



Performance Evaluation and Analysis of Multicast Routing Protocols in Wireless Mesh Networks

Madhurima*

Department of Computer Science and Engineering
Punjabi University, Patiala, Punjab, India

Amardeep Kaur

Department of Computer Science and Engineering
Punjabi University, Patiala, Punjab, India

Abstract— *Wireless Mesh Networks (WMNs) is the multihop communication technology. Numerous internet based applications of WMNs are based on multicasting technology such as video conferencing, webcast, online distributed gaming etc. This technology especially arises for group communication. It provides high mobility to the network and reduces the chances of frequent failures. To support multicasting, various multicast routing protocols have been proposed. This paper demonstrates the efficiency of some of these MRPs and analyse their performance in terms of scalability and mobility. Six Multicast Routing Protocols (MRPs) are considered for simulation and evaluation of their performance under certain network parameters.*

Keywords— *MAODV, MOLSR, MOSPF, Multicast Routing Protocols, ODMRP, PIM-DM, SRMP, and Wireless Mesh Networks.*

I. INTRODUCTION

WMN has a dynamic wireless infrastructure, which is self-organised, self-optimized and fault tolerant. It enables the mobile nodes to establish a wireless network automatically with mesh connectivity. WMN is made up of radio nodes and access points organized in a mesh topology. Each node with its own packet can communicate with each other by transferring the packets to one another. Its main constituents are mesh clients, mesh routers and gateways [1]. Mesh clients are the nodes which form peer-to-peer mesh networks among themselves. Mesh routers are those access points which connect WMNs to most commonly used technology devices such as desktops, laptops, PDA's, Phones etc. These devices behave like mesh clients and mesh routers are responsible for communication among them through gateways. Gateways are those nodes which provide internet connectivity to the WMNs nodes. In WMNs, it is easy to extend coverage range of radio nodes due to its multi-hop nature and communication among them is facilitated by multicast routing.

II. RELATED WORK

In earlier research works [2] – [10], several MRPs have been proposed based on MANETs. MRPs are basically follows two approaches; tree-based and mesh-based. In tree-based approach, there exists only a single path between source and destination nodes. Tree-based protocols provide high data forwarding efficiency and low overhead but it is not robust in high mobile environments. It is scalable and manageable. Multicast routing protocols under tree-based approach can be shared or source oriented [3]. In tree-based approach, there is only one route exists between a source node and a destination node. Therefore these routing protocols are capable of link transmissions. In mesh-based approach, there are multiple paths in between source and destination nodes. Due to redundancy in paths, it provides robustness to the network. In this approach nodes can be fully connected or partially connected. Two node networks are fully connected and the network in which some nodes connected to more than other node is partially connected.

All the work in this research will be based on performance comparison and analysis of both types of MRPs. Some of the related work has been done on multicast routing protocols in the field of MANET and WMN are reviewed as follows:

In [3], the authors analysed the performance of Multicast Routing Protocols based on Core based and Centralized routing strategies: MOSPF, DVMRP, PIM-SM and PIM-DM, which have power constraints and scarce bandwidth. In [4], the authors compared the performance of the tree-based routing protocol MAODV and mesh-based routing protocol ODMRP with respect to the control overhead, forwarding efficiency and packet delivery ratio. In [5], the authors proposed a new mesh-based on-demand multicasting protocol SRMP with respect to robustness and connectivity and compare it with ODMRP and MAODV. In [6], the authors have proposed a new approach HWMP which is the combination of both the classes tree-based and mesh-based and its performance is also compared with MAODV. In [9], authors have analysed the performance of ODMRP in terms of throughput by varying node mobility and group sizes. Six MRPs- MAODV, MOLSR, MOSPF, ODMRP, SRMP and PIM-DM are considered for performance comparison in this paper.

III. MULTICAST ROUTING PROTOCOLS (MRPs)

Multicast Routing Protocols (MRPs) are the kind of routing protocols which are used in multipoint wireless networks and supports group communication [2]. Many users can access same wireless channel at a time for communication. It sends a data packet over a path shared by a communication link from a source node to multiple destination nodes. It is

efficient in saving network resources and bandwidth. In WMNs, it represents huge enhancement of the network capacity. Basically they follow to main approaches on the basis of topology of network [3]: tree-based and mesh-based. In tree based routing only single path is connecting the source node and destination node, while in mesh based routing, multiple routes are connecting the source node and destination node. This paper presents the performance of following MRPs:

A. Multicast Ad Hoc On-Demand Vector (MAODV)

It is a multicast extension of unicast AODV routing protocol. A multicast group of nodes are formed into a tree where non-members nodes are required for the connection of tree. The group leader of the tree is a root node [4]. Multicast data packets are propagated among the tree and distributed in all the nodes. It merges two disconnected trees into a new tree and improves scalability. It tells about how to form the tree and repair the tree when a link is broken.

B. Multicast Optimized Link State Routing (MOLSR)

It is a modified version of unicast OLSR protocol. It calculates shortest path of trees on-demand when it receives multicast packet. It contains distributed set of multipoint relays which is not shared among all the nodes and it does not provide reliability [2]. They are responsible to manage the entire network from the diffusion of forwarding control traffic by reducing the required transmissions. It does not incorporate any mechanism for interconnecting to the internet.

C. Multicast Open Shortest Path First (MOSPF)

It is an extension to the OSPF protocol to support multicast routing. Nodes and routers are linked together to create source-based trees. It is a data-driven protocol in which router constructs shortest path tree and share information [3]. It is having fragile multicast tree structure, which must be readjusted as connectivity changes and the trees needed to recalculated, each time the link state changes in between nodes.

D. On-Demand Multicast Routing Protocol (ODMRP)

It is a mesh-based protocol for routing multicast and unicast traffic. It follows the concept of group forwarding nodes. It creates routes on demand and helps to reduce network traffic. It provides alternative paths in case of link failures. But it suffers from a route acquisition delay because of asymmetrical links [4]. The path is not remains same in to and fro from one node to another.

E. Source Routing-based Multicast Protocol (SRMP)

It is a mesh-based on-demand routing protocol. It assigns uniform routes based on connection availability according to prior prediction of routes [5]. It pre-determines the route quality then constructs a mesh to connect group nodes which reduces traffic and avoids channel overhead. It also improves scalability.

F. Protocol Independent Multicast-Dense Mode (PIM-DM)

It is a source-based mesh multicast routing protocol used for Internet Protocol (IP) networks that provide one-to-many and many-to-many distribution of data over a wireless network. It is independent of any unicast routing mechanism. It is suitable for high bandwidth area which densely populated and group members are frequently available [3]. It eliminates routing dependencies and overhead. It is easy to implement but poor in scalability.

IV. NETWORK PARAMETERS

Network parameters are the metrics used for the performance evaluation of routing protocols and they also known as performance metrics. These network parameters have a great impact on overall performance of a communication network. This paper has dealt with four parameters are defined as follows:

A. Delay

It is the time interval between sending of a packet from source node and receiving of that packet at destination node. It indicates how long it took for a packet to travel from the source to destination [5].

B. Throughput

The rate at which the data is transferred from one node to another node communication network is known as throughput. The unit of throughput is bits/sec [6].

C. Network Load

It is when there is lot of traffic going on in a network and it is becoming difficult for a network to handle the traffic it is said that network is having a load on it [7].

D. Jitter

It is the variation in time of a periodic signal or the shifting of a signal in time domain. It tells about packet loss while transmission [8].

V. SIMULATION ENVIRONMENT

Multicast Routing Protocols (MRPs) are implemented using application-specific simulation tool. Fig.1 shows the simulation environment which is created by using an open source and discrete event simulation software known as OPNET (Optimized Network Engineering Tool) Modeler 14.5.

The simulation focused on the performance of routing protocols with increase in scalability and constant mobility. Therefore, three simulation scenarios consisting of 30 nodes, 50 nodes and 100 nodes considered which are arranged in cellular hexagon pattern. The nodes are randomly placed within certain gap from each other in 1000 x 1000 m office environment for 30, 50 and 100 nodes respectively. Every node in the network was configured to execute MAODV, MOLSR, MOSPF, ODMRP, SRMP and PIM-DM respectively. An integrated approach is used to deploy WMNs. High resolution video traffic and PCM quality voice traffic is generated in the network explicitly i.e. user defined via Application and Profile configuration. DES simulation criterion is configured and run for total time of 300 seconds. The overall simulation was monitored within the 128 seed value and update interval in 50000 events. Events specifies how

often simulation calculates events/second data. Kernel type preference is chosen for simulation kernel because it runs faster than the remaining other two simulation kernels i.e. development and optimized.

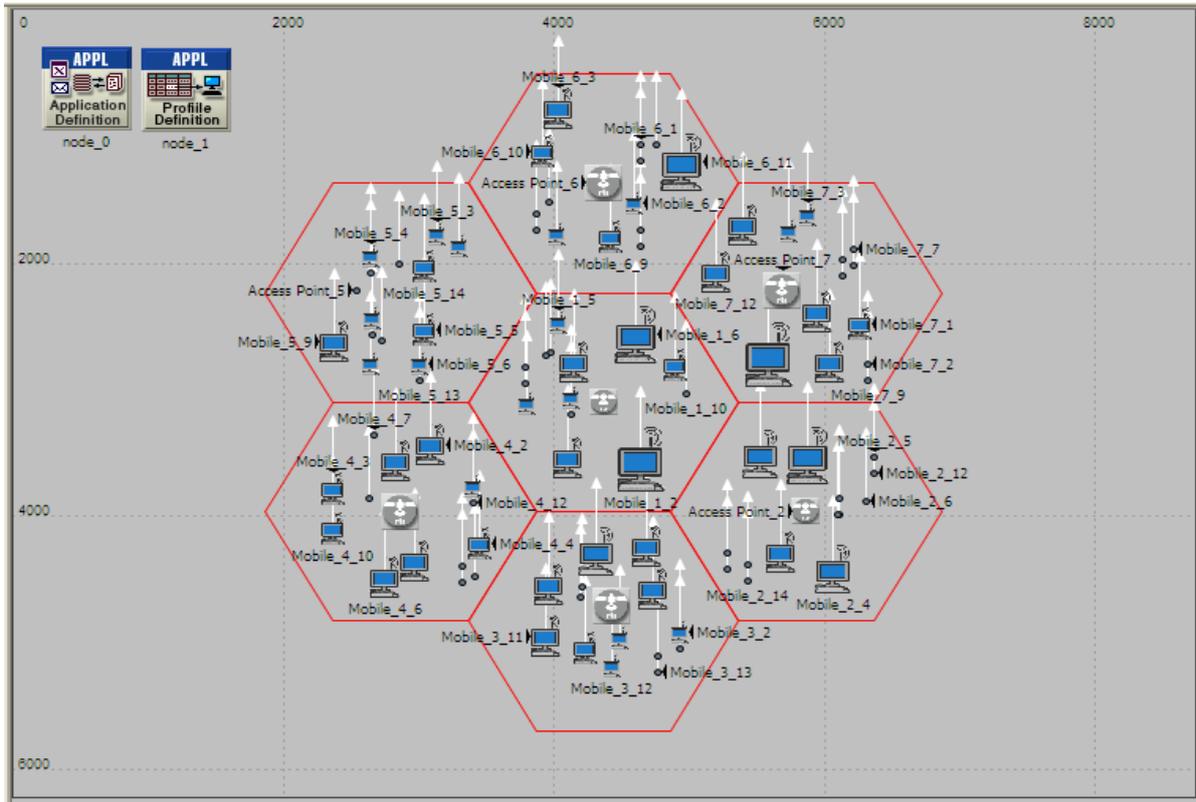


Fig. 1 Simulation Environment

The simulation parameters are the basic requirements for the node model for simulation of each routing protocols is shown in Table I.

TABLE I
SIMULATION ENVIRONMENT PARAMETERS

Parameters	Values
Number of Nodes	30, 50 and 100
Network Size	1000 x 1000 meters
Mobility	Random Waypoint Model. Maximum speed is 5m/s
Type of Service	WLAN, Voice and Video traffic
Multicast Routing Protocols	MAODV, MOLSR, MOSPF, ODMRP, SRMP and PIM-DM
Network Parameters	Delay, Throughput, Network Load and Jitter
Simulation Time	300 seconds
Packet Size	128 kb
Frame Size	4ms
Data Rate	2Mbps
Traffic Type	Multicast Constant Bit Rate (MCBR)
Network Topology	Cellular Hexagon grid

VI. SIMULATION ENVIRONMENT

The results are displayed in the form of graphs, where all the graphs are displayed as average. The WLAN, video and voice traffic type is used in simulations for all the three scenarios in equal amount. All the scenarios are experimented separately against six selected routing protocols.

A. Scenario 1 Results

In first scenario, simulation model is consists of 30 nodes, 7 access points and a server. All the six MRPs (MAODV, MOLSR, MOSPF, ODMRP, SRMP and PIM-DM) are tested against the four performance metrics (Delay, Throughput, Network Load and Jitter).

The overall performance of Multicast Routing Protocols (MRPs) in 30 nodes scenario is shown in Fig.2-Fig.5. These graphs depict that SRMP outperforms the other routing protocols in terms of throughput and delay while in network load it looks like that MAODV is attaining greater numeric value as compared to SRMP. MAODV multicast data packets are

propagated among the tree and distributed in all nodes, it improves scalability. MOSPF has given least throughput. For jitter, PIM-DM represents the highest loss of packets because it is unable to repair broken links. MOLSR gives least packet loss because it calculates the shortest path trees on-demand when it receives the multicast packet. For MAODV, ODMRP and SRMP, it looks like they have no packet loss during packet transmission as they have the least numeric value. For network load, it looks like PIM-DM is showing better result than other routing protocols, as it is putting low load on a network.

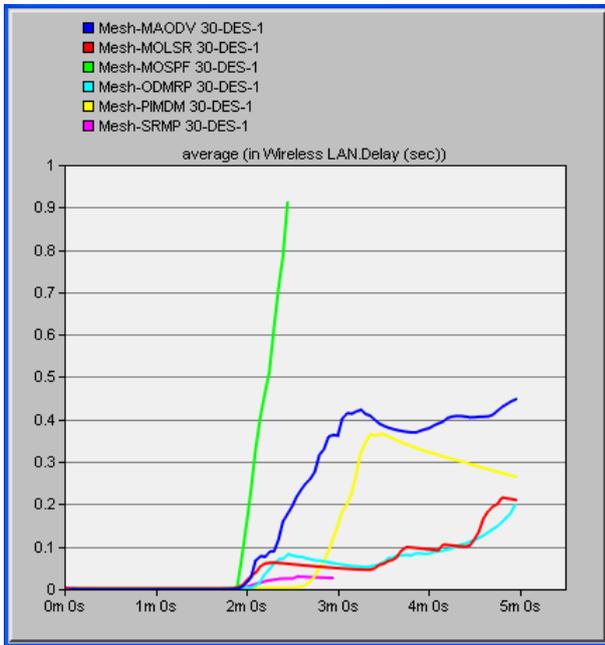


Fig. 2 Delay-Scenario 1

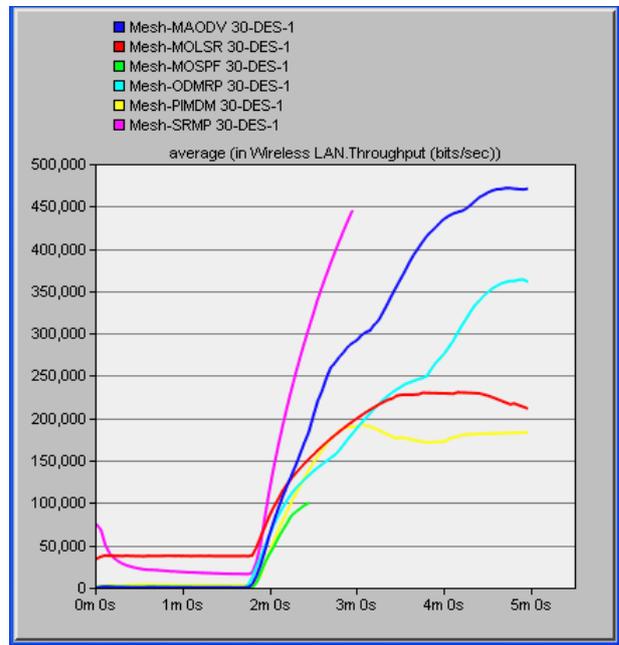


Fig. 3 Throughput-Scenario 1

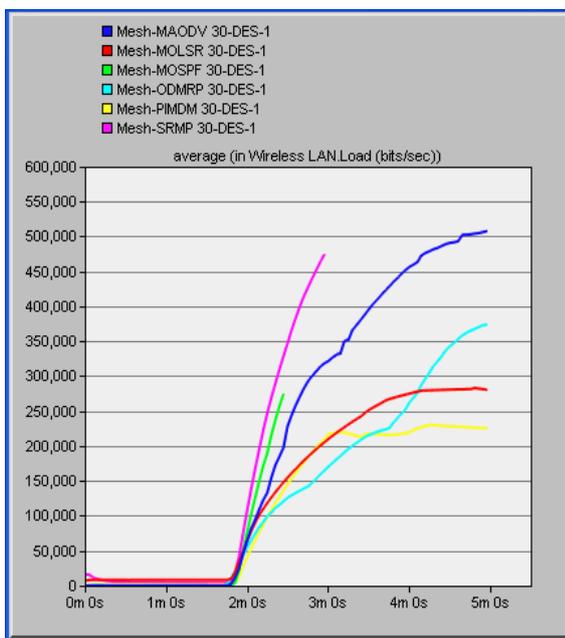


Fig. 4 Network Load-Scenario 1

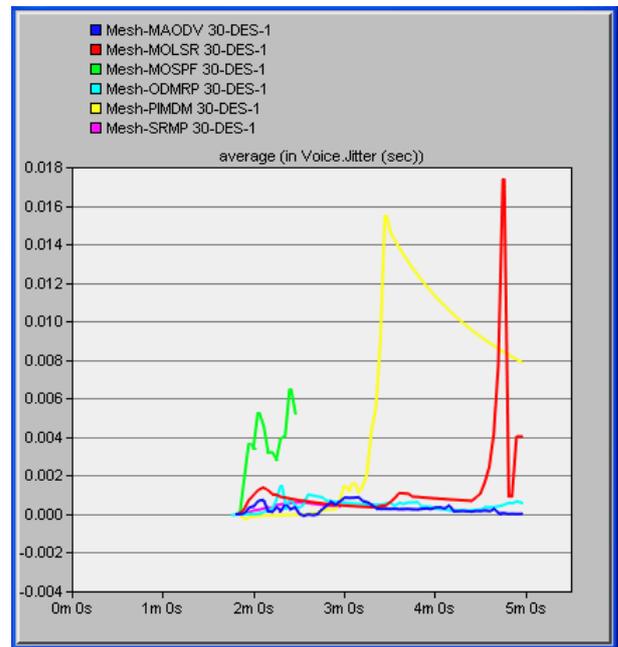


Fig. 5 Jitter-Scenario 1

Scenario 1

B. Scenario 2 Results

In second scenario, simulation model is consists of 50 nodes, 7 access points and a server. All the six MRPs (MAODV, MOLSR, MOSPF, ODMRP, SRMP and PIM-DM) are tested against the four parameters (Delay, Throughput, Network Load and Jitter). With the increase in number of nodes some variations occurred in the behaviour of the protocols.

The overall performance of Multicast Routing Protocols (MRPs) in 50 nodes scenario is shown by graphs in Fig.6- Fig.9. These graphs illustrate that SRMP is again outperforming the other routing protocols in terms of delay and throughput. In terms of network load MOLSR is putting greater load on network because it contains distributed set of multipoint relays (MPRs) which is not shared among all the nodes and does not provide reliability. ODMRP is attaining higher throughput after MOLSR as it helps to reduce network traffic and has less delay. MOSPF has given least

throughput. From the graphs it is shown that for jitter, PIM-DM again has the highest loss of packets as the number of nodes increases because it cannot repair broken links. On the other side, SRMP and MAODV have no packet loss transmission because it avoids channel overhead and reduce network traffic.

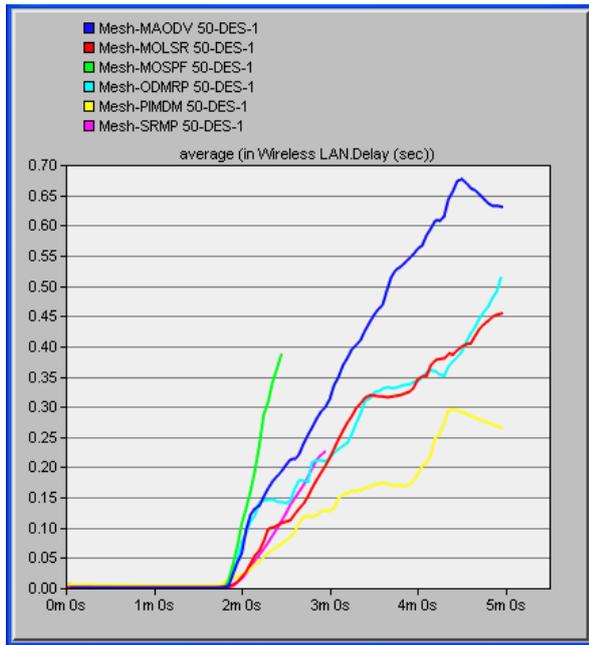


Fig.6 Delay-Scenario 2

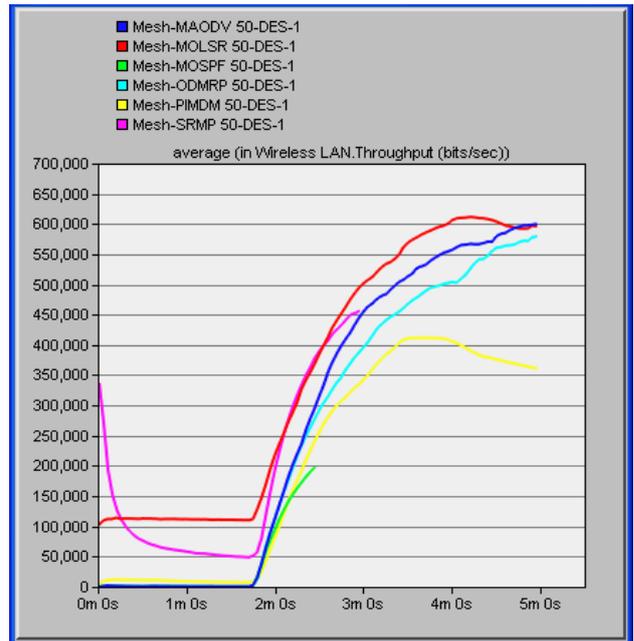


Fig.7 Throughput-Scenario 2

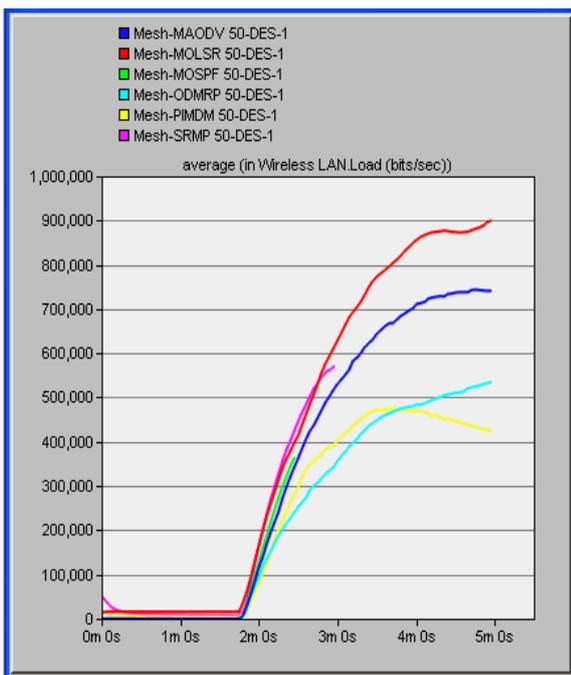


Fig.8 Network Load-Scenario 2

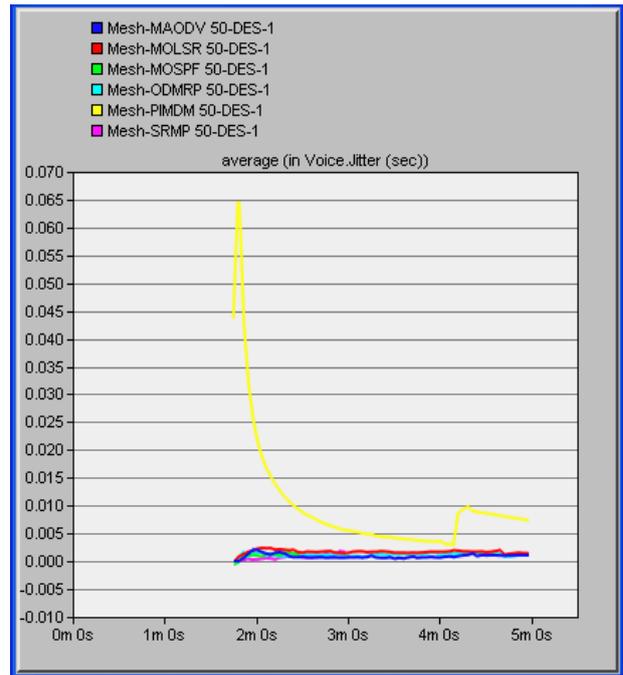


Fig.9 Jitter-Scenario 2

C. Scenario 3 Results

In third scenario, now simulation model is consists of 100 nodes, 7 access points and a server. Again all the six MRPs (MAODV, MOLSR, MOSPF, ODMRP, SRMP and PIM-DM) are tested against the four parameters (Delay, Throughput, Network Load and Jitter). With that much increase in number of nodes, the behaviour of these protocols slightly changes.

The overall performance of Multicast Routing Protocols (MRPs) in 100 nodes scenario is shown in graphs from Fig.10- Fig.13. These graphs depicts that SRMP is again outperforming the other routing protocols in terms of all parameters i.e. delay, network load, throughput and jitter in this scenario. Because this time SRMP graph for network load graph is under the graphs of ODMRP and MOLSR which means that SRMP has a better result in terms of network load also. It is because as the number of node increase it improves the scalability of the network and avoids channel overhead. MAODV and ODMRP are having slightly maximum throughput value than SRMP in the 100 nodes scenario. In case of jitter, MOSPF and SRMP are showing extreme maximum and minimum loss of packets respectively, than all other routing protocols.

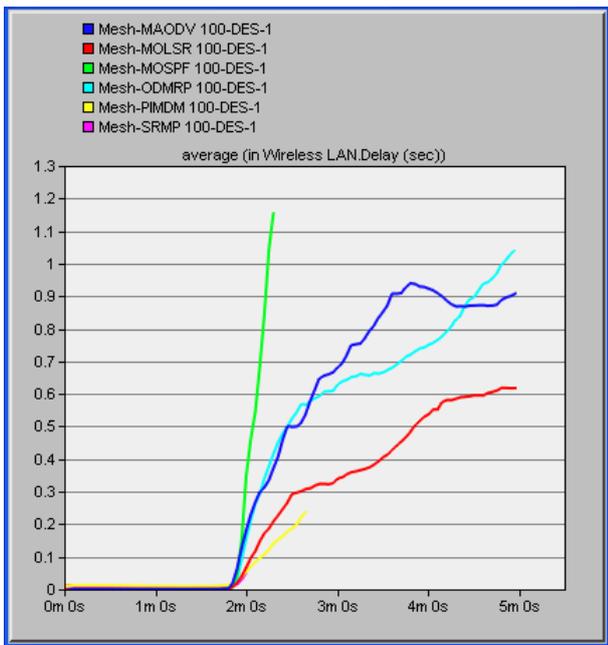


Fig.10 Delay-Scenario 3

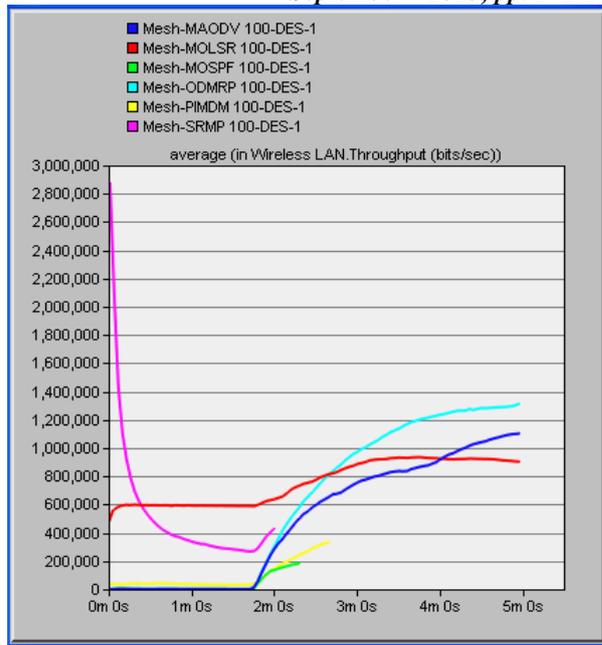


Fig.11 Throughput-Scenario 3

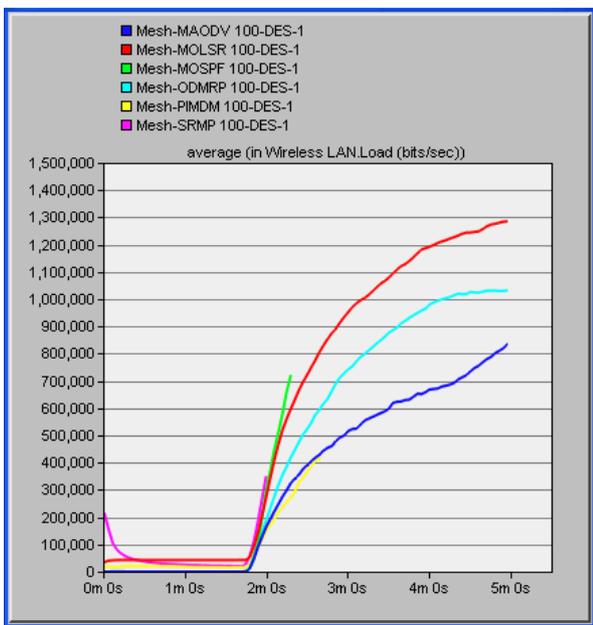


Fig.12 Network Load-Scenario 3

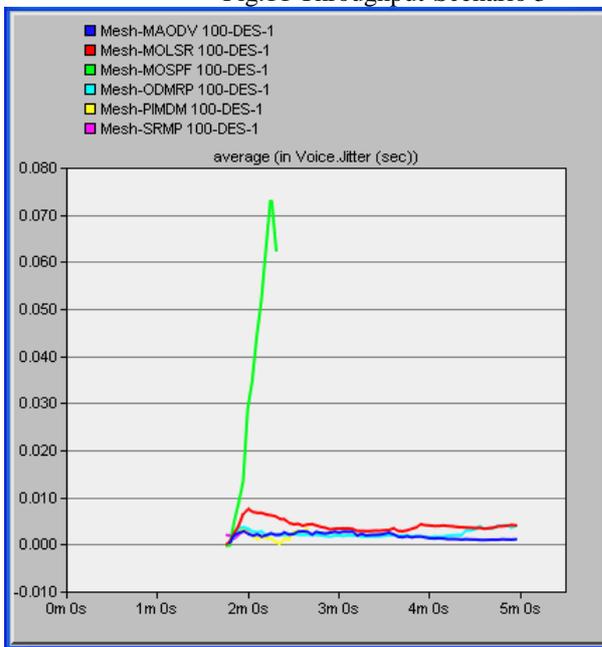


Fig.13 Jitter-Scenario 3

VII. DISCUSSIONS

Analytically, SRMP and MAODV both Multicast Routing Protocols (MRPs) are best to use among these six routing protocols. Moreover the performance of ODMRP is good but it can observe that SRMP and MAODV, in terms of Delay, Throughput, Network Load and Jitter have outstanding good results, as shown in Fig.5-Fig.13. MOLSR and PIM-DM are having average performance under varying network parameters. MOSPF gives poor performance among all routing protocols as it has experienced almost highest delay and jitter, average network load and least throughput in all the three scenarios. Because it has fragile multicast tree structure, each time the link state changes in between the nodes. All the six Multicast Routing Protocols (MRPs) can be arranged in descending order according to their performance-

$$SRMP > MAODV > ODMRP > MOLSR > PIMDM > MOSPF$$

VIII. CONCLUSION

Tree based and mesh based multicast routing protocols performance is analysed in this paper. The simulation study of this research reveals that, SRMP and MAODV work better than all other four Multicast Routing Protocols (MRPs). ODMRP performance is also good in terms of throughput and jitter. ODMRP and SRMP both are mesh based MRPs and MAODV is tree-based protocol. ODMRP creates route on-demand but suffers from delay although it helps in reducing network traffic. SRMP gives better results in terms of delay, throughput, network load and jitter as it provides stable paths based on link availability according to future prediction of links. It constructs a mesh to connect group nodes to avoid channel overhead and improve scalability. MAODV gives better results in terms of network load, throughput and

jitter as it multicast all nodes of a group linked as a tree and the root of the tree is a group leader. Although MAODV gives efficient throughput but experience maximum delay as the number of nodes increased. According to simulations it can be concluded that Mesh based protocols gives better results than tree based protocols in terms of scalability and mobility.

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