Performance Comparison of DSR, OLSR and FSR Routing Protocols in MANET Using Random Waypoint Mobility Model

Ashish K. Maurya, Dinesh Singh, and Ajeet Kumar

***Abstract*—Mobile Ad hoc NETwork (MANET) is a collection of mobile nodes that are arbitrarily located so that the interconnections between nodes are dynamically changing. In MANET mobile nodes form a temporary network without the use of any existing network infrastructure or centralized administration. A routing protocol is used to find routes between mobile nodes to facilitate communication within the network. Route should be discovered and maintained with a minimum of overhead and bandwidth consumption. A wide range of routing protocols for MANETs has been proposed by researchers to overcome the limitations of wired routing protocols. This paper presents performance evaluation of three different routing protocols, i.e., Dynamic Source Routing (DSR), Optimized Link State Routing (OLSR) and Fisheye State Routing (FSR) in variable pause time. We have used Random Waypoint mobility model and performed simulations by using QualNet version 5.0 Simulator from Scalable Networks. Performance of DSR, OLSR and FSR is evaluated based on Average end to end delay, Packet delivery ratio, Throughput and Average Jitter.**

***Index Terms*—MANET, DSR, OLSR, fisheye, random waypoint mobility model, qualnet version 5.0.**

I. Introduction

Mobile Ad Hoc Networks are the self-organizing and self-configuring wireless networks which do not rely on a fixed infrastructure and have the capability of rapid deployment in response to application needs. Nodes of these networks function as routers which discover and maintain routes to other nodes in the network. Ad-hoc networks were first mainly used for military applications. Since then, they have become increasingly more popular within the computing industry. Applications include casual conferences, meetings, virtual classrooms, emergency search-and-rescue operations, disaster relief operations, automated battlefield and operations in environments where construction of infrastructure is difficult or expensive. In MANETs, due to lack of centralized entity and the mobile nature of nodes, network topology changes frequently and unpredictably. Hence the routing protocols for ad hoc wireless networks have to adapt quickly to the frequent and unpredictable changes of topology [1]. There are many routing protocols available for Ad-hoc networks such as AODV, CGSR, DSDV, DSR, DYMO, FSR, GSR, OLSR, STAR, TORA, WRP and ZRP etc. In this paper we study three routing protocols: DSR, OLSR and FSR and evaluated the performance of these three routing protocol as a function of pause time.

A. DSR

Dynamic Source Routing (DSR) [2] is a reactive routing protocol designed for mobile ad hoc networks. DSR contains two phases: Route Discovery and Route Maintenance. Route Discovery phase involves finding a path and Route Maintenance phase involves maintaining a path. It is On-Demand Routing protocol as the process to find a path is only executed when a path is required by a node. In DSR, when a node does not have a route to the destination in its Route Cache, it floods a Route Request (RREQ) [3] packet to the network by specifying target and a unique identifier. Each RREQ also contains a record, listing the address of each intermediate node through which this particular copy of the RREQ has been forwarded. If receiver node is not the destination node, it forwards the RREQ to all its neighbors except the initiator and appends its own address to the route record in the RREQ. Receiver node discards the RREQ, if it has recently received request for the same target or if the address of the receiver node is already listed in route record. The Destination node on receiving the first RREQ sends a Route Reply (RREP) packet back to the source node which includes a copy of the list of addresses of intermediate nodes from source to target. The source node caches this route in its Route Cache after receiving this RREP. When source node sends a data packet to destination node, the entire route is included in the packet header. Each node along the route is responsible for confirming that the next hop in the Source Route receives the packet and each packet is only forwarded once by a node. If a packet can't be received by a node, it is retransmitted up to some maximum number of times until a confirmation is received from the next hop. If confirmation is not received within this limit, a Route Error (RERR) message is sent to the source node, identifying the link from itself to the next node is broken. The source node then removes that Source Route from its Route Cache and checks its Route Cache for another route to the destination node. If there is no any route available in the cache, source node broadcasts a RREQ packet and starts Route Discovery process again to find a route to the destination.

B. OLSR

Optimized Link State Routing (OLSR) [4], [5] protocol is a table-driven proactive routing protocol for wireless mobile

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Ashish K. Maurya and Ajeet Kumar are with the department of Computer Science and Engineering, Shri Ramswaroop Memorial University, Uttar Pradesh, India (e-mail: devverma.iit@gmail.com).
Mr. Dinesh Singh is with the Department of Computer Science and Engineering, Motilal Nehru National Institute of Technology, Allahabad, India.

ad hoc networks. This protocol optimizes the flooding process and reduces the control message overheads by marking subset of neighbors as multi-point relays (MPRs). In OLSR, each node periodically broadcasts two types of messages: HELLO messages and Topology Control (TC) messages. A HELLO message contains two lists in which one list includes the addresses of the neighbors to which there exists a valid bi-directional link and the other list includes the addresses of the neighbors from which control traffic has been heard but bidirectional links are not confirmed. Upon receiving HELLO message, a node examines list of addresses, if its own address is in the list, it is confirmed that bidirectional communication has been established with the sender. HELLO messages also allow each node to maintain information describing link between neighbor node and nodes which are two-hop away. The set of nodes among the one-hop neighbors with a bi-directional link are chosen as multipoint relays (MPRs). Only these nodes forward topological information about the network [6]. On the reception of HELLO messages, each node maintains a neighbor table which contains one-hop neighbor information, their link status information and a list of two hop neighbors. Each node also maintains a set of its neighbors which are called the MPR Selectors of the node. When these selectors send a broadcast packet, only its MPR nodes among its entire neighbors forward the packet. The MPR nodes periodically broadcast its selector list throughout the network. The smaller set of multipoint relay provides more optimal routes. The path to the destination consists of a sequence of hops through the multipoint relays from source to destination. A TC message contains the list of neighbors who have selected the sender node as a multipoint relay and is used to diffuse topological information to the entire network. Based on the information contained in the neighbor table and the TC message, each node maintains a routing table which includes destination address, next-hop address, and number of hops to the destination [5]. OLSR routing mechanism is shown in Fig. 1.

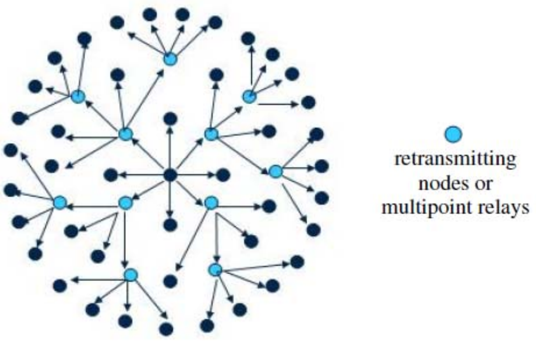

Fig. 1. OLSR Routing mechanism

C. FSR

Fisheye State Routing (FSR) [7] protocol is a proactive (table driven) ad hoc routing protocol and its mechanisms are based on the Link State Routing protocol used in wired networks. FSR is an implicit hierarchical routing protocol. It reduces the routing update overhead in large networks by using a fisheye technique. Fish eye has the ability to see the objects better when they are nearer to its focal point that means each node maintains accurate information about near nodes and not so accurate about far-away nodes. The scope of fisheye is defined as the set of nodes that can be reached within a given number of hops. Fig. 2 shows the scope of fisheye. The number of levels and the radius of each scope will depend on the size of the network. Entries corresponding to nodes within the smaller scope are propagated to the neighbors with the highest frequency and the exchanges in smaller scopes are more frequent than in larger. That makes the topology information about near nodes more precise than the information about farther nodes. FSR minimized the consumed bandwidth as the link state update packets that are exchanged only among neighboring nodes and it manages to reduce the message size of the topology information due to removal of topology information concerned far-away nodes. Even if a node doesn't have accurate information about far away nodes, the packets will be routed correctly because the route information becomes more and more accurate as the packet gets closer to the destination. This means that FSR scales well to large mobile ad hoc networks as the overhead is controlled and supports high rates of mobility.

The FSR concept originates from Global State Routing (GSR) [5]. GSR can be viewed as a special case of FSR, in which there is only one fisheye scope level and the radius is infinite. As a result, the entire topology table is exchanged among neighbors that consume a considerable amount of bandwidth when network size becomes large.

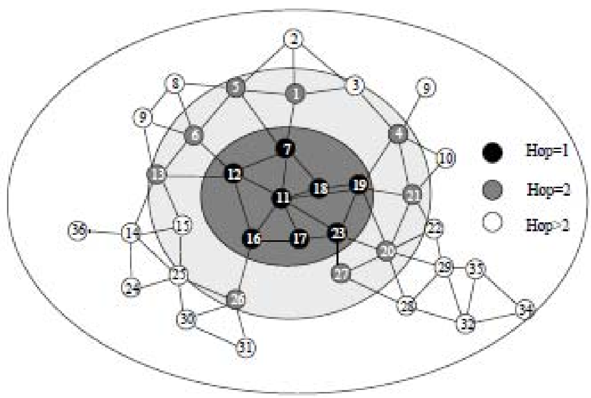

Fig. 2. OLSR Routing mechanism

II. Simulation Environment and Performance Evolution

We performed simulations on QualNet 5.0 [8] for the performance evaluation of DSR, OLSR and FSR routing protocols. For simulation we have used random waypoint mobility model with different pause time. The simulation parameters are summarized in Table I. Traffic source for network is Constant Bit Rate (CBR).

A. Random Waypoint Mobility Model

In this model, the node selects a random position, moves towards it in a straight line at a constant speed that is randomly selected from a range, and pauses at that destination. The node repeats this, throughout the simulation [9] [10].

To evaluate the performance of routing protocols, we used four different quantitative metrics to compare the performance of DSR, OLSR and FSR routing protocol.

They are Average end to end delay, Packet delivery ratio, Throughput and Average Jitter.

TABLE I: SIMULATION PARAMETERS

Simulation Parameters	Values
Dimension of space	1500m X 1500m
No. of nodes	50
Minimum velocity (v min)	10 m/s
Maximum velocity (v max)	20 m/s
Simulation Time	300 sec
Traffic Sources	CBR
Item size	512 bytes
Source data pattern	4 packets/sec
Node Placement Strategy	Random
Pause time	20s, 40s, 60s, 80s, 100s
No. of simulations	15

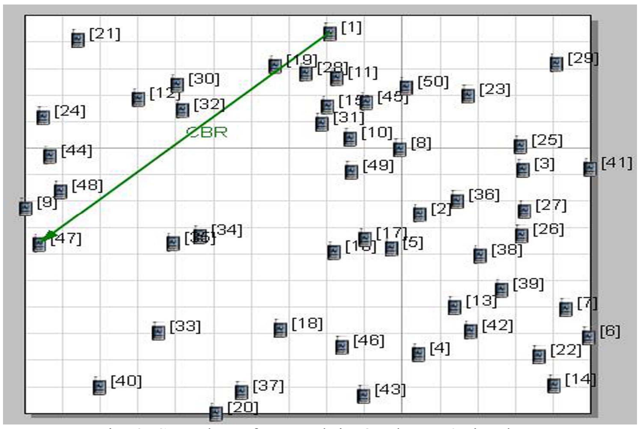

Fig. 3. Snapshot of network in QualNet5.0 simulator

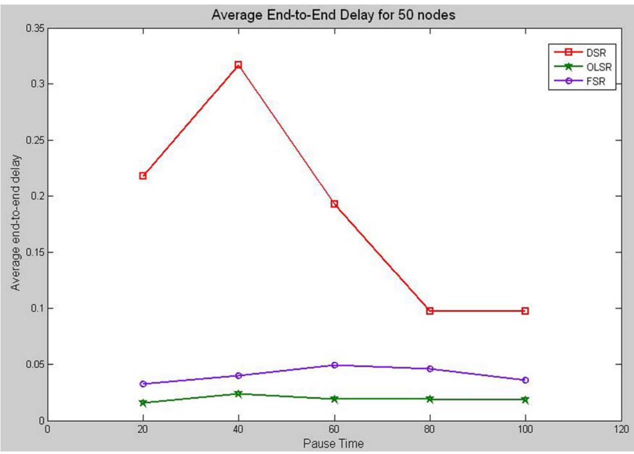

Fig. 4. Average end-to-end delay for 50 nodes

B. Average End to End Delay

End-to-end delay indicates how long a packet takes to travel from the CBR source to the application layer of the destination [11]. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC layer, propagation and transfer times. The average delay from the source to the destination's application layer is shown in Fig. 4. According to our simulation results, delay for OLSR and FSR is always below 0.05 seconds while for DSR it is below 0.35 seconds. Best performance is shown by OLSR having lowest end to end delay with a maximum delay of .015 sec. Actually OLSR and FSR both demonstrate lower delay than DSR due to their operation which is table driven in nature. The presence of routing information in advance leads to lower average end-to-end delay. DSR leads to greater end-to-end delay as it needs more time in route discovery.

C. Packet Delivery Ratio

Packet delivery ratio (PDR) is the fraction of packets sent by the application that are received by the receivers and is calculated by dividing the number of packets received by the destination through the number of packets originated by the application layer of the source. For a correct routing protocol, it should be better [12]. The packet delivery ratio is shown in Fig. 5. According to our simulation results, DSR performs better than OLSR and FSR. Initially DSR delivers more than 55 percent of all CBR packets but its delivery rate suddenly decreases when pause time increases from 20 seconds to 40 seconds. After 80 seconds pause time DSR delivers almost 50 percent of CBR packets. Delivery rate of CBR packets for all three protocols increases when pause time increases from 40 seconds. FSR has lower performance than other protocols.

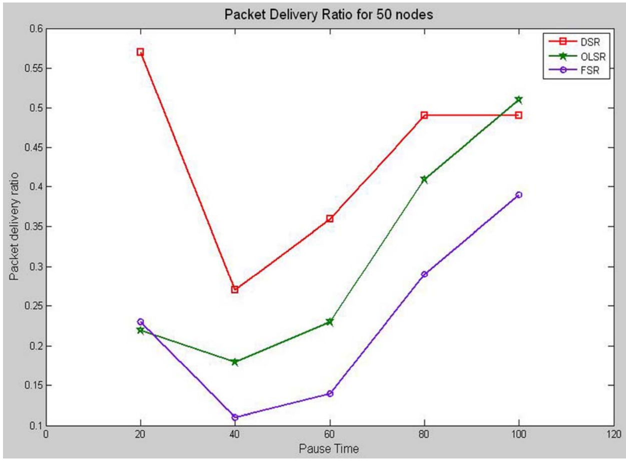

Fig. 5. Packet delivery ratio for 50 nodes

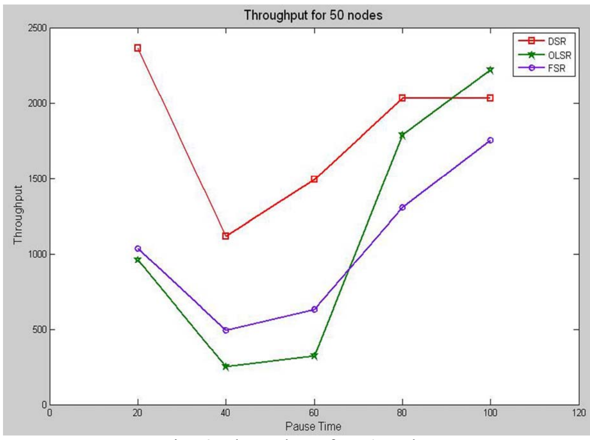

Fig. 6. Throughput for 50 nodes

D. Throughput

The throughput is defined as the total amount of data a receiver receives from the sender divided by the time it takes for the receiver to get the last packet. The throughput is measured in bits per second (bit/s or bps) [13]. According to our simulation results, DSR shows better performance than OLSR and FSR because it can adjust dynamically in case of the change in the network topology and can do better route repair function than others. For pause time of 100 seconds OLSR delivers data packets at higher rate in comparison to DSR and FSR, its throughput suddenly increases after 60 seconds pause time.

E. Average Jitter

Jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes. Jitter should be small for a routing protocol to perform better [14]. According to our simulation results, OLSR shows best performance and DSR shows worst performance in terms of average jitter. In DSR, there is more chance for jitter as source node initiates route discovery mechanism by broadcasting a route request packet to its neighbors. OLSR has less jittering than other protocols as it uses multipoint relaying technique for selective flooding of control messages to provide optimal routes in terms of number of hops.

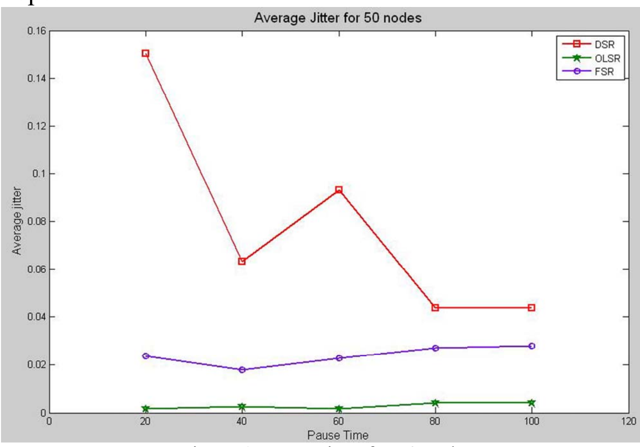

Fig. 7. Average Jitter for 50 nodes

III. CONCLUSION

In this paper, a performance comparison of DSR, OLSR and FSR routing protocol for mobile ad-hoc networks is presented as a function of pause time. Performance of DSR, OLSR and FSR routing protocol is evaluated with respect to four performance metrics such as average end to end delay, packet delivery ratio, throughput and average jitter. OLSR shows best performance than DSR and FSR in terms of average end-to-end delay and average jitter. DSR delivers more than 40 percent of all CBR packets when network is presented as a function of pause time and its throughput is better than other two protocols. FSR shows worst performance for packet delivery fraction while DSR shows worst performance for average end-to-end delay and average jitter. In future, different node placement strategy, more sources, additional metrics such as TTL based average hop count, routing overhead may be used.

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Ashish K. Maurya is currently working as an Assistant Professor in the department of Computer Science and Engineering, Shri Ramswaroop Memorial University, Uttar Pradesh, India. He was awarded M.Tech degree in Computer Science and Engineering by prestigious Indian Institute of Technology Roorkee, India in the year 2011. He has likely 3 years experience in research and teaching. He has published a number of research papers in International journals of repute. At present he is guiding many students in pursuing their master degrees in eminent area of research. His research interest includes ad-hoc networks, mobile computing and data mining.

Dinesh Singh is presently an Assistant Professor in the Department of Computer Science and Engineering, Motilal Nehru National Institute of Technology, Allahabad, INDIA. He completed Master of Technology (2011) in Information Technology from Indian Institute of Technology, Roorkee, India. He has likely 5 years experience in research and teaching. He is member of editorial boards and technical committees of several international and national levels and also published a number of research papers in International journals of repute those have been indexed by IEEE and many more. His research interest includes Ad-hoc Networks and Image Processing.

Ajeet Kumar is currently working as an Assistant Professor in Computer Science and Engineering Department, Shri Ramswaroop Memorial University, Uttar Pradesh, India. He has received his M.Tech degree in Computer Science and Engineering from Indian Institute of Technology Roorkee, India in the year 2012 and PGDAC Degree from CDAC pune, India in 2009, B.Tech Degree in Computer Science and Engineering from Bhagalpur College of Engineering, Bhagalpur, India in 2008. His research interest includes ad-hoc networks and data mining.