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STUDY OF PERFORMANCE OF ROUTING PROTOCOLS FOR MOBILE ADHOC NETWORKING IN NS-2

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Abstract- ***MANET (Mobile ADHOC Network) is a self organizing and self configuring network without the need of any centralized base station. In MANETs, the nodes are mobile and battery operated. As the nodes have limited battery resources and multi hop routes are used over a changing network environment due to node mobility, it requires energy efficient routing protocols to limit the power consumption, prolong the battery life and to improve the robustness of the system. This paper addresses issues pertaining to three different routing protocols Destination Sequenced Distance vector (DSDV), ADHOC Om Demand Multipath Distance Vector Routing (AOMDV) and Dynamic Source Routing (DSR) protocols, which are used for efficient routing under different scenarios in Mobile Ad-hoc Network (MANET), which plays a critical role in places where wired network are neither available nor economical to deploy. My objective was to implement the two routing protocols using Network Simulators and run it for different number of nodes. Then I compared the two routing protocols for different network parameters and studied the efficient protocol under a particular scenario on the basis of two metrics. Packet delivery ratio and Routing load DSDV is a Proactive gateway discovery algorithm where the gateway periodically broadcasts a gateway advertisement message which is transmitted after expiration of the gateways timer. DSR is a Reactive gateway discovery algorithm where a mobile device of MANET connects by gateway only when it is needed. Simulation results show that AOMDV performs better than DSDV, respectively in packet delivery ratio and AOMDV, DSR both perform better than DSDV in terms of average End-To-End Delay.***

Keywords — MANET, DSDV, AOMDV, DSR, NS-2.35.

I INTRODUCTION

MANET is a wireless infrastructure less network having mobile nodes. Communication between these nodes can be achieved using multi hop wireless links. Each node will act as router and forward data packets to other nodes. Mobile ADHOC networks are operating without any centralized base station. It uses multi hop relaying. Since the nodes are independent to move in any direction, there may be frequent link breakage. The advantage of MANET is its instant deployment. Future generation wireless systems will require easy and quick deployment of wireless networks. This quick network deployment is not possible with the existing structure of current wireless systems.[2] Recent advancements such as Bluetooth introduced a new type of wireless systems known as mobile ad-hoc networks. Mobile ad-hoc networks or "short live" networks operate in the absence of fixed infrastructure. They offer quick and easy network deployment in situations where it is not possible otherwise. Ad-hoc is a Latin word, which means "for this or for this only." Mobile ad-hoc network is an autonomous system of mobile nodes connected by wireless links; each node operates as an end system and a router for all other nodes in the network. Nodes in mobile ad-hoc network are free to move and organize themselves in an arbitrary fashion. Each user is free to roam about while communication with others. The path between each pair of the users may have multiple links and the radio between them can be heterogeneous. This allows an association of various links to be a part of the same network. [3]

A mobile ad-hoc network is a collection of mobile nodes forming an ad-hoc network without the assistance of any centralized structures. These networks introduced a new art of network establishment and can be well suited for an environment where either the infrastructure is lost or where deploy an infrastructure is not very cost effective.

The popular IEEE 802.11 "WI-FI" protocol is capable of providing ad-hoc network facilities at low level, when no access point is available. However in this case, the nodes are limited to send and receive information but do not route anything across the network. Mobile ad-hoc networks can operate in a standalone fashion or could possibly be connected to a larger network such as the Internet. [3] Mobile ad-hoc networks can turn the dream of getting connected "anywhere and at any time" into reality. Typical application examples include a disaster recovery or a military operation. Not bound to specific situations, these networks may equally show better performance in other places. As an example, we can imagine a group of peoples with laptops, in a business meeting at a place where no network services is present. They can easily network their machines by forming an ad-hoc network. This is one of the many examples where these networks may possibly be used.

1.1 Project Description

The ad hoc routing protocols DSDV, DSR and AOMDV are three of the promising routing protocols. They can be used in mobile ad hoc networks to rout packets between mobile nodes. The main objectives of this thesis project are:

- Implementing the existing DSDV,DSR and AOMDV routing protocols in ns2
- Comparing the performance of three protocols under following metrics
    - Packet delivery ratio
    - End-to-end delay

II. ADHOC NETWORKING

This chapter gives an overview of Mobile Ad Hoc Networking. Section 2.1 introduces the protocol stacks used in the Internet and MANET and compares them with the Open Systems Interconnection (OSI) model. Section 2.2 and 2.3 describes the proactive and reactive gateway discovery. Then Section 2.4 and 2.5 describes the different routing concepts of DSDV and DSR.

2.1 Features of ADHOC Networks

MANETs is an IEEE 802.11 framework. It is an interconnected collection of wireless nodes where there is no networking infrastructure in the form of base stations, devices do not need to be within each other‘s communication range to communicate, the end-users devices also act as routers, nodes can enter and leave over time, data packets are forwarded by intermediate nodes to their final destination. Mobile ad hoc network nodes are furnished with wireless transmitters and receivers using antennas, which may be highly directional (point-to-point), Omni directional (broadcast), probably steer able, or some combination thereof [6].

At a given point in time, depending on positions of nodes, their transmitter and receiver coverage patterns, communication power levels and co-channel interference levels, a wireless connectivity in the form of a random, multihop graph or "ad hoc" network exists among the nodes. This ad hoc topology may modify with time as the nodes move or adjust their transmission and reception parameters.

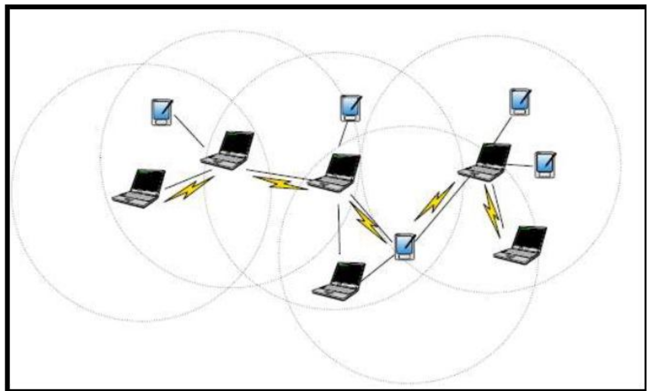

Fig 1: Mobile ADHOC Networks

2.2 Proactive Gateway Discovery

All the proactive approach algorithms are based on traditional distance vector and link state protocols developed for use in wireless approach. The primary characteristic of proactive approach is that each node in the maintenance of network is to maintain a route to every other node in the network all the times regardless of whether or not these routes are needed. In order to maintain correct route information, a node must periodically send control messages. Updates to route table are triggered or by certain events which caused in manipulation of other nodes (neighbouring) route table. Link addition and removal can trigger an event triggered updating of routing table. In proactive approach the main advantage is that the rout to each node is instantly found because the table contains all the nodal address. Source only need to check the routing table and transfer a packet. The major disadvantage of proactive approach is that each node is prone to rapid movement. So the overhead of maintaining a rout table is very high, and amount of routing state maintained at each node scales as order of o[n] where n is the number of nodes in the network. It becomes inefficient for a large network. GSR introduced below is a proactive routing protocol.

Global State Routing (GSR) is based on the Link State (LS) routing method. In the LS Routing method, each node floods the link state information into the whole network (global flooding) once it realizes that links change between itself and its neighbours. The link state information includes the delay to each of its neighbours. A node will know the whole topology when it obtains all link information.LS routing works well in networks with static topologies. When links change quickly, however, frequent global flooding will inevitably lead to huge control overhead. [4] Unlike the traditional LS method, GSR does not

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flood the link state packets. Instead, every node maintains the link state table based on up-to-date LS information received from neighbouring nodes, and periodically exchanges its LS information with its neighbours only (no global flooding). Before sending an LS packet, a node assigns the LS packet a unique sequence number to identify the newest LS information. LS information is disseminated as the LS packets with larger sequence numbers replace the ones with smaller sequence numbers. The convergence time required to detect a link change in GSR is shorter than in the Distributed Bellman-Ford (DBF) protocol. The convergence time in GSR is O (D*I) where D is the diameter of the network and I is the link state update interval. The convergence time is normally smaller than O(N*I) in DBF, where N is the number of nodes in the networks and I is the update interval. Since the global topology is maintained in every node, preventing routing loops is simple and easy. [3][4]

The drawbacks of GSR are the large size of the update messages, which consume a considerable amount of bandwidth, and the latency of the LS information propagation, which depends on the LS information update interval time. ``Fisheye'' technology can be used to reduce the size of update messages. In this case, every node maintains highly accurate network information about the immediate neighbouring nodes, with progressively fewer details about farther nodes.

2.3 Reactive Gateway Discovery

Reactive routing technique is also known as on-demand routing. It takes a different approach of routing which overcomes the disadvantages of proactive routing. In reactive approaches those nodes which require connectivity to the Internet reactively find Internet gateways by means of broadcasting some kind of solicitation within the entire ad hoc network. This approach reduces the overhead of maintaining the route table as that of proactive. The node dynamically checks the route table, and if it does not find an entry for its destination or it finds an outdated entry it performs route discovery to find the path to its destination. [5]

The signalling overhead is reduced in this method, particularly in networks with low to moderate traffic loads. However it has a drawback of route acquisition latency. That is when corresponding entry is not found the route discovery mechanism occurs which takes a very large amount of time, and for that time the packet waits for updating of the table.

2.4 DSDV

DSDV is one of the most well known table-driven routing algorithms for MANETs. It is a distance vector protocol. In distance vector protocols, every node i maintains for each destination x a set of distances $\{dij(x)\}$ for each node j that is a neighbor of i. Node I treats neighbor k as a next hop for a packet destined to x if $dik(x)$ equals $minj\{dij(x)\}$. The succession of next hops chosen in this manner leads to x along the shortest path. In order to keep the distance estimates up to date, each node monitors the cost of its outgoing links and periodically broadcasts to all of its neighbors its current estimate of the shortest distance to every other node in the network. The distance vector which is periodically broadcasted contains one entry for each node in the network which includes the distance from the advertising node to the destination. The distance vector algorithm described above is a classical Distributed Bellman-Ford (DBF) algorithm.

DSDV is a distance vector algorithm which uses sequence numbers originated and updated by the destination, to avoid the looping problem caused by stale routing information. In DSDV, each node maintains a routing table which is constantly and periodically updated (not on demand) and advertised to each of the node‘s current neighbors. Each entry in the routing table has the last known destination sequence number. Each node periodically transmits updates, and it does so immediately when significant new information is available. The data broadcasted by each node will contain its new sequence number and the following information for each new route: the destinations address the number of hops to reach the destination and the sequence number of the information received regarding that destination, as originally stamped by the destination. No assumptions about mobile hosts maintaining any sort of time synchronization or about the phase relationship of the update periods between the mobile nodes are made. Following the traditional distance-vector routing algorithms, these update packets contain information about which nodes are accessible from each node and the number of hops necessary to reach them.

Routes with more recent sequence numbers are always the preferred basis for forwarding decisions. Of the paths with the same sequence number, those with the smallest metric (number of hops to the destination) will be used. The addresses stored in the route tables will correspond to the layer at which the DSDV protocol is operated. The list which is maintained is called routing table. The routing table contains the following:

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- All available destinations' IP address
- Next hop IP address
- Number of hops to reach the destination
- Sequence number assigned by the destination node
- Install time

The sequence number is used to distinguish stale routes from new ones and thus avoid the formation of loops. The stations periodically transmit their routing tables to their immediate neighbours. A station also transmits its routing table if a significant change has occurred in its table from the last update sent. So, the update is both time-driven and event-driven.

As stated above one of "full dump" or an incremental update is used to send routing table updates for reducing network traffic. A full dump sends the full routing table to the neighbours and could span many packets whereas in an incremental update only those entries from the routing table are sent that has a metric change since the last update and it must fit in a packet. If there is space in the incremental update packet then those entries may be included whose sequence number has changed. When the network is relatively stable, incremental updates are sent to avoid extra traffic and full dump are relatively infrequent. In a fast-changing network, incremental packets can grow big so full dumps will be more frequent. [4]

Each route update packet, in addition to the routing table information, also contains a unique sequence number assigned by the transmitter. The route labelled with the highest (i.e. most recent) sequence number is used. If two routes have the same sequence number then the route with the best metric (i.e. shortest route) is used. Based on the past history, the stations estimate the settling time of routes. The stations delay the transmission of a routing update by settling time so as to eliminate those updates that would occur if a better route were found very soon.

Each row of the update send is of the following form:

<Destination IP address, Destination sequence number, Hop count>

After receiving an update neighbouring nodes utilizes it to compute the routing table entries. To damp the routing fluctuations due to unsynchronized nature of periodic updates, routing updates for a given destination can propagate along different paths at different rates. To prevent a node from announcing a routing path change for a given destination while another better update for that destination is still in route, DSDV 11 requires node to wait a settling time before announcing a new route with higher metric for a destination.[2]

2.5 DSR

Dynamic Source Routing (DSR) is a routing protocol for wireless mesh networks. It is similar to AODV in that it establishes a route on-demand when a transmitting mobile node requests one. However, it uses source routing instead of relying on the routing tablet each intermediate device each node maintains a route cache, where all routes it knows are stored. The route discovery process is initiated only if the desired route cannot be found in the route cache.

Dynamic source routing protocol (DSR) is an on-demand, source routing protocol, whereby all the routing information is maintained (continually updated) at mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration. The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network. An optimum path for a communication between a source node and target node is determined by Route Discovery process. Route Maintenance ensures that the communication path remains optimum and loop-free according the change in network conditions, even if this requires altering the route during a transmission.

Route Reply would only be generated if the message has reached the projected destination node (route Record which is firstly contained in Route Request would be inserted into the Route Reply. To return the Route Reply, the destination node must have a route to the source node. If the route is in the route cache of target node, the route would be used. Otherwise, the node will reverse the route based on the route record in the Route Reply message header (symmetric links). In the event of fatal transmission, the Route Maintenance Phase is initiated whereby the Route Error packets are generated at a node. The incorrect hop will be detached from the node's route cache; all routes containing the hop are reduced at that point. Again, the Route Discovery Phase is initiated to determine the most viable route. The major dissimilarity between this and the other on-demand routing protocols is that it is beacon-less and hence it does not have need of periodic hello packet (beacon) transmissions, which are used by a node to inform its neighbors

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of its presence. The fundamental approach of this protocol during the route creation phase is to launch a route by flooding Route Request packets in the network. The destination node, on getting a Route Request packet, responds by transferring a Route Reply packet back to the source, which carries the route traversed by the Route Request packet received.

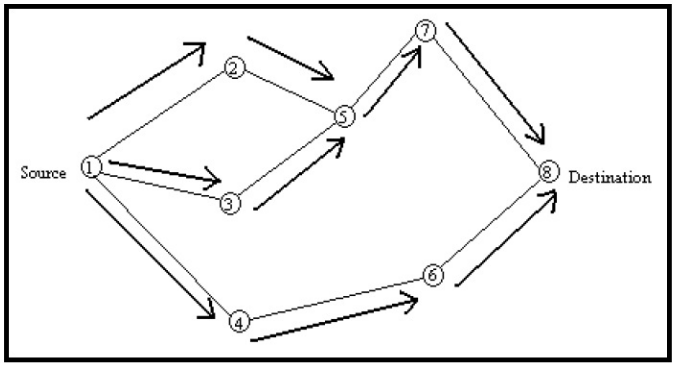

Fig 2: Propagation of request (PREQ) packet

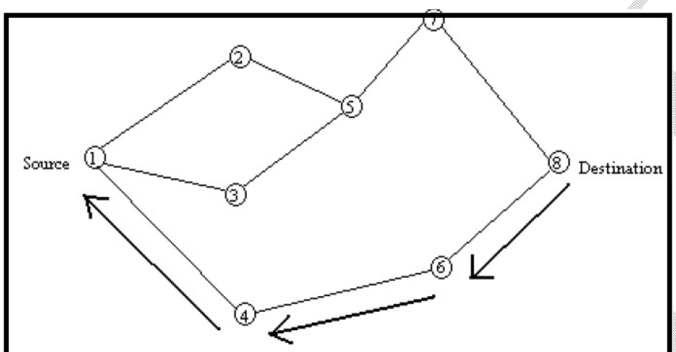

Fig 3 : Path taken by the Route Reply (RREP) packet

2.6 AOMDV

Ad-hoc On-demand Multi path Distance Vector Routing protocol is an extension to the AODV protocol for computing multiple loop-free and link disjoint paths. The routing entries for each destination contain a list of the next-hops along with the corresponding hop counts. All the next hops have the same sequence number. This helps in keeping track of a route. For each destination, a node maintains the advertised hop count, which is defined as the maximum hop count for all the paths, which is used for sending route advertisements of the destination. Each duplicate route advertisement received by a node defines an alternate path to the destination.

Loop freedom is assured for a node by accepting alternate paths to destination if it has a less hop count than the advertised hop count for that destination. Because the maximum hop count is used, the advertised hop count therefore does not change for the same sequence number. When a route advertisement is received for a destination with a greater sequence number, the next-hop list and the advertised hop count are reinitialized.

III. NETWORK SIMULATOR

DSDV and DSR routing protocols can be implemented using Network Simulator 2.35. NS is a discrete event simulator targeted at networking research. It provides substantial support for TCP routing and multicast protocols over wired and wireless networks. Using Xgraph (A plotting program) we can create graphical representation of simulation results. All the work is done under Linux platform, preferably ubuntu.[2]

3.1 About NS-2

NS is an object oriented simulator, written in C++, with an OTcl interpreter as a frontend. NS uses two languages because simulator has two different kinds of things it needs to do. On one hand, detailed simulations of protocols require a systems programming language which can efficiently manipulate bytes, packet headers, and implement algorithms that run over large data sets. For these tasks run-time speed is important and turn-around time (run simulation, find bug, fix bug, recompile, re-run) is less important.

On the other hand, a large part of network research involves slightly varying parameters or configurations, or quickly exploring a number of scenarios. In these cases, iteration time (change the model and re-run) is more important. Since configuration runs once (at the beginning of the simulation), run-time of this part of the task is less important.

NS meets both of these needs with two languages, C++ and OTcl .C++ is fast to run but slower to change, making it suitable for detailed protocol implementation. OTcl runs much slower but can be changed very quickly (and interactively), making it ideal for simulation configuration.

In NS-2, the frontend of the program is written in TCL (Tool Command Language). The backend of NS-2 simulator is written in C++ and when the TCL program is compiled, a trace file and namfile are created which define the movement pattern of the nodes and keeps track of the number of packets sent, number of hops between 2 nodes, connection type etc at each instance of time. In addition to these, a scenario file defining the destination of mobile nodes along with their speeds and a connection pattern file (CBR file) defining the connection pattern, topology and packet type are 17 also used to create the trace files and nam files which are then used by the simulator to simulate the network [1] Also the network parameters can be explicitly mentioned during the creation of the scenario and connection-pattern files using the library functions of the simulator.

IV. SIMULATION

To be able to implement the Destination Sequenced Distance Vector and Dynamic Source Routing protocols certain simulation scenario must be run. This chapter describes the details of the simulation which has been done and the results of the simulations done for the protocols. The simulations were conducted under UBUNTU (Linux) platform [2].

4.1 Simulation of DSDV, DSR And AOMDV

Aim here was to implement DSDV, DSR and AOMDV routing protocol for 10 nodes sending CBR packets with random speed. First the CBR files and scenario files are generated and then using DSDV protocol simulation is done which gives the nam file and trace file. Then another nam and Trace files are created DSR protocol. [2]

The following figures are the execution of the nam files instances created. For each execution of the same program different nam files are created and we can view the output on the network simulator.

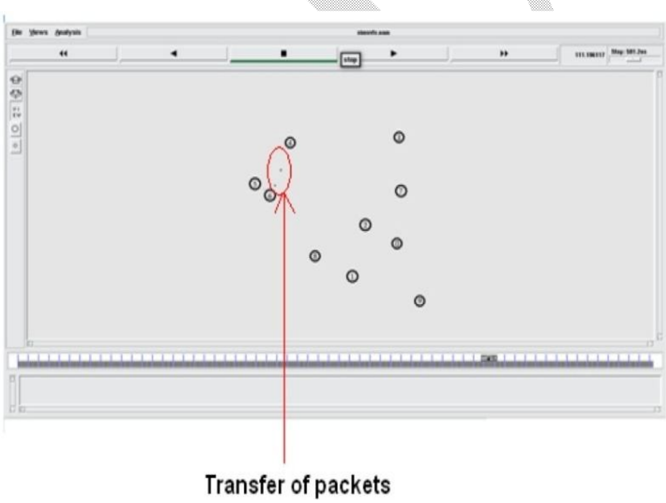

Fig 4 : Transfer of Packet

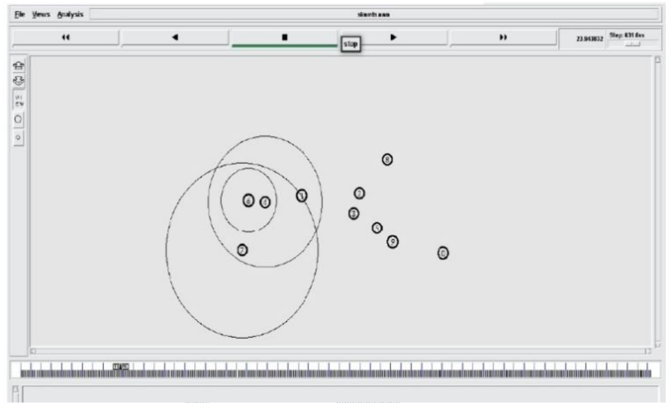

Fig 5: dropping of packets

4.2 Performance Metrics

The second goal of this project is to compare the performance of the two protocols under different scenario. Comparing the different methods is done by simulating them and examining their behaviour. In comparing the two protocols, the evaluation could be done in the following three metrics:

- The packet delivery ratio defined as the number of received data packets divided by the number of generated data packets

- The end to end delay is defined as the time a data packet is received by the destination minus the time the data packet is generated by the source

Table 1 - General parameter

Parameter	Value
Transmission Range	250 m
Simulation time	110 s
Topology Size	800m x 500m
Number of nodes	10,20,,40,60,80,100
Number of source	4
Number of Gateway	2
Traffic Type	Constant bit raye
Packet rate	5 packets / s
Packet size	512 bytes
Maximum speed	10 m/s

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V. RESULT

5.1Packet Delivery Ratio

Fig. 6 shows packet delivery ratio with pause time varying from 2 to 10 for DSDV, DSR, AOMDV routing protocol. The red line shows graph for DSDV and the green line shows the graph for DSR protocol. The delivery ratio for both the protocols is always greater than 90 percent. The basic difference between the two protocols is very less. But generally the graph for the DSR protocol lies above than that of DSDV for most cases. However in certain cases the DSDV protocols is also better. It is more likely for the mobile nodes to have fresher and shorter routes to a gateway and thereby minimizing the risk for link breaks.

Link breaks can result in lost data packets since the source continues to send data packets until it receives a RERR message from the mobile node that has a broken link. The longer the route is (in number of hops), the longer times it can take before the source receive a RERR and hence, more data packets can be lost. When the pause time interval increases, a mobile node receives less gateway information and consequently it does not update the route to the gateway as often as for short advertisement intervals. Therefore, the positive effect of periodic gateway information is decreased as the advertisement interval increases.

5.2 Average end to end delay

The average end-to-end delay is less for the AOMDV approach than for DSDV and the DSR approach. The reason is that the periodic gateway information sent by the gateways allows the mobile nodes to update their route entries for the gateways more often, resulting in fresher and shorter routes.

With the DSR (reactive approach) a mobile node continues to use a route to a gateway until it is broken. In some cases this route can be pretty long (in number of hops) and even if the mobile node is much closer to another gateway it does not use this gateway, but continues to send the data packets along the long route to the gateway further away until the route is broken. Therefore, the end-to-end delay increases for these data packets, resulting in increased average end-to-end delay for all data packets.

The average end-to-end delay is decreased slightly for short pause time intervals when the advertisement interval is increased. At the first thought this might seem unexpected. However, it can be explained by the fact that very short advertisement intervals result in a lot of control traffic which lead to higher processing times for data packets at each node.

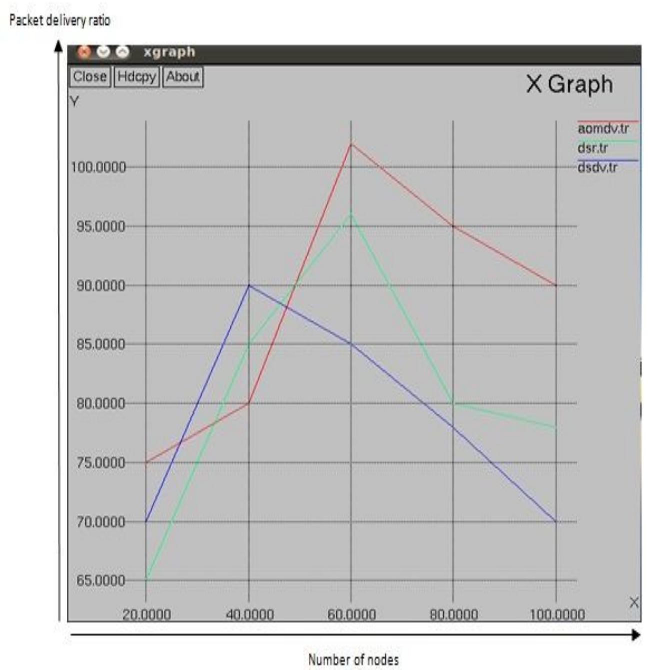

Fig 6 . Packet delivery ratio Vs pause time

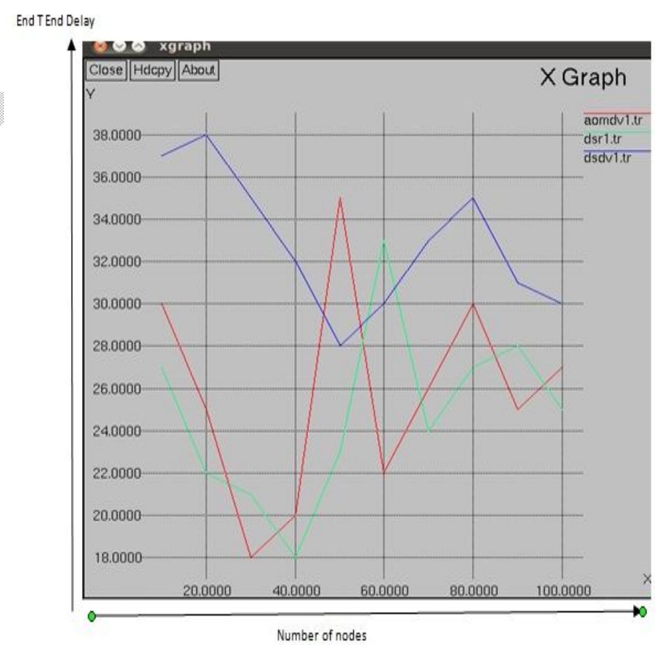

Fig 7: Average end to end delay Vs pause time

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VI. CONCLUSION

The results of the simulation show that performance of the AOMDV protocol is superior to both DSDV, DSR protocols. It is also found that when the number of nodes is increased the performance is better especially. Simulation results conclude that AOMDV performs better than DSDV and DSR protocol respectively in packet delivery ratio. However the statistic of AOMDV delivery ratio is close to DSDV. But for higher number of nodes AOMDV outperform other two protocols. In case of DSDV protocol it gives lowest packet delivery ratio. Average end-to-end delay of AOMDV is lesser than both DSDV and DSR. However DSDV statistics for average end-to-end delay is close to AOMDV but still it is higher than AOMDV. DSR statistics for end-to-end delay is highest. Finally we can conclude that AOMDV outperformed both DSDV and DSR in terms of two qualitative measures and it is preferable protocol than both DSDV and DSR in case of packet delivery ratio, end-to-end delay.

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