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AN EFFICIENT ROUTING PROTOCOL FOR SHORTEST PATH SELECTION IN MOBILE ADHOC NETWORKS [1]

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Abstract

Mobile Adhoc Network (MANET) helps us in setting up a network of mobile nodes like laptop, smart phones, tablet etc. without the need of any infrastructure. We can develop a temporary network in the battle field, forest, hilly area, meeting rooms, disaster area etc. The nodes in this network can move freely and change their position and thus the topology of the network at any time. Nodes are battery operated and resource constrained. MANET uses wireless media for data communication. In this paper we proposed an efficient routing protocol for shortest path selection in mobile Adhoc networks and that is simulated with other protocols on the basis of throughput, packet loss and end to end delay.

Keywords: Routing Protocols, NS-2, MANET.

Introduction

The wireless network is a network setup which uses radio frequency signals for communication among nodes of network Perkins (CE, Bhagat P(1994) It can be a Wi-Fi network, a wireless LAN, a Mobile Ad hoc network (MANET) or a Vehicular Ad hoc network (VANET). Nowadays the wireless ad hoc networks are getting popular for setting up network in laboratories, meeting rooms, hostel building etc. as they are easy to setup and no cabling or pres existing infrastructure is involved Pravin (R. Satav,2018) The battery operated nodes like laptop, tablet, smart phone etc. can be both an end system as well as a router in such network.

Routing in MANET

Routing is one of very important basic operations of any network (Perkins CE, Bhagat P,1994), Routing is a process of searching a path for a packet on which it travels to reach from its source to destination. Routing techniques are designed based on the architecture and characteristics of the network (Abolhasan, Hagelstein and Wang, 2009)Mobile adhoc network are wireless network with all or some mobile nodes. MANET doesn't have any wireless router or access point. Each node acts as a router to send or receive data packets to or from the other nodes. In a MANET, the node uses multihop routing for communication. The following unique characteristics of the mobile adhoc network make routing very challenging:

1. Asymmetric links: In MANET, the radio signals are used as a communication media. Two nodes can communicate with each other through radio signal. The wireless link between two nodes is not always bidirectional. Meaning, if a node A sends data to node B, it is not always necessary that node B can also send data to node A. This is due to the moving nature of the mobile nodes that breaks the communication link in-between. Due to such link routing will be very difficult (Pravin R. Satav, 2018)

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2. Low bandwidth: The wireless channels use for MANET is low bandwidth channels. They are also shared by all nodes. The routing should be designed in such a way that it will add minimum routing overhead and spare more bandwidth for data transmission (.Pravin R. Satav.,2018)

3. Resource constrained nodes: The nodes in MANET are battery operated. To ensure long life of the node, Routing protocol should be energy efficient.

4. Dynamically changing topology: It is a major problem while designing routing protocols for MANET. As the network topology constantly changing with time it is very difficult to update routing table or link information frequently without introducing network traffic or computing overhead.

5. Interference: Due to usage of wireless media, one transmission may affect or interfere other transmission in the same radio range. The nodes within same radio range can overhear the communication of each other. This should be taken care while designing routing protocols for security reasons (Abolhasan, Hagelstein and Wang, 2009)

The all routing protocols designed for MANET are mainly classified into two broad categories: proactive routing protocols, and reactive routing protocol (shown in following figure 1)

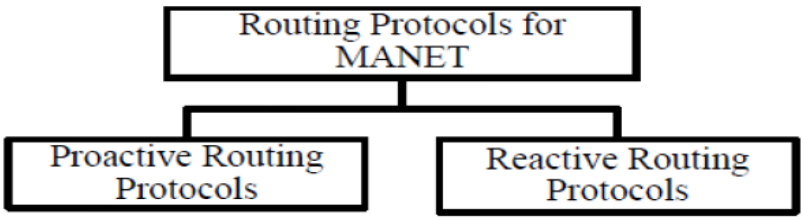
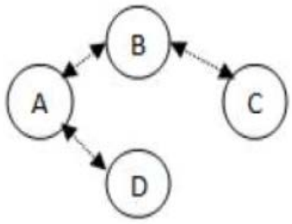


Figure 1 MANET Routing Protocols

2.Proactive Routing Protocols: It is a table driven routing protocol. Proactive routing protocols maintain precise information about routes in routing table on each node. It tries to evaluate all existing routes in a network and continuously update the routing table accordingly. Each node maintains up to date information towards all destinations and periodically broadcast this information to the entire network (Johnson, Maltz and Broch, 2001). In this type of protocol when source node has data to send to any destination, route to that destination already found in its routing table and can immediately be used. This makes data transmission fast. For maintaining up-to-date routing information on each node introduce a huge overhead in the network. Some of the most popular proactive routing protocols are DSDV and OLSR. (Lee, Kimm and Reinhart, 2007)

2.1.Destination Sequence Distance Vector (DSDV): It is a table driven routing scheme. The contribution of this algorithm is to solve count to infinity problem. Each entry in the routing table has a unique sequence number. If a link is being used then the corresponding sequence number is even, otherwise corresponding sequence number is odd.(Murthy and Garcia-Luna-Aceves,1996). The sequence number is generated by destination node and sent to all with a next update message. Route information is distributed among nodes of the network by sending the whole route table periodically by each node and update information more frequently. Each node maintains a route table storing route towards all the nodes of the network. The entries in the route table are destination node, next hop node, total hops for that destination, sequence number, and install time. The example of the DSDV routing table is shown in figure 2



Destination	NextHop	hops	Seq.No.	InstallTime
A	A	0	124	1200
B	B	1	3B6	1500
C	B	2	A42	1600
D	D	1	112	1700

Figure 2 Example of DSDV Routing Table

2.2 Optimized Link State Routing (OLSR): This protocol is based on link state routing algorithm (Sholander, Yankopolus, Coccoli and Tabrizi, 2002). It is also a table driven algorithm just like DSDV [13]. To maintain changes in network topology, periodically messages are exchanged among nodes of the network. OLSR is an optimal way of implementing link state routing. To optimize link state routing, OLSR reduces size of announcement messages/control packets and number of transmission used for flooding the message in whole network. OLSR uses a multi point selector to identify multi point relay (MPRs) nodes who flood the message to all nodes of the network. It is not necessary to broadcast messages to all the nodes. Instead, the node multicast messages to MPRs. The MPRs are the nodes in network selected in such a way that they are connected with all nodes of the network. (Gorlatova, Maria A,2006). Thus MPRs used to control number of transmission of link update messages when flooding. We can use this protocol with a large number of nodes in MANET. The limitation of this protocol is, they assumes that the link between nodes are bi directional which is not always true with wireless media (radio frequency signals). Also, sometimes the removal of redundant flooding becomes problematic when it is used with a network with large packet drop rate.

3.Reactive Routing Protocols: Reactive protocols search for a route when needed. They are not maintaining route information on each and every node of the network. The search for a route is initiated by flooding a route request packet in the network when needed. They don't have the overhead of maintaining the global routing table (Gorlatova, Maria A, 2006). They quickly react to topology changes of the network due to movement of the nodes. Though there are advantages of reactive routing, they are having some limitation also. They introduce network traffic due to flooding mechanism. The route finding process takes more time compared to proactive routing. Some of the most popular examples of reactive routing protocols are DSR and AODV.

3.1 Dynamic Source Routing (DSR): It computes and maintains the route when needed. In this scheme the sender node will initiate the route searching process, when it has data to send to any destination. As a result of this search, sender obtain a complete sequence of nodes travelling through which packet can reach to the destination. This node sequence is stored in a packet header and used by each node forwarding a data packet to the next node until the destination node is reached. (Gorlatova, Maria A, 2006). There are two stages of DSR: route discovery and route maintenance. A source node starts route discovery broadcasting route request packet which is received by all the nodes available in its radio range. The destination node receives this packet and send route reply packet to source node with list of sequences of nodes from source to destination. While route is in use the source node monitors the link status of the whole route. This is called route maintenance. If any link break found during the monitoring, route discovery process started to discover the new route. In DSR, the route is a part of the packet, so there is no problem of loops.

3.2 Adhoc On demand Distance Vector (AODV): In this routing scheme, the route from source node to destination node is discovered only on demand. AODV uses the concept of distance vector routing protocol.(Gorlatova, Maria A,2006). It solves count to infinity problem using sequence number with each update message. Actually AODV uses features of both DSDV and DSR routing protocols. It uses on demand route discovery and route maintenance processes from DSR and hop by hop routing and sequence number from DSDV. In this routing each node maintains a route table which stores entries for all active routes toward destinations through neighbours and two counters: broadcast ID and sequence number. When a node wants to send data to any destination, it will search for a valid route toward the destination node in its route table. If route found, node will use that route for sending data packets. Otherwise the node initiates a route discovery process by incrementing its broadcast id and broadcast route request packet (RREQ) to its neighbours. RREQ has source address, source sequence number (broadcast id), destination address, destination sequence number and hop count fields. The broadcast id and source address uniquely identifies the RREQ. On receiving an RREQ, the neighbour nodes check for valid route toward the destination nodes mentioned in the RREQ in their routing tables. If any neighbour node has a valid route to the destination node, it creates RREP packet and sends it back to maintain more accurate information. The tables that are maintained by a node are the following: distance table (DT), routing table (RT), link cost table (LCT), and a message retransmission list (MRL).

Literature Review

DSDV (Kavitha Balamurugan, K. Chitra, 2018), Destination Sequence Distance Vector proposed that the proactive routing approach is based on Bellman Ford routing Pravin R. Satav, 2018) algorithm with some extension. In DSDV the packets are transmitted between the nodes of the network by using routing tables which are stored at each node of the network. Each routing table at each of the nodes lists all available destinations and the number of hops to each nodes. The mail contribution of the algorithm was to solve the routing loop problem. Each entry in the routing table contains a sequence number, the sequence numbers are generally even if a link is present, else an odd number is used. The number is generated by the destination.

WRP (Pravin R. Satav,2018) Wireless Routing Protocol proposed that this is proactive routing approach belongs to path finding algorithm defined shortest path algorithm that calculates the path using information regarding the length and second to last hop of the shortest path to each destination. WRP reduces the number of overhead cases in which a temporary routing loop can exist. For the purpose of routing each node maintains four things 1. A distance table 2. Routing table 3. A link cost table 4. Message retransmission list

OLSR Optimized Link State Routing is point to point routing protocol. This protocol is based on traditional link state algorithm. The OLSR will minimizes the size of each control message and it also introduces the number of rebroadcasting nodes during each topology update, each node in the network select a set of neighboring nodes for the retransmission of its packets.

AODV[4] Adhoc On Demand Distance Vector Routing is an extension of DSDV. It is an proactive routing protocol. AODV protocol reduces the number of broadcasts by generating routes based on demand that is neither the case for DSDV protocol which is a proactive routing protocol. In AODV Protocol when sender wants to send any packets or information to its destination in first it broadcasts a route request packets. This process passes through the intermediate nodes until the packets reach destinations.

DSR (Dube R, Rias CD, Wang K-Y, Tripathi SK, 1997)Dynamic Source Routing is a reactive protocol based on the source route approach. This protocol is based on the link state algorithm in which source first starts the route discovers on demand basis. The sender examines the route from source to destination and the sender adds the address of intermediate nodes to the route record in the packets. It is similar to AODV in that it forms a route on demand when a transmitting node request one.

4. Proposed Algorithm: The extended Global On-Demand Routing (xGOR) is a clever hybrid routing protocol for the MANET. To simplify simulations in GOR, it assumes

1. All nodes are homogeneous;
2. The transmission range of each node is k; and
3. Each node has an ID and a pair of positive x and y coordinates to represent its location in the network. Algorithm xGOR Protocol: Inputs: The ID and (x, y) coordinates of each node. Outputs: Destination nodes receive data packets from sources nodes.

Begin:

1. Select a center or near-center node in the initial network as the root node (RN).
2. The RN runs the Double-Flooding Algorithm (DFA) to create the location table (LT), sorts the LT by IDs in ascending order, and broadcasts the LT to each node in the network.
3. Each node uses the LT to generate its own distance table (DT) concurrently. Then, each node marks any distance that is longer than the transmission range k in the DT as "∞" (infinity). the source node on the same path from where the RREQ comes. If no valid route available at any neighbour, they further broadcast RREQ to their neighbours. While RREQ travels from one node to other nodes, each node sets up a reverse path towards source node by recording address of node from where RREQ comes. This way of keeping track of the path is called reverse path setup.

Wireless Routing Protocol (WRP): The Wireless Routing Protocol (WRP) is a proactive unicast routing protocol for MANETs. WRP uses an enhanced version of the distance-vector routing protocol, which uses the Bellman-Ford algorithm to calculate paths. Because of the mobile nature of the nodes within the MANET, the protocol introduces mechanisms which reduce route loops and ensure reliable message exchanges. The wireless routing protocol (WRP), similar to DSDV, inherits the properties of the distributed Bellman-Ford algorithm. To solve the count-to-infinity problem and to enable faster convergence, it employs a unique method of maintaining information regarding the shortest path to every destination node and the penultimate hop node on the path to every destination node in the network. Since WRP, like DSDV, maintains an up-to-date view of the network, every node has a readily available route to every destination node in the network. It differs from DSDV in table maintenance and in the update procedures. While DSDV maintains only one topology table, WRP uses a set of tables to Each node calls the Dijkstra's Algorithm to generate the one-to-all shortest-path table (SPT) concurrently (see Figure below). If a new node joined to the network, an existing node moved out of the transmission range of its any neighbor nodes, or an existing node left from the network, then it calls the Node-Reorganization Algorithm (NRA) to ask other nodes to update (or mark as "new" nodes if any) their own LT for these changes consequently. If any node wants to send packets via or to the above joined or moved nodes, it has to (1) use the updated LT in Step 5 to update its DT (or mark the "∞" distances if any); (2) run the Dijkstra's algorithm again to update its SPT; (3) reset all nodes in the LT to "old" nodes; and (4) follows the paths in the new SPT to send packets to its destination nodes. If network topology changed again, repeat steps 5 and 6 until the whole network dismissed.

End of x GOR Protocol.

Figure 3 below shows some shortest paths within the transmission range k for node 1. In this figure, the shortest path between nodes 1 and 6 is (1, 3, 6) not (1, 6) because node 6 locates outside the circular transmission range k of node 1. Note we have marked all "∞" distances in steps 3 and 6 respectively in the main algorithm (Algorithm xGOR Protocol).

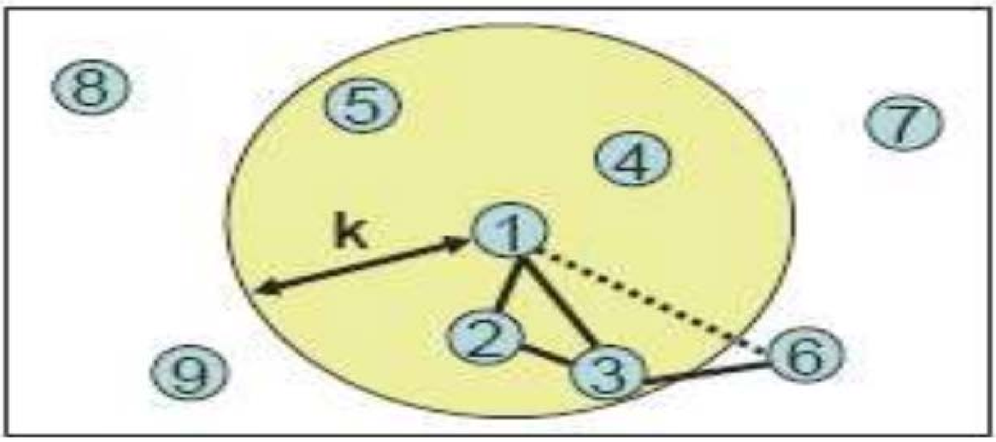


Figure 3 Shortest Paths in A MANET

This algorithm proposed an extended hybrid global on-demand routing (called xGOR) protocol for mobile ad hoc networks. This protocol does not update the routing tables immediately if any node changed its status in the network, such as movement, addition or deletion. Instead, it only handles a node whose move changed the MANET topology or whose move distance is greater than the transmission range k. This critical strategy prevents other nodes from updating the routing tables frequently and hence reducing unnecessary computation and node-reorganization overheads dramatically. The xGOR protocol not only keeps the advantages of proactive and reactive protocols, but also improves the sub-optimal routing overhead and memory consuming problems in local hybrid protocols. Because this protocol retains high throughput, packet delivery rate and low end-to-end delay.

Research Results

1 End to End Delay: Time elapsed between the generation of a packet at a source and the reception of that packet by a group member. Delay is the amount of time that it takes for a packet to be transmitted from one point in network to another point in a network. It refers to the time taken for a packet to be transmitted across a network from source to destination (Sholander, Yankopolus, Coccoli and Tabrizi, 2002), End-To-End delay was monitor at each multicast listener. The delay for AODV was relatively more than the rest of the protocols. AODV protocol also created a shared tree but the delay was much higher. The reason is the processing time at the RP. The delay has a fairly constant value for all the four protocols. Second highest delay is produced by WRP. All the three Remaining Protocols shows almost constant delay after one second which is not

the case in AODV. They delay is highest in last time interval as the distance is also highest to move from source to destination (farthest receiver).

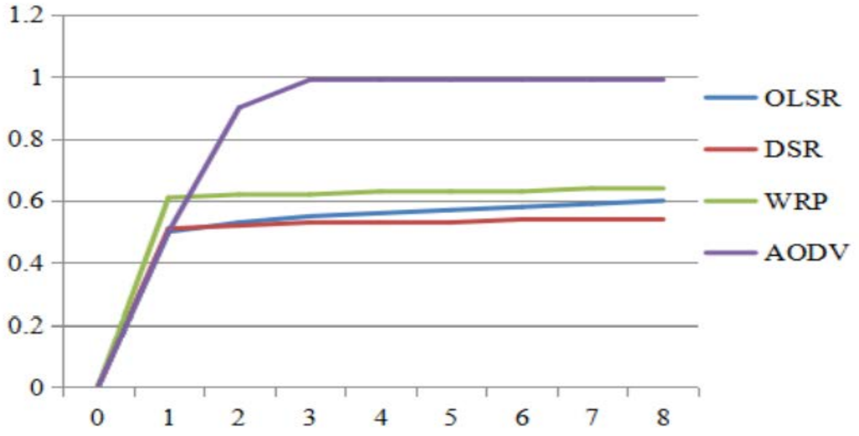


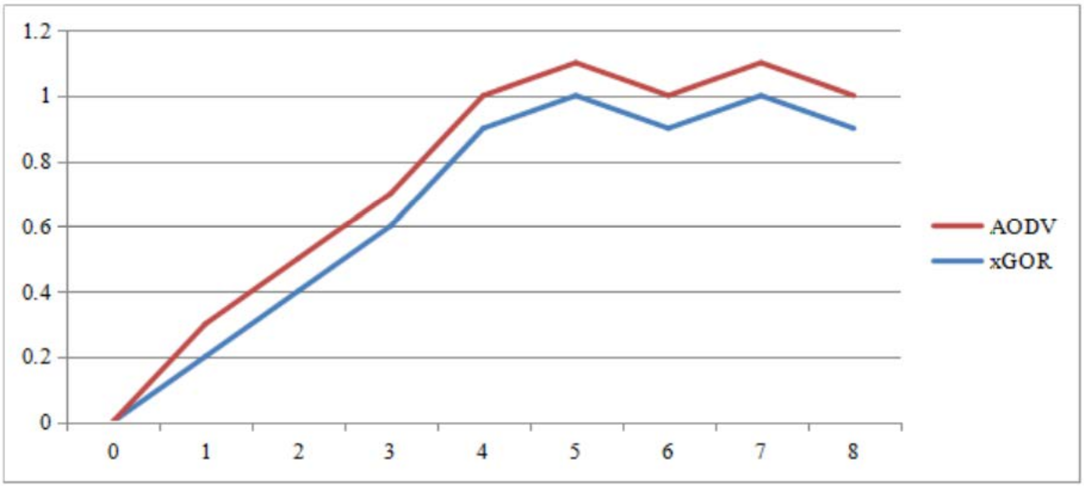
Figure 4 End To End Delay (Infra. Based)

End to End delay for different Protocols according to varying topology is shown in table 1 For real time application or critical applications end to end delay should be less. Lesser the end to end delay better will be the performance. End to End delay for all Multicast routing protocols is shown in the graph corresponding to the simulation time. End to End delay bears large variation in the graph, somewhere it is more and somewhere it is less. DSR is better than OLSR when comapred according to end to end delay metric. And among OLSR, WRP, DSR and AODV , DSR provides less end to end delay.

Table 5 End To End Delay (Infra. Based)

No. of Group Members	**Four**	**Eight**	**Sixteen**	**Thirty Two**
OLSR	10346964 x $(10)^{-9}$	10436984 x $(10)^{-9}$	10434949 x $(10)^{-9}$	10445958x $(10)^{-9}$
WRP	10424771 x $(10)^{-9}$	10436727 x $(10)^{-9}$	10425853 x $(10)^{-9}$	10435789 x $(10)^{-9}$
DSR	10426456 x $(10)^{-9}$	10427867 x $(10)^{-9}$	10428769 x $(10)^{-9}$	10446770 x $(10)^{-9}$
AODV	11217 x $(10)^{-6}$	11237 x $(10)^{-6}$	11237 x $(10)^{-6}$	11217 x $(10)^{-6}$

In ad-hoc networks End to End to End delay is as following



Simulation Time (in Sec)

Figure 5 End To End Delay (Infra. Less)

xGOR has less End to End Delay. xGOR and MAODV are both receiver-oriented protocols. However, xGOR is a mesh-based protocol and provides multiple routes from senders to receivers. MAODV, on the other hand, is a tree based protocol and provides only a single route between senders and receivers.

Table 6 End To End Delay (Infra. Less)

No. of Group Members	Four	Eight	Sixteen	Thirty Two
MAODV	$9734380 \times (10)^{-9}$	$9796479 \times (10)^{-9}$	$1 \times (10)^{-6}$	$2133430 \times (10)^{-6}$
xGOR	$1 \times (10)^{-16}$	$1 \times (10)^{-16}$	$1 \times (10)^{-16}$	$1 \times (10)^{-16}$

Based on the results shown in Figure 6 higher End-to-end delay values imply that routing protocol is not fully efficient and causes congestion in the network. As against the MAODV, xGOR exhibits lesser values of End-to-end delay.

End-2-End delay = time (in seconds) when packet was received by OTHER NODE - time (in seconds) when packet was sent by CURRENT NODE (for calculations)

Throughput: Throughput is a generic term used to describe the capacity of the system to transfer data. Throughput is nothing but the bandwidth of the transmission channel. Throughput is the rate at which network sends or receives data[13]. Throughput is much harder to define and measure because there are numerous ways through which throughput can be calculated:

The packet or byte rate across the network.

The packet or byte rate of a specific application flow.

The packet or byte rate of host to host aggregated flows, or

The packet or byte rate of network to network aggregated flows.

We have calculated throughput using following formula: Throughput = Packets received / Packets forwarded

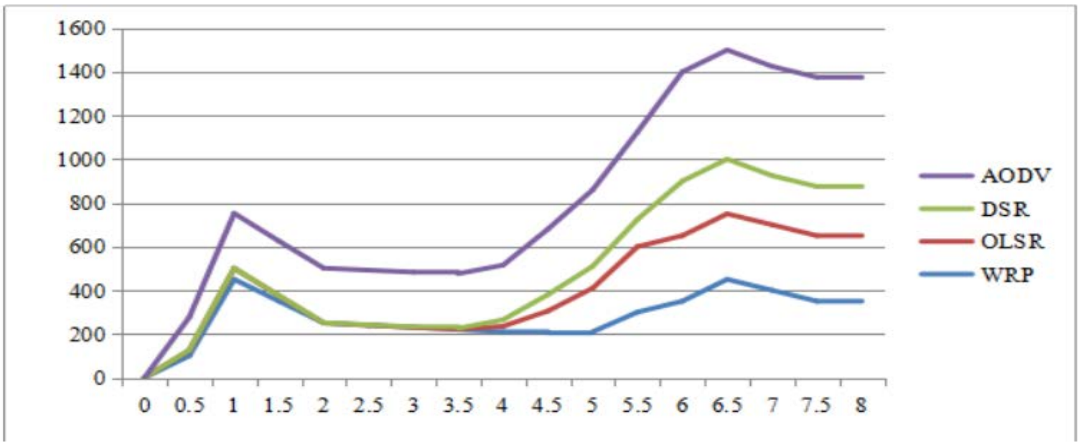


Figure 6 Throughput (Infra. Based)

Table 7 Forwarded Packets (Infra. Based)

No. of Group Members	Four	Eight	Sixteen	Thirty Two
OLSR	2626	13249	23003	54333
WRP	2608	13129	43822	43587
DSR	3473	13231	34397	64351
AODV	3225	14302	35444	62339

Throughput of AODV is higher than all protocols while DSR does not achieved the expected throughput, same is the case for OLSR but it performs good as compared to DSR. Both sparse mode protocols performs very well as compared to both compared to dense mode protocols .The basic reason behind this is initial flooding by OLSR and DSR . That's why the packets meant for actual receivers are too less as compared to sent packets. In ad-hoc networks extended Global On Demand Routing Protocol (xGOR) outperforms as compared to MAODV because it relies on very good technique of announcements. The chances of failure are less, because it can choose its leader dynamically without the interference of Network designer[14]. So there is no single point failure like problems.

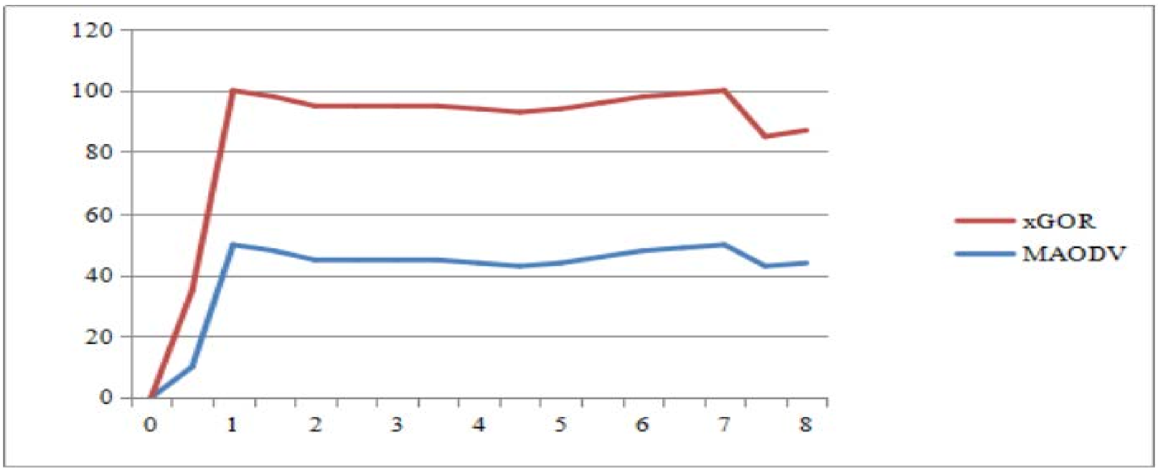


Figure 7 Throughput (Infra. Less)

Figure 7, shows the Throughput analysis. For increasing number of nodes the throughput of xGOR is higher than the MAODV.

Based on the simulation results shown in Fig. 1.6, the packet delivery fraction of xGOR is higher than MAODV for varying number of nodes.

Packet Loss

Packet loss is where network traffic fails to reach its destination in a timely manner (Kathole A.B., Pardakhe N.V., Kute D.S. and Patil A.S(2012).Packet Lost = amount of packets received - amount of packets forwarded There are three causes of packet loss in the network

A break in Physical link that prevents the transmission of a packet

A packet that is corrupted by a noise and is detected by a checksum failure at downstream node and Network congestion that leads to buffer overflow.

No. of Group Members	Four	Eight	Sixteen	Thirty Two
MAODV	32	40	47	51
xGOR	94	98	101	103

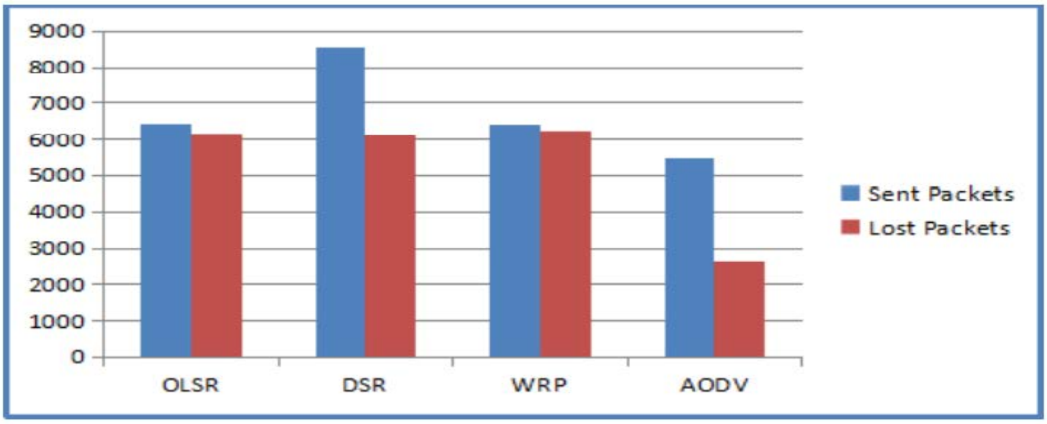


Figure 8 Packet Loss (Infra. Based)

The no. of packets that are lost during simulations and can be computed by subtracting the no. of received packets from forwarded packets. The no. of Packets lost by CBT are much less as compared to all another protocols.

Table 8 Packet Loss (Infra. Based)

No. of Group Members	Four	Eight	Sixteen	Thirty Two
OLSR	5237(5362)	6187(6234)	6322(6445)	6171(7634)
WRP	5347(5432)	6284(6154)	6311(6232)	6213(6254)
DSR	5233(5643)	6138(6165)	6137(8515)	6123(3463)
AODV	3312(5453)	4237(6132)	2665(5454)	4143(6211)

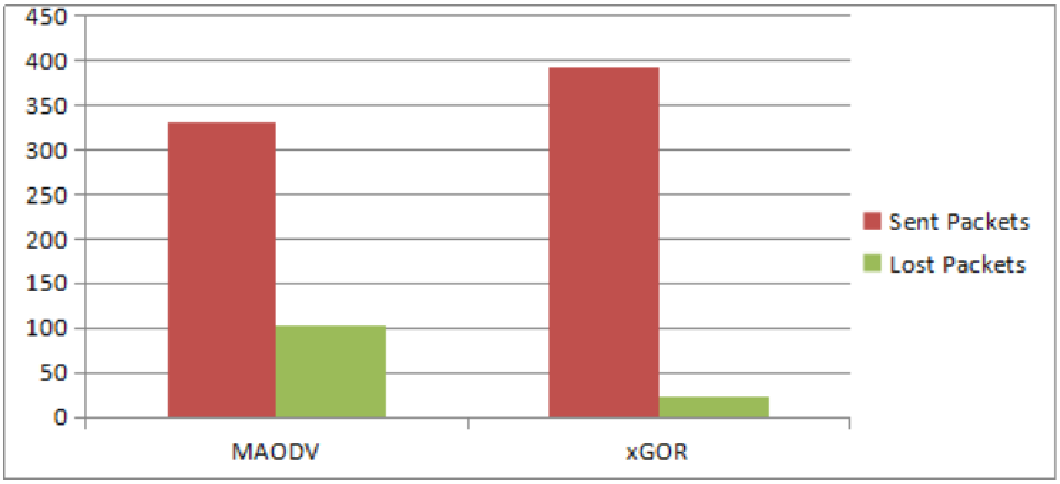


Figure 9 Packet Loss (Infra. Less)

The no of packets loss by xGOR is one fourth of the packets loss by MAODV protocol.

Table 1.6: Packet Loss (Infra. Less)

No. of Group Members	Four	Eight	Sixteen	Thirty Two
MAODV	30(200)	80(320)	100(325)	111(330)
xGOR	10(200)	17(250)	20(380)	25(400)

Discussion of Research Results

When Multicast routing protocols are compared on the basis of End to End delay then all protocol shows very different results then DSR give better performance that is less delay, while AODV has maximum delay so it best to choose DSR. Multicast routing protocols performance differed when compared in terms of performance metrics. The experimental results suggest that configuration parameters do indeed play a role in how well the various multicast routing protocols perform. A network designer should be aware of this fact and should choose an appropriate Routing Protocol. In general, in various situations OLSR and DSR performed similarly to one another in a specific traffic pattern context.AODV give Best performance as compared to all while WRP is also giving better results as Compared to both Dense mode Protocols.

Understandably, none of the protocols behave as a 'best-case' protocol for all scenarios in infrastructure based environments. As multicasting is used in various applications, different in their requirements, a protocol suited best for one application will be totally out of place with another. But still on the basis of three parameters AODV performs better. extended Global On Demand Routing Protocol (xGOR) incurs far less overhead as compared to MAODV. It has higher packet delivery fraction and throughput. The lesser values of End-to-end delay imply a better performance than other protocol. So, extended Global On Demand Routing Protocol (xGOR) has been selected best from infrastructure less protocols for efficient routing for selection of shortest path in mobile adhoc networks.

References

Abolhasan, Hagelstein and Wang(2009), "Real-world Performance of Current Proactive Multi-hop Mesh Protocols", Proceedings of IEEE APCC, Shanghai, China, 10/2009.

Bal Jatinder(2017) "A Study of Particle Swarm Optimization based K-means Clustering for Detection of Dental Caries in Dental X-ray Images" International Journal of Advanced Research in Computer Science, vol 8 no 4 pp.289-294

Chiang C-C, Wu H-K, Liu W, Gerla M(1997), " Routing in Clustered Multihop, Mobile Wireless Networks with Fading Channe" Proceeding of IEEE SICON, volume 3, pp. 197-211.

Dube R, Rias CD, Wang K-Y, Tripathi SK(1997), "Signal Stability Based Adaptive Routing for Mobile Adhoc Networks" IEEE Personal Communications, volume 4, pp. 36-45. 10/2002.

Gorlatova, Maria A(2006). "Detecting Wormhole Attacks in Mobile Ad Hoc Networks through Protocol Breaking and Packet Timing Analysis", Military Communications Conference, MILCOM 2006. IEEE.

Gorlatova, Maria A(2006). "Detecting Wormhole Attacks in Mobile Ad Hoc Networks through Protocol Breaking and Packet Timing Analysis", Military Communications Conference, MILCOM 2006. IEEE.

Jao-Ng M, Lu(1999), " A Peer to Peer Zone Based Two Level Link State Routing for Mobile Adhoc networks", IEEE Journal on Selected Areas in Communications, volume 17, pp. 1415-1425.

Johnson, Maltz and Broch(2001), "DSR: The Dynamic Source Routing Protocol for Multi-Hop Wireless Ad Hoc networks", in: Ad Hoc Networking, publisher: Edison Wesley

Kavitha Balamurugan, K. Chitra(2018), "Performance Evaluation of Hierarchical Routing Protocol with Multiple Transceivers and Cluster Based Routing Protocol in FSO MANET" Taga Journal vol 14, issue 4, pp. 1169-1178.

Kathole A.B., Pardakhe N.V., Kute D.S. and Patil A.S(2012). "A Review Paper On Comparison And Analysis Of Different Attack And Intrusion Detection System", International Journal of Cryptography and Security Volume 2, Issue 1.

Iwata A, Chiang, Pei, G, Gerla M, Chang T-W(1999), "Scalable Routing Strategies for Adhoc Wireless Networks" IEEE Journal on Selected Areas in Communications volume 17, pp. 1369-1379

Lee, Kimm and Reinhart(2007), "A Global On-Demand Routing Protocol for Mobile Ad Hoc Networks", Proceedings of IEEE NC, Boston, MA, 7/2007.

Murthy and Garcia-Luna-Aceves(1996), "An Efficient Routing Protocol for Wireless Networks", Mobile Networks and Applications, Volume 1, Issue 2, pp183- 197.

Pravin R. Satav(2018) " An Energy Efficient Route Selection in MANET with AOMDV Routing Algorithm" International Conference on Research in Intelligent and Computing in Engineering (RICE) IEEE Vol 25, issue 7 pp. 1005-1015

Perkins CE, Bhagat P(1994), "Highly Dynamic Destination Sequenced Distance Vector Routing(DSDV) for Mobile Computers", Proceedings of ACM SIGCOMM, volume 24, pp. 234-244.

Sholander, Yankopolus, Coccoli and Tabrizi(2002), "Experimental Comparison of Hybrid and Proactive MANET Routing Protocols", Proceedings of MILCOM, Anaheim, CA, 10/2002.

Y. Zhang, W. Lee, and Y. Huang(2003), "Intrusion detection techniques for mobile wireless networks," Wireless Networks, vol. 9 no. 5, pp. 545- 556.