitioning throughout the entire simulation. The data transmission rate is 2Mbps. At physical layer PHY 802.11b is used and at MAC layer MAC 802.11 model is used. The network protocol used is IPv4. A two ray path loss model is applied to avoid random pat loss component. The simulation time for each experiment is 100 sec.

The main traffic source in the simulation is Multicast Constant Bit Rate (MCBR) traffic. Each multicast group has one sender for each protocol in each experiment. A member joins the multicast session at the beginning of the simulation and remains as a member throughout the simulation. The packet size without header is 512 bytes. The length of the queue at every node is 50 Kbytes where all the packets are scheduled on a First-in-First-out (FIFO) basis.

Parameters	Values
Network Size	1500m X 1500m
Simulation Time	100 sec
Coordinate System	Cartesian
Path Loss Model	Two Ray
Fading Model	None
Shadowing Model	Constant
Battery Model	None
Antenna Model	Omni-directional
No. of Channels	1
Channel Frequency	2.4 GHz
Data Rate	2 Mbps
Item (Packet) Size	512 Bytes
No. of Source	1
Traffic Generator	MCBR
MCBR Items to Send	100
MCBR Item Size	512 Bytes
Physical Layer Model	PHY 802.11b
Data Link Layer Model	MAC 802.11s
Network Layer Protocol	IPv4
Multicast Routing Protocols	DVMRP, MOSPF, ODMRP

Table 1: Standard parameters for overall scenarios

To evaluate the performance of routing protocols both qualitative and quantitative metrics are needed. Most of the routing protocols ensure the qualitative metrics. Therefore, four different quantitative metrics are used to compare the performance.

- Throughput: It is the amount of data a receiver actually receives from the sender divided by the time between receiving the first packet and last packet. It is measured in bits per second (bps).
- Packet Delivery Ratio: It is defined as the ratio of total no. of data packets actually received at the receivers to the no. of data packets supposed to be received. PDR is a measure of efficiency of protocol.
- Average End-to-End Delay: It is the average time it takes a data packet to reach the destination. . ETED evaluates the ability of the protocol to use the network resources efficiently.
- Average Jitter: It is average amount of variation in the end-to-end packet transit time. Jitter is the variation in the time between packets arrived, caused by network congestion, timing drift or route changes.

V. RESULTS AND DISCUSSION

Results have been obtained by simulating the protocols under different node placement models such as Random Placement, Uniform Placement and Grid Placement and by varying no. of nodes and node speed in each placement model. Values of throughput, packet delivery ratio, average ETED and average jitter have been obtained in each test scenario.

A. Effect of varying no. of nodes

In Fig. 3 to Fig. 6 simulations are carried out by varying no. of nodes and keeping other parameters such as node speed, multicast group size constant. Graphs for throughput, packet delivery ratio, average ETED and average jitter have been obtained under three placement models namely Random, Uniform and Grid Placement.

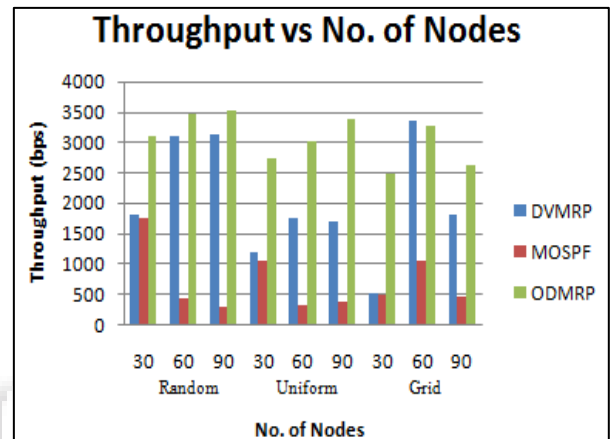


Fig. 3: Throughput vs No. of Nodes

Fig. 3 shows the variation in throughput of all three protocols by changing node density under different placement models. ODMRP shows highest throughput in all node density under all three placement models. MOSPF performs worst in all node density. Among placement models, ODMRP shows highest throughput in Random Placement.

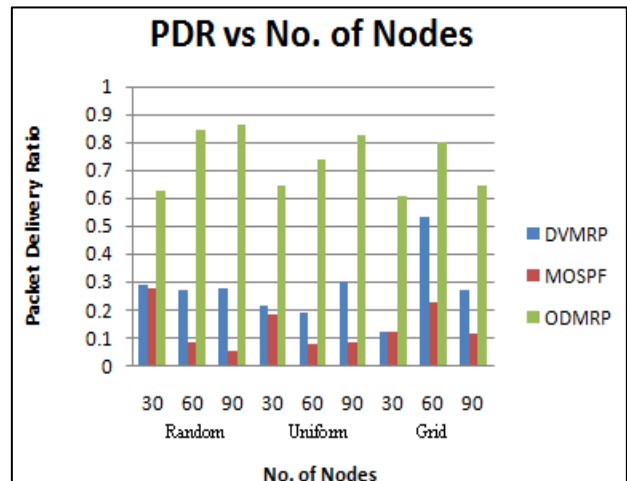


Fig. 4: PDR vs No. of Nodes

Fig. 4 shows PDR with change in no. of nodes under different placement models. ODMRP performs much better than all other protocols under different placement models. Performance of MOSPF is quite poor compared to ODMRP in every situation. Performance of DVMRP is average in every situation. ODMRP shows highest PDR in Random Placement.

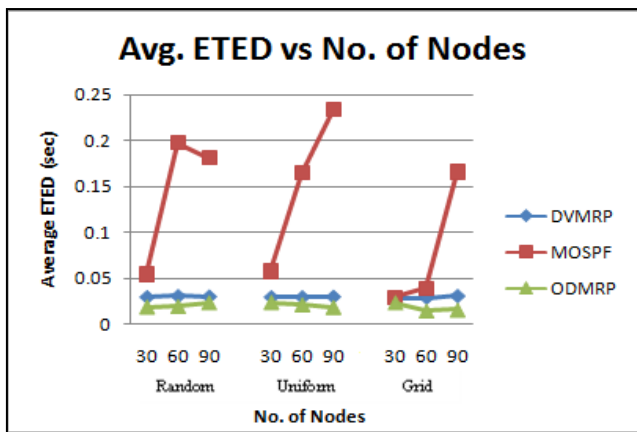


Fig. 5: Avg. ETED vs No. of Nodes

Fig. 5 shows how avg. ETED changes with no. of nodes in different placement models. ODMRP outperforms all other protocols in terms of ETED under all three placement models. ETED of DVMRP is slightly more than that of ODMRP. MOSPF shows highest avg. ETED in all three placement models. Different placement models seem to have negligible effect on ETED of ODMRP and DVMRP.

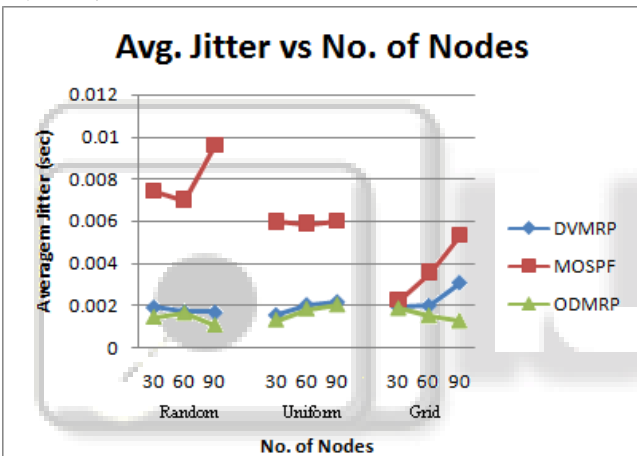


Fig. 6: Avg. Jitter vs No. of Nodes

Fig. 6 shows the impact of varying node density on routing protocols in all three placement models. In all three placement models ODMRP has lowest value of jitter and MOSPF has highest jitter. In Random Placement, MOSPF has highest jitter while it has lowest jitter in Grid Placement. In Uniform Placement, jitter of MOSPF is almost constant. DVMRP has slightly larger values of jitter than ODMRP in Random and Grid Placement but in Uniform Placement it has same jitter value as that of ODMRP.

B. Effect of varying node speed

In Fig. 7 to Fig. 10 simulations are carried out by varying node speed and keeping other parameters such as no. of nodes, multicast group size constant. Graphs for throughput, packet delivery ratio, average ETED and average jitter have been obtained under three placement models namely Random, Uniform and Grid Placement.

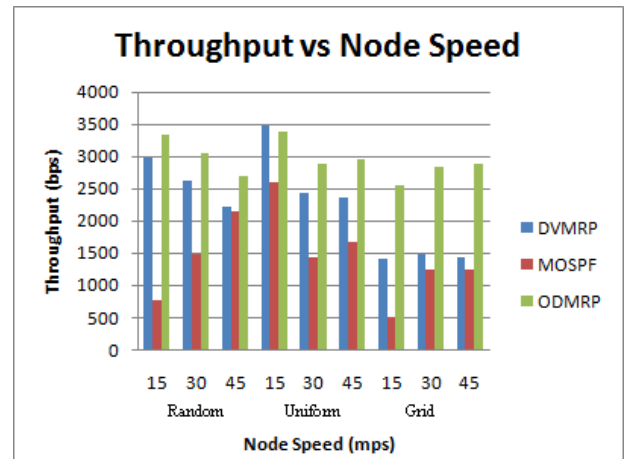


Fig. 7: Throughput vs Node Speed

Fig. 7 shows how throughput of routing protocols changes with increase in node speed under different placement models. From the graph it is clear that ODMRP outperformed remaining protocols in different placement models. MOSPF shows lowest value of throughput in different placement models.

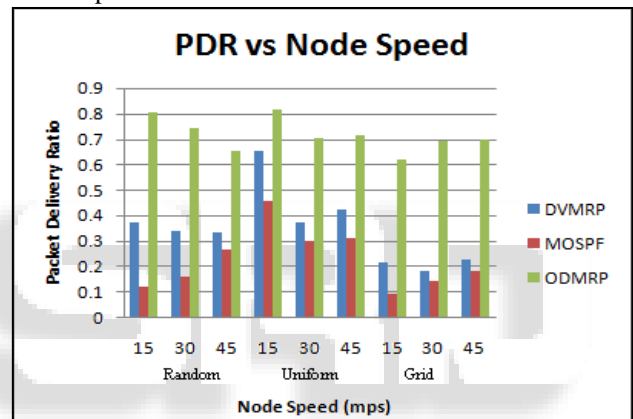


Fig. 8: PDR vs Node Speed

Fig. 8 shows variation in PDR with node speed under different placement models. From the graph it is clear that performance of ODMRP is much better than remaining protocols in all three placement models.

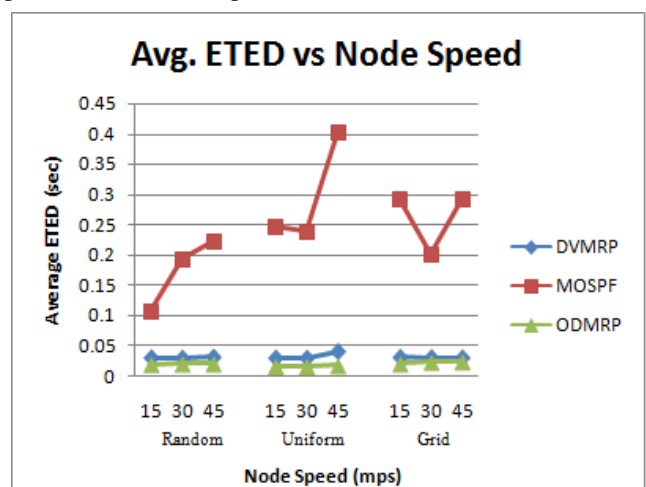


Fig. 9: Avg. ETED vs Node Speed

Fig. 9 shows the performance of protocols in terms of avg. ETED by varying node speed in different placement models. ODMRP and DVMRP have nearly same value of avg. ETED which almost remains constant with increase in node speed under all placement models. MOSPF has highest

avg. ETED among all three protocols and shows much variation in its value with node speed and placement model.

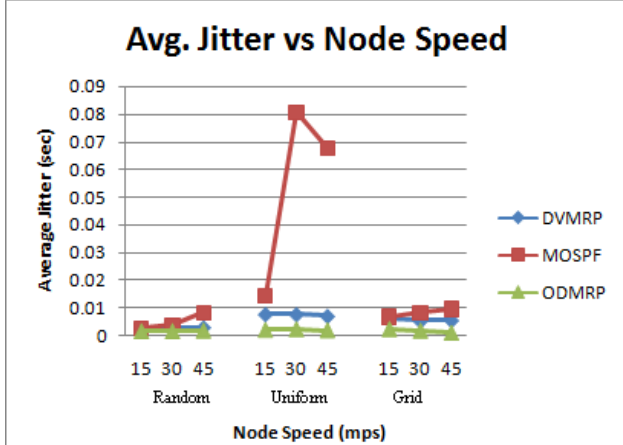


Fig. 9: Avg. Jitter vs Nodes Speed

Fig. 10 shows impact of node speed on avg. jitter of all three protocols under different placement models. In Random Placement model all three protocols have nearly same value of avg. jitter which almost remains constant with increase in node speed. Protocols show high values of avg. jitter in case of Uniform Placement model. In Grid Placement model ODMRP has lowest value of avg. jitter and DVMRP & MOSPF has slightly higher values than that of ODMRP.

VI. CONCLUSION

In this paper performance analysis of three multicasting routing protocols namely ODMRP, MOSPF and DVMRP is carried out using QualNet 5.2 simulation platform. Performance of protocols is compared with respect to various performance metrics like throughput, PDR, avg. ETED and avg. jitter by varying node density and node speed in Random, Uniform and Grid Placement models. ODMRP shows much better performance than other two protocols in various node densities. In scenarios comprising variation in node speed, MOSPF is the worst performer in terms of all performance metrics while ODMRP shows best performance. From the results, it can be concluded that ODMRP is best suited for MANET in high node density and highly dynamic scenarios.

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