Comparative Study of On-demand Routing Protocols for Mobile Ad-hoc Network

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ABSTRACT
A Mobile Ad-hoc Network (MANET) is a dynamic wireless network that can be formed without the need for any pre-existing infrastructure in which each node can act as a router. One of the main challenges of MANET is the design of robust routing algorithms that adapt to the frequent and randomly changing network topology. A variety of routing protocols have been proposed and several of them have been extensively simulated or implemented as well. In this paper, we compare and evaluate the performance metrics of three types of On-demand routing protocols- Ad-hoc On-demand Distance Vector (AODV) routing protocol, which is unipath, Ad-hoc On-demand Multipath Distance Vector (AOMDV) routing protocol and Dynamic Source routing (DSR) protocol. This paper investigates all these routing protocols corresponding to packet delivery fraction (pdf), throughput, normalized routing load and end to end delay. The ns-2 simulation results showed that AODV has always low routing load compared to AOMDV in both static and dynamic network for each set of connections. AOMDV provided better results at high pause time but worst in case of end to end delay. We have also seen that, DSR performed well in terms of end to end delay in both static and dynamic networks.

Index Terms
Ad hoc, aodv, aomdv, dsr, manet, ns-2, route cache, latency.

1. INTRODUCTION
A mobile ad-hoc network (MANET) [1] is a collection of mobile nodes forming an ad-hoc network without the assistance of any centralized structures. These networks introduced a new art of network establishment and can be well suited for an environment where either the infrastructure is lost or where deploy an infrastructure is not very cost effective. Nodes in mobile ad-hoc network are free to move and organize themselves in an arbitrary fashion. Each user is free to roam about while communication with others. The path between each pair of the users may have multiple links and the radio between them can be heterogeneous. This allows an association of various links to be a part of the same network. In MANET, communication there is always a need of routing over multi-hop [4] paths. The main objective of this paper is to study the routing protocols [2] in a mobile ad hoc network using a simulator software NS-2 [3]. This paper carries out the analysis and discussion on the result set to find out which protocol is the best between AODV [6], AOMDV [10], and DSR [7].

2. CLASSIFICATION OF ROUTING PROTOCOLS
In Topology based approach, routing protocols are classified into three categories, based on the time at which the routes are discovered and updated.

a. Proactive Routing Protocol (Table Driven)

b. Reactive Routing Protocol (On-Demand)

c. Hybrid Routing Protocol

The Proactive routing approaches designed for ad hoc networks are derived from the traditional routing protocols. These protocols are sometimes referred to as table-driven protocols since the routing information is maintained in tables. Proactive approaches have the advantage that routes are available the moment they are needed. However, the primary disadvantage of these protocols is that the control overhead can be significant in large networks or in networks with rapidly moving nodes. Proactive routing protocol includes Destination-Sequenced Distance-Vector (DSDV) protocol, Wireless Routing Protocol (WRP), Optimized Link State Routing Protocol (OLSR) etc.

Reactive routing approaches take a departure from traditional Internet routing approaches by not continuously maintaining a route between all pairs of network nodes. Instead, routes are only discovered when they are actually needed. When a source node needs to send data packets to some destination, it checks its route table to determine whether it has a route. If no route exists, it performs a route discovery procedure to find a path to the destination. Hence, route discovery becomes on-demand. The drawback to reactive approaches is the introduction of route acquisition latency. That is, when a route is needed by a source node, there is some finite latency while the route is discovered. In contrast, with a proactive approach, routes are typically available the moment they are needed. Hence, there is no delay to begin the data session. Reactive routing protocol includes Dynamic Source Routing (DSR) protocol, Ad hoc On-demand Distance Vector (AODV) protocol, Ad hoc On-demand Multiple Distance Vector (AOMDV) protocol etc.

Hybrid protocols seek to combine the Proactive and Reactive approaches. An example of such a protocol is the Zone Routing Protocol (ZRP).

Our discussion is limited to three On-demand ad-hoc routing protocols AODV, AOMDV and DSR as follows:

2.1 AODV

Ad–hoc on demand distance vector routing (AODV) is a stateless on-demand routing protocol [7, 15]. The Ad-hoc On Demand Distance Vector (AODV) [5] classified under reactive protocols. The operation of the protocol is divided in two functions, route discovery and route maintenance. In Ad-hoc routing, when a route is needed to some destination, the protocol starts route discovery. Then the source node sends route request message to its neighbors. And if those nodes do not have any information about the destination node, they will send the message to all its neighbors and so on. And if any neighbor node has the information about the destination node, the node sends route reply message to the route request message initiator. On the basis of this process a path is recorded in the intermediate nodes. This path identifies the route and is called the reverse path. Since each node forwards route request message to all of its neighbors, more than one copy of the original route request message can arrive at a node. A unique id is assigned, when a route request message is created. When a node received, it will check this id and the address of the initiator and discarded the message if it had already processed that request. Node that has information about the path to the destination sends route reply message to the neighbor from which it has received route request message. This neighbor does the same. Due to the reverse path it can be possible. Then the route reply message travels back using reverse path. When a route reply message reaches the initiator the route is ready and the initiator can start sending data packets.

2.2 DSR

The Dynamic Source Routing protocol (DSR) [11] is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration. Dynamic Source Routing, DSR, is a reactive routing protocol which uses source routing, i.e. the source determines the complete sequence of hops that each packet should traverse. This requires that the sequence of hops is included in each packet's header. The protocol is composed of the two main mechanisms of "route discovery" and "route maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network. Route discovery is used whenever a source node desires a route to a destination node. First, the source node looks up its route cache to determine if it already contains a route to the destination. If the source finds a valid route to the destination, it uses this route to send its data packets. If the node does not have a valid route to the destination, it initiates the route discovery process by broadcasting a route request message. The route request message contains the address of the source and the destination, and a unique identification number. Route maintenance is used to handle route breaks. When a node encounters a fatal transmission problem at its data link layer, it removes the route from its route cache and generates a route error message. The route error message is sent to each node that has sent a packet routed over the broken link. When a node receives a route error message, it removes the hop in error from its route cache [7].

2.3 AOMDV

Ad-hoc On Demand Multipath Distance Vector Routing Algorithm (AOMDV) is proposed in [5]. AOMDV employs the "Multiple Loop-Free and Link-Disjoint path" technique. In AOMDV only disjoint nodes are considered in all the paths, thereby achieving path disjointness. For route discovery route request packets are propagated throughout the network thereby establishing multiple paths at destination node and at the intermediate nodes. Multiples Loop-Free paths are achieved using the advertised hop count method at each node. This advertised hop count is required to be maintained at each node in the route table entry. The route entry table at each node also contains a list of next hop along with the corresponding hop counts. Every node maintains an advertised hop count for the destination. Advertised hop count can be defined as the "maximum hop count for all the paths". Route advertisements of the destination are sent using this hop count. An alternate path to the destination is accepted by a node if the hop count is less than the advertised hop count for the destination [8].

3. METHODOLOGY

3.1 Simulation Environment

Simulation environment is as follows:

Parameter	Values
Traffic type	CBR
Simulation time	100 seconds
Number of nodes	100
Pause time	0, 25, 50, 75 and 100 second
Maximum connections	15, 30 and 45
Maximum speed of nodes	10 meter per second
Transmission rate	10 packets per second
Area of the network	800m X 800m

3.2 NS-2 (Network Simulator-2)

The NS-2 [3] is a discrete event driven simulation and in this the physical activities are translated to events. Events in this are queued and processed in the order of their scheduled occurrences. The functions of a Network Simulator [9] are to create the event scheduler, to create a network, for computing routes, to create connections, to create traffic. It is also useful for inserting errors and tracing can be done with it. Tracing packets on all links by the function trace-all and tracing packets on all links in nam format using the function namtrace-all.

3.3 Performance Metrics

We report four performance metrics for the protocols:

Packet Delivery Fraction (PDF): The ratio between the number of data packets received and the number of packets sent.

Throughput: Throughput is total packets successfully delivered to individual destination over total time divided by total time.

End-to-End Delay: It is the ratio of time difference between every CBR packet sent and received to the total time difference over the total number of CBR packets received.

Normalized Routing load: The Normalized routing loads measures by the total number of routing packets sent divided by the number of data packets delivered successfully.

4. SIMULATION RESULTS AND ANALYSIS

We ran the simulation environments for 100 sec for five scenarios with pause times varying from 0 to 100 second and also maximum connections varying in between 15 to 45 connections. Packet delivery fraction, routing load, end to end delay and throughput are calculated for AODV, AOMDV and DSR. The results are analyzed below with their corresponding graphs.

4.1 Packet Delivery Fraction

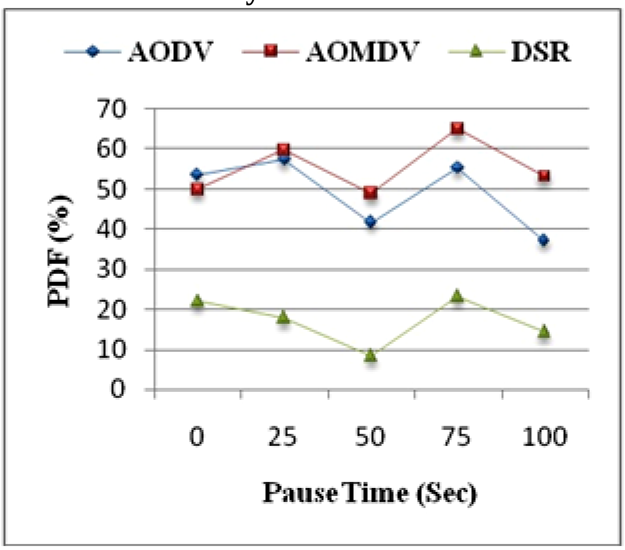

Fig. 4.1(a) Comparison of AODV, AOMDV and DSR on basis of PDF at maximum connection 15

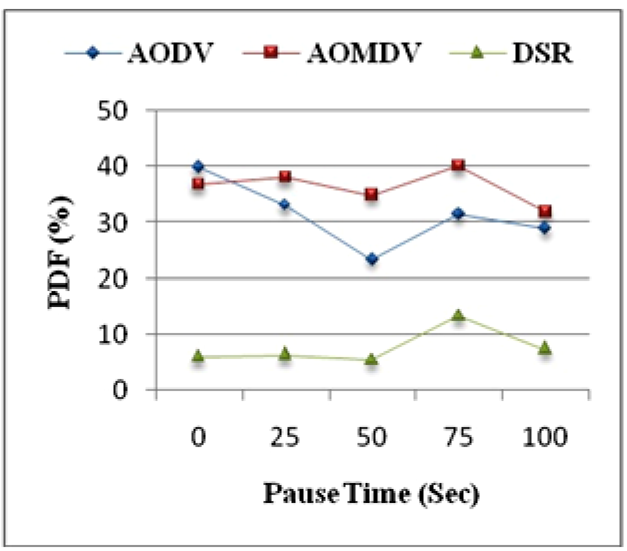

Fig. 4.1(b) Comparison of AODV, AOMDV and DSR on basis of PDF at maximum connection 30

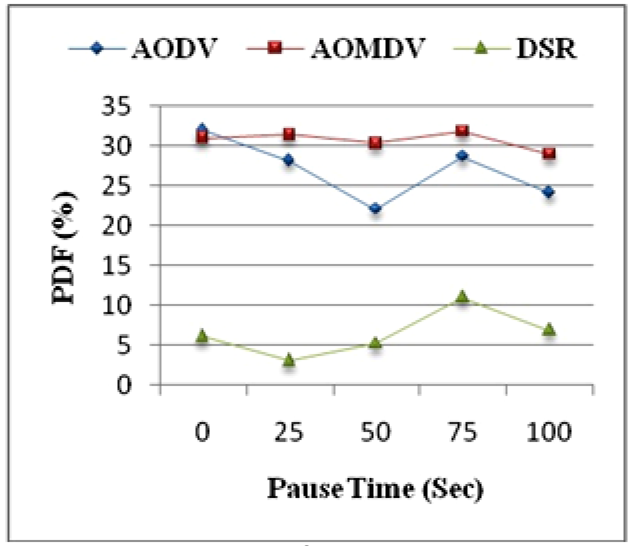

Fig. 4.1(c) Comparison of AODV, AOMDV and DSR on basis of PDF at maximum connection 45

Analysis of the result

We note that at pause time 0 sec, AODV has a better PDF value when compared to AOMDV and DSR for each set of connections. But AOMDV gives better performance with increasing pause time. At pause time 100 sec, AOMDV has best PDF value compared to AODV, DSR for each set of connections.

4.2 Throughput

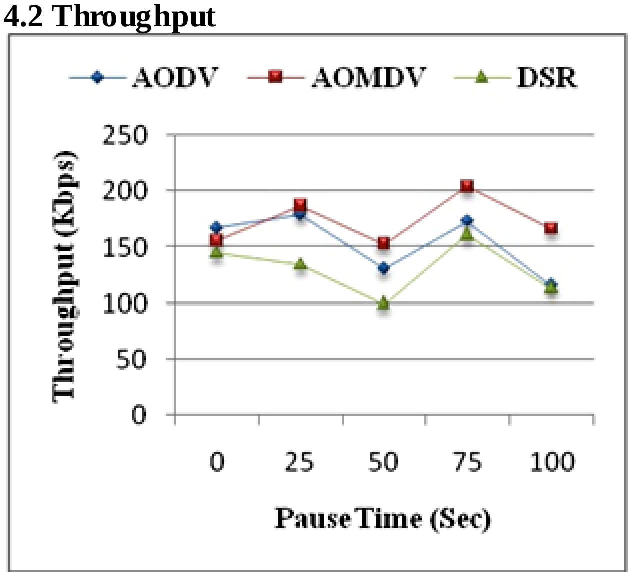

Fig. 4.2(a) Comparison of AODV, AOMDV and DSR on basis of Throughput at maximum connection 15

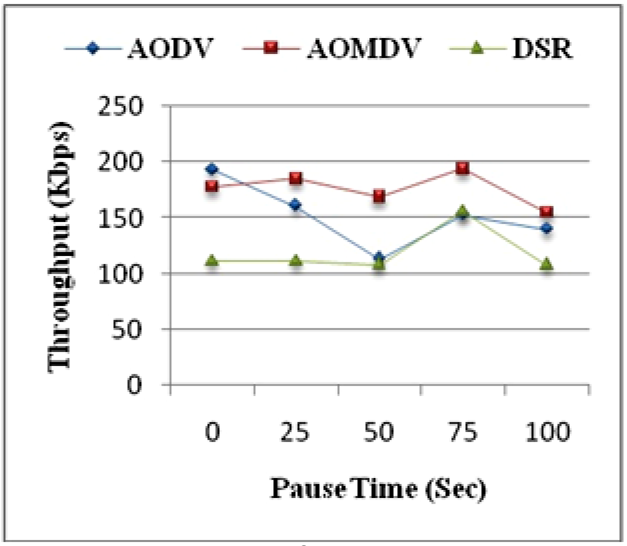

Fig. 4.2(b) Comparison of AODV, AOMDV and DSR on basis of Throughput at maximum connection 30

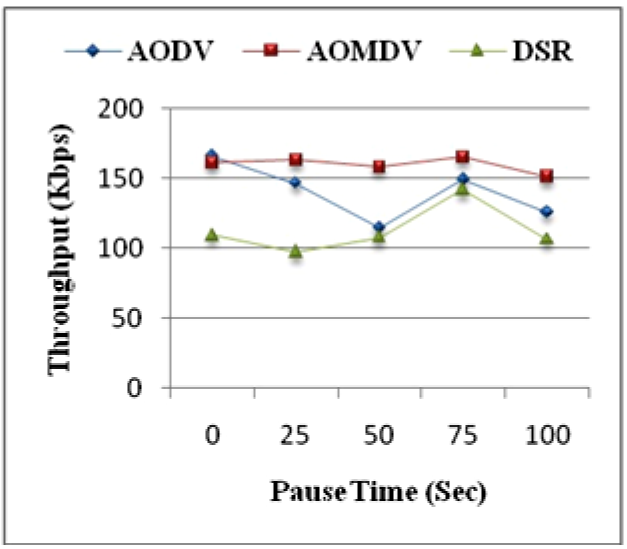

Fig. 4.2(c) Comparison of AODV, AOMDV and DSR on basis of Throughput at maximum connection 45

Analysis of the result

From studying the figures (Fig 4.2) for throughput, we note that at pause time 0 sec, AODV has a better throughput when compared to AOMDV and DSR for each set of connections. But with increasing pause time, AOMDV provides higher throughput compared to AODV, DSR for each set of connections.

4.3 End to End delay

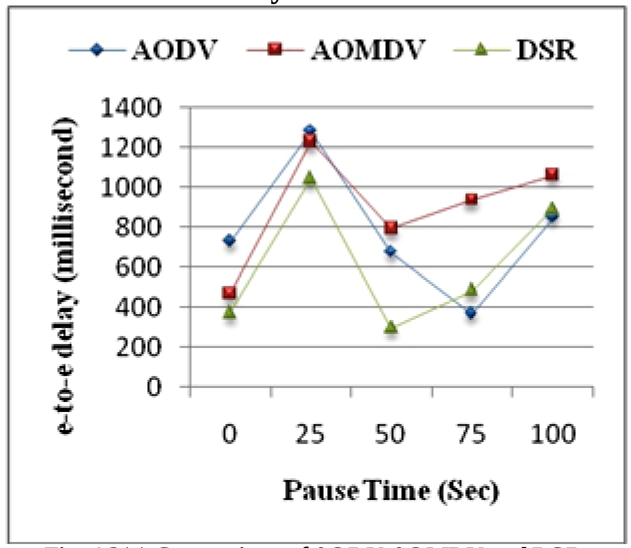

Fig. 4.3(a) Comparison of AODV, AOMDV and DSR on basis of end to end delay at maximum connection 15

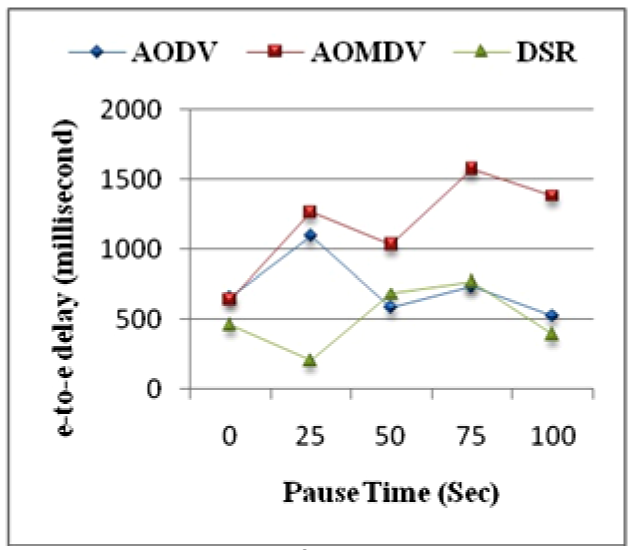

Fig. 4.3(b) Comparison of AODV, AOMDV and DSR on basis of end to end delay at maximum connection 30

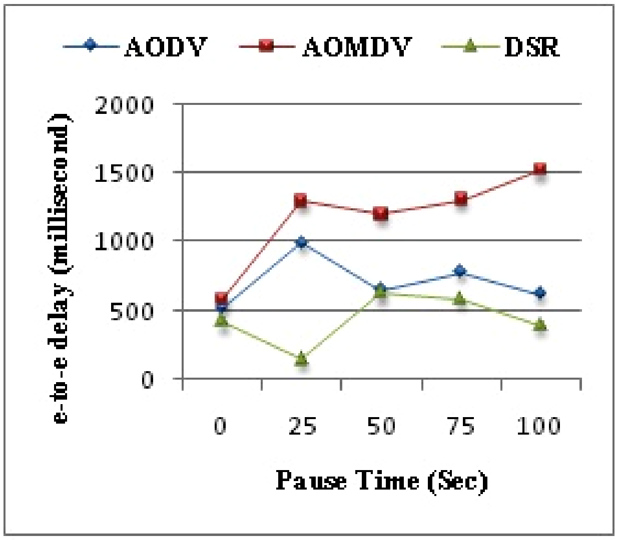

Fig. 4.3(c) Comparison of AODV, AOMDV and DSR on basis of end to end delay at maximum connection 45

Analysis of the result

We have seen that in maximum simulation scenarios, DSR has better end to end delay from AOMDV and AODV protocols. AOMDV incurs worse end to end delay when compared to AODV in all simulation scenarios.

4.4 Normalized Routing Load

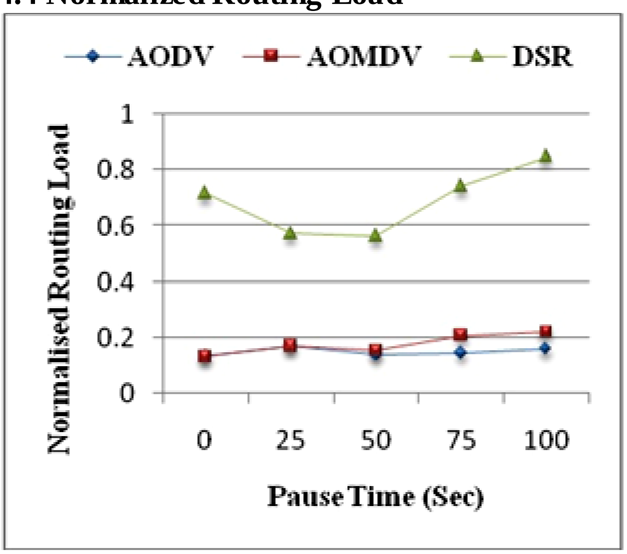

Fig. 4.4(a) Comparison of AODV, AOMDV and DSR on basis of normalized routing load at maximum connection 15

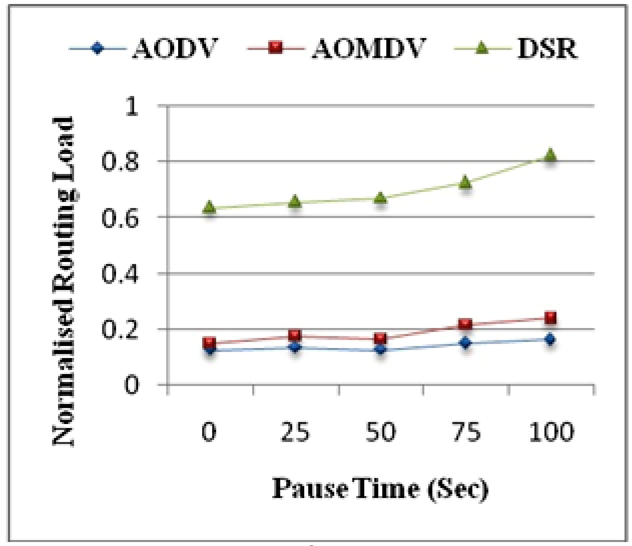

Fig. 4.4(b) Comparison of AODV, AOMDV and DSR on basis of normalized routing load at maximum connection 30

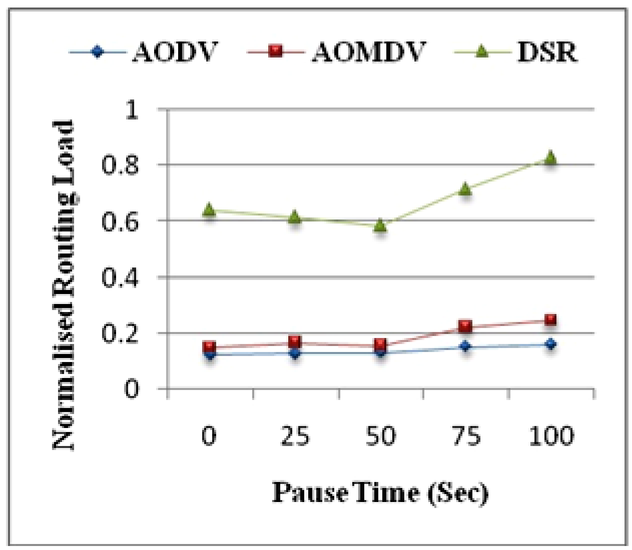

Fig. 4.4(c) Comparison of AODV, AOMDV and DSR on basis of normalized routing load at maximum connection 45

Analysis of the result

We note that AODV always have low routing load among all three protocols in all simulation scenarios and AOMDV has better routing load when compared to the DSR for each set of connections.

5. CONCLUSION

This paper evaluated the performance of AODV, AOMDV and DSR using ns-2. Comparison was based on the packet delivery fraction, throughput, end-to-end delay and normalized routing overhead. We concluded that in the dynamic network (pause time 0 sec), the performance of AODV is better as compared to the AOMDV and DSR in terms of packet delivery fraction, throughput and normalized routing overhead. In the static network (pause time 100 sec), AOMDV gives better performance as compared to AODV and DSR in terms of packet delivery fraction and throughput but worst in terms of end-to-end delay. We have also seen that DSR routing protocol is best in terms of end-to-delay in both Static and dynamic network for each set of maximum connections.

6. REFERENCES

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