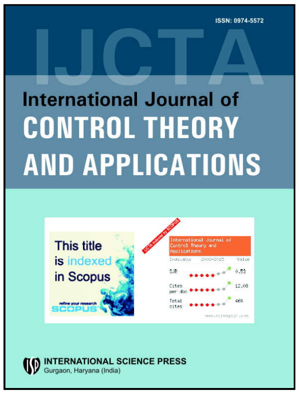

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Performance Evaluation of MOSPF, ODMRP, DVMRP and MAODVAd-Hoc Routing Protocols

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Abstract: A mobile ad-hoc network (MANET) is a dynamic network of autonomous mobile devices with capability to rearrange themselves in a number of ways without any wired infrastructure. MANET presents a very challenging task – the design of a multicast routing protocol to achieve efficient dissemination of multicast data over the network. A number of routing protocols for MANETs have been proposed and evaluated for their performances. In this paper, we plan to analyze and evaluate the performance of MOSPF, ODMRP, DVMRP, and MAODV protocols. The parameters we used for evaluating performances are: packet delivery ratio, throughput, average end-to-end delay, and average jitter. We evaluate the effect of multicast group size on these parameters using extensive simulations.

Keywords: MANET,MOSPF,DVMRP,ODMRP,MAODV

1. INTRODUCTION

A mobile ad-hoc network (MANET) is a dynamic, self-reconfigurable network of free or autonomous mobile nodes with either direct or indirect wireless communication between the nodes via radio waves. These mobile devices have the license to arrange themselves in a number of ways since the MANET is an infrastructure-less wireless network. The devices move arbitrarily and function as both a host and a router as well, at the same time. The limit imposed on range of radio signals of wireless nodes causes a node to function as a router for those two communicating nodes which are not in direct contact/radio range. Some infrastructure less scenarios like rescue operations, military combat, calamity management, teleconferencing, etc. make use of the MANET.

In a MANET, what is more challenging is the designing of multicast routing protocols used to efficiently disseminate the multicast data over the multi-hop wireless networks. Routing is said to be the process of moving data packets transmitted from a source node to a destination node via a route, and this routing is governed by the routing protocols that specify the communication between the routers. Routing protocols in MANET can be broadly classified into two general categories called as proactive and reactive routing protocols [15], based on how the routing information is being updated among the mobile nodes. In proactive routing, all available routes are evaluated by each node and a table is maintained with the information about the network topology by every node irrespective of their use at a particular time. Therefore, a route towards the intended destination can be discovered instantly by the source node. While in reactive routing, a route discovery takes place whenever there is a necessity of exchange of information between two nodes [1]. It lowers the burden on the network as the routes which are currently being used are maintained. MAODV and ODMRP are examples of reactive routing and MOSPF, DVMRP and AMRoute are some examples of proactive routing. Figure 1 depicts a typical classification of multicast routing protocols in Mobile Ad-hoc Networks.

In this paper, we plan to analyze and study the performances of various multicast routing protocols such as MOSPF, DVMRP, ODMRP and MAODV based on certain QoS metrics using Qualnet simulator. Certain QoS metrics are identified and a simulation scenario is designed over which the evaluation is carried out and performances of multicast routing protocols are compared.

The rest of the paper is organized as follows. Section II contains the description of the multicast protocols in MANET selected for evaluation. We have discussed the research works that have been carried out in the past, in section III. In section IV, we describe the QoS service metrics and discuss our scenarios for simulation, followed by the results and its discussions in section V. The last section presents the conclusion of our work.

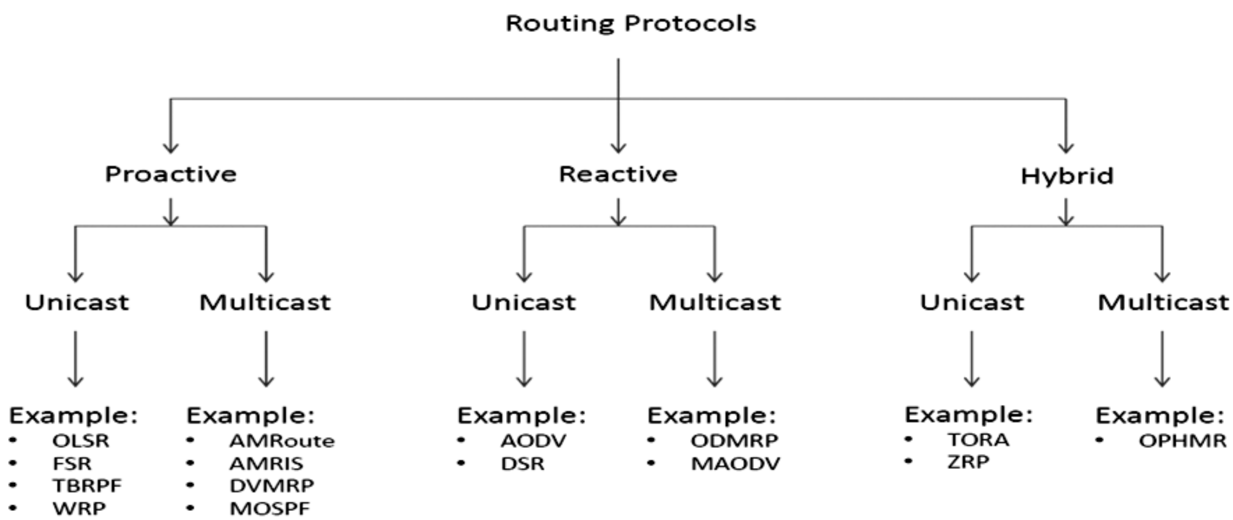

Figure 1: Classification of Routing Protocols for MANET

2. INTRODUCTION TO MULTICAST ROUTING PROTOCOLS

This section includes a concise introduction to the routing mechanism that the protocols MOSPF, DVMRP, ODMRP and MAODV make use of.

2.1. Multicast Open shortest Path First protocol (MOSPF)

It is a multicast add-on to the unicast OSPF (Open Shortest Path First) routing protocol that provide an efficacious multicasting in the network. Link state advertisement protocol is the basis of MOSPF. Every router in MOSPF uses IGMP (Interior gateway Multicast Protocol) to maintain the record of nodes, groups and the position of group members. By flooding of OSPF LSAs, the group information is transmitted in the network. Routers build the shortest path tree using this information and Dijkstra's algorithm [2]. For each source-destination group pair, a separate shortest path is constructed. A faster network convergence can be achieved using MOSPF than DVMRP. However, it involves heavy computation at each router that leads to high computational cost.

2.2. Distance Vector Multicast Routing Protocol (DVMRP)

It is a distance-vector routing algorithm based multicast protocol in which a route table with all those destinations which are reachable is maintained by each router. Address of destination, hop count or distance and the next hop to reach the destination are the entries to the route table. A periodic exchange of route table takes place with immediate neighbors in order to obtain the latest routing information by a router. Each exchange results in the computation of shortest paths by routers and updating of current new information to the routing table. For one and all multicast group, a multicast tree is created by the routing information distributed among the routers. Whenever there is an introduction of a new router in the network, the multicast streams, and the new router get the route table information of the neighboring nodes. The router has to send a prune message to leave a multicast session.

2.3. On-Demand Multicast Routing Protocol (ODMRP)

ODMRP is an on-demand mesh based strategy in which a group of forwarding nodes forms a mesh. The data packets are forwarded by these nodes between the source and destination, keeping a message cache to detect the duplicity of data and control packets. There is no need to send any distinct or explicit control message in order to join or leave a group as it uses the soft approach. Two control packets: *JoinReq* and *JoinReply* are used to establish the multicast group forwarding mesh [3]. The sender has to periodically flood the network with a *JoinReq* control message whenever it has information to send. A *JoinReply* control message is what the receivers send through the shortest reverse path in response to the sender's request. An intermediate node becomes a forwarding group member by setting a forwarding flag on receiving a *JoinReply* message. ODMRP has high robustness, minimal data packet loss and low channel and storage overhead, but at the same time, it suffers from higher control overhead and low efficiency of multicast group because of multiple transmissions of same data packets. Figure 2 shows the formation of a mesh in ODMRP protocol.

2.4. Multicast Ad-Hoc On-Demand Distance Vector Routing protocol (MAODV)

The tree based multicast routing protocol MAODV is a multicast extension of AODV [4]. In MAODV, for a multicast group, a group tree is created and the same is shared by all sources and receivers. The multicast group

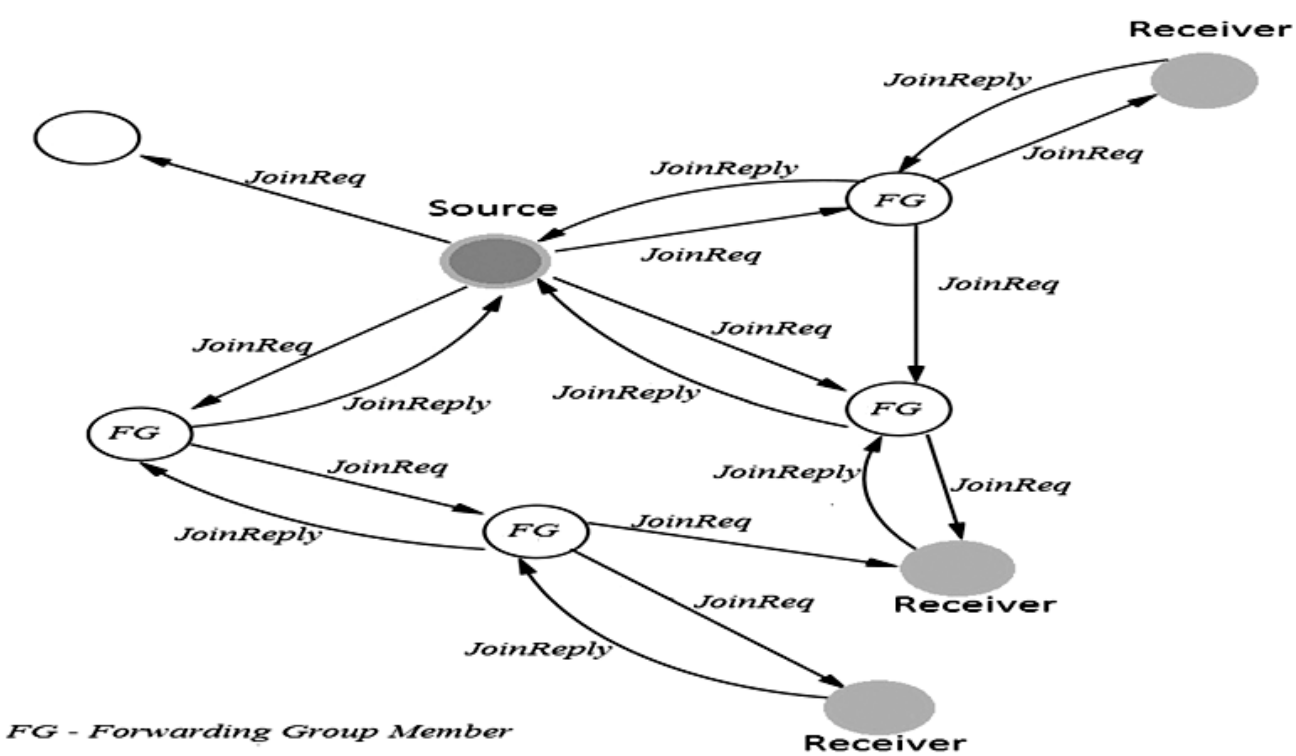

Figure 2: Mesh Formation in ODMRP

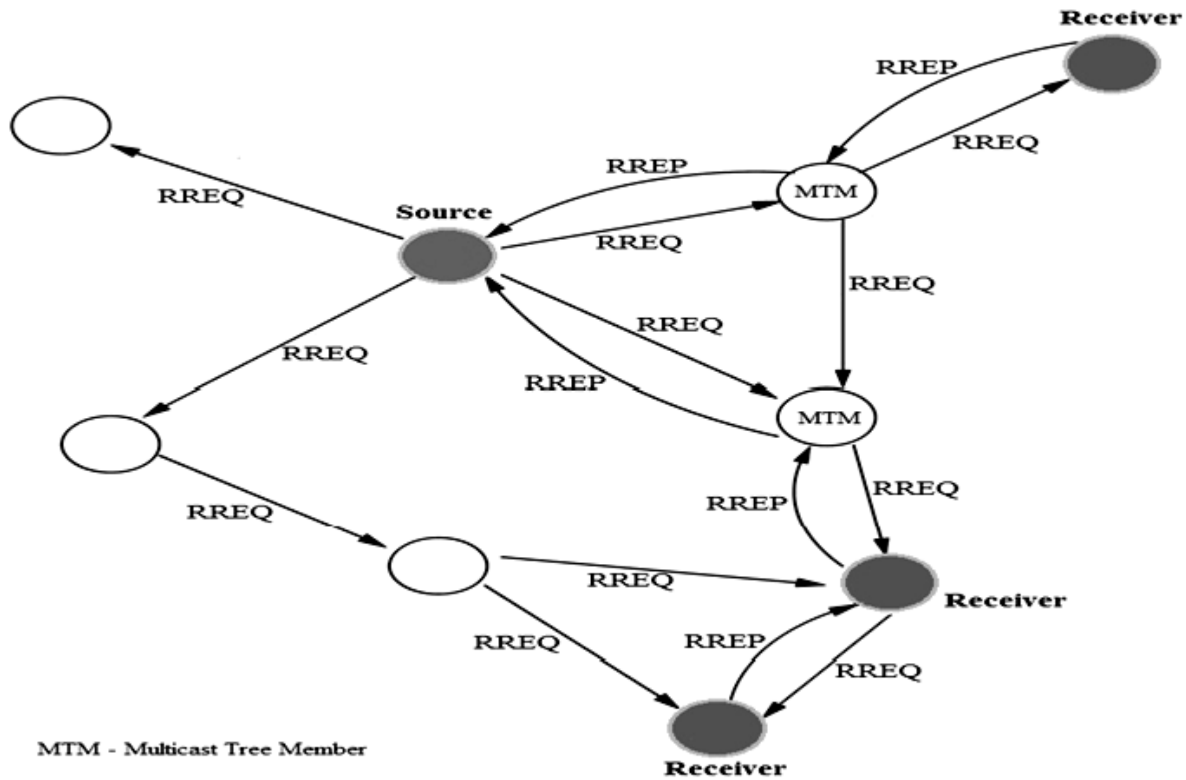

Figure 3: Tree Formation in MAODV

sequence number is maintained by the group leader which essentially is the first member or the root of the group tree and it also update the change, to the other nodes, with group hellos (GRPHs). Multicast route discovery takes place on demand by making use of a broadcast route-discovery mechanism, and sequence numbers are useful in finding the most recent routes. A *route request* (RREQ) message is broadcasted by a mobile node in order to join a multicast group. It gets a *route reply* (RREP) message as a response from either the group leader or an intermediate node of the multicast tree with a current route to the group leader. The freshest sequence number or the least hop count in case of identical sequence number are the criteria to choose a route if there are multiple reply messages to the source for its route request. Multicast state between the shared tree and the newly joined receiver is set up by a control message *multicast activation* (MACT) sent by the source node. The HELLO packets are periodically broadcasted by each node to detect the broken links in the network. Figure 3 shows the formation of a tree in MAODV protocol.

3. RELATED WORK

The highly dynamic topological nature of MANET brings some serious challenging tasks. Various routing protocols have been proposed for MANET with the goal to find a reliable path for data transfer among the nodes with optimized consumption of resources and reduced transmission overhead. The on-demand route discovery process and avoidance of unnecessary routing updates make the reactive routing protocols more efficient than proactive routing protocols.

Several research studies have been carried out in context to compare the routing protocols in mobile ad-hoc networks. These performance comparisons of multicast routing protocols give an idea about their behavior and effectiveness. A relatively earliest comparison of multicast protocols namely ODMRP,AMRoute, CAMP, AMRIS and flooding is presented by [5] using simulator GloMoSim. He has taken into consideration the metrics packet delivery ratio (PDR), number of control and data packets as well as number of data packets broadcasted per data packets delivered, and the number of control bytes transmitted per data byte delivered for evaluation by varying the number of senders, multicast group size, mobility rate and the network traffic load, concluding that mesh based protocols has the upper hand over tree based protocols in mobile networks. Three challenges in MANET namely contention, congestion and connectivity must be dealt effectively by the multicast routing protocols [6]. The paper compares protocols such as DSR, AODV and TORA for their routing performances.

A different approach of comparison is taken in [7]. The authors have taken into account the protocols MAODV, ODMRP, MOSPF and PIM for performance comparison through the metrics throughput, packet delivery ratio and E2E (end-to-end) delay for different values of the parameters group size receivers, mobility, and traffic source using Qualnet 5.0.2 simulator. Their results conclude that an ODMRP multicast protocol is best among all.

Another evaluation approach is taken in [8] for protocols ADMR, ODMRP and SRMP on NS2 simulator. They have presented a view on the efficiency of SRMP in comparison to other protocols through the perspective of energy consumption on the basis of metrics they have considered for evaluation, PDR, E2E (end-to-end) delay and control overhead. In [9], the authorshave evaluated the performance of ODMRP and ADMR multicast protocol under non-identical mobility models like RWP (Random Way Point) model, Manhattan model and RD (Random Drunken) model. Results show that in the high mobility scenario, ADMR maintains good throughput in comparison to ODMRP. However, under different mobility model, ADMR has increased delay and transmission overhead. ODMRP performs better under Random Way Point model as compared with other mobility models.

In [10], author evaluated the impact of the change in the number of sources, the number of receivers and number of nodes on the performance of protocols MAODV, AMRIS, and ODMRP and suggest that MAODV performs better than ODMRP in terms of packet delivery ratio with increasing group number size. While incrementing the number of senders from 0 to 20, we found better effectiveness of ODMRP than MAODV in terms of packet delivery ratio.

The author presents an evaluation study of performances of protocols MAODV and ODMRP in the context of varying node density, multicast group size, a number of senders and node mobility for metrics packet delivery ratio, average end-to-end delay, throughput, and routing overhead in [11]. With an increase in each of the above parameter, the average end-to-end delay and routing overhead increase while the packet delivery ratio decreases for both MAODV as well as ODMRP. The throughput increases with an increase in all parameters except for node mobility. Overall, MAODV performs better than ODMRP in the case when CBR data and video are taken together as multimedia traffic. For CBR data traffic, ODMRP has higher packet delivery ratio and routing overhead than MAODV.

In [12], the author compared MAODV, DVMRP and Gossip protocol using GloMoSim tool for the impact of the number of nodes, transmission range and mobility of nodes on metrics packet delivery ratio and average end-to-end delay. They conclude that ODMRP has a poor packet delivery ratio, but better stability and lower average end-to-end delay. MAODV is better suitable in lower mobility scenarios.

The author evaluated the performance of ODMRP, MOSPF and PIM-DM over various metrics like PDR, Avg. end-to-end delay and throughput with respect to a change in parameters like mobility speed, node placement, and traffic load in [13]. ODMRP shows better performance with low packet loss, a lower average end to end delay, high PDR, and throughput than other protocols.

The performance of ODMRP and FRRM multicast protocol is evaluated in [14]. The parameters for performance evaluation are throughput, energy consumption, and PDR. They observed that energy consumption in case of FRRM is less than ODMRP and so is the PDR but has higher throughput. Therefore, FRRM is much better protocol than ODMRP.

This research work compares the performances of multicasting routing protocols such as MOSPF, DVMRP, ODMRP and MAODV by varying multicast group size and evaluating its effect on performance metrics like packet delivery ratio, throughput, end to end delay and average jitter using Qualnet 6.1 simulator.

4. PERFORMANCE METRICS AND SIMULATION SCENARIOS

4.1. Performance Metrics

In this paper, our overall goal is to evaluate and analyze the performances of MOSPF, DVMRP, ODMRP and MAODV multicast routing protocols through a simulation results. For the purpose of evaluating performances of routing protocols, we have considered following metrics.

4.1.1. Packet Delivery Ratio (PDR)

It is a quantitative metric which tells about the effectiveness of a protocol. Higher packet delivery ratio represents a better performance. We define the packet delivery ratio as a fraction of the total number of multicast packets received having unique ID at the receiver to the number of total multicast packets broadcasted by the multicast source.The expression for PDR can be given by:

$$PDR = \frac{P_{U_R}}{\sum P_S} \tag{1}$$

Where, P_{U_R} and P_S are the number of unique multicast packets received at receiver and number of total multicast packets broadcasted by the source respectively.

4.1.2. Throughput

Throughput may be defined as the total amount of data packets delivered successfully from a source to the destination over a period of time. Usually, bits/second is used to measure throughput. For better performance, throughput should be high. It is given by:

$$Throughput = \frac{\sum P_R}{\left(T_S - T_E\right)} \tag{2}$$

Where, P_S, T_S, and T_E are the number of packets received at receiver, start time and end time of transmission respectively.

4.1.3. Average End-to-End Delay

End to end delay refers to how long it took for a data packet to be transmitted across a network from a source node to a destination node [17]. The unit of measurement is seconds and it is better to have a lower average end-to-end delay for better performance. The expression for the average end-to-end delay is given by:

$$Avg.\ End\ to\ End\ Delay = \frac{\sum_{t=1}^{N}\left(R_t - S_t\right)}{N} \tag{3}$$

Where, R_t, S_t, and N are the time when t^{th} data packet was received, time when t^{th} data packet was sent and total number of received multicast data packets.

4.1.4. Average Jitter

Jitter is defined as a variation in the delay of received multicast data packets [16]. It is measured in seconds. For better performance, the value of jitter needs to be low. It is given as:

$$Avg.\ Jitter = \frac{\sum_{t=1}^{N}\left(EED_t - EED_{t-1}\right)}{N} \tag{4}$$

Where, EED_t, EED_{t-1}, and N are t^{th} packet's end-to-end delay, packet's $(t-1)^{th}$ end-to-end delay and total number of received multicast data packets.

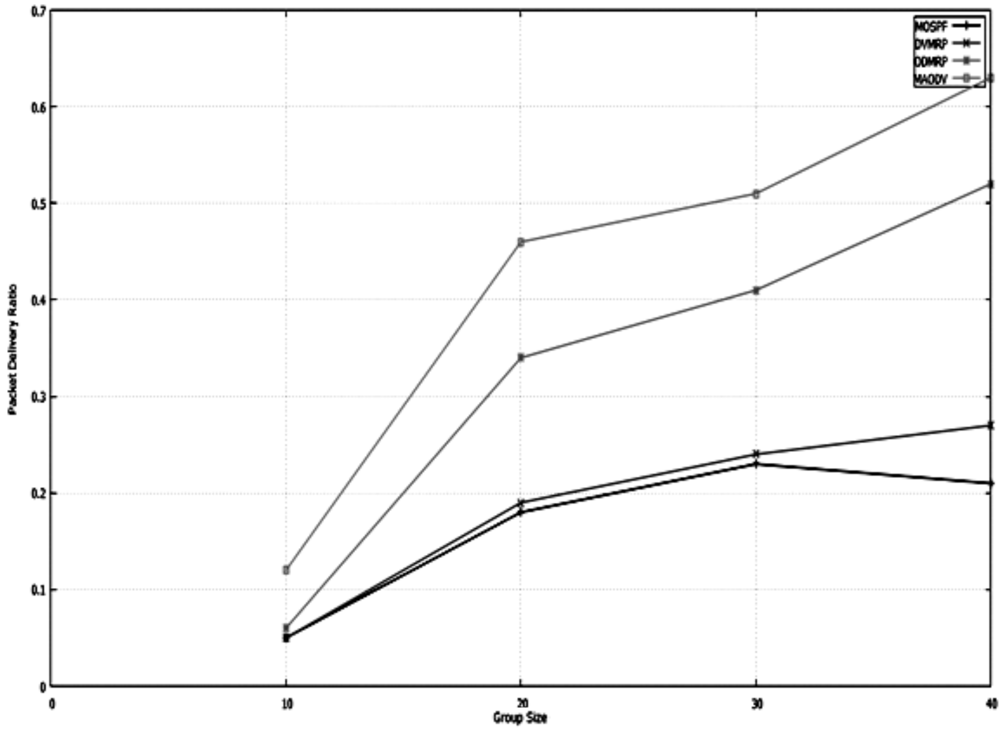

Figure 4: PDR versus group size (multicast)

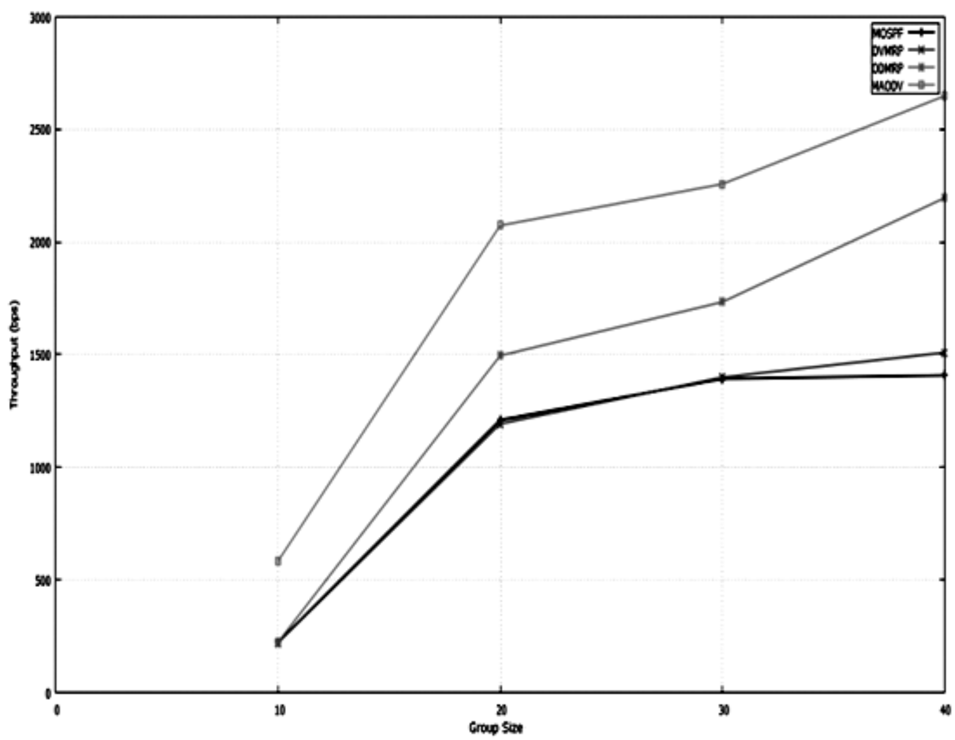

Figure 5: Throughput versus group size (multicast)

4.2. Simulation Scenario

The evaluation experiment is carried out using the network simulator Qualnet 6.1 with the overall goal of analyzing the impact of multicast group size on the performances of multicast protocols discussed above.

We have taken the terrain dimension as 1500m × 1500m area. Each simulation experiment is done for 200 seconds and the number of packets to be sent is 200 with a packet size of 512 bytes. The packet interval time is 1ms and the data transmission rate for broadcast is 2 Mbps with random node placement model. Multicast Continuous Bit Rate (MCBR) traffic is the main source of traffic in the simulation. The simulation is done over Random Way Point mobility model with a mobility speed of 25-150mps. Each multicast group has one sender and the multicast group size varies from 10-40 nodes.

5. RESULT AND DISCUSSION

The simulation is done using Qualnet 6.1. This section presents the results of performance comparisons of routing protocols MOSPF, DVMRP, ODMRP and MAODV based on the simulation. The protocols are evaluated for various performance metrics as a function of multicast group size.

5.1. Packet Delivery Ratio

The result shown in figure 4 shows the behavior of the simulated protocols in terms of the size of the multicast group on the PDR.The result shows a gradual increase in the PDR as the size of multicast group increases. The observed behavior is because while increasing the size of the multicast group there would be chances of more link establishment as a result of lesser time in route discovery. With an increase in group size, MAODV posses highest packet delivery ratio in comparison to other protocols while MOSPF performs poorer than others.

5.2. Throughput

Throughput as a function of the size of the multicast group for variously discussed protocols is shown in figure 5. The result shows a gradual increase in throughput as the group size increases, and it may happen as a result of increased probability of finding a node for route discovery with an increase in the size of the multicast group. With an increase in group size, MAODV results in higher throughput as compared to other protocols while MOSPF performs poorer than others.

5.3. Average End-to-End Delay

Average end-to-end delay as a function of the size of the multicast group for variously discussed protocols is shown in figure 6.We can see a gradual increase in average end-to-end delay for MOSPF, DVMRP and ODMRP as the group size increases while for MAODV, it first increases and then decreases. With an increase in the multicast group size more and more traffic is emitted into the network, which causes an increase in queuing and propagation delay. Because of this, overall delay increases. We can see from the result that MAODV has the highest average end to end delay and it is because of its topology which causes the excessive processing delay.

5.4. Average Jitter

Average jitter as a function of multicast group size for variously discussed protocols is shown in figure 7. The result shows a gradual increase in average jitter as the size of multicast group increases. The possible reason is that as the size of multicast group increases, the average end-to-end delay also increases. Average jitter is represented by the variations in the end to end packet delays, so it also increases with an increase in group size.

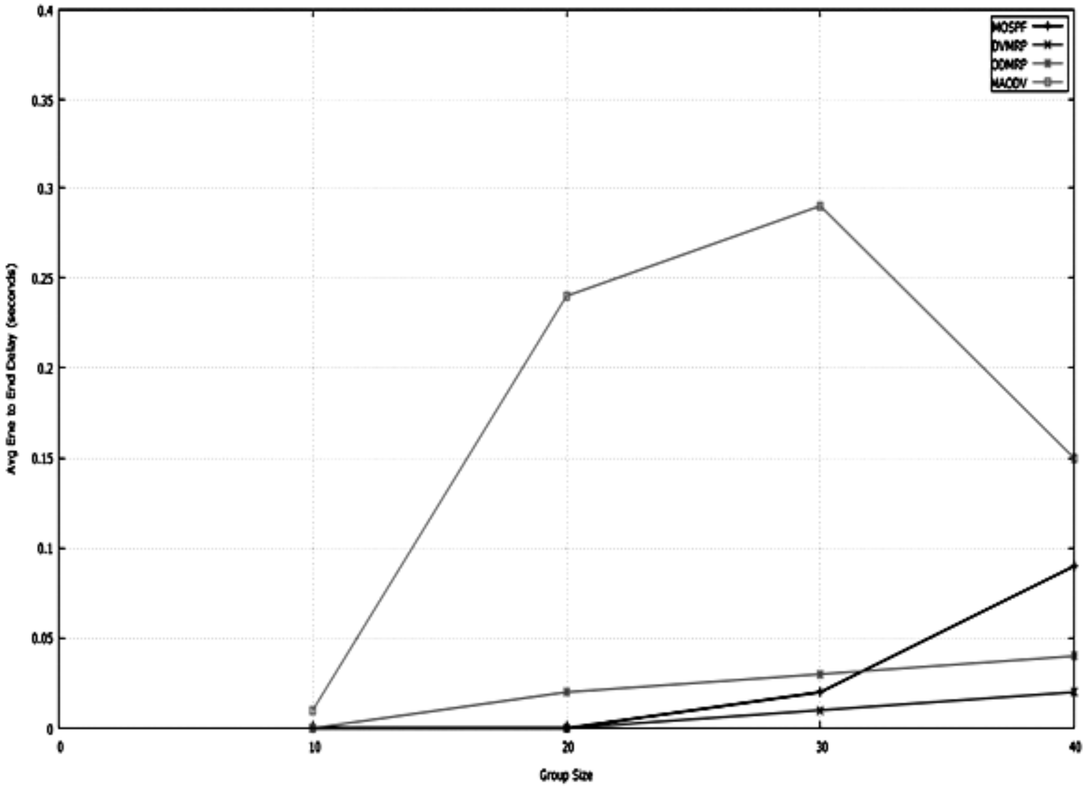

Figure 6: Average end-to-end delay versus group size (multicast)

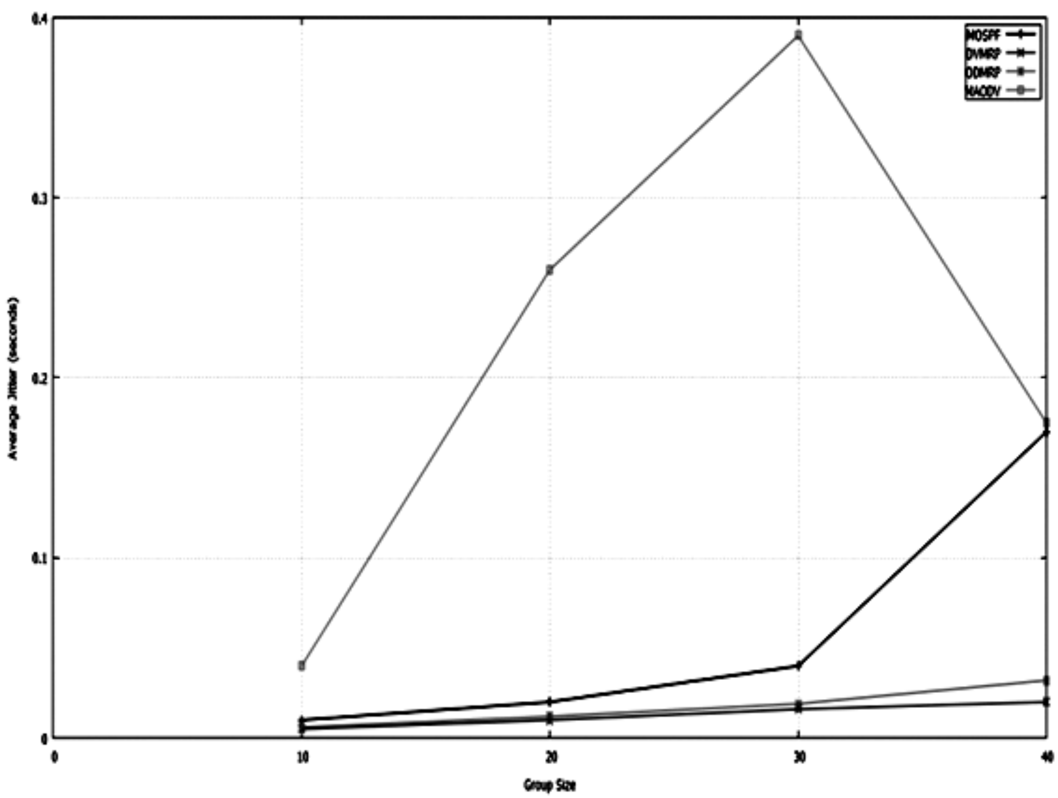

Figure 7: Average jitter versus group size (multicast)

6. CONCLUSION

In this paper, we evaluate the behavior of multicast routing protocols. The contributions made in this paper are as follows.

- We analyze the performance of MOSPF, ODMRP, DVMRP, and MAODV protocols.
- The parameters we focused for the evaluation of the performancesare: packet delivery ratio, throughput, average end-to-end delay, and average jitter.
- The maximum and minimum packet delivery ratio are achieved by MAODV and MOSPF respectively. The ODMRP is second to MAODV.
- The maximum and minimum throughput are achieved by MAODV and MOSPF respectively. The ODMRP is second to MAODV.
- The maximum and minimum average end-to-end delay are achieved by MAODV and DVMRP respectively. The ODMRP is second to DVMRP.
- The maximum and minimum average jitters are achieved by MAODV and DVMRP respectively. The ODMRP is second to DVMRP.

By analyzing the results, we conclude that the overall performance of ODMRP is better than the rest of the protocols.

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