Impacts of Linear Mobility on MANETs Routing Performance under Different Network Loads

Zeinab R. Khaleel, and Dr. Mahmoud M. AL-Quzwini
College of Engineering, Alnahrain University,
Baghdad, Iraq
Department of Computer Engineering

Abstract

Routing is the biggest challenge and significant area of research within Ad Hoc networks due to nodes mobility, dynamic topology, frequent link breakage, limitation of nodes (memory, battery, bandwidth, and processing power), and lack of central point like base stations or servers. Analyzing and comparing different MANET routing protocols give a solution to the challenges in the Ad Hoc routing in different situations. OMNET++ is used to simulate MANET routing under different mobile node speeds and different network loads based on the following performance metrics: packet delivery ratio, lost packets, average transmission delay, throughput and overhead of two reactive routing protocols (AODV and DSR) and one proactive protocol (OLSR) to show the differences and to bring usefulness of these algorithms. In line network topology when using a heavy network load under variable node speeds, the performance of AODV is better than both DSR by 66.9% and OLSR by 36.9% with respect to packet transmission ratio (PTR), the AODV protocol overhead is less than that of DSR by 30.9% and OLSR by 51.6%; however for transmission time delay, DSR outperforms both AODV by 6.02% and OLSR by 1.5%.

Keywords: *Mobile Ad-Hoc Network; MANET; Routing; AODV; DSR; OLSR; Packet Transmission Ratio (PTR); packet transmission time delay; Throughput; lost packets; Overhead.*

1.1 INTRODUCTION

A Mobile Ad-Hoc Network (MANET) is a set of mobile nodes which communicate over radio signals and do not need any infrastructure [1]. Generally, each node can only be a transmitter (TX) or a receiver (RX) at a time. Communication among mobile nodes is limited within a certain transmission range and nodes share the same frequency domain. So, within such a range, only one transmission channel is used, covering the entire bandwidth. Therefore packet delay is caused by not only the traffic load at the node, but also the traffic load at the neighboring nodes, which is called “traffic interference.”

A medium Access Control MAC protocol (IEEE 802.11g standard) operates in the 2.4 GHz band with a maximum physical layer bit rate of 54 Mbit/s [2, 3]. A MAC protocol play an important role in MANETs, it defines how each mobile unit can share the limited wireless bandwidth resource in an efficient manner. The source and destination could be far away, and each time packets need to be relayed from one node to another in multi-hop fashion, a medium has to be accessed. Accessing a medium properly requires only informing the nodes within the vicinity of transmission. MAC protocols control access to the transmission medium [4].

MANET is very flexible and suitable for several situations and applications, so does not operate under predetermined topology means it is self-organizing, self-managing, and self-remedial type of networks [5-8]. When two nodes are not within the radio range of one another, they use intermediate nodes to route packets for them [9].Therefore, this kind of networks are also called mobile multi-hop Ad-Hoc networks. Nodes not only have to fulfill the functionality of hosts, but also each node has also to be a router, i.e., forwarding packets for other nodes, to allow nodes to communicate with those not in direct wireless transmission range, hence MANET can be deployed easily with a high degree of freedom and low cost [1, 7,9,10].

Important properties of MANET [11]:

1. Support for multi-path: Each node has a routing table with entries for all its neighbors. Hence, every node in the MANET can assist in routing of packets.
2. MANET can be formed without any preexisting infrastructure.
3. It follows dynamic topology where nodes may join and leave the network at any time and the multi-hop routing may keep changing as nodes join and depart from the network.
4. Limited bandwidth and limited power.

Most interesting applications for MANET are disaster and military applications, with upcoming radio technologies, e.g., IEEE 802.11a [2] and Bluetooth [12], the realization of multimedia applications over MANETS comes closer. Under such application environments, MANET has dynamic topology changes due to the mobility of nodes or simply due to transmission errors, which make routing as a challenging task in MANETS .the major concern for routing is high node mobility; so adaptive routing protocols should be used to handle such mobility in order to enhance the overall network throughput while maintaining low energy consumption for packet processing and communications [9, 11, 13, 14].

Copyright (c) 2014 International Journal of Computer Science Issues. All Rights Reserved.

The remainder of this paper is organized as follows. Section 1.2 gives an overview of the related work. In section 2 we present the basics and the background of MANET routing protocols and describe the idea and procedure of AODV, DSR and OLSR routing algorithm in detail. Subsequently, in section 3 we present simulation model and parameter setup; results and discussion are explained in section 4.

Finally, section 5 draws the conclusion of this paper.

1.2 RELATED WORK

Many studies have been undertaken to analyze and evaluate the performance of different routing protocols for different types of MANET network scenarios, this section surveys the most pertinent studies presented in recent years:

- **T. H. Clausen, Jacquet and Viennot, in 2002[15]** evaluated AODV, DSR and OLSR routing protocols in varying network conditions (node mobility, network density) and with varying traffic conditions (TCP, UDP). Their evaluation showed that OLSR performs comparatively well against the reactive protocols.
- **L. Tao, Midkiff and Park, in 2003[16]** presented comparison of overhead of AODV and OLSR protocols, the results showed that the AODV protocol may suffer large overhead when establishing routes with high mobility. While OLSR, study showed that the overhead is independent of the network traffic.
- **R.A.Santos et al., in 2005[17]** compared AODV and DSR .the authors concluded that although AODV and DSR perform almost equally well under vehicular mobility, the location-based routing schema provides excellent performance.
- **Gowrishankar et al., in 2007[18]** made performance comparison of AODV and OLSR .The comparison showed that the OLSR protocol is more efficient in networks with high density and highly sporadic traffic. Moreover, this comparison illustrated that the AODV protocol will perform better in the networks with static traffic, when the number of source and destination pairs is relatively small for each host.
- **S.Tamilarasan and P. A. Abdul saleem, in 2011[19]** presented a logical survey of routing protocols and compared the performances of the AODV, DSR, DSDV and OLSR routing protocols.

Most of these researches are based on random nodes' distribution (grid network) for evaluated protocols. However, the performance of these protocols in network with linear topology was not tested, since in line topology there are a limited numbers of routes for transferring the data between the nodes. Therefore the performance of these protocols must be studied under linear topology in order to find the best protocol that performed well in line networks.

2. MANET ROUTING ALGORITHMS

Routing in MANET is difficult as a result of the dynamic nature of network topology and the resource constraints. The issue of link reliability in MANET is a main problem to transmit messages through the wireless channels. Wireless channels have high channel bit error rate and limited bandwidth. The high bit error rate degrades the quality of transmission and the network performance [6]. So routing is a challenging task since there is no central coordinator, such as base station, or fixed routers in other wireless networks that manage routing decision. Each node act as a router/base station to forward the information, the broadcasting is inevitable and a common operation in Ad-Hoc network. It consists of diffusing a message from a source node to all the nodes in the network. A special form of routing protocols is necessary. Many routing protocols have been developed for Ad Hoc networks. The routing protocols are classified as follows on the basis of the way the network information is obtained in these routing protocols [13]:

1. Proactive or table-driven routing protocols:
The proactive protocols maintain routing information about each node in the network. The information is updated throughout the network periodically or when topology changes. Each node requires storing their routing information. For example: Destination Sequenced Distance Vector routing (DSDV) and Optimized Link State Routing (OLSR).

2. Reactive or on-demand routing protocols:
The reactive routing protocols attempt to establish a route when a communication request occurs. When a source wants to send to a destination, it invokes the route discovery mechanisms to find the path to the destination. Reactive protocols are more popular set of routing algorithms for mobile computation because of their low bandwidth consumption. For example: Ad-Hoc On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR) [11].

3. Hybrid Routing Protocols:
These protocols are using the best features of both the on demand and table driven routing protocols. For example: Temporally Ordered Routing Algorithm (TORA) and Zone Routing Protocol (ZRP) [13].

2.1. AD HOC ON-DEMAND DISTANCE VECTOR (AODV)

AODV protocol is a reactive routing protocol proposed by IETF MANET Working Group [20] .AODV is distance vector type routing where it does not involve nodes to maintain routes to destination that are not on active path [11]. AODV discover route to destination when required. AODV consists of routing table which helps to discriminate between expiry and fresh routes. The routing table at node encloses the

Copyright (c) 2014 International Journal of Computer Science Issues. All Rights Reserved.

sequence number and next hop information [8, 13, 21]. The working of protocol is consists of two phases:
1. Route discovery.
2. Route maintenance.

In *route discovery* process, the source node create RREQ packet, if the path to destination is not stored in the routing table, and pass it to the neighboring nodes. The neighboring nodes will pass it to their neighbors and so on. When the packet arrive at to the destination node, then destination node create RREP (Route Reply) packet and send it back to the source node. Thus the path is created between source and destination node. Each RREP also contains a destination sequence number, which is used to prevent routing loops and helps nodes determine the freshness of routing information. The source, on receiving the RREP starts sending data.

In *route maintenance* process, each node broadcasts periodic HELLO messages to advertise its presence. A node learns that a link to a neighbor is broken, when it does not receive a HELLO from that neighbor for a predetermined time. When a broken link is detected, the detecting node sends Route Error (RERR) messages to all predecessor nodes that use the broken link to reach their respective destinations. This RERR packet, travels back to the sources who reinitiate route discovery. There are two main factors that cause link failures; these are battery life time and mobility [5, 7, 8, 21].

Figures 1, 2 and 3 show the route mechanisms of the AODV routing protocol.

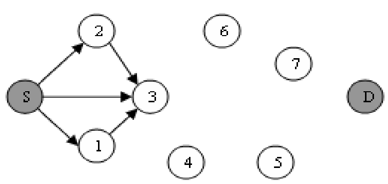

Figure 1: AODV Route Request Broadcast [22]

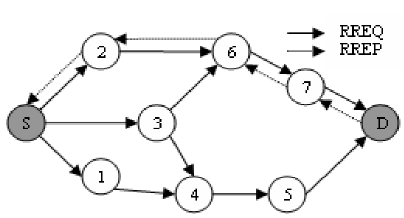

Figure 2: AODV Route Reply Phase [22]

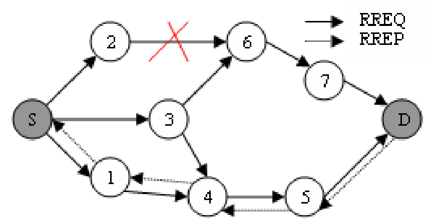

Figure 3: AODV Route Maintenance Phase [22]

2.2. DYNAMIC SOURCE ROUTING (DSR)

DSR is a reactive On-demand source routing protocol. The key characteristic of DSR is based on the concept of source routing, in which each packet to be routed carrying in its header the full ordered list of nodes through which the packet should pass. The key benefits of source routing is that intermediate nodes do not need to maintain up-to-date routing information in order to route the packets they forward, since the packets themselves already contain all the routing decisions. This fact, coupled with the on demand nature of the protocol, eliminates the need for the periodic route advertisement and neighbor detection packets present in other protocols. Nodes in DSR 'learn' and cache multiple routes to each destination (either as a response to a request, forwarding, or overhearing) to be used in case of route loss. In addition, this also helps in reducing routing overheads [13, 22].

Several additional optimizations have been proposed such as:
1. Salvaging: An intermediate node can use an alternate route from its own cache, when a data packet meets a failed link on its source route.
2. Gratuitous route repair: A source node receiving a RERR packet piggybacks the RERR on the following RREQ. This helps clean up the caches of other nodes in the network that may have the failed link in one of the cached source routes.
3. Promiscuous listening: When a node overhears a packet not addressed to it, it checks if the packet could be routed via itself to gain a shorter route [23].

DSR protocol has two main mechanisms: Route Discovery and Route Maintenance, which work together to allow nodes to discover and maintain routes in order to send the data packets to the destination [11].
1. Route Discovery:
Figure 4 shows the route discovery mechanism of DSR. Whenever source node (S) wants to sends data packets to the destination node (D). First, it checks its route cache for a route to the destination, if route is found then source forward the packet according to route. Otherwise, source node (S) broadcasts Route Request Packet (RREQ) to its neighbor nodes which are in its transmission range. Each RREQ packet

Copyright (c) 2014 International Journal of Computer Science Issues. All Rights Reserved.

contains source address, destination address, request ID, and route record. Each intermediate node appends its ID to the request message before re-transmitting it until the request reaches the requested node “D”

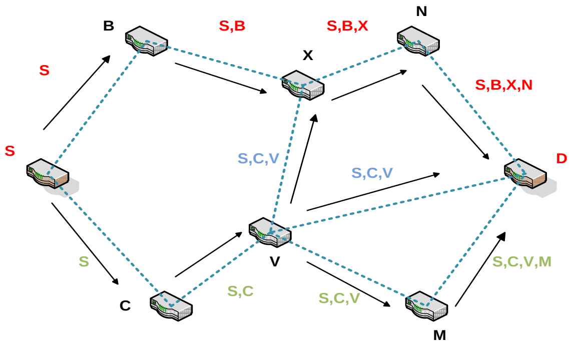

Figure 4: DSR route discovery mechanism [23]

When the destination, node “D”, receives the route request, it checks its cached routes to find a better route to the request initiated by “node S”. If it finds a route in its cached routes, then it sends a route reply to the request initiator using the source routing mechanism, otherwise it uses the reverse of the route that has been used by the request message to send the reply [23].

2. Route Maintenance:

When relay node transmitting the packet and found that the next node in source route is not reachable due to any reason then it sends route error to source. To salvage the packet relay node first check its route cache for any other route to destination, if route found then it forward the packet and inform the source about new route to destination. When source node receives route error packet then it discards all routes which contain the failure link [6, 13, 24].

AODV is based on DSR algorithm. It uses the route discovery and route maintenance practice of DSR. DSR packet carries the complete route information, while the packet of AODV only carries the destination address, it has less routing overhead than DSR. At the same time, AODV makes use of routing messages and sequence numbering. Here AODV is evaluated and analyzed from the aspect the energy utilization metric. AODV consists of routing table which helps to differentiate between expiry and fresh routes. The routing table at node contains the sequence number and next hop information. The route acquisition procedure in DSR allows more routes to be detected and cached than in AODV, which obtains a single route per RREQ. With DSR, packets wait less time during route acquisition than with AODV [22].

2.3. OPTIMIZED LINK STATE ROUTING PROTOCOL (OLSR)

The Optimized Link State Routing Protocol (OLSR) is a Proactive protocol developed for MANETS by the IETF MANET Working Group [25]. It operates as a table driven protocol, i.e., exchanges topology information with other nodes of the network regularly. The protocol is an optimization of the pure link state algorithm. The key concept used in the protocol is that of multipoint relays (MPRs). The MPR set is selected such that it covers all nodes that are two hops away. The node N, which is selected as a multipoint relay by its neighbors, periodically announces the information about who has selected it as an MPR. Such a message is received and processed by all the neighbors of N, but only the neighbors who are in N’s MPR set retransmit it. Only nodes, selected as such MPRs are responsible for forwarding control traffic, intended for diffusion into the entire network. MPRs provide an efficient mechanism for flooding control traffic by reducing the number of transmissions required. OLSR is suitable when the communicating pairs change over time since routes are maintained for all known destinations at all times [26, 27].

For route calculation, each node calculates its routing table using a “shortest hop path algorithm” based on the partial network topology it learned. MPR selection is the key point in OLSR. The smaller the MPR set is the less overhead the protocol introduces. Table 1 shows how node B selects MPR(s), based on the network depicted in Figure 5:

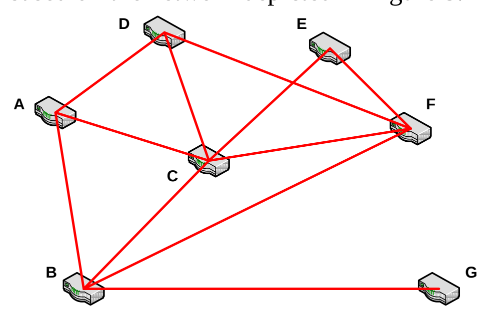

Figure 5: Network Example for MPR Selection of OLSR [28]

Table 1: MPR Selection in OLSR [28]

Node	***1 Hop Neighbors***	***2 Hop Neighbors***	***MPR(s)***
B	**A,C,F,G**	**D,E**	**C**

From the perspective of node B, both C and F cover all of node B’s 2-hop neighbors. However, C is selected as B’s MPR as it has 5 neighbors while F only has 4[28].

OLSR uses two kinds of control messages: Hello and Topology Control (TC). Hello messages are used for finding information about the link status and the host’s neighbors. With the Hello message, the Multipoint Relay (MPR) Selector set is constructed which describes which neighbor has chosen this host to act as MPR. The Hello messages are sent only one hop away but the TC messages are broadcast throughout the entire network. The TC messages are broadcast periodically and only the MPR hosts can forward the TC messages [27, 29].

3. SIMULATION MODEL AND PARAMETERS SETUP

OMNET++ simulator (Verga 2003) is adopted in this paper to assess the performance of three MANET routing protocols (AODV, DSR and OLSR). The simulation parameters setup is shown in table 2.

To simulate the real active behaviors of the nodes in MANET we use linear mobility model [4, 28, 30], 40 nodes are distributed along both sides of the freeway in line topology with 250 meter separations between each two lines of a simulation area of a 5-km area straight freeway section with two lanes in one direction. The mobile nodes' speeds are ranged between 1m/s as the minimum speed and 30 m/s as the maximum speed, the traffic model used is CBR (Constant Bit Rate) with packet size of 512 bytes, packet rate(frequency) of 10 packets/s. and simulation time of 500s. The source-destination pairs are chosen such that for light network load , one fixed source node sends to one mobile node (destination) and for heavy network load, ten fixed nodes (sources) send data to ten mobile nodes (destinations). The performance of AODV, DSR and OLSR routing protocols are evaluated using the following performance metrics [22, 31]:

1. Network Throughput: defined as the percentage of successfully transmitted radio-link level frames per unit time. It is calculated according to this formula:

$$\text{throughput} = \frac{\text{Number of delivered packet} * \text{Packet size} * 8}{\text{Total duration of simulation}}$$

The network throughput is directly influenced by packet loss, which may be caused by general network faults or uncooperative behavior.

2. Packet Transmission Ratio (PTR): PTR is used to measure the reliability. It is defined as the number of packets received by all destinations over the number of packets sent by all sources. The average PTR is calculated according to this formula: PTR = Packets Received / Packets Sent considering all the nodes in the network.

3. Lost packets: Packet loss is a measure of the number of packets dropped by the nodes due to various reasons and it represents the difference between the number of packets sent by the source node and the packets received at the destination node.

4. Protocol overhead: the number of necessary control messages for all nodes in the network to maintain the routing table or a source node to establish and maintain a route to the destination node. Protocol overhead can be expressed as a percentage of non-application bytes (protocol and frame synchronization) divided by the total number of bytes in the message.

5. Packet transmission time delay: is defined as the interval between the frame arrival time at the MAC layer of a transmitter and the time at which the transmitter realizes that the transmitted frame has been successfully received by the receiver. The mathematical representation of time delay can be expressed as:

$$\text{Average packet transmission delay} = \frac{\sum[\text{Time received} - \text{Time sent}]}{\text{Total number of data Packets Received}}$$

This includes all the delays caused during route acquisition, buffering and processing at intermediate nodes, retransmission delays, etc. It is measured in milliseconds [10, 13].

Table 2: Simulation Parameter setup

parameter	*value*
Network Size	5000 x 100 m
Traffic bandwidth	54 Mbps
Transmit Power	2 mW
Carrier frequency	2.4 GHz
Mobility model	linear mobility
MAC protocol	802.11g
Traffic Type	CBR
Packet size	512 bytes
packet frequency	10 packets/s
Nodes number	40
Speed of nodes	1-30 m/s
Simulation time	500s

4. RESULTS AND DISCUSSION

Figure 6 shows the network throughput (in Kbps) versus the node speed for a light network load. For each protocol, the network throughput starts to decrease when node speed increases. The average throughput percentage decrease for AODV, OLSR and DSR are about 1.165%, 10.185%, and 19.734% respectively. This is because the AODV reacts relatively quickly to the topological changes and updates only the hosts that may be affected by the change.

Copyright (c) 2014 International Journal of Computer Science Issues. All Rights Reserved.

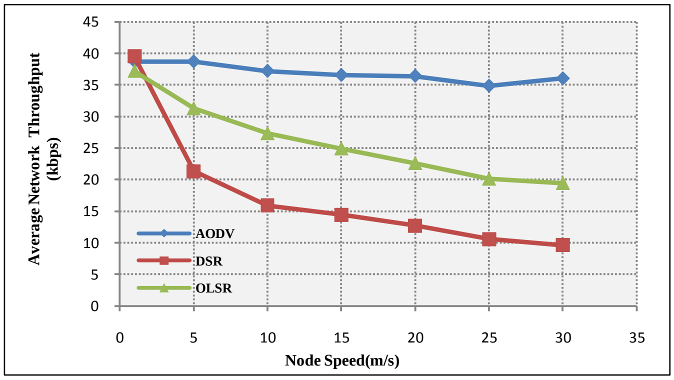

Figure 6: Average Network Throughput vs. Node Speed for Light Network Load

Figure 7 shows the number of lost packets versus the node speed. It shows that the number of lost packets increases for all three routing protocols as a result of increasing the node speed, because the routing protocols should act quickly to accommodate the relatively fast changing environments. AODV shows the lowest packet loss, while DSR is the highest; this is because the DSR cannot react quickly to recover the broken link, especially when there is no route in its cache to the unreachable destination. Also, DSR can only rediscover new routes to the unreachable destination by the source node rather than the upstream node of the broken link performing a local repair.

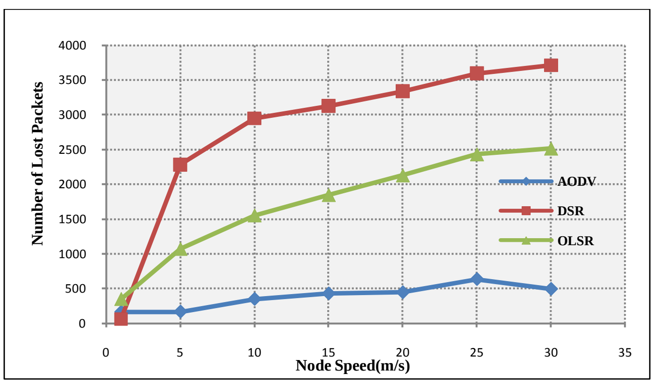

Figure 7: Number of Lost Packets vs. Node Speed for Light Network Load

Figure 8 shows the PTR versus node speed. For each protocol, the network PTR starts to decrease as node speed increases. The AODV performs well, and that the average percentage PTR decreases when using AODV slightly about 1.167 %, and less than the average decrease when using other protocols (DSR, about 19.741% and OLSR, about 10.186%). This is because the AODV reacts relatively quickly to the topological changes in the network; resulting in a small number of lost packets. Moreover, the figure shows that the PTR of OLSR is better than that of DSR but less than that of AODV. This behavior is due to the proactive nature of OLSR.

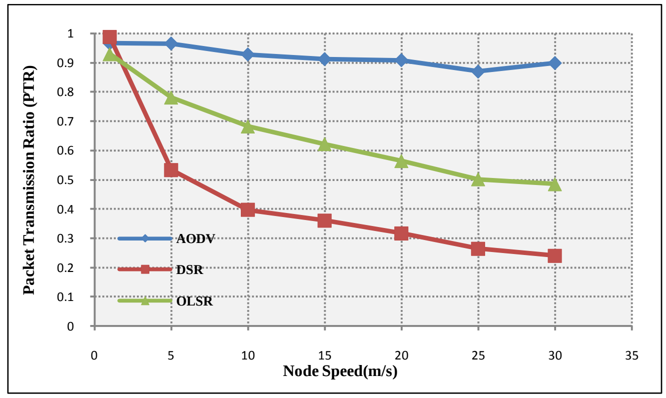

Figure 8: Packets Transmission Ratio (PTR) vs. Node Speed for Light Network Load.

Figure 9 depicts the average packet transmission time delay versus node speed (m/s). It shows that the packet transmission time increases with an increase of node speed for all three protocols, OLSR shows a lower delay than that of DSR and AODV for all speed values. This is attributed to the fact that OLSR continuously maintains routes to all destinations in the network. When link breakage occurs, it can quickly find a new route since the routing table has routes for all available hosts in the network. In reactive protocols, if there is no routes to a destination, packets to that destination are stored in a buffer while a route discovery procedure is conducted which takes some time. DSR has a lower delay than that of AODV for all speed values due to the route acquisition procedure in DSR, which allows more routes to be detected and cached than in AODV, which obtains a single route per RREQ. Therefore; with DSR, packets wait less time during route acquisition than with AODV.

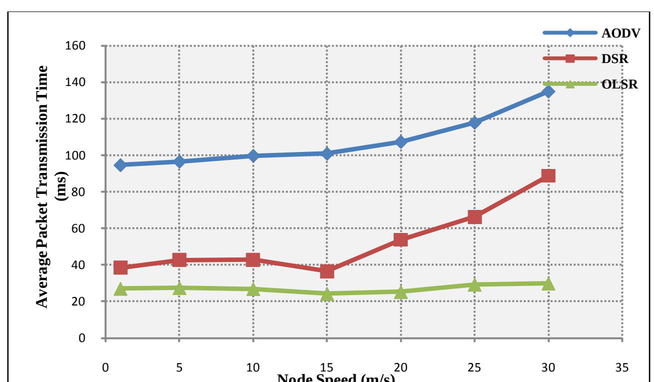

Figure 9: Average Packet Transmission Time vs. Node Speed for Light Network Load

Protocol overhead represents the total number of bytes generated by a routing protocol for routing operations within a network. Increased protocol overhead will negatively affect

Copyright (c) 2014 International Journal of Computer Science Issues. All Rights Reserved.

the network performance by consuming bandwidth. Figure 10 shows protocol overhead versus node speed for a light network load. It also demonstrates that the OLSR has the highest overhead due to the proactive nature of OLSR, which makes it exchange topology information with other network nodes regularly and periodically, that leads to overhead increase. In contrast, the DSR overhead is demonstrably lower than the AODV overhead by 13.795% due to the multiple routes detected and cached with the same RREQ while in AODV single route detected per one RREQ, thus reducing the protocol overhead in DSR.

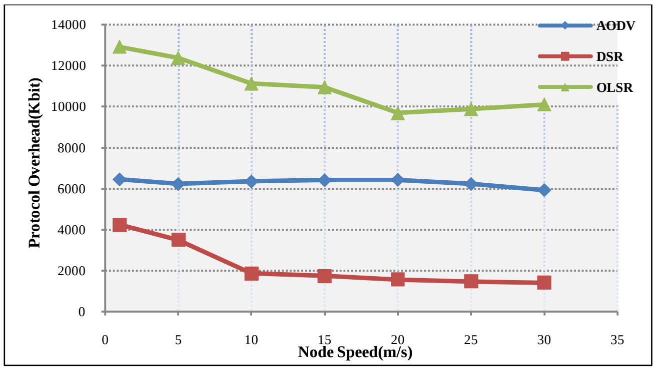

Figure 10: Protocol Overhead vs. Node Speed for Light Network Load

Figure 11 shows the network throughput (in Kbps) versus the node speed for a heavy network load. This figure demonstrates that AODV outperforms DSR by 16.876% and OLSR by 9.451%. When node speed is increased, DSR exhibits the highest drop in throughput due to frequently link breakage which lead to more outdated routes in DSR cache that cannot be used instead of broken link; therefore, at higher mobility coupled with a heavy network load, AODV and OLSR are more robust than DSR.

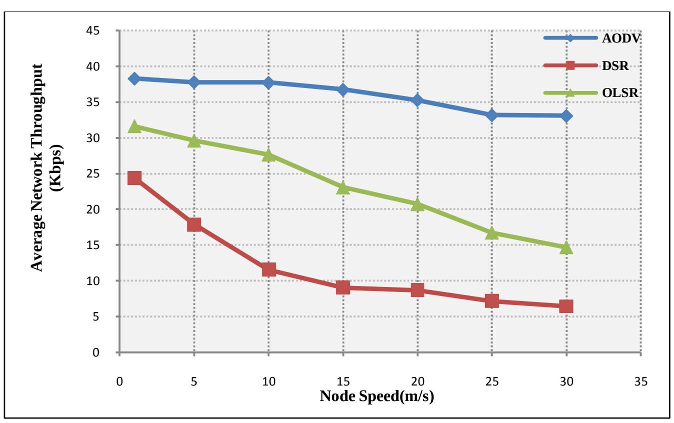

Figure 11: Average Network Throughput vs. Node Speed in for Heavy Network Load

Figure 12 shows the number of lost packets versus node speed for a heavy network load. It also shows that the AODV outperforms the OLSR by 5.039% and DSR by 13.05%. The OLSR continuously maintains routes to all destinations in the network which leads to less time for packets to be delayed in buffer for transmission to its destination. This figure also shows that the number of dropped packets when using DSR is more than the number of dropped packets for AODV and OLSR. This is because the DSR cannot react quickly to recover the broken link, especially when there is no route in its cache to the unreachable destination. Thus, DSR incurs a higher packet loss than AODV and OLSR.

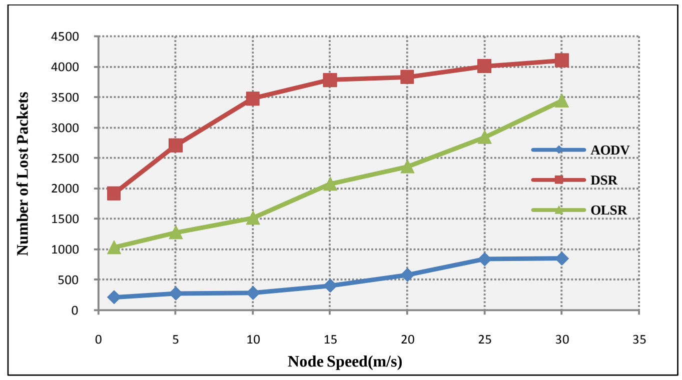

Figure 12: Number of Lost Packets vs. Node Speed for Heavy Network Load

Figure 13 shows the PTR declines with increased speed for a heavy network load for all three routing protocols. The decline, when using a heavy network load, is larger than when using a light network load, because increasing the network load (number of users) means increasing the amount of data pushed into the network which leads, in turn, to more packet drops. This figure also shows that the OLSR outperforms the DSR protocol.

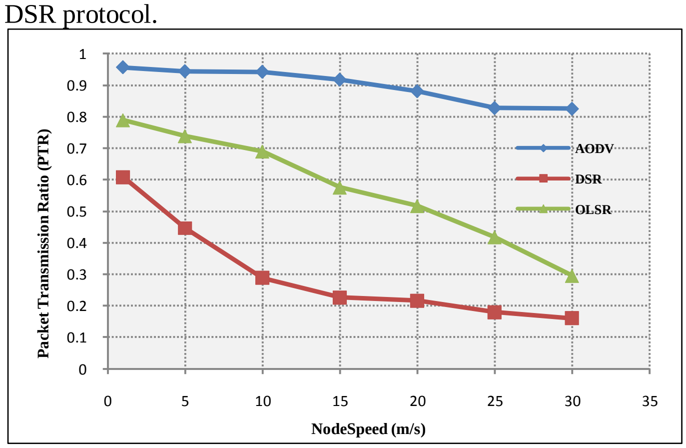

Figure 13: Packets Transmission Ratio (PTR) vs. Node Speed for Heavy Network Load

Copyright (c) 2014 International Journal of Computer Science Issues. All Rights Reserved.

Figure 14 shows the average transmission delay versus node speed. All protocols exhibit higher delays when using a heavy network load because the buffers become full much more quickly, so the packets have to stay in buffers for a longer period of time before they are sent. This figure also demonstrates that the packet transmission time delay of DSR is the lowest when compared to AODV and OLSR delays. This is likely because with a higher mobility and heavier traffic load, links are more frequently broken. Since routes are available in the DSR cache, the DSR route discovery procedure requires less time than the others. AODV discovers routes whenever a change in the topology is detected and the source node is responsible about route discovery. While in OLSR, routes are immediately available due to periodically exchange of routing table information for all network nodes. Therefore, packet transmission delay at using OLSR is less than packet transmission delay at using AODV.

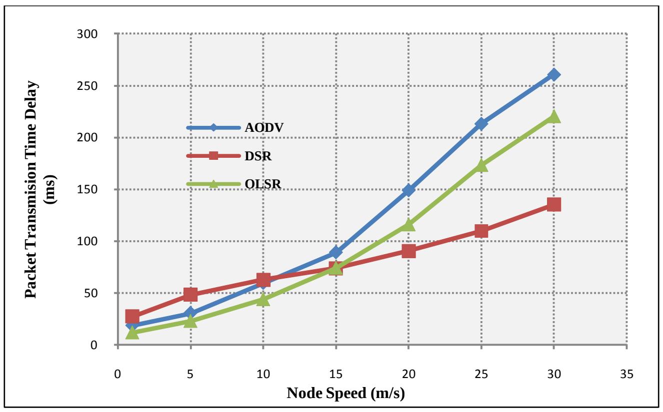

Figure 14: Average Packet Transmission Time vs. Node Speed for Heavy Network Load

Figure 15 demonstrates that the AODV overhead is lower than the both OLSR and DSR overheads by 6.713% and 4.654% respectively. Due to its proactive nature, The OLSR overhead is highest than both DSR and AODV. The DSR overhead is higher than the AODV overhead because DSR is based on source routing algorithm and every data packet must hold the entire route from the source to the destination in its header which increases the DSR overhead.

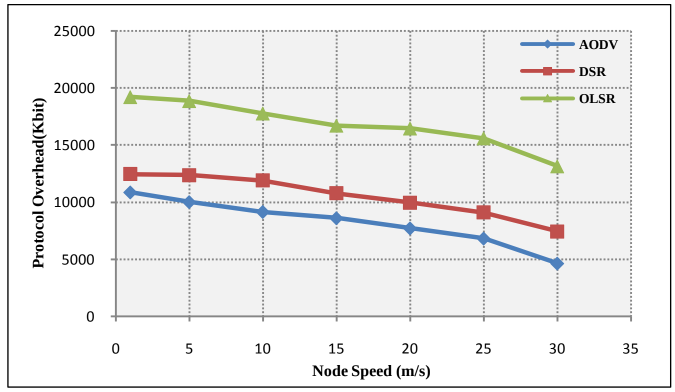

Figure 15: Protocol Overhead vs. Node Speed for Heavy Network Load

5. CONCLUSIONS

In this paper AODV, DSR and OLSR MANET routing protocols are modeled and compared in line network topology. The performance of the routing algorithms has been studied by varying both the mobility speed and network load. The amount of load generated by each source node affects the performance of the network. AODV outperforms DSR by 66.9% and OLSR by 36.9% with respect to PTR; while the AODV protocol overhead is less than that of DSR by 30.9% and OLSR by 51.6%; however for transmission time delay, DSR outperforms AODV by 6.02% and OLSR by 1.5%. Finally, we found that it's preferred to use AODV protocol regardless of network load and speed.

REFERENCES

[1] M. Gunes , U. Sorges and I. Bouazizi," ARA – The Ant-Colony Based Routing Algorithm for MANETs", Department of Computer Science, Aachen University of Technology, Germany ,International Workshop on Ad Hoc Networking (IWAHN), August 18-21, 2002.

[2] http://standards.ieee.org/getieee802/download/802.11g-2003.pdf.

[3] Supplement to IEEE Standard for Information Technology-Higher-Speed Physical Layer Extension in the 2.4 GHz Band. (2000). *IEEE Std 802.11b-1999*, i-90.

[4] S. K. Sarkar, T. G. Basavaraju and C. Puttamadappa, "Ad Hoc Mobile Wireless Networks", Auerbach Publications Taylor & Francis Group, 2008.

[5] T. Nema, et al.," Energy Efficient Adaptive Routing Algorithm in MANET with Sleep Mode", International Journal of Advanced Computer Research, Volume-2 Number-4 Issue-6, pp.431-435, December-2012.

[6] F. Alnajjar and Y. Chen," SNR/RP Aware Routing Algorithm: Cross-Layer Design For Manets", Department of Electrical Engineering, City College and Graduate Center of City

Copyright (c) 2014 International Journal of Computer Science Issues. All Rights Reserved.

University of New York New York, USA, International Journal of Wireless & Mobile Networks (IJWMN), Vol 1, No 2,pp.127-136 ,November 2009.

[7] P. Malhotra," A Survey of Energy Efficient AODV Routing Algorithms in MANET", International Journal Of Computer Engineering & Technology (IJCET), Volume 4, Issue 2, pp. 213-220, March – April (2013).

[8] E. Ravindra, V. V Kohir and V. D Mytri, "A Local Route Repair Algorithm Based On Link Failure Prediction in Mobile Ad Hoc Network", World Journal of Science and Technology, pp.64-67, 2011.

[9] A. Ambhaikar, H.R. Sharma and V. K. Mohabey," Improved AODV Protocol For Solving Link Failure In MANET", International Journal of Scientific & Engineering Research (IJSER), Volume 3, Issue 10, October-2012.

[10] S. Sankar and V.Sankaranarayanan,"Performance Enhancement of AODV Protocol for Dense MANETS", Asian Journal of Scientific Research, pp.170-177, 2012.

[11] A. Shrivastava, et al. ," Overview of Routing Protocols in MANET's and Enhancements in Reactive Protocols".

[12] http://ieeexplore.ieee.org/servlet/opac?punumber=7932.

[13] S. F. Abbas , et al., "Metric Base Analysis and Modeling Experiments of Routing Protocols in MANETs and VANETs Wireless Network using Real Time Scenarios",**IJCSI** International Journal of Computer Science Issues, Vol. 10, Issue 5, No 1, September 2013.

[14] I. F. Akyildiz, " Wireless Mesh Networks", 1st Ed., John Wiley & Sons Ltd, United Kingdom, 2009.

[15] Clausen, T. H., Jacquet, P., & Viennot, L. (2002). *Comparative Study of Routing Protocols for Mobile Ad-hoc Networks*. Paper presented at the 1st IFIP MedHocNet Conference.

[16] Tao, L., Midkiff, S. F., & Park, J. S. (2003, March 20). *A framework for wireless ad hoc routing protocols.* Paper presented at the Wireless Communications and Networking, 2003. WCNC 2003. 2003 IEEE.

[17] R.A.Santos, Edwards, A., R.M.Edwards, & N.L.Seed. (2005). Performance evaluation of routing protocols in vehicular ad-hoc networks. *International Journal of Ad Hoc and Ubiquitous Computing Vol. 1* (1/2).

[18] Gowrishankar, S., Basavaraju, T. G., Singh, M., & Sarkar, S. K. (2007). Scenario based Performance Analysis of AODV and OLSR in Mobile Ad hoc Networks. *", International Journal of the Computer, the Internet and Management, Vol. 5*(4).

[19] S.Tamilarasan, & P. A. Abdul saleem. (2011). Performance Analysis and Comparison of Different Routing Protocols in MANET. *International Journal of Computer Science and Network Security 11* (6), pp87-92.

[20] C. Perkins, E. Belding-Royer and S. Das, " Ad Hoc On-Demand Distance Vector (AODV) Routing", Internet Engineering Task Force, RFC: 3561, , www.ietf.org, July 2003.

[21] Vijayalakshmi P**,** et al., "Energy-Aware Performance Metric for AODV and DSDV Routing Protocols in Mobile Ad-Hoc Networks", **IJCSI** International Journal of Computer Science Issues, Vol. 8, Issue 4, No 1, July 2011.

[22] T. A. Sonawale and S. Nema, "Performance Comparison with Accessibility Prediction and Link Breakage Prediction in MANETs", International Journal of Computer & Communication Technology, Vol.3, Issue-5, pp.13-19, October 2012.

[23] L. A. Hassnawi, et al., " Performance Analysis of Various Routing Protocols for Motorway Surveillance System Cameras' Network",International Journal of Computer Science Issues (**IJCSI**), Vol. 9, Issue 2, No.1, pp. 369-373, March 2012.

[24] P. Yadav, J. Bhattacharjee and R. Soni," A Novel Routing Algorithm Based on Link Failure Localization for MANET", International Journal on Computer Science and Engineering (IJCSE), Vol. 4 No. 10, pp.1738-1743, Oct 2012.

[25] T. Clausen and P. Jacquet," Optimized Link State Routing Protocol (OLSR)", Internet Engineering Task Force, RFC: 3626, www.ietf.org, October 2003.

[26] P. Jacquet, et al., "Optimized Link State Routing Protocol for Ad Hoc Networks ", Multi Topic Conference IEEE INMIC, pp. 62 – 68, 2001.

[27] T. Lin, "Mobile Ad-Hoc Network Routing Protocols: Methodologies and Applications", Ph.D. Dissertation Computer, Virginia Polytechnic Institute and State University, 19th March 2004.

[28] Roy, R. R. (2011). *Handbook of Mobile Ad Hoc Networks for Mobility Models.* London: Springer.

[29] Tamilarasan-Santhamurthy,"A Quantitative Study and Comparison of AODV, OLSR and TORA Routing Protocols in MANET", **IJCSI** International Journal of Computer Science Issues, Vol. 9, Issue 1, No 1, January 2012.

[30] A.A.F. Mahmoud, "A Survey of Mobility Models for Ad Hoc Network Research", M.Sc. thesis, Computer Science, the American University in Cairo School of Sciences and Engineering, May 2005.

[31] S. Corson and J. Macker**,** "Mobile Ad hoc Networking (MANET): Routing Protocol Performance Issues and Evaluation Considerations", Internet Engineering Task Force, RFC: 2501, www.ietf.org, January 1999.

Copyright (c) 2014 International Journal of Computer Science Issues. All Rights Reserved.