I. MOTIVATION

- Characteristics of MANETs
  Mobile ad hoc networks (MANETs) are self-configuring networks with mobile nodes connected by wireless links to form an arbitrary topology without an infrastructure. In MANETs, nodes are mobile and as such both end and intermediate systems. Routing in MANETs are challenged by the mobility of the nodes. Maintaining connectivity with wireless channels and nodes moving out of range from one another is another challenge in MANETs.

- Challenges for MANET Routing Simulation
  Routing protocols are essential to the performance of wireless networks especially in mobile ad-hoc scenarios. The development of new routing protocols requires comparing them against known protocols in various simulation environments. Discrete event network simulator ns-3 is proposed as successor of ns-2 and is still under development, providing greater flexibility, evolvability, modularity, and the support of heterogeneity including hybrid wired and wireless models. Despite its advantages, ns-3 is relatively new with limited number of protocol models incorporated into its release distribution; existing built-in MANET routing protocols are limited to the OLSR (optimised link state routing) and AODV (ad hoc on-demand distance vector). We have implemented DSDV (destination-sequence distance vector) and DSR (dynamic source routing) protocols in ns-3. Additionally, we compare performance of DSDV and DSR against AODV and OLSR.

- MANET Routing Protocol Types
  MANET routing protocols can be classified into two categories based on their update mechanisms: proactive and reactive. Proactive routing protocols maintain updated routing information of all the nodes in the network by periodically distributing routing tables among each other. The advantage is that the routes to any destination are ready to use when needed. However, routing table grows with the size and node density of the network, rather than the number of routes actually needed. The overhead of flooding route advertisements to maintain convergence is a major drawback of proactive protocols. DSDV and OLSR are two major proactive routing protocols while proactive routing protocols like proactive routing protocols use route discovery protocols construct routes only when needed for data transmission. When a route to a new destination is requested, the node initiates a route request and waits until the route is discovered. There is no need to distribute their routing information periodically or to maintain routes for all the nodes in the network. Disadvantage is the delay in finding routes to new destinations. DSR and AODV are two well-studied reactive routing protocols.

II. RESEARCH GOALS

- Implement DSDV and DSR and share these models with the networking research and education community
- Carry out simulations to analyse the performance of different routing protocols
- Provide baseline performance comparison cases for new protocol design

III. IMPLEMENTATION OF PROTOCOLS in ns-3

- DSDV Implementation in ns-3
  DSDV uses the Bellman-Ford algorithm to calculate paths. The cost metric used is the hop count, which is the number of hops it takes for a packet to reach its destination. DSDV is a table-driven proactive protocol, thus it maintains a routing table with entries for all the nodes in the network and not just the neighbors of a node. The changes are propagated through periodic and trigger update mechanisms used by DSDV. Due to these updates, there is a chance of having routing loops within the network. To eliminate routing loops, each update from the node is tagged with a sequence number, in which an even sequence number represents normal route update whereas an odd sequence number represents route error message. The sequence number from each node is independently chosen but it must be incremented each time a periodic update is made by a node. The sequence number of normal update must be an even number, since each time a periodic update is generated the node increments its sequence number by 2 and adds its update to the routing message it transmits. The node cannot change the sequence number of other nodes. If a node wants to send a packet to its neighbors, only then it increments the sequence number of the disconnected node by 1. The nodes receiving this update will then look at the sequence number and if it is odd, will remove the corresponding entry from the routing table.

- DSR Implementation in ns-3
  We implemented the DSR routing protocol in ns-3 and the protocol contains fixed-size header and option headers, and they are essentially shim headers between the transport layer and network layer as shown in Figure 2. There are option headers after the fixed-size header and different options are needed for different routes. Figure 3a shows the route request header and route reply header is shown in Figure 3b. The source route header is used for data packet transmission and is shown in Figure 3c. We have also declared route cache to store all the routes that have been discovered in previous route discovery process. Similarly, we have declared the send buffer class to store all unused data packets and route request packet to avoid duplicate route request and we also declared the rate of consecutive route requests for one destination. The maintenance buffer is used to store the data packet when sent out from the send buffer and waiting for delivery of acknowledgment from the next hop node. Route request table is used to save route request information and it keeps track of route request initiated by the node itself and control the frequency of sending new route request messages.

- Comparison of MANET Routing Protocols
  We perform the simulations over an area of 1500×300 m². All the simulations are run 10 times with each simulation running for 1000 s; some are averaged over 20 runs to increase confidence. Simulations are performed with 50 nodes. The mobility patterns are random walk with speed 10, 20 and 30. We perform experiments with a packet size of 64 bytes to exclude the potential network congestion caused by large packets. All the nodes are configured to send 4 packets/s. Using this lower packet rate, we can correctly evaluate the performance of the routing protocols. We use the ns-3 On-Off application to generate CBR (constant bit rate) traffic. The 802.11b MAC is the link layer over the Friis propagation loss model to limit the transmission ranges of nodes. The transmission range of the nodes is set at 250 m for evaluation. To achieve this transmission range, the transmit power is set to 8.9048 dBm. The mobility model used is steady-state random way point with random velocities from 0.01–20.0 m/s and pause times of 0–900 s.

IV. RESULTS and ANALYSIS

- Performance Measures
  The performance metrics for the evaluation are packet delivery ratio (PDR), routing overhead, and delay.

- Results
  We compare the packet delivery ratio of existing MANET routing protocols implemented in ns-3 with DSR. From Figure 4, we can see that DSR outperforms DSDV, DSR, and AODV. While the pause time increases, the PDR for all the protocols increases linearly.

V. REFERENCES

- The ns-3 network simulator, http://www.nsnam.org

Acknowledgements: This project is supported in part by the National Science Foundation FIND and IFT