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Editorial Board

Title

PERFORMANCE EVALUATION OF ON-DEMAND AODV AND DSR ROUTING PROTOCOLS IN MOBILE AD-HOC NETWORK

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Abstract:

Wireless networks history began in the period of 1970s and the awareness has been increasing ever since. Mobile Ad hoc Network (MANET) is a collection of wireless mobile nodes, which build network dynamically, and does not require any infrastructure support for transferring data packet between two mobile nodes. These are often known as infrastructure-less networking because the mobile nodes in such network establish routes between themselves dynamically. Communication and administrative tasks can be carried out between the computers without using any wire. MANETs are recognized by infrastructureless environment, multihop wireless connectivity, and frequently changing topology. An experimental analysis regarding performance evaluation of well known ad hoc protocols AODV and DSR has been carried out using network simulators OPNET 14.0. To evaluate the performance of AODV and DSR random mobility model is used and performance differential parameters are analyzed in terms of throughput, end to end delay, network load and packets dropped with varying node speed, network density and pause time.

Keywords: MANET, Reactive, Proactive, Hybrid, OPNET 14.0, Mobility, Analysis

1 Introduction:

The wireless networks are classified into two different networks known as Infrastructure less and Infrastructured networks. The mobile node in infrastructure wireless network can move while communicating, the base stations are fixed in this type of network and as the node goes out of the range of a base station, it gets into the range of another base station. On the other hand the mobile nodes can move while communicating in infrastructureless or Ad Hoc wireless network, all the nodes in the network act as routers and there are no fixed base stations in such type of network. In this network, the topology may change rapidly and each node behaves both as a host and as a router (Taneja *et al.*, 2010).

Figure: 1 given below illustrates an ad hoc network, which is an example of different nodes where there are several combinations of transmission regions. From the source station to the destination station, at a given point of time there are several paths of links. Data transmitted by source can only forward to node B but data at B can be forwarded either to C or Destination.

Figure 1: MANET

MANET is a self-configuring network of associated hosts and mobile routers connected by wireless links, the combination of which establishes a random topology. MANETs are usually set up in emergency situations for short-term operations (Jaafar and Zukarnain, 2009).

An ad hoc network is composed of mobile nodes without the presence of a fixed infrastructure and communications among nodes are accomplished by forwarding data packets for each other, on a hop-by-hop basis. In ad hoc network a node that wants to communicate with other node might not be in communication range but can communicate if other device is lying between them. Ad hoc network can set up communication by executing flooding. Different protocols have been proposed from avoidance of flooding (Bamis *et al.*, 2007).

Proactive protocols used in MANET for communication are those which always maintain a route to every possible destination while reactive protocols are those that discover and maintain a route to a destination only when one is required (Taneja and Kush, 2010). Whereas hybrid routing protocols are the combination of reactive and proactive routing protocols (Lakhtaria and Patel, 2010).

A MANET consists of mobile platforms (e.g., wireless communications devices and a router having multiple hosts) here in simply referred to as "nodes" which are free to move about randomly (Corson and Macker, 1999).

2 Related Work:

Broch *et al.* (1998) worked and analyzed the performance comparison of both reactive and proactive protocols (TORA, AODV, DSR and DSDV). It was observed that at all mobility rates and node speeds that performance of DSR is good. At high rates of node mobility, AODV produced more routing overhead than DSR. Their simulations didn't include ZRP, neither they tried to find the impact of specific attributes of DSR or AODV in network performance

Royerd and Perkins (1999) studied and explained that an ad hoc network is the joint commitment of a group of mobile nodes without the need of any existing infrastructure or centralized access point. They concluded that loop free routes are obtained through AODV even while repairing broken links between nodes.

Das *et al.* (2001) worked on two different scenarios and analyzed and presented a in depth performance evaluation of two routing protocols knows as AODV and DSR using ns-2 simulator. Two different scenarios were considered. The NS-2 simulator supports a radio model similar to Lucent's Wave LAN radio interface.

Jorg (2003) evaluated and studied the performance of different protocols having dynamic network topology in MANET. By varying number of nodes and network sizes the performance of routing protocols was carried out. But did not investigated the performance of protocols under heavy loads like large number of traffic sources, high mobility and larger number of nodes in the network, which results in congestion. In his simulation, small size packets and one source node was only taken into account.

Gowrishankar *et al.* (2007) compared the performance of two major routing protocols in MANET: AODV and OLSR protocol. Packet delivery ratio, average end-to-end delay and expense of the protocol by measurements during the simulation were chosen to evaluate the performance of these protocols using NS-2 simulator. The OLSR protocol is the best performance in networks where there is high density and very sporadic traffic is present.

Gupta *et al.* (2010) evaluation the performance analysis of AODV, DSR and TORA routing protocols using network simulator NS-2. Performance metrics used for evaluating the performance are, PDF and end-to-end delay by using random waypoint mobility model. They observed that DSR is observed to be suitable for networks with moderate mobility rate whereas AODV has the best all round performance.

Taneja and Kush (2010) studied the analyzed the performance of TORA, AODV and DSR against following matrices Routing overhead, Average Delay, Throughput, Media Access Delay, Packet Delivery Ratio and Path optimality. It is observed that AODV at faster speeds keeps on improving with denser mediums. The evaluation indicates that in some cases AODV and DSR has a little more overhead TORA outperforms in all cases. Regarding Route updating and maintenance process the AODV is still considered better.

Annapurna and Shailendra (2010) compared the performance of three reactive routing Protocols for MANET AODV, DSR, and TORA by varying the size of the Networks using Opnet simulator. They concluded that DSR and AODV have better performance than TORA for minimum as well as maximum number of nodes.

Hassan *et al.* (2010) studied and analyzed the performance of MANET Routing Protocols DSDV, AODV and DSR over Mobility Speed by using Random waypoint mobility model. Simulation was performed using well known NS-2 simulator. They only observed the effect of mobility speed over MANET routing protocols having packet size of 12 bytes.

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

The AODV protocol is entirely based on DSDV and DSR, and is a variant of the target sequence-Distance-Vector (DSDV) routing protocol. Routes are obtained as and when required and kept only as long as necessary. AODV does not need to keep defeat from one node to every other node in the network. A feature of AODV routing protocol are route discovery. When a source node needs to transfer a data packet to a target node, the entries in the route table confirmed the warranty if there is a current path to that destination node or not (Gupta *et al.*, 2010). If there is a data packet is routed to the correct next hop towards the destination. If not, the discovery process, the journey began. AODV protocol initiates a route discovery process by using Request Path (RREQ) and Reply Route (RREP) (Gowrishankar *et al.*, 2008). Mostly, the sequence numbers are examined and used to learn the news of each packet data and IP address and broadcast ID created each one unique identifier for RREQ on unique identification of each request. The source node will contain a RREQ packet containing the address IP, number of the last row of the destination IP address of the destination, the current number of the identity and program. Increase ID is transmitted each time the source node starts RREQ. Requests sent through the RREQ message and the information regarding the formation of a route is having back forwarded message RREP. The RREQ packet is transmitted from source node to its neighbors and then the timer is set to wait for an answer. The node creates a reverse route entry for the source node's route table to process the RREQ. In fact, a life linked to the reverse path input and path information is deleted if it has not been used in this life. The source node may be transmitted again using travel search engine, if the RREQ is lost during transmission (Taneja and Kush, 2010).

4.2 Distance Source Routing (DSR)

Dynamic Source Routing (DSR) is a routing protocol for wireless networks. It is similar to AODV in that it forms a route on-demand when a transmitting computer requests one. However, it uses source routing instead of relying on the routing table at each intermediate device. Many successive refinements have been made to DSR, including DSR FLOW. Determining source routes requires accumulating the address of each device between the source and destination during route discovery. The accumulated path information is cached by nodes processing the route discovery packets. The learned paths are used to route packets. To accomplish source routing, the routed packets contain the address of each device the packet will traverse. This may result in high overhead for long paths or large addresses, like IPv6. To avoid using source routing, DSR optionally defines a flow id option that allows packets to be forwarded on a hop-by-hop basis. This protocol is truly based on source routing whereby all the routing information is maintained (continually updated) at mobile nodes. It has only 2 major phases which are Route Discovery and Route Maintenance (Bindra *et.at*, 2010). Route Reply would only be generated if the message has reached the intended destination node (route record which is initially 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 Destination Node's route cache, 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 (Taneja and Kush, 2010). The erroneous hop will be removed from the node's route cache, all routes containing the hop are truncated at that point. Again, the Route Discovery Phase is initiated to determine the most viable route.

5 Evaluation of Results:

Each and every finding is properly explained. There are basically three aspects which are discussed.

- Firstly, it is studied about the working of same protocol in different scenarios for its evaluation.
- Secondly, it is studied about the working of different protocols in same scenario.
- Thirdly, it is studied about the working of different protocols in different scenarios.

6 Performance Matrics:

For the performance evaluation purpose regarding any MANET routing protocols there are number of quantitative matrices that can be taken into account for analyzing the performance of a protocol.

6.1 Route Discovery Time

The time to discover a route to a specific destination is the time when a route request was sent out to discover a route to that destination until the time a route reply is received with a route to that destination.

6.2 Throughput

It is the ratio of data packets transmitted to the destination node to those generated by the sources (Bobade and Mhala, 2010). It is computed by dividing the number of received packets by destination through the number packet originated from source (Said *et al*., 2011).

6.3 Routing Load

Represents the total load (in bits/sec) submitted to wireless LAN layers by all higher layers in all WLAN nodes of the network.

6.4 Average End-to-End Delay (second)

It signifies the average time taken by packets to reach one end to another end (Source to Destination).

6.5 Total Packets Dropped

This statistic represents the total number of application packets discarded by all nodes in the network.

Table 1: Simulation Parameters

Parameter	***Value***
Number of Nodes	10, 20, 30, 40, 50
Area Size x(m)	1000
Area Size y(m)	1000
Application Traffic Type	FTP
Node Speed (m/s)	10, 20, 30, 40, 50
Pause Time (sec)	0, 100, 200, 300, 400
Simulation Time	30 min
Topology	Random Waypont
Routing Protocols	AODV, DSR
Simulator Used	OPNET 14.0
MAC Protocol	IEEE 802.11
Mobility Speed (Constant)	10 m/s
Data Rate	11 Mbps
Application	FTP as High load, HTTP

	as Heavy browsing
Node Placement	Random
Node type (mobile node)	manet_station

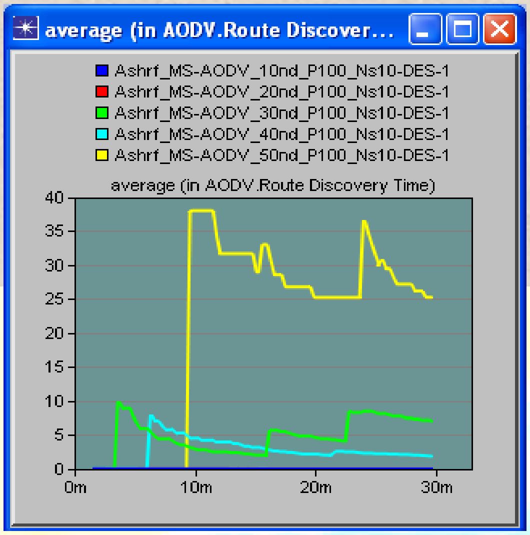
8 Application configuration:

Application configuration in OPNET MODELER is a set of rules which has varieties of libraries to generate the traffic on the network according to the user requirement. In order to simulate the OPNET MODELER simulation for each new project in the software there is a need to configure the application configuration. FTP is configured as high load in application configuration. The reason for generation high load on this application is to generate more traffic on the network as the load on network will heaver it will be a good practice to understand the result and having analysis on them.

9 Simulation Parameters used in AODV, DSR and ZRP MANET Routing Protocols Scenarios:

The area used in network simulation was set to 1000 m *1000 m and simulation of network was carried out having simulation time of 3600 sec. The performance parameters used in the simulation are Rout Discovery Time, Throughput, Retransmission Attempts, Network Load, Media Access Delay, End to End Delay, Data Dropped against varying network parameters like Pause Time, Number of Nodes and Node Speed. The pause time is set to 0, 100, 200, 300, and 400 second, number of nodes are set to 10, 20, 30, 40 and 50 and node speed is set to 10, 20, 30, 40, 50 m/s. Random waypoint mobility model is used using FTP traffic with high load with MAC protocol IEEE 802.11. Hassan *et al.*, 2010 only focused only on mobility speed to observe the PDR, End to End Delay, Routing Overhead and Normalized Load of AODV and DSR routing protocols. But other parameters like Pause time, and varying traffic type was not to be taken into account. We have observed the performance of these protocols under varying pause time, node speed, number of nodes, and traffic type HTTP, FTP, TCP and UDP.

10 Route Discovery Time:



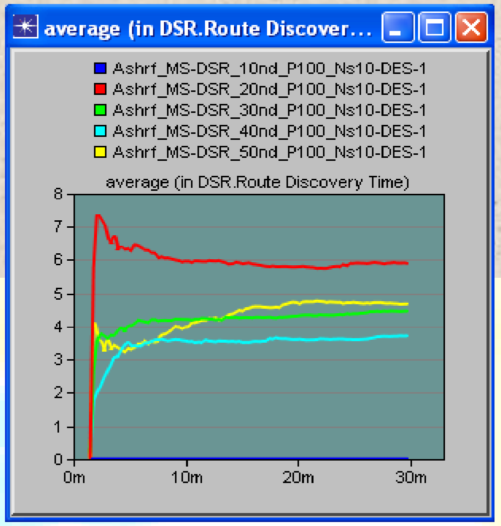


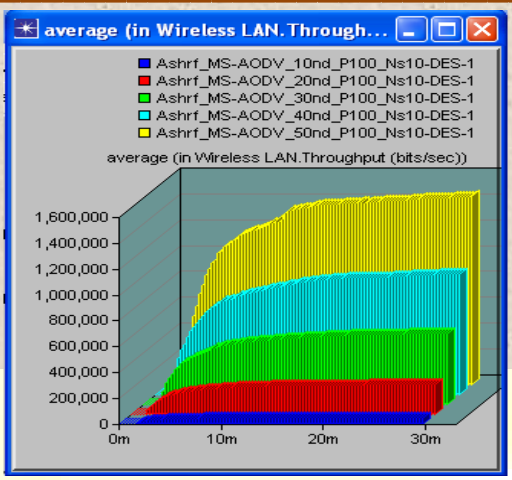
Figure 2: AODV Route Discovery Time Figure 3: DSR Route Discovery Time

The route discovery time of AODV under varying no. of nodes form 10 sec to 50 gives different results. So its performance regarding route discovery is much influenced by varying No. of nodes. So by analyzing above both graphs of AODV and DSR, it is clear that AODV performing better than DSR. DSR needs more hops than AODV in every route. AODV has an excellent performance, taking minimum route discovery time and less number of hops per route.

11 Throughput Comparison:

Three scenarios are generated to evaluate the throughput of AODV and DSR routing protocols. In the first scenario throughput of AODV and DSR is compared against varying numbers of mobile nodes (10, 20, 30, 40, 50). In second scenario throughput is observed by varying pause time (0, 100, 200, 300, 400 sec) and third scenario shows the throughput by varying node speed (10, 20, 30, 40, 50 m/s).

11.1 Throughput Vs No. of Nodes



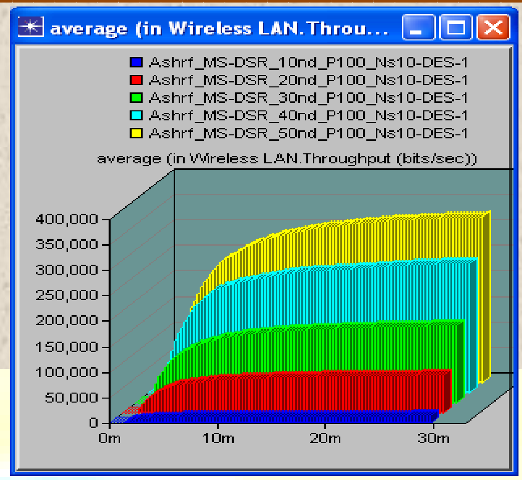


Figure 4: AODV Throughput Vs No. of Nodes   Figure 5: DSR Throughput Vs No. of Nodes

The figures 6-7 are resultant of half hour working of simulation. It is analyzed that when the network node density is high the AODV routing protocol gives high throughput as compared to DSR. It is analyzed that varying number of nodes is more effective to AODV than DSR.

11.2 Throughput Vs Pause Time

The following graphs show the Throughput of AODV and DSR routing protocols with respect to pause time.

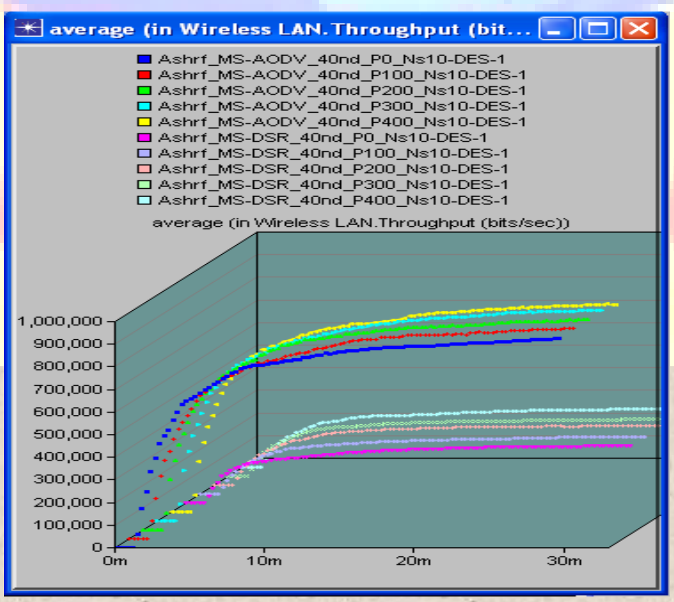


Figure 6: AODV and DSR Throughput Vs Pause Time

Throughput of AODV and DSR protocols is analyzed by varying pause time in the intervals of 0, 100, 200, 300, 400, and keeping number of nodes to constant 40. According to our simulation results, AODV shows best performance than DSR as a function of pause time.

11.3 Throughput Vs Node Speed

Comparative analysis of throughput of AODV and DSR with respect to node speed is observed where the number of nodes used in the MANET network are kept constant to 40. It is observed while changing the speed of nodes from 10, 20, 30, 40 to 50 m/s, AODV routing protocol gives optimum performance as compared to DSR routing protocol.

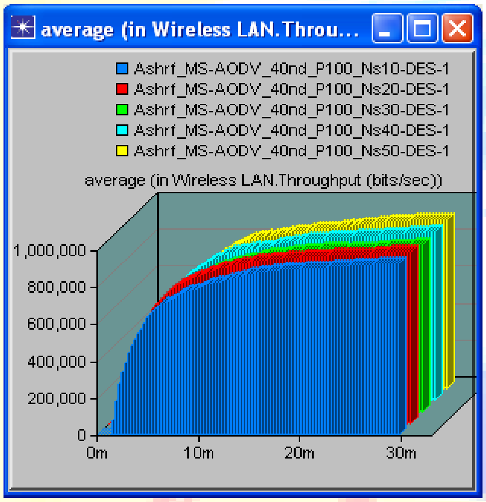


Figure 7: AODV Throughput Vs Node Speed

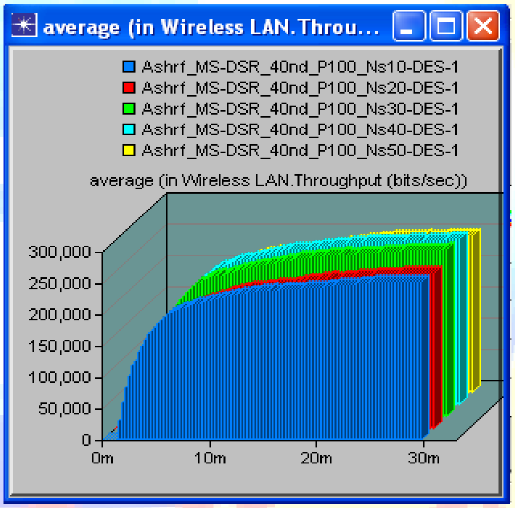
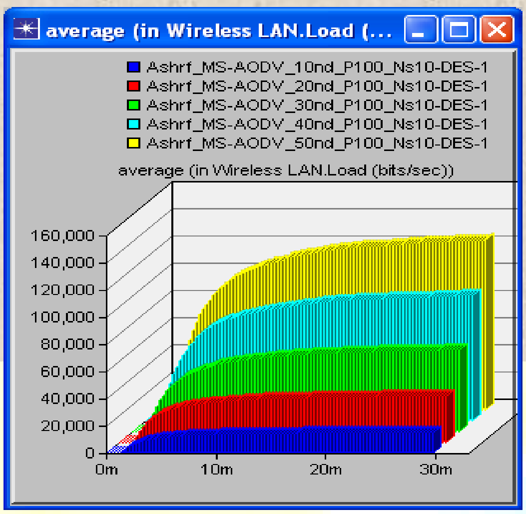


Figure 8: DSR Throughput Vs Node Speed

12 Network Load Comparison (bits/sec):

12.1 Network Load Vs No of Nodes (bits/sec)

The network load of AODV and DSR is analyzed by varying nodes from 10, 20, 30, 40 to 50 by keeping pause time as constant to 100 and node speed to 10 m/s. Random waypoint mobility model is used to perform the simulation.



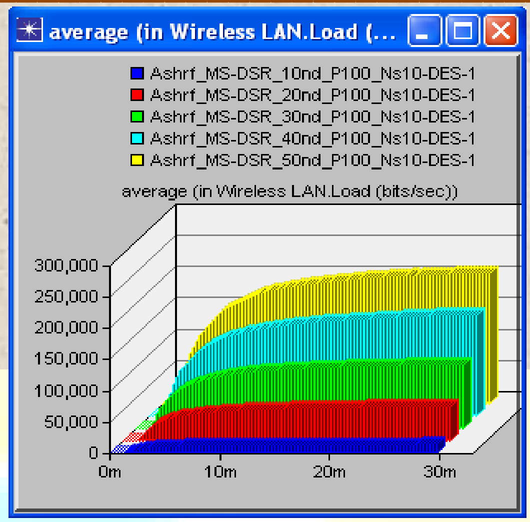


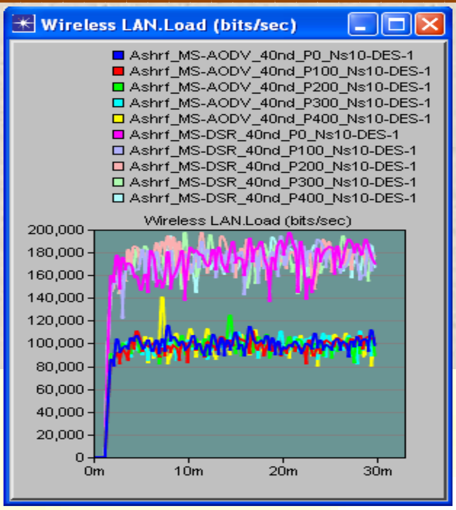
Figure 9: AODV Network Load Vs no. of Nodes

Figure 10: DSR Network Load Vs no. of Nodes

It is observed that the network load slowly increases with the increment of number of nodes in the network. But under varying number of nodes, each line falling under the concern density gives a parallel behavior after certain simulation time. The values for the DSR protocol were less as compared to the AODV which show fairly stable results even after increasing the number of sources. If normalized routing load is stable, the protocol is considered to be scalable. DSR finds the route in the cache as a result of aggressive caching. This helps to avoid a frequent route discovery process in DSR thereby decreasing the routing overhead for DSR when compared to AODV.

12.2 Network Load Vs Pause Time (bits/sec)

The network load of AODV and DSR does not influence more by varying node speed, since node speed has a minor impact on network load. On the other by varying pause time, it also has a minor impact on network load regarding AODV and DSR routing protocols.



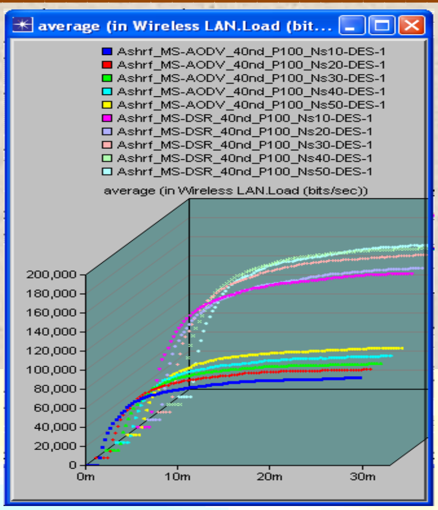
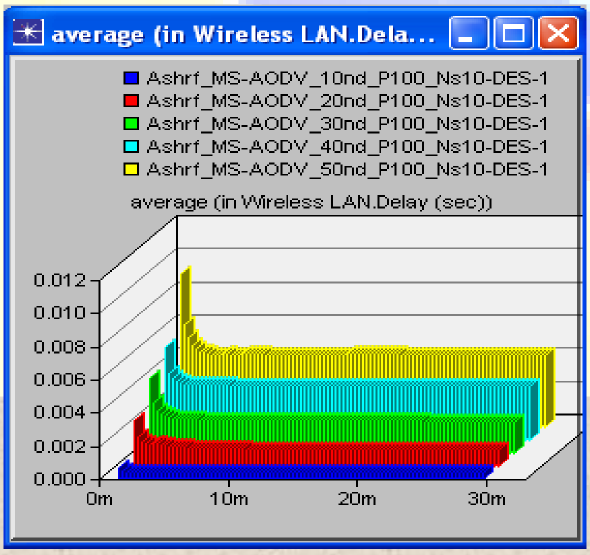


Figure 11: AODV and DSR Network Load Vs. Pause Time

Figure 12: AODV and DSR Network Load Vs. Node Speed

13 End to End Delay Comparison:

13.1 End to End Delay Vs No. of Nodes



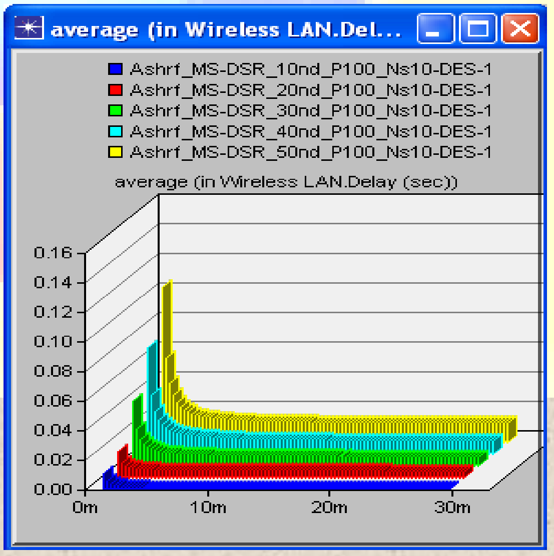
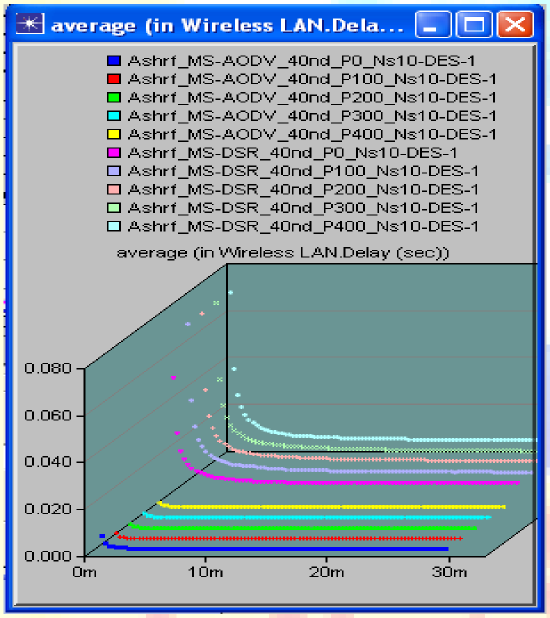


Figure 13: AODV End to End Delay Vs No of Nodes

Figure 14: DSR End to End Delay Vs No of Nodes

The resultant graph shows the end to end delay of AODV routing protocol by varying number of nodes. It is analyzed that by increasing the number of nodes, end to end delay also reduces, and if there are minimum number of nodes in the network, end to end delay is high. In this scenario end to end delay of DSR is observed by varying number of nodes in the network. The resultant graph shows the end to end delay of DSR routing protocol by varying number of nodes. It is analyzed that by increasing the number of nodes, end to end delay reduces, and if there are minimum number of nodes in the network, end to end delay is high. When network density is increased then after certain time the behavior of the curves shows parallel results.

13.2 End to End Delay Vs Pause Time and Node Speed



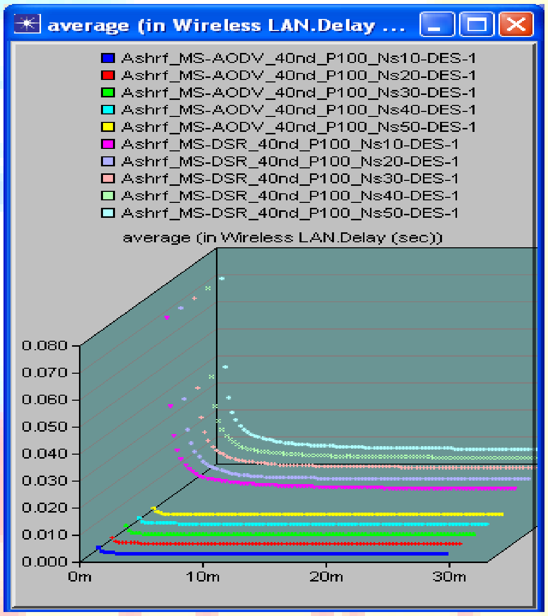


Figure 15: AODV and DSR End to End Delay Vs Pause Time

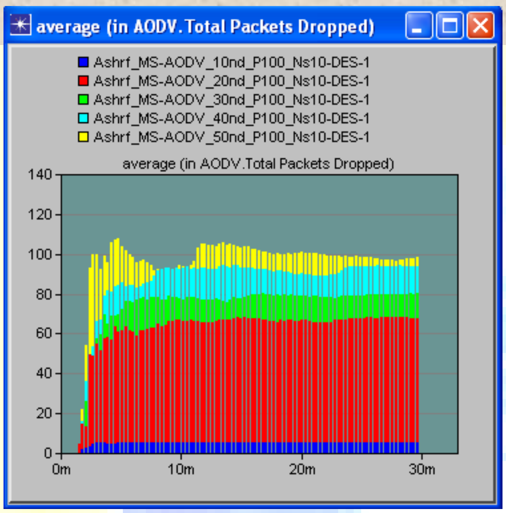
Figure 16: AODV and DSR End to End Delay Vs Node Speed

14 <u>Total Packets Dropped Comparison:</u>

The packets queued to the destination are dropped by the mobile node when no route is found to the destination. This parameter denotes the total number of application packets discarded by all nodes in the network; this statistic is collected in the bucket mode with the "Sum" of the values within the bucket by default

14.1- Total Packets Dropped Vs No. of Nodes

This figure 4.19 represents the total number of dropped packets by AODV routing protocol regarding number of nodes.



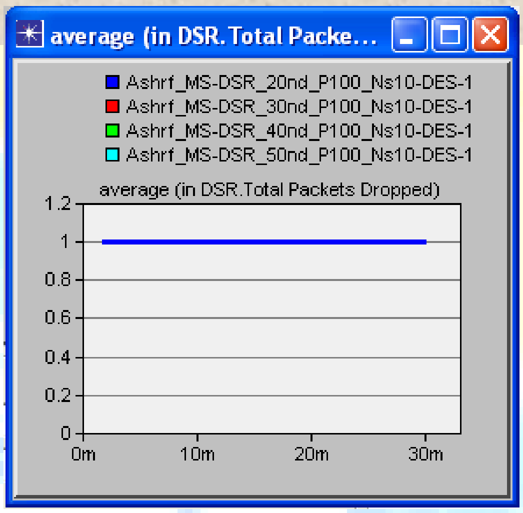


Figure 17: AODV Total Packets Dropped Vs No of Nodes

Figure 18: DSR Total Packets Dropped Vs No of Nodes

When the network density is high the ratio of data packets dropped by AODV is high. But as for DSR routing protocol concern, data packets dropped by it are less as compared to AODV routing protocol. DSR performs better by comparing with AODV regarding increasing number of nodes.

15 Delay and Throughput Analysis of AODV and DSR Protocols against HTTP Vs FTP and TCP Vs UDP:

In order to compare the performance of AODV and DSR routing protocols against HTTP Vs FTP and TCP Vs UDP, following parameters are used, node speed is set to 10 m/sec using random waypoint mobility model under pause time=100 and number of nodes which are used for simulation are 10. The following graphs show the performance of AODV and DSR protocol under various traffic types like TCP, UDP, FTP and HTTP.

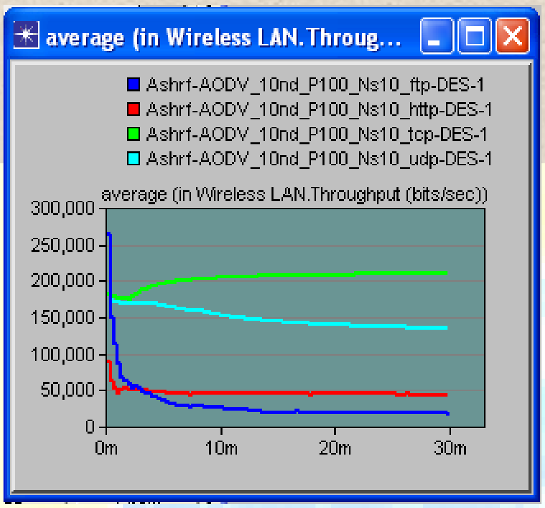


Figure 19: AODV throughput against

HTTP Vs FTP and TCP Vs UDP

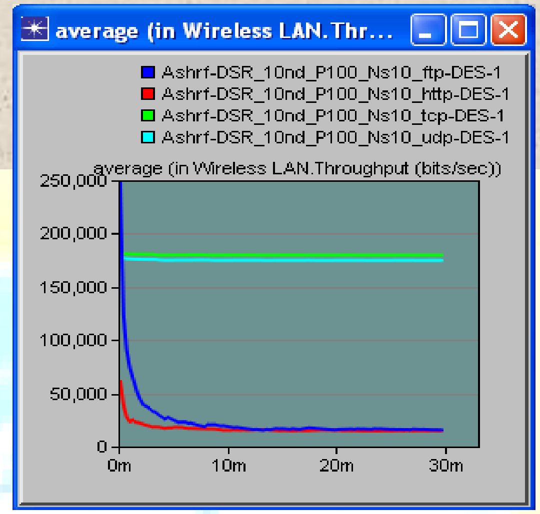


Figure 20: DSR throughput against

HTTP Vs FTP and TCP Vs UDP

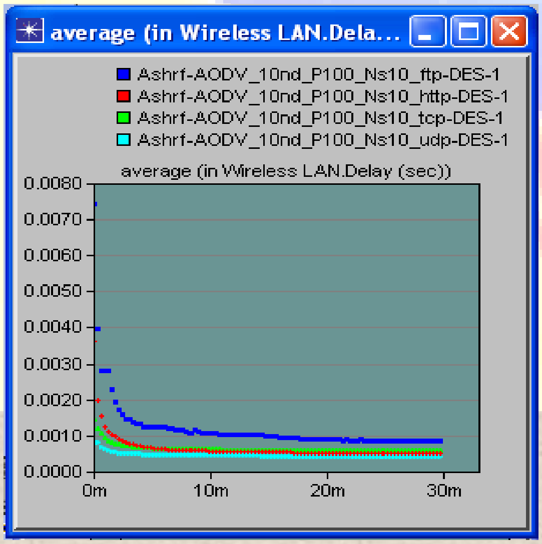


Figure 21: AODV Delay against

HTTP Vs FTP and TCP Vs UDP

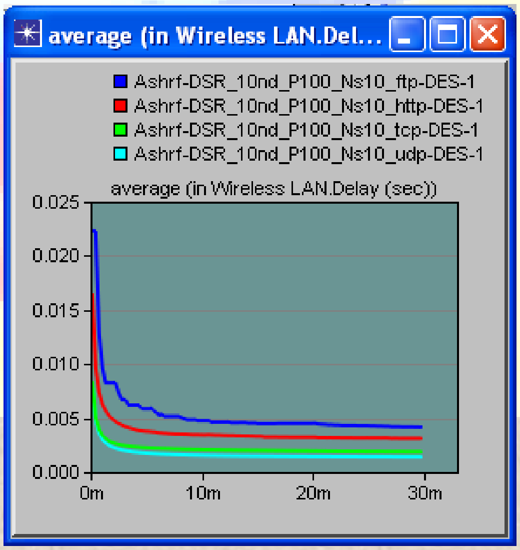


Figure 22: DSR Delay against

HTTP Vs FTP and TCP Vs UDP

As for AODV End to End Delay concern against HTTP Vs FTP traffic, it performs better under HTTP traffic. So in both cases regarding Throughput and End to End Delay, AODV performs better under HTTP traffic. On the other hand the performance of AODV and DSR under TCP Vs UDP concern, UDP traffic has good impact on both protocols in terms of End to End Delay rather than TCP. The Delay and Throughput of DSR ad hoc routing protocol is almost consistent under HTTP and FTP traffic. Its behavior under both traffic types remains same. Only AODV protocol performance influenced by changing traffic type regarding end to end delay and throughput.

CONCLUSION:

In this thesis we have compared the performance of two ad hoc routing protocols AODV and DSR in different scenarios using OPNET 14.0. The main performance metrics which are used for analysis are throughput, routing load and average end-to-end delay by varying pause time, node speed, no. of nodes and traffic type like FTP, HTTP, TCP and UDP. It is observed through simulation that in all the models AODV outperformed regarding packets delivery ratio. As for speed and pause time models concern, only AODV protocol maintained high delivery ratio where ratio of routes breaking was very high. As AODV is categorized in the class of on-demand routing protocols therefore it always selects active and fresh route which made it possible to deliver large number of data packets. However this quick route discovery of AODV routing protocol in the network caused more routing packets, so, its routing overhead is high and also showed slightly high delay as compared to DSR protocol. In load scenario where workload was increasing, the performance of AODV and DSR protocols despoiled. It is observed that when sending rate is high, protocols are not capable to response well. At moderate traffic load DSR performed better than AODV for all tested mobility values, while AODV performed better than DSR at higher traffic loads. Overall, the proactive protocols under study (AODV and DSR) behaved similarly in terms of delay and throughput. On the basis of this study both should be considered suitable for mobile ad-hoc networks. However, a number of differences between the protocols do exist. The source routes used by DSR give increased byte overhead compared to AODV when routes have many hops and packet rates are high. DSR is, on the other hand, efficient in finding (learning) routes in terms of the number of control packets used, and does not use periodic control messages. The simulations in this work show that DSR performs better than AODV for low traffic loads, since it discovers routes more efficiently. At higher traffic loads, however, AODV performs better than DSR due to less additional load being imposed by source routes in data packets. Lack of affective congestion control mechanism, limited resources of nodes such as bandwidth, storage and transmission range make it very difficult for protocols to handle high data rate. Average end-to-end delay of both AODV and DSR protocols was also very low. Based on the evaluations studied in this paper, we can conclude that, there is no a single protocol which gives optimum performance in all scenarios. It is especially well adapted to large networks and diverse mobility patterns. AODV on the other hand performed admirably and it would be the clear winner if not for its bad behavior in high traffic cases.

Future Directions:

For the all possible parameters, this study can be extended regarding the working of AODV and DSR. In the future, extensive complex simulations could be carried out using other existing performance metrics, in order to gain a more in-depth performance analysis of the ad hoc routing protocols. It has been further concluded that due to the dynamically changing topology and infrastructure less, decentralized characteristics, security and power awareness is hard to achieve in MANETs. Hence, security and power awareness mechanisms should be built-in features for all sorts of applications based on ad hoc network. The focus of the study is on these issues in our future research work and effort will be made to propose a solution for routing in Ad Hoc networks by tackling these core issues of secure and power aware/energy efficient routing. Some of the aspects in all previous review of research papers are still under observation as the performance is still to be compared with TORA, STAR and ZRP. More metrics like end to end delay and throughput, load and node life time is still to be taken into account. Energy and security are other concerns for the study. Work is on these directions and a sincere effort will be made to prove which protocol is best in overall performance in future.

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