

Performance Evaluation of Routing Protocols in Mobile Ad Hoc Networks Using Hypertext Transfer Protocol Traffic

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ABSTRACT Mobile Ad Hoc Networks (MANETs) are receiving significant interest and are becoming very popular in the world of wireless networks and telecommunication. MANETs consist of mobile nodes, which can communicate with each other without any infrastructure or centralized administration. In MANETs, the movement of nodes is unpredictable and complex, thus making the routing of the packets challenging. Most of the work done on the performance evaluation of routing protocols is done using the Constant Bit Rate (CBR) traffic. This paper involves the modeling and simulation of Mobile Ad hoc Networks (MANETs). The performance analysis of the MANET routing protocols such as Ad hoc on Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Temporary Ordered Routing Algorithm (TORA), and Optimized Link State Routing (OLSR) of MANET routing protocols are evaluated under different scenarios using Hypertext Transfer Protocol (http) traffic. The overall results show that the proactive routing protocol (OLSR) performs better in terms of delay and throughput than the reactive routing protocols AODV, DSR and TORA for a medium size MANETs.

INTRODUCTION

Mobile Ad hoc Networks (MANETs) are becoming very popular in the world of wireless networks. MANETs are ad hoc networks consisting of mobile nodes, which can communicate with each other without any infrastructure. In MANETs, there is no need for infrastructure or central administration since the temporary networks formed by the mobile nodes are self-configuring, self-routing and self-organizing. Every node in a MANET acts as a router or as a relay station (Irshad et al. 2008), and each node participates in routing packets (Naumov et al. 2005). That is, the sender node can either forward the packet directly to the destination when it is close enough or through intermediate nodes when the destination node is out of reach (Campos et al. 2007). MANET nodes can form the network at anytime and anywhere, thus making the network topology highly dynamic and the routing of packets complex. Hence, there is a need for MANETs to have routing protocols, which can adapt to the mobility and dynamically changing topology of the network. It should be noted that in ad hoc networks like MANET, the topology changes frequently and

interferences problems are inevitable in many cases, as a result link failures can arise. For this, Djellouli A et al. (2014) proposed multipath routing approach where in some cases as an extension of the traditional routing algorithms are incorporated.

Some researchers have classified routing protocols into two categories, namely, link-state protocols and distance-vector protocols (Belding-Royer et al. 2003), while others (De Rango et al. 2008) classified them into four categories, that is, proactive protocols, reactive protocols, hybrid protocols and cluster-based protocols. In MANETs, the movement of the nodes is unpredictable, and hence reliable routing protocols should be able to adapt to the unpredictable and dynamic topology of the network caused by the random displacement of mobile nodes within a specific area (Campos et al. 2007). As stated earlier, many routing protocols have been proposed and implemented by researchers. However, most of them use Constant Bit Rate (CBR) traffic (Bamis et al. 2008; Bai et al. 2003; Campos et al. 2007; De Rango et al. 2008; Gupta et al. 2010; Naumov et al. 2005; Trung et al. 2007) because CBR traffic attempt to preserve constant bandwidth and minimizes packet loss

during transmission. However, with the increased use of Internet services recently, there is a need to analyze routing protocols using hypertext transfer protocol (http) traffic. Palaniappan and Chellan (2015) proposed a stable and energy-efficient routing technique so as to provide a stable and reliable route for the uninterrupted communication.

This paper evaluates the performance of MANET's routing protocols, for example, Ad Hoc on Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Temporally Ordered Routing Algorithm (TORA) and Optimized Link State Routing (OLSR) protocols in terms of delay and throughput as a function of the load for a common and simple support application such as http.

Routing Protocols Overview

The challenges and flexibility of MANETs have generated a lot of research in routing protocols for such networks. The network research community has been working intensively on modeling, designing and implementing new routing protocols for MANETs. De Rango et al. (2008) classify MANET routing protocols into four categories, that is, proactive protocols, reactive protocols, hybrid protocols and cluster-based protocols. Three popular reactive routing protocols, DSR, AODV and TORA and a popular proactive routing protocol, OLSR, will be briefly discussed in the next section.

Ad hoc on Demand Distance Vector (AODV)

AODV routing protocol is a reactive routing protocol, which was first proposed by an IETF Internet draft in 1997. According to Belding-Royer et al. (2003), AODV was proposed to meet the following goals, that is, *minimal control overhead*, *minimal processing overhead*, *multi-hop path routing capability*, and *dynamic topology maintenance and loop prevention*. The operation of AODV is done using the following two mechanisms namely, route discovery and route maintenance (Belding-Royer et al. 2003; Trung et al. 2007). Route discovery is a mechanism by which a source node wishing to send a packet to destination node obtains dynamically a source route when it does not have a route in its routing table. In the route maintenance mechanism is whereby route has to establish first and

the source node will maintain the route for as long as it needs it.

Dynamic Source Routing (DSR)

DSR is a reactive routing protocol developed at CarnegieMellon University, Pittsburgh USA, for use of multi-hop wireless MANET. DSR allows the network to be completely self-organizing and self-configuring (Gupta et al. 2010). The operation of DSR is also done using the route discovery and route maintenance mechanism (De Rango et al. 2008). Here route maintenance is performed when there is an error with an active route. When a node of the network that is part of some route notices that it cannot send packets to the next hop, it will create a message containing the addresses of the node that sent the packet and of the next hop that is unreachable, and send that to the source node.

Temporally Ordered Routing Algorithm (TORA)

TORA is an efficient, highly adaptive, and scalable routing protocol based on link reversal algorithm (Park et al. 2001). TORA provides multiple routes to transmit data packets between source and destination nodes of the MANET. According to Gupta et al. (2010), the TORA protocol consists of three basic functions of creating routes, maintaining routes, and erasing routes. Creating routes corresponds to the selection of heights to form a directed sequence of links leading to the destination in a previously undirected network or portion of the network. Maintaining routes refers to adapting the routing structure in response to network topological changes. During this erasing routes process, routers set their heights to null and their adjacent links become undirected.

Optimized Link State Routing (OLSR)

OLSR is an MANET proactive routing protocol that uses the concept of Multi Point Relays (MPRs). MPR is an optimized flooding control protocol used by OLSR to construct and maintain routing tables by diffusing partial link state information to all nodes in the network (De Rango et al. 2008). The functioning of OLSR can be divided into the following three mechanisms of *neighbor/link sensing*, *efficient con-*

trol flooding using MPR and optimal route calculation using the shortest route algorithm. Besides the OLSR, an advanced OLSR (AOLSR) protocol based on a modified Dijkstra's algorithm, which enables routing in multiple paths of dense and sparse network topologies was proposed by Natarajan and Rajendran (2014).

Related Work

Many researchers have studied MANETs routing protocols especially in terms of performance analysis. A study by Gupta et al. (2010) analyzed the performance of AODV, TORA and DSR using simulation. The simulator used for evaluation was Network Simulator version 2 (NS-2). The simulation was done in a rectangular field of 500m x 500m with 50 nodes. The traffic sources used were CBR traffic and the simulation time was 200s. The performance metrics used were Packet Delivery Fraction (PDF) and average end-to-end delay. The traffic generated indicated that the AODV protocol has the best overall performance. The result also demonstrated that the DSR protocol is suitable for networks with moderate mobility rate and since it has a low overhead that makes it suitable for low bandwidth and low power networks. The results also proved that TORA protocol is suitable for operation in large mobile networks having a dense population of nodes.

A study by Kulla et al. (2010) compared the performance of AODV and OLSR for different source and destination moving scenarios. They implemented a MANET test-bed, which provides the environment to make different measurements for indoor and outdoor communications. AODV and OLSR were implemented using four scenarios, that is, Static Scenario, Source Moving Scenario, Destination Moving Scenario and Source-Destination Moving Scenario. The researchers performed the experiments in an indoor environment with the size nearly 70m x 25m. The packet size was fixed to 512 kilobyte and they used CBR over UDP to create the traffic. The performance metrics used were bit rate, delay, and packet loss. The results indicated that OLSR performs better than AODV in all the scenarios when both source nodes and destination nodes are moving during the communication. A study by Naumov et al. (2005) analyzed the impact of the network size (up to 550 nodes),

nodes mobility, nodes density and suggested data traffics on AODV and DSR performance. NS-2 was used since it supports the popular Wave LAN cards to study the performance of AODV and DSR in the areas of 2121m x 425m, 3000m x 600m, 3675m x 735m, 4250m x 850m, and 5000m x 1000m populated by 100, 200, 300, 400, and 550 mobile nodes, respectively.

METHODOLOGY

This section presents the simulation setup as well as the performance metrics used in this paper.

Simulation Setup

The performance evaluation of the routing protocols mentioned earlier was done using the discrete event simulator OPNET (Optimized Network Engineering Tools) version 14. The simulation models in this paper were run with 30 nodes and a Wireless Local Area Network (WLAN) server randomly distributed in a square area of 1000m x 1000m. The nodes moved following the random waypoint mobility model with a speed of 2 meters per second and a pause time of 100 seconds. The MAC protocol used was the IEEE 802.11b and the transmission range was set to 150 meters. The nodes have applications running over TCP/IP and UDP/IP. They support wireless communication at rate of up to 11Mbps. The WLAN server has applications running over TCP. Depending on the scenarios, WLAN server supports http and ftp support applications.

The nodes in the MANET modeled supported a data rate transmission of 3Mbps with a power of 0.005 Watts. The packet size used for modeling was 1024 bytes. Figure 1 shows the simulation arrangement used in this paper. In this paper, two profiles namely, http light and http heavy (Thaker 2000) were modeled:

1. http light: Under light browsing conditions. Its load is characterized by the following parameters of *Page Rate (Pages/hour): 5, Page Size (Objects/page): 10, and Average Object Size (bytes/object): 12,000.*

2. http heavy: Under heavy browsing conditions. Its load is characterized by the following parameters of *Page Rate (Pages/hour): 60, Page Size (Objects/page): 10, and Average Object Size (bytes/object): 12,000.*

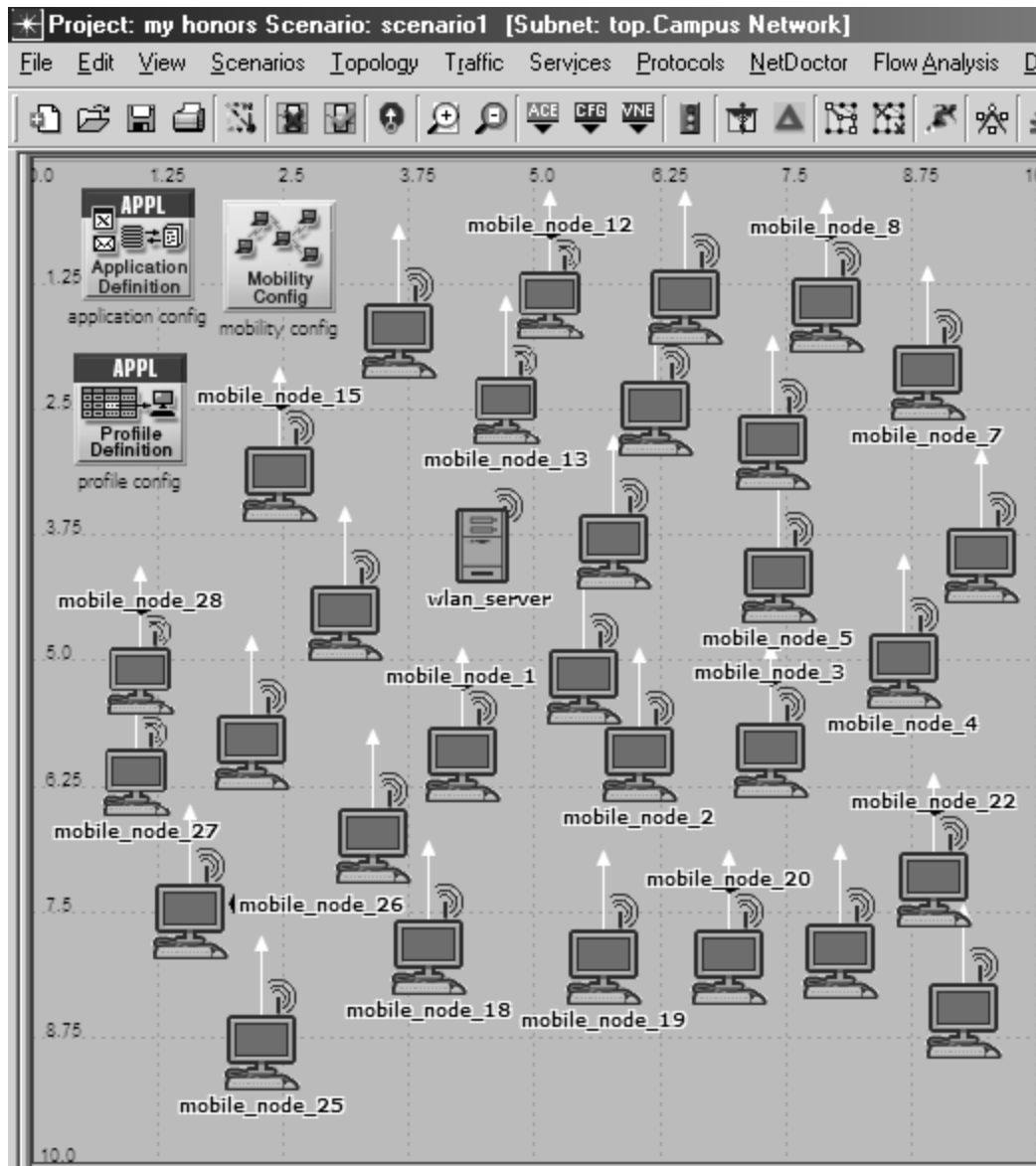


Fig. 1. Simulation setup used in this paper
Source: Author

3. Performance Metrics: The performance metrics used in this paper are:

- **Throughput:** This is the sum of data packets transmitted and successfully received by every source in the network. It is expressed in bits per second. In wireless networks, high throughput is desirable. The throughput reflects the completeness and correctness of the routing protocol (Gupta et al. 2010).
- **Delay:** This is the time it takes for a packet to be transmitted from the source node to the destination nodes. It is expressed in seconds. Short delay is desirable.

The throughput and the delay metrics are the most important performance metrics for traffic modeling (Boukerche 2004).

RESULTS AND DISCUSSION

In this section, the experiment's results are presented and discussed. The performance analysis of the routing protocols AODV, DSR, OLSR and TORA are done according to the performance metrics cited earlier, that is, based on the delay and the throughput. In terms of delay, TORA experiences oscillations due to the slow route reconstruction after a connection has been lost between nodes. Also in terms of delay, all the reactive routing protocols start to generate traffic only after a certain amount of time (simulation time), that is due to the route discovery mechanisms of reactive protocols in MANETs.

Delay Comparison Under Low and Heavy Browsing Traffic

The performance in terms of delay of AODV, DSR, OLSR and TORA routing protocols over http light browsing and http heavy browsing is respectively shown Figure 2 and Figure 3. Un-

der light browsing, Figure 2 shows that TORA experience the longest delay, this is due the fact that TORA route construction does not occur quickly, leading to potential long delays while waiting for discovery of new routes. Figure 3 indicates that the DSR has the second longest delay, and this is due to its the route discovery mechanism. This is also due to probable collisions that could occur between route request messages transmitted by neighboring nodes.

Figure 2 also indicates that under light and heavy browsing, AODV competes with OLSR in terms of shorter delay. The absence of high latency induced by the route discovery processes in OLSR explains its relatively low delay under light and heavy browsing conditions (Gupta et al. 2010). The AODV has a shorter delay as compare to other reactive protocols DSR and TORA, and this is due to the hop-to-hop initiation process by AODV protocol on nodes.

Throughput Comparison Under Low and Heavy Browsing Traffic

The performance in terms of throughput of the MANETs routing protocols AODV, DSR, OLSR and TORA for http light browsing and

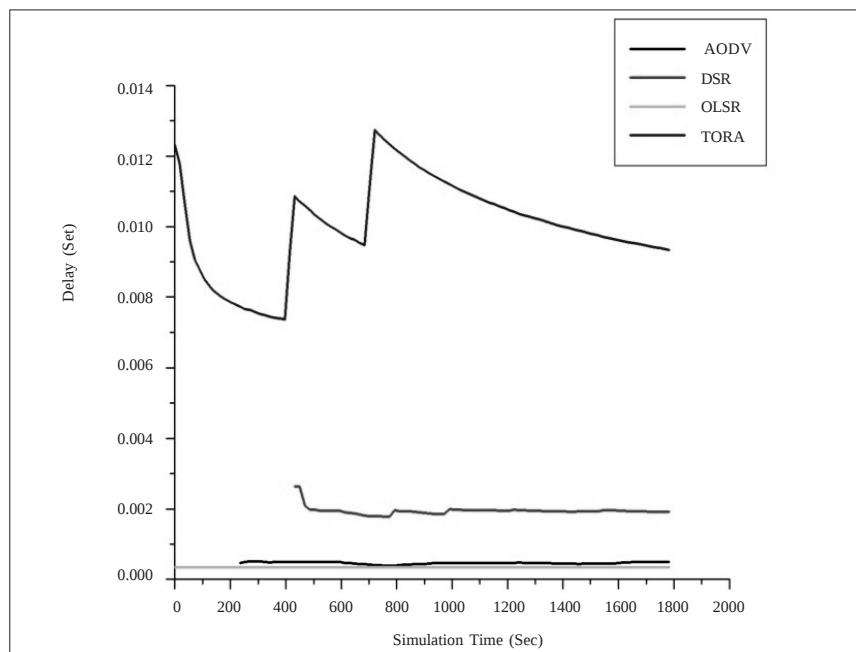


Fig. 2. Delay of routing protocols under light browsing conditions

Source: Author

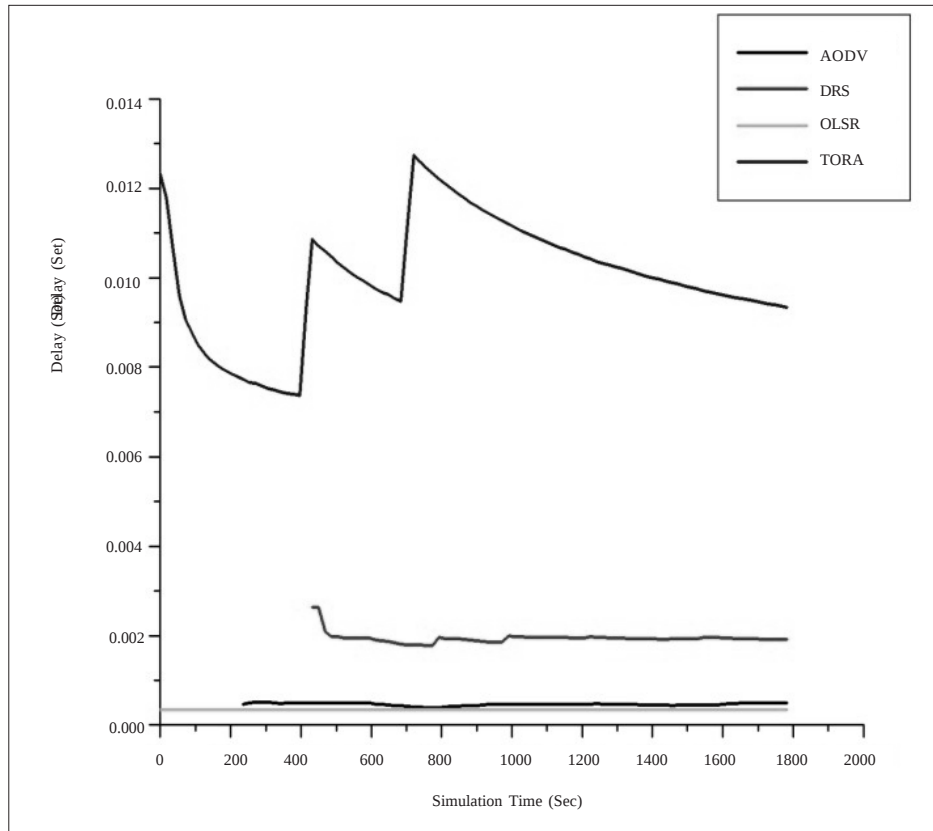


Fig. 3. Delay of routing protocols under heavy browsing conditions

Source: Author

http heavy browsing is respectively shown in Figure 4 and Figure 5. It shows that routing protocol OLSR outperforms the routing protocols AODV, DSR and TORA respectively under low http browsing and heavy http browsing. This is due to the fact that OLSR does not need to find routes to the destination since all the paths are already available. Thus, the source nodes are able to transmit more data packets when the OLSR routing is applied on the nodes. Figure 5 also indicates that under heavy browsing, TORA has the lowest throughput (close to zero). This is due to the fact that as the load increases, TORA becomes more sensitive to the packets drop, hence leading to a decrease in throughput (Gupta et al. 2010).

CONCLUSION

From the results generated above, it can be concluded that, in terms of **delay**, OLSR com-

peted with AODV for the shorter delay, and DSR had the second longest delay behind TORA, which had an extremely long delay under heavy browsing (http heavy) causing the delay graph to be out of scale. Still in terms of delay, it was noticed that TORA oscillates and that was due to the time TORA take to rebuild the route after a link failure.

In terms of **throughput**, OLSR outperformed AODV, DSR and TORA in all the scenarios. DSR had the lowest throughput. This is due to its route discovery process. Under heavy browsing, the throughput of TORA is very low. However, under heavy ftp load, TORA routing protocols had a better throughput than the others reactive routing protocols.

The overall results showed that the proactive routing protocol OLSR performed better than the reactive routing protocols AODV, DSR and TORA for medium size MANETs. One of

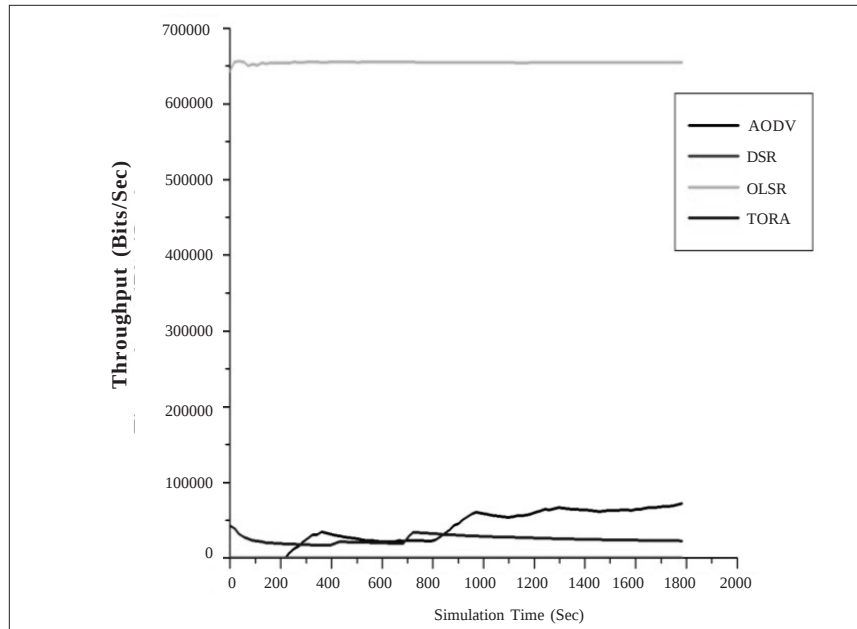


Fig. 4. Throughput of routing protocols under light browsing traffic

Source: Author

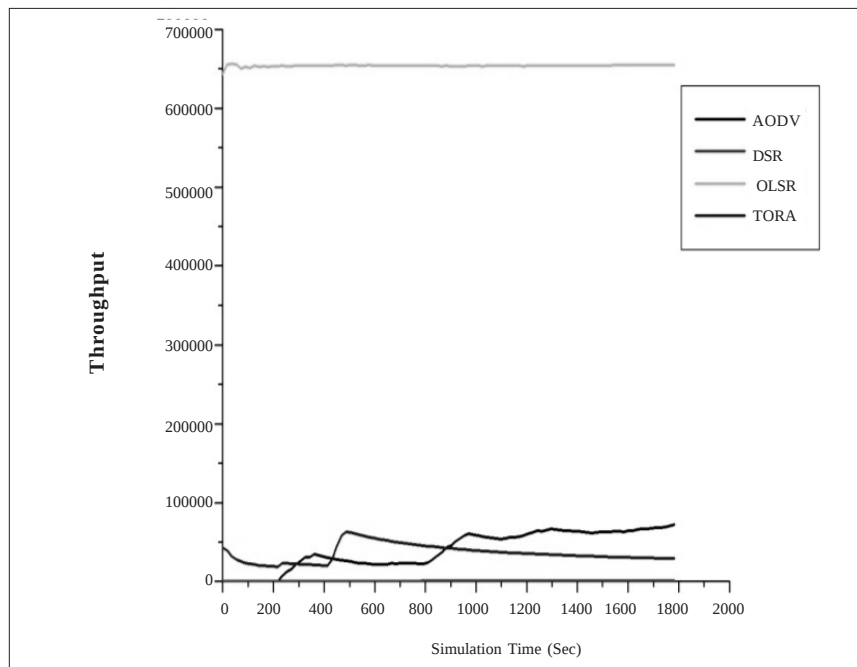


Fig. 5. Throughput of routing protocols under heavy browsing traffic

Source: Author

the main reasons for the good performance of OLSR is that proactive routing protocols transmit control messages to all the nodes and update their routing information even if there is no actual routing request, and hence the routes are always up to date. OLSR is therefore a routing protocol suitable for medium sizes MANET. The MANET modeled and designed in this paper uses the Random Waypoint as a mobility model.

RECOMMENDATIONS

Further studies could be done by modeling the Reference Group Point mobility model and using it as a mobility model under the same conditions as the ones used in this paper. Further studies could also look at voice over IP traffic for the evaluation of MANETs under the same conditions as the ones used in this paper.

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