Comparative Study of Adhoc Routing Protocol AODV, DSR and DSDV in Mobile Adhoc NETwork

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Abstract

A Mobile Ad hoc NETwork is a kind of wireless ad-hoc network, and is a self configuring network of mobile routers connected by wireless links. Mobile Ad-Hoc Network (MANET) is a wireless network without infrastructure. Self configurability and easy deployment feature of the MANET resulted in numerous applications in this modern era. Efficient routing protocols will make MANETs reliable. Various research communities are working in field of MANET and trying to adopt the protocols and technology in other applications as well. In this paper, an attempt has been made to compare three well know protocols AODV, DSR and DSDV by using three performance metrics packet delivery ratio, average end to end delay and routing overhead. The comparison has been done by using simulation tool NS2 which is the main simulator, NAM (Network Animator) and excel graph which is used for preparing the graphs from the trace files.

Keywords: MANET, NS-2, AODV, DSDV, DSR

1. INTRODUCTION

An ad-hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any stand-alone infrastructure or centralized administration [1]. Mobile Ad-hoc networks are self-organizing and self-configuring multihop wireless networks where, the structure of the network changes dynamically. This is mainly due to the mobility of the nodes [3]. Nodes in these networks utilize the same random access wireless channel, cooperating in a friendly manner to engaging themselves in multihop forwarding. The node in the network not only acts as hosts but also as routers that route data to/from other nodes in network [2].

Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. Routing in ad-networks has been a challenging task ever since the wire- less networks came into existence. The major reason for this is the constant change in network topology because of high degree of node mobility. A number of protocols have been developed for accomplish this task.

Routing is the process of selecting paths in a network along which to send network traffic.
In packet switching networks, routing directs packet forwarding, the transit of logically addressed packets from their source toward their ultimate destination through intermediate nodes.
An ad hoc routing protocol is a convention, or standard, that controls how nodes decide which way to route packets between computing devices in a mobile ad-hoc network .

In ad hoc networks, nodes do not start out familiar with the topology of their networks; instead, they have to discover it. The basic idea is that a new node may announce its presence and should listen for announcements broadcast by its neighbors. Each node learns about nodes nearby and how to reach them, and may announce that it, too, can reach them.

Wireless ad-hoc networks have gained a lot of importance in wireless communications. Wireless communication is established by nodes acting as routers and transferring packets from one to another in ad-hoc networks. Routing in these networks is highly complex due to moving nodes and hence many protocols have been developed. In this paper we have selected three main and highly proffered routing protocols for analysis of their performance. Figure1 below represents the scenario of MANET.

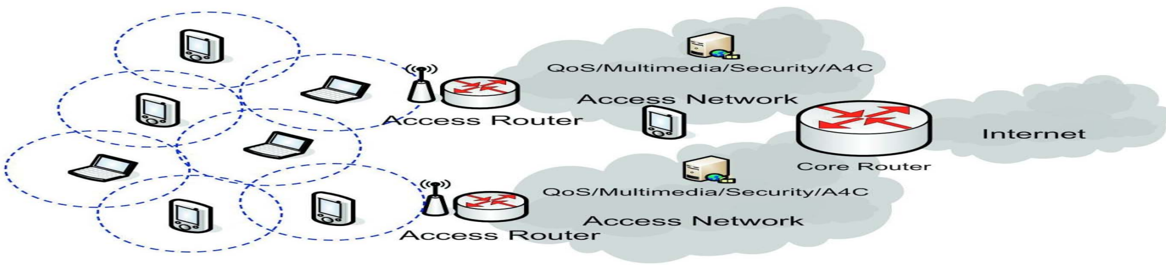

Figure1. Ad-hoc network architecture [4]

2. Applications of MANET

With the increase of portable devices as well as progress in wireless communication, ad hoc networking is gaining importance with the increasing number of widespread applications. Figure2 below represents an application scenario of MANET. Typical applications include [5]:

- Military battlefield. Military equipment now routinely contains some sort of computer equipment. Ad hoc networking would allow the military to take advantage of commonplace network technology to maintain an information network between the soldiers, vehicles, and military information head quarters. The basic techniques of ad hoc network came from this field.

- Commercial sector. Ad hoc can be used in emergency/rescue operations for disaster relief efforts, e.g. in fire, flood, or earthquake. Emergency rescue operations must take place where non-existing or damaged communications infrastructure and rapid deployment of a communication network is needed. Information is relayed from one rescue team member to another over a small handheld. Other commercial scenarios include e.g. ship-to-ship ad hoc mobile communication, law enforcement, etc.

Figure2. Applications of MANET

- Local level. Ad hoc networks can autonomously link an instant and temporary multimedia network using notebook computers or palmtop computers to spread and share information among participants at a e.g. conference or classroom. Another appropriate local level application might be in home networks where devices can communicate directly to exchange information. Similarly in other civilian environments like taxicab, sports stadium, boat and small aircraft, mobile ad hoc communications will have many applications.

- Personal Area Network (PAN). Short-range MANET can simplify the intercommunication between various mobile devices (such as a PDA, a laptop, and a cellular phone). Tedious wired cables are replaced with wireless connections. Such an ad hoc network can also extend the access to the Internet or other networks by mechanisms e.g. Wireless LAN (WLAN), GPRS, and UMTS. The PAN is potentially a promising application field of MANET in the future pervasive computing context.

3. Challenges of MANET

The following list of challenges shows the inefficiencies and limitations that have to be overcome in a MANET environment [9]:

- Limited wireless transmission range: In wireless networks the radio band will be limited and hence data rates it can offer are much lesser than what a wired network can offer. This requires the routing protocols in wireless networks to use the bandwidth always in an optimal manner by keeping the overhead as low as possible [6].

- Routing Overhead: In wireless adhoc networks, nodes often change their location within network. So, some stale routes are generated in the routing table which leads to unnecessary routing overhead.

- Battery constraints: This is one of the limited resources that form a major constraint for the nodes in an ad hoc network. Devices used in these networks have restrictions on the power source in order to maintain portability, size and weight of the device. By increasing the power and processing ability makes the nodes bulky and less portable. So only MANET nodes has to optimally use this resource [7].

- Asymmetric links: Most of the wired networks rely on the symmetric links which are always fixed. But this is not a case with ad-hoc networks as the nodes are mobile and constantly changing their position within network. For example consider a MANET (Mobile Ad-hoc Network) where node B sends a signal to node A but this does not tell anything about the quality of the connection in the reverse direction [8].

- Time-varying wireless link characteristics: The wireless channel is susceptible to a variety of transmission impediments such as path loss, fading, interference and blockage. These factors resist the range, data rate, and the reliability of the wireless transmission. The extent to which these factors affect the transmission depends upon the environmental conditions and the mobility of the transmitter and receiver. Even the two different key constraints, Nyquist's and Shannon's theorems, that govern the ability to transmit information at different data rates can be considered [6].

- Broadcast nature of the wireless medium: The broadcast nature of the radio channel, that is, transmissions made by a node are received by all nodes within its direct transmission range. When a node is receiving data, no other node in its neighborhood, apart from the sender, should transmit. A node should get access to the shared medium only when its transmissions do not affect any ongoing session. Since multiple nodes may contend for the channel simultaneously, the possibility of packet collisions is quite high in wireless networks [6]. Even the network is susceptible to hidden terminal problem and broadcast storms [4]. The hidden terminal problem refers to the collision of packets at a receiving node due to the simultaneous transmission of those nodes that are not within the direct transmission range of the sender, but are within the transmission range of the receiver [6].

- Packet losses due to transmission errors: Ad hoc wireless networks experiences a much higher packet loss due to factors such as high bit error rate (BER) in the wireless channel, increased collisions due to the presence of hidden terminals, presence of interference, location dependent contention, uni-directional links, frequent path breaks due to mobility of nodes, and the inherent fading properties of the wireless channel [6].

- Mobility-induced route changes: The network topology in an ad hoc wireless network is highly dynamic due to the movement of nodes; hence an on-going session suffers frequent path breaks. This situation often leads to frequent route changes. Therefore mobility management itself is very vast research topic in ad hoc networks [7].

- Potentially frequent network partitions: The randomly moving nodes in an ad hoc network can lead to network partitions. In major cases, the intermediate nodes are the one which are highly affected by this partitioning [7].

- Ease of snooping on wireless transmissions (security issues): The radio channel used for ad hoc networks is broadcast in nature and is shared by all the nodes in the network. Data transmitted by a node is received by all the nodes within its direct transmission range. So an attacker can easily snoop the data being transmitted in the network. Here the requirement of confidentiality can be violated if an adversary is also able to interpret the data gathered through snooping [6].

4. Classification of Adhoc Routing Protocol

Routing protocol in MANET can be classified into several ways depending upon their network structure, communication model, routing strategy, and state information and so on but most of these are done depending on routing strategy and network structure[3,10]. Based on the routing strategy the routing protocols can be classified into two parts: 1.Table driven and 2. Source initiated (on demand) while depending on the network structure these are classified as flat routing, hierarchical routing and geographic position assisted routing[3]. Flat routing covers both routing protocols based on routing strategy.

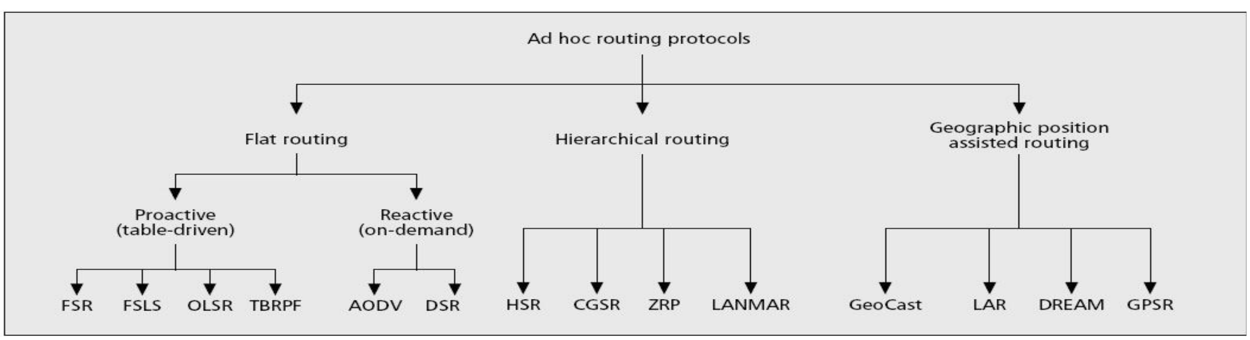

Figure3. Classification of Adhoc Routing Protocol [3]

In this paper three adhoc routing protocols are used, AODV, DSDV and DSR. AODV and DSR is Reactive (On demand) where as DSDV is Proactive (Table driven) Routing protocol.

4.1 Ad hoc On-Demand Distance Vector (AODV) Routing Protocol

The Ad hoc On-Demand Distance Vector (AODV) [11] algorithm enables dynamic, self-starting, multihop routing between participating mobile nodes wishing to establish and maintain an ad hoc network. AODV allows mobile nodes to obtain routes quickly for new destinations, and does not require nodes to maintain routes to destinations that are not in active communication. AODV allows mobile nodes to respond to link breakages and changes in network topology in a timely manner. The operation of AODV is loop-free, and by avoiding the Bellman-Ford "counting to infinity" problem offers quick convergence when the adhoc network topology changes (typically, when a node moves in the network). When links break, AODV causes the affected set of nodes to be notified so that they are able to invalidate the routes using the lost link. Route Requests (RREQs), Route Replies (RREPs) and Route Errors (RERRs) are message types defined by AODV [11].

4.2 Dynamic Source Routing (DSR)

The Dynamic Source Routing protocol (DSR) is (Perkins, 2007), an on demand routing protocol. DSR is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. Using DSR, the network is completely self-organizing and self-configuring, requiring no existing network infrastructure or administration. The DSR protocol is composed of two main mechanisms that work together to allow the discovery and maintenance of source routes in the ad hoc network [12]:

- Route Discovery is the mechanism by which a node S wishing to send a packet to a destination node D obtains a source route to D. Route Discovery is used only when S attempts to send a packet to D and does not already know a route to D.

- Route Maintenance is the mechanism by which node S is able to detect, while using a source route to D, if the network topology has changed such that it can no longer use its route to D because a link along the route no longer works. When Route Maintenance indicates a source route is broken, S can attempt to use any other route it happens to know to D, or it can invoke Route Discovery again to find a new route for subsequent packets to D. Route Maintenance for this route is used only when S is actually sending packets to D.

In DSR Route Discovery and Route Maintenance each operate entirely" on demand"[12].

4.3 Destination-Sequenced Distance-Vector Routing (DSDV)

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Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing scheme for adhoc mobile networks based on the Bellman-Ford algorithm. It was developed by C. Perkins and P.Bhagwat in 1994.

It eliminates route looping, increases convergence speed, and reduces control message overhead.

In DSDV, each node maintains a next-hop table, which it exchanges with its neighbors. There are two types of next-hop table exchanges: periodic full-table broadcast and event-driven incremental updating. The relative frequency of the full-table broadcast and the incremental updating is determined by the node mobility. In each data packet sent during a next-hop table broadcast or incremental updating, the source node appends a sequence number. This sequence number is propagated by all nodes receiving the corresponding distance-vector updates, and is stored in the next-hop table entry of these nodes. A node, after receiving a new next-hop table from its neighbor, updates its route to a destination only if the new sequence number is larger than the recorded one, or if the new sequence number is the same as the recorded one, but the new route is shorter. In order to further reduce the control message overhead, a settling time is estimated for each route. A node updates to its neighbors with a new route only if the settling time of the route has expired and the route remains optimal [13].

5. Simulation Based Analysis using Network Simulator (NS-2)

In this section we have described about the tools and methodology used in our paper for analysis of adhoc routing protocol performance i.e about simulation tool, Simulation Setup(traffic scenario, Mobility model) performance metrics used and finally the performance of protocols is represented by using excel graph.

5.1 Simulation Tool

In this paper the simulation tool used for analysis is NS-2 which is highly preffered by research communities.

NS is a discrete event simulator targeted at networking research. Ns provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks [14]. NS2 is an object oriented simulator, written in C++, with an OTcl interpreter as a frontend. This means that most of the simulation scripts are created in Tcl(Tool Command Language). If the components have to be developed for ns2, then both tcl and C++ have to be used.The flow diagram given in figure4 shows the complete working of NS2 for Analysis.

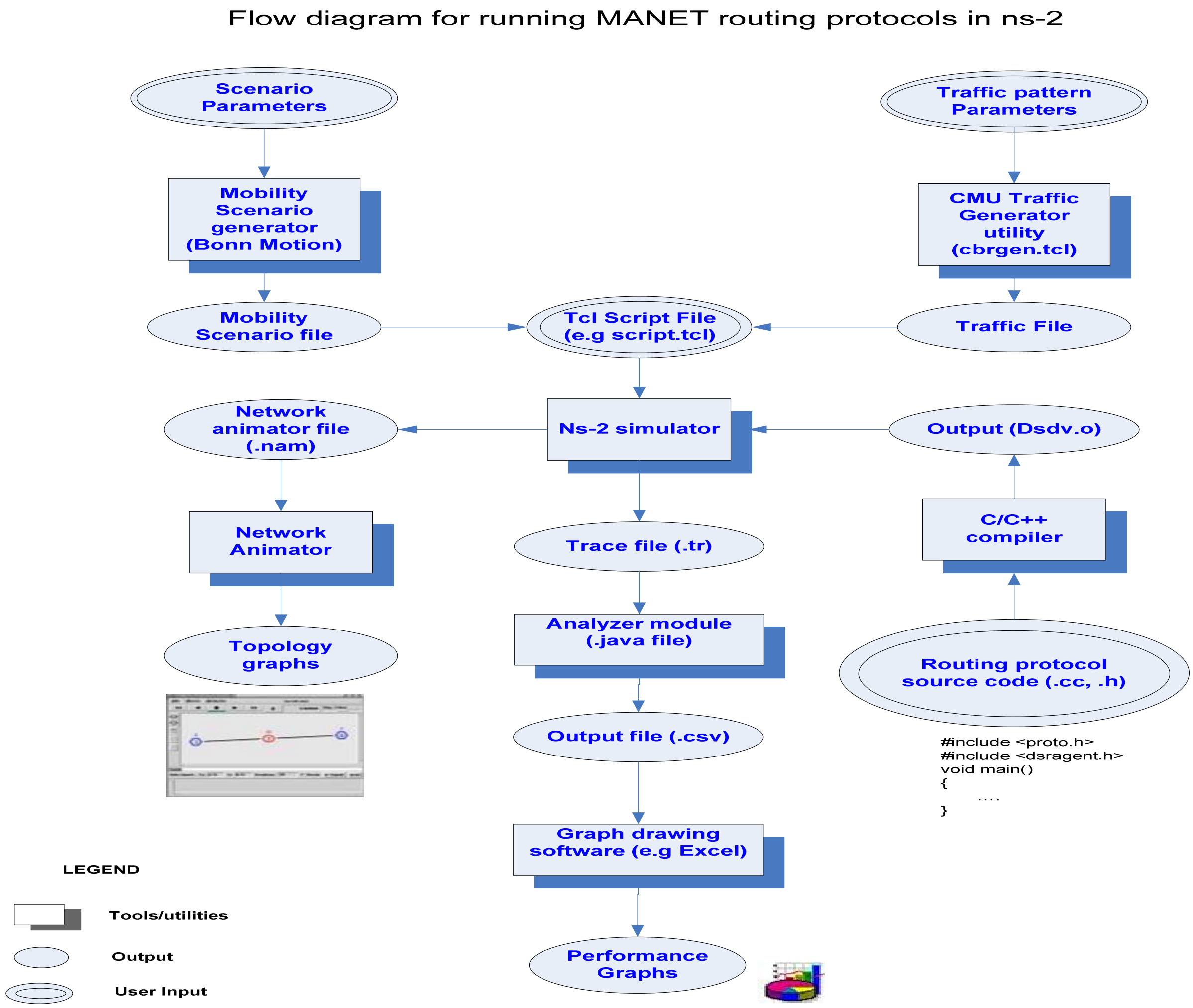

Figure4. Flow diagram for running MANET protocols in ns-2[16]

5.2 *Simulation Setup*

The performance analysis is done on Windows Vista Operating System. Ns –allinone-2.29 was installed on the platform using cygwin.

Table1. Simulation Setup

Platform	Windows Vista Ultimate (using Cygwin 1.7)
NS version	Ns –allinone-2.29
Pause time	0, 20, 40, 80, 120, 160, 200
Simulation time	200 s
Number of nodes	50 wireless nodes
Traffic	CBR(Constant Bit Rate)
CBR Packet size	512 bytes
Transmission Range	250 m
Simulation Area size	500 x 500 m
Node Speed	fixed to 20 m/s
Mobility model	Random WayPoint mobility

5.3 Performance Metrics Used

The following metrics are used in this paper for the analysis of AODV, DSR and DSDV routing protocols.
i) Packet Delivery Ratio
ii) Average End to End Delay
iii) Throughout

Packet delivery ratio The packet delivery ratio in this simulation is defined as the ratio between the number of packets sent by constant bit rate sources (CBR, "application layer") and the number of received packets by the CBR sink at destination.

Packet Delivery Ratio = $\sum$ CBR PKtRcvd by CBR sinks / $\sum$ CBR PKtSent by CBR sources

It describes percentage of the packets which reach the destination.

Routing Overhead It is the number of packet generated by routing protocol during the simulation and can be defined as: overhead= $\sum_{i}^{n} overhead_i$

Where overhead$_i$ is the control packet number generated by node i. The generation of an important overhead will decrease the protocol performance.

Average end-to-end delay of data packets
There are possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times. Once the time difference between every CBR packet 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. This metric describes the packet delivery time: the lower the end-to-end delay the better the application performance [15].

Avg E2E delay= $\sum_{1}^{n} CBRsentTime - CBRrecvTime$ / $\sum_{1}^{n} CBRrec$

5.4 Simulation Result

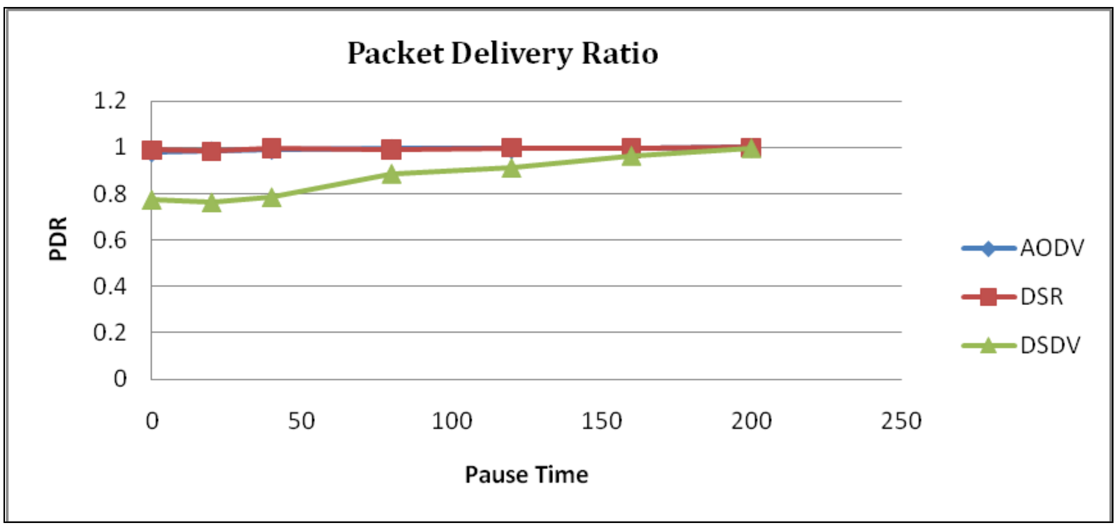

Figure5. Packet delivery ratio versus pause time for AODV, DSR and DSDV
(Number of node = 50, Area space = 500m x 500m)

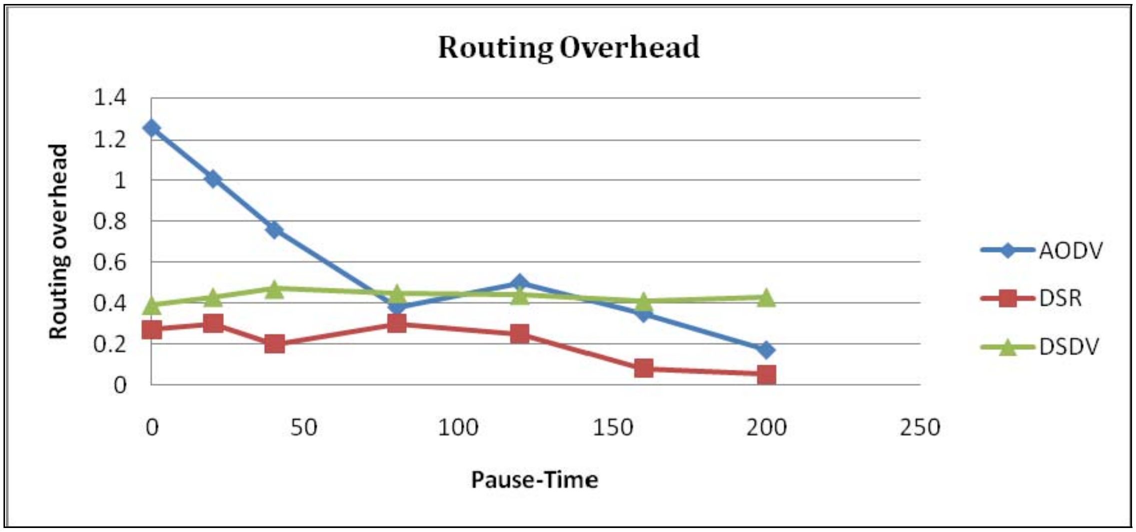

Figure6. Routing overhead versus pause time for AODV, DSR and DSDV
(Number of node = 50, Area space = 500m x 500m)

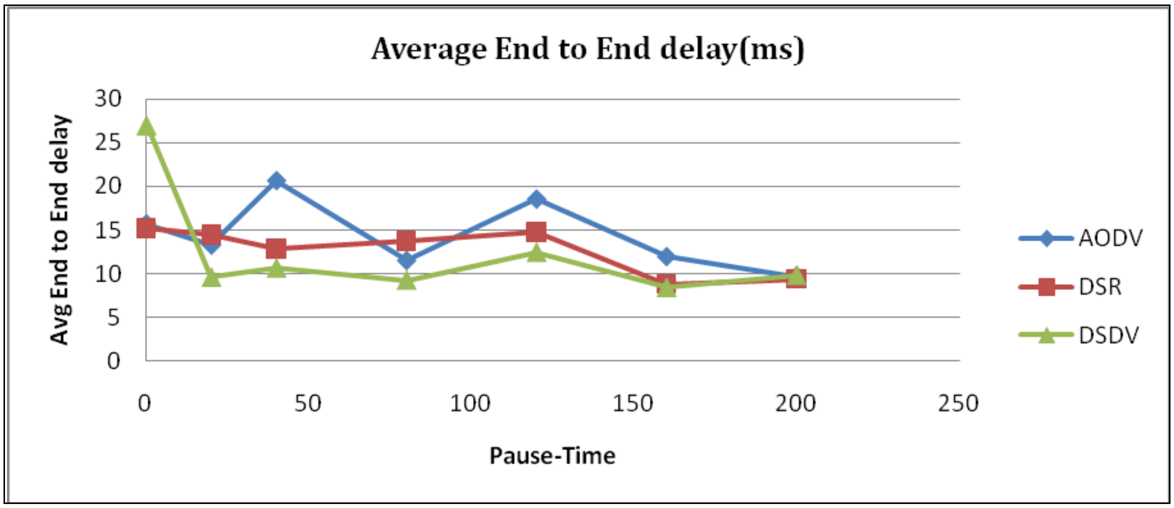

Figure7. Avg. end to end delay versus pause time for AODV, DSR and DSDV
(Number of node = 50, Area space = 500m x 500m)

6. Conclusion

In this paper the analysis of adhoc routing protocol is done in the above mentioned mobility and traffic pattern on different pause time. We analyzed that when pause time set to 0 each of the routing protocols obtained around 97% to 99% for packet delivery ratio except DSDV which obtained 77%.

DSR and AODV reached approx 100% packet delivery ratio when pause time equal to 200 while DSDV obtained only approx 94% packet delivery ratio.

DSR and DSDV has low and stable routing overhead as comparison to AODV that varies a lot. Avg. End to End delay of DSDV is very high for pause time 0 but it starts decreasing as pause time increases. DSR performs well as having low end to end delay.

When we compare the three protocols in the analyzed scenario we found that overall performance of DSR is better than other two routing protocols.

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