QoS Analysis of different Routing Protocols for Scaling MANET

Deepank Modi [1], Amar Nath Dubey [2], Aanshi Saxena [3], Mayurika Patel [4]
Department of Electronics and Communication
Medi-caps Institute of Technology and Management, Indore, MP, India

Abstract

Mobile Ad hoc Network (MANET) consists of self-organized mobile nodes forming an arbitrary network topology by means of wireless link without using any pre-existing infrastructure. The unavailability of infrastructure increases the challenge regarding functionality of the networks, while network reliability depends on the routing protocol. Since the performance of a routing protocol in MANET is sensitive to scalability and traffic load. Therefore in this paper simulation experiments are performed over different size networks with different number of connections in order to determine the performance variations. The protocols used for quality of service (QoS) analysis are AODV, DSDV, DSR and OLSR. The performance evaluation of these routing protocols is done by using network simulation tool (NS-2) with respect to average throughput, average end-to-end delay, normalized routing load (NRL) and packet delivery ratio (PDR). Finally, comparison is done to determine the efficient routing protocol.

***Keywords*— MANET (Mobile Ad hoc Network), QoS (Quality of Service), AODV (Ad hoc On-demand Distance Vector), DSDV (Destination Sequenced Distance Vector), DSR (Dynamic Source Routing), OLSR (Optimized Link State Routing Protocol), NS-2 (Network Simulator 2)**

1. Introduction

A MANET is a self-organized wireless network comprises of a number of mobile nodes [1]. MANETs are easily and fast deployable as they do not require any fixed infrastructure [2]. Wireless nodes with fixed transmission range has limited coverage area to communicate with each other, therefore it is not possible for all the nodes to be in direct contact. Hence transmission of information between distant nodes takes place through multi-hop communication in which a packet is delivered to intended destination after travelling through multiple nodes. Due to its low cost and easy configuration MANET has high applicability in situations such as disaster, emergency deployment, tactical military operations, search and rescue. Other future applications may include home networking, conferencing, and personal area network [3].

The mobile nature of nodes and other characteristics of network make routing a complex task. Therefore conventional routing protocols for wired network cannot be used for MANETs due to its characteristics such as limited bandwidth, dynamic topology, and energy constraints [4]. Due to the dynamic nature of MANET the development of routing protocol must ensure the ability of finding efficient route between pairs of communicating nodes. Hence some routing protocols have been developed by considering different characteristics of MANET [5]. The three classes of routing protocols are proactive, reactive and hybrid routing protocol. Most important proactive routing protocol includes DSDV and OLSR. While reactive routing protocols are AODV and DSR. On the other hand ZRP (Zone Routing Protocol) comes under the category of hybrid routing protocols [6]. In proactive routing protocol each node tries to maintain routing information in the form of routing tables. The reactive routing protocol establish route on demand basis by initiating route discovery mechanism whenever a path is required. The hybrid routing protocol exploits the advantages of both proactive and reactive protocol by utilizing their approach at different hierarchical level [7].

In 2011, S.S Kushwaha et. al. investigated AODV, DSDV, and DSR for varying node mobility in terms of packet delivery fraction (PDF) [8]. In 2012, B. S. Gauda et. al. compared ERAODV (Energy AODV), AODV and DSDV in terms of NRL, PDR and energy by varying number of nodes [7]. In 2013, Qutaiba Razouqi et. al. compared DSDV, DSR and AODV in terms of different traffic type using metrics Average energy consumption, Average throughput, NRL and PDR [9].

Substantial research work has been done by the authors regarding performance analysis of routing protocols. Our aim in this paper is to carry out detailed simulation analysis of four routing protocols with varying number of connections in different size network. Analyzing the behavior of routing protocols at varying network size and connections make it easy to understand the behavior of routing protocols and to find most efficient and adaptive protocol.

The rest of the paper is organized as follows. Section 2 briefly describes the four routing protocols. In Section 3, we describe simulation environment and metrics. Results are analyzed in section 4. Finally, the conclusion is presented in section 5.

2. Description of Routing Protocols

2.1 Ad Hoc On-demand Distance Vector (AODV)

AODV is a reactive routing protocol that combines the features such as flooding of Route Request (RREQ) and use of destination sequence number from DSR and DSDV respectively [8]. Whenever a source node wishes to transmit a data to a destination then first it checks routing table for a valid specific route. If, it finds the route then data is transmitted otherwise route discovery mechanism is initiated to get a valid route. A node finds route by flooding RREQ packet throughout the network. A RREQ packet contains the source identifier (SId), Broadcast identifier (BId), Source sequence (SSeq) number, destination sequence (DSeq) number and TTL (Time to live) fields. An intermediate node either forwards the RREQ packet or a RREP packet is sent in response if a valid route is present in its route cache. The destination sequence number in the “RREQ” is compared with the sequence number at the intermediate node to check the validity of a route [7]. Hello messages are broadcasted periodically by a node to indicate its presence to the neighboring nodes. If a neighboring node does not receive hello message from a particular node within a specified time then the link is considered as broken link, notified by sending a Route Reply (RERR) packet to the affected set of nodes [10].

2.2 Destination Sequenced Distance Vector (DSDV)

The DSDV protocol is based on classical Bellman-Ford table driven routing mechanism. The improvement in the protocol includes decrease in convergence time and freedom from infinite-loop problem. A routing table is maintained at each node in the network that contains entries of all reachable nodes along with the first node in the path to reach a destination node. A sequence number is maintained by each node in the network that increases monotonically whenever any update is sent. Each route entry is tagged with a sequence number marked by the destination node which is used to detect stale route entries so that the loop formation can be avoided [8]. Route entries are updated upon reception of new routes with higher sequence number. A node also maintains the highest sequence number for each destination so that the freshness of a particular route can be determined [10]. Periodically broadcasting of tables between neighbor nodes help in the maintenance of an updated view of the network topology. There are two ways of sending table updates: incremental or full dump. In incremental update, information of only those entries are sent which are changed since last update, whereas whole routing table is exchanged between neighbors in full dump update [9].

2.3 *Dynamic Source Routing (DSR)*

It is a reactive routing protocol. In which a route discovery mechanism is initiated between communicating nodes. In this mechanism, a source node broadcast a RREQ packet throughout the network until it reaches the destination node. After receiving the RREQ packet, either by the destination node or an intermediate node with valid route to the destination node, a RREP packet is sent. A RREP packet contains intermediate nodes address between the source and the destination node and follows the reverse path back to the sender. In DSR, the source node stores the complete route to destination that includes the entire intermediate node address and stores this list in the packet header. That is to be followed by the data packet [11]. Whenever any link of the existing path breaks, a RERR packet generated by the affected node is forwarded towards the source node. If the path is still required, then route establishment process is reinitiated by the source node [9].

2.4 Optimized Link-State Routing Protocol (OLSR)

It is a proactive routing protocol based on classical link state routing algorithm in which optimization is achieved with the help of MPR (Multipoint Relaying) technique [2]. MPR nodes are used for efficient transmission of control messages throughout the network. Each node maintains a minimal subset of nodes called MPR set among one-hop neighbors to cover all the two-hop neighbors. If a node broadcast control message to one hop neighbor then the nodes that do not belong to its MPR set can only read and process the information but do not forward the packet. Only MPR nodes are allowed to generate link state information, thereby reducing the number of control messages to achieve further optimization. Thus making it’s suitable for large and dense network by substantial reduction in the message overhead [12], [13]. Hello packets and topology control (TC) messages are used by the nodes in order to maintain topology information of the network. Each node in the network also maintains a set of nodes called MPR selectors of that node with the help of HELLO messages. Hello messages are transmitted periodically by the nodes to its immediate neighbors that contain information about its neighbors and their link status [14]. The selection of MPR set is the key concept in OLSR because smaller set of MPR nodes introduces less overhead in the network [15]. TC messages that contain originating node address and its MPR selector list are used for broadcasting information to its entire MPR selector set [16].

3. Simulation Environment and Performance Metrics

The simulation experiments are conducted using a discrete event simulator ns-2.35 on the Linux platform Ubuntu 12.04. The experiments are performed over 1000m×1000m simulation area with 200 seconds simulation time to evaluate the effect of scalability and number of maximum connection for performance analysis of the routing protocol. We have generated 10 traffic pattern files and 10 node movement files by considering different scales of network and traffic load. The different scales of network include 30, 60, 90, 120 and 150 nodes (as shown in table I) that are distributed randomly. The traffic load is generated using 15 and 25 maximum connections between pair of nodes that are selected randomly. Random waypoint mobility model is used to bring randomness in the node movement pattern. In RWP the nodes are placed randomly in the simulation area and then they select a location called waypoint and start moving in that direction with constant velocity. The pause time corresponds to a period of time during which a node halts at the waypoint. Again it selects a new waypoint and follows the same procedure during the total simulation time [16].

Table 1
Simulation Parameters

Parameter	Value
Simulation Area	1000m×1000m
MAC Protocol	IEEE 802.11
Mobile Nodes	30,60,90,120 and 150
Antenna Type	Omni-Antenna
Propagation Model	Two Ray Ground
Number of Connections	15 and 25
Packet Size	512 bytes
Routing Protocols	AODV, DSDV, DSR and OLSR
Traffic Source	CBR (UDP)
Simulation Time	200s
Pause Time	20s
Connection Rate	4 Packets/s
Speed	Up to 20m/s

These are the following parameters used to analyze QoS of different routing protocols for scaling MANET-

1.) *Throughput*: It is the amount of data received over the total duration of simulation time. It is expressed in kilobits per second [2].

2.) *End-to-end delay*: The average time taken by all the packets to travel from constant bit rate (CBR source to application layer of the destination.

3.) *Packet delivery ratio*: The ratio of the data packets received at the receiver nodes to the packets generated at the sender nodes [13].

4.) *Normalized Routing Load*: It is the ratio of the number of routing packets sent to the number of data packets received by the destination nodes [9].

4. Result and Analysis

4.1 Simulation result for throughput

For 15 connections, AODV has the highest values of throughput in the different size of network. DSDV starting with the least values of throughput shows improvement in the performance till 120 nodes and a drastic fall as well. OLSR with higher values of throughput than DSDV till 90 nodes network has significant performance degradation thereafter. DSR with high variations in the values has an average performance in the networks, shown in Figure 1.

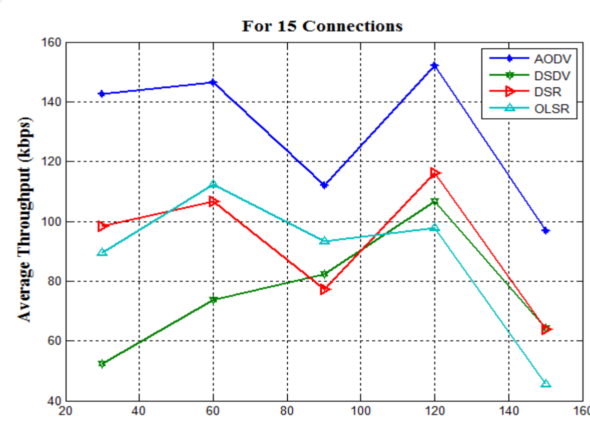

Figure 1. Average Throughput v/s No. of Nodes

For 25 connections, the DSR protocol has least values of throughput under high traffic load. Comparatively the performance of DSDV is satisfactory till 120 nodes with respect to DSR, starting with the least value of throughput. The performance of OLSR is better than DSR and DSDV but decreases gradually as the network size increases. In terms of throughput, AODV is better for 25 connection network, hence it decreases significantly for higher number of nodes, shown in figure 2.

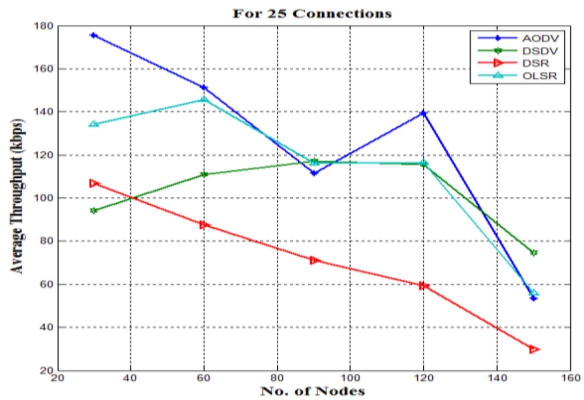

Figure 2. Average Throughput v/s No. of Nodes

4.2 Simulation result for end-to-end delay

For 15 connections, it is analyzed that the DSR protocol starting with the highest value of end-to-end delay, it decreases in the range till 120 nodes and then again increases. The DSDV protocol with least values of end-to-end delay for all size networks produces constant performance till 120 nodes and then further increases. The performance of OLSR is similar to DSDV till 60 nodes, then the values increases with increasing the number of nodes and finally attains the highest value of end-to-end delay. The AODV protocol has higher end-to-end-delay as compare to DSDV and OLSR till 90 nodes, but always lower than DSR, shown in figure 3.

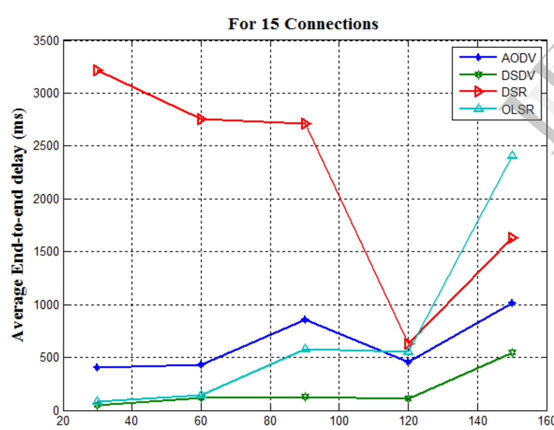

Figure 3. Average End-to-end delay v/s No. of Nodes

For 25 connections, the end-to-end delay of DSR is highest. So, DSR is performing low under high traffic condition. The DSDV protocol produces best performance as compare to AODV, DSR and OLSR for used number of nodes. Actually, use of multipoint relaying (MPR) technique make the performance of OLSR better than AODV and DSR. But, due to increase in number of MPR nodes in the network OLSR produces comparable performance with AODV for increasing number of nodes, shown in figure 4.

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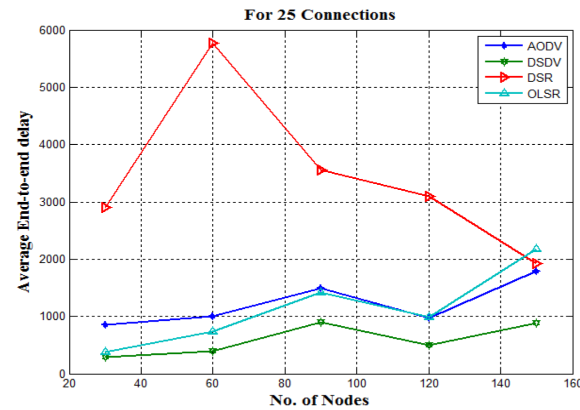

Figure 4. Average End-to-end delay v/s No. of Nodes

4.3 Simulation result for packet delivery ratio

For 15 connections, the packet delivery ratio (PDR) of DSDV increases till 120 nodes. On an average, the OLSR protocol has comparable PDR than DSR and DSDV till 90 nodes. After that the performance of DSDV is partially better than DSR as well as OLSR for higher nodes. The AODV protocol producing the highest values of PDR in different size networks, and provides better performance than all used protocols. It has found, all used protocols have lowest PDR values at 150 nodes network, shown in figure 5.

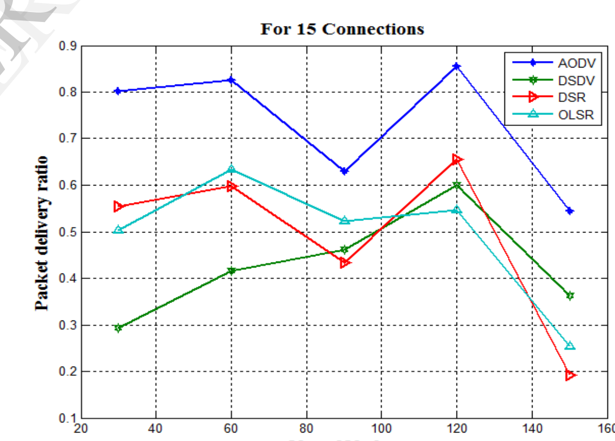

Figure 5. Packet delivery ratio v/s No. of Nodes

For 25 connections, the packet delivery (PDR) ratio of DSR protocol is lowest and its value decreases linearly as the network size increases. The PDR of DSDV increases gradually till 90 nodes, then found sharp decrement at 150 nodes network. On an average, the performance of OLSR is better than DSR and DSDV. The AODV protocol starting with the highest value of PDR has continuous degradation in the performance with respect to increasing number of nodes in the network, shown in figure 6.

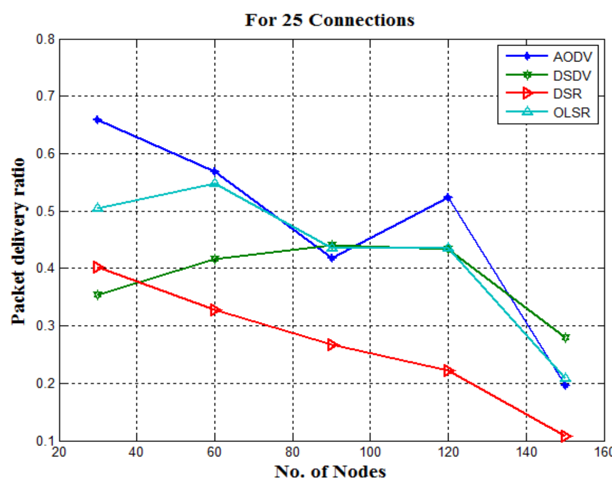

Figure 6. Packet delivery ratio v/s No. of Nodes

4.4 Simulation result for normalized routing load

For 15 connections, the DSDV protocol produces the least values of normalized routing load (NRL) for all size networks. The performance of DSR is quite comparable with OLSR and AODV for less number of nodes and not good performance at 150 nodes network with highest value of NRL. The OLSR has comparable performance with DSR and DSDV till 90 node network, and then it attains increasing values for higher nodes. The performance of AODV protocol is better as compare to DSR and OLSR at higher nodes network, shown in figure 7.

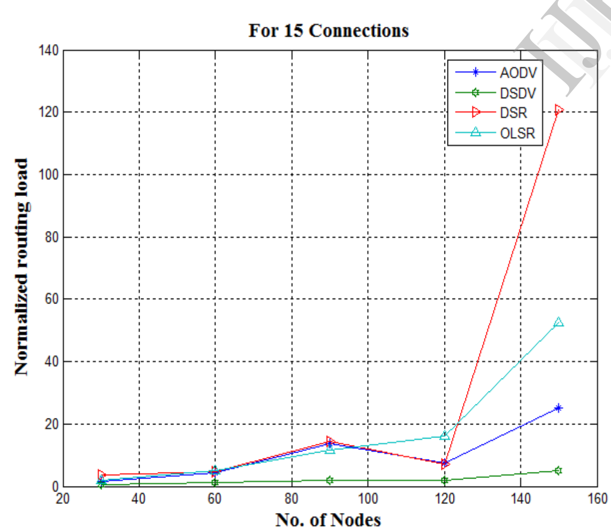

Figure 7. Normalized routing load vs No. of Nodes

For 25 connections, the DSDV protocol has the best performance in terms of NRL. The OLSR protocol has far better performance than AODV and DSR protocols due to its proactive routing approach for high traffic load. The NRL values of all the protocols increases gradually as the network size increases. The performance of AODV is better than DSR in all size networks in terms of NRL. In high density connections DSR has attained highest values of NRL at different size networks. It is found, all the protocols have experienced highest values of NRL at 150 nodes network, shown in figure 8.

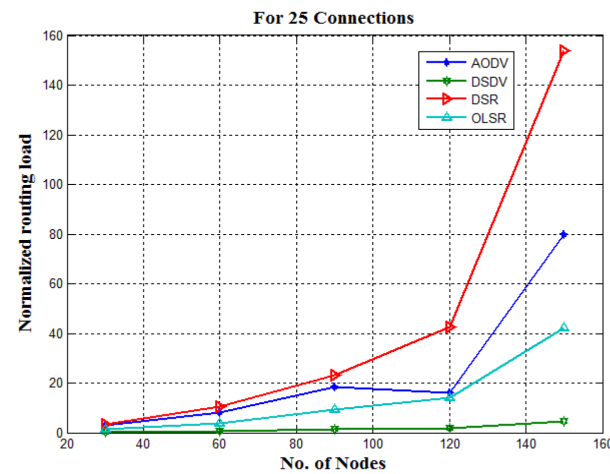

Figure 8. Normalized routing load vs No. of Nodes

5. Conclusion

A detailed performance analysis of routing protocols for MANET has been presented in this paper. It has analysed through various parameters of QoS by increasing the density of nodes and traffic load. The AODV protocol produced best result in all network scenarios and traffic conditions with respect to throughput and packet delivery ratio. The proactive protocol DSDV guarantees lowest values of delay and shown best performance in terms of end-to-end delay for all size networks. DSR has worst performance in congested network conditions of high traffic load in terms of all the parameters. The OLSR protocol produces better performance in terms of delay and NRL with compare to AODV and DSR but not performed as well in terms of throughput and PDR.

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