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Performance Analysis and Simulation of Reactive Routing Protocols (AODV, DSR and TORA) in MANET using NS-2

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Abstract: The field of Mobile Ad hoc Networks (MANETs) has gained an important part of the interest of researchers and become very popular in last few years. Mobile ad hoc network (MANET) is an autonomous system of mobile nodes connected by wireless links. Each node operates as an end system and also as a router to forward packets. The nodes are free to move about and organize themselves into a network. These nodes change position frequently. They can be studied formally as graphs in which the set of edges varies in time. The main method for evaluating the performance of MANETs is simulation. The simulation is carried out using ns2 simulator. In this paper we are comparing the performance of three reactive routing protocols in Mobile Ad-hoc Networks (MANETs). We have tested the effect of speed, no. of packets transmitted, lost, bytes, bitrate and packet delay for Dynamic Source Routing (DSR), Ad-hoc On Demand Distance Vector (AODV) and Temporally Ordered Routing Algorithm(TORA) with respect to time / number of nodes. This detailed simulation results illustrate the importance in carefully evaluating and implementing routing protocols in an adhoc environment.

Keywords: Reactive protocols, AODV, DSR, TORA, NS2, Performance metrics.

I. INTRODUCTION

Wireless networks provide connection flexibility between users in different places. Moreover, the network can be extended to any place or building without the need for a wired connection. Wireless networks are classified into two categories; Infrastructure networks and Ad Hoc networks as shown in Figure 1.

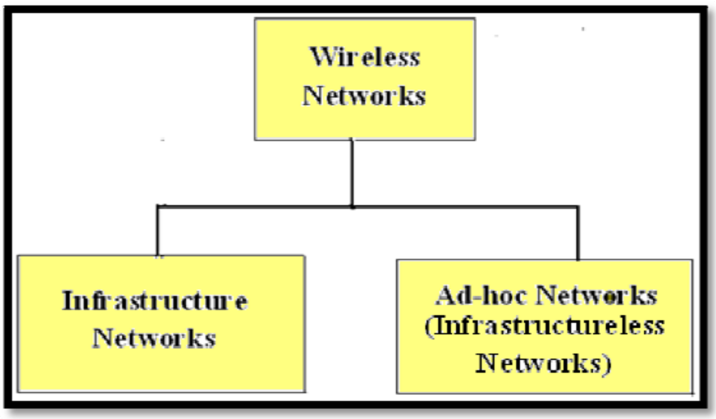

Figure1: Wireless Networks Categories

Ad hoc networks are emerging as the next generation of networks and defined as a collection of mobile nodes forming a temporary (spontaneous) network without the aid of any centralized administration or standard support services. MANETs have several salient characteristics: 1) Dynamic topologies 2) Bandwidth constrained, variable capacity links 3) Energy-constrained operation 4) Limited physical security.

Reactive protocols, such as AODV and DSR find the route only when there is data to be transmitted and as a result, generate low control traffic and routing overhead. They set up a path between the sender and the receiver only if a communication is waiting. An advantage of a reactive protocol is its scalability as long as there is only light traffic and low mobility. The disadvantages of these protocols are: (a) the initial search latency may degrade the performance of the interactive applications, (b) the quality of the path is unknown in advance, and (c) route caching mechanism is useless in high mobility networks as routes change frequently.

PAPER OUTLINE: The paper is organized as follows:

Section 2 presents the definition of mobile ad hoc routing protocols categories. Section 3. provides an overview of the routing protocols used in the study. The simulators are described in Section 4. Section 5 present the Simulation parameters and metrics. The Performance comparison and then the results are presented in Section 6. Finally Section 7 concludes the paper.

II. Routing Protocols in MANET

Routing protocols for Mobile ad hoc networks can be broadly classified into three main categories:

1. Proactive or table-driven routing protocols
2. Reactive or on-demand routing protocols
3. Hybrid Routing protocols

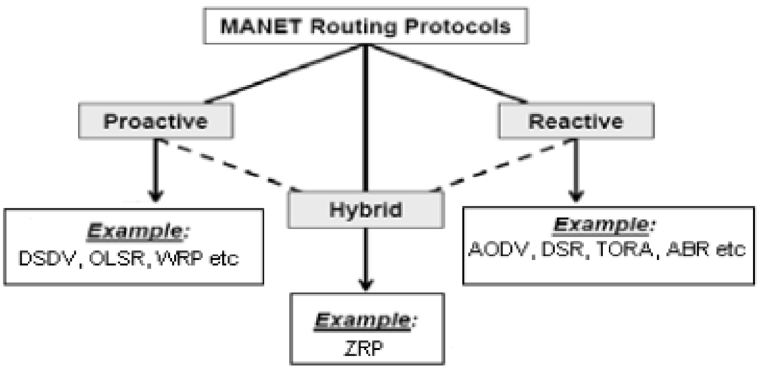

Figure2. Classification of MANET routing protocols

2.1. Table Driven Routing Protocols (Proactive)

In this protocol, all the nodes continuously search for routing information within a network; every node maintains one or more tables representing the entire topology of the network. These tables are updated regularly so that when a route is needed, the route is already known. If any node wants to send any information to another node, path is known, therefore, latency is low. However, when there is a lot of node movement then the cost of maintaining all topology information is very high.

2.2. On-Demand Routing Protocols (Reactive)

Routing information is collected only when it is needed, and route determination depends on sending route queries throughout the network. That is whenever there is a need of a path from any source to destination then a type of query reply dialog does the work. Therefore, the latency is high; however, no unnecessary control messages are required.

2.3. Hybrid routing protocols

This protocol incorporates the merits of proactive as well as reactive routing protocols. Nodes are grouped into zones based on their geographical locations or distances from each other. Inside a single zone, routing is done using table-driven mechanisms while an on-demand routing is applied for routing beyond the zone boundaries. The routing table size and update packet size are reduced by including in them only art of the network (instead of the whole); thus, control overhead is reduced.

III. OVERVIEW OF REACTIVE ROUTING PROTOCOLS(AODV,DSR &TORA)

3.1. Ad hoc On-demand Distance Vector Routing (AODV)

AODV belongs to the class of Distance Vector Routing Protocols (DV). Ad hoc On Demand Distance Vector (AODV) is a reactive routing protocol which initiates a route discovery process only when it has data packets to transmit and it does not have any route path towards the destination node, that is, route discovery in AODV is called as on-demand. AODV is composed of the following three mechanisms:

- Route Discovery process
- Route message generation
- Route maintenance

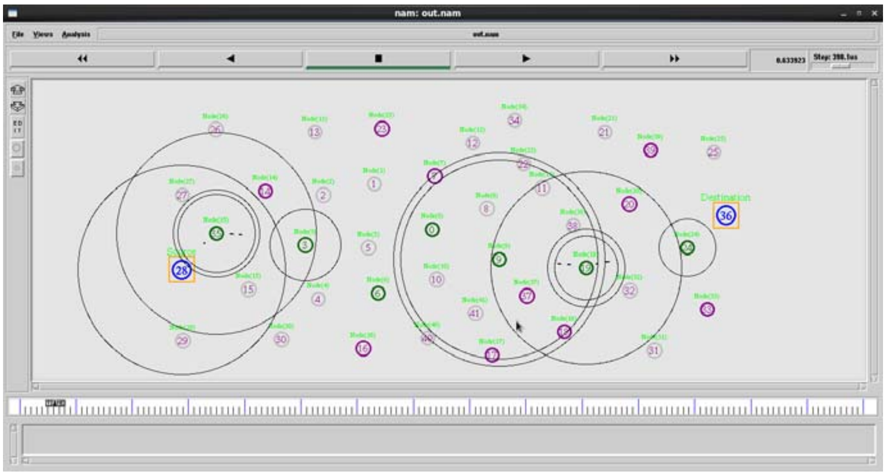

Figure3. AODV Routing path

3.2. Dynamic Source Routing (DSR)

The Dynamic Source Routing (DSR) is one of the purest examples of an on-demand routing protocol that is based on the concept of source routing. It is designed especially for use in multihop ad hoc networks of mobile nodes. It allows the network to be completely selforganizing and self- configuring and does not need any existing network infrastructure or administration. DSR is composed of the two mechanisms

- Route Discovery
- Route Maintenance

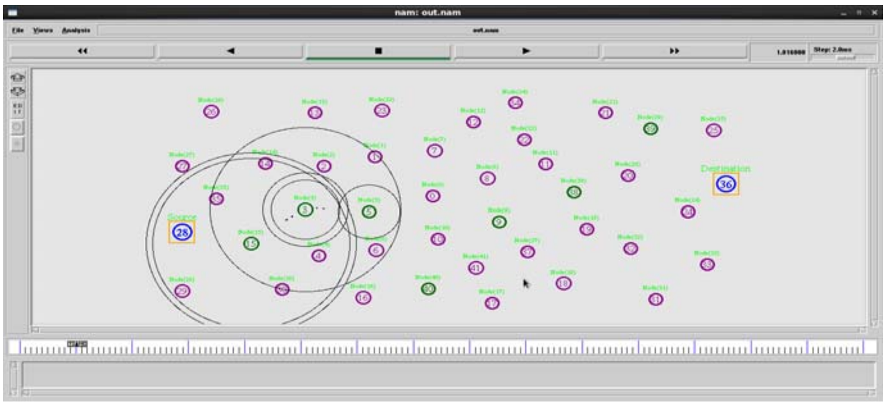

Figure4. DSR Routing path

3.3. Temporally Ordered Routing Algorithm (TORA)

The Temporally Ordered Routing Algorithm (TORA) is a highly adaptive, efficient and scalable distributed routing algorithm based on the concept of link reversal. TORA is proposed for highly dynamic mobile, multi-hop wireless networks. It is a source-initiated on-demand routing protocol. It has a unique feature of maintaining multiple routes to the destination so that topological changes do not require any reaction at all. The protocol reacts only when all routes to the destination are lost. In the event of network partitions the protocol is able to detect the partition and erase all invalid routes. The protocol has three basic functions:

- Route Creation
- Route Maintenance
- Route Erasure

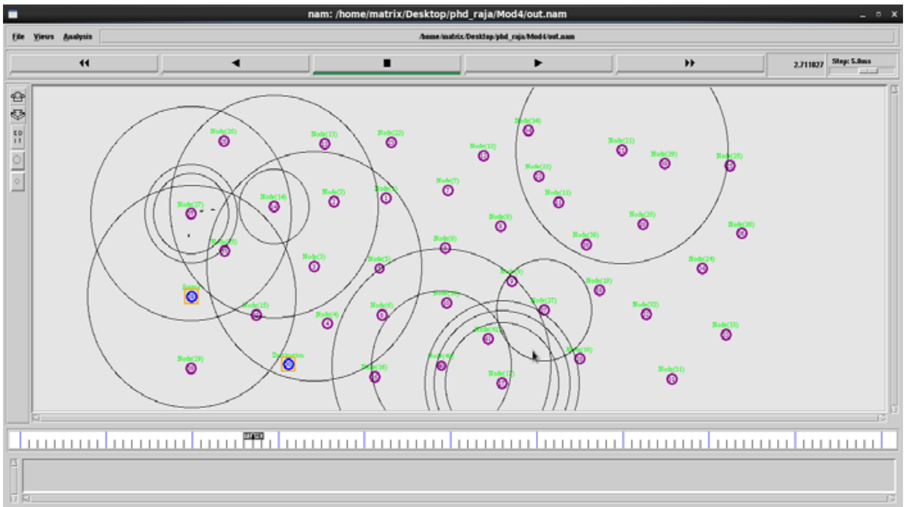

Figure5. TORA Routing path

IV. Network Simulators

MANETs simulators exhibit different features and models. The choice of a simulator should be driven by the requirements. Determining the level of details required is key. If high-precision PHY layers are needed, then ns-2 is clearly the wisest choice. On the contrary, if the wireless technology has not impact on the targeted protocol, recent simulators (like NAB or Jane) which propose high-level abstractions and polished object-oriented designs will be more adapted. The number of nodes targeted also determines the choice of the simulation tool. Sequential simulators should not be expected to run more that 1,000 nodes. Finally, most non-commercial simulators suffer from a lack of good documentation and support. Using a commercial one might help in case of troubles. Moreover, commercial simulators usually feature extensive lists of supported protocols, while open source solutions give full empowerment.

Name	Popularity	Licence
NS2	88.8%	Open source
GloMoSim	4%	Open source
OPNet	2.61%	Commercial
OMNet++	1.04%	Free for academic and educational use
J-Sim	0.45%	Open source
GTNets	0.13%	Open source

Table1. Various Simulators

In this, we used NS2 (2.34 & 2.35) simulator for simulating different reactive routing protocols. It uses a visual tool called NAM. NAM is a Tcl/AWK based animation tool for viewing network simulation traces and real world packet trace data. The first step to use NAM is to produce the trace file. The trace file contains topology information, e.g., nodes, links, as well as packet traces. During an NS simulation, a user can produce topology configurations, layout information, and packet traces using tracing events in NS. When the trace file is generated, it is ready to be animated by NAM. Upon startup, NAM will read the trace file, create topology, pop up a window, do layout if necessary.

V. Simulation Parameters

The traffic sources are CBR (continuous bit –rate). The source-destination pairs are spread randomly over the network. The mobility model uses 'random waypoint model' in a rectangular filed of 1050m x 600m with 42 nodes. During the simulation, each node starts its journey from a random spot to a random chosen destination. Once the destination is reached, the node takes a rest period of time in second and another random destination is chosen after that pause time. This process repeats throughout the simulation, causing continuous changes in the topology of the underlying network. Different network scenario for different number of nodes and pause times are generated. The model parameters that have been used in our experiments are summarized in Table 2.

Experiment Parameter	Experiment value	Description
Simulation Time	0 – 10 mps	Simulation Duration
Terrain Dimension	[1050*600]m	X,Y Dimension of motion
No. of mobile nodes	42	No. of nodes in a network
Node Placement	Random Waypoint	Change Direction randomly
Mobility Speed	0 – 10 mps	Mobility of nodes
Packet Size	256,512,625,712,850	Size of packets
Mobility Model	Random	Mobility direction
Routing Protocols	AODV, DSR, TORA	Path-finding
MAC Protocol	802.11	Wireless Protocol
Channel Type	Wireless Channel	Types of Channel
Maximum Packets	50	No. of packets

Table 2. Parameter Metrics

Packet delivery ratio:

The ratio between the number of packets originated by the CBR sources and the number of packets received by the CBR sink at the final destination. It describes the loss rate seen by the protocol.

Throughput:

It is defined as total number of packets received by the destination. It is a measure of effectiveness of a routing protocol. There is two representations of throughput one is the amount of data transferred over the period of time expressed in kilobits per second (Kbps). The other is the packet delivery percentage obtained from a ratio of the number of data packets sent and the number of data packets received.

Avg. End-to-End Delay:

Average amount of time taken by a packet to go from source to destination. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission on delays at MAC, and propagation and transfer times

Route overhead:

The total number of routing packets transmitted during the simulation. If control and data traffic share the same channel, and the channels capacity is limited, then excessive control traffic often impacts data routing performance. This is the ratio between the total control packets generated to the total data packets during the simulation time.

Energy Consumption:

Energy consumption of a node is mainly due to the transmission and the reception of data or controlling packets. To measure this amount of energy consumed during the transmission process (noted txEnergy), we should multiply the transmission power (txPower) by the time needed to transmit a packet:

$$txEnergy = txPower \times (packetsize/bandwidth)$$

And for a received packet:

$$rxEnergy = rxPower \times (packetsize/bandwidth)$$

VI. PERFORMANCE COMPARISON AND RESULT

As already outlined we have taken three On-demand (Reactive) routing protocols, namely Ad hoc On-Demand Distance Vector Routing (AODV) and Dynamic Source Routing (DSR) and Temporary Ordered Routing Algorithm (TORA). We have used NS2 network simulator, NAM editor to show the animated schema of the three protocols AODV, DSR and TORA, their performances and their routing paths. Furthermore we have used X-graph to graphically represent the throughput, packet delivery ratio and avg. end-to-end delay for all the protocols and hence comparing them.

The graphs below shows the performance of the routing protocol with respect to different metric considered above. The X-Axis shows the pause times of the nodes and the y axis shows the Metric considered for simulation.

Packet delivery ratio:

The PDF tells about the performance of a protocol that how successfully the packets have been delivered. Higher the value gives the better results. In our simulation it has been noticed that AODV outperforms DSR and TORA in almost all the scenarios we have taken into account.In terms of PDF with respect to varied pause time, AODV performs well, which is shown in the below Fig. 6. The performance of DSR decreases with the increasing number of nodes and TORA performance is poor.

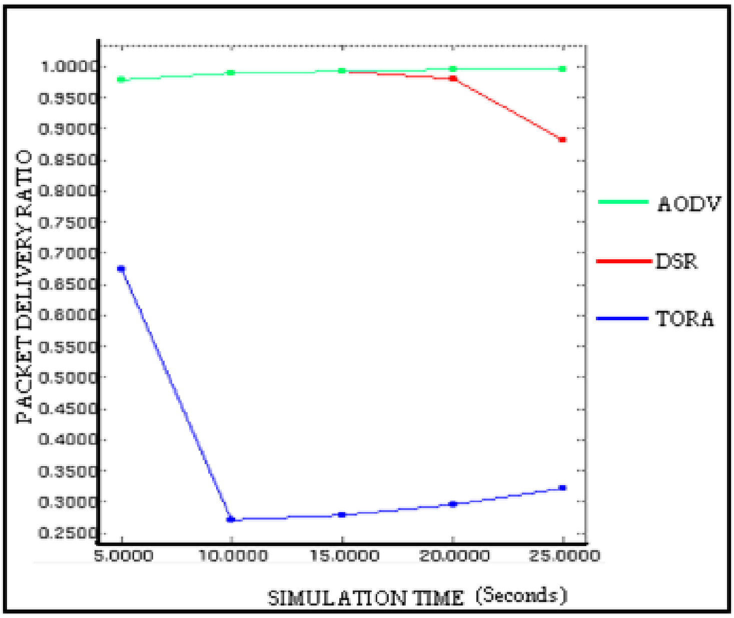

Figure 6. Packet Delivery Ratio for AODV, DSR and TORA

Throughput:

Once the time difference between every CBR packets sent and received was recorded, dividing the total time difference over the total number of CBR packets received gave the average end-to-end delay for the received packets. Lower the end to end delay better is the performance of the protocol. In terms of end-to-end delay, AODV is the best performer.

In Fig. 7. With DSR & TORA, the delay time increases sharply.

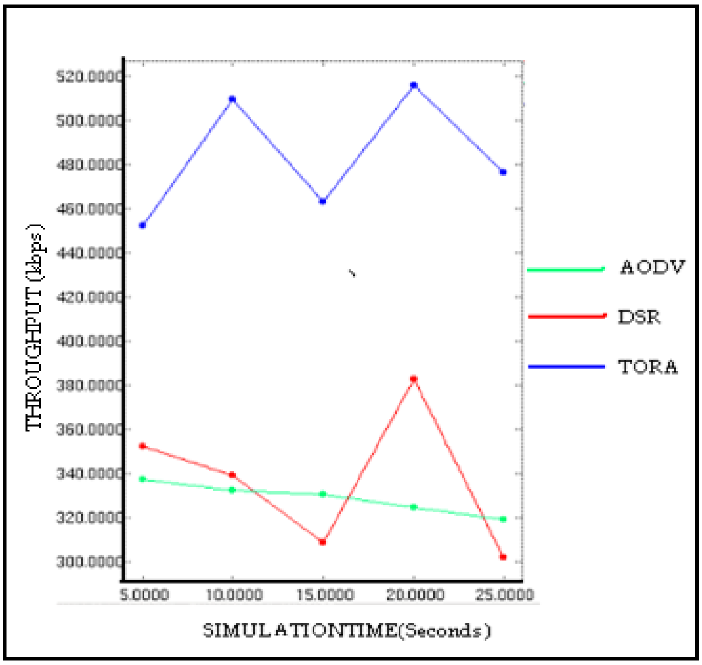

Figure 7. Throughput for AODV, DSR and TORA

End-to-End Delay:

In Fig. 8, With respect to varied pause time, throughput decreases comparatively in AODV & DSR. DSR consumes considerable power and gives lower throughput due to network failure. TORA has the highest throughput.

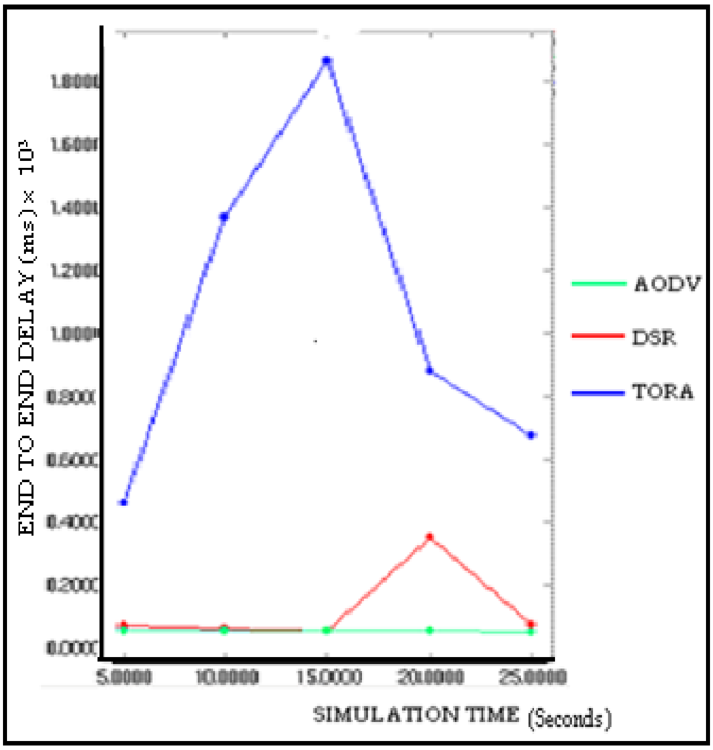

Figure 8. End to End Delay for AODV, DSR and TORA

Route overhead:

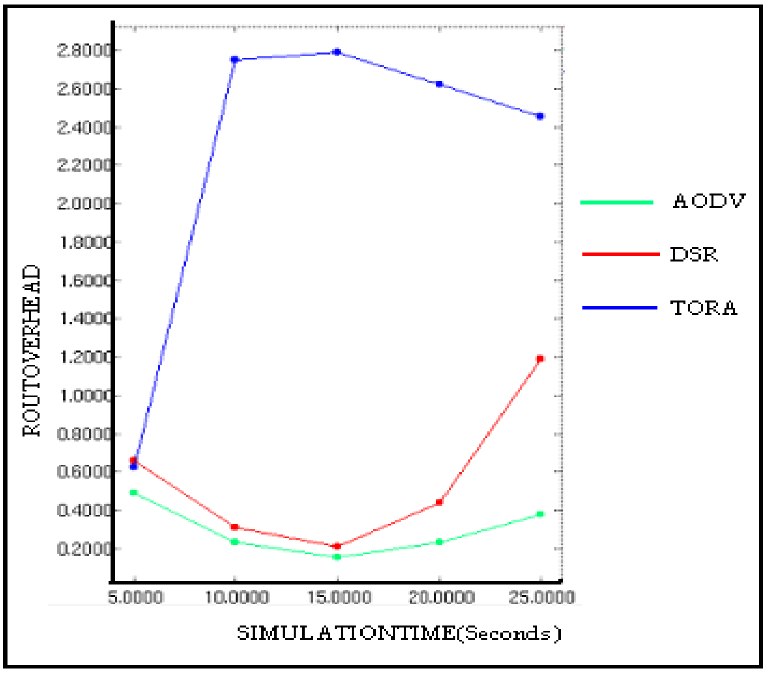

Figure 9. Route Overhead for AODV, DSR and TORA

AODV have more routing overhead in comparison to DSR and TORA. In AODV & DSR, the routes are maintained only between the nodes those want to communicate as well as a single route discovery may yield many routes to the destination, therefore, the routing overhead is less. As number of nodes increases, the routing overhead increases because of increasing node density. In AODV, routing overhead increases by a large amount where as, in DSR, it increases marginally. Which is shown in the below Fig. 9.

Energy Consumption:

The total energy consumption for the three protocols with Random Waypoint mobility model. In the routing layer, the energy consumption is more with CBR traffic in comparison of Exponential and Pareto traffic for the three protocols. AODV and DSR consumes less energy then TORA as shown in the below graph Fig. 10.

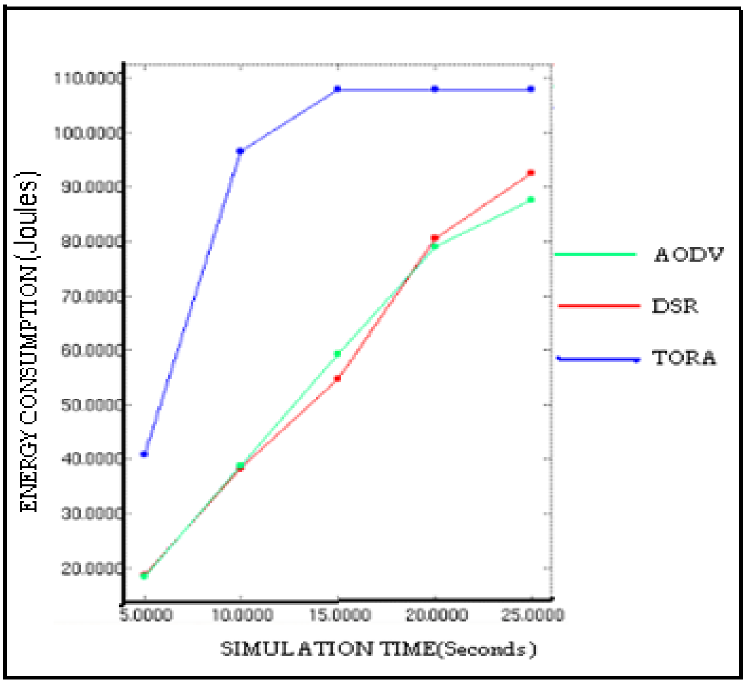

Figure 10. Energy Consumption for AODV, DSR and TORA

VII. Conclusion

This work is an attempt towards a comprehensive performance analysis of three commonly used mobile adhoc routing protocols (DSR, TORA and AODV). Over the past few years, new standards have been introduced to enhance the capabilities of ad hoc routing protocols. As a result, ad hoc networking has been receiving much attention from the wireless research community. In this paper, using the latest simulation environment NS 2, we evaluated the performance of three widely used ad hoc network routing protocols using packet-level simulation. The simulation characteristics used in this research, that is, packet delivery fraction and end-to-end delay are unique in nature, and are very important for detailed performance evaluation of any networking protocol. 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. Whereas TORA is suitable for operation in large mobile networks having dense population of nodes. The major benefit is its excellent support for multiple routes and multicasting.

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