Performance Analysis of MANET Routing Protocols: OLSR and TORA

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Abstract:
The Mobile ad hoc network is a self configured and self organized network. The routing of packets inside network is one of its key issues. Many routing protocols have been proposed and analyzed since last fifteen years. This paper presents the analysis of MANET routing protocols OLSR and TORA. This evaluation is achieved by simulations in Optimized Network Engineering Tools (OPNET) with respect to performance metrics i.e. control traffic overhead, end-to-end delay, network throughput and network load. By comparing OLSR and TORA through simulations, our results specify that OLSR performance is better than TORA in terms of the metrics above. OLSR has lower control traffic overhead, higher throughput, higher load and shorter end-to-end delay as compared to TORA. OLSR maintained consistent routes which brings shorter delays. Node mobility affects negligibly on OLSR whereas it affects slightly to TORA. But in general, this difference is not obvious in our simulations. The simulation results also prove that OLSR is more reliable and efficient than TORA.

Keywords:
MANET, TORA, OLSR, performance analysis, OPNET

1. INTRODUCTION

A Mobile Ad Hoc Network is constructed by a set of self-configured mobile nodes, terminals, autonomous nodes that are connected by wireless links without infrastructure. A MANET node can move freely within network communication range, and server as a host and a router which can forward data packets to other hosts according to configured routing protocol. MANET technology has two main significances over other traditional wireless networks. Firstly, it has remarkable characteristics such as easy deployment, decentralized nature, low cast and self configuration. MANET can be deployed any where due to these characteristics. Secondly, it is used in calamity recovery where communication infrastructure is destroyed e.g. Floods, earthquakes, storms, .It is also used in emergency circumstances where need temporary infrastructure e.g. in hospitals, war fields (for enemy tracking), crowd control etc. Hence, Mobile Ad Hoc Network is highly adopted data communication network around the World due to its applications and characteristics. The nodes of MANET are intelligent and of multi hop nature, so it can connected to other node directly or indirectly and can start data transmission. The movement of MANET nodes causes connection breaking between them and network topology change rapidly and unpredictably.

The Routing of packets in MANET is a key issue because of its unpredictable nature [1]. The successful routing of MANET packets, many protocols are developed in the past. The classification of the MANET protocols are made on the basis of strategy .On strategy, mobile ad hoc network routing protocols has two major classes; Pro-active or table driven and reactive or on-demand. In pro-active routing protocols, every node keeps up-to-date routing information of every other node within the network. The reactive routing protocols find and retain routes when required so that routing overheads can be reduced where the rate of topology change is very high [1,12,15].

As MANET is highly adaptive network technology, our research contributes in the field of its routing by providing study and evaluation of routing protocols (TORA, OLSR) both theoretical as well as practical implementation in OPNET[11]. For other researchers, this study will help in understanding routing protocols including selecting suitable routing protocol for their MANET by judging their performance. The OLSR (proactive) and TORA (reactive) are selected for evaluation because these protocols are widely investigated since fifteen years [5, 6, 7, 10, 13, 15].Another goal of this study is to differentiate between proactive and reactive protocols. The TCP traffic used in simulations is created by a FTP server.

The other sections of paper are ; Section 2 is discussing about routing protocols OLSR and TORA, section 3 is describing simulation setup .Section 4 is presenting simulation results and discussion. Finally, section 5 is concluding the paper.

2. Routing protocols in MANETs

In this paper, two routing protocols are studied; namely OLSR and TORA .The description of these protocols are as follows.

OLSR [1]: Optimized Link State Routing is a protocol belongs to class proactive routing. OLSR optimizes the links state algorithm by compressing the size of the control

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packets that enclose link-state information. It is achieved by reducing the number of transmissions required to flood these control packets to the entire network [13, 14].

In OLSR a central node selects a set of instant one hop neighbors is called the multi-point relays (MPRs) of that node. MPRs of that node must cover all the nodes that are two hops away from central node. Every node within a two-hop neighborhood of central node must have bi-directional links with the MPRs of that node. OLSR decreases the size of the control packets since in each control packet a node puts only the link state information of the neighboring MPRs instead of all neighbors. It minimizes flooding of control traffic since only the MPRs, instead of all neighbors, of a node are responsible for relaying network-wide broadcast traffic. The MPRs is selected, by the every node through broadcasting of HELLO messages to its one-hop neighbors. Each node, receiving a HELLO message, can learn the link-state information of all neighbors up to two hops. This information is stored in a neighbor table and used to select MPRs. The specific controls messages are broadcast by each node are called the topology control (TC) messages. Each TC message, originating from that particular node, contains the list of MPRs of particular node with a sequence number and is forwarded only by the MPRs of the network. Each node retains a topology table that represents the topology of the network built from the information obtained from the TC messages. Each node also maintains a routing table where each entry in the routing table corresponds to a best route, in terms of the number of hops, to a particular destination. Each entry consists of a destination address, next-hop address, and the number of hops to the destination. The routing table is constructed based on the information available in the neighbor table and the topology table to other nodes. The information will be updated when there is change in neighborhood is detected, a better or shortest route is found for destination, and a route of destination is expired [3, 13, 14].

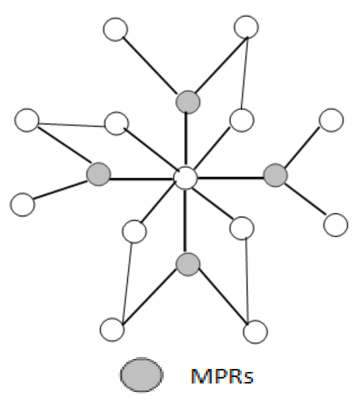

Figure 2.1 OLSR Multi-point Relays(MPRs)

TORA [5]: Temporally Ordered Routing Algorithm is a reactive or on-demand routing protocol uses directed acyclic graph, rooted at a destination, to represent multiple routes for a source and destination pair. However; it restricts the propagation of control messages to a very small set of nodes close to the occurrence of a topological change by using the concept of link reversal proposed by Gafni and Bertsekas (1981) [8,12,13,14]. TORA uses heights of links which is assigned from higher source node to lower destination node as shown in figure 2.2.

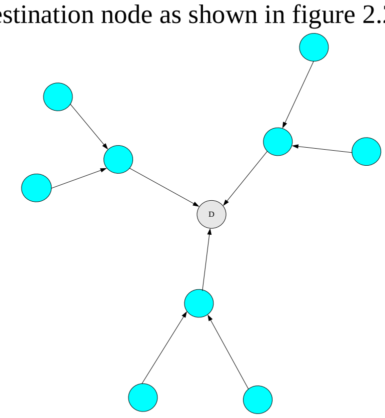

Figure 2.2 DAG rooted at destination

The TORA works on following three basic functions.

- Route Establishment
- Route Maintenance
- Route Erasing

<u>*Route Establishment*</u>**:** This function of TORA is used when source node desire to send data to destination node without having any information about the directed link/route. Hence, the route establishment between source and destination node, TORA uses following two packets.

- QUERY (QRY)
- UPDATE (UPD)

The QRY packet used to arrange a route and this is broadcast by source node encloses destination address via network. This QRY packet traverses MANET nodes till its destination or it arrive at centre node which keeps the destination route. The centre or destination node stops QRY packet and broadcast a UPD packet enclosing its height regarding to destination. At destination node height will be zero. Every node which obtains UPD packet puts its height to a greater value of height of neighbor node as of which it got UPD packet and so on. This is a sequence of DAG for creating routes rooted to destination in the network. The value of heights is used to control the nodes from sending packets only from downstream not from upstream.

Considering the figure 2.3, A QRY packet is generated by source node A to node G (destination). That QRY packet is passed by middle nodes B, C, D, E, and F towards G which is destination node. This QRY is searching for a node that keeps destination information.

Each node height metric is represented by a quintuple (τ, oid, r, δ, i) which includes the following values.

- τ : Logical Time of a link failure
- oid :Unique ID of the node that defined the reference level
- r : Reflection indicator bit
- δ : Propagation ordering parameter
- i : Unique ID of the node

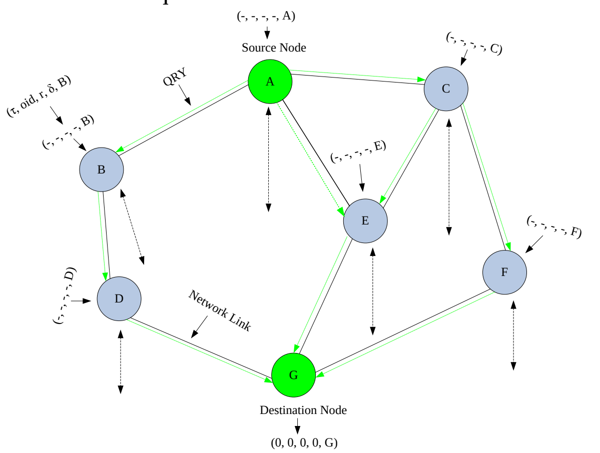

Figure 2.3 Route establishment of TORA using the QRY packet

When it reached node G (destination node) that is keeping route to destination will launch a UPD packet towards node (source) A back via neighbors nodes and four paths as shown in figure 2.4 below. After receiving the UDP packet the source node is able to find shortest path from four available paths for sending data [5].

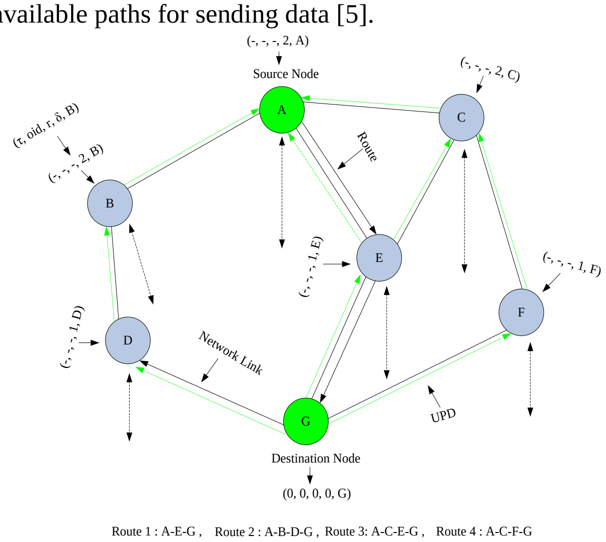

Figure 2.4 Route establishments of TORA using UPD packet

***Route Maintenance*:** This function is used when a particular link failed due to node movement or absence of DAG route. When this happens (link failure) the height of those nodes is set higher than all neighboring node. So that packet of data will reverse back for getting new substitute route [5].

The link breaking between nodes E and G is shown in figure 2.5.

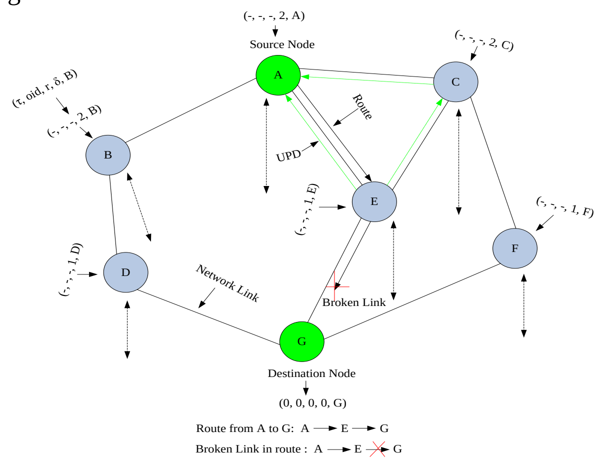

Figure 2.5 Route Maintenance of TORA

Now, the node E (node lost link) reverses the path from neighbor nodes to itself for sending UPD packet encloses with information about link breakage to source node. If the source node has information regarding new substitute routes to destination, i.e. it has option of sending data through other routes, it will pick one optimal route from them and forward data packet else a fresh QRY/UPD process will start to find out a new route by source node.

Route Erasing: this phase is used when a TORA node finds link failure in network; it changes its own height value and the heights of intact neighbor's node's value to null in its table. A broad cast clear packet (CLR) is flooded over the entire network to erase routes which are not valid for the destination by that node. This node will also update values in its link table accordingly.

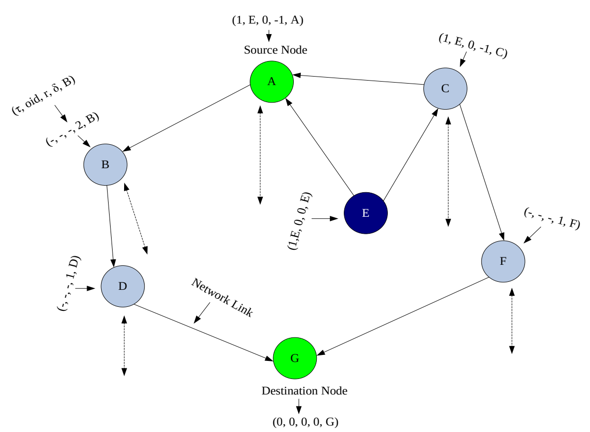

Figure 2.6 Route erasing of TORA

3. Simulation Setup

The two campus networks have been designed by using OPNET simulation server in lab for MANET routing protocol TORA and OLSR. Each network is selected under the single subnet. The mobile WLAN stations, a FTP server (TCP traffic) with mobility configuration, profile configuration and application configuration are used for networks. The wireless LAN platform and network topology random way point have been selected for both networks. These two networks are classified as.

- MANET_protocols_7nodes Network
- MANET_protocols_30nodes Network

The design and configuration parameters for above networks are shown below in Table 1 and Table 2.

Table 1 Design Parameters for 7 nodes Network

Number of wireless nodes	7
Routing protocols	TORA,OLSR
Movement work space	4000m x 4000m
Node movement speed	15,20 m/s
pause time	300s
Simulation time	1200,1800sec
Topology	Random way point
Server node (FTP)	1

Table 2 Design Parameters for 30nodes Network

Number of wireless nodes	30
Routing protocols	TORA,OLSR
Movement work space	10000m x 10000m
Node movement speed	15,20 m/s
pause time	240s
Simulation time	1200,1800sec
Topology	Random way point

Routing Overhead: Routing overhead is total number of bits or packets/sec transmitted through the network. As soon as MANET is growing larger by adding more nodes (network scalability) it increases routing overhead by including control traffic data and normal data. Different routing protocols have different routing overhead; if it is less then protocol is considered to be good quality routing protocol. When routing overhead increases it causes data error and network congestion due to number of nodes between source and destination. Furthermore, MANET nodes mobility, transmitter power problem and channel utilization can also effect overhead. Some protocols depend on fast nodes of the network for transmission of data between sender node and receiver node.

End-to-End Delay: It is the average time that a packet acquires to go across the network. It is measured in bits per second and packet per second. This delay is cause by many reasons such as low transmission power of signal, traffic overhead, and network congestion.

Network Throughput: It is the total amount of data that network transports over time from sender to receiver since the last packet is received. It can be measured in packet per second and as well as bit per second. Throughput can distress by these factors such as bandwidth limitation, limitation of energy, communication unreliability and rapid changing topology.

Network Load: It is the data delivery of network that how well it can transport data when data is increased. Normally what happens when data is increased on network its performance start degrade mean it is not transporting data in actual speed. So load uniformity is advantageous for data communication. High load is desirable for any network.

4. Results and Discussion

In this paper, we have considered a number of metrics in evaluating the performance of OLSR and TORA. The comparisons of these metrics are as follows.

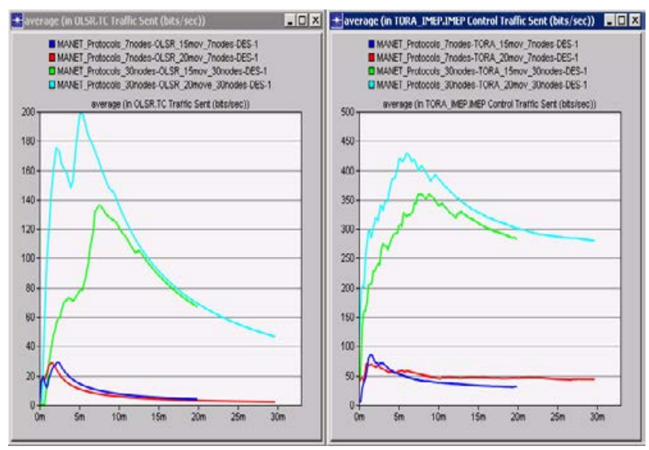

Figure 4.1 The Control Traffic comparisons of OLSR and TORA

From figure 4.1, OLSR sent less control traffic than TORA in 7 and 30 nodes network for all scenarios with nodes movement constant speed 15m/sec and 20m/sec. The average maximum control traffic sent by scenario TORA 30nodes network with 20 m/sec node movement is 430 bits /sec whereas , OLSR for same scenario it is 200 bits/sec. Similarly in all scenarios OLSR has less control traffic sent than TORA.

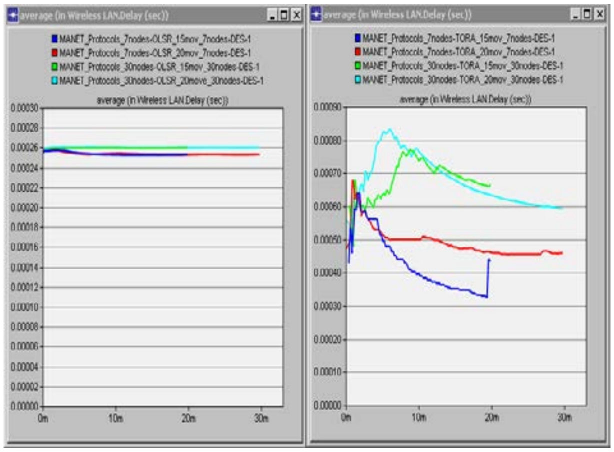

Figure 4.2 OLSR and TORA End to End Delay

From figure 4.2, the End to End Delay of OLSR is less than TORA for all scenarios. OLSR delay is uniform at 15m/sec and 20m/sec node mobility for 7 nodes network while it is observed slightly higher in 30 nodes network with same mobility speed.

In TORA, it is observed higher in both 7 nodes and 30 nodes network with node mobility 15m/sec and 20 m/sec. The maximum delay in OLSR is .00026/sec whereas; the maximum delay in TORA is .00083/sec as shown in above figure 4.2.

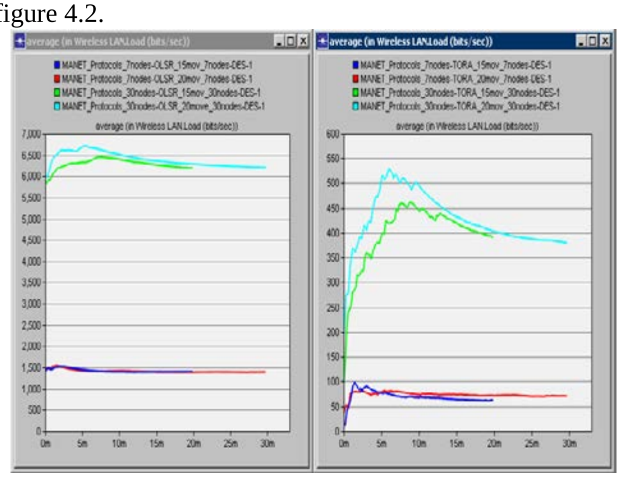

Figure 4.3 Network Load of OLSR and TORA

From figure 4.3, it is observed that OLSR has high network load than TORA in All scenarios. The mobility of nodes did not affect much on OLSR because in the 7 nodes, the network load is uniform whereas, in 30 nodes network, is high due to no. of nodes (traffic resources). In TORA, the average load is observed low on both 7 nodes and 30 nodes network. The node mobility affect is found more in 30 nodes network while in 7 nodes it has slight difference in load. In 30 nodes case; the maximum network load in OLSR is 1500 bits/sec whereas; the maximum load in TORA is 525 bits/sec.

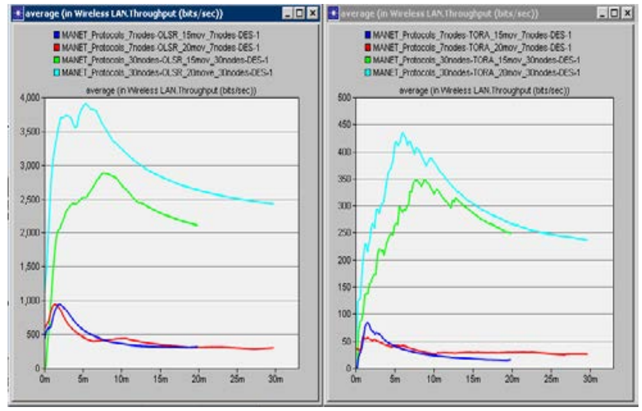

Figure 4.4 Network Throughputs of OLSR and TORA

From figure 7.5 it is observed OLSR has high throughput in all scenarios than TORA. The maximum average throughput of OLSR of 30 nodes network with mobility 20 m/sec is 3900 bits/sec while TORA 425 bits/sec in same scenario.

Result Summary: Considering the results of figure 4.1, it is observed that OLSR sent minimum control traffic into the network whereas; TORA sent more control traffic in to the network. This observation is valid for all considered scenarios during simulations. Hence, in terms of overhead, OLSR causes minimum overhead over TORA. It is because; OLSR's MPR function reduces flooding broadcast messages and controlling information. The controlling function bounds packet that it must not be sent two times in a same region which reduces network overhead. On the other hand, TORA's Hello packet / periodic beacon and link sensing method created more overhead. It is also observed that increasing node's movement in OLSR and TORA did not considerable affect on routing overhead. The no. of traffic resources increased the overhead in both TORA and OLSR.

Considering the result from 4.2, In terms of End-to- End Delay, OLSR caused minimum delay in all scenarios because it is a pro-active protocol which keeps routes always ready for data transmission. These routes are available for all times due to periodic routing updates. The route discovery process of OLSR also explains low delay. Hence, OLSR has minimum delay due to its pro-active routing characteristic.

TORA is more susceptible to End to End delay. One reason is its route discovery which expresses delay and second reason is no. of traffic resources. It is observed that TORA has less delay in 7 nodes network with mobility 15m/sec and 20 m/sec scenario while it has more delay in 30 nodes network with same mobility which justifies TORA no. of traffic resources delay.

Considering the results of figure 4.3 OLSR has high load over TORA for all scenarios. OLSR maintains consistent network load because OLSR has minimum delay and maximum throughput. TORA has more delay and less through put so TORA has low load. Load also depends on no. traffic resources.

Considering the result of figure 4.4, it is observed that OLSR throughput is high in all scenarios due to OLSR‘s proactive routing nature in which routes are always available and ready for traffic. OLSR sustains low delay which results high throughput as throughput is function of routing traffic and delay. The throughput may be low, in case when network grows larger and larger routing table becomes bigger causes congestion and delay.

In TORA the throughput is observed due to large end to end delay and control traffic over head. This observation is valid for all simulation scenarios.

5. Conclusion

In this paper, we evaluated two different MANET routing protocols; OLSR and TORA. Our research presented performance of OLSR and TORA in two aspects; reliability and efficiency of protocols. The reliability aspect was checked by end-to-end delay, throughput and load, whereas, efficiency is checked by control traffic overhead. OLSR sent minimum control traffic and caused low control overhead which showed its efficiency. TORA sent high control traffic which caused high control overhead and degraded network efficiency. OLSR created minimum and consistent end-to end delay, high load and high throughput which showed high reliability. On the other hand TORA created more end-to-end delay, low throughput and low network load which indicated lacked in reliability.

From the simulation results and discussion we came to conclusion that OLSR is a reliable and efficient MANET routing protocol over TORA .This has been proved by four performance metrics including control traffic overhead, end to end delay, network load, and network throughput. This result is valid for our research scenarios, other researcher’s may differ.

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