



Performance Evaluation of Routing Protocols for Mobile Ad hoc Networks through Simulation

Sona Malhotra¹, Naveen Kumar²

¹Faculty of Computer Science & Engineering, ²Research Scholar

Department of Computer Science & Engineering, University Institute of Engineering and Technology,
Kurukshetra University, Kurukshetra-136 119, Haryana, INDIA.

Abstract: Mobile ad hoc network (MANET) is an autonomous system of mobile nodes connected by wireless link. Nodes in the network cooperate in multi-hop forwarding and utilize the same random access wireless channel. A node forwards and receives packets to and from other nodes, and hence acts both as client or a server. Since the nodes are mobile, a dynamic routing protocol is needed. Since the routing in ad-hoc networks has become a challenging issue. In this work an attempt has been made to evaluate the performance of three protocols LEACH, AODV, TORA. Evaluation is made on the basis of average end-to-end delay, packet delivery fraction, packet loss. In this paper we have taken 2 different scenarios for simulation and then analyzed the results. As per our findings the differences in the protocol mechanics lead to significant performance differentials for these three protocols. The performance differentials are analyzed using varying simulation time. These simulations are carried out using the ns-2 network simulator. The result presented in this work illustrate the importance in evaluating and implementing routing protocols in MANET and weaknesses in these protocols can be found through analysis and their solutions can be proposed.

Keywords: MANET, AODV, TORA, LEACH, PDF, IETF

I. INTRODUCTION

Mobile Ad hoc Network (MANET) is a group of wireless node, which rapidly moves, changes and forms a network without need of centralized controlling entity. MANET consist of mobile platform which communicate with each other through wireless links, without any predetermined infrastructure. MANETs allow the applications running on these wireless devices to share data of different types and characteristics. If the source and destination nodes are not within the transmission range of each other, then intermediate nodes would be served as intermediate routers for the communication between the two nodes. Moreover, mobile platform moves autonomously and communicates via dynamically changing network. So the network's wireless topology may dynamically change in an unpredictable manner since nodes are free to move and this frequent change of the network topology is a main challenge and the Information is transmitted in a store-and forward manner using multi hop routing. Each node is equipped with a wireless transmitter and a receiver with an appropriate antenna. We assume that it is not possible to have all nodes within each other's radio range. When the nodes are close-by i.e., within radio range, there are no routing issues to be addressed. At a given point in time, wireless connectivity in the form of a random multi-hop graph exists between the nodes.

A. CHARACTERISTICS OF MANETS

- *Dynamic topologies:* Network topology may change dynamically as the nodes are free to move.
- *Bandwidth-constrained, variable capacity links:* Realized throughput of wireless communication is less than the radio's maximum transmission rate. Collision occurs frequently.
- *Energy-constrained operation:* Some nodes in the ad hoc network may rely on batteries or other exhaustible means for their energy.
- *Limited physical security:* More prone to physical security threats than fixed cable networks.

B. APPLICATIONS OF MANET

- *Virtual navigation:* Data from a remote database is transmitted periodically in small relevant blocks using links present in the path of the automobile. This database may contain the graphical

representation of streets, buildings, maps and the latest traffic information, which may be used by the driver to decide on a route.

- *Tele-medicine*: Conference assistance from a surgeon for an emergency intervention.
- *Tele-Geo processing*: Queries regarding location information of the users.
- *Crisis-management*: Natural disasters, where the entire communication infrastructure is in disarray.
- *Education*: via the internet.

C. DESCRIPTION OF MANET ROUTING PROTOCOL

Mobile Ad-hoc networks are self-organizing and self-configuring multi-hop wireless networks, where the structure of the network changes dynamically [3][8]. Nodes in the network cooperate in multi-hop forwarding and utilize the same random access wireless channel. A node forwards and receives packets to and from other nodes, and hence acts both as client or a server. Since the nodes are mobile, a dynamic routing protocol is needed. Since the routing in ad-hoc networks has become a challenging issue, the Internet Engineering Task Force (IETF), MANET [6] working group is working continuously to ensure standardization of routing protocols. Each node participates in topology discovery and thus acts as a router for other nodes. In order to select optimum route for data transmission many routing algorithms have been proposed.

D. CLASSIFICATION OF ROUTING PROTOCOL

The routing protocols can be divided as flat-routing, hierarchical routing and geographic position assisted routing depending on the network structure [2][8].

Flat Routing Protocols: These protocols are further subdivided into Reactive routing-protocol (on-demand), Proactive routing protocol (table-driven) and Hybrid-protocols [3][8]. Proactive routing is mostly based on LS (link-state) while on-demand routing is based on DV (distance-vector).

- Proactive: when a packet needs to be forwarded, the route is already known. An example of this protocol is Destination Sequenced Distance Vector (DSDV) [6].
- Reactive: Determine a route only when there is data to send. Examples of On-demand routing protocol are Dynamic Source Routing (DSR), Ad-hoc On-demand Distance Vector Routing (AODV) [6].

Hybrid Routing Protocols [2][8]: The different types of delays and overheads suffered by reactive and proactive protocols are recovered in a hybrid network. Whenever the network is small, proactive routing is used and reactive routing is used for larger networks making it a hybrid network. The protocol is suitable for highly versatile networks, characterized by a large range of node mobility and large network diameters. An example of it is ZRP (Zone Routing Protocol) [3].

Hierarchical Routing Protocols [2][8]: A Hierarchical-network is used when the size of network inside a MANET[8] increases tremendously. Some examples of the protocol are Hierarchical State Routing (HSR), Zone Routing Protocol (ZRP), Cluster-head Gateway Switch Routing Protocol (CGSR), Land-Mark Ad-Hoc Routing Protocol (LANMAR)[3][8][9][7].

Geographical Routing Protocols [2][8]: Two approaches to geographic mobile ad-hoc networks are i.e. Actual geographic coordinates (as obtained through GPS – the Global Positioning System) and Reference points in some fixed coordinate system. For the effective location-based routing, the routing updates must be done faster in compare of the network mobility rate as the node positions changes quickly in the network. Some of its examples are: Geo-Cast (Geographic Addressing and Routing), DREAM (Distance Routing Effect Algorithm for Mobility), GPSR (Greedy Perimeter Stateless Routing).

E. DESCRIPTION OF ROUTING PROTOCOLS : AODV, LEACH, TORA

AODV

AODV is a reactive routing protocol. It is an improvement over DSDV network as the size of network may increase depending on the number of nodes. AODV avoids the counting-to-infinity problem unlike other distance vector protocols by using sequence number for each route. In AODV, all nodes maintain a routing table containing the entry for each destination node. Each entry includes the next hop, sequence number and number of hops requires for reaching destination node. Nodes that are not in a selected path do not maintain routing

information or participate in routing table exchanges. A source node initiates a path discovery process to locate the other intermediate nodes (and the destination), by broadcasting a Route Request (RREQ) packet to its neighbors. Path discovery is accomplished by flooding the Route Request (RREQ) packet, when RREQ arrive at the destination or the intermediate node having route to destination, it send off a Route Reply (RREP) packet in unicast mode.

LEACH

LEACH is based on a hierarchical clustering structure model and energy efficient cluster-based routing protocols for sensor networks. In this routing protocol, nodes self-organize themselves into several local clusters, each of which has one node serving as the cluster-head. Operation of Leach broken into following rounds:

Set-up phase:

Advertisement Phase:

- Each node decides whether or not to become a cluster head for a round based on a threshold.
- Each node say node n generates a random number between 0 and 1. If the random number is less than a threshold $T(n)$ then the node elects itself to be a cluster head.

$$T(n) = P / (1 - P * (r \bmod 1/P)) \text{ if } n \in G$$

$$= 0 \text{ otherwise}$$

P – desired percentage of cluster heads ($P = 0.05$)

r – current round

G – is the set of nodes that have not been cluster head in last $1/P$ rounds

- Each node that elects itself cluster-head for current round broadcasts a message to the rest of the nodes
- All cluster-heads transmit their advertisement with the same transmit energy
- Non cluster heads keep their receivers on
- Based by the received signal strength, each non-cluster node decides to which cluster head to join(assuming symmetric propagation channels)

Cluster Set up Phase:

- Each non-cluster-head node informs the cluster-head to whom it wants to join.
- During this phase all heads should keep their receivers on

Schedule Creation:

Each cluster head based on the number of nodes in its cluster creates a TDMA schedule which is broadcasted to its cluster

Data Transmission:

- Radios of non-heads are off when its not transmitting, to preserve energy.
- When all data has been received from all the nodes the head performs signal processing to compress the data into a single signal
- This is then send directly to the base station by a high energy transmission.

TORA

This is highly adaptive, loop-free, distributed routing algorithm based on the concept of link reversal. Proposed to operate in a highly dynamic mobile networking environment. It is source initiated and provides multiple routes for any desired source/ destination pair. This algorithm requires the need for synchronized clocks. Concept of TORA is that control messages are localized to a small set of nodes nearby a topological change & nodes maintain routing information about their immediate one hop neighbours. Three basic functions of TORA are: route creation, route maintenance, route erasure. During the route creation and maintenance phases nodes use a height metric to establish a Directed Acyclic Graph (DAG) rooted at the destination. Thereafter links are assigned a direction based on the relative heights.

II. RELATED WORK

There are many comparisons like performance comparison of AODV, DSR, DSDV, and TORA according to effect of speed, no. of packets transmitted, no. of packets lost, bytes, bitrate, packet delay. By that comparison they showed that DSR, TORA shows the better performances as compared to AODV, DSDV. Using NS2 they presented simulation.[4].

In [5] there is comparison of different protocols in MANETs and WSNs. In MANET there are AODV, DSDV, and TORA protocol. In which AODV performance is better in MANET but TORA is very poor and unreliable. Whereas in WSN, protocols taken AODV, DSDV, TORA, LEACH. Performance of AODV, LEACH is better but AODV is less reliable than LEACH because the result of AODV is fluctuated but that of LEACH is not. AODV performs better in both MANETs and WSNs.

In [6] new version of LEACH is created called VLEACH. We concluded that no. of messages created by VLEACH is less than the message created by original LEACH. If messages created by VLEACH are less that mean the network energy remaining using VLEACH is more than the remaining network energy using original LEACH. Therefore version of LEACH performs much better.

In [7][8] there are comparison of DSR, ZRP, LAR1, AODV, in which ZRP fails to deliver a greater percentage of the originated data packets. When network size grows AODV performs better therefore DSR, ZRP completely fail in performance in large network. DSR shows extreme high delays. LAR1 is better in term of delivery ratio and routing overhead but LAR1 additionally uses geographical information.

In[9] there is comparison of AODV, DSDV routing protocols in MANETs using NS2. Delay in AODV is high but later low but in case of DSDV it is very low at starting and increased gradually specially for UDP packets. DSDV gives better jitter performance because of low node mobility and free channel. But packet arrival time and jitter will be high in AODV due to high node mobility and availability of free channel. Therefore performance of AODV is better than DSDV routing protocol for real time application.

III. EVALUATIONS OF AODV, LEACH, TORA

AODV: It is the base protocol. It tries to minimize required no. of broadcast. It is the improved version of DSDV. It creates routes on a on-demand basis as opposed to maintain a complete list of routes for each destination. It has path discovery process, maintaining routes. It leads to frequent system wide broadcasts. Its size is strongly limited. AODV provides both a route table for unicast routes and a multicast route table for multicast routes. It combine unicast, multicast, and multicast communications but it uses symmetric links between neighbouring nodes.

LEACH: A node in network is no longer useful when its battery dies so we use LEACH. It space out the lifespan of the nodes allowing it to do the only minimum work it needs to transmit data. It has 2 phases: setup phase, where cluster head are chosen and steady phase, in which CH is maintained when data is transmitted between nodes. Goal of LEACH is to increase the life of network. It is clustering based routing protocol minimizes global energy usage by distributing load to all nodes at different point in time.

TORA: This is adaptive and scalable routing algorithm based on the concept of link reversal. It finds multiple routes from source to destination in a highly dynamic mobile networking environment. The concept of TORA is that control messages are localized to a small set of nodes

A. SIMULATION BASED ANALYSIS

This section described the simulation tool, network setup, Simulation parameters and simulation results. The performances of routing protocols was evaluated on the basis of three performance metrics: packet delivery fraction (PDF), average end-to-end delay, packet loss.

Simulation Tool: In this paper simulation of routing protocols is done by using network simulator (NS2) software due to its simplicity and availability. NS is a discrete event Simulator targeted at networking research. NS2 is written in C++ and OTCL. C++ for data per event packets and OTCL are used for periodic and triggered event. NS2 include a network animator called network animator which provides visual view of simulation. NS2 pre-processing provides traffic and topology generation and post processing provide simple trace analysis. AWK programming is used for trace file analysis.

Simulation Parameters: The following simulation parameters are used in this paper to analyze the performance of routing protocols.

TABLE1: Various parameters used while varying number of connections

PARAMETER	VALUE
Number of nodes	10, 20, 30, 40, 80, 25, 50, 100, 200, 300
Simulation time	30 sec
Routing protocol	LEACH, TORA, AODV
Simulation model	Two Ray Ground
MAC Type	802.11
Link Layer Type	LL
Interface Type	Queue
Traffic Type	CBR
Packet Size	512 MB
Queue Length	50
Pause Time	05 sec
Node speed	20 m/s

Performance Metric: The performances of routing protocols was evaluated on the basis of three performance metrics: packet delivery fraction (PDF), average end-to-end delay, packet loss.

Packet delivery fraction(PDF): it is a ratio of data packet delivered to the destination to those generated by the constant bit rate sources.

Average end to end delay: this includes all the possible delays caused by buffering during route discovery, latency, queuing at the interface queue, retransmission delay at the MAC, and propagation and transfer times.

Packet loss: a packet is dropped in two cases : the buffer is full when packet needs to be buffered and the time that the packet has been buffered exceeds the limit.

Simulation Results: The simulation results are shown in the following section in the form of graphs and charts. In this paper an attempt has been made to evaluate the performance of three routing protocol AODV, LEACH and TORA according to his simulation results. NS2 simulator generated a AODV.tcl, LEACH.tcl, TORA.tcl file which contains all the statistics regarding number of packet send, average end-to-end delay(in seconds) and packet loss. The simulation results are generated through the graphs according to above mentioned criteria shown in table.

B. Varying the number of nodes

The number of nodes in the simulation setup varies from 10 to 80 in Scenario 1 and from 25 to 300 in Scenario 2. The simulation results for both the Scenario are shown in the following section in the form of graphs for all three Performance Metric.

C. Evaluation using packet delivery fraction

Packet delivery fraction is calculated by extracting data from TORA.tcl file, LEACH.tcl file, AODV.tcl file and three curves one for TORA, one for LEACH, one for AODV are plotted by taking %age of nodes on X-axis and %age of PDF on Y-axis as shown in figure1 for 10, 20, 30, 40, 80 nodes and 25, 50, 100, 200, 300 nodes respectively from figure it is clear that with the increase in number of nodes PDF in TORA will increase and in AODV PDF is better but in LEACH PDF performance is not good.

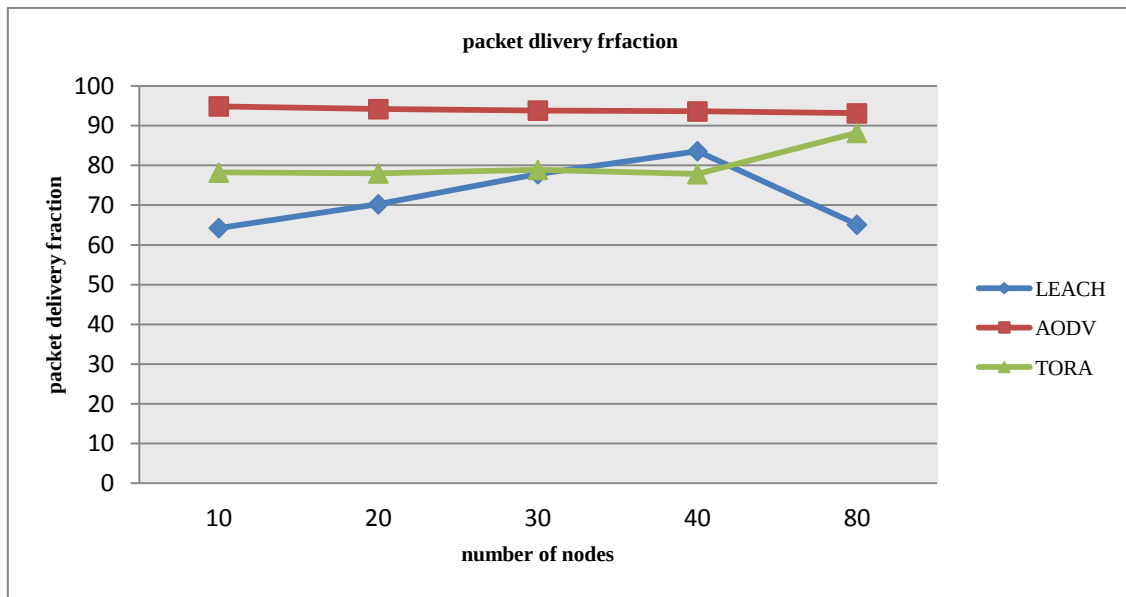


Fig.1 (a) average end to end delay for AODV, LEACH, TORA (Scenario 1)

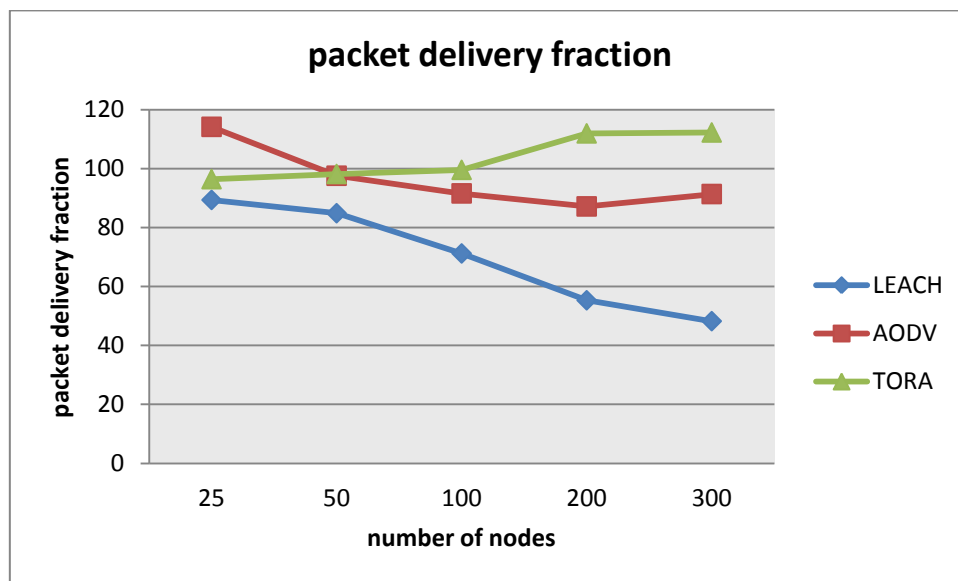


Fig.1 (b) average end to end delay for AODV, LEACH, TORA (Scenario 2)

D. Evaluation using average end-to-end delay

Average end-to-end delay is calculating by extracting data from, TORA.tcl AODV.tcl LEACH.tcl, file and three curves one for TORA, one for AODV LEACH, one for LEACH are plotted by taking %age of number of nodes on X-axis and average end-to-end delay on Y-axis as shown in figure for 10, 20, 30, 40, 80 nodes and 25, 50, 100, 200, 300 nodes respectively. From figure2, it is clear that the average end-to-end delay is less in LEACH but it has increased in case of AODV, due to overhead increased and it has been calculated that with the increase in number of nodes average end-to-end delay will increase in TORA.

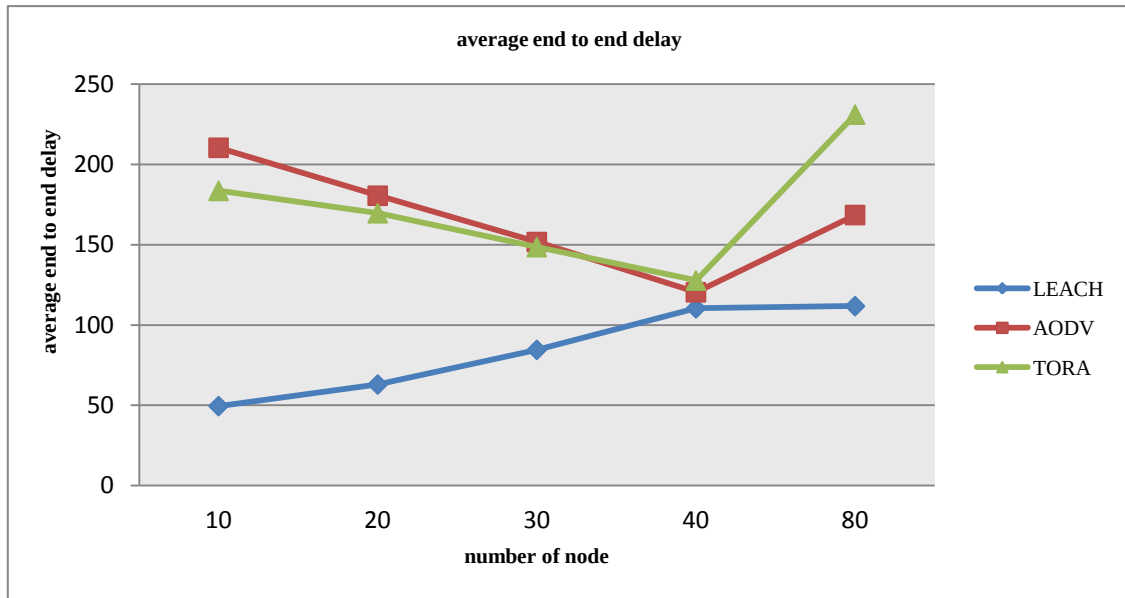


Fig.2(a) packet delivery fraction for AODV, LEACH, TORA (Scenario 1)

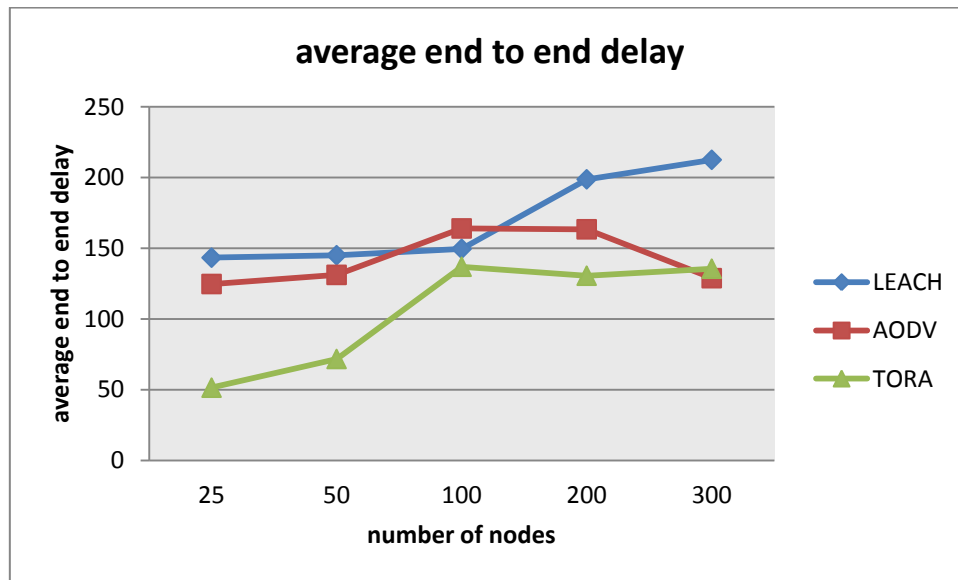


Fig.2(b) packet delivery fraction for AODV, LEACH, TORA (Scenario 2)

E. Evaluation using packet loss

Packet loss is calculated by extracting data from AODV.tcl, LEACH.tcl, TORA.tcl files and three curves, one for AODV, one for LEACH, one for TORA are plotted by taking 5age of number of nodes on X-axis and packet loss on Y-axis as shown in figure3 for 10, 20, 30, 40, 80 nodes and 25, 50, 100, 200, 300 nodes respectively. From figure it is quite clear that in LEACH packet loss is not as much as compared to AODV, TORA. With the

increase in number of nodes the packet loss has increased in case of AODV with some value. In TORA packet loss will increase because of delay.

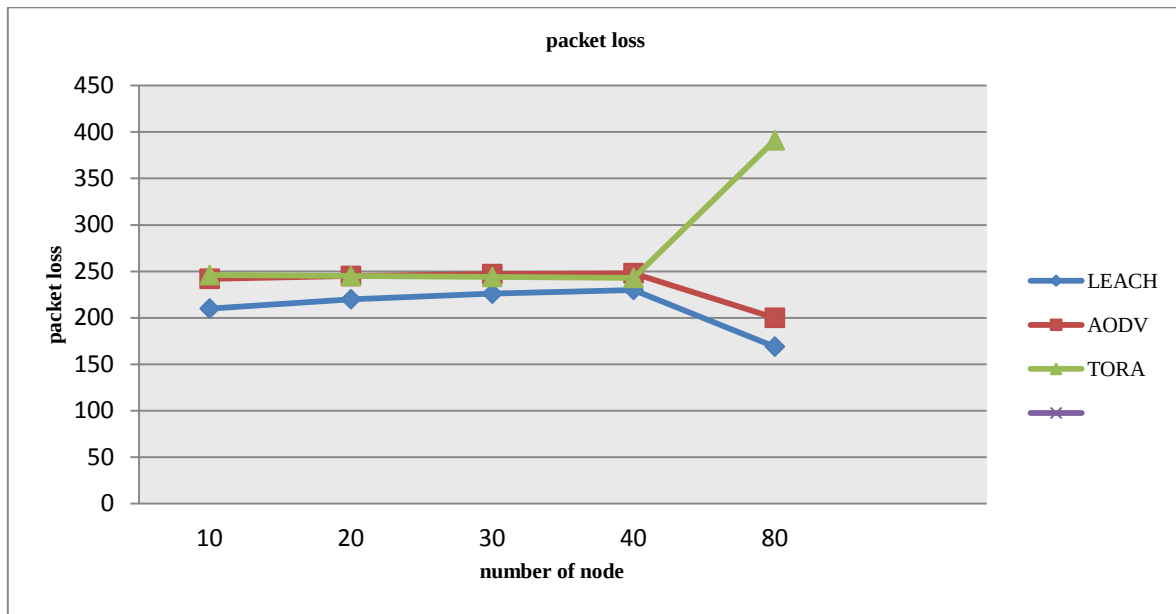


Fig.3(a) Packet loss for AODV, LEACH, TORA (Scenario 1)

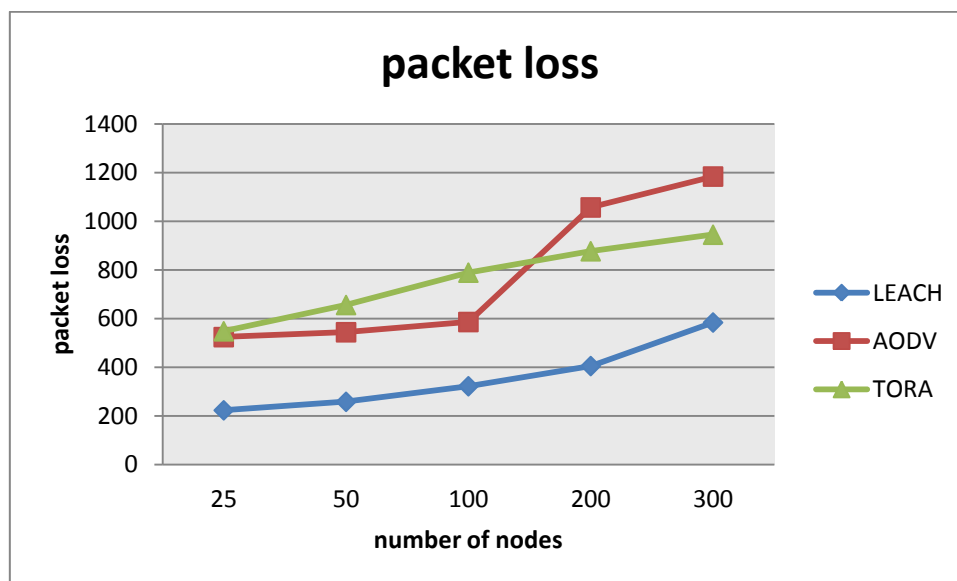


Fig.3(b) Packet loss for AODV, LEACH, TORA (Scenario 2)

IV. CONCLUSION

In this paper we have evaluated three protocols- AODV, LEACH, TORA. These protocols have been tested on NS2 simulator by using three metrics- packet delivery fraction, average end-to-end delay, packet loss. The packet delivery fraction (PDF) metric has shown that AODV and TORA gives better performance but LEACH is not better for PDF. Hereas in TORA, initial value will be less for PDF but as we increases number of nodes PDF will increase. The average end-to-end delay metric has shown that average delay has increased in case of AODV, TORA, but in case of LEACH, it will be less as compared to AODV, TORA. The packet loss metric has shown that number of packet loss in AODV, TORA will be more due to overhead, but in case of LEACH packet loss will be less. We can say that LEACH protocol has become better for average end-to-end delay and packet loss.

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