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Design and Analysis of QOS Based Secure On-Demand Routing in Multi-Hop Wireless Mobile Ad Hoc Networks

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Abstract: The research paper is to find a new on-demand stable and secure routing protocol, using five performance metrics for packet delivery fraction, end to end delay throughput, and routing load packet loss. The approach includes simulation based implementation of routing protocols to study the operational performance of different routing protocols. It discusses the implementation of one table driven protocol (DSDV) and two on-demand routing protocols (DSR, AODV) in the first phase followed by implementation of multipath on-demand protocol AOMDV and compared with unipath protocol AODV in the next phase. In addition, when the malicious nodes enter into the network, various performance metrics begin the efforts can be made in the direction of improving hash functions to avoid collisions, using stronger hash keys by making them dependent on additional parameters like biometric credentials, passwords, IP addresses etc. the ultimate goal for ad-hoc network security is to develop against both known and unknown security threats.

Keywords: Wireless Sensor networks, Design issues, Routing protocols, Applications

I. INTRODUCTION

As our study expose Mobile ad-hoc networking environment contains special challenges, such as lack of permanent infrastructure, high level of heterogeneity, mobility of devices, resource constraints and unreliable communication. Therefore, provisioning services require special systems designed for such environments. QoS issues in MANET and nature of MANET traffic network, performance analysis and security issues currently pertaining to MANET are discussed. A detailed study of network traffic and various congestion-based situations are analyzed. An analysis of congestion avoidance schemes like DiffServ (Hannon Xioa et al 2000), AODV (Perkins 2001), TORA (Park and Corson 1997), are schemes used to manage real-time traffic in MANET networks The present research work involves implementing of four routing protocols namely DSDV (Table driven), DSR, AODV and AOMDV (On-demand), and the comprehensive analysis of unipath on demand routing protocols like DSR, AODV and multipath on-demand routing protocol like AOMDV using NS-2 (version NS-2.31) simulator.

II. PERFORMANCE EVALUATION METRICS FOR NETWORK TRAFFIC

1. Throughput:

Throughput is the measure of sent packets through the number of packets delivered to the receiver provides the throughput of the network. The throughput is defined as the total amount of data a receiver actually receives from the sender divided by the time it takes for receiver to get the last packet [17].

$$\text{Throughput} = Pr/Pf$$

Where Pr is the total number of Received Packets and Pf is the total number of Forwarded Packets. [17].

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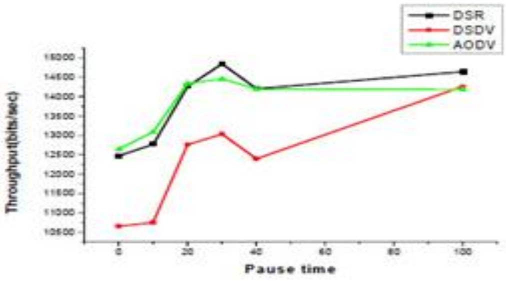
Pause Time Vs Throughput (bits/sec)

Pause time (sec)	Throughput (bits/sec)		
	DSR	DSDV	AODV
0	12472	10657	12642
10	12769	10749	13082
20	14261	12756	14343
30	14841	13032	14452
40	14203	12391	14187
100	14641	14254	14181



Pause Time Vs Throughput

2. ***Packets Dropped*:**

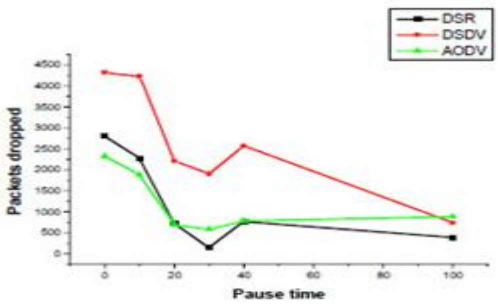
Some of the packets generated by the source will get dropped in the network due to high mobility of the nodes, congestion of the network etc.

Packet Loss % = (1-Pr/Ps)*100

Where Pr is total number of Received Packets and Ps is total number of Sent Packets.

Pause Time Vs Packets Dropped

Pause time (sec)	Packets Dropped		
	DSR	DSDV	AODV
0	2805	4319	2328
10	2270	4224	1884
20	720	2206	692
30	148	1898	584
40	769	2566	783
100	386	736	885



Pause Time Vs Packets Dropped

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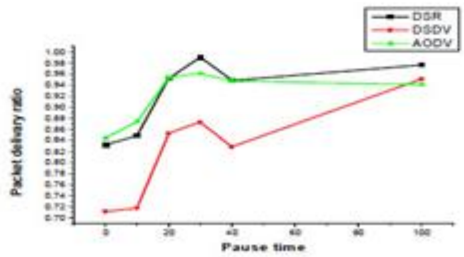
3. Packet Delivery Ratio

The ratio of the data packets delivered to the destinations to those generated by the CBR sources. It is the fraction of packets sent by the application that are received by the receivers [23].

Pause Time Vs Packet Delivery Ratio

Pause time (sec)	Packet Delivery Ratio		
	DSR	DSDV	AODV
0	0.8324	0.71163	0.84454
10	0.84911	0.71792	0.87416
20	0.952	0.85261	0.95403
30	0.99019	0.87292	0.96122
40	0.94869	0.82849	0.94776
100	0.97698	0.95096	0.94131

PDF = (PR/PS)*100

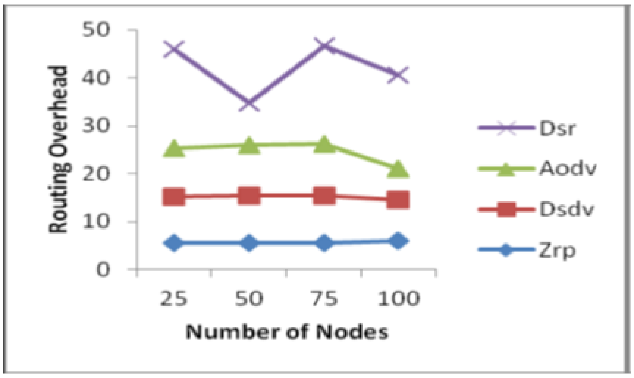


Pause Time Vs Packet Delivery Ratio

It is calculated by dividing the number of packet received by destination through the number packet originated from source. Where Pr is total Packet received & Ps is the total Packet sent.

4. Normalized Routing Overhead:

The number of routing packets transmitted per data packet delivered at the destination. Each hop-wise transmission of a routing packet is counted as one transmission. The routing overhead describes how many routing packets for route discovery and route maintenance need to be sent in order to propagate the data packets [25].



Overhead = number of RTR packets (or)
NRL = Routing Packet/Received Packets

Pause Time Vs End-to-End Delay

Pause time (sec)	End-to-End delay		
	DSR	DSDV	AODV
0	0.01492	0.01448	0.01493
10	0.02120	0.01922	0.02442
20	0.02345	0.02033	0.02374
30	0.01815	0.01598	0.01669
40	0.02623	0.025	0.02722
100	0.03292	0.03092	0.03498

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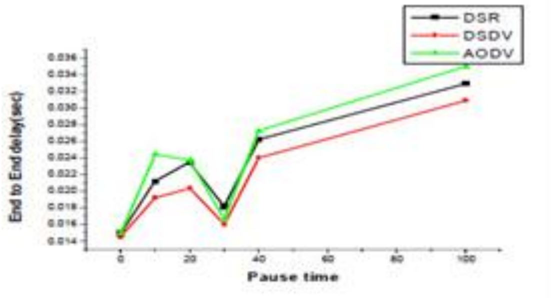

Pause Time Vs End-to-End Delay

5. *End-to-End Delay:*

End-to-End delay indicates how long it took for a packet to travel from the source to the application layer of the destination. [65]. i.e. the total time taken by each packet to reach the destination. Average End-to-End delay of data packets includes all possible delays caused by buffering during route discovery, queuing delay at the interface, retransmission delays at the MAC, propagation and transfer times.

D = (Tr –Ts)

Where Tr is receive Time and Ts is sent Time.

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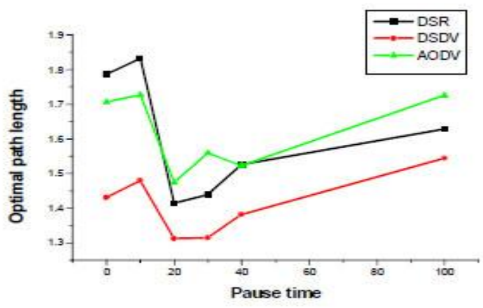
Where Tr is receive Time and Ts is sent Time.

6. *Optimal Path Length :*

Pause Time Vs Optimal Path Length

Pause time (sec)	Optimal Path Length		
	DSR	DSDV	AODV
0	1.78615	1.43066	1.70628
10	1.83209	1.47935	1.72687
20	1.4137	1.31173	1.47379
30	1.43930	1.31457	1.55866
40	1.52515	1.38126	1.52317
100	1.62812	1.54367	1.72510



Pause Time Vs Optimal Path Length

It is the ratio of total forwarding times (depends on number of hops) to the total number of received packets. Optimal path length increases as the number of hops on optimal path increases.

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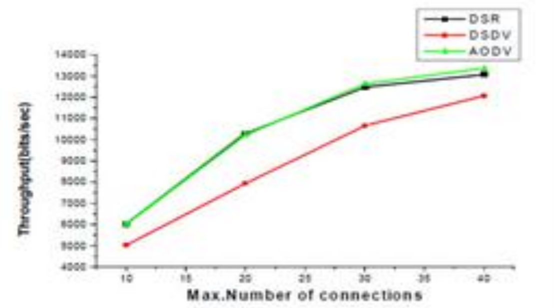
III. Effect Of Traffic Load Based On Simulation Results

To study the effect of traffic load on the network, number of connections was varied as 10, 20, 30 and 40 connections.

Max. Number of Connections Vs Throughput (Bits/Sec)

Max. Number of Connections	Throughput		
	DSR	DSDV	AODV
10	6031	5033	6015
20	10299	7937	10223
30	12471	10656	12641
40	13070	12067	13354



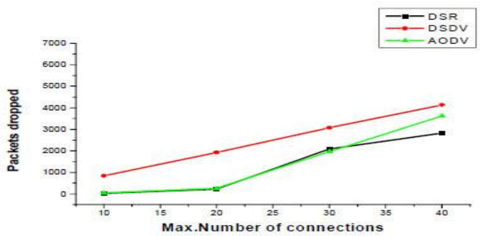
Max. Number of Connections Vs Throughput (bits/Sec)

AOMDV outperforms AODV in all traffic conditions. The reason is AOMDV always maintains multiple paths between source and destination; traffic gets distributed among the multiple paths to achieve load balancing and bandwidth aggregation.

Packets Dropped

Max. Number of Connections Vs Packets Dropped

Max. Number of Connections	Packets Dropped		
	DSR	DSDV	AODV
10	19	843	47
20	225	1930	261
30	2092	3074	1967
40	2830	4139	3627

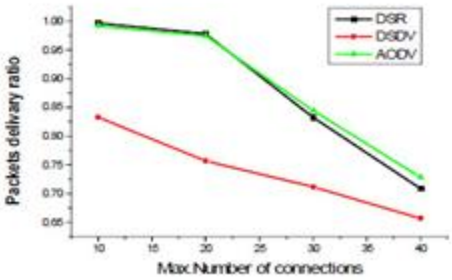


Max. Number of Connections Vs Packets Dropped

Packet Delivery Ratio

Max. Number of Connections Vs Packet Delivery Ratio

Max. Number of Connections	Packet Delivery Ratio		
	DSR	DSDV	AODV
10	0.99703	0.83287	0.99242
20	0.97835	0.75707	0.97468
30	0.8325	0.71166	0.84455
40	0.70837	0.65715	0.72854



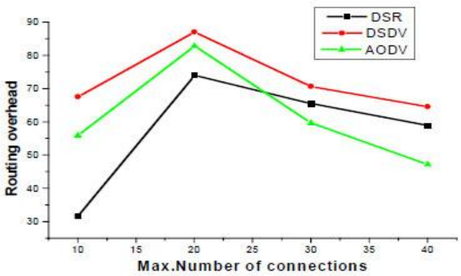
Max. Number of Connections Vs Packet Delivery Ratio

AODV and DSR to build the routing information as and when they are required to send data. This makes them more adaptive and results in better performance with respective to high packet delivery fraction. AODV delivers more packets at high traffic load compared to DSR.

Routing Overhead

Max. Number of Connections Vs Routing Overhead

Max. Number of Connections	Routing Overhead		
	DSR	DSDV	AODV
10	31.60854	67.5907	55.89838
20	73.98120	87.03740	82.86778
30	65.43854	70.64646	59.64726
40	58.88029	64.5658	47.21769



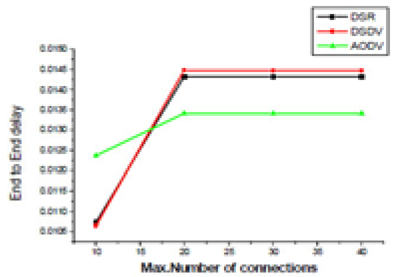
Max. Number of Connections Vs Routing Overhead

Periodic broadcasts of control packets of DSDV increase routing load in the network and hence DSDV has more routing overhead irrespective traffic load. Further this worsens with increasing number of node. Even understand still condition of network DSDV keeps on sending periodic updates at regular intervals among the nodes. AODV performs better at high traffic since it computes route as and when needed and it adapts hop-by-hop routing. However DSR performs better at low and moderate sized traffic load because it uses source routing and the length of packet header will not be too large at low and moderate sized traffic.

End-to-End Delay

Max. Number of Connections Vs End to End Delay (Sec)

Max. Number of Connections	End-to-End Delay		
	DSR	DSDV	AODV
10	0.01074	0.01065	0.01238
20	0.01433	0.01448	0.01349
30	0.01433	0.01448	0.01342
40	0.01433	0.01448	0.01342



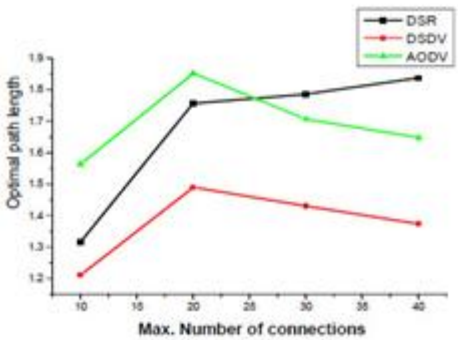
Max. Number of Connections Vs End to End Delay (Sec)

As DSDV always holds optimal paths to all other destinations in their routing tables, delay involved in sending data packets at lower traffic load is very less. As traffic load increases AODV performs better as it adopts hop-by-hop routing. DSR performs better at lower and moderate traffic load as it uses source routing.

Optimal Path Length

Max. Number of Connections Vs Optimal Path Length

Max. Number of Connections	Optimal Path Length		
	DSR	DSDV	AODV
10	1.31704	1.21122	1.56327
20	1.75623	1.48924	1.8525
30	1.78615	1.43066	1.70628
40	1.83723	1.37384	1.64813



Max. Number of Connections Vs Optimal Path Length

Optimal path length varies as the traffic load varies. DSDV performs better in terms of optimal path irrespective of variation in traffic load as the nodes in DSDV always hold the optimal path to every other destination in their routing tables and the routing table is periodically updated. Optimal path length of DSR is less compared to AODV at moderate traffic, but at high traffic DSR has a more optimal path length compared to AODV. This is due to probable number of hops go high with increasing traffic.

IV. Comparison of Results of AODV (Unipath) and AOMDV (Multi-Path) On-Demand Protocols Based On Simulation Result

To analyze the effect of mobility, pause time was varied from 0 seconds (high mobility) to 100 seconds (no mobility). The numbers of nodes are taken as 50 and the maximum number of connection as 20.

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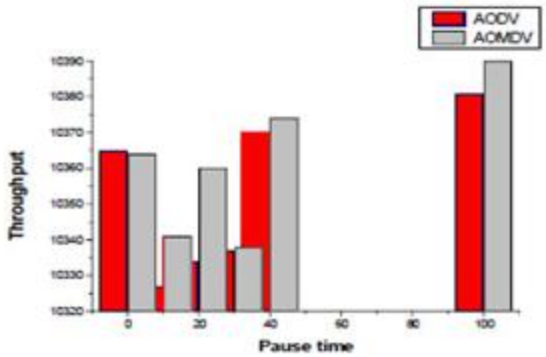
Throughput:

Pause Time Vs Throughput (Bits/Sec)

Pause time (sec)	Throughput	
	AODV	AOMDV
0	10366	10365
10	10328	10342
20	10335	10361
30	10338	10339
40	10371	10375
100	10382	10391



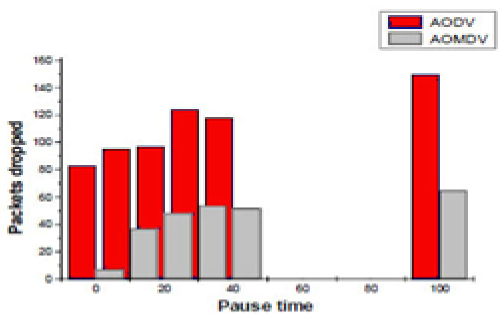
Pause Time Vs Throughput (bits/Sec)

Due to several inherent properties of AOMDV like Load Balancing and Bandwidth Aggregation, AOMDV always outperforms AODV. When a link becomes over utilized and causes congestion, AOMDV can choose to divert traffic through alternate paths and hence throughput increases.

Packets dropped

Pause Time Vs Packets Dropped

Pause time (sec)	Packets Dropped	
	AODV	AOMDV
0	84	8
10	96	38
20	98	49
30	125	55
40	119	53
100	151	66



Pause Time Vs Packets Dropped

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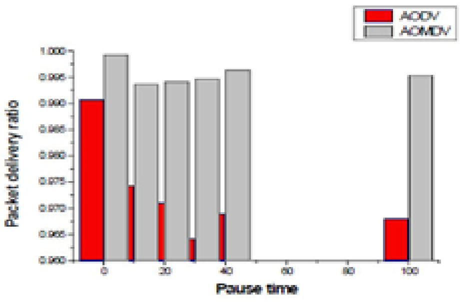
The packet dropped varies with mobility. Number of packets dropped in AOMDV is always less compared to AODV. Multipath nature of AOMDV attributes to less packet drop.

Packet delivery ratio

Pause Time Vs Packet Delivery Ratio

Pause time (sec)	Packet Delivery Ratio	
	AODV	AOMDV
0	0.99084	0.99934
10	0.97429	0.99372
20	0.97117	0.99420
30	0.96421	0.99479
40	0.96900	0.99644
100	0.96813	0.99539



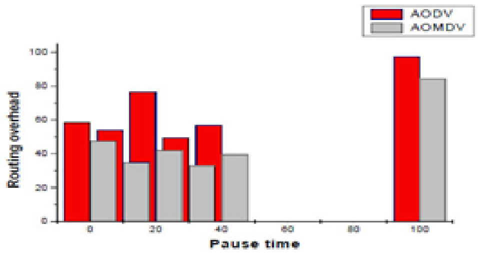
Pause Time Vs Packet Delivery Ratio

Packet delivery ratio in AOMDV is always more, due to availability of multiple paths as compared to AODV irrespective of variation in mobility. When a link becomes over utilized resulting into congestion or failures, multipath routing protocols can divert traffic through alternate paths

Routing overhead:

Pause Time Vs Routing Overhead

Pause time (sec)	Routing Overhead	
	AODV	AOMDV
0	58.54318	47.7036
10	53.78136	34.9193
20	76.5048	42.25950
30	49.3754	32.9055
40	57.29027	39.7950
100	97.378	84.4295



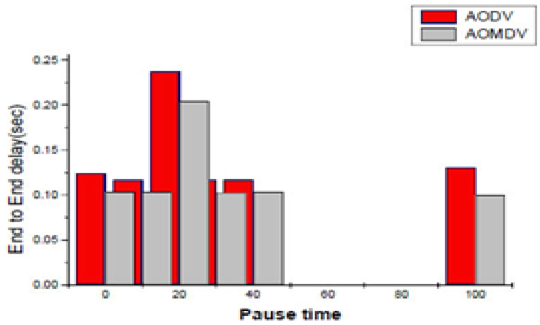
Pause Time Vs Routing Overhead

Routing overhead in AOMDV is less compared to AODV, because the frequency of route discovery is less in AOMDV as multiple routes are always available. New route discovery is needed only when the entire link-disjoint paths fails. The probability such situation is very less.

End-to-End Delay (sec):

Pause Time Vs End-to-End Delay (Sec)

Pause time (sec)	End-to-End Delay (Sec)	
	AODV	AOMDV
0	0.12442	0.10383
10	0.11664	0.10364
20	0.23726	0.20437
30	0.11664	0.10296
40	0.11722	0.10352
100	0.13098	0.10018



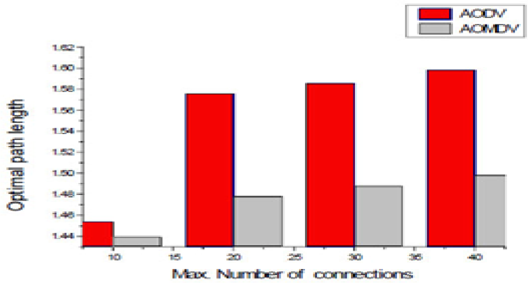
Pause Time Vs End-to-End Delay

AOMDV protocol is designed to adopt multiple paths architecture of network,which is a step towards achieving a high QoS, and hence delay involved in sending a data packets is less compared to AODV.

Optimal Path Length

Number of Connections Vs Optimal Path Length

Max. Number of Connections	Optimal Path Length	
	AODV	AOMDV
10	1.45392	1.43944
20	1.57584	1.47816
30	1.58584	1.48816
40	1.59859	1.49816



Max. Number of Connections Vs Optimal Path Length

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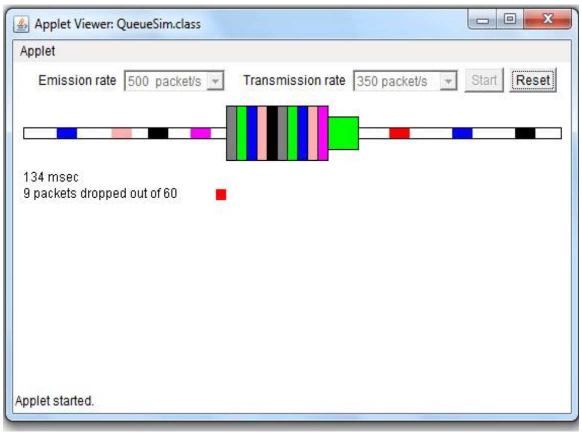
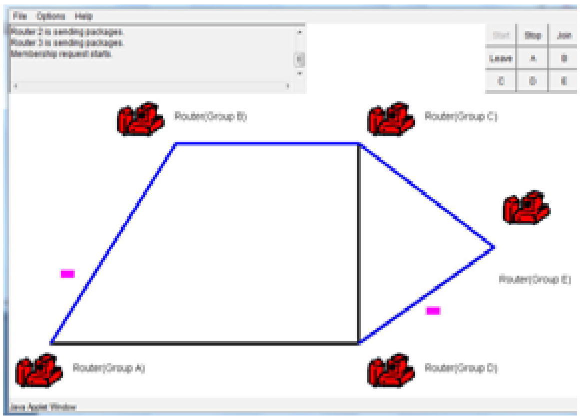
The optimal path length in terms of number of hops present across the route between sauce and destination is less in AOMDV irrespective of variations in traffic load due to availability of best optimal paths among the multiple paths in AOMDV.

V. Summary Of Result Analysis

The presence of high mobility implies frequent DSDV fails to converge at lower pause time, hence performance of the protocol decreases as mobility increases. At higher rates of mobility (lower pause times), DSDV performs poorly dropping more number of packets. As DSDV maintains only one route per destination, each packet that the MAC layer is unable to deliver is dropped since there are no alternate routes. For DSR and AODV, packet delivery ratio is independent of offered traffic load, with both protocols delivering between 82% and 100% of the packets in all cases. The reason for having better packet delivery ratio of DSR and AODV is that both allow packets to stay in the send buffer for 30 seconds for route discovery and once the route is discovered, data packets are sent on that route to be delivered at the destination. To achieve lower routing overhead, better throughput, lower end-to-end delay, to be more resilient to route failures and alleviate congestion for robust scenario where mobility is high, nodes are dense and traffic is more, AOMDV is the best choice. The overall conclusion is that a multipath routing protocol, AOMDV is best choice to move towards a network with better Quality of Service (QoS).





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