



Performance Evaluation of MANET Routing Protocols with Scalability using QoS Metrics of VOIP Applications

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Abstract- Mobile Ad Hoc Networks (MANET) is wireless network without infrastructure, where every node functions as transmitter, router and data sink. As many previous works have shown that the routing performance is greatly dependent on the availability and stability of wireless links. With the growth of the Internet services, Voice over IP (VoIP) has been playing a key role in cutting the costs of telephone calls. It can be seen that since demand of VoIP over wireless network is growing, use of VoIP over Mobile Ad-hoc Network (MANET) is expected to grow as well. This paper aims to compare performance of three routing protocols for Mobile Ad-Hoc networks (MANET's). Since routing is a critical issue in MANET, so the focus of this paper along is the performance analysis of routing protocols. We compared three routing protocols i.e. AODV, OLSR and TORA and its simulated in OPNET modeller tool. The performance of these routing protocols is analyzed by five matrices: delay, network load and throughput, jitter, mean opinion score. All the three routing protocols are explained on a deeper level with matrices. The comparative study of protocols will be conducted and in the last the conclusion will be presented as to which routing protocol is the best one for mobile ad hoc networks. The final valuation is presented at the end of this paper.

Keywords— MANET, AODV, OLSR, TORA, OPNET, VOIP

1. INTRODUCTION

A MANET [1,2] is a collection of mobile nodes that can communicate with each other without the use of predefined infrastructure or centralized administration. Since no fixed infrastructure or centralized administration is available, these networks are self-organized and end-to-end communication may require routing information via several intermediate nodes. Nodes can connect each other randomly and forming arbitrary topologies. Each node in MANET acts both as a host and as a router to forward messages for other nodes that are not within the same radio range. The up to date standardized protocols are classified into three categories: Proactive routing protocols, Reactive routing protocols, Hybrid routing protocols. Proactive protocols, such as Optimized Link State Routing (OLSR) [3, 4] attempt to monitor the topology of the network in order to have route information between any source and destination available at all time. Proactive Routing Protocols are also called table driven routing protocols as all the routing information is usually kept in tables. Reactive routing protocols such as Ad hoc On Demand Distance Vector (AODV) [5, 6], find the route only when there is data to be transmitted and as a result, generate low control traffic and routing overhead. Hybrid protocols such as Gathering-based routing protocol (GRP) [8] could be derived from the two previous ones, containing the advantages of both the protocols, using some quality of one type and enhancing it with the participation of the other one. In this paper we evaluate the performance of a Proactive Routing Protocol (OLSR), a Reactive routing protocol AODV and TORA. This paper is organized as follows: Section 2 presents overview of Routing protocols in MANETs. Section 3 describes the Simulation Environment studied. Section 4 analyzes results and discussion. Section 5 concludes this paper.

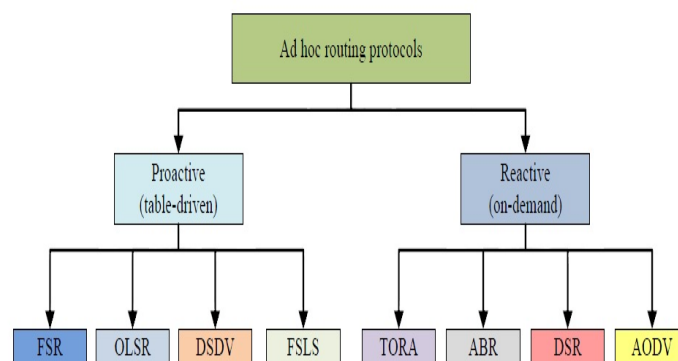


Figure 1: Classification of Routing Protocols

2. Routing Protocols in MANETs

Routing protocols in MANET [9] [10] are divided into three categories: proactive, reactive and hybrid routing protocols. The most popular ones are AODV, TORA (reactive), OLSR (proactive) and GRP (hybrid). This section describes the main features of three protocols AODV (Ad Hoc On-Demand Distance Vector Protocol), OLSR (Optimized Link State Routing) and TORA (Temporally Ordered Routing Algorithm) deeply studied using OPNET 14.5. An ad-hoc routing protocol is a convention, or standard, that it improves the scalability of wireless networks compared to infrastructure based wireless networks because of its decentralized nature.

2.1 Ad Hoc On-Demand Distance Vector Protocol (AODV)

Mobile nodes in the Ad Hoc network are dynamic and they use multi-hop routing by using Ad-Hoc On-Demand Distance Vector algorithm. AODV [11] will not maintain the routes unless there is a request for route. Mobile nodes respond to the any change in network topology and link failures in necessary times. In case of the link failures the respective defective nodes are notified with the message, and then the affected nodes will revoke the routes using the lost link. This will help AODV to avoid the Bellman-Ford “counting to infinity” problem and then its operation is known as loop-free. AODV uses Destination Sequence Numbers (DSN) for every route entry. DSN [12] is created by the destination this DSN and the respective route information have to be included by the nodes while finding the routes to destination nodes. Routes with the greatest DSN are preferred in selecting the route to destination. AODV uses the message types Route Request (RREQ), Route Replies (RREP) and Route Error (RERR) in finding the route from source to destination by using UDP (user datagram protocol) packets. The advantage of AODV is that it tries to minimize the number of required broadcasts. It creates the routes on an on-demand basis, as opposed to maintain a complete list of routes for each destination. Therefore, the authors of AODV classify it as a pure on-demand route acquisition system.

2.2 Optimized Link State Routing (OLSR)

OLSR [13] is a proactive IP routing protocol for mobile ad hoc networks. It can also be implemented in any Ad Hoc network. Lately, it is also used in Wi-MAX Mesh (Backhaul). OLSR is classified as proactive due to its nature. Nodes in the network use topology information derived from HELLO packets and Topology Control (TC) messages to discover their neighbors. Not all nodes in the network route broadcast packets. Only Multipoint Relay (MPR) nodes route broadcast packets. Routes from the source to the intended destination are built before use. Each node in the network keeps a routing table. This makes the routing overhead for OLSR [14] higher than any other reactive routing protocol such as AODV or DSR. However, the routing overhead does not increase with the number of routes in use since there is no need to build a new route when needed. This reduces the route discovery delay. In OLSR, nodes send HELLO messages to their neighbors at a predetermined interval. These messages are periodically sent to determine the status of the links. For example, if node X and node Y are neighbors, node X sends the HELLO message to node Y. If node Y receives the message, the link is said to be asymmetric. The same holds true for the HELLO message sent by node Y to node X. If the two-way communication is possible, the link is symmetric as shown in Figure 2 below. These HELLO messages contain all the information about all their neighbors. This makes a node in the network build a table with information about its multiple hop neighbors. In addition, once these symmetric connections are made, a node chooses a minimal number of MPR nodes that broadcast TC messages with link status information at a predetermined TC interval. A TC message contains information about which MPR node each node in the network has selected. TC messages also handle the calculation of routing tables.

2.3 Temporally Ordered Routing Algorithm (TORA)

TORA [15] is a routing algorithm. It is mainly used in MANETs to enhance scalability. TORA is an adaptive routing protocol. It is therefore used in multi-hop networks. A destination node and a source node are set. TORA [16] establishes scaled routes between the source and the destination using the Directed Acyclic Graph (DAG) built in the destination node. This algorithm does not use ‘shortest path’ theory, it is considered secondary. TORA builds optimized routes using four messages. Its starts with a Query message followed by an Update message then clear message and finally Optimizations message. This operation is performed by each node to send various parameters between the source and destination node. The parameters include time to break the link (t), the originator id (oid), Reflection indication bit (r), frequency sequence (d) and the nodes id (i). The first three parameters are called the reference level and last two are offset for the respective reference level. Links built in TORA are referred to as ‘heights’, and the flow is from high to low.

3. Simulation Environment

The simulation mainly focuses on the performance of the routing strategies to react on the different scenarios in MANET [17]. Because the three protocols (AODV, OLSR and TORA) cover different routing strategies mentioned above, we will discuss these routing strategies based on the simulation results of the three protocols. In this paper, we evaluate the performance in terms of network throughput, delay and network load, jitter and mos. We carried out simulations on Opnet simulator [18] [19].

The simulation parameters are summarized in table 1. Modeler is commercial network simulation environment for network modelling and simulation. It allows the users to design and study communication networks, devices, protocols, and applications with flexibility and scalability.

Table 1: NETWORK PARAMETERS

Statistic	Value
Simulator	OPNET 14.5
Routing Protocols	AODV,OLSR and TORA
802.11 data rate	11 Mbps
Node	15,30
Scenario Size	2.5*2.5 km
Application Traffic	VOIP
Simulation Time	900 second
Channel Type	Wireless/GSM Voice channel
Network Interface Type	Phy/WirelessPhy
Performance Parameter	Throughput, Delay, Network Load, Jitter, MOS

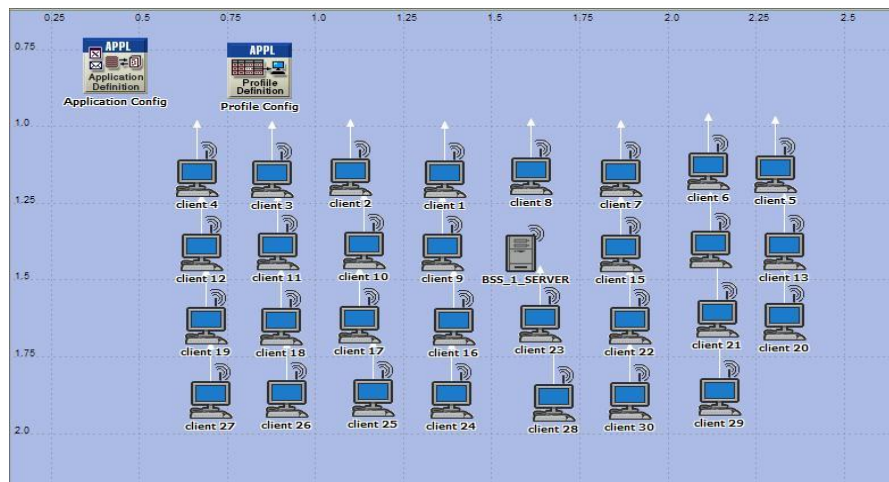


Figure 2: Network Topology Used

Figure 2. Shows a sample network created with 15 and 30 Nodes, application configuration and profile configuration and VOIP traffic for the network in which GSM voices channel has been chosen as an application. Simulation environment consists of 30 wireless mobile nodes which are placed uniformly and forming a Mobile Ad-hoc Network, moving about over a 2.5 X 2.5 km area for 900 seconds of simulated time. Nodes move according to GSM voice channel. In communication model, traffic sources are VOIP (Voice over Internet Protocol).Figure 2 depicts a network with 30 fixed nodes whose behaviour has to be analyzed nodes in the network with respect to time to determine the effecting features of each protocol. We evaluate five parameters in our study on overall network performance.

4. RESULT ANALYSIS AND DISCUSSION

We carried out simulations on Opnet simulator 14.5. The results show differences in performance between considered routing protocols, which are the consequence of various mechanisms on which protocols are based. We carried out our simulations with 30 nodes. Figures 3,4,5,6 and 7 depicts the throughput, delay and network load, jitter and mos of this network with respect to total simulation time which is taken as 30 minutes for which the simulation was run. In this simulation, the network is set to 15 and 30 nodes, the traffic is VOIP mode, the data transmission rate is 11 Mbps and the simulation time is 30 minutes.

4.1 Delay

The maximum network delay variation for 15 and 30 nodes a scenario is shown in respectively figure 3. Calculate average packet end-to-end delay of each transmitted packet during the simulation time period in 30 nodes and 15 nodes of MANET network. From the graph, it is observed that AODV average delay performance is less, nearly 9.5s, than that of OLSR and TORA which is nearly 1.4s and 1s for GSM voice traffic data. We see that average packet delay increases with increase in number of nodes. The end to end delay in OLSR and TORA is lower side and is maximum in AODV.

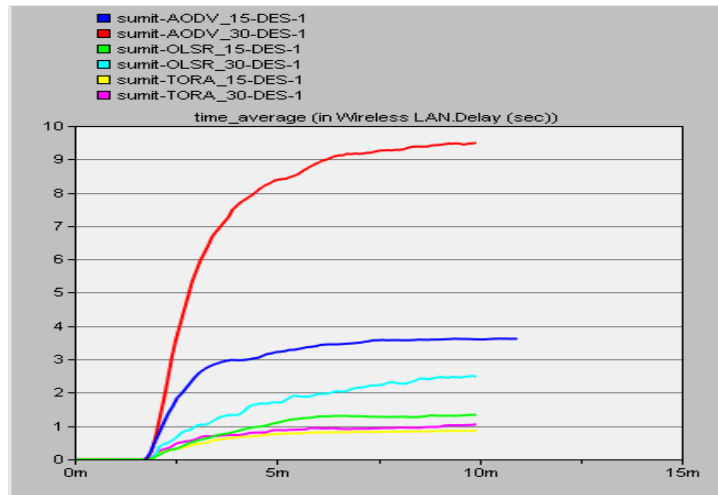


Figure 3: Delay comparison in routing protocols with 15 and 30 nodes

4.2 Network Load

The maximum network load variation for 15 and 30 nodes a scenario is shown in respectively figure 4. Based on wireless LAN load Networks load represents the total load bit/sec submitted to wireless LAN layer, when there is more traffic coming into the network, it is difficult for the network to handle all this traffic. An efficient network can easily cope with large traffic coming in, and to make the best possible network. fig 4 shows that, for different number of nodes, loads are varying compared to each other for 30 nodes initial network load for AODV network is high, but decreases sharply with 15 nodes. On the other hand, for any load, TORA and OLSR are showing a considerable good performance which is 900 kbps and 700 kbps for both 30 and 15 nodes of MANET network respectively.

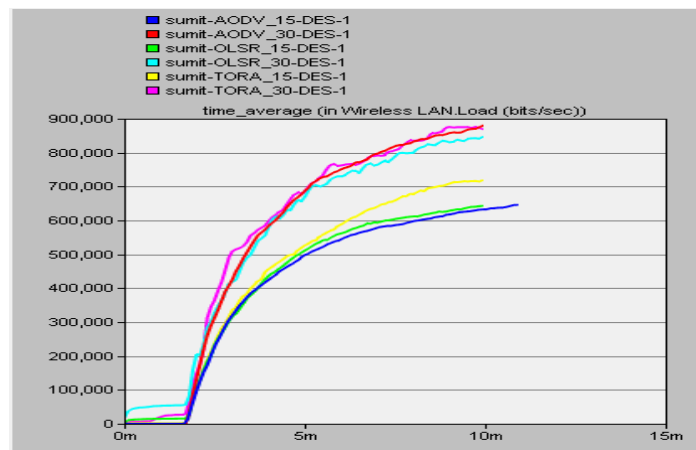


Figure 4: Network Load comparison in routing protocols with 15 and 30 nodes

4.3 Throughput

The ratio of the total amount of data that reaches a receiver from a sender to the time it takes for the receiver to get the last packet is referred to as throughput. It is measured by bits/sec or packets per second. A high throughput network is desirable. we are comparing these protocols like as AODV ,TORA and OLSR and obtain the throughput for both 15 and 30 client nodes from the scenario which is given below. Figure 5 it is clear throughput of TORA increases sharply with simulation time and mobility and becomes nearly 700 kbps at the end of simulation. On the other hand there is drop in throughput from initial 500 kbps to 550 kbps at the end of simulation in case of AODV. With the decrease in the number of nodes of the network i.e. from 30 to 15 nodes, in case of OLSR throughput initially 600 kbps to 490 kbps as compared to AODV and TORA at the end of simulation. This is due to reason that behaviour of proactive protocols OLSR in smaller networks with nodes failing shows that the proactive protocols can handle mobility better than reactive protocols.

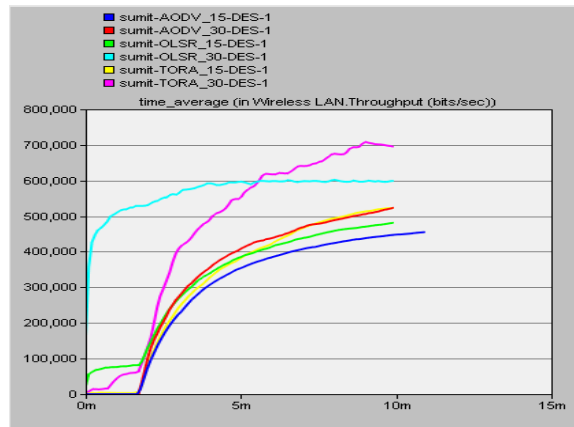


Figure 5: Throughput comparison in routing protocols with 15 and 30 nodes

4.4 Jitter

Jitter describes the degree of variability in packet arrivals, which can be caused by network congestion (bursts of data traffic), timing drift or because of route changes. Jitter is the delay variance from point-to-point or Tx. to Rx. [18]. The figure 6 shows a detail graphical description of Jitter delay for 15 nodes and 30 nodes. Initially every protocol (AODV, TORA and OLSR) show irregular jitter curves. After few minutes simulation time the variation of voice packet jitter is quite steady for different protocols, i.e. the jitter of all protocols show steady curves maintaining small variations. To be more specific; in the beginning of simulation OLSR got higher jitter compared to AODV and TORA. TORA maintains little jitter of about 0.05 (sec) and TORA have maximum jitter compared to AODV and OLSR.

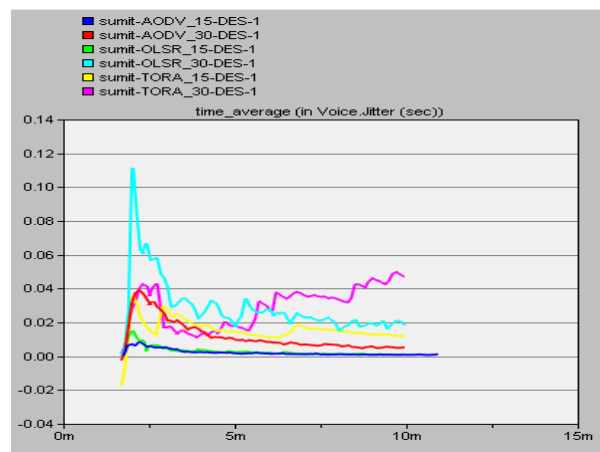


Figure 6: Jitter comparison in routing protocols with 15 and 30 nodes

4.5 MOS (Mean Opinion Score)

In voice communication, quality usually dictates whether the experience is a good or bad one. Besides the qualitative description we hear like 'quite good' or 'very bad', there is a numerical method of expressing voice quality. It is called Mean Opinion Score (MOS). MOS gives a numerical indication of the perceived quality of the media received after being transmitted

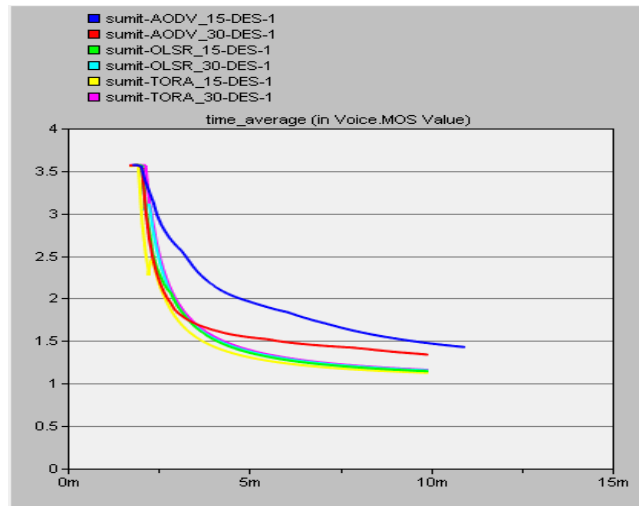


Figure 7: MOS comparison in routing protocols with 15 and 30 nodes

and eventually compressed using codec's. MOS is expressed in one number, from 1 to 5, 1 being the worst and 5 the best. The mean opinion value is taken for different network size firstly we are taken 15 and 30 nodes and in fig.7 compared three routing protocols and observed that AODV has the good voice quality for 15 nodes and 30 nodes.

5. CONCLUSIONS

In this paper, we discussed the three routing protocols (AODV, OLSR and TORA) based on OPNET simulations. Our motive was to check the performance of these three routing protocols in MANET on the above mentioned parameters. We analysed for different reactive and proactive ad-hoc routing protocols with different mobile nodes transmitting GSM voice traffic data. Finally it is concluded that the overall performance of OLSR is better choice for small and large networks. The performance of TORA does scale well with large and small sized network as compared to AODV. Simulation result also showed TORA reactive routing protocol is the finest suited for MANET protocol in dense population of nodes, whereas AODV has very poor QoS in high populated node networks with GSM voice traffic data. At the end we came to the point that the performance of routing protocols vary with network. It is the selection of accurate routing protocols (taking into consideration the type of network) that ultimately influence the efficiency of that network in magnificent way. So proactive protocol OLSR outperforms in terms of throughput jitters and gets the same low delay as OLSR. In future, we will focus on how to get stable and acceptable performance in dynamic ad hoc networks by constructing virtual bone networks using local broadcasting strategy in OLSR.

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