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Performance Evaluation of AODV and DSR Protocols in MANET

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Abstract*— MANETs are being widely used and it is the technology that is attracting a large variety of applications. Routing in MANETs is considered a challenging task due to the unpredictable changes in the network topology, resulting from the random and frequent movement of the nodes and due to the absence of any centralized control. Efficient routing protocols can provide significant benefits to mobile Ad-Hoc networks in terms of both performance and reliability. In this paper, we evaluate the performance of two reactive routing protocols, Ad hoc On demand Distance Vector (AODV) and Dynamic Source Routing (DSR). The major goal of this study is to analyze the performance of well known MANETs routing protocol in random mobility case. Hence it becomes important to study the impact of mobility on the performance of these routing protocols. The simulation has done in NS-2 simulator and the performance is analyzed with respect to performance matrices like Average End-to-End Delay, Normalized Routing Load (NRL), Packet Delivery Fraction (PDF), and Throughput and also measures the performance of TCP and UDP packets. Simulation results verify that AODV gives better performance as compared to DSR.

***Index Terms*—MANET, Routing protocols, AODV, DSR, NS-2.**

I. INTRODUCTION

Mobile networks can be classified into infrastructure networks and Mobile Ad Hoc Networks (MANET) according to their dependence on fixed infrastructures [1]. In an infrastructure mobile network, mobile nodes have wired access points (or base stations) within their transmission range. In contrast, Mobile Ad Hoc networks are autonomously self-organized networks without support of infrastructure. In a Mobile Ad Hoc Network, nodes move arbitrarily, therefore the network may experience rapid and unpredictable topology changes. Routing paths in MANETs potentially contain multiple hops, and every node in MANET has the responsibility to act as a router. Routing in MANET [2, 3] has been a challenging task ever since the wireless 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 to accomplish this task.

Elizabeth Royer and Chai-Keong Toh wrote "A Review of Current Routing Protocols for ad hoc Mobile Wireless Networks" [3] in 1999, ad hoc networks have made significant progress. Many new classes of protocol have been developed, expanding the two main classes considered in [3], namely Source driven and Table driven protocols, to a whole collection of more specific classes. These classes are Hybrid Protocols, Geographically Aware Protocols, Clustering Protocols, Locally Repairing Protocol and Energy Efficient Protocols. The categorization of routing protocols in [3] placed a clear distinction between Source driven and Table driven protocols. With the additional classes mentioned above, the distinction between protocols is not so clear. Protocols have properties of one or more classes or ad hoc protocol. For example ZRP [11] is a Hybrid protocol and has features of both Source and Table driven protocols.

Routing is the process of selecting paths in a network along which to send data packets. 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 nearby nodes and how to reach them, and may announce that it can reach them too. The routing process usually directs forwarding on the basis of routing tables which maintain a record of the routes to various network destinations. Thus, constructing routing tables, which are held in the router's memory [2, 4] and the route establishment and data delivery are perform on the basis of routing table.

Rests of the paper is organized as follows: section 2 represents the classification of routing protocols and section 3 represents literature survey. Problem statement is described in section 4 and proposed works are in section 5.

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Simulation and results are shown in section 6, performance evaluation in 7 and at last the conclusion and future work are in section 8.

II. CLASSIFICATION OF ROUTING PROTOCOLS

In order to reliable communication within the network, a routing protocol is used which are call MANET routing protocol. The major function of such an MANET routing protocol is to establishment short and real route between a pair of nodes so that messages may be delivered in a timely manner. Classification of routing protocols in MANET's can be done in many ways, but most of these are done depending on routing strategy and network structure [3, 5]. According to the routing strategy the routing protocols can be categorized as Table-driven and source initiated, while depending on the network structure these are classified as flat routing, hierarchical routing and geographic position assisted routing [6]. Both the Table-driven and source initiated protocols come under the Flat routing see fig. given below.

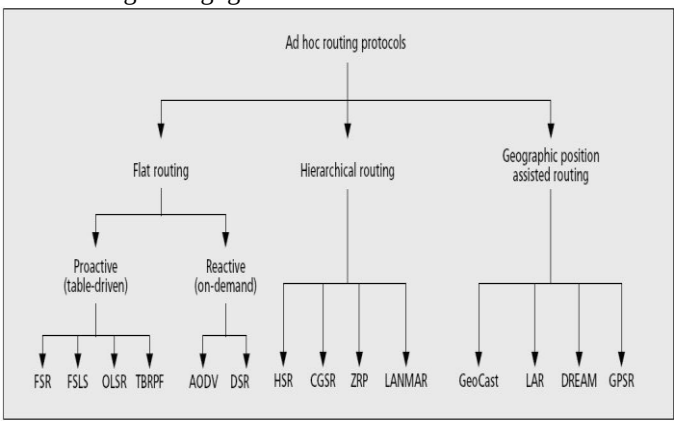

FIG 1. CLASSIFICATION OF ROUTING PROTOCOLS

A. Ad-hoc On-demand distance vector (AODV)

Reactive protocols discover routes only as needed. When a node wishes to communicate with another node, it checks with its existing information for a valid route to the destination. If one exists, the node uses that route for communication with the destination node. If not, the source node initiates a route request procedure, to which either the destination node or one of the intermediate nodes sends a reply back to the source node with a valid route [7]. A soft state is maintained for each of these routes, if the routes are not used for some period of time, the routes are considered to be no longer needed and are removed from the routing table. Example of this type algorithm is DSR and AODV.

AODV is a reactive protocol, even though it still uses characteristics of a proactive protocol [8]. AODV takes the interesting parts of DSR [9] and DSDV [3,10] in the sense that it uses the concept of route discovery and route maintenance of DSR and the concept of sequence numbers and sending of periodic hello messages from DSDV. The protocol uses different messages to discover and maintain links:
Route Requests (RREQs)
Route Replies (RREPs)
Route Error (RERR)

AODV uses a destination sequence number for each route entry. The destination sequence number is created by the destination for any route information it sends to requesting nodes. Using destination sequence numbers ensures loop freedom and allows knowing which of the available routes is fresher and requesting node always selects the one with greatest sequence number. When a node wants to find a route, it broadcasts a RREQ to all network till either destination is reached or another node is found with a „fresh enough" route to the destination. Then a RREP is sent back to the source and the discovered route is made available.

Note: Fresh Enough route is a valid route entry for the destination whose associated sequence number is at least as great as that contained in RREQ. Nodes that are part of an active route may offer connectivity information by broadcasting periodically local hello messages (special RREP messages) to its immediate neighbors.

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If hello messages stop arriving from a neighbor beyond some given time threshold, the connection is assumed to be lost. When a node detects that a route to a neighbor node is not valid it removes the routing entry and sends a RERR message to neighbors that are active and use the route; this is possible by maintaining active neighbor lists. This procedure is repeated at nodes that receive RERR messages. A source that receives an RERR can reinitiate a RREQ message.

- Advantages:

Routes are established on demand and destination sequence numbers are used to find the latest route to the destination.
Lower delay for connection setup.

- Disadvantage:

AODV doesn't allow handling unidirectional links.
Multiple Route Reply packets in response to a single Route Request packet can lead to heavy control overhead.
Periodic beaconing leads to unnecessary bandwidth consumption

B. Dynamic Source Routing (DSR)

The DSR [9, 10] network is totally self organizing and self configuring. The protocols is just compose of two mechanisms i.e. route discovery and route maintenance. The DSR regularly updates its route cache for the sake of new available easy routes. In route discovery, it has two messages i.e. route request (RREQ) and route reply (RREP). When a node wishes to send a message to a specific destination, it broadcast the RREQ packet in the network. The neighbor nodes in the broadcast range receive this RREQ message and add their own address and again rebroadcast it in the network. This RREQ message if reached to the destination, so that is the route to the specific destination. The first message reached to the destination has full information about the route. That node will send a RREP packet to the sender having complete route information. This route is considered the shortest path taken by the RREQ packet. The source node now has complete information about the route in its route cache and can starts routing of packets. The route maintenance uses two kind of messages i.e. route error (RERR) and acknowledgement (ACK). The messages successfully received by the destination nodes send an acknowledgement ACK to the sender. If there is some problem in the communication network a route error message denoted by RERR is transmitted to the sender, that there is some problem in the transmission.

- ***Advantages***

This protocol uses a reactive approach which eliminates the need to periodically flood the network with table update messages which are required in a table-driven approach. In a reactive (on-demand) approach such as this, a route is established only when it is required and hence the need to find routes to all other nodes in the network as required by the table driven approach is eliminated. The intermediate nodes also utilize the route cache information efficiently to reduce the control overhead.

- ***Disadvantages***

The disadvantage of this protocol is that the route maintenance mechanism does not locally repair a broken link. Stale route cache information could also result in inconsistencies during the route reconstruction phase. The connection setup delay is higher than in table driven protocols. Even though the protocol performs well in static and low-mobility environments, the performance degrades rapidly with increasing mobility. Also, considerable routing overhead is involved due to the source-routing mechanism employed in DSR. This routing overhead is directly proportional to the path length.

C. Difference in AODV and DSR

The main difference between DSR and AODV is in the way they keep the information about the routes: in DSR it is stored in the source while in AODV it is stored in the intermediate nodes. However, the route discovery phase of both is based on flooding. This means that all nodes in the network must participate in every discovery process, regardless of their potential in actually contributing to set up the route or not, thus increasing the network load.

III. LITERATURE SURVEY

In [12], OPNET 14.5 was used for simulation. The simulation study for MANET network under five routing protocols AODV, DSR, OLSR, TORA and GRP were deployed using FTP traffic analyzing. These protocols were tested with three QOS parameters. From their analysis, the OLSR outperforms others in both delay and throughput.

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khan et al. [13] conclude that when the MANET setup for a small amount of time, then AODV is better because of low initial packet loss. DSR is not prefers because of its packet loss. On the other hand if we have to use the MANET for a longer duration so we can use both protocols, because after sometimes both have the same behavior. AODV have very good packet receiving ratio in comparison to DSR. At the end, they concluded that the combined performance of both AODV and DSR routing protocol could be the best solution for routing in MANET.

In [14], Bindra et al. evaluate the performance of AODV and DSR routing protocol for a scenario of Group Mobility Model such as military battlefield. They used Reference Point Group Mobility (RPGM) Model for their scenario. They concluded that in Group mobility model with CBR traffic sources, AODV is better than DSR but when TCP traffic used, DSR perform better in stressful situation like high load or high mobility. DSR routing load is always less than AODV in all type of traffic. Average end-to-end delay of AODV is less than DSR in both type of traffic. Over all the performance of AODV is better than DSR in CBR traffic and real time delivery of data. But DSR perform better in TCP traffic under limitation of bandwidth.

In [15], Barakovic et al. compared performances of three routing protocols: DSDV, AODV and DSR. They analyzed these routings with different load and mobility scenarios with Network Simulator version 2 (NS-2). They concluded that in low mobility and low load scenarios, all three protocols react in a similar way, but when mobility or load is increasing, DSR outperforms AODV and DSDV.

Karthikeyan Bhagavan and Carl A Gunter [16] demonstrated the simulation analysis of Ad hoc On-demand Distance Vector (AODV) routing protocols for packet radio networks. The integrated system version consisting of a network simulator and logic based –checker for traces of events which corrects the network simulation properties has been demonstrated and showed its flexibility to improve the turn-around time in debugging.

R.S.AL Qassas [17] evaluated a Vector Routing Protocol (VRP) which lowers the communication overhead to establish a route from source to destination and proved that VRP reduced communication overhead than DSDV and AODV routing protocols. This protocol increases packet delivery ratio, routing overhead and number of routing packets.

Srdjankrco , marjna dupcinor [18] overcomed the problem of affecting the neighbor detection algorithm of the AODV protocol by significantly deteriorates network performance. All routes are established over good quality links as good neighbors only are kept in routing tables. This improves the parameters such as data throughput, decrease delays and overall user performance.

Vincent W.S.Wong [19] compared the performance of Load Balancing (LB) AODV protocol with both the original AODV and gossip based routing protocols. LB AODV delivers more data packets to the gateway and decreases the end to end delay of packets. Vincent W.S. Wong considered a mobile Ad hoc wireless access network in which the mobile nodes can access the Internet via one or more stationary gateway nodes and controlled the on-demand routing overhead by Load Balancing(LB) AODV routing protocol.

Z. Fan [20] developed a reactive routing algorithm for multirate ad hoc wireless networks which enhances the AODV protocol results in higher throughput over traditional Ad-Hoc routing protocols. The Medium Access Control (MAC) delay protocol is a very useful metric to identify congestion hot spots and measure the link interference in an Ad-Hoc network. This MAC delay protocol outperforms the old protocol mainly in low mobility scenarios. The significance of the routing protocol is to find the least cost path from the source to the destination.

Nianjun Zhou and Huaming Wu [21] presented a mathematical and simulative framework for quantifying the overhead of reactive routing protocols such as dynamic source routing and ad hoc on-demand distance vector routing in wireless topology networks. The effect of traffic on routing has been studied and the result is possible to design infinite reactive routing protocol for variable.

IV. PROBLEM STATEMENT

A lot of competitive research is going on to find optimal solutions for MANET routing protocols. The

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challenges in this field are to design an effective routing protocol that responds to dynamic changes in node connectivity and works at low data rates. The primary concerns of ad-hoc routing protocols remain connectivity and reduced control overhead. Proactive routing protocols use different techniques to minimize their control overhead and achieve higher throughput.

V. PROPOSED WORK

This paper examines two routing protocols for mobile ad hoc networks. the Dynamic Source Routing (DSR), the table driven protocol and the Ad hoc On- Demand Distance Vector routing (AODV), an On–Demand protocol. It evaluates both protocols based on packet delivery fraction, average delay and throughput while varying number of nodes and pause time using NS-2 (Network Simulator). Traffic pattern and node mobility is generated using ns-2 utility and network performance is measures on the basis of performance metrics.

VI. SIMULATION ENVIRONMENT AND RESULTS

Network Simulator version 2 (ns-2) is an object-oriented discrete event-driven network simulator. Computation delays do not affect the simulation parameters and metrics, which is a major benefit of discrete event simulators. The internal workings of ns-2 are documented in [22]. In ns-2 the various network components are designed as class objects called agents. These include the routing agent, application agent, channel agents and so forth. Based on the simulation setup ns-2 links the various agents (called plumbing in ns-2) to create a complete network.

A. Simulation Parameters

Table 1 represents the following simulation parameters to make the scenario of routing protocols.

Simulation Parameters

Simulator Used	NS-2.31
Number of nodes	10,50
Dimension of simulated area	800m×600m
Routing Protocol	AODV and DSR
Simulation time	100 sec.
Traffic type (TCP & UDP)	CBR (3pkts/s)
Packet size	512 bytes
Number of traffic connections	5,30
Node movement at maximum Speed	random (30 m/s)
Transmission range	250m

B. Performance Evaluation

The performance of AODV and DSR are measures on the basis of following performance matrices.

- Packet Delivery Percentage:

The ratio of total application data received at the destination and the application data sent from the source gives the packet delivery ratio.

- End-to-End Delay:

This is measured as the time delay between the application layer packet sent at the source node to the destination node. This metric describes the packet delivery time. The lower the end-to-end delay the better the application performance.

- Routing Overhead:

The bandwidth consumed by all the control packets of the routing protocol is measured as control packet overhead. This quantity helps to determine the scalability of a given routing protocol.

- Throughput

The number of packets sends in per unit of time. A lower control packet overhead with a higher throughput is a much desired optimization in MANETs.

The present simulation environment each of the above metrics is averaged over all of the nodes in the network.

C. Result

Packet Delivery Analysis

This graph represents the Packet Delivery Ratio (PDR) in case of AODV and DSR routing protocols. Here we clearly visualized that in case of AODV protocol the PDF is high it means that this protocol has gives the better

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result as compare to DSR protocol. Now at start time the performance of both the routing protocol are same because the nodes are not mobile at that time. But at time about 10 sec. the performance of DSR protocol, are more due to their routing mechanism but after time about 20 sec. the performance of AODV protocol are enhanced up to simulation time of 100 sec. due to the on demand mechanism. Now in case of AODV protocol the PDR is more of about 93% and DSR is about 87%, it means that the performance of AODV in terms of PDR are 6% more.

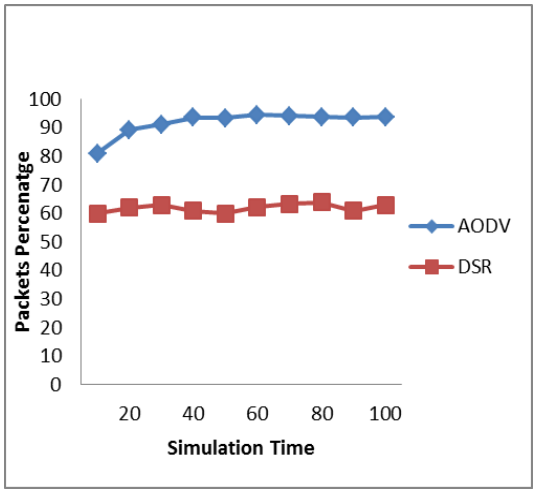

Fig 2. PDR Analysis of AODV and DSR

Routing Packets Analysis

This graph represents the number of routing packets or connection establishment packets are delivering by AODV and DSR protocol in network. Here we clearly visualized that the number of routing packets are deliver by ADV protocol are more. It means that the routing load in case of AODV protocol is more, but in summery section table 2 the normal routing load of DSR is more, it means that the more number of data packets are deliver in network in case of AODV protocol as compare to DSR protocol more number of packets are received that are shown in fig. 3Then here the conclusion is that if the AODV has deliver more routing packets then it also deliver more data packets as compare to DSR. Now if count the Normal Routing Load (NRL) of both the protocol then DSR protocol routing load is more.

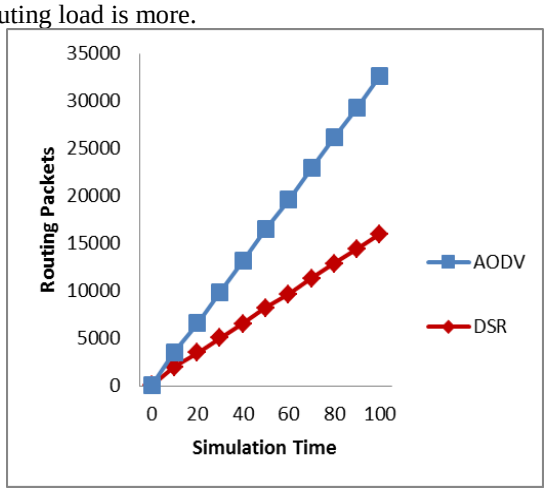

Fig 3. Routing Packets Analysis of AODV and DSR

Packets Received Analysis

This graph represents the packet received analysis in case in case of AODV and DSR routing protocol. Here we clearly visualized that in case of AODV routing protocol about 2000 User Datagram Packets (UDP) packets are deliver in network within a particular simulation time. But in case of DSR protocol about the 1700 UDP packets are deliver in network. It means about 300 more packets are deliver in case of AODV protocol in network. UDP

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packets are not the reliable packets in network because it is connection less mechanism of connection establishment. Then in case of UDP no confirmation is delivering to sender about the successful data delivery. The more number of packets are delivering in case of AODV protocol it means that the AODV protocol is more reliable than DSR protocol.

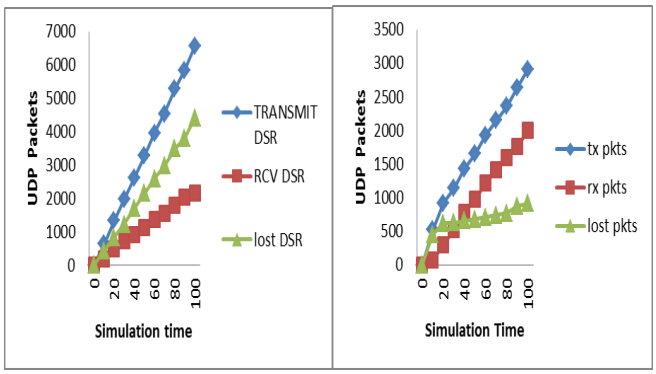

Fig 4. UDP Packet Received Analysis of DSR and AODV Routing Protocol

Throughput Analysis

Throughput is the one of the important performance parameter to measures the performance of any routing protocol in network. Good Throughput is depend on the number of packets send or received in per unit of time in network. In this graph clearly represents that, in case of AODV protocol throughput is high as compare to DSR protocol. Here in case of AODV routing protocol highest number of packets send or received in per unit of time are about 1100 packets but in case of DSR routing protocol only 800 packets are send or received in network. It means that the routing mechanism of AODV protocol is better as compare to DSR protocol.

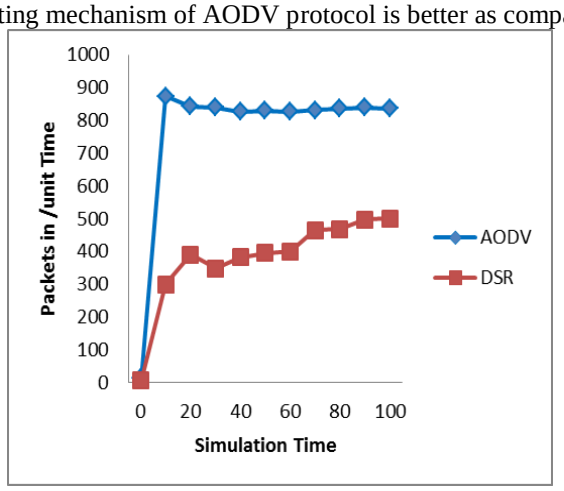

Fig 5. Throughput Analysis of AODV and DSR

TCP Congestion Window Analysis

TCP (Transmission Control Protocol) is a connection oriented protocol for reliable communication in network. The main advantage of this protocol is without receiving acknowledgement from receiver sender is not transmit the next number of packets. If receives then again transmit number of packets according to window size. In comparison graphs 6, 7 and 8 sent, received and dropped packet analysis has been given for TCP.

where we clearly visualized that in case of AODV routing protocol highest number of TCP packets are transmitted as compared to DSR routing protocol and after that the window size of DSR protocol is very high in given simulation time. In AODV protocol the window size are not too high and packets are successfully delivered.

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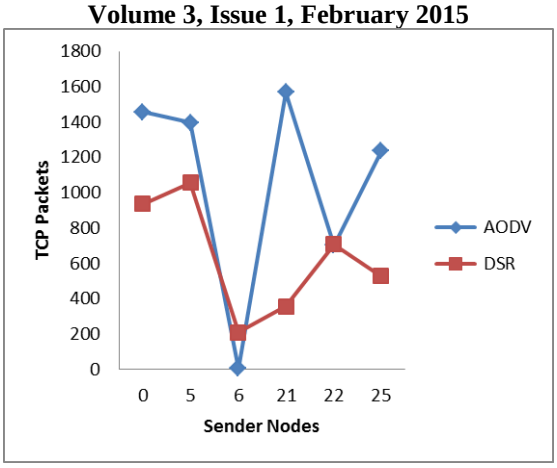

Fig 6. TCP sent packet Analysis of AODV and DSR

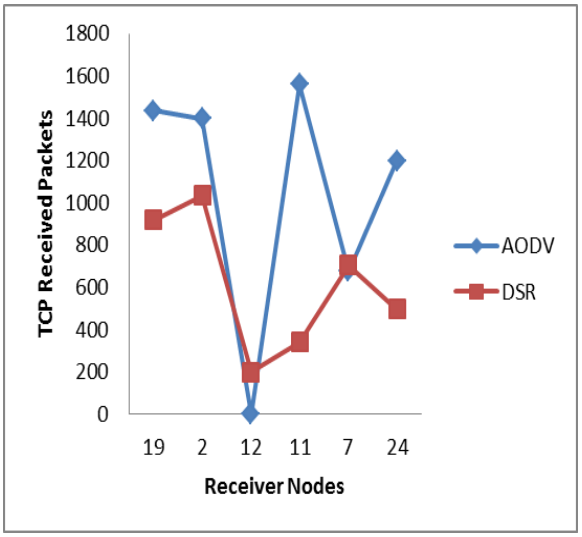

Fig 7. TCP received packet analysis

Now if we visualized this graph the observation about the highest number of packets delivered in network by AODV. TCP received packet analysis is shown in fig 7.Which is again better with AODV and it can be clearly stated that in AODV protocol nodes receive more packets with lesser number of dropped packets.

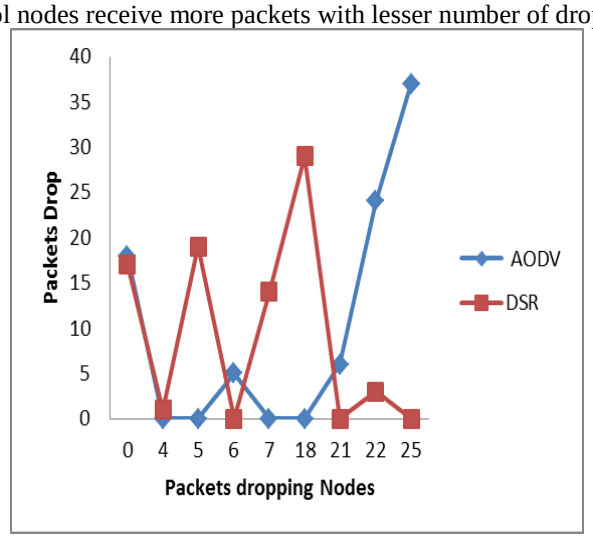

Fig 8. TCP dropped packet analysis

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It is clear from fig that DSR causes more data to be dropped. Though individually, in AODV node 25 has dropped maximum number of packets but overall performance regarding packet drop is good as it manages to transmit packets more than DSR.

In TCP, the packets are sent, only when the sender receives the acknowledgement. This feature makes TCP protocol more reliable. For AODV, ack packets are received by nodes are more than that of DSR .

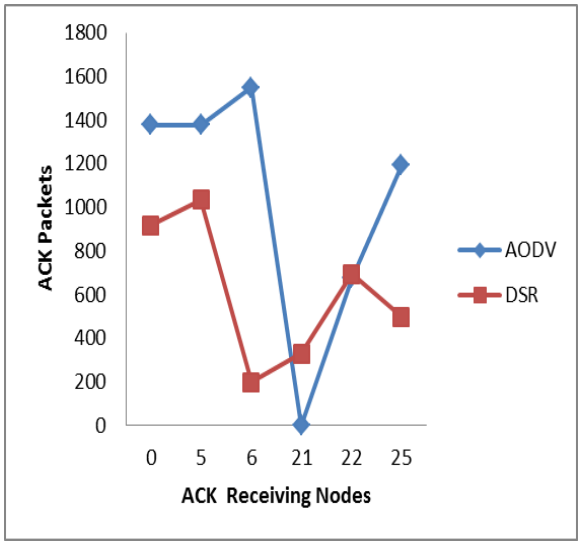

Fig 9. Received ACK analysis

UDP Packet analysis of AODV routing protocol

Due to the connection less behavior, UDP packets delivery are unreliable and if in the network the percentage of UDP packets receiving in network are more than the performance of routing protocol it means the procedure of routing protocol very reliable for communication. In this table we observe that only 484 packets are delivering in network and 2001 are received in network and the node that drop these packets are node 18.

UDP Packet Analysis of AODV Routing Protocol

Sender Node	Total UDP Packets Sends	Receiver Node	Total UDP Packets Receives	Drop Node	Total UDP Pkt. Drop
18	2179	3	277	18	454
20	278	10	1724		
Total Pkts. sends	2457	Total Pkts. Receive	2001	Total Pkts. Drop	454

UDP Packet analysis of AODV routing protocol

This table represents the UDP packets drop analysis. Here we clearly visualized that here 771 packets are drop in network out of 2457 packets. Now here the numbers of nodes in the network are more as compare to AODV protocol that drop the number of packets in network. It means that the performance of AODV is better than DSR protocol.

UDP Packet analysis of DSR Protocol

Sender Node	Total UDP Packets	Receiver Node	Total UDP Packets	Drop Node	Total UDP Pkt.

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	Sends		Receives		Drop
18	2179	3	148	1	1
20	278	10	1534	11	5
-	-	-	-	18	700
-	-	-	-	19	60
-	-	-	-	20	5
Total Pkts. sends	2457	Total Pkts. Receive	1682	Total Pkts. Drop	771

VII.CONCLUSION AND FUTURE WORK

The goal of this performance evaluation is a comparison of a MANET between AODV and DSR routing protocols. AODV in the simulation experiment shows the overall best performance. A TCP and UDP packet Table 2 and Table 3 represents a performance of protocol. In this evolution the numbers of efforts are on to simulate the two schemes w.r.t. end to end delay and throughput as well. It has been further observed that due to the dynamically changing topology and infrastructure less and decentralized characteristics are hard to achieve in mobile ad hoc networks. In this paper we observed DSR working better than AODV in constrained situation of several CBR traffic sources leading to same destination in the mobile communicating nodes. Now at last the overall summer (table 6) represents the performance of both the protocol. On the basis of performance matrices we observe that the performance of AODV protocol is better in random mobility scenario as compare the DSR protocol.

Now, security and power awareness mechanisms are the major issue in ad hoc network. The focus of the study is on these issues in the 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.

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