A COMPARATIVE ANALYSIS ON ROUTING PROTOCOLS OF MOBILE AD HOC NETWORK

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ABSTRACT

In this modern era, Mobile Ad hoc Network (MANET) is widely used for its mobility and self-configuring features. Hence, a better security approach is needed for maintaining high level network performance in mobile ad hoc network. This paper presents the comparative analysis of quality of service (QoS) of MANET protocols. In this regard, three types of most widely used protocols, named, Ad hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Optimized Link State Routing Protocol (OLSR) have been used to analyze. Therefore, AODV is selected in distributed ad hoc setting for the path discovery. Also, AODV is a reactive improvement of Dynamic Destination Sequence Vector (DSDV) protocol. On the other hand, the number of route broadcast is decreased by source routes on demand in AODV, which is opposite of DSDV algorithm. In this research, the quality of service parameters of network paths are also included to develop trust in the links to defend from various attacks. Moreover, a comparative analysis of delay, congestion, packet losses, transit time between source and destination is illustrated on AODV and DSR. In simulation time, packet drop-outs and link failures for probe packets are examined and analyzed under network attack.

KEYWORDS

MANET, ADOV, DSDV, OLSR, Routing Protocol.

1. INTRODUCTION

Ad-hoc mobile nodes are free to move that's why there is no specific network topology.   A numbers of routing protocols designed for mobile ad-hoc network to maintain communication among mobile nodes [2]. There are different types of routing protocol- proactive, reactive and hybrid. The objective of this dissertation is to analysis performance of different routing protocols for Mobile Ad-Hoc Networks. Most popular routing protocols are AODV, DSR and OLSR.

Nowadays mobile ad-hoc networks have been growing rapidly according to availability of new generation mobile devices. Since the characteristics of MANET- nodes are mobile. So protocol performance is key issue for any mobile ad-hoc network. In a mobile ad-hoc network implementation of high performance mobile routing protocol is very essential to get better network performance. Ad-hoc network are decentralized and each mobile node can acts as a host and router to communicate with other node.

The aim of this research is to investigate the characteristics of mobile ad-hoc network protocols specially Ad-hoc On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR) and improve their quality of service in several situations. Also Compare to Optimize Link state routing protocols (OLSR) in different mobile ad-hoc network scenarios.

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In this regard, OPNET is applied to design different mobile ad-hoc network scenarios like node mobility, network load and node density by using popular mobile routing protocols (AODV, DSR, OLSR).

Then it is required to collect OPNET simulated data from different designed network scenarios and analyze simulated data considering MANET routing protocol metrics.

2. METHODOLOGY

To evaluate performance of different routing protocol following metrics are considered [3]

2.1. Average End-to-end Delay

Average end-to-end delay defines how long it takes for an entire message to completely arrive at the destination from the time the first bit is sent out from the source. It is average of latency for route discovery, interface queues, propagation delay and retransmission delay. [1]

2.2. Routing Overhead

Routing overhead is ratio between the numbers of routing packet transmitted for simulation and number of data packet transmitted. [3] This ratio indicates the number of routing control packets required for each data packet transmission.

2.3. Throughput

Throughput is the average rate of successful packet delivery from source to destination during simulation [3].

2.4. Network Load :

Network load indicates the utilization of link capacity between mobile nodes (amount of traffic or packets/sec passing through it) [3]. If metric value of network load changes very frequently, then it can affect overall mobile network performance.

The goal of this paper is performance analysis of different routing protocols for Mobile Ad-Hoc Networks in different network scenarios. Three types of network metric are used, that is, Network mobility, Network load and Node density, to evaluate routing performance. AODV, DSR and OLSR protocols are considering here for each network scenario. In this project, total 36 scenarios are designed for AODV, DSR and OLSR protocol where the simulation time for each scenario is about 3600 second.

For each protocol (AODV, DSR, OLSR) 12 scenarios- Mobility (10m/sec, 20m/sec, 30m/sec and 40m/sec), Network load (512 bit/sec, 1024 bit/sec, 1536 bit/sec and 2048 bit/sec) and Node density (N15, N20, N25 and N30).

Each scenario for node mobility and network load containing 20 nodes. Since mobility is the fundamental basis of mobile ad-hoc network. Random waypoint used here for define mobility speed (10m/sec, 20m/sec, 30m/sec and 40m/sec) and node mobility rectangular dimensional area is 1400m x 1200m. Packet size for all node mobility scenarios are 1024 bits/sec and packet rate 5 packet/sec.

To evaluate performance of network load, MANET traffic generation parameter used here for define different packet size (512bits/sec, 1024bits/sec, 1536bits/sec and 2048bits/sec). Packet inter arrival time (sec) is exp (0.2) and packet rate 5 packet/sec.

To evaluate performance of node density one node density scenario duplicated into 3 scenarios (N15, N20, N25 and N30). Packet size for all node density scenarios are 1024 bits/sec and packet rate 5 packet/sec.

3. EXPERIMENTAL RESULTS

There are three types of network scenarios with different parameter designed for simulation. All together 36 scenarios are designed here with different metric values. Node mobility scenarios consider different movement speeds such as 10m/sec, 20m/sec, 30m/sec and 40m/sec. Network load scenarios consider different packet size such as 512bits/sec, 1024bits/sec, 1536bits/sec and 2048bits/sec. Node density scenarios consider different network size such as 15 nodes, 20 nodes, 25 nodes and 30 nodes. All scenarios simulation time is 3600 seconds.

Illustrative discussion between three types of routing protocol according to node mobility, load and density has been given below:
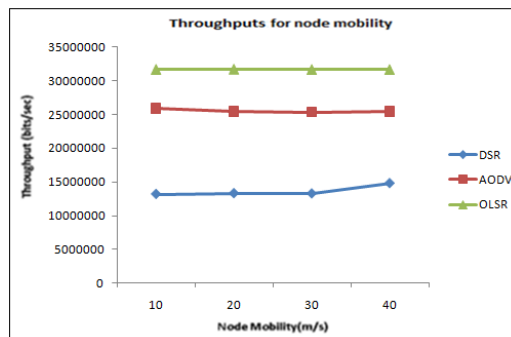
3.1. Node Mobility Throughput

Figure 1. Spam traffic sample

Table 1. Throughputs of Node Mobility

Meter/second	DSR	AODV	OLSR
10	13194613	25918050	31698811
20	13313627	25438436	31725779
30	13271109	25337785	31684856
40	14791561	25429430	31675822

Node mobility is basic characteristics of mobile ad-hoc network. The above graph in Figure 1 presenting the node mobility scenarios throughputs of selected routing protocols (AODV, OLSR and DSR).   Proactive protocol OLSR shows highest throughput performance among other protocols and DSR showing lowest throughput performance. Since OLSR protocol is table 1 driven and uses multi-point relay broadcast, so it can provides better throughput. AODV protocol capable to form tree to multicast routing so, its performance is good compare with DSR. Since

DSR is a proactive protocol and uses route discovery process to reach destination, its throughput level is not good for communication latency. OLSR and AODV exchange 'Hello' messages to keep stable connectivity with next hop neighbour nodes.
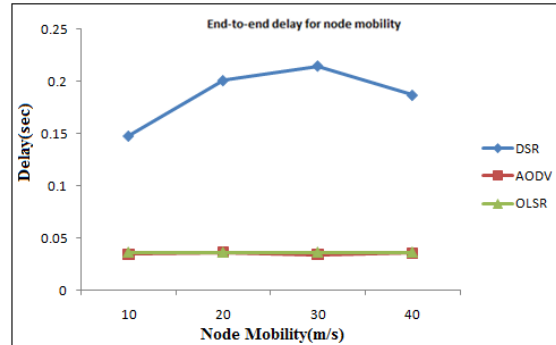
3.2. Node Mobility End-to-end Delay

Figure 2. End-to-end delays for node mobility

Table 2. End-to-end delays for different node mobility speed

Meter/second	DSR	AODV	OLSR
10	0.14764	0.034692	0.036385
20	0.200927	0.036432	0.036459
30	0.214962	0.034284	0.036464
40	0.186824	0.03591	0.036528

The above graph in Figure 2 presenting node mobility's end-to-end delays for selected routing protocols. OLSR and AODV introducing end-to-end delay between 45-50 milliseconds for different node mobility speed. DSR introducing higher end-to-end delay (150 milliseconds) compare than other routing protocols and end-to-end delay increasing according to change of mobility speed.   Since AODV protocol is proactive and capable to form tree for multicast routing, it can exchange routing information faster than DSR. OLSR also capable for multi-point relay and introduce less delay for exchange routing information.
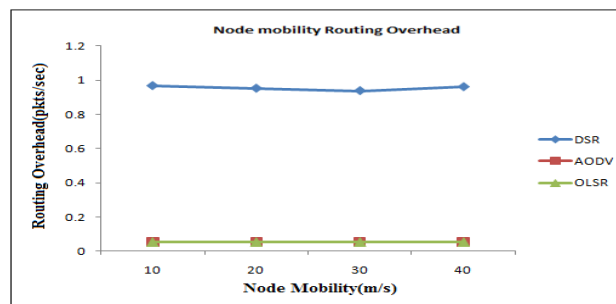
3.3. Node Mobility Routing Overhead

Figure 3. Node mobility routing Overhead

Table 3. Routing overhead for different node mobility speed

Meter/second	DSR	AODV	OLSR
10	0.966	0.05302	0.053
20	0.951	0.0533	0.053
30	0.9372	0.0532	0.053
40	0.9599	0.0533	0.053

The above graph in Figure 3 presenting node mobility's routing overhead for selected routing protocols. DSR introducing highest routing overhead compare with other two protocols OSLR and AODV. DSR uses route discovery process to select route towards destination that introduces routing overhead. But AODV and OLSR introducing low routing overhead because both protocol uses 'Hello' message to exchange neighbours' routing information. DSR can work perfectly in moderate speed mobility scenario. If mobility speed change frequently, DSR introduce more routing overhead.
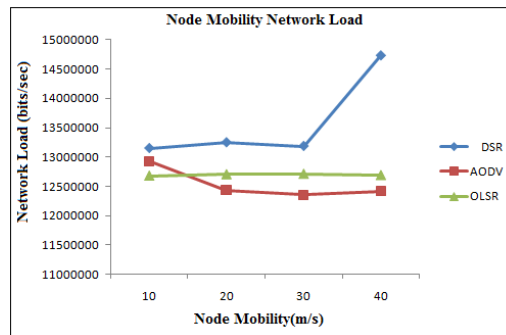
3.4. Node Mobility Network Load

Figure 4. Node Mobility Network Load

Table 4. Node Mobility Network Load

Meter/second	DSR	AODV	OLSR
10	13150055	12930895	12676968
20	13248376	12433042	12701646
30	13185216	12353051	12708582
40	14732280	12420371	12686963

The above graph in Figure 4presenting network loads for selected protocols (OLSR, AODV and DSR). DSR introducing high network load compare than other protocols. OLSR shows stable performance for different mobility speed. DSR introduces high network load when mobility speed increase from 30m/s to 40m/sec. AODV introducing low network load when node mobility speed increase. Since DSR can work perfectly in moderate speed mobility, so network load increasing rapidly according to speed change.

3.5. Network Load (varied packet size) Scenario:

There are 4 network load scenarios designed to evaluate routing performance. Random away point for each duplicate is 1400m x 1200m. MANET traffic generation parameter used to define different packet size (512bits/sec, 1024bits/sec, 1536bits/sec and 2048bits/sec). Inter arrival time (sec) for packet is exp (0.2) and packet rate 5 packet/sec.

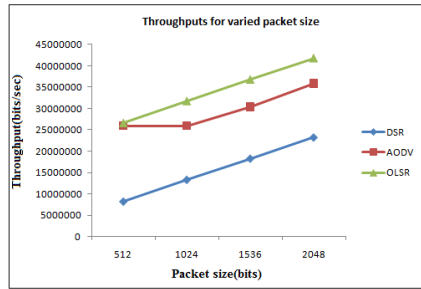### 3.6. Varied Network Packet Size Throughputs:

Figure 5. Varied Packet size

Table 5. Varied packet size Throughputs

packet size	DSR	AODV	OLSR
512	8265657	25918050	26653261
1024	13363220	25918050	31771411
1536	18304053	30386404	36793256
2048	23263544	35831837	41787249

The above graph in Figure 5 presenting network load (varied packet size) scenarios throughputs of selected routing protocols (AODV, OLSR and DSR). OLSR and AODV providing good throughput compare than DSR. Since mobility speed is low, each protocol can provide better throughput performance if packet size increase. Since OLSR protocol is proactive and uses multi-point relay broadcast, so it can provides batter throughput. Though DSR uses route discovery process to reach destination, its throughput level is good compare than mobility scenario, because DSR spent less time to establish connection with neighbour or next hop nodes.
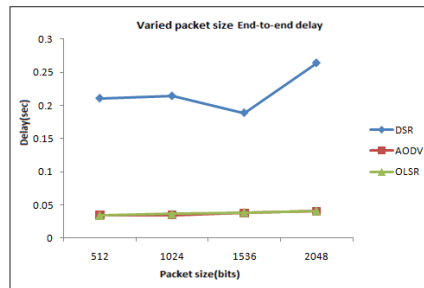
3.7. Varied Packet Size End-to-end Delay:

Figure 6. Varied Packet size end-to-end delay

Table 6. Varied Packet size end-to-end delay

Packet size	DSR	AODV	OLSR
512	0.21044	0.03469	0.03406
1024	0.2139	0.03469	0.03618
1536	0.1884	0.0375	0.03854
2048	0.26382	0.04012	0.04083

The above graph in Figure 6 is presenting end-to-end delays for varied packet size network load. OLSR and AODV introducing low end-to-end delay for different packet size compare than DSR. OLSR uses multi-point relay facilities to broadcast routing information which reduce end-to-end delay.

AODV protocol is capable to form tree during multicast routing. DSR protocol introduces high end-to-end delay during route discovery process. Though mobility speed of network load scenario is moderate, DSR unable to perform well due to varied packet size queuing process.
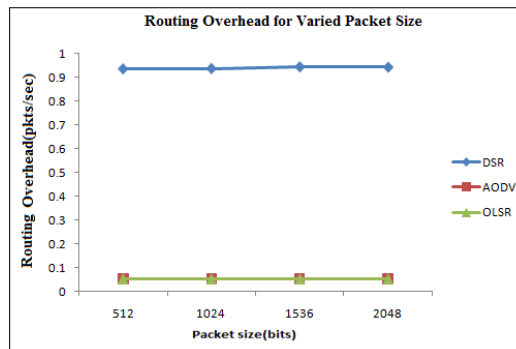
3.8. Varied Packet Size Routing Overhead:

Figure 7. Varied packet size routing Overhead

Table 7. Varied packet size routing Overhead

Packet size	DSR	AODV	OLSR
512	0.9365	0.053	0.0526
1024	0.9377	0.053	0.0526
1536	0.9442	0.0532	0.0526
2048	0.9429	0.0533	0.0526

The above graph Figure 7 presenting the routing overheads of network load with varied packet size. Generally DSR introduce low overhead for low mobility scenario, but still introducing highest routing overhead compare with other two protocols OSLR and AODV. AODV and OLSR protocol uses 'Hello' message to exchange neighbour's routing information, that reduce routing overhead.
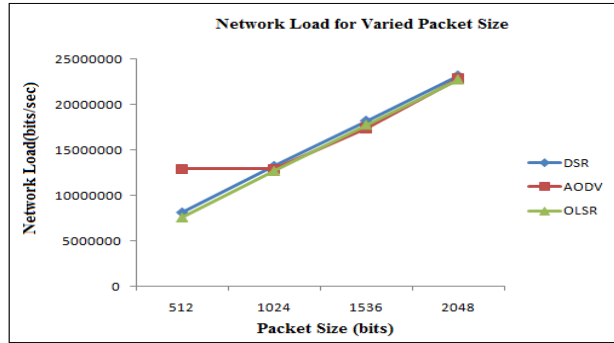
3.9. Network Load for Varied Packet Size:

Figure 8. Varied packet size Network Load

Table 8. Varied packet size Network Load

Packet size	DSR	AODV	OLSR
512	8177526	12930895	7631579
1024	13277855	12930895	12728644
1536	18232244	17408549	17798027
2048	23186119	22844991	22772754

The above graph in Figure 8 presenting network loads with varied packet size. In varied packet network scenario all protocol performing similar performance. Network load increased regularly due to change of packet size.

3.10. Node Density Scenario:

There are 4 node density scenarios designed to evaluate routing performance. Packet size for all node density scenarios are 1024 bits/sec and packet rate 5 packet/sec.
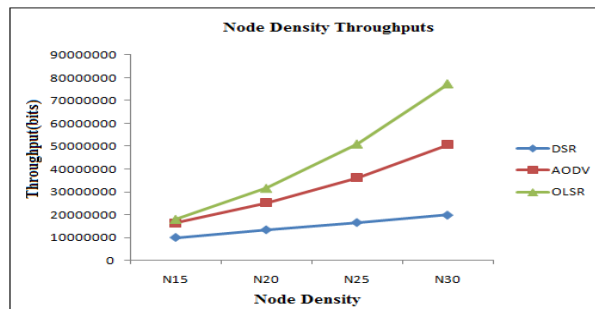
3.11. Node Density Throughput:

Figure 9. Node density throughputs

Table 9. Node density throughputs

Network Size	DSR	AODV	OLSR
N15	9948098	16351222	18132559
N20	13380463	25325218	31675822
N25	16656741	36241892	50999476
N30	19965378	50720054	77225799

The above graph presenting the node density scenarios throughputs of selected routing protocols (AODV, OLSR and DSR). Table driven routing protocol OLSR shows highest throughput performance among other protocols and DSR showing lowest throughput performance. The graph shows that throughputs of all routing protocol increase through, when node density increase. Since OLSR protocol uses multi-point relay technique to broadcast, so density of mobile nodes can provides batter throughput for OLSR. On-demand routing protocol AODV also showing better performance than DSR, because AODV can provide rapid route selection process using uni-cast and multicast routing technique. On other hand DSR uses route discovery process to reach destination, so increase of node density never affect DSR protocol performance.
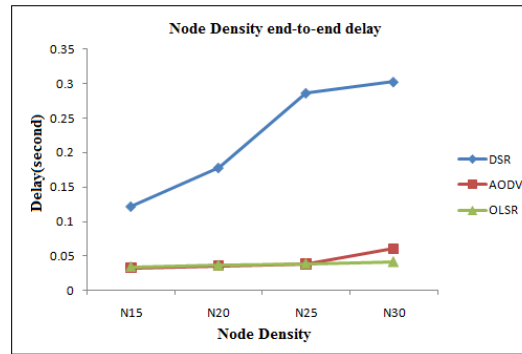
3.12. Node Density Throughput:

Figure 10. Node Density end-to-end delay

Table 10. Node density end-to-end delay

Network Size	DSR	AODV	OLSR
N15	0.121797	0.032539	0.034262
N20	0.177977	0.035767	0.036528
N25	0.286455	0.038447	0.038771
N30	0.302646	0.060549	0.041331

The above graph presenting node density scenario's end-to-end delays during routing process. DSR introducing high end-to-end delay compare than other two routing protocol. OLSR introducing lowest end-to-end delay compare than other routing protocol. OLSR uses multi-point relay during routing process, so increase of node density enhance the capability of exchange 'Hello' message and Topology control message perfectly that reduce delay for exchange routing information. Above graph shows that when node density increase from N25 to N30 AODV

introduces extra delay. Because each node multicast routing information to all surrounding neighbours' node that may introduce additional delay during routing process. On the other hand end-to-end delay of DSR increase when node density increase, because each node maintain a route cache for all possible destination and forward topology change or update information by flooding through whole network that introduce network latency.
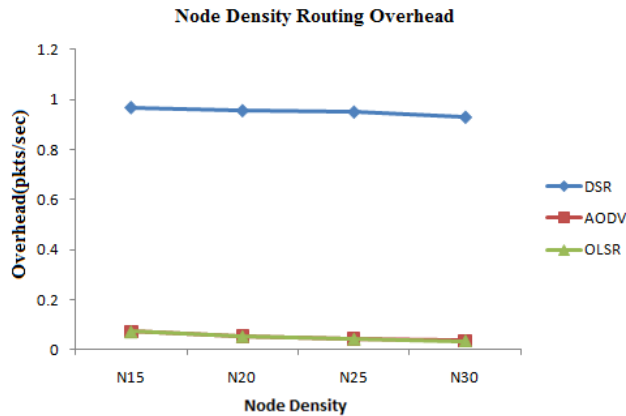
3.13. Node Density Overhead:

Figure 11. Node Density Routing Overhead

Table 11. Node Density Routing Overhead

Network Size	DSR	AODV	OLSR
N15	0.9661	0.07197	0.07191
N20	0.9542	0.0532	0.0526
N25	0.9487	0.0421	0.0416
N30	0.9285	0.03608	0.0344

The above graph presenting node density scenario's routing overhead during routing process. DSR introducing highest routing overhead compare than OSLR and AODV. DSR uses route discovery process before select a route toward destination, which is the reason for high routing overhead but overhead level is stable for all topological change. AODV and OLSR introducing low routing overhead during routing process to exchange neighbours' routing information using 'Hello' message. OLSR and AODV can exchange 'Hello' message and Topology control message perfectly with neighbour nodes, when node density increase within network.
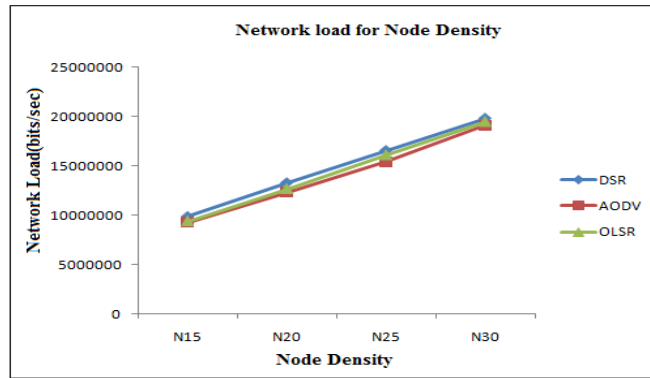
3.14. Node Density Network Load:

Figure 12. Node Density Network Load

Table 12. Node Density Network Load

Node Density	DSR	AODV	OLSR
N15	9914678	9304493	9393939
N20	13319293	12336487	12686963
N25	16569224	15441027	16098506
N30	19818532	19117896	19491134

The above graph presenting network loads for node density scenario. All protocols network load increasing according to node density increase. DSR introducing higher network load and AODV introducing low network load.   After that process continues repeatedly for Network Load and Node Density.

4. COMPARATIVE ANALYSIS

In these paper three types of MANET scenario considered for simulation. 4 node mobility scenarios with different movement speed, 4 Network load scenarios with different packet size and 4 Node density scenarios with different network size. Each protocols performance can be analyse according to performance metrics and key findings from whole study are given below:

4.1. Throughut:

AODV and OLSR provide better network throughput for three different network scenarios compare than DSR protocol. Since OLSR protocol support multi-point relay, it introduce high throughput for all types of network scenarios . Throughput performance of AODV also good for all scenarios compare than DSR throughput performance. But DSR fail to achieve standard throughput performance for any types of network scenarios compare than other protocols. All protocol performs comparatively well in network load (varied packet size) scenarios because mobility speed was low. On other hand in node density scenarios all routing protocol increase throughput, when node density increase.

4.1. End-to-end Delay:

DSR introduces higher end-to-end delay in all scenarios compare than OLSR and AODV protocol delay. In mobility scenarios end-to end delay increase when mobility speed increase. Though, DSR perform well at moderate node speed but unable to perform well in network load scenarios due to varied packet size. In node density scenarios OLSR perform well compare than other two protocols. When node density increase OLSR reduce end-to-end delay due to enhancement of exchange routing capability. On other hand DSR introduce additional delay when node density increase.

4.3. Routing Overhead:

DRS introduce highest routing overhead in all scenarios compare than OLSR and AODV. Since DSR only capable to perform with moderate speed, so in mobility scenario it cost additional overhead due to mobility speed change. AODV and OLSR uses 'Hello' message for exchange routing information that is why both protocol introduces low routing overhead compare than DSR.

4.4. Network Load:

In node mobility scenario OLSR performed stable performance, but DSR introduces high network load due to increase of node mobility. AODV reduce network load when mobility of nodes increase. All protocol increase network load when packet size and node density increase in network load scenarios and node density scenarios respectively.

5. CONCLUSION

This paper is representing performance analysis of different routing protocols for Mobile ad-hoc network. According to this paper Researchers tried to discuss all common mobile routing protocol with their features and mode of operation. Here OPNET network simulator has been used to evaluate performance. Since OPNET is a study version of simulation tool, so it has limited choice of routing protocol. From OPNET protocol parameter option, OLSR, DSR and AODV routing protocols has been selected to performance evaluation. So, it was really hard to evaluate routing performance for all discussed (within this paper) routing protocols perfectly in realistic scenario.

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