Assessment of Mobile Ad-Hoc Network Routing Protocols in Increasing number of Mobile Nodes Scenario

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ABSTRACT
Mobile Ad Hoc Networks (MANETs) are advanced wireless communication networks consisting of mobile nodes connected by wireless links. Mobile nodes in MANETs are usually laptops, PDAs or mobile phones. In this paper an attempt has been made to describe the characteristics of MANETs, and analyze and compare the performance of ad-hoc routing protocols (AODV, OLSR, DSR and TORA) using OPNET Modeler. Representative traffic is submitted to the simulated MANET and the performance of different routing protocols has been analyzed by two parameters: delay and throughput for four different scenarios having 3, 5, 15, and 30 mobile nodes. Delay in case of AODV is minimum and maximum in TORA. Throughput is maximum in case of AODV and minimum in TORA. Thus AODV gives the best all round performance for MANETs.

Keywords
MANET, AODV, DSR, TORA, OLSR, OPNET

1. INTRODUCTION
Mobile Ad Hoc Networks (MANETs) [1] are advanced wireless communication networks. It is an autonomous system of mobile nodes connected by wireless links. Each node operates as an end system and a router for all other nodes in the network. As the network topology is dynamic, a routing protocol is needed to support the proper functionality of the network. Some of the prominent and promising among the routing protocols are Ad hoc On-demand and Distance Vector (AODV), Dynamic Source Routing (DSR), TORA and OLSR. In this paper efforts have been done to study through simulation the four routing protocols (DSR, AODV, TORA, and OLSR) for mobile ad-hoc networks using OPNET modeler. The main objective of this study is to create a choice guide of routing protocol for a given network scenario, based on the relative performance of the protocol under different scenarios.
The study briefly describes the routing protocols; the simulation tool used for this work, simulation environment, brief discussion on simulation mode, results and concluding remarks.

2. Ad-Hoc ROUTING PROTOCOLS
This section describes briefly the main features of the four protocols i.e. DSR, AODV, OLSR, and TORA.

2.1 Dynamic Source Routing (DSR)
DSR [4] is an on-demand reactive routing protocol designed to restrict the bandwidth consumed by control packets in ad hoc wireless networks by eliminating the periodic table update messages required in the table-driven approach. The major difference between this and the other on-demand routing protocols is that it is beacon-less and hence does not require periodic hello packet transmissions, which are used by a node to inform its neighbors of its presence. The protocol consists of two route-related processes: the route discovery process and the route maintenance process.

2.2 Ad-hoc on demand distance vector (AODV)
Ad-hoc On-demand distance vector (AODV) [4] [5] is another variant of classical distance vector routing algorithm. It shares DSR's on-demand characteristics hence discovers routes whenever it is needed via a similar route discovery process. However, AODV adopts traditional routing tables; one entry per destination which is in contrast to DSR. Whenever a route is available from source to destination, it does not add any overhead to the packets. AODV uses a broadcast route discovery algorithm and then the unicast route reply massage.

2.3 Optimized Link State Routing (OLSR)
OLSR [5] is a modular proactive hop by hop routing protocol. It is a modular protocol which consists of an always required core, and a set of auxiliary functions. It is a proactive approach, so it continuously tries to find routes to all possible destinations in the network. Due to its proactive basis, it has the advantage of having routes immediately available whenever they are required. OLSR introduces

2.4 Temporally Ordered Routing Algorithm (TORA)
Temporally-Ordered Routing Algorithm (TORA) is a distributed protocol designed to be highly adaptive so it can operate in a dynamic network. For a given destination, TORA uses a arbitrary "height" parameter to determine the direction of a link between any two nodes. As a consequence of this multiple routes are often present for a given destination, but none of them are necessarily the shortest route.

3. OPNET MODELER
Optimized Network Evaluation Tool (OPNET) modeler is commercial network simulation environment for network modeling. It simulates the network graphically and its graphical editors mirror the structure of actual networks and network components. It provides a variety of toolboxes to design, simulate and analyze a network topology, routing protocols on the basis of various network parameters. OPNET modeler version 14.5 is used for simulations.

4. SIMULATION ENVIRONMENT
Efficiency of the Ad-hoc routing protocols have been analyzed and verified through simulation using OPNET

modeler. The computation platform used is a desktop (2.5 GHz, 1GB RAM). Figure 1 shows a network taken up for the study. It consists of 30 mobile nodes, one static FTP (File Transfer Protocol) server node with server applications running. This node supports one underlying IEEE 802.11 connection at 1 Mbps or 2 Mbps. For the study FTP has been chosen as an application. Network's performance on the basis of the delay and throughput on the network has been analyzed. Mobility configuration will decide the mobility model of every node which is selected as random waypoint for this simulation. Attributes of workstation will set the routing protocol used for the simulation.

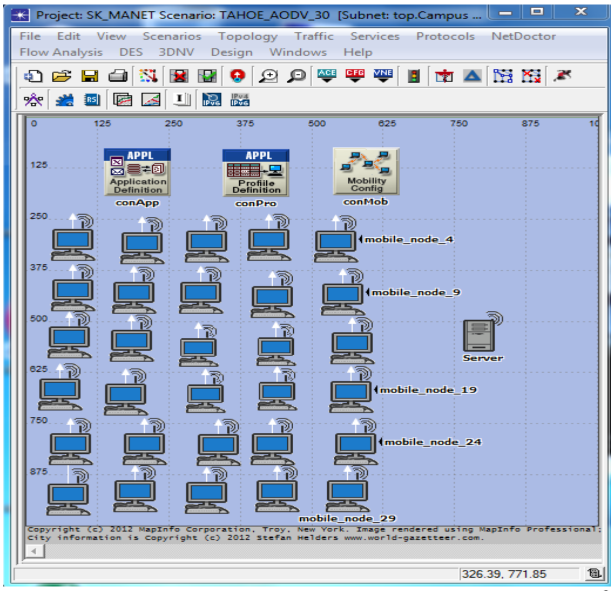

Figure 1. MANET Scenario

5. SIMULATION MODEL

Main characteristics of the scenarios maintained are depicted in the Table 1.

Table 1: Characteristics of Scenario

Statistic	Value
Scenario Size	10 X 10 KM
Simulation Time	10 min.
Nodes	3, 5, 15,30
802.11 data rate	11 Mbps
Mobility Model	Random Waypoint

5.1 Traffic Modeling

This simulation environment consists of 30 wireless nodes forming an ad-hoc network, moving in the proximity over about 10 x 10 kilometer flat space for about 10 minutes of simulated time.

5.2 Performance Matrices

The parameters on the basis of which the protocols are evaluated are the default parameters of the protocols. There are a number of metrics using which one can compare between these four protocols.

Throughput (bps) is the average rate of successful message delivery over a communication channel. The time it takes by the receiver to receive the last message is called as throughput. Throughput is expressed as bytes or bits per sec. Some factors that affect the throughput are: topology changes in the network, unreliable communication between nodes, limited bandwidth available and limited energy [5]. A high throughput is always desirable in every network.

Delay (sec) can be defined as time taken to push the packet's bits onto the link. The delay of a network specifies how long it takes for a bit of data to travel from one node to another across the network. Delay should be as small as possible.

6. SIMULATION RESULTS

Figure 2-17 gives the delay and throughput of a network when the number of nodes increases from 3, 5, 15 and 30 nodes for various routing protocols. The observations are as follows:

Delay:

- For TORA delay increases from 0.0037 sec (3 nodes) to 0.065 sec (30 nodes).
- Delay in OLSR is more than AODV.
- For DSR the delay is least (3 nodes) and it increases to more than AODV & OLSR (30 nodes).

Throughput:

- AODV initially takes a bit of time to discover the route and then start sending the packets. As we increase the number of nodes the throughput of AODV remains almost equal but higher than other three protocols.
- In case of DSR, initially it takes much time as it has to make multiple entries of routes gathered after route discovery in its routing table. After route discovery its throughput increases uniformly but less than AODV, OLSR but more than TORA.
- Throughput in case of OLSR increases continuously and is more than DSR & TORA but less than AODV.

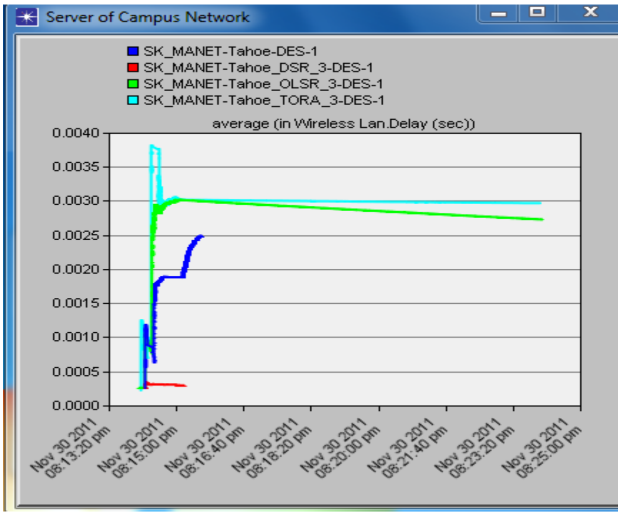

Figure 2. 3 Nodes

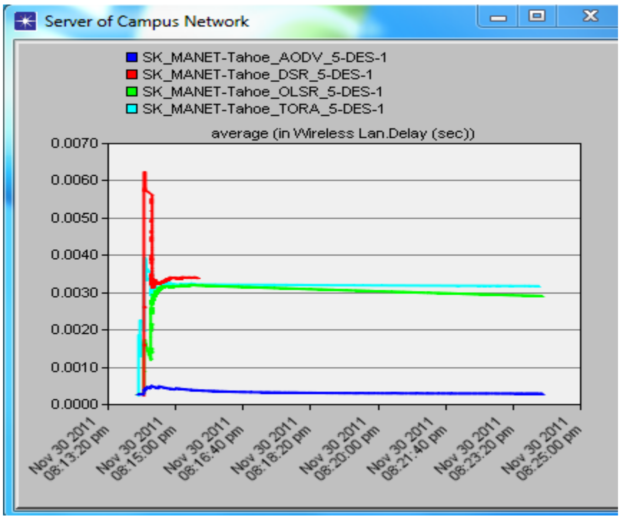

Figure 3. 5 Nodes

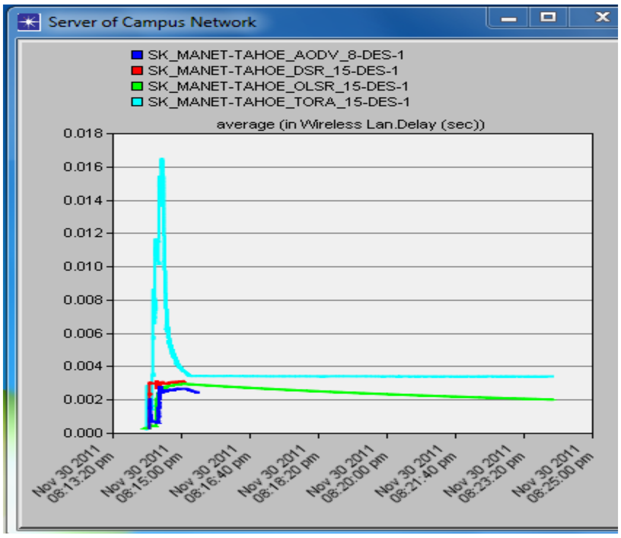

Figure 4. 15 Nodes

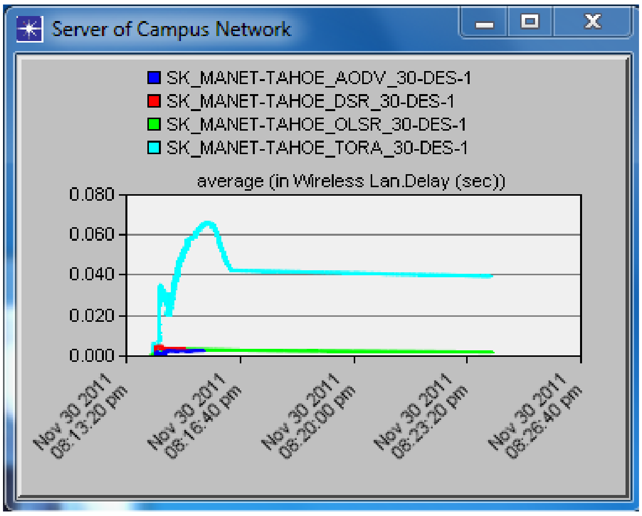

Figure 5. 30 Nodes

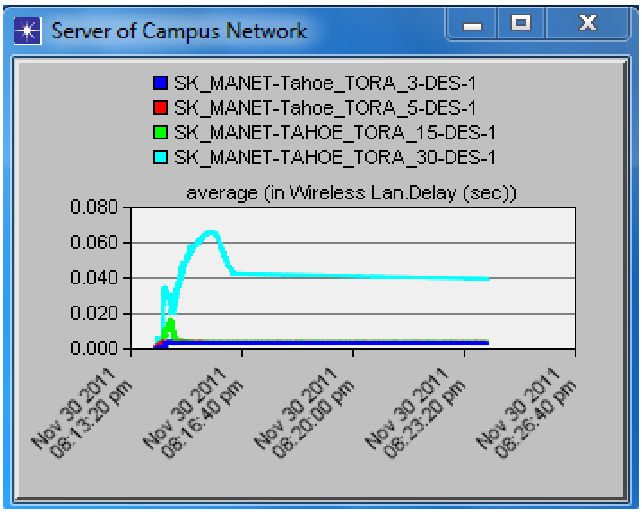

Figure 6. Varying nodes for TORA

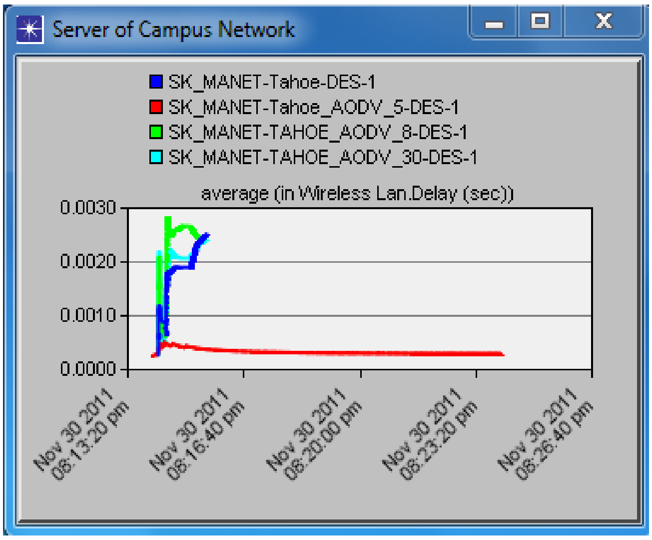

Figure 7. Varying nodes for AODV

Simulation time Vs Delay

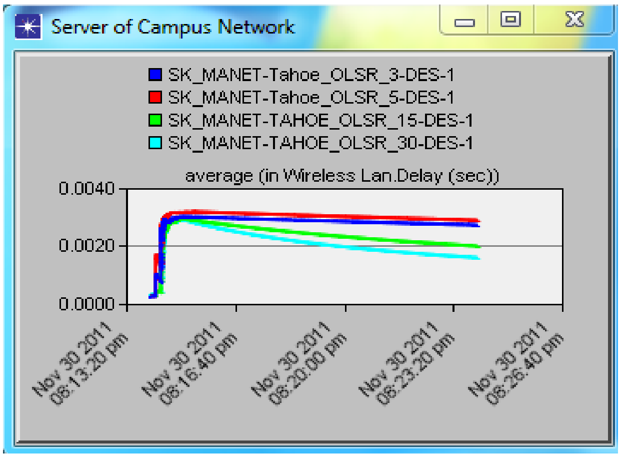

Figure 8. Varying nodes for OLSR

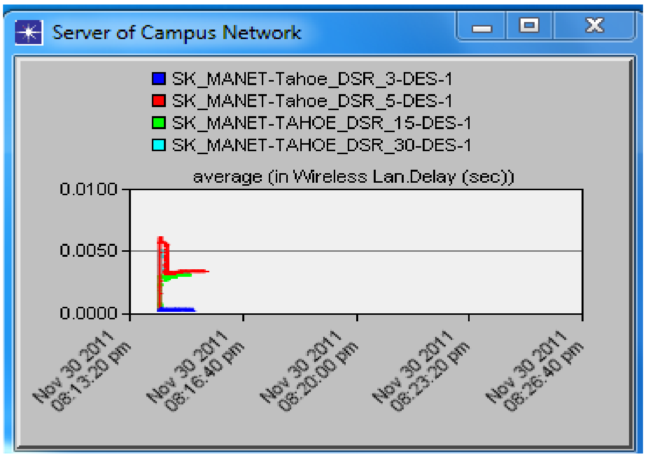

Figure 9. Varying nodes for DSR

Simulation time Vs Delay contd...

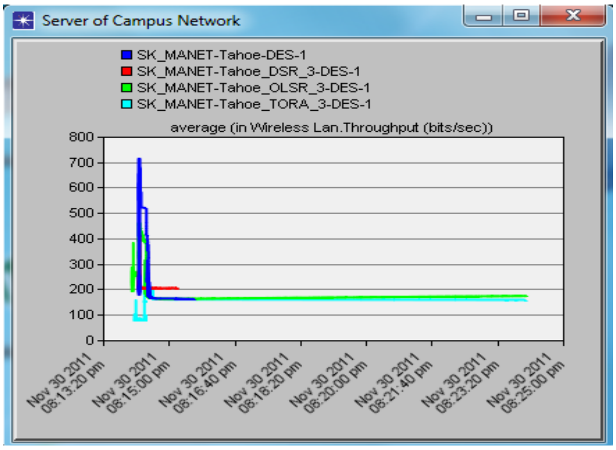

Figure 10. 3 Nodes

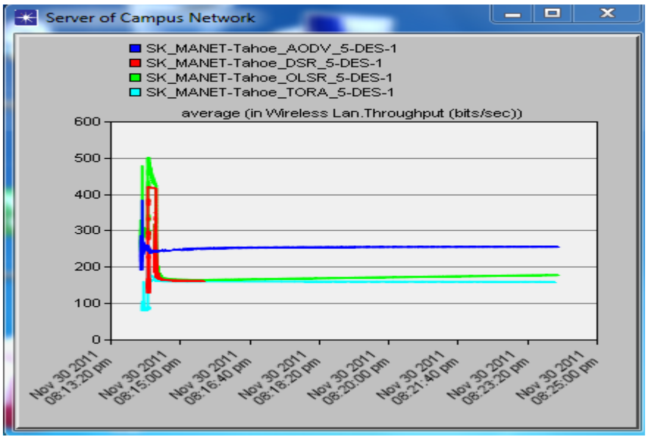

Figure11. 5 Nodes

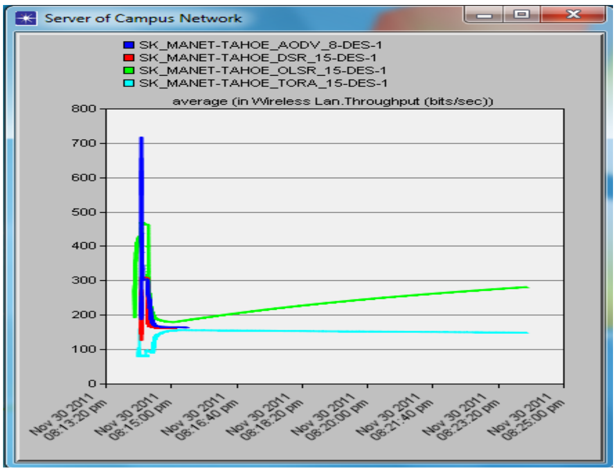

Figure 12. 15 Nodes

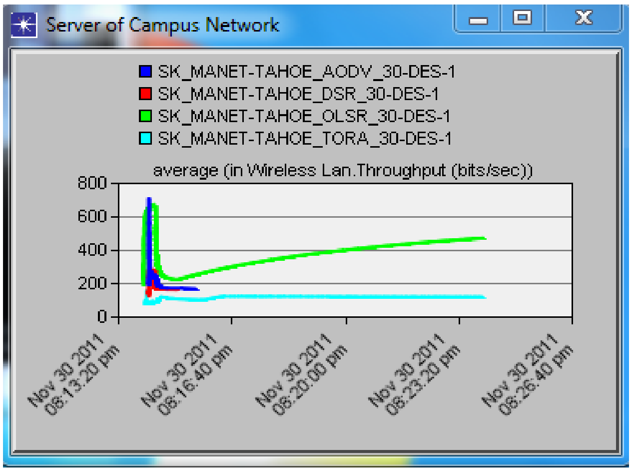

Figure 13. 30 Nodes

Simulation time Vs Throughput

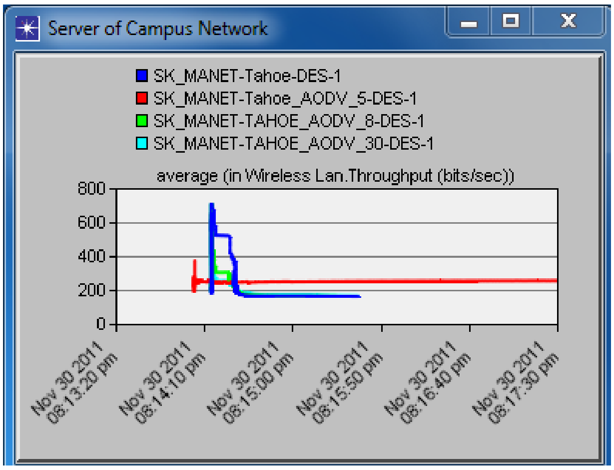

Figure 14. Varying nodes for AODV

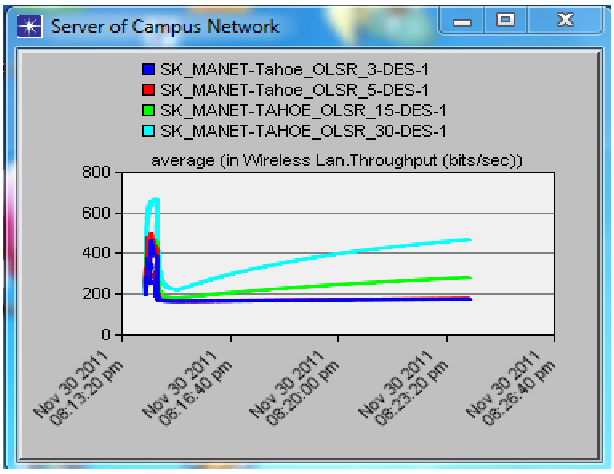

Figure 15. Varying nodes for OLSR

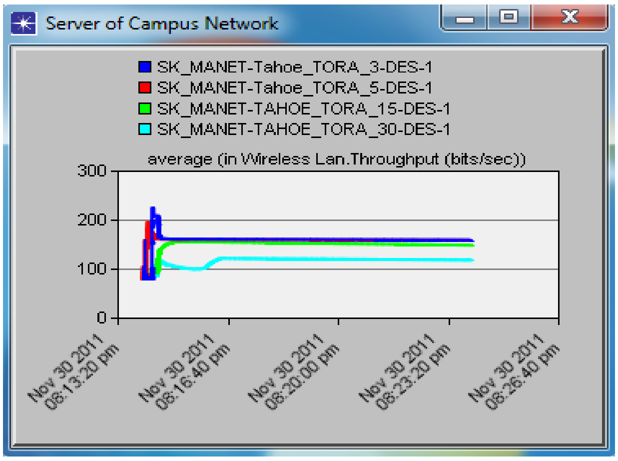

Figure 16. Varying nodes for TORA

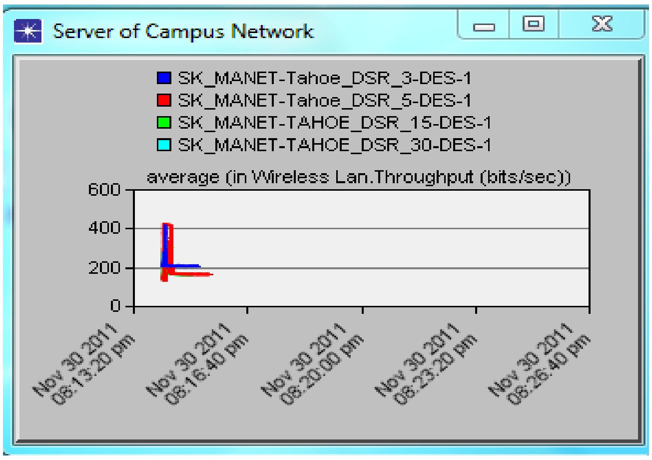

Figure 17. Varying nodes for DSR

Simulation time Vs Throughput contd...

7. CONCLUSION

From the above analysis it is concluded that delay in case of AODV is minimum and maximum in case of TORA. As least Delay is desirable, use of TORA as a routing protocol in case of MANET is ruled out. Throughput is maximum in AODV and is comparable to OLSR for higher no. of nodes. Hence to summarize the simulation results, AODV presents best all round performance.

8. ACKNOWLEDGEMENT

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