Chapter 3

Performance Evaluation of DSR Routing Protocol in MANET

3.1 Description of Reactive DSR Routing Protocol

Dynamic Source Routing protocol (DSR) is a reactive, on-demand routing protocol, which finds the route as and when required, dynamically (Gomez et al., 2005). DSR routing protocol manage the network without centralized administrator or infrastructure. In route discovery this protocol discovers for the routes from source node to destination. In DSR, data packets stored the routing information of all intermediate nodes in its header to reach at a particular destination (Gowrishankar et al., 2007, Al-Ani R. et al., 2011). Routing information for every source node can be change at any time in the network and DSR updates it after each change occurs (Nadesh et al., 2011). Intermediate routers don’t need to have routing information to route the passing traffic, but they save routing information for their future use (Annapurna et al., 2010). Basic purpose to develop DSR was to reduce the overhead on the network and designing self-organizing and self-configuring protocol to support wireless networks. The DSR protocol contains two phases in its routing mechanism (Timcenko et al., 2009).

a) Route discovery: In the route discovery phase the source node establishes a route by flooding route request packets (RREQ) (Gowrishankar et al., 2007, Vetrivelan N. et al., 2008). The RREQ contains the source IP address and destination IP address. The neighbor nodes accumulate the traversed path into the RREQ and broadcast to its next neighbor if the current node is not the destination node. Each mobile host participating in the Ad hoc network maintains a route cache in which it caches source routes that it has learned. When one host sends a packet to another, the sender first checks its route cache for a source route to the destination. If the route is found, the sender uses that route entry to transmit the packet. If no route entry is found, the sender may attempt to discover one using the route discovery mechanism. Until the route is discovered, the sender host will be waiting and during this time it can do
other operations like sending or forwarding other packets. Once the route is discovered, the sender sends its required packet using the new learned route (Nadesh et al., 2011). Finally the packet of interest is received by the destination. The sender updates its route caches too for that particular destination for future use (Annapurna et al., 2010). When a sender does not know the path to a node to which it wants to send a packet, it generates a route request packet and broadcasts to its neighbors.

![Figure 3-1 Route Establishment in DSR (Murthy and Manoj, 2005)](image)

DSR routing is explained in Figure 3.1. There are three paths (Path 1, Path 2 and Path 3) [Figure 3-1] which can be used by source node A to initiates a RREQ packet for destination node O. After receiving the RREQ packet from node A, all its neighboring nodes, i.e., nodes B, E, and F, forward it. Node B and E forwards the RREQ Node D. Node D forwards the first RREQ it receives from any one of the nodes B and E and discards the other redundant/duplicate RREQ packets. The RREQ is propagated till it reaches the destination node O which initiates the RREP. The neighbors get the packet and give route information either if they have that in their cache or if the destination is their neighbor. Otherwise they again re-broadcast the same packet to their non recipient neighbors. Finally, when this packet reaches to the destination, it replies a route reply packet through the reverse path the packet traveled. When this packet comes back to the originator, it updates its routing cache and start sending packets using this newly discovered path (Sarao et al., 2013). If the
originator receives multiple route reply packets, it keeps the shortest one. Also it stores the current time along with the cache entry in order to keep track of how old the path is. Since topology of an ad-hoc network might change frequently, a path is not used for a long time. Therefore, a cache expiration time is enforced after which the entry is deleted. A route maintenance agent periodically checks all links and updates the route cache of a node.

b) Route Maintenance: Route maintenance can be accomplished by two different processes: Hop-by-hop acknowledgement at the data link layer and End-to-end acknowledgements. Hop-by-hop acknowledgement is the process at the data link layer which allows an early detection and re-transmission of lost packets. If the data link layer determines a fatal transmission error, a route error packet is being sent back to the sender of the packet (Nadesh et al., 2011; Kumar M. et al., 2009). The route error packet contains the information about the address of the node detecting the error and the host’s address which was trying to transmit the packet. Whenever a node receives a route error packet, the hop is removed from the route cache and all routes containing this hop are truncated at that point (Gowrishankar et al., 2007). When wireless transmission between two hosts does not process equally well in both directions, End-to-end acknowledgement may be used. As long as a route exists, the two end nodes are able to communicate and route maintenance is possible. In this case, acknowledgements or replies on the transport layer used to indicate the status of the route from one host to another. However, with end-to-end acknowledgement it is not possible to find out the hop which has been in error. DSR has special feature that there is no need of periodic updates to send over the network about neighbors or link state information. This reduces overhead on the network by eliminating the periodic updates send on the network (Bokade et al., 2014). The both operations of DSR are on demand basis. A node may save more than one route for the same destination. In DSR it is carried out by listening to passing traffic, or by saving the additional routes when attempts for single route discovery. This property make DSR to use cache route in case of one route broke down, there is no need of route discovery as alternative routes are already available to the destination. Another important property of DSR routing protocol is network flexibility (Sarao et al., 2013).
A packet using DSR routing protocol can reach its destination even when the intermediate nodes are using different type of network. DSR make it possible that nodes with different network types can participate in Ad hoc networks, DSR protocol consider them as Ad hoc Network. There is unidirectional link support. The basic algorithm for route discovery can be optimized in many ways. To avoid too many broadcasts, each route request could contain a counter (Gowrishankar et al., 2007). Every node rebroadcasts the request increments the counter by one. Knowing the maximum network diameter, nodes can drop a request if the counter reaches this number. A node can cache path fragments from recent requests. These fragments can now be used to answer other route requests much faster. A node can also update this cache from packet headers while forwarding other.

Advantages and Disadvantages

This protocol uses a reactive approach which eliminates the need to periodically flood the network with table update messages which are required in a table-driven approach. In a reactive (on-demand) approach such as this, a route is established only when it is required and hence the need to find routes to all other nodes in the network as required by the table-driven approach is eliminated. The intermediate nodes also utilize the route cache information efficiently to reduce the control overhead. The disadvantage of this protocol is that the route maintenance mechanism does not locally repair a broken link. Stale route cache information could also result in inconsistencies during the route reconstruction phase (Gulati et al., 2014). The connection setup delay is higher than in table-driven protocols.

Even though the protocol performs well in static and low-mobility environments, the performance degrades rapidly with increasing mobility. Also, considerable routing overhead is involved due to the source-routing mechanism employed in DSR (Bouhorma M. et al., 2009). This routing overhead is directly proportional to the path length.
3.2 Simulation Environment

For the performance Analysis of DSR, AODV, HYBRID and their performance comparison, we have used MATLAB software as network simulator. The mobility model chosen is Random Way Point mode

Table-3:1 Simulation Environment For the performance Analysis of DSR Routing Protocol

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>USED IN SIMULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulator</td>
<td>MATLAB(R2010a)</td>
</tr>
<tr>
<td>Channel type</td>
<td>wireless channel</td>
</tr>
<tr>
<td>Antenna type</td>
<td>Omni Antenna</td>
</tr>
<tr>
<td>Radio-propagation model</td>
<td>Two ray ground</td>
</tr>
<tr>
<td>Protocols studied</td>
<td>DSR</td>
</tr>
<tr>
<td>Simulation area</td>
<td>500m×500m, 1000m×1000m, 1500m×1500m</td>
</tr>
<tr>
<td>Transmission range</td>
<td>250m</td>
</tr>
<tr>
<td>Node movement model</td>
<td>Random waypoint</td>
</tr>
<tr>
<td>Traffic type</td>
<td>CBR(UDP)</td>
</tr>
<tr>
<td>Packet size</td>
<td>512 Bytes</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>10, 20, 30, 40, 50, 60, 70, 80, 90, 100</td>
</tr>
<tr>
<td>Node Speed</td>
<td>10m/s and 50m/sec</td>
</tr>
</tbody>
</table>

3.3 Performance Metrics

Packet delivery ratio: The ratio between the number of packets originated by the CBR sources and the number of packets received at the final destination. It describes the loss rate seen by the protocol.
**Throughput:** It is defined as total number of packets received by the destination. It is a measure of effectiveness of a routing protocol. Throughput is the amount of data transferred over the period of time expressed in kilobits per second (Kbps).

**Avg. End-to-End Delay:** Average amount of time taken by a packet to go from source to destination. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission on delays at MAC, and propagation times.

**Route overhead:** The total number of routing packets transmitted during the simulation. If control and data traffic share the same channel, and the channels capacity is limited, then excessive control traffic often impacts data routing performance. This is the ratio between the total control packets generated to the total packets during the simulation time.

**Energy Consumption:** Energy consumption of a node is mainly due to the transmission and the reception of data or controlling packets. To measure this amount of energy consumed during the transmission process (noted Tx Energy), we should multiply the transmission power (Tx Power) by the time needed to transmit a packet.

### 3.4 Simulation Results and Discussion for DSR Routing Protocol

In this section we present the simulation results for DSR routing protocol along with a detailed Analysis of the performance. The analysis is based on the comparison of different terrain area for DSR routing protocol. For the analysis we have considered the metric packet delivery ratio, Throughput, end to end delay, routing overhead and energy consumption.

1) **Small Terrain Area**- Analysis is based on small terrain area (500mx500m) with 100 number of nodes with node speed 10m/s and 50m/s for different performance metric.
Packet Delivery Ratio: As no. of nodes increases, packet delivery ratio decreases. Cause of decrease of packet delivery ratio is due to network congestion. At low mobility, link break is less, and packet delivery ratio is better due to use of alternate route. At high mobility, packet delivery ratio decreases due to more link break. For 10 no. of nodes it is 71% at node speed of 10 m/s and it is 64% at node speed of 50 m/s.

![Packet Delivery Ratio vs Number of nodes](image)

Fig 3-2 Packet delivery fraction vs. no. of nodes, Terrain area=500mx500m for a MANET of 100 nodes, node speed 10 m/s and 50 m/s

For 100 no. of nodes it is decreased to 66.5% at node speed of 10 m/s and 57% at node speed of 50 m/s. It is observed that packet delivery ratio decreased by 7% for 10 no. of nodes and 9.5% for 100 no. of nodes at node speed of 50 m/s.

Throughput: Throughput decreases as no. of nodes increases. Cause of decrease of Throughput is due to network congestion. Throughput for 10 no. of nodes is 76% at node speed of 10 m/s and 64.4% at node speed of 50 m/s. It decreases to 70.3%, 66.2% for 50,100 nodes respectively at node speed of 10 m/s and 59.5%, 56.3% for 50,100 nodes respectively at node speed of 50 m/s. It is observed that at higher speed, throughput decreases as compared to low speed. It is due to more link breaks at higher speed.
Figure 3-3 Throughput vs. no. of nodes. Terrain area=500mx500m for a MANET of 100 nodes, node speed 10 m/s and 50 m/s.

It is observed that Throughput decreased by 11.6% at 10 no. of nodes and 9.9 % at 100 no. of nodes at node speed of 50m/s.

**Average end to end delay:** At high mobility, link break is more, due to this more route reply messages to the source node and more is end to end delay. Average end to end delay for 10 no. of nodes is 3.0 ms at node speed of 10 m/s and 15 ms at node speed of 50 m/s. It is 3.2 ms, 3.1ms for 50,100 nodes respectively at node speed of 10m/s and 15.8 ms, 15.2ms for 50,100 nodes respectively at node speed of 50 m/s.

Figure 3-4 end to end delay vs. no. of nodes. Terrain area=500mx500m for 100 nodes.
Results shows that there is slight change in Average end to end delay for entire node density but there is 12 ms increase in end to end delay for 10 no. of nodes at node speed 50 m/s and 12.6 ms increase in end to end delay for 100 no. of nodes at node speed 50 m/s.

**Normalized Routing load:** Increased node density increase the collision of traffic, more packets drops, which require more Route requests to establish the route and consequently this increases the routing load.

![Normalized Routing Overhead vs Number of nodes](image)

Figure 3-5  Routing Overhead vs. no. of nodes, Terrain area=500x500 for a MANET of 100 nodes, node speed 10 m/s and 50 m/s

Routing load increases as mobility increases. Normalized Routing load for 10 no. of nodes is 12.7% at node speed of 10 m/s and 17 % at node speed of 50 m/s .It is 11.8%, 12.0% for 50,100 nodes respectively at node speed of 10m/s and 18.2%, 18.5 % for 50,100 nodes respectively at node speed of 50 m/s. It is observed that Normalized Routing load increased by 6.5 % for 100 nodes at node speed of 50 m/s.

**Energy consumption:** Energy consumption increases as node speed increases. Energy consumption for 10 no. of nodes is 12.6 J at node speed of 10 m/s and 17.6 J at node speed of 50 m/s .It is 12.9 J, 13.2 J for 50,100 nodes respectively at node speed of 10m/s and 17.6 J, 25.0 J for 50,100 nodes respectively at node speed of 50 m/s. It is observed that Energy consumption increased by 89.4 % at 100 nodes for node speed of 50 m/s in comparison to low speed10 m/s.
Figure 3-6 Energy consumption vs. no. of nodes Terrain area=500mx500m for a MANET of 100 nodes, node speed 10 m/s and 50 m/s

2) Medium Terrain Area-

Analysis is based on medium terrain area (1000mx1000m) for 100 number of nodes with node speed 10m/s and 50m/s for different performance metrics.

Packet Delivery Ratio: For high mobility condition, link break is more .Link break is due to stale routes and hence the packet delivery fraction reduces drastically.

Figure 3-7 Packet delivery fraction vs. no. of nodes Terrain area=1000mx1000m for a MANET of 100 nodes, node speed 10 m/s and 50 m/s
In low mobility condition link break is less; due to this packet delivery is more at low node speed. At high mobility, packet delivery ratio decrease due to more link break. For 10 no. of nodes, it is 75.4 % at node speed of 10 m/s and it is 68.2% at node speed of 50 m/s. At100 no. of nodes it is decreased to 68.5 % at node speed of 10m/s and 58.6 % at node speed of 50m/s. It is observed that packet delivery ratio decreased by 7.2 % at10 no. of nodes and 9.9 % at100 no. of nodes at node speed of 50m/s.

**Throughput:** Throughput decreases as no. of nodes increases. Cause of decrease of Throughput is due to stale routes. Due to stale routes, retransmission of route requests needs to establish the route. Throughput at10 no. of nodes is75.8% at node speed of 10 m/s and 63.8 % at node speed of 50 m/s. It decreases to 70.2%, 66.8% for 50,100 nodes respectively at node speed of 10m/s and 60.0%, 57.0% for 50,100 nodes respectively at node speed of 50 m/s .It is observed that Throughput decreased by 12.0% at10 no. of nodes and 9.8 % at100 no. of nodes at node speed of 50m/s.

![Throughput vs. Number of nodes](image)

**Figure 3-8** Throughput vs. no. of nodes Terrain area=1000x1000 for a MANET of 100 nodes, node speed 10 m/s and 50 m/s
**Average end to end delay:** At high mobility, link break is more, due to this more route reply messages to the source node and more is end to end delay.

![Average End to End Delay vs Number of nodes](image)

Figure 3-9 End to End Delay vs. no. of nodes, Terrain area=1000mx1000m for a MANET of 100 nodes, node speed 10 m/s and 50 m/s

Average end to end delay for 10 no. of nodes is 1.9 ms at node speed of 10 m/s and 10.4 ms at node speed of 50 m/s. For 100 nodes It is 2.1 ms at node speed of 10m/s and 11.0 ms at node speed of 50 m/s. Results shows that there is slight change in Average end to end delay for entire node density but there is 8.5 ms increase in end to end delay for 10 no. of nodes at node speed 50 m/s and 8.9 ms increase in end to end delay for 100 no. of nodes at node speed 50 m/s in comparison to low speed 10 m/s.

**Normalized Routing load:** Routing load mostly depends on mobility. At low mobility, link break is less, which leads to decrease in routing load. At higher speed, routing load is more. Routing load increases as mobility increases. Normalized Routing load for 10 no. of nodes is 11.6% at node speed of 10 m/s and 16.3 % at node speed of 50 m/s.
Figure 3-10 Routing overhead vs. no. of nodes, Terrain area=1000mx1000m for a MANET of 100 nodes, node speed 10 m/s and 50 m/s

It is 11.8%, 12.7% for 50,100 nodes respectively at node speed of 10 m/s and 16.8%, 18.0 %for 50,100 nodes respectively at node speed of 50 m/s. It is observed that Normalized Routing load increased to 5.3 % for 100 nodes at node speed of 50 m/s.

**Energy consumption:** Energy consumption increases as node speed increases. For transmission of route requests and reception of requests more energy is consumed at nodes Energy consumption at10 no. of nodes is11.3 J at node speed of 10 m/s and 16.4 J at node speed of 50 m/s.

Figure 3-11 Energy consumption vs. no. of nodes Terrain area=1000mx1000m for a MANET of 100 nodes, node speed 10 m/s and 50 m/s
It is 13.5 J, 13.6 J for 50,100 nodes respectively at node speed of 10 m/s and 17.4 J, 18.4.0 J for 50,100 nodes respectively at node speed of 50m/s. It is observed that Energy consumption increased by 35.3 % for100 nodes at node speed of 50 m/s in comparison to low speed 10 m/s.

3) **Large Terrain Area**-

Analysis is based on large terrain area (1500mx1500m) for 100 number of nodes with node speed 10 m/s and 50 m/s for different performance metrics.

**Packet Delivery Ratio:** In large terrain area, the node density per unit area is low. So the network congestion decreases. For high mobility condition, link break is more. Packet delivery fraction for DSR decreases due to link break. In low mobility condition link break is less; due to this packet delivery is more at low node speed. For10 no. of nodes, it is74.0% at node speed of 10 m/s and it is 64.0% at node speed of 50 m/s.

![Graph showing packet delivery ratio vs. number of nodes](image)

Figure 3-12 Packet delivery fraction vs. no. of nodes Terrain area=1500mx1500m for a MANET of 100 nodes, node speed 10 m/s and 50 m/s

For100 no. of nodes it is decreased to 70.2% at node speed of 10m/s and 59.0 % at node speed of 50m/s. It is observed that packet delivery ratio decreased by 10 % for10 no. of nodes and 10.3 % for100 no. of nodes at node speed of 50 m/s.
**Throughput:** Throughput decreases as no. of nodes and node speed increases. Cause of decrease of Throughput is due to stale routes and not finding proper route to destination at high mobility. Due to this, retransmission of route requests needs to establish the route. Throughput for 10 no. of nodes is 76.0% at node speed of 10m/s and 65.0% at node speed of 50 m/s. It decreases to 70.2%, 66.8% for 50,100 nodes respectively at node speed of 10 m/s and decreases to 60.0%, 57.0% for 50,100 nodes respectively at node speed of 50 m/s.

![Throughput vs. Number of nodes](image)

Figure 3-13 Throughput vs. no. of nodes Terrain area=1500mx1500m for a MANET of 100 nodes, node speed 10 m/s and 50 m/s

It is observed that Throughput decreased by 11.0% at 10 no. of nodes and 9.8 % at 100 no. of nodes at node speed of 50 m/s. It is also observed that there is no change in PDR for 100 nodes for medium terrain Area and high terrain area due to high node speed 50 m/s.

**Average end to end delay:** At high mobility, link break is more, due to this more route reply messages to the source node and more is end to end delay. Average end to end delay for 10 no. of nodes is 8.8 ms at node speed of 10 m/s and 15.4 ms at node speed of 50 m/s. It is 9.5ms for 100 nodes at node speed of 10 m/s and 16.3 ms for 100 nodes at node speed of 50 m/s.
Figure 3-14 End to End Delay vs. no. of nodes Terrain area=1500mx1500m for a MANET of 100 nodes, node speed 10 m/s and 50 m/s

Results shows that there is slight change in Average end to end delay for entire node density but there is 75 % increase in end to end delay at 10 no. of nodes for node speed 50 m/s and 71.6 % increase in end to end delay at 100 no. of nodes for node speed 50 m/s.

**Normalized Routing load:** Routing load mostly depends on mobility. At low mobility, link break is less, which leads to decrease in routing load. At higher speed, routing load is more. Routing load increases as mobility increases. Link break leads to more retransmission attempts and this increases the routing load significantly.

Normalized Routing load for10 nodes is12.4 % at node speed of 10 m/s and 16.4 % at node speed of 50 m/s. Routing load is 12.0%, 12.3% for 50,100 nodes respectively at node speed of 10 m/s and 17.0%, 18.0 % for 50,100 nodes respectively at node speed of 50m/s. It is observed that Normalized Routing load increased by 5.7 % for 100 nodes at node speed of 50 m/s.
Figure 3-15 Normalized Routing Overhead vs. no. of nodes Terrain area=1500x1500 for a MANET of 100nodes, node speed 10 m/s and 50 m/s

**Energy consumption:** At high mobility, link break is more, due to this more route reply messages to the source node. Hence Energy consumption increases as node speed increases. For transmission of route requests and reception of requests more energy is consumed at nodes. Energy consumption at 10 no. of nodes is 11.8 J at node speed of 10 m/s and 16.5 J at node speed of 50 m/s.

Figure 3-16 Energy Consumption vs. no. of Nodes, Terrain area=1500mx1500m for a MANET of 100 nodes, node speed 10 m/s and 50 m/s
It is 12.2 J, 13.1 J for 50,100 nodes respectively at node speed of 10m/s and 17.0 J, 17.5 J for 50,100 nodes respectively at node speed of 50m/s. It is observed that Energy consumption increased by 33.58% at 100 nodes for node speed of 50 m/s.

3.5 Summary

In this work, performance of mobile Ad hoc network routing protocol DSR has been studied and evaluated in small terrain area, medium terrain area and large terrain area by using MATLAB. Performance carried out in terms of packet delivery ratio, Throughput, end to end delay, routing overhead and energy consumption. From the analysis, it is observed that packet delivery ratio, throughput decreases as node density and node speed increases. The number of link break is more at high speed, due to this end to end delay and routing overhead increases as node density and node speed increases. It is also observed that performance is comparatively better in case of medium terrain area.