Evaluation Comparison of Mesh-Based routing Protocols in MANET

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Abstract— A multicast routing protocol manages group membership and controls the path that multicast data takes over the network in mobile ad hoc network. This process is done through either tree-based or mesh-based protocols. The mesh-based protocols are more reliable and robust against the tree based protocols. One of the most used on-demand multicast routing protocol is ODMRP (On-Demand Routing Protocol). However, it has the significant overhead due to redundant data delivery group and path maintenance. This overhead has been eliminated through the forwarding node reduction and link break time prediction algorithm (FNRLP). This work aims to exhibit the performance characteristics of mesh-based on-demand multicast routing protocols ODMRP and ODMRP-FNRLP.

Keywords*-MANET, Multicast routing protocol, ODMRP, overhead, ODMRP-FNRLP*

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I. INTRODUCTION

The Multicast Routing Protocol designed for static networks may be unsuccessful to handle with node movement and dynamic topology, because of the freedom of movement and protocol overheads. If a multicast routing protocol for the fixed network is used in wireless networks, several problems appear because those protocols are designed for static hosts, so when they build the multicast delivery tree, it anticipates permanent locations [7]. However, in wireless networks, multicasting routing protocol design comprises several design issues. They are scalability, dynamic topology structure, limited bandwidth, control overhead, Quality of Service, need on the unicast protocol, resource controlling, congestion control, energy-aware resource consumption, mobility forecast, link stability, multisource multicasting, reliable multicasting, security in multicasting and load balancing[3]. The MANET has three primary classifications of multicast algorithms [5]. An ingenuous approach is to flood the network only. Every node floods the receiving message to its neighbors. The proactive approach pre-computes the paths to all destinations and stores the information in the routing table. The routing information is periodically scattered all over the network. The concluding approach is the reactive or query-response approach. The pathways are generated by the hosts on demand. Once query touches the destinations, the response phase starts and forms the path. The multicast routing protocols are mainly distributed based on i) topology (Tree-based and Mesh-based and Hybrid) ii) how routing information attained and kept (Proactive and Reactive, Hybrid). The mesh based multicast routing protocol has robust against frequent topology changes than tree based protocols but they have high overheads during mesh and path maintenance as well as data delivery. So the protocol ODMRP-FNRLP tried to reduce such overheads.

The paper has to explore the performance of proposed algorithm in various scenarios against existing protocol ODMRP. The paper has following sections: section II gives the introduction about ODMRP protocol. Section III depicts the ODMRP-FNRLP. Section V is the simulation and result discussion. Section V concludes the work.

II. REVIEW OF ON-DEMAND MULTICAST ROUTING PROTOCOL

The ODMRP protocol is an on-demand meshed-based multicast protocol. In this ODMRP, source node initiates the route detection and route preservation through flooding. A set of nodes called forwarding nodes are selected and maintained to send multicast data on the shortest path to build a forwarding mesh for each multicast group. By using mesh, the drawbacks faced in multicast trees are avoided. In ODMRP soft state approach is taken. There is a reduction of channel overhead by this ODMRP, which makes this scalable. The group association and multicast paths are established and restructured by the source on demand. The ODMRP is similar to on-demand unicast routing protocols, a request and reply phase comprises the protocol. While multicast host has packets to direct, then it broadcast to the entire network a member publicity packet called as JOIN REQUEST. These packets correspondingly update the routes. When a node receives a non-duplicate JOIN-REQUEST, it stores the upstream node id and rebroadcast. When this packet touches a multicast receiver, it updates or creates the source record in member table. When a node accepts a JOIN TABLE, it checks if the next node ID equals its ID. If it ensures, the node understands that it is on the path to the source and thus is part of the forwarding group. It then sets the FG Flag and announcements its JOIN TABLE. The JOIN TABLE is propagated by individual forwarding group member until it reaches the multicast spring via the shortest path. These nodes form the forwarding group. A multicast destination node can also be a forwarding group node if it is on the path between a sender and another receiver.

Flooding redundancy among forwarding group helps overcome node dislocations and channel dwindling. Therefore, unlike trees, regular reconfigurations are not prerequisite. Suppose the path from S1 to R2 is S1-A-B-R2. In a tree arrangement, if the link between nodes A and B pauses, R2 cannot be given any packets from S1 while waiting for the tree is reconfigured. The ODMRP already has a redundant route (e.g., S1-A-C-B-R2) to deliver packets without going through the broken link between nodes A and B. After the group creation and route assembly process, a multicast source can deliver packets to receivers via designated routes and forwarding groups. When getting a multicast data packet, a node ahead only non-duplicate, and the setting of the FG Flag for the multicast group has not passed away. If a multicast source wishes to leave the group, it merely breaks directing JOIN REQUEST packets. If a receiver no extended needs to obtain from a particular multicast group, it eliminates the corresponding entries from its Member Table and does not convey the JOIN TABLE for that group. The data structures like Member table, routing table, Forwarding group table, Message cache are maintained. Not only ODMRP can work with any unicast routing protocol, but it can also function as both multicast and unicast. Thus, ODMRP can route without any original unicast protocol.

The ODMRP has the redundant paths to receivers for improving the reliability of data delivery. It floods Join_Query periodically to maintain the forwarding nodes and paths. These lead to overhead in the routing process. So the proposed algorithm ODMRP-FNRLP reduces these overhead by reducing redundant paths and setting refresh interval time by using link break prediction time.

III. REVIEW OF PROTOCOL: ODMRP-FNRLP

The forwarding node reduction with link prediction algorithm (FNRLP) was suggested to minimize the redundant paths to a destination and minimize the flooding of control packets for link and forwarding group maintenance. This algorithm had aggregation of two algorithms at mesh creation phase and maintenance phase. The heuristic distributed count algorithm to select the minimum cost spanning tree for mesh creation. So the redundant paths have reduced. The JOIN REPLY packet has the count for forwarding nodes. The source node selects the node with minimum count value as the forwarding node [4].

In maintenance phase, the refresh interval time is modified according to the link break time prediction. The predicted break time is compared with the minimum refresh time. If the predicted time is less than the minimum refresh time, then the forwarding node or source node floods the JOIN REQUEST query. So that the periodic control message for route maintenance is avoided by this method. The source sends the join query only when current active route break immediately. The route maintenance phase is simplified with minimal control messages.

IV. OBSERVED RESULTS

A. *Environment for simulation*

The NS2.32 (Network Simulator) is used for simulation. The 1000 x 1000 m is the area of the simulation. The time taken for simulation is 200s. The traffic type is CBR. The Mac protocol 802.11 has used. The RWM model and TRWG RP model are taken for this work. The packet size is 2000 to 2900 bits. The number of nodes varies from 60 to 100. The pause time and node speed are considered from 5 to 25 ms and 1-5 m/s respectively. The proposed ODMRP-FNRLP is compared with the ODMRP protocol.

B. *Performance metrics*

The performance metrics like normalized overhead, throughput, packet dropping ratio, delay, and jitter are measured for the performance analysis of the varying number of nodes, pause time, interval time, mobility speed and simulation time.

Normalized Routing Load (or Normalized Overhead) is defined as the total number of routing packet transmitted per data packet. It is calculated by dividing the total number of routing packets sent (includes forwarded routing packets as well) by the total number of data packets received. Throughput is the number of successfully received packets in a unit, and it is represented in bps. Jitter (End-to-end delay) is the end-to-end delay variation between two consecutive packets. It is an indicator of stability and effectiveness of the network. The refresh interval time is the critical performance parameter for evaluating a routing protocol. The pause time and speed are revealed the mobility nature of the nodes. Their high values for pause time and speed show their high mobility. The lower values are for low mobility environment.

C. *Results Discussion*

Table.1 shows the performance metrics fields against the varying number of nodes scenario. If the density of network increases, the normalized overhead also increases because of limited bandwidth, overhearing. As in fig. 1(a), fig. 1(c), fig. 1(e), ODMRP-FNRLP has less normalized overhead, dropping ratio and jitter than ODMRP. The ODMRP-FNRLP has more throughput and delay than ODMRP.

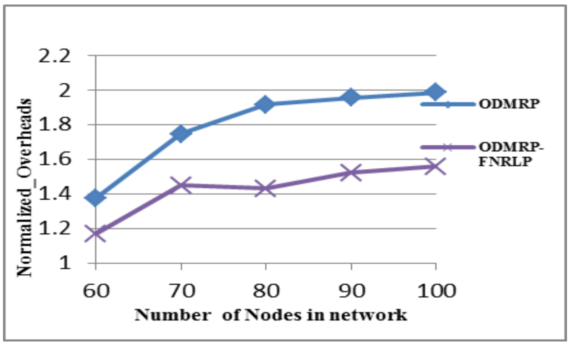

Figure 1(a). A number of nodes in network Vs. normalized overheads

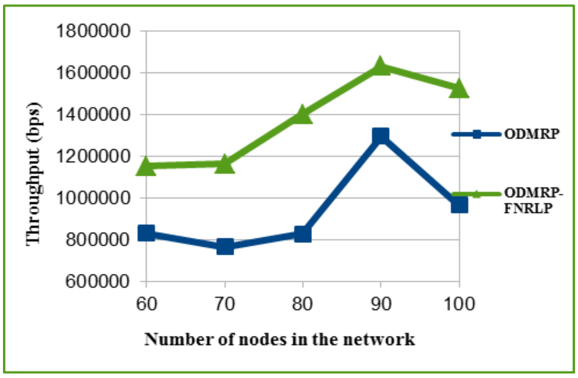

Figure 1(b). A number of nodes in network Vs. Throughput

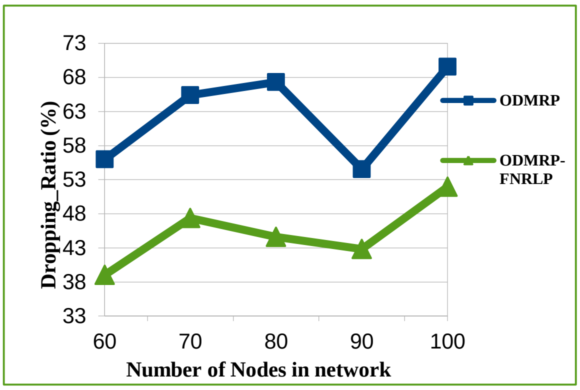

Figure 1(c). A number of nodes in network Vs. Dropping ratio

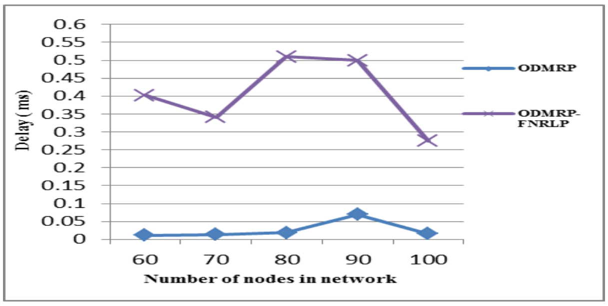

Figure 1(d). A number of nodes in network Vs. delay

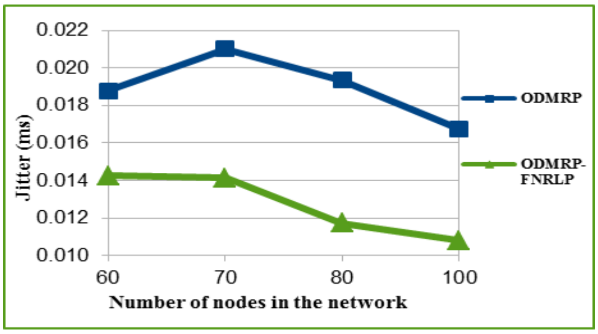

Figure 1(e). A number of nodes in network Vs. Jitter

Table.2 shows the performance metrics fields against the varying refresh interval time scenario. This interval time determines the flooding of Join query packet. The shortest time makes frequent flooding. The larger time interval does not match for frequent topology changes. For this scenario, the ODMRP-FNRLP has the less normalized overhead (fig. 2(a)), dropping ratio (fig.2(c)) and jitter (fig. (d)) than the ODMRP. The ODMRP-FNRLP has more throughputs (fig. 2(b)) and delay (fig. 2(e)) than ODMRP.

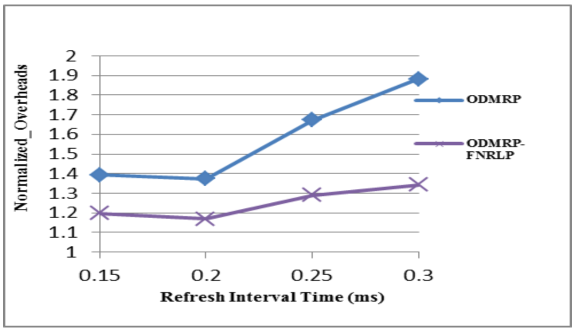

Figure 2(a). Refresh Interval Time Vs. Normalized Overhead

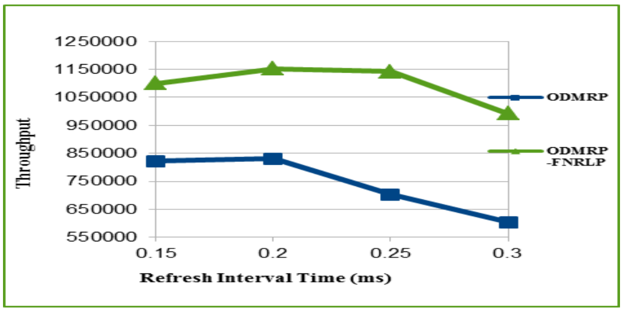

Figure 2(b). Refresh Interval Time Vs. Throughput

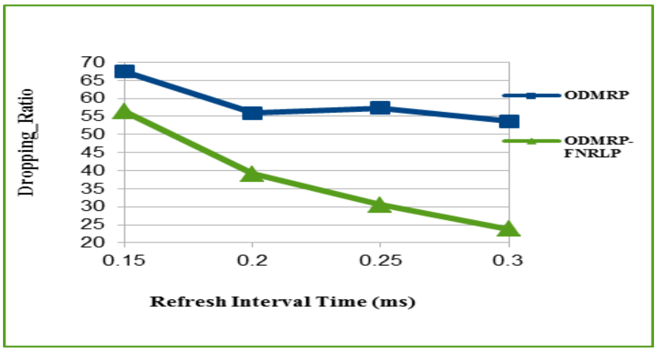

Figure 2(c). Refresh Interval Time Vs. Dropping Ratio

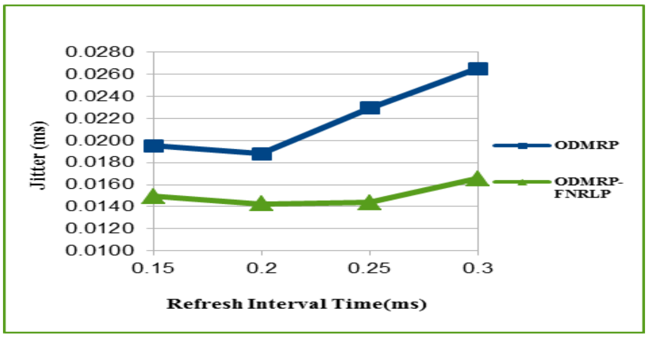

Figure 2(d). Refresh Interval Time Vs. Jitter

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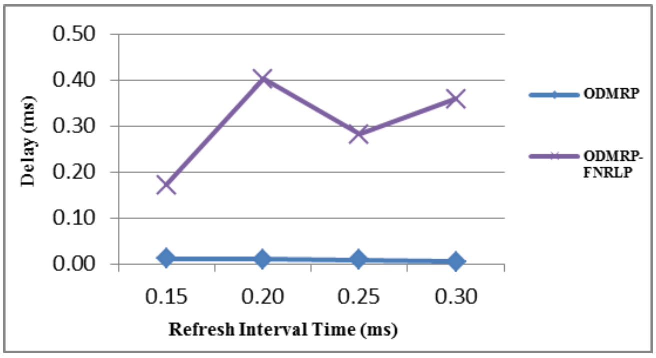

Figure 2(e). Refresh Interval Time Vs. Delay

Table.3 shows the performance metrics fields against the varying pause time scenario. The pause time shows the mobility of nodes. The ODMRP-FNRLP is well suited for high mobility environment than ODMRP because it has more throughput and less normalized overhead, dropping ratio, jitter as shown in fig. fig.3(a), fig. 3(c) and fig. 3(e) respectively.

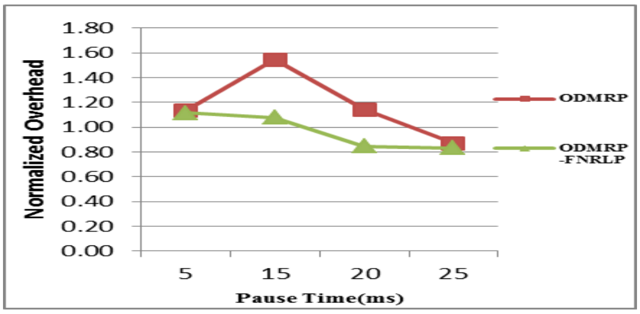

Figure 3(a). Pause Time Vs Normalized Overhead

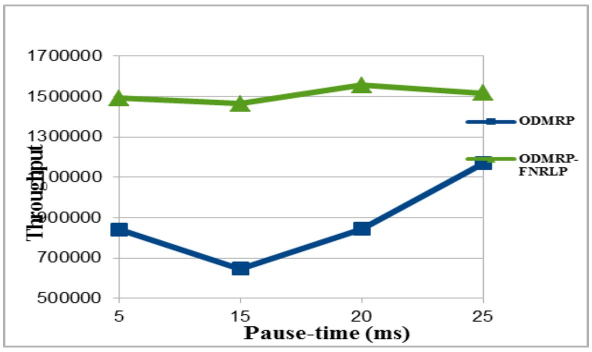

Figure 3(b). Pause Time Vs. Throughput

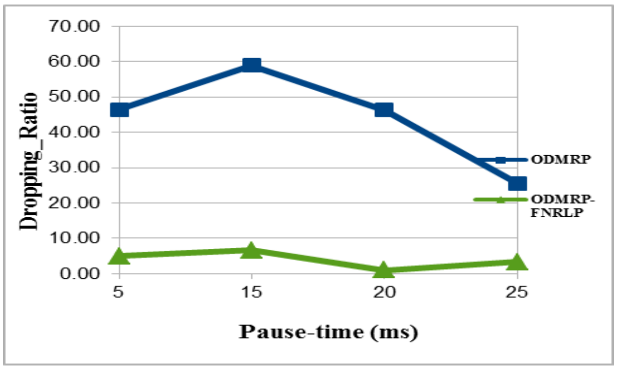

Figure 3(c). Pause Time Vs Dropping ratio

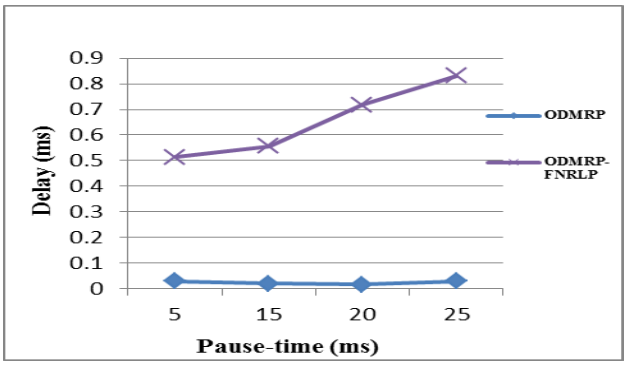

Figure 3(d). Pause Time Vs Delay

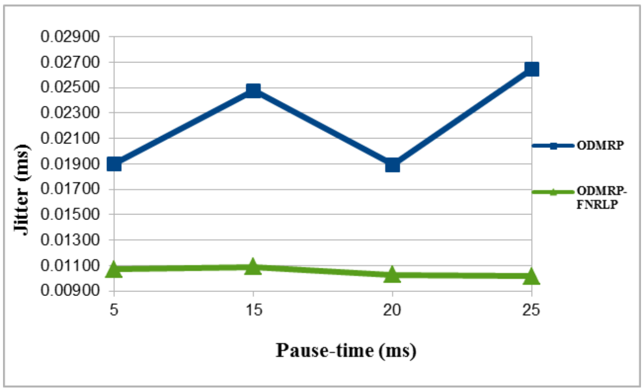

Figure 3(e). Pause Time Vs. Jitter

Table.4 shows the performance metrics fields against the varying simulation time scenario. The long simulation time is considered for stability of the proposed protocol. The fig. 4(a), 4(b), 4(c), 4(d), 4(e) shows the ODMRP-FNRLP's performance.

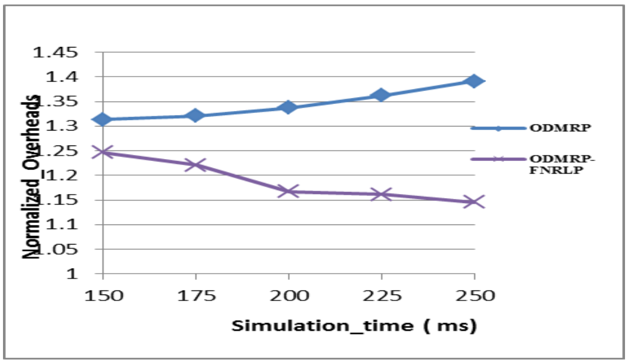

Figure 4(a). Simulation Time Vs Normalized overhead

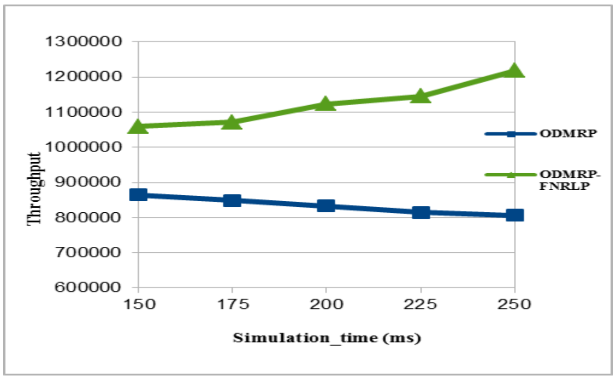

Figure 4(b). Simulation Time Vs Throughput

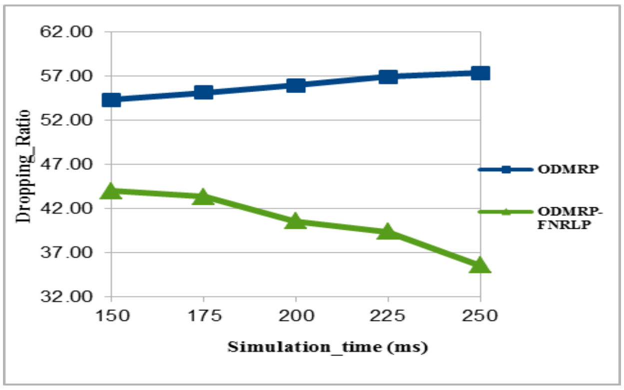

Figure 4(c). Simulation Time Vs. Normalized overhead

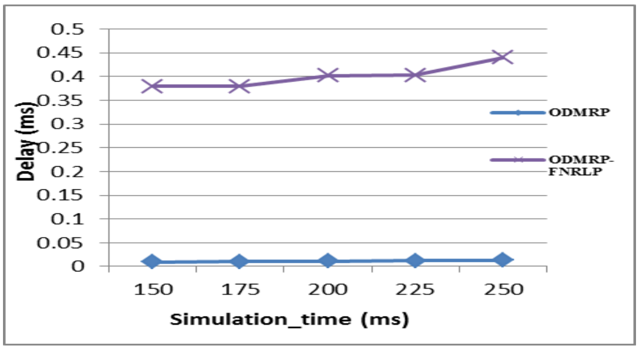

Figure 4(d). Simulation Time Vs. Throughput

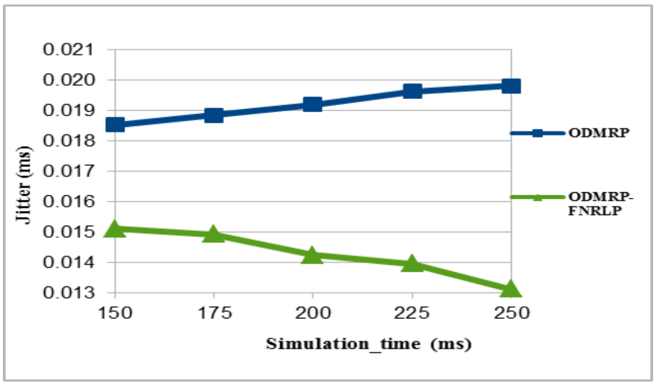

Figure 4(e). Simulation Time Vs. Jitter

Table.5 shows the performance metrics fields against the varying nodes' speed scenario. This speed consideration makes frequent topology changes. The fig. 5(a), 5(b), 5(c), 5(d) and 5(e) show that the ODMRP-FNRLP has better performance than ODMRP.

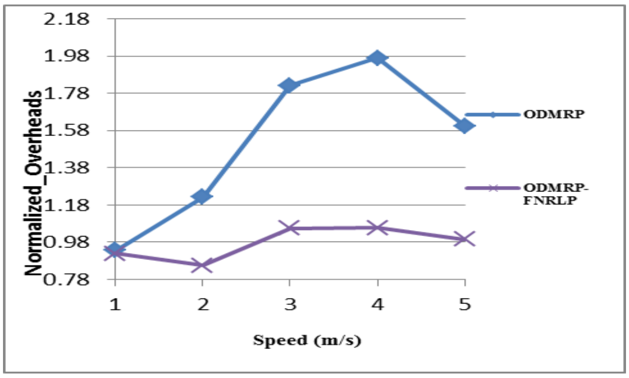

Figure 5(a). Speed Vs Normalized overhead

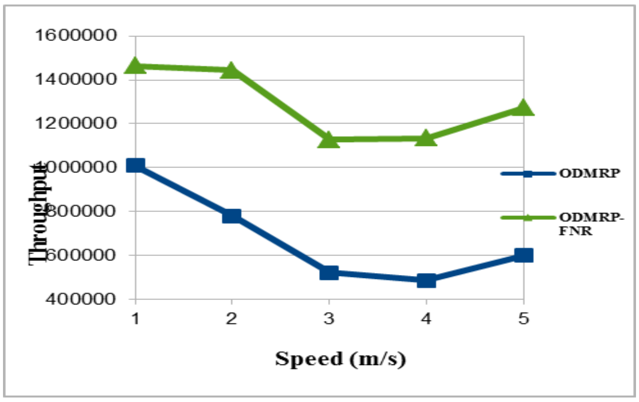

Figure 5(b). Speed Vs Throughput

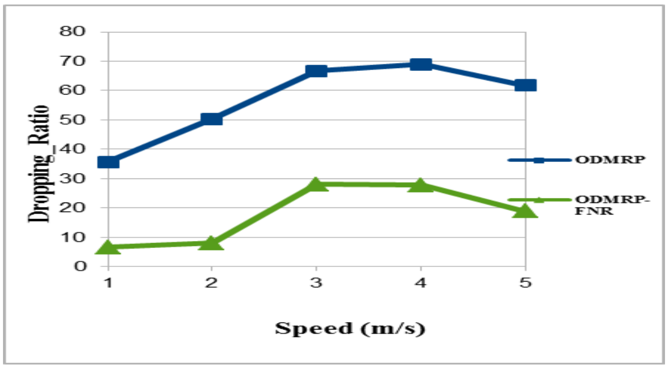

Figure 5(c). Speed Vs Dropping Ratio

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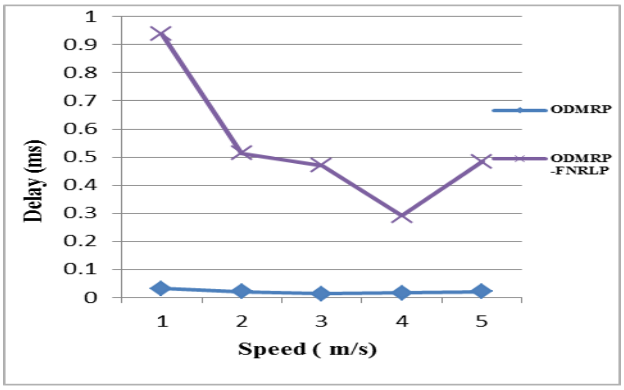

Figure 5(d). Speed Vs Delay

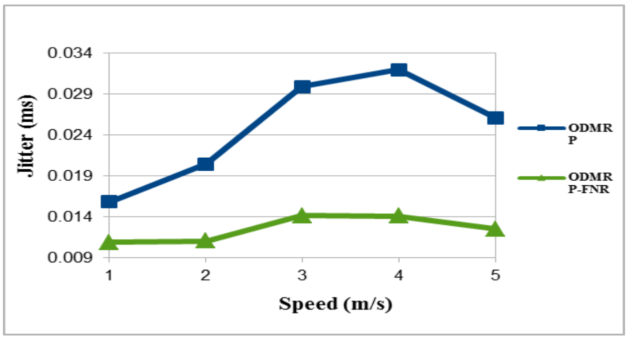

Figure 5(e). Speed Vs Jitter

Table.6 shows the performance metrics fields against the varying packet size scenario. The fig. 6(a), 6(b), 6(c), 6(d) and 6(e) shows the ODMRP-FNRLP's performance against heavy packet size.

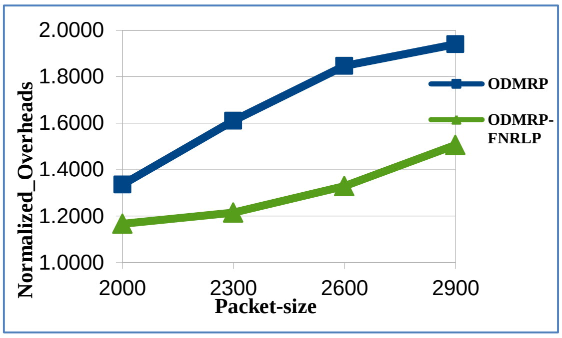

Figure 6(b). Packet size Vs Normalized Overhead

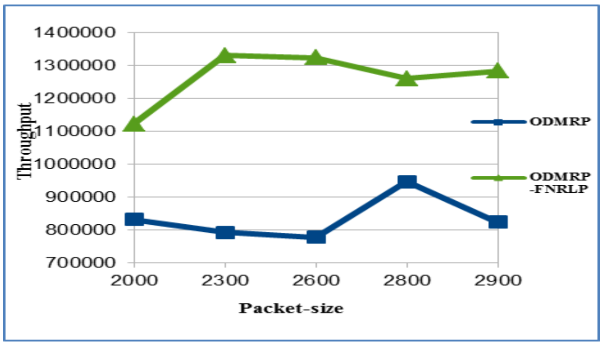

Figure 6(b). Packet size Vs Throughput

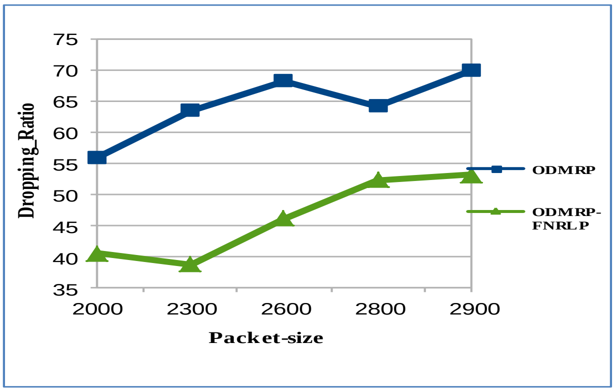

Figure 6(c). Packet size Vs Dropping Ratio

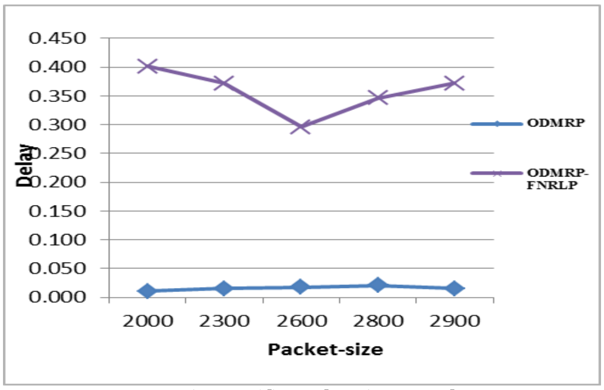

Figure 6(d). Packet size Vs Delay

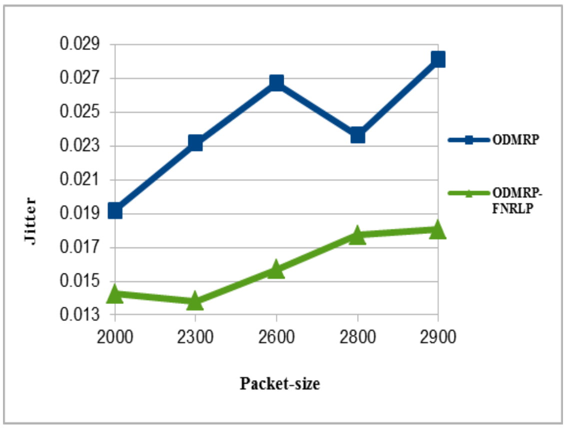

Figure 6(e). Packet size Vs. Jitter

V. Conclusion

The overhead in routing protocols determines its efficiency. Usually, mesh-based multicast routing protocols have more overhead than tree-based routing protocols. The proposed ODMRP-FNRLP reduces overheads with minimal routes to the receivers and minimal control messages for route maintenance. It reduces latency time between source and receivers. It prevents the collisions among forwarding nodes. It also provides the high packet delivery ratio and low normalized overhead in the routing process. The frequent topology changes and link breaks due to mobility speed are handled in setting the route refresh-time and forwarding group

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time-out by the ODMRP-FNRLP. So this proposed protocol has the low normalized overhead in high mobility scenario. When the mobility is high, the routes are frequently broken, and the prediction algorithm is applied to find alternative routes and update the forwarding group nodes. The alternative routes are usually longer than the old ones. Thus, the data packets take more time to reach their destinations. Also, the increase of the speed in the proposed schemes yields more control packets; therefore, congestion and collisions are more likely to happen due to the limited bandwidth, which means an increase in the end-to-end delay.This protocol is well suited for high-speed mobility environment. This protocol has more forwarding efficiency than the other protocols when the size of the multicast group in the network is increased. For the further work, we will think through energy level of forwarding nodes while creating the mesh structure to avoid delay due to alternate paths forwarding.

VI. References

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Table.1. Performance comparison of ODMRP and ODMRP-FNRLP with respect to number nodes in the network

No. of nodes	ODMRP					ODMRP-FNRLP				
	Normalized overhead	Throughput	Dropping ratio	Delay	Jitter	Normalized overhead	Throughput	Dropping ratio	Delay	Jitter
60	1.3740	831556	56.0046	0.010980	0.01878	1.1688	1152360	39.0320	0.401947	0.01425
70	1.7470	764889	65.3967	0.013279	0.02101	1.4468	1163290	47.3733	0.340580	0.01412
80	1.9150	827556	67.3007	0.018667	0.01935	1.4289	1401330	44.6290	0.509569	0.01172
90	1.9450	1296000	54.5449	0.069130	0.01703	1.4500	1630220	42.8226	0.499789	0.01101
100	1.9855	965689	69.5512	0.015764	0.01673	1.5587	1523470	51.9641	0.274805	0.01078

Table.2. Performance comparison of ODMRP and ODMRP-FNRLP with respect to refresh interval time in the network

Interval Time(ms)	ODMRP					ODMRP-FNRLP				
	Normalized overhead	Throughput	Dropping ratio	Delay	Jitter	Normalized overhead	Throughput	Dropping ratio	Delay	Jitter
0.15	1.3925	822400	67.3577	0.011622	0.019540	1.1986	1100270	56.3288	0.172333	0.014933
0.20	1.3740	831556	56.0046	0.010980	0.018785	1.1688	1152360	39.0320	0.401947	0.014254
0.25	1.6723	702146	57.2862	0.008633	0.022955	1.2891	1142930	30.4717	0.281464	0.014381
0.30	1.8826	604138	53.6764	0.005243	0.026542	1.3437	993192	23.8448	0.358473	0.016549

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Table.3. Performance comparison of ODMRP and ODMRP-FNRLP with respect to refresh interval time in the network

Pause-time (ms)	ODMRP					ODMRP-FNRLP				
	Normalized overhead	Throughput	Dropping ratio	Delay	Jitter	Normalized overhead	Throughput	Dropping ratio	Delay	Jitter
5	1.135460	841427	46.3955	0.027489	0.0189916	1.113244	1492320	4.9290	0.512973	0.0107095
15	1.545760	645968	58.8476	0.019205	0.0247361	1.078760	1464910	6.6756	0.556409	0.0109070
20	1.143656	844195	46.2192	0.014751	0.0189323	0.845460	1555030	0.9345	0.717096	0.0102776
25	0.867870	1169380	25.5025	0.028132	0.0264567	0.830238	1516630	3.3808	0.830238	0.0101566

Table.4. Performance comparison of ODMRP and ODMRP-FNRLP with respect to simulation time in the network

Simulation time (s)	ODMRP					ODMRP-FNRLP				
	Normalized overhead	Throughput	Dropping ratio	Delay	Jitter	Normalized overhead	Throughput	Dropping ratio	Delay	Jitter
150	1.31296	863976	54.3063	0.009194	0.0185176	1.24605	1058870	43.9987	0.379025	0.0151079
175	1.32048	848100	55.1355	0.010407	0.0188408	1.22112	1070900	43.3494	0.379042	0.0149215
200	1.33732	832519	55.9523	0.010982	0.0191977	1.16691	1122850	40.5910	0.401653	0.0142334
225	1.36161	814552	56.8974	0.012434	0.0196238	1.16153	1145680	39.3757	0.403088	0.0139518
250	1.39123	806128	57.3389	0.012687	0.0198159	1.14567	1217630	35.5615	0.440067	0.0131286

Table.5. Performance comparison of ODMRP and ODMRP-FNRLP with respect to various nodes' speed in the network

Speed	ODMRP					ODMRP-FNRLP				
	Normalized overhead	Throughput	Dropping ratio	Delay	Jitter	Normalized overhead	Throughput	Dropping ratio	Delay	Jitter
1	0.93615	1009040	35.7176	0.031688	0.015838	0.91834	1464650	6.6922	0.937856	0.010911
2	1.22328	780108	50.3019	0.020326	0.020487	0.85437	1443110	8.0641	0.512942	0.011075
3	1.82100	522292	66.7265	0.012832	0.029931	1.05410	1128650	28.0976	0.470397	0.014160
4	1.96891	486832	68.9855	0.016212	0.031962	1.05794	1134530	27.7229	0.289973	0.014086
5	1.60328	600822	61.7237	0.020961	0.026130	0.99572	1272300	18.9459	0.483500	0.012561

Table.6. Performance comparison of ODMRP and ODMRP-FNRLP with respect to packet size in the network

Packet size(bits)	ODMRP					ODMRP-FNRLP				
	Normalized overhead	Throughput	Dropping ratio	Delay	Jitter	Normalized overhead	Throughput	Dropping ratio	Delay	Jitter
2000	1.3358	832519	55.9523	0.010982	0.0191977	1.1667	1122850	40.5910	0.401653	0.0142334
2300	1.6103	793885	63.4751	0.015554	0.0231476	1.2147	1331070	38.7607	0.371629	0.0138079
2600	1.8457	778370	68.3210	0.017764	0.0266931	1.3283	1324570	46.0913	0.296275	0.0156849
2900	1.9399	824666	69.9088	0.014989	0.0281019	1.5057	1283780	53.1565	0.371804	0.0180501