Performance analysis of TORA and OLSR routing protocols for Mobile Ad Hoc Networks

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Abstract — Mobile Ad hoc Networks (MANETs) are collection of wireless mobile nodes. These types of networks are temporary and infrastructure less networks. MANETs don't have a fixed static infrastructure. As MANETs work without fixed infrastructure nodes themselves, work as receiver, transmitter as well as router. Nodes in MANETs are also mobile so providing stable route is a huge challenge. There are several different approaches to find route in such networks and all approaches have some protocols. In this paper we will try to analyze two of the Mobile Ad Hoc Networking protocols, Optimized Link State Routing (OLSR) and Temporarily Ordered Routing Algorithm (TORA). OLSR uses proactive or table driven approach to route the data whereas TORA is a reactive protocol and uses on demand routing. The aim of this paper is to highlight different aspect of both protocols and compare them. So, one can decide which protocol is better suited to their needs.

Keywords - MANET; Protocol; TORA; OLSR; Proactive; Reactive; Routing; Route discovery; Link State; Route Update; Packet Delivery; Average Delay; Throughput; Routing Load.

I. INTRODUCTION

Mobile Ad hoc Network (MANET) is a collection of nodes where nodes can communicate over a wireless medium without any fixed infrastructure. Every node in network works as host as well as router and all of them are mobile. Nodes either communicate directly with each other or they use other intermediate nodes to forward data from source to destination. Almost everything in MANETs can be variable like number of nodes, speed, topology etc. MANETs are made up of independent nodes and nothing is fixed in them. To support a network with such dynamic nature, network has to be self configurable. As MANETs have so many constraints like limited bandwidth, speed, energy so development of protocols for MANETs is a great challenge. Three main approaches are used to develop routing protocols for MANETs which are shown below in figure 1.1

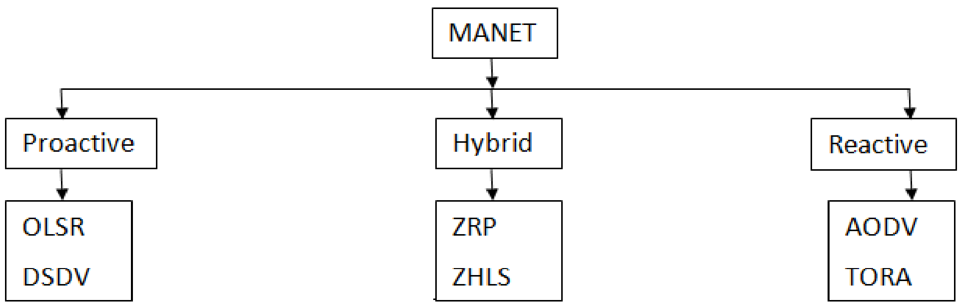


Figure 1.1

II. PROACTIVE (TABLE DRIVEN) ROUTING PROTOCOL

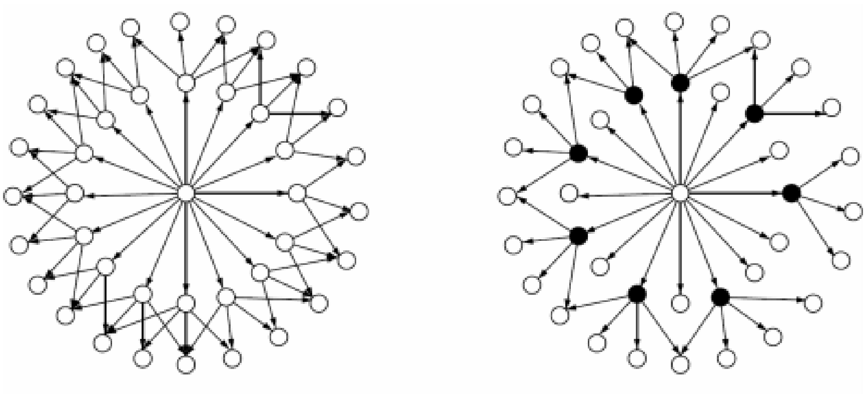
In proactive routing protocols each node maintains a routing table just like we have in wired routing protocols. That's why these protocols are called table driven protocols. Table contains latest information about routes and cost of routes to reach a particular destination. When any change in the topology occurs or any new node is added route update information is sent to all the nodes by broadcasting. These protocols are not able to perform well if network topology changes too frequently or if network has too many nodes, because of too much routing overheads. Some of the proactive protocols are Destination Sequenced Distance Vector (DSDV) and Optimized Link State Routing (OLSR). In this paper our main concern will be OLSR for our study.

A. OPTIMIZED LINK STATE ROUTING (OLSR)

Optimized Link State Routing (OLSR) is proactive table driven protocol. It is an optimization over a classical link state protocol to support MANETs. Like other proactive protocols OLSR is also a table driven proactive protocol and it maintains routing table. OLSR updates its routing tables by continuous communication with neighboring nodes. This increases network overheads but as a result, it decreases delays, occur to find routes when required. OLSR uses three mechanisms for routing.

- It uses Hello messages to sense its neighbors.
- It uses Topology Control packets by using Multipoint Relays (MPR).
- Path selection is done by shortest path first method.

Each node uses its two hops by Multipoint Relay selection in such a way that all of its two hops neighbours are accessible. Hello messages and Topology Control messages are used to discover and broadcast all link state information throughout the network. OLSR includes timeout values and validity information within the messages. It allows us to use different timeout values for different nodes.



(A) (B)

Figure 2.1 –Two hop neighbours with Multipoint Relay.

(A) Pure flooding - when all the nodes retransmit the broadcast

(B) When only MPRs of nodes retransmit the broadcast (Black nodes denotes MPRs)

Figure 2.1 shows travel path of broadcast message to find route information. First figure A shows pure flooding where each node rebroadcast the message whereas second figure B shows scenario where only Multipoint relay nodes retransmit the broadcast. When a broadcast message is initiated, all the source's neighbours receive the data and process it. But only the neighbours which are in a MPR set of source node and haven't received the message yet are the ones, which will retransmit the message. This is very useful in reducing number of broadcast messages and thus reducing the overheads of control messages considerably.

III. REACTIVE (ON DEMAND) ROUTING PROTOCOL

Reactive Routing Protocols don't keep routing tables and don't react on any changes in topology or on addition of a new node. These protocols search for a route only when some node attempts to send data over the network. When a node attempts to send data, it request for a route and then only these protocols search for a route by flooding the route request packets throughout the network. Some of the reactive routing protocols are Ad hoc On demand Distance Vector (AODV) and Temporarily Ordered Routing Algorithm (TORA). In this paper our main concern will be TORA for our study.

A. TEMPORARILY ORDERED ROUTING ALGORITHM (TORA)

Temporarily Ordered Routing Algorithm (TORA) is a reactive on demand routing protocol for MANETs. TORA is highly adaptive, efficient and scalable routing algorithm. This distributed algorithm is based on link reversal concept. TORA is proposed to support highly dynamic, multi hop wireless networks. It is based on source initiated on demand routing. When a node in TORA needs to start communication, it initiates demand for available routes. Almost all available routes to destination are found and source selects one route from all routes found. One main quality of TORA is that control messages are transferred locally to a very small set of nodes near to the place where topology change has occurred.

This protocol is based on three main functions:

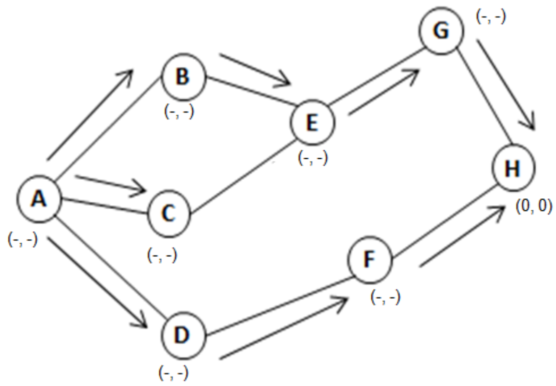
- Route creation: to create best possible route from source to destination.
- Route maintenance: to maintain the session created between source and destination until all the data is transferred.
- Route eraser: this function is used to end the session after data transfer is complete and it is ensured that no data is available in route for certain period of time and route is free.

In MANETs biggest problem is due to topological changes which are handled in TORA by maintaining multiple routes. Each node in TORA has a quintuple associated with it which are as follows:

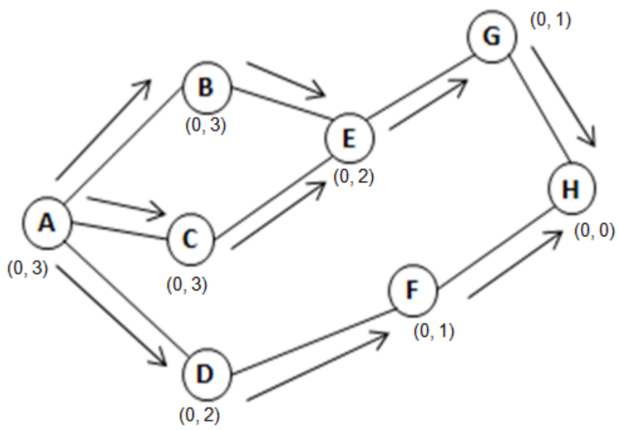
- Logical time of a link failure.
- Unique ID of the node to define new reference level.
- A bit to indicate reflection.
- Propagation ordering parameter.
- Unique ID of the node.

First three elements of the quintuple collectively represent reference level and last two node values define delta with respect to reference level. Each time a node loses its last downstream link due to failure; this is treated as a new reference level.

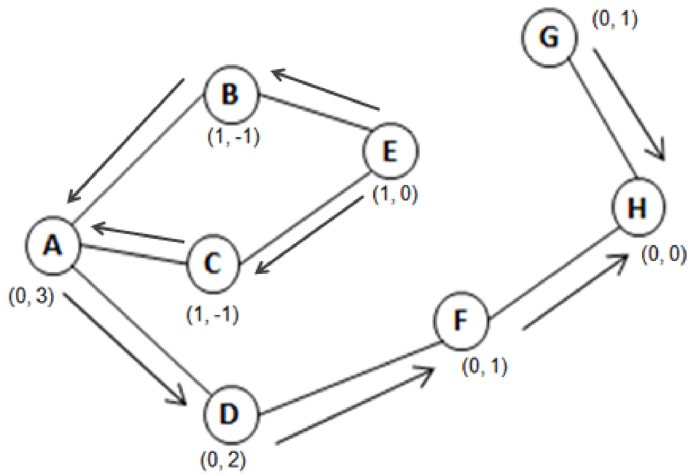
Route is created using QRY and UPD packets. Route creation algorithm starts with setting height of destination to 0 and height of all other nodes to null. QRY packet is broadcasted with destination ID and when it reaches to a node with non null height, that node responds with UPD packet that has its height in it. On receiving UPD packet all nodes sets their heights in reference to the node which generated the UPD. Nodes with higher height are treated as upstream and with lower height treated as downstream. Propagation of QRY packets, Route creation and Re-creation are shown in figure 3.1



I) Propagation of QRY Message, Destination H has reference level (0, 0) rest are NULL



II) Route creation - numbers in brackets are reference level



III) Re-creating route at the time of route failure between E-G

Figure 3.1 Propagation of QRY packets, Route creation and Re-creation

IV. TABLE 1

Shows Comparison of OLSR and TORA based on certain Protocol Properties, features and techniques used by protocol:

Protocol Property	OLSR	TORA
Table Driven / On Demand	Table Driven	On Demand with Routing Table
Need of Hello Message	Yes	Yes (QRY)
Route Selection	Link State	Shortest or Next Available
Route Update	Periodic	Event Driven
Route Computation Method	Flooding	Broadcast
Route Mechanism / Maintenance in	Route Table	Route Table
Scalability	Medium	High
Network Overheads	Medium	Medium
Node / Caching Overheads	Medium	Low
Routing Overheads	Medium	Medium
Update Information	Link State	Reference Level
Loop Free	Yes	Yes
Route Discovery	Yes	Yes
Route Maintenance	No	Yes
Mechanism of Routing	One Hope	Node Heights
Multiple Routes	No	Yes
Path Selection	Shortest Path First	Shortest Path First
Number of Nodes Suitability	Medium	Highly Dynamic

Protocol Type	Proactive	Reactive
Packet Size	Uniform	Uniform
Routing Philosophy	Flat	Flat
Multicast Support	No	No
Distributed	No	Yes
Periodic Broadcast	Yes	No
Quality of Service	In Low Mobility	In High Mobility

Table 1 shows the comparison of both of the protocols. But still this comparison is quite theoretical. Although it's such a descriptive and elaborate theoretical comparison that, one can easily decide which type of protocol from OLSR and TORA is best suited to their needs but still its good idea to come up with some firm practical data to compare the actual performance of both the protocols. That can be quite ensuring than just the comparative theoretical analysis. That's why now we will have some simulated data for both of the protocol to show how they perform in simulated conditions and parameters.

V. RANDOM WAY POINT MODEL

Random Way Point model is used for this simulation. This model is first proposed by Johnson and Maltz and it became a benchmark to evaluate MANET routing protocols due to its simplicity and wide availability. RWP model is a random model for mobile users and how their location, acceleration and velocity change over time. In RWP model initially, all the nodes are distributed randomly over the simulation area. Node selects its random destination among the other nodes with in simulation area. After selection of this random destination, velocity is chosen from a uniform distribution. After reaching destination node, a small "pause time" is given and then again next random destination is selected by MN. MN also chooses a speed uniformly distributed between minimum to maximum speed. To reflect the degree of mobility some parameters could be set for value of travelling speed which is chosen uniformly in the interval. At this selected speed, MN continues its journey towards newly selected destination. After reaching on destination again the whole process is repeated after pause time.

VI. SIMULATION ANALYSIS AND RESULTS

For this study topology of fixed area of 700 x 700 m^2 is used with varying number of nodes 25, 50, 75, 100. Speed used is 20 ± 3 m/s, pause time is 15 ± 3 s, packet size is 512 B, simulation time is 300 s and traffic node is 10, 20, 40, 60 respectively with 25, 50, 75, 100 nodes in simulation. We consider effect of mobility on 4 major factors which are Packet Delivery Ratio, Average End to End Delay, Normalized Routing Overheads and Throughput of the MANET.

A. PACKET DELIVERY RATIO

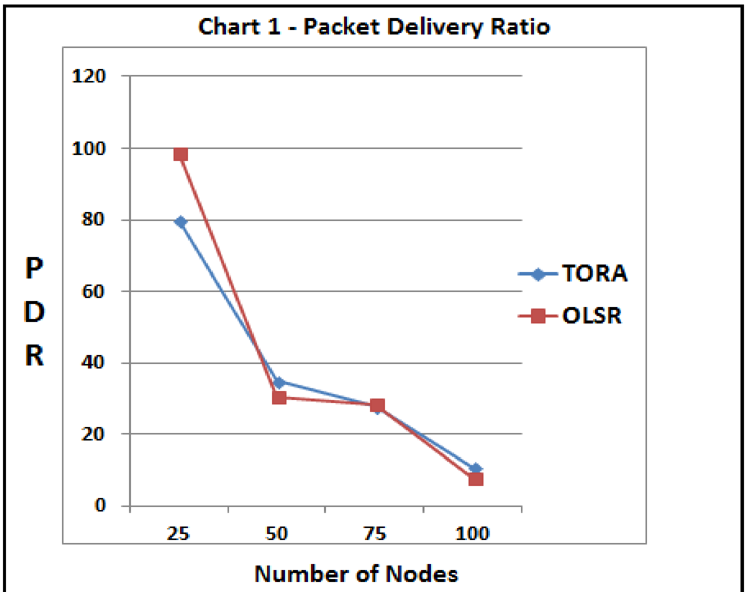
Packet Delivery Ratio is the ratio of total number of packets successfully received by the destination nodes to the number of packets sent by the source nodes throughout the simulation. It also describes the loss rate of the packets, which affects the maximum throughput that can be supported by the network. Formula to calculate Packet Delivery Ratio is as follows:

$$PDR = (Pr / Ps) * 100$$

Where PDR = Packet Delivery Ratio,

Pr = Total number of packets received and

Ps = Total number of packets sent.



No of Nodes	25	50	75	100
TORA	79.92	34.81	27.87	10.77
OLSR	98.84	30.48	28.38	7.75

B. AVERAGE END TO END DELAY

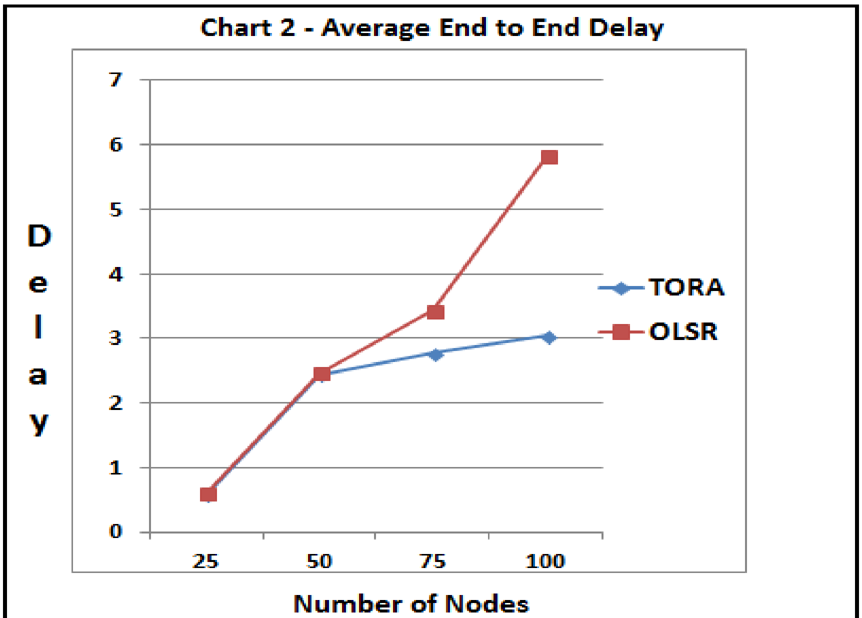
Average End to End Delay is defined as the average delay in the transmission of a packet between both nodes. A higher value of end to end delay means that the network is congested and the routing protocol does not perform well. Average end to end delay is calculated using following formula:

$$AD = \Sigma (Ta - Ts) / n$$

Where AD = Average Delay,

Ta = Arrival time of packet and

Ts = Start time of packets



No of Nodes	25	50	75	100
TORA	0.58	2.44	2.78	3.04
OLSR	0.59	2.46	3.43	5.83

C. NORMALIZED ROUTING LOAD

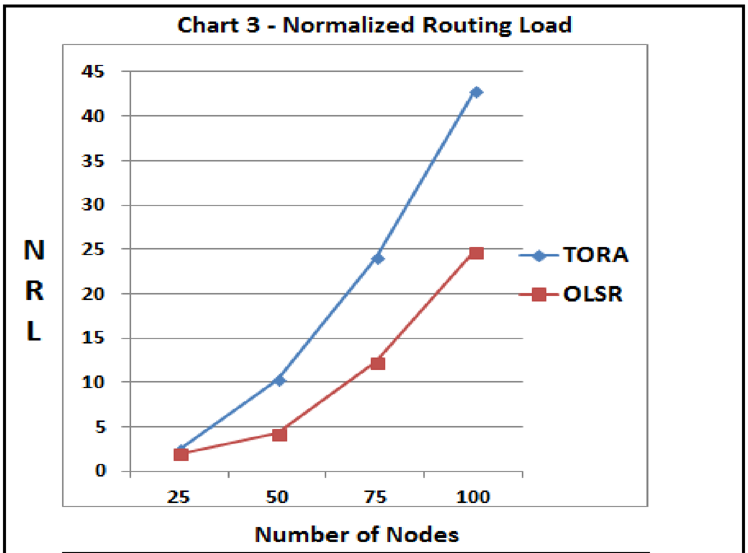
Normalized Routing Load is calculated as the ratio between the numbers of routing packets transmitted to the number of packets actually received means it's an accounting of dropped packets. The higher NRL value means higher overheads of routing packets and consequently lower the efficiency of the protocol. NRL is defined as number of routing packets transmitted per data packets delivered at destination. Each hop wise transmission of a routing is counted as one transmission. It is sum of all control packets sent by all nodes in network to discover and maintain route. The formula by which Normalized Routing Load is calculated is:

NRL = Pro / Pre

Where NRL = Normalized Routing Load,

Pro = Transmitted Routing Packets and

Pre = Received Data Packets



No of Nodes	25	50	75	100
TORA	2.46	10.24	24.07	42.82
OLSR	1.98	4.3	12.34	24.75

D. THROUGHPUT

Throughput is the average rate at which the total number of data packets is delivered successfully from one node to another over a network. Measuring unit for throughput is KB/Sec and formula by which throughput is calculated is as follows:

Tp = (NPD * Ps) / TDS

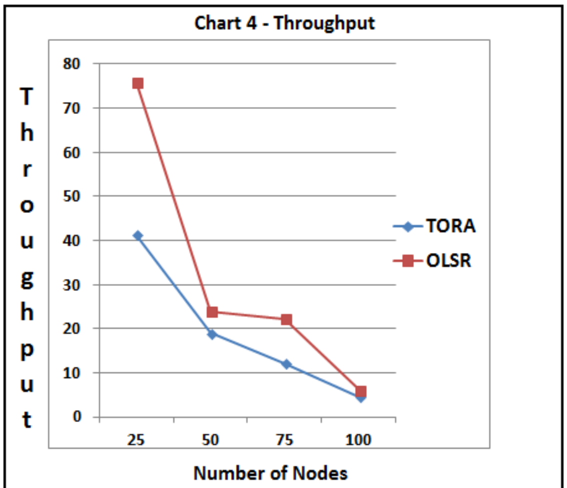
Where Tp = Throughput,

NPD = Number of delivered packets,

Ps = Packet Size and

TDS = Total duration of simulation

Line charts given below for all four factors will show the performance of both protocols in reference with number of nodes.



No of Nodes	25	50	75	100
TORA	41.41	19.01	12.17	4.62
OLSR	76.03	24.01	22.34	6.25

VII. CONCLUSION

In this paper, we picked up two routing protocols which are used for Mobile Ad-hoc Networks. The protocols we have selected here are OLSR and TORA. Although both the protocols are used in routing for MANETS, both of them are using different approaches for routing. OLSR is a proactive table driven protocol whereas TORA is reactive on demand protocol. We have tried to compare them for Packet Delivery Ratio, Average End to End Delay, Normalized Routing Load and Throughput by using Random Waypoint model for the simulation by which this data is collected. As per results it is very clear that increasing number of nodes affects both the protocols to a very great extent. But the effect of increasing number of nodes is not same for all four performance factors we are taking in consideration. In Packet Delivery Ratio for fewer devices like 25 nodes OLSR performs a bit better than TORA. But when number of devices increases performance of both the protocols is comparable. For Average End to End Delay for fewer number of devices like 25 -50 nodes, both protocols works same but when we increase the number of nodes, performance of OLSR decreases drastically, TORA's performance also decreases but it's much better than OLSR. For Normalized Routing Load as we increase the number of nodes, load in OLSR is clearly and continuously much better than TORA. As we have seen both protocols are better and worse in different parameters. But, when we see throughput, for fewer number of nodes OLSR is the clear winner but when we increase the numbers, performance suffers greatly in both protocols. But still OLSR performs a bit better then TORA even when nodes are increased up to 100.

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