A Survey cum Simulation on Routing Protocols for Mobile Ad-Hoc Network

Nidhi bajpai,Anuradha,Rajat Dixit

ABSTRACT

The following work represents study of two types of Routing Protocols in Mobile Ad Hoc Network (MANET). Mobile ad-hoc network is a dynamic collection of wireless mobile nodes that interconnection between nodes may change with time and nodes are not connected to any base station. Routing is a challenging issue in mobile ad-hoc network because of randomness. Analysis of DSDV and AODV routing protocol and comparison between them with simulation is presented in this paper. It also demonstrates advantage and limitation of above two protocols.

KEYWORDS

Ad-Hoc Networks, Routing protocols, DSDV, AODV, Network Simulator (NS2)

1. INTRODUCTION

Network is defined as the group of people or systems or organizations who share their information collectively. In context of computer terminology the definition for networks is similar as a group of computers logically connected for the sharing of information or services. A network can be characterized as wired or wireless. Wireless can be distinguished from wired as no physical connectivity between nodes are needed. Mobile Network is further classified in to infrastructure and infrastructure less network. Network with fixed and wired gateways are defined as infrastructure. The bridges for these networks are known as base stations .When a mobile node travels out of range of one base station and enters the range of another base station then hand off occurs from old base station to new base station.

Second one is infrastructure less i.e. Mobile Ad-Hoc Network (MANET). These have no fixed routers and all the nodes are capable of moving dynamically and randomly. Nodes of these network work as routers. An Ad-Hoc network is a collection of mobile nodes forming an instant network without fixed topology. Each node acts as both routers and host simultaneously and can move out or join in network freely. These are the networks where each node communicates with each other using multi-hop links.

2. ROUTING

Routing is the act of moving information from a source to a destination in an internetwork. In routing at least one inter node is being encountered which acts as a router for the network. Routing concepts generally involves two activities i.e. determining optimal routing path and transferring the packets of information through an internetwork. The later concept is called packet switching which is simple and path determining could be very complex. Routing protocol uses standard information like number of hops, cost, and length to determine the optimal path for the destination. Routing tables generally consist of number of information which is generated by the routing algorithms. Most common entries in the routing table are ip-address prefix and the next hop..

2.1. Problems in Mobile Ad-Hoc Networks

2.1.1. Asymmetric link: All the wired networks are always fixed. But in case of ad-hoc networks the nodes are mobile and can constantly change their position within network. Let us consider an example of MANET (Mobile Ad-Hoc Network) where a node sends data of information to other but this does not tell about quality of connection in reverse direction [3].

2.1.2. Routing overhead: In ad-hoc network nodes continuously keeps on changing their position within the network that results in generation of some stale routes in the routing table which ultimately leads to resulting in unnecessary overhead.

2.1.3. Interference: One of the major problems of ad-hoc network is that as the links come and go depending on the transmission characteristics results in interference in network and ultimately corrupts the whole network.

2.2 Classification of Routing Protocol

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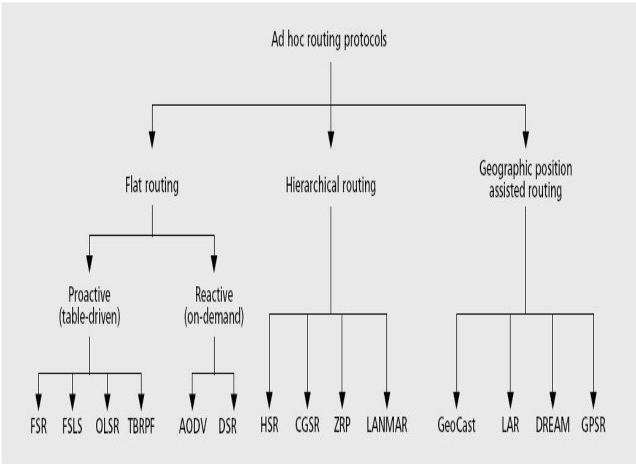

Figure 1. Classification of routing protocol in mobile ad-hoc network

2.2.1. Flat Routing Protocols: These are basically divided in two category proactive routing (table driven) and reactive (on-demand) routing protocols. They are further been classified in different protocols; proactive routing is mostly based on Link state where as reactive or on-demand routing is based on Distance vector algorithm.

2.2.1(a). Table-Driven routing protocols: Also called proactive protocols since they maintain routing information even before it is needed. These protocols governed each node to maintain one or more routing information in form of routing table, and they respond to changes in network topology by propagating updates throughout the network in order to maintain a consistent network view. Many of these routing protocols are like the link state routing. Between the protocols that come under this category, there always exists some difference among them that depends on the routing information being updated in each routing table. The areas in which they differ are the number of necessary routing-related tables and the methods by which changes in network structure are broadcasted. The main drawback of these type of protocol is that the life span of the link is significantly short. This phenomenon is brought about by the increased mobility of the nodes, which will render the routing information in the table invalid quickly. Proactive MANET protocols work suited for larger network as they need to maintain node entries at each node present in the routing table which lead to more overhead in the table and of ultimately consumption more bandwidth.

Examples of Proactive MANET Protocols include:

1) Optimized link state routing (OLSR) [8].

2) Topology Destination Sequenced Distance Vector (DSDV) [5].

2.2.1(b). On Demand Routing Protocols: Also called reactive protocols as they don't maintain routing in the network when there exist no communication. This type of routing creates routes only when desired by the source node. Whenever there is any requirement of route to destination for any node then it initiates a route discovery process within the network. If a node wants to send any data packet to another node then only it searches the route available in the network in an on-demand manner and establishes the connection in order to transmit and receive the packet. This process completes only when once a route is found or all the permutations of routes gets complete or examined. The route discovery is generally done by flooding the route request packets throughout the network. Once a route has been established, it is maintained by a route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired. The design of these types of protocols basically follows the idea that each node tries to decrease the routing over-head in the network by only sending the routing packets when communication is needed.

Examples of Reactive MANET Protocols include:
a) Ad-Hoc On-Demand Distance Vector (AODV).
b) Dynamic Source Routing (DSR).
c) Temporally Ordered Routing Algorithm (TORA).

2.2.2. Hierarchical routing protocols:

Some times the size of wireless network increases so much that flat routing protocols may start creating overhead for the MANET, in that case hierarchical protocols are very much useful as they have different solutions to the organization of the routing of nodes in a MANET.

Examples of Hierarchical Routing Protocols:
a) Cluster head-Gateway Switch Routing (CGSR).
b) Hierarchical State Routing (HSR).
c) Zone Routing Protocol (ZRP).
d) Landmark Ad Hoc Routing Protocol (LANMAR).

2.2.3. Geographical routing protocols: We can approach to geographical mobile ad-hoc network by one of the following ways given below:
a) Actual Geographic Coordinates (obtained with the help of GPS- Global Positioning system)
b) Reference points in some fixed Co-ordinate system.

The advantage of this type of network is that they prevent network –wide searches for destination. We can send and control data packets to any direction in geographical coordinates known to us. This reduces control overhead up to a very large extent. The disadvantage however is that all the nodes must provide their geographical coordinates to make this type of protocols useful. The routing update must be done faster than the network mobility rate to make the location-based routing effective. This is because the nodes locations may change quickly in a MANET.

Examples of Geographical Routing Protocols include:

a) Geographic cast and routing (Geo Cast).

b) Greedy Perimeter Stateless Routing (GPSR).

3. ROUTING PROTOCOL DSDV

The Distance Sequenced Distance Vector (DSDV) is a proactive routing protocol .It is developed by Perkin in 1994. As it is a proactive protocol so all the nodes present in this network maintains routing information before it is needed. It is just the modification of Bellman-Ford routing algorithm [2]. The main contribution of this protocol is to solve the routing loop problems that occur frequently in link state protocols. This protocol adds a new parameter, sequence number to each route table at each node. The sequence no is generally even in the protocol if the link is present otherwise it is odd. Sequence number helps the mobile node in keeping difference between stale routes and new routes so there does not occur a problem of loop routing in this protocol. The count to infinity problem is also solved by use of DSDV protocol. Each mobile node in this network maintains the routing table which contains the number of possible destination present in the network and the number of hops required to reach the destination. Routing table which is maintained at each node and with this table, node transmits the packets to other nodes in the network.

In DSDV we have collection of mobile nodes which are basically not close to base station and still can exchange data along changing arbitrary path of inter connection. Packets are transmitted between stations of network by using routing tables stored at each station of network. In each routing table there are fields for all available destinations number of hops to each node. The number is generated by the destination, and the emitter needs to send out the next update with this number. Since the topology is varying frequently the update should be available to each station. Updates are transmitted as soon as it is available .Time synchronization between mobile host should not be kept in mind. We analyze phase relationship of update period between mobile nodes. These packets give an indication of the station accessible from each station (as in Distance Vector).We also know the number of hops to reach the destination. Packets transmitted either from layer two addresses and layer three addresses [3].

We can break route updates from the routers nodes in two packets i.e. full dump and incremental packets [6]. Small incremental packets are being sent more frequently in comparison to a full dump packet which is generally sending infrequently during routing. Generally a full dump packet contains all the information about the routing whereas an incremental packet contains the information of only last full dump. The mobile nodes maintain an additional table where they store the data sent in the incremental routing information packets. It will also require mobile nodes to maintain additional information about data sent in incremental packet in their routing tables. This should fit in one network protocol data unit. When a node receives routing information that may be new routing information or may be modified information, after receiving it node will update its routing table according to received information and will transmit it ,this transmission will go(not necessary node may move) to the sender node. At the same time if sender transmits then collision will happen. To avoid this collision sender has to wait for some time. Time gap between the two transmissions or between broadcasting routing information should be chosen carefully, it is very important factor. To decide this time delay we may use this algorithm. There will be two routing tables kept at each mobile node, one for forwarding information packet and other for incremental packets. Forwarding routing table will be used in case, when node is working as router for a node which is out of coverage area of sender node, otherwise incremental table will be used. As scenario is mobile, node movements are random. When a node moves out of coverage area then there will be a broken link. A broken link will be represented by metric infinity in routing table.

The data broadcast by each node contains its new sequence number and following information about each new route:

a) The destination address.

b) The next hop for each destination.

c) The number of hop required to reach the destination.

d) The new sequence number, originally given by destination.

e) Install Time.

f) Stable Data.

The routing table also consists of hardware address, network address of mobile node transmitting the table. It also contains the sequence number which is created by transmitter so the new sequence is preferred for making forwarding decision.

Destination	Next Hop	Hops/Metric	Seq. No.	Install Time	Stable Data

Figure 2.Fields of Routing Table.

When a data packet is sent by one node to another node, it compares the sequence number of packet with the available sequence number for that entry. If the sequence number is larger, then it updates the routing information with the new sequence number and if the information arrives with the same sequence number it looks for the routing table and finds the number of hops and if number of hops is less than the previous one then it updates the information otherwise it discards the information.

d) It is difficult to maintain the routing table's advertisement for larger network. Each and every host in the network should maintain a routing table for advertising. But for larger network this would lead to overhead which consumes more bandwidth.

4. Routing Protocol: AODV (Ad-Hoc on Demand Distance Vector)

AODV [7] basically works in mobile network. AODV only finds the route to the destination when it is demanded by a node and hence is demand driven and the link is broken as soon as the packet is transferred. The problem of looping is eliminated by providing a sequence number to the packets. The routing table in AODV contains destination address, next hop, and number of hops, destination sequence number, the number of neighbors that are active and the life time. In this method control messages are sent to the neighbour, these control messages are in the form of route request, route reply, route error, and hello messages route request. When a route is not available for the destination, a route request packet is sent by the method of flooding throughout the network. The fields contained in the route request packet contains source address, request id, source sequence number, destination address, destination sequence number and hop count. The request ID is incremented each time the source node sends a new route request packet. Source address and request is used for recognizing a route request. On receiving a route request message each node checks the source address and the request ID. If the node has a route request with same source address and request id the new route request packet will be discarded, otherwise the route request packet will be forwarded or replied with route reply packets. If the node has no route entry for destination or it has one but this is not updated for long time the route request will be rebroadcasted and the hop count is increased. If the node has a route with a sequence number greater than or equal to route request packet a route reply message will be sent to the source. There is limitation on the number of route requests that can be sent from a node.

Route request packet contains time to live that is number of times a message is sent or broadcasted. Time to live which is set in first transmission is increased when the message is retransmitted. If a node is the destination, or has a valid route to the destination, it sent a route reply message back to the source. The route reply packet is sent, so that every node sending the route request message caches a route back to the source node. All nodes are monitoring their neighbors. When a node in an active route gets lost, a route error message is generated to notify the other nodes on both sides of the link of the loss of this link. Each node can get to know its neighbors by using broadcast messages that is a HELLO message, the nodes that it can directly communicate with. Here AODV is demand driven but it sends periodic HELLO messages to inform the neighbors that the link is still alive. The HELLO messages will not be forwarded because they are broadcasted with Time to live value1. When a node receives a HELLO message it is re-alive.

4.1. Importance of sequence number

As count to infinity problem [11] arises when a link maybe broken. This problem is avoided in AODV by providing sequence numbers for each route.

4.2. Route Discovery in AODV

Route discovery process starts when a source node does not have routing information for a node with which it wants to interact with. Route discovery is initiated by broadcasting a route request message. The route is established when a route reply message is received. A source node may receive multiple route request messages with different routes. It then updates its routing entries if the route request reply has a greater sequence number, while transmitting route request messages through the network each node notes the reverse path to the source. When the destination node is found the route reply message will go through this path, and hence there will now be no more broadcasts. And for this reason, the node on receiving route request packet from a neighbor records the address of this neighbor. While a route request message is being sent through the network each node notes the reverse path to the source. Route request packet from a neighbor records the address of this neighbor if the new Route request reply has a greater destination sequence number, then the route should be updated, and route request reply should be sent to nodes which are before. if the sequence numbers in the

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destination in old and new Route request reply are the same, but the new Route request reply has a smaller hop count, this new Route request reply should be preferred and forwarded Otherwise all later arriving Route request reply will be discarded.

5. Simulation

We simulated routing protocols DSDV & AODV on Network Simulator (NS2-2.35)

5.1. Simulation Model

We wrote different tool command language (.tcl) file for simulation. These .tcl files accepts as input a *scenario file* that describes the exact motion of each node and the exact packets originated by each node, together with the exact time at which each change in motion or packet origination is to occur. The detailed trace file created by each run is stored to disk, and analyzed using a variety of scripts, particularly one called file *.tr that counts the number of packets successfully delivered and the length of the paths taken by the packets, as well as additional information about the internal functioning of each scripts executed. This data is further analyzed with AWK file and using "grep" command to extract the data and MATLAB to produce the graphs also we generate the movement file.

5.1.1. Format of Trace File

Event	Time	From node	To node	Pkt type	Pkt size	Flags	Fid	Src addrs	Dst addrs	Seq num	Pkt id

Figure 3: Fields of trace file.

The first field is the event type and given by one of four available symbols r, s, M and D which correspond respectively to receive, send, moved and dropped. The second field is telling the time when the event occurs. The third and fourth fields are the input and output node of the link at which the events takes place. The fifth is the packet type such as continuous bit rate (cbr) or transmission control protocol (tcp). The sixth is the size of the packet and the next field is some kind of flags. The eighth field is the flow identity of IPv6, which can specify stream color of the NAM display and can be use for further analyze purposes. The ninth and tenth fields are the source and destination address in the form of "node. Port". The eleventh is the network layer protocol's packet sequence number. NS keeps track of UDP packet sequence number for the analysis purposes. The twelfth, which is the last field, is the unique identity of the packet. For different versions of NS simulator this format may varies.

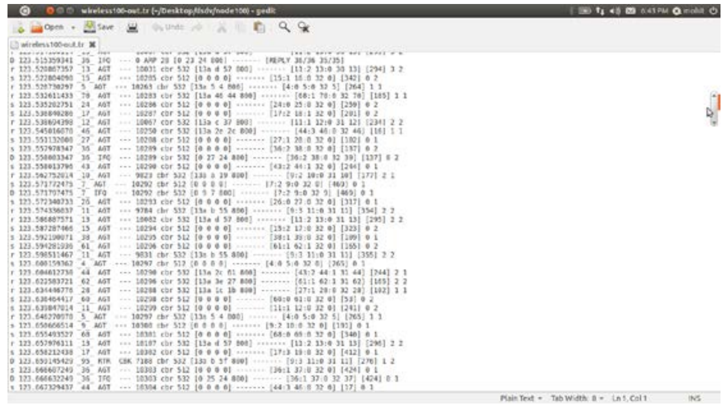

Figure 4: Snap shot of trace file.

5.2. Simulation of routing protocols

Table 1. Network Parameter Definition

Parameters	**Values**
Channel type	Channel/wireless channel
Netif	Phy/wireless phy
Mac protocol	Mac/802_11
Queue length	50
Number of nodes	Variable
Routing Protocol	DSDV/AODV
Grid Size	670x670m^2
Packet size	512 Bytes
Simulation Time	400 sec
Topology	Random
IFQ	Queue/Drop tail/Pre-queue
IFQLEN	50 (Max packet in IFQ)
ANT	Omni antenna
Transmission range of a node	250 meter

5.2.1. The Simulation Assumptions

a) For simplicity, all flows in the system are assumed to have the same type of traffic source. Each sender has constant bit rate (CBR) traffic with the rate of data rate/number of stations packet per second.

b) RTR trace is off in our simulation. Only AGT simulation is ON during the simulation

5.3. Analysis of DSDV and AODV

The analysis which we have done during our simulation is given below

5.3.1. Packet delivery fractions (PDF):

Also known as the ratio of the data packets delivered to the destinations to those generated by the CBR sources. The PDF shows how successful a protocol performs delivering packets from source to destination. The higher for the value give use the better results. PDF is the ratio of number of received packets(r) and send packets(s) which we extracted from the .tr by using “grep” and “awk” commands.

Table 2. Scenario Conditions

No of nodes	5,10,15,20,25
Grid Area	670x670 m^2
Speed	Max up to 10 m/sec
Packet Size	512 Bytes
Data rate	4 packet/sec
Pause Time	2 sec
Maximum number of connection	Variable according to number of nodes

5.3.1(a) When the traffic is low

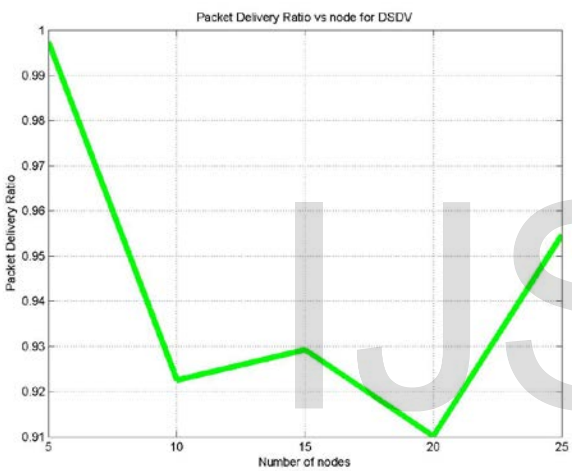

Figure 5. Packet delivery fraction v/s number of node for DSDV

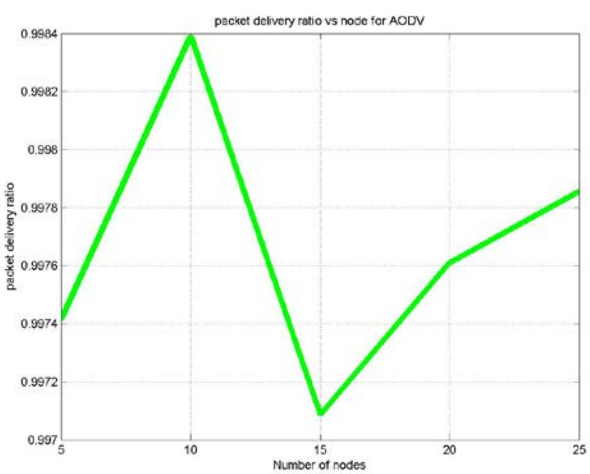

Figure 6. Packet delivery fraction v/s number of node for AODV

As it is clear to see when the traffic is very low (<10) , PDF of DSDV (Table Driven Protocol) is better than that of AODV but as number of nodes increases PDF of AODV becomes better than that of DSDV.

5.3.1(b). When the traffic is high

All the above scenario conditions remain the same while changing number of nodes from 25 to 100 means when the traffic is high.

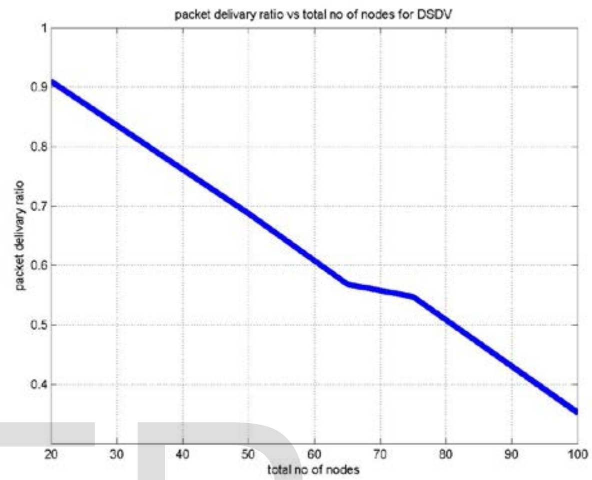

Figure 7. Packet delivery fraction v/s number of node for DSDV

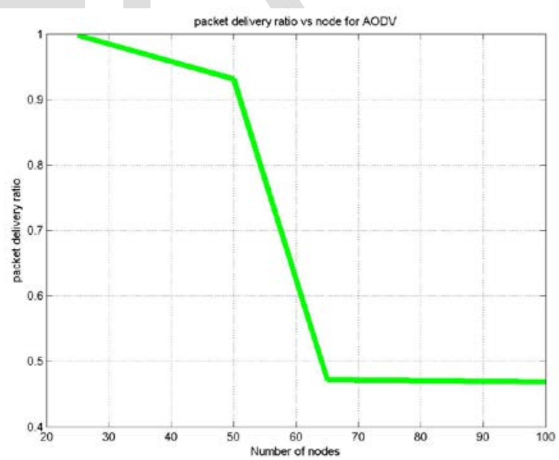

Figure 8. Packet delivery fraction v/s number of node for AODV

As it is clear from graph as no. of nodes are increasing PDF of AODV is better.

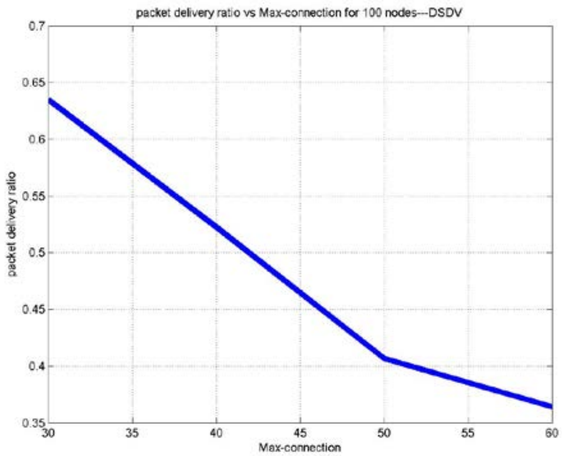

Figure 9. Packet delivery fraction v/s Maximum connections for DSDV for 100 nodes.

When we increase number of maximum connection for 100 nodes topology, PDF decreases as connection increases. It means in dense traffic less number of packets are being received by the destination nodes in comparison to the nodes which are being send.

5.3.1(c). Packet delivery fraction v/s Pause –Time

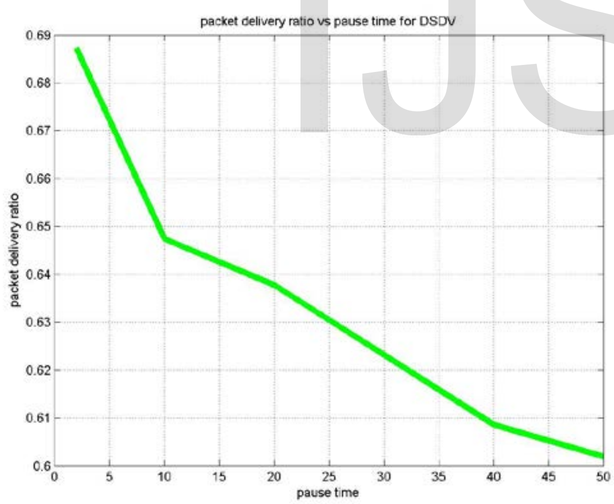

Figure 10. Packet delivery fraction v/s Pause time for DSDV

Figure 11. Packet delivery fraction v/s Pause time for AODV

5.3.2. Packet Lost fraction (PLF):

Also known as the ratio of the data packets dropped(lost) to the destinations to those generated by the CBR sources which we extracted from the .tr by using "grep" and "awk" commands.

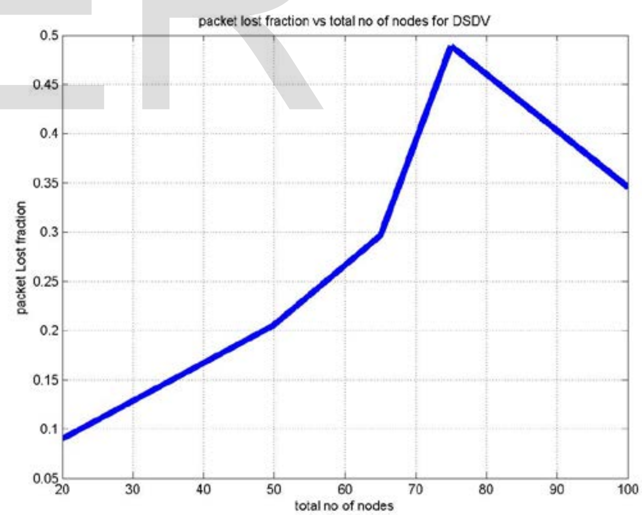

Figure 12. Packet lost fraction v/s number of node for DSDV

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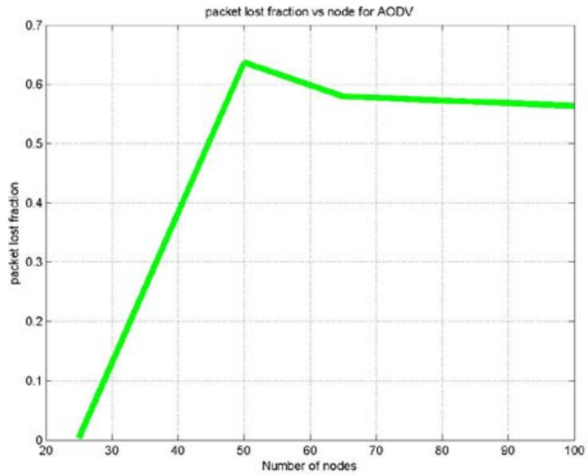

Figure 13. Packet lost fraction v/s number of node for AODV

5.3.2(a). Packet lost fraction v/s Pause –Time

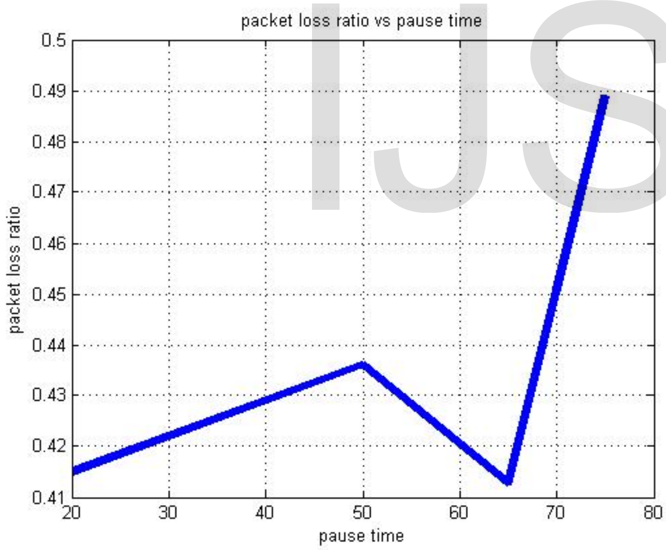

Figure 15. Packet lost fraction v/s Pause time for AODV

5.3.2(b). Packet lost fraction v/s Maximum speed of nodes

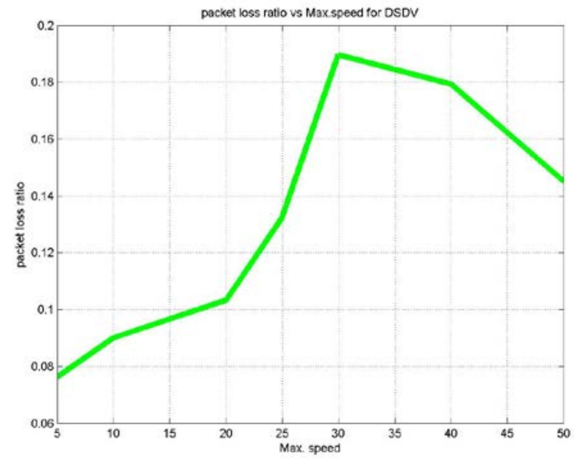

Figure 16. Packet lost fraction v/s Maximum speed for DSDV

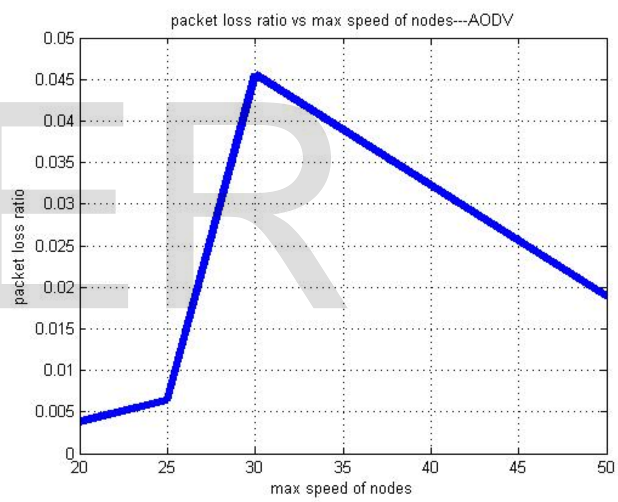

Figure 17. Packet lost fraction v/s Maximum speed for AODV.As shown in above figure packet loss ratio remains almost same with respect to speed.

5.3.3. THROUGHPUT:

The throughput of the protocols can be defined as percentage of the packets received by the destination among the packet sent by the source. It is the amount of data per time unit that is delivered from one node to another via a communication link. The throughput is measured in bits per second (bit/s or bps).

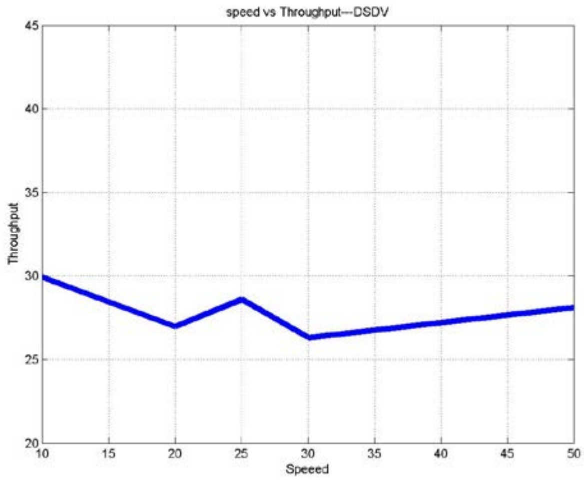

Figure 18. Throughput v/s Maximum speed for DSDV

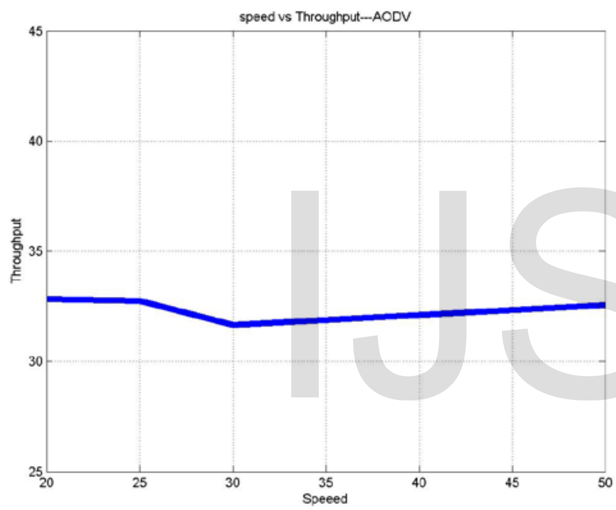

Figure 19. Throughput v/s Maximum speed for AODV

As it clear from graph the throughput of AODV is better than that of DSDV. And it remains almost constant with the maximum speed of nodes.

5.3.3(a) Variation of Throughput with Pause time

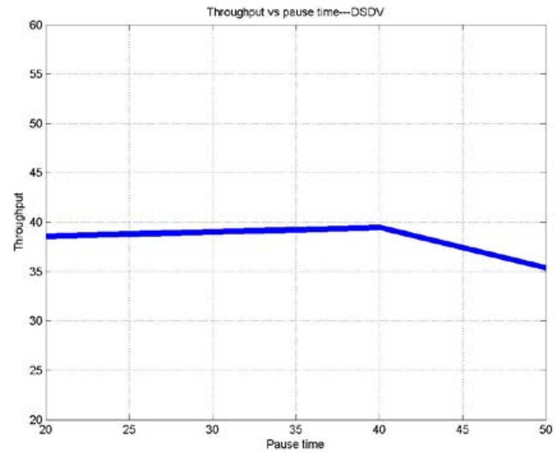

Figure 20. Throughput v/s Pause time for DSDV

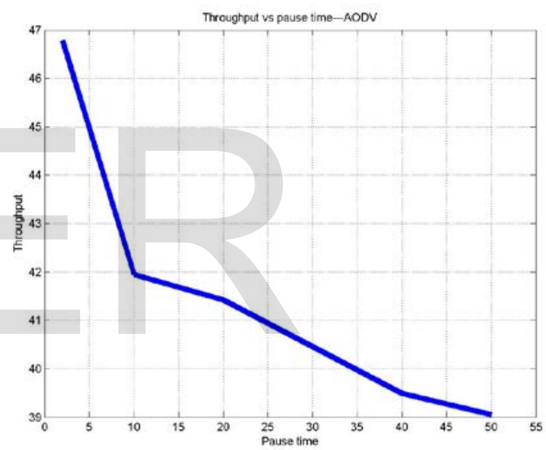

Figure 21. Throughput v/s Pause time for AODV

In DSDV nodes sent routing table updates periodically which is independent of route changes and hence throughput is not affected much by changes in the pause time. However AODV, which uses route request and route reply and hence are more dependent on route stability.
As we can see from the graph initially the performance of DSDV is better than that of AODV but as the pause time increases performance of DSDV decreases significantly.

6. Conclusion

From the simulation result we can interpret that AODV uses lesser bandwidth in comparison to DSDV. The excess band width in DSDV is due to excess routing traffic. In AODV throughput is not affected by increasing the speed. However DSDV perfectly scales to small network with low node speed. However for simplicity DSDV is rated higher than other complex technique without sacrificing performance. We have examined packet loss for AODV and DSDV and from our simulation we conclude that in AODV the packet loss is mainly due to mobility, however in DSDV the packet loss is mainly due to congestion.

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