Evaluation of Routing Protocols for Mobile Ad hoc Networks

Gaurav Kakhani , S Gnanendra Reddy

Abstract: Mobile Ad hoc network is a self-configuring infrastructure less network of mobile devices connected by wireless links. Each device in a MANET is free to move independently in any direction and links will be changed frequently with other devices. Each host acts like a router and forward to its neighbors. To forward packets between routers we have various MANET routing protocol. An Ad hoc routing protocol is a convention that controls how nodes decide which way to route packet between computing devices in a mobile ad hoc network. In this paper our main focus is to analyze, simulate and evaluate the performance of Routing Protocols (DSR, AODV and TORA).

Index Terms: AODV, DSR, TORA, MANET.

I. INTRODUCTION

Wireless communication between mobile users is becoming more popular than ever before. This is due to recent technological advances in laptop computers and wireless data communication devices, such as wireless modems and wireless LANs. This has lead to lower prices and higher data rates, which are the two main reasons why mobile computing continues to enjoy rapid growth. Like traditional wired networks, wireless networks are formed by routers and hosts. In a wireless network, the routers are responsible for forwarding packets in the network and hosts may be sources or sinks of data flows. The fundamental difference between wired and wireless networks is the way that the network components communicate. A wired network relies on physical cables to transfer data. Mobile ad hoc network:

A mobile ad hoc network is formed by mobile hosts. Some of these mobile Hosts are willing to forward packets for neighbours. Examples include vehicle-to-vehicle and ship-to-ship networks that communicate with each other by relying on peer-to-peer routings, as shown in Figure. Generally speaking, traditional routing protocols that are used in wired networks can support routing in fixed wireless networks and mobile networks with fixed access points. Only one-hop routing is required over a link in a wireless network with fixed access points and many fixed wireless network.

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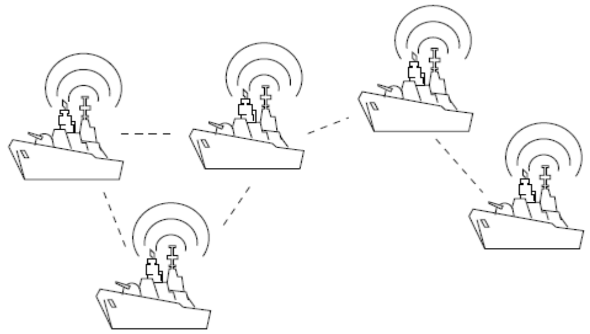

Figure 1. An example of a mobile ad hoc network [1]

Routing in mobile ad hoc networks and some fixed wireless networks use multiple-hop routing. Routing protocols for this kind of wireless network should be able to maintain paths to other nodes and in most cases, must handle changes in paths due to mobility. Traditional routing cannot properly support routing in a MANET. This paper focuses on mobile ad hoc routing. Ad-hoc networks are also capable of handling topology changes and malfunctions in nodes. It is fixed through network reconfiguration. For instance, if a node leaves the network and causes link breakages, affected no des can easily request new routes and the problem will be solved. This will slightly increase the delay, but the network will still be operational.

II. PROBLEM STATEMENT & OBJECTIVE

Mobile ad hoc networks (MANETs) are rapidly evolving as an important area of wireless mobility. MANETs are infrastructure less and wireless in which there are several routers which are free to move arbitrarily and perform management of routes. Network topology changes very rapidly and unpredictably in which many mobile nodes moves to and from a wireless network without any fixed access point where routers and hosts move, so topology is dynamic. Most current Mobile Ad hoc routing protocols assume that the wireless network in benign and every node in the network strictly follow the routing behavior and is willing to forward packets to other nodes. Most of these protocols cope well with the dynamically changing topology. However, they do not address the problems when misbehavior nodes are present in the network.

A commonly observed misbehavior is packet dropping. Practically, in a MANETs, most devices have limited computing and battery power while packet forwarding consumes a lot of such resources. The design of routing protocols for MANETs must consider the

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power and resource limitation of the network nodes, the time varying quality of wireless channels and possibility of packet loss and delay. To address these design requirements several design strategies for MANETs have been proposed. AODV, DSR and TORA are some of the common protocols. Each one having it's fair share of advantages and limitations. Routing protocols use several metrics to calculate the best path for routing the packets to its destination. The process of path determination is that, routing algorithms initialize and maintain routing tables, which contain the total route information for the packet. This route information varies from one routing algorithm to another.

These protocols are also called reactive protocols since they don't maintain routing information or routing activity at the network nodes if there is no communication. If a node wants to send a packet to another node then this protocol searches for the route in an on-demand manner and establishes the connection in order to transmit and receive the packet. The route discovery usually occurs by flooding the route request packets throughout the network.
AODV expects/requires that the nodes in the broadcast medium can detect each other's broadcasts. AODV is a reactive routing protocol. This means that AODV does not discover a route until a flow is initiated. This route discovery latency result can be high in large-scale mesh networks.

A. Objective and Sub-tasks

Routing in these networks is highly complex due to moving nodes and hence many protocols have been developed. This Master thesis concentrate mainly on routing protocols and their functionality in Ad-hoc networks with a discussion being made on three selected protocols AODV,DSR and TORA, ending with their comparison.

- To analyze the three protocols - AODV, DSR and TORA.
- To simulate the three protocols - AODV, DSR and TORA in a simulation environment.
- To evaluate the three protocols - AODV, DSR and TORA in a simulation environment.

III. RESULTS, PERFORMANCE & ANALYSIS

This section described simulation of thee routing protocols and the analysis is being done by using results of *.nam file and *.tr file of each protocol, comparison between the AODV, DSR and TORA routing protocol using the average end to end delay, packet loss and packet delivery fraction performance metrics [2]. The value of simulation in studies of protocols is that it allows near perfect experimental control: experiments can be designed at will and then rerun while varying an experimental variable and holding all other variables constant [3]. The nam is a built-in program in ns2-allinone package. It helps us to see the flow of packets between various nodes. With this, we are also able to know whether the packets have reached to their destination properly or dropped in between. NAM is invoked within the Tcl file. We are able to analyze the simulation of AODV, DSR and TORA with different number of nodes, with the help of 2D and 3D graphs. These graphs are generated with a program called tracegraph. The NAM scripts are stored in *.nam file and scripts for tracegraph are stored in *.tr file.
The simulation is divided in to two Scenarios (With 15nodes and 25 nodes) that have been created, basis on the number of nodes that vary, in each scenario the simulation is done in the following:

- Simulation of AODV routing protocol
- Simulation of DSR routing protocol
- Simulation of TORA routing protocol

A. Scenario 1

In the first simulation scen acbr_15node_15con_3rate scenario files have been used as movement scenario and traffic scenario respectively. It can easily be inferred from the name of the scenario files, it have 15 mobile nodes with a 1 seconds of pause time and with a maximum speed of 10m/s in a 1000x1000 region. After the simulation and analyzing the trace files, it has been obtained the graphs as presented figure 1 Simulation of AODV routing protocol: My aim here was to simulate AODV routing protocol for 15 nodes sending cbr packets with random speed. First the cbr files and scenario files are generated and then using AODV protocol simulation is done which gives the nam file and trace file.

(a) Simulation of AODV Routing Protocol

The following figures are the execution of the nam files instances created. We can view the output on the network simulator. The figure-2 shows that the source is broadcasting its data to all its neighboring nodes. The source (node 12) is broadcasting RREQ message to all its neighbors and Node 4, which is the destination node, is sending RREP (route reply) back to the source. RREP in red color has been shown in figure 3. As the energy of the nodes decreases, packet dropping starts. Packet dropping has been shown with the 3D graph. As the packet dropping starts, again broadcast will happen and different route will be followed.

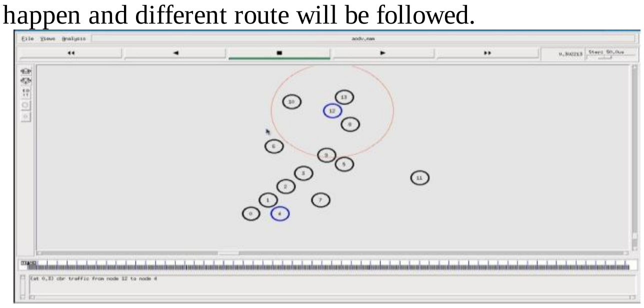

Figure 2. AODV (Random Topology): Source Node broadcasts RREQ

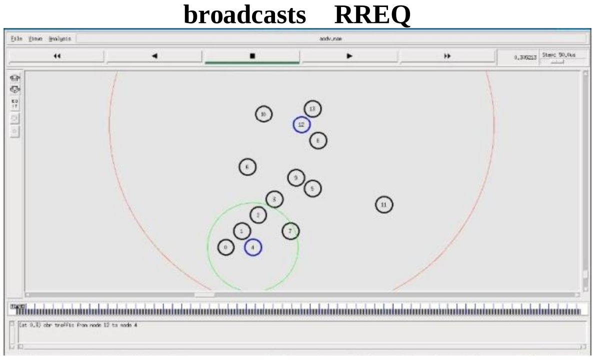

Figure 3. AODV: Destination Node sends back RREP.

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The trace graph snapshots have been taken with the simulation time of 150 seconds. In figure 4, the entire simulation scenario has been displayed along with the end-to-end delay. The throughput of sending and receiving protocols has been displayed in figure 5 and 6.

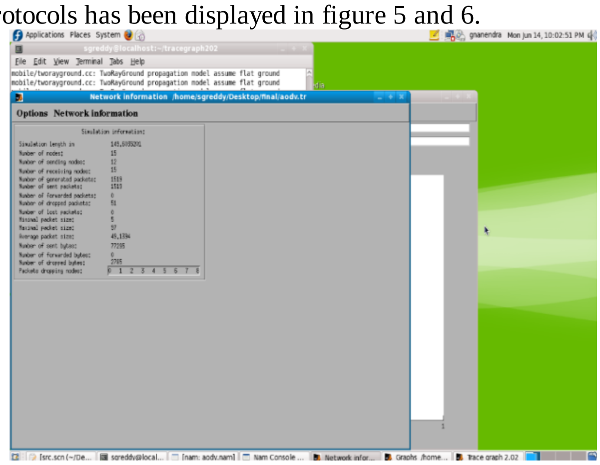

Figure 4. AODV: (Random Topology): Simulation Details

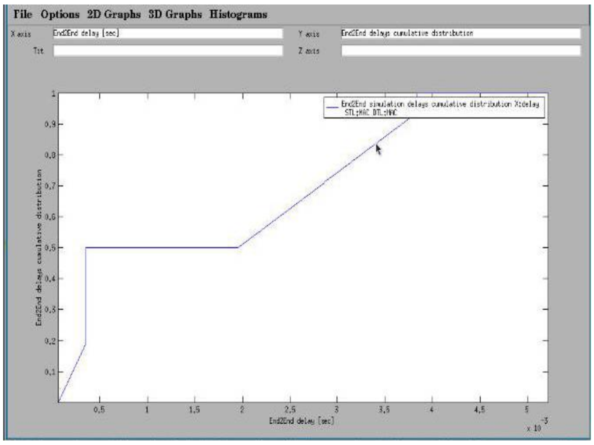

Figure 5. AODV(Random Topology): End-to-end Simulation Delay Cumulative Distribution

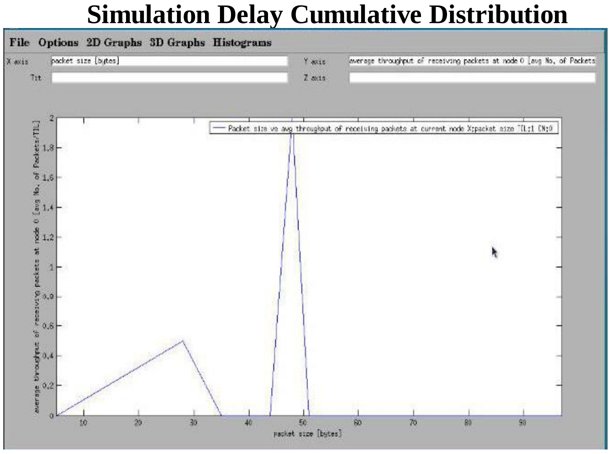

Figure 6. (AODV): Average throughput of receiving packet at node verses packet size (bytes)

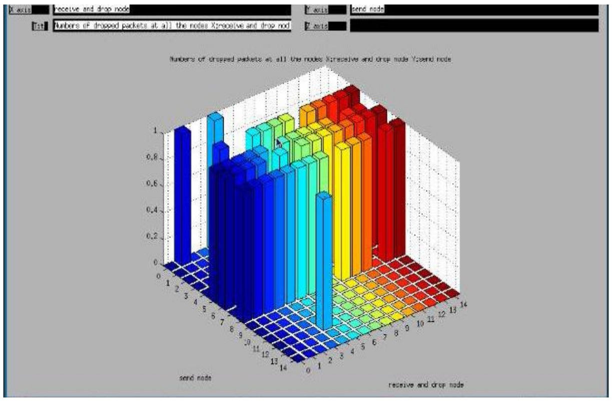

Figure 7. AODV (Random Topology): Dropped Packets

(b) Simulation of DSR routing protocol

The simulation of DSR routing protocol for 15 nodes sending cbr packets with random speed. First the cbr files and scenario files are generated and then using DSR protocol simulation is done which gives the nam file and trace file. [4]. The following figures are the execution of the nam files instances created. We can view the output on the network simulator and the analysis is being done by using results of *.tr file of protocol with the 2D and 3D graphs which were created by using tracegraph. as shown below:

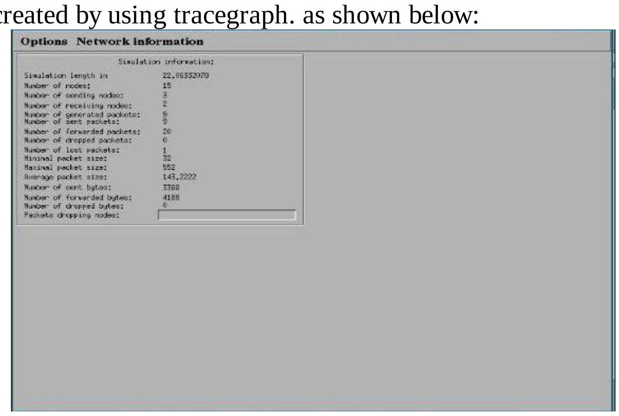

Figure 8. DSR (Random Topology): Simulation Details

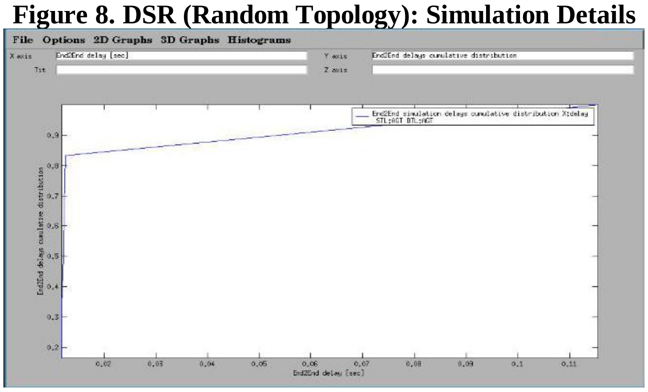

Figure 9. DSR (Random Topology): End-to-end Simulation Delay Cumulative Distribution

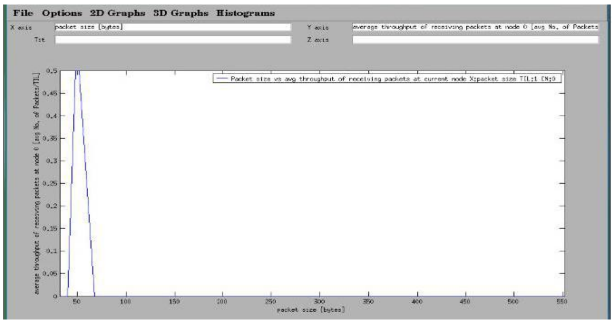

Figure 10. (DSR): Average throughput of receiving packet at node verses packet size(bytes)

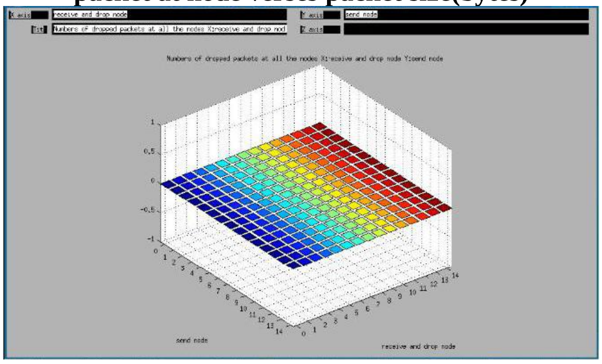

Figure 11. DSR (Random Topology): Dropped Packets

(c) Simulation of TORA routing protocol

The simulation of TORA routing protocol for 15 nodes sending cbr packets with random speed. First the cbr files and scenario files are generated and then using TORA protocol simulation is done which gives the nam file and trace file [4]. The following figures are the execution of the nam files instances created. We can view the output on the network simulator and the analysis is being done by using results of *.tr file of protocol with the 2D and 3D graphs which were created by using tracegraph. as shown below:

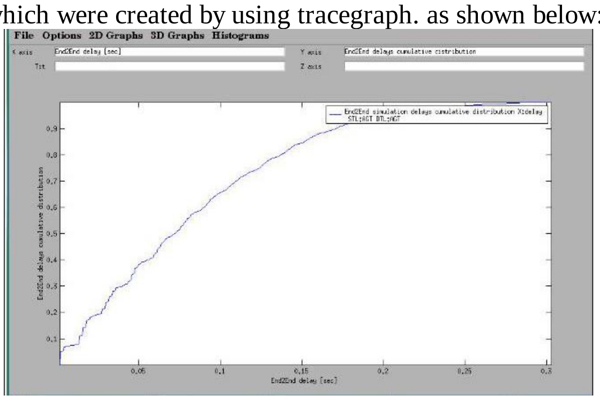

Figure 12. TORA (Random Topology): End-to-end Simulation Delay Cumulative Distribution

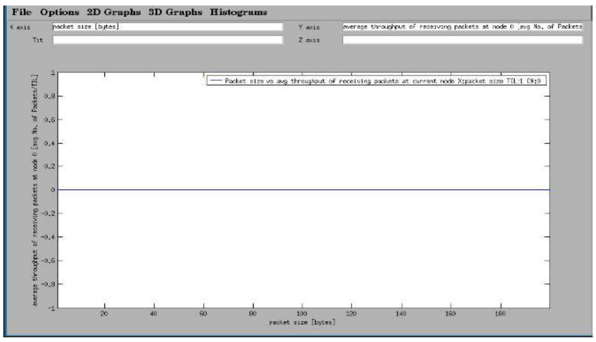

Figure 13. Average throughput of receiving packet at node verses packet size(bytes)

Table 1 Outputs of the Simulation under Scenario 1

Metrics	AODV	DSR	TORA
No of Packets Received	104480	17864	16684
No of Packets Drop	203600	58698	38657
Packet Delivery Ratio	50.431	50.73	50.62

B. Scenario 2

In the second scenario , let us focus on two scenarios scen_20node_1s_10mps_150sim_1000x1000 and cbr_20node_20con_3rate scenario files have been used as movement scenario and traffic scenario respectively. This simulation may enable us to see what would be the performances of the protocols when the number of nodes increased. After the simulation and analyzing the trace files, we have obtained the graphs from which we concluded that; the performances of the protocols are approximately similar with the first simulation performances. Again DSR protocol is extremely reliable when look at throughput and packet delivery fraction.

(a) Simulation of AODV routing protocol

The following figures are the execution of the nam files instances created. We can view the output on the network simulator with 20 nodes of AODV routing protocol and also analyzing the trace files, we have obtained the graphs from which we concluded that; the performance of the AODV routing protocol.

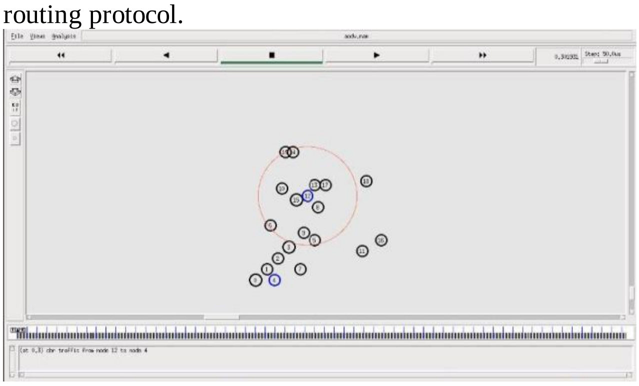

Figure 14. AODV(Random Topology):Simulation Environment (NAM)

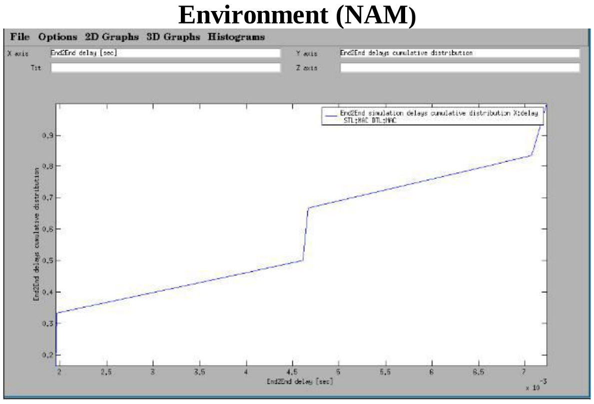

Figure 15. AODV(Random Topology): End-to-end Simulation Delay Cumulative Distribution

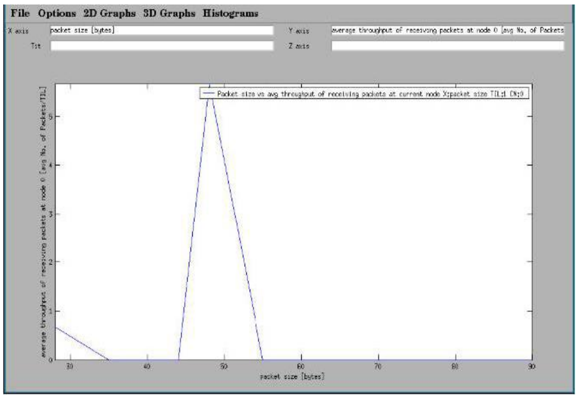

Figure 16. (AODV): Average throughput of receiving packet at node verses packet size (bytes)

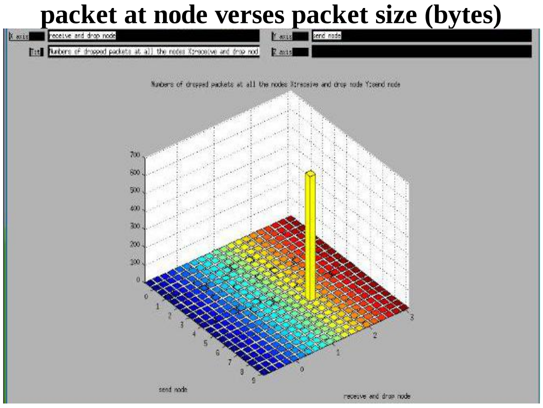

Figure 17. AODV (Random Topology): Dropped Packets

(b) Simulation of DSR routing protocol

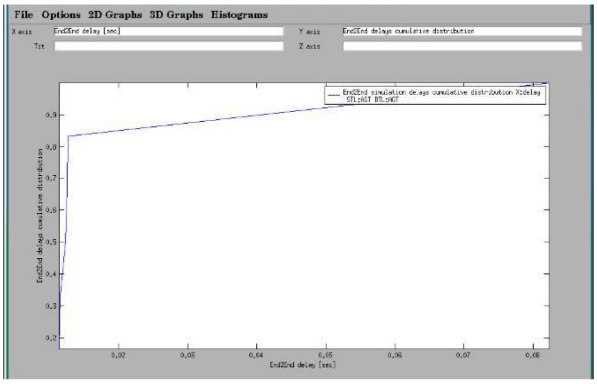

Figure 18. DSR (Random Topology): End-to-end Simulation Delay Cumulative Distribution

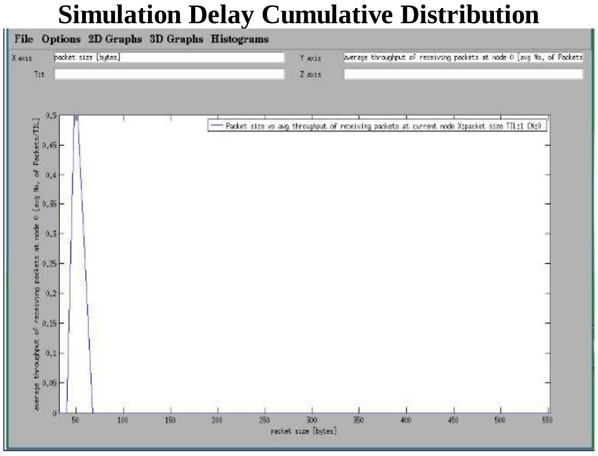

Figure 19. (DSR): Average throughput of receiving packet at node verses packet size (bytes)

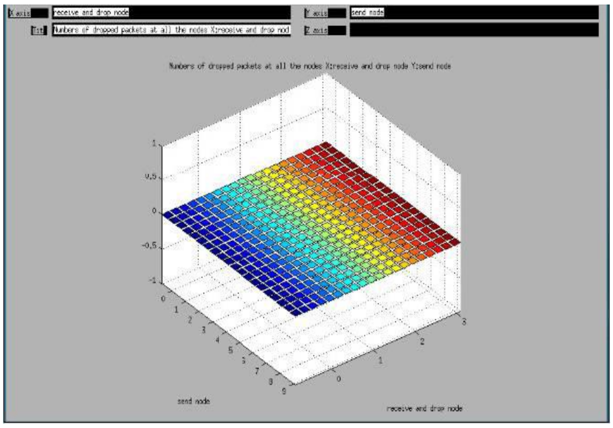

Figure 20. DSR (Random Topology): Dropped Packets

(c) Simulation of TORA routing protocol

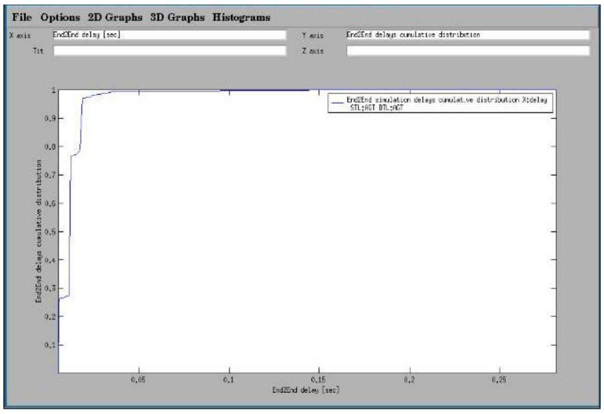

Figure 21. TORA(Random Topology):End-to-end Simulation Delay Cumulative Distribution

IV. COMPARISON OF THE THREE ROUTING PROTOCOLS

The simulation results are revealed in the following section in the form of line graphs. Graphs illustrate comparison between the three protocols by varying different numbers of sources on the basis of the above-mentioned metrics as a function of pause time.

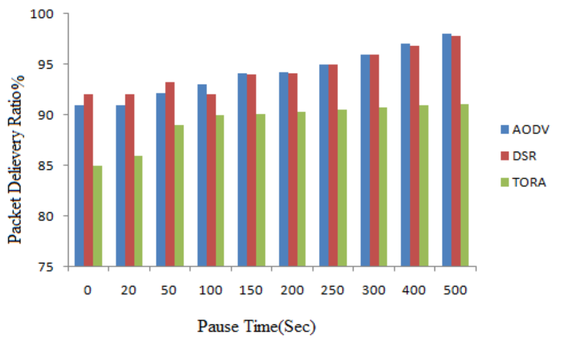

Figure 22. Packet delivery fraction vs. Pause time for 15-node model with10 sources

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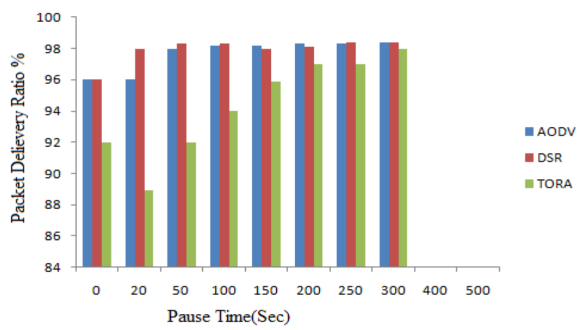

Figure 23. Packet delivery fraction vs. Pause time for 20-node model with20 sources

V. PERFORMANCE OF AD HOC ROUTING PROTOCOLS

This section presents a conversation on the performance of the previously described ad hoc routing protocols. The interpretation are based on various studies that have been done to compare the performance of routing protocols for MANETs

(a) Performance of DSR

When low mobility DSR performs very well and delivers close to 95% of its packets. At high mobility, the throughput drops to about 70%. The throughput in DSR also decreases as a function of the number of nodes in the network. At high load, high mobility and large number of nodes, the throughput can be as low as 50%. The per-packet overhead in DSR is high because it embeds the complete source route in the packet header. This overhead can reach 100% for small sized data packets. DSR tend to keep the routing overhead relatively low even under high loads and large number of nodes. DSR finds close to optimal routes in most cases. Underneath low network loads, the average end-to-end delay in DSR is very low. However, the average delay can increase 5-6 times for modest to high network loads.

(b) Performance of AODV

The AODV shows well performance in networks of up to 100 nodes regardless of node mobility and network load. Under these conditions, it delivers close to 95% of its packets and the throughput can approach 100% in fairly static networks. The throughput decreases as the number of nodes increases due to longer routes and higher collision rate. At number of nodes becoming more, the throughput becoming low .The packet delivery ratio also drops with increase in nodal mobility. The routing overhead is lower than proactive protocols but is high compared to DSR. However, AODV outperforms DSR in terms of per-packet overhead. Under conditions of high mobility, high load and larger number of nodes, the throughput can drop to 70%. Unlike many protocols, AODV does not find the optimal route in most cases and the difference in the optimal route and the route found by AODV can be up to four hops. It is interesting to note that the average delay in AODV decreases as the mobility increases.

(b) Performance of TORA

When the numbers of nodes are low, TORA performs very well even at the highest rate of node mobility and delivers about 93% of its packets. TORA is based on the theory of link reversal and this can build the configuration of short lived routing loops. This problem is responsible for greater part of the packet drops in TORA. The performance of TORA suffers a ruthless joggle as the number of nodes increases and the packet delivery ratio can fall to about 9% in huge networks. TORA fails to converge in huge networks with high mobility rates and can undergo a congestive collapse. However, the performance of TORA is poor compared to protocols like DSR and AODV and it has been found that TORA had the most overhead compared to these protocols. The routing overhead in TORA is the sum of constant mobility-independent overhead (due to neighbor sensing) and variable mobility-dependent overhead.

VI. CONCLUSION AND FUTURE SCOPE

Mobile Ad hoc Networks (MANETs) have received increasing research attention in recent years. There are many active research projects concerned with MANETs. Mobile ad hoc networks are wireless networks that use multi-hop routing instead of static networks infrastructure to provide network connectivity. MANETs have applications in rapidly deployed and dynamic military and civilian systems. The network topology in MANETs usually changes with time. Therefore, there are new challenges for routing protocols in MANETs since traditional routing protocols may not be suitable for MANETs. Researchers are designing new MANETs routing protocols, comparing and improving existing MANETs routing protocols before any routing protocols are standardized using simulations. In the presented work, we have discussed a comparison of three routing protocols (AODV,DSR and TORA) for Mobile ad hoc (MANETs) network in two scenarios with varying of nodes. We sincerely hope that our work will contribute in providing further research directions in the area of routing.

This comparison study is an attempt towards a comprehensive performance evaluation of three commonly used mobile ad hoc routing protocols (DSR, TORA and AODV) .Simulation was done with simulation time of 150 seconds and with some varying parameters, using the latest simulation environment ns-2. For short-range wireless communication in MANETs, AODV, DSR and TORA are used and the results are compared on the issues like throughput of sent packets, dropped packets, end-to-end delay and are very important for detailed performance evaluation of any networking protocol. We can summarize our final conclusion from our experimental results as follows:

- Increase in the density of nodes yields to an increase in the mean End-to-End delay.
- Increase in the pause time leads to a decrease in the mean End-to-End delay.
- Increase in the number of nodes will cause increase in the mean time for loop detection.

In short, AODV has the best all round performance. DSR is suitable for networks with moderate mobility rate. It has low overhead that makes it suitable for low bandwidth and low power network. TORA is suitable for operation in large mobile ad hoc networks having dense population of nodes. The major benefit is its excellent support for multiple routes and multicasting.

For the future work, this area will investigate not only the comparison between AODV, DSR and TORA routing protocols but more on the vast areas, extensive complex simulations could be carried out using other existing performance metrics, in order to gain a more in-depth performance analysis of the ad hoc routing protocols. Other new protocols performance could be studied too.

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