Simulation and Comparison of AODV, DSR and AOMDV Routing Protocols in MANETs

Manveen Singh Chadha, Rambir Joon, Sandeep

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. Mobile ad hoc network (MANET) is an autonomous system of mobile nodes connected by wireless links. Each node operates not only as an end system, but also as a router to forward packets. The nodes are free to move about and organize themselves into a network. These nodes change position frequently. The main classes of routing protocols are Proactive, Reactive and Hybrid.A Reactive (on-demand) routing strategy is a popular routing category for wireless ad hoc routing The design follows the idea that each node tries to reduce routing overhead by sending routing packets whenever a communication is requested.In this work an attempt has been made to compare the performance of three prominent on demand reactive routing protocols for MANETs:- Ad hoc On Demand Distance Vector (AODV), Dynamic Source Routing (DSR) protocols and Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV) . DSR and AODV are reactive gateway discovery algorithms where a mobile device of MANET connects by gateway only when it is needed. AOMDV was designed primarily for highly dynamic ad hoc networks where link failures and route breaks occur frequently. It maintains routes for destinations in active communication and uses sequence numbers to determine the freshness of routing information to prevent routing loops. It is a timer-based protocol and provides a way for mobile nodes to respond to link breaks and topology changes.***

The performance differentials are analyzed using varying simulation time. These simulations are carried out using the ns-2 network simulator. The results presented in this work illustrate the importance in carefully evaluating and implementing routing protocols in an ad hoc environment.

Keywords: MANETS, AODV, DSR, AOMDV

I. INTRODUCTION

A mobile ad hoc network [1] is a collection of digital data terminals equipped with wireless transceivers that can communicate with one another without using any fixed networking infrastructure. Communication is maintained by the transmission of data packets over a common wireless Channel.

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The absence of any fixed infrastructure, such as an array of base stations, makes ad hoc networks radically different from other wireless LANs.

Whereas Communication from a mobile terminal in an infrastructure network, such as a cellular network, is always maintained with a fixed base station, a mobile terminal (node) in an ad hoc network can communicate directly with another node that is located within its radio transmission range. In order to transmit to a node that is located outside its radio range, data packets are relayed over a sequence of intermediate nodes using a store-and-forward “multi hop” transmission principle. All nodes in an ad hoc network are required to relay packets on behalf of other nodes. Hence, a mobile ad hoc network is sometimes also called a multi hop wireless network. The design of adhoc network faces many challenges. The first is that all nodes in an ad hoc network, including the source nodes, the corresponding destinations, as well as the routing nodes forwarding traffic between them, may be mobile. As the wireless transmission range is limited, the wireless link between a pair of neighboring nodes breaks as soon as they move out of range.

A second reason that makes the design of ad hoc networks complicated is the absence of centralized control. All networking functions, such as determining the network topology, multiple accesses, and routing of data over the most appropriate multi hop paths, must be performed in a distributed way. These tasks are particularly challenging due to the limited communication bandwidth available in the wireless channel. These challenges are resolved by different layers. The physical layer must tackle the path loss, fading, and multi-user interference to maintain stable communication links between peers. The data link layer (DLL) must make the physical link reliable and resolve contention among unsynchronized users transmitting packets on a shared channel. The latter task is performed by the medium access control (MAC) sub layer in the DLL. The network layer must track changes in the network topology and appropriately determine the best route to any desired destination. The transport layer must match the delay and packet loss characteristics specific to such a dynamic wireless network. Even the application layer needs to handle frequent disconnections.

II. CLASSIFICATION OF ROUTING PROTOCOLS

Classification of routing protocols in mobile ad hoc network can be done in many ways; the routing protocols

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can be categorized as Proactive (Table Driven), Reactive (on-demand) and Hybrid depending on the network structure.

A. proactive routing protocols

Proactive protocols perform routing operations between all source destination pairs periodically, irrespective of the need of such routes. These protocols attempt to maintain shortest path routes by using periodically updated views of the network topology. These are typically maintained in routing tables in each node and updated with the acquisition of new information. Proactive protocols have the advantage of providing lower latency in data delivery and the possibility of supporting applications that have quality-of-service constraints. Their main disadvantage is due to the wastage of bandwidth in sending update packets periodically even when they are not necessary, such as when there are no link breakages or when only a few routes are needed Examples of Proactive MANET Protocols include: Optimized Link State Routing (OLSR), Fish-eye State Routing (FSR), Destination-Sequenced Distance Vector (DSDV) etc.

B. Reactive routing protocols

Reactive protocols are designed to minimize routing overhead. Instead of tracking the changes in the network topology to continuously maintain shortest path routes to all destinations, these protocols determine routes only when necessary. Typically, these protocols perform a route discovery operation between the source and the desired destination when the source needs to send a data packet and the route to the destination is not known. As long as a route is live, reactive routing protocols only perform route maintenance operations and resort to a new route discovery only when the existing one breaks. The advantage of this on-demand operation is that it usually has a much lower average routing overhead in comparison to proactive protocols. However, it has the disadvantage that a route discovery may involve flooding the entire network with query packets. Flooding is wasteful, which can be required quite frequently in case of high mobility or when there are a large number of active source-destination pairs. Moreover, route discovery adds to the latency in packet delivery as the source has to wait till the route is determined before it can transmit. Despite these drawbacks, on-demand protocols receive comparatively more attention than proactive routing protocols, as the bandwidth advantage makes them more scalable.

On-demand (reactive) routing presents an interesting and significant departure from the traditional proactive approach. Main idea in on-demand routing is to find and maintain only needed routes. Recall that proactive routing protocols maintain all routes without regard to their ultimate use. The obvious advantage with discovering routes on-demand is to avoid incurring the cost of maintaining routes that are not used. This approach is attractive when the network traffic is sporadic, burst and directed mostly toward a small subset of nodes. However, since routes are created when the need arises, data packets experience queuing delays at the source while the route is being found at session initiation and when route is being repaired later on after a failure. Another, not so obvious consequence of on-demand routing is that routes may become suboptimal, as time progresses since with a pure on-demand protocol a route is used until it fails. The different types of On Demand driven protocols are Ad hoc On Demand Distance Vector (AODV), Dynamic Source routing protocol (DSR), temporally ordered routing algorithm (TORA), Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV).

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:

C. Ad Hoc on Demand Distance Vector (AODV)

The ad hoc on-demand distance-vector (AODV) routing protocol is an on-demand routing protocol; all routes are discovered only when needed, and are maintained only as long as they are being used. Routes are discovered through a route discovery cycle, whereby the network nodes are queried in search of a route to the destination node. When a node with a route to the destination is discovered, that route is reported back to the source node that requested the route the following sections describe the features of AODV that allow it to discover and maintain loop free route.

Route Discovery

When a source node has data packets to send to some destination, it checks its routing table to determine whether it already has a route to that destination. If so, it can then utilize that route to transmit the data packets. Otherwise, the node must perform a route discovery procedure to determine a route to the destination. To initiate route discovery, the source node creates a Route Request (RREQ) packet. In that packet the node places the IP address of the destination, the last known sequence number for the destination, its own IP address, its current sequence number, and a hop count that is initialized to zero. If there is no last known sequence number for the destination, it sets this value to zero. The source then broadcasts the RREQ to its neighbors. When a neighboring node, or any other more distant node, receives the RREQ, it first increments the hop count value in the RREQ and creates a reverse route entry in its routing table for both the source node and the node from which it received the request. In this way, if the node later receives a RREP to forward to the source, it will know a path to the source along which it can forward the RREP. After creating this entry, the node then determines its response to the request. The node can send a reply to the request if it either

- is the destination, or
- has a current route to the destination.

A current route is an unexpired route entry for the destination whose sequence number is at least as great as that contained in the RREQ. If this condition holds, the node creates a Route

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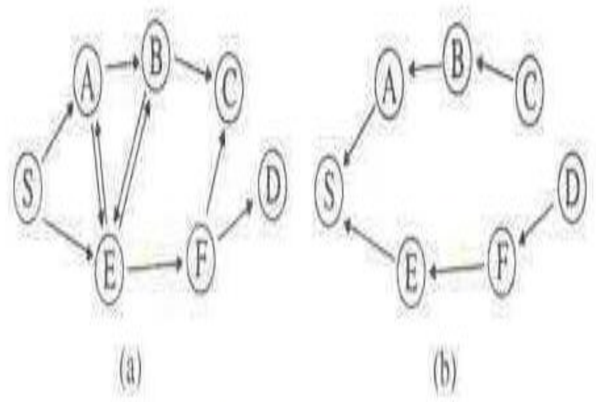
Reply (RREP) for the destination node. Otherwise, if the node does not have a current route to the destination, it simply rebroadcasts the RREQ to its neighbors. Fig. 1.1(a) illustrates the flooding of a RREQ, originating at the source node S, through the network. In this example, we assume nodes C and D have routes to the destination D. A node creates a RREP by placing the IP address of the destination node, as well as its record of the destination's sequence number, into the RREP. It also includes the source node IP address and it distance, in hops, to the destination. The node then unicasts the RREP to the next hop towards the source node. In Fig 1.1(b), both nodes C and D have routes to the destination D that meet the reply criteria. Hence, both nodes generate a RREP.



Route Discovery 1.1 (a) RREQ broadcast and (b) RREP propagation. When the next hop receives the RREP, it first increments the hop count value in the RREP and then creates a forward route entry to both the destination node and the node from which it received the reply. This ensures that all nodes along the path will know the route to the destination in the event that the source selects this route for data packet transmission. The node then unicasts the RREP to its next hop towards the source node. This hop-by-hop forwarding continues until the RREP reaches the source. Once the source receives a RREP, it can begin using that path for data packet transmission. In the event that the source receives multiple RREPs along different paths, it selects the route with the greatest destination sequence number and the smallest hop count for communication with the destination.

Route discovery operations often require processing and communications capacity at every node in the ad hoc network. For this reason, we often describe the discovery operation as "flooding" even though the RREQs are only locally broadcast messages. Since the messages are changed at each hop by AODV processing, we could not use any system-wide broadcast or multicast address. Nevertheless, it is of great importance to use careful broadcast techniques to minimize any spurious retransmission of RREQ packets.

For instance, each node is required to keep track of which RREQ messages it has received, and to discard duplicates that it receives from multiple neighboring nodes. In order to detect duplication, the node identifies each RREQ by using the IP address of the originating node, and the RREQ ID for the RREQ message data. In Fig 1.1(a), by this algorithm node E would discard RREQs it hears from nodes A, B, and F after receiving the original RREQ from the source S. These identifying values have to be stored for a time that is long enough to ensure no other node in the ad hoc network could still be processing messages resulting from the same route discovery operation. It is difficult to predict how long this time is, because it depends on the present state of congestion in the network as well as the size and current topology of the network. For correctness, it is better to maintain the broadcast identification information for few minutes.

3oute maintenance

In an ad hoc network, links are likely to break due to the mobility of the nodes and the ephemeral nature of the wireless channel. Hence, there must be a mechanism in place to repair routes when links within active routes break. An active route is defined to be a route that has recently been utilized for the transmission of data packets. When such a link break occurs, the node upstream of the break (i.e., the node closer to the source node), invalidates in its routing table all destinations that become unreachable due to the loss of the link. It then creates a Route Error (RERR) message, in which it lists each of these lost destinations. The node sends the RERR upstream towards the source node. If there are multiple previous hops that were utilizing this link, the node broadcasts the RERR; otherwise, it is unicast. In Fig. 1.2, the link between nodes B and C on the path from S to D is broken. Node B invalidates its route table entries for both nodes C and D, creates a RERR message listing these nodes, and sends the RERR upstream towards the source.

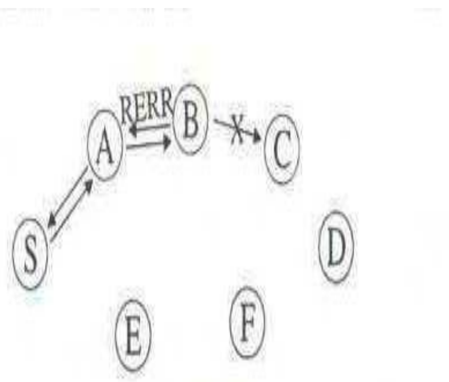


Figure 1.2 Link breaks Notification

When a node receives a RERR, it first checks whether the node that sent the RERR is its next hop to any of the destinations listed in the RERR. If the sending node is the next hop to any of these destinations, the node invalidates these routes in its route table and then propagates the RERR back towards the source. The RERR continues to be forwarded in this manner until it is received by the source. Once the source receives the RERR, it can re-initiate route discovery if it still requires the route

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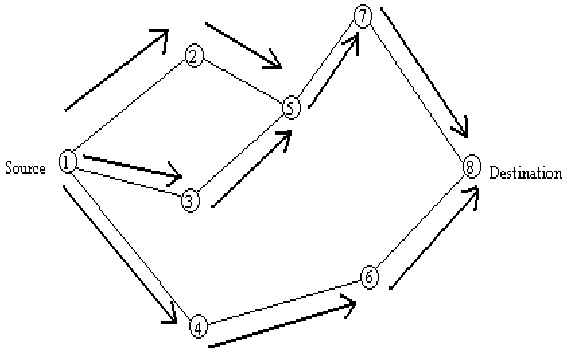
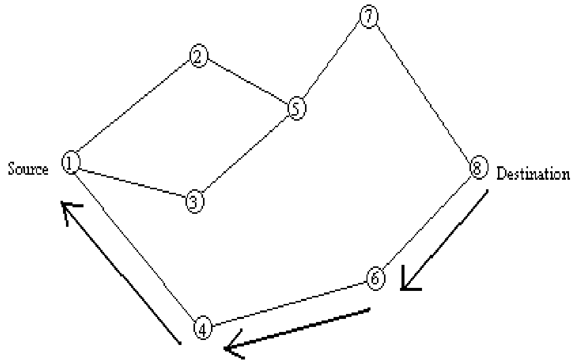
D. Dynamic Source Routing (DSR)

The Dynamic Source Routing (DSR) is an on demand source routing protocol [8] that employs route discovery and route maintenance procedures similar to AODV. In DSR, each node maintains a route cache with entries that are continuously updated as a node learns new routes. Similar to AODV, a node wishing to send a packet will first inspect its route cache to see whether it already has a route to the destination. If there is no valid route in the cache, the sender initiates a route discovery procedure by broadcasting a route request packet, which contains the address of the destination, the address of the source, and a unique request ID. As this request propagates through the network, each node inserts its own address into the request packet before rebroadcasting it. As a consequence, a request packet records a route consisting of all nodes it has visited. When a node receives a request packet and finds its own address recorded in the packet, it discards this packet and does not rebroadcast it further. A node keeps a cache of recently forwarded request packets, recording their sender addresses and request IDs, and discards any duplicate request packets. Once a request packet arrives at the destination, it will have recorded the entire path from the source to the destination. In symmetric networks, the destination node can unicast a response packet, containing the collected route information, back to the source using the exact same path as taken by the request packet. In networks with asymmetric links, the destination can itself initiate a route discovery procedure to the source, where the request packet also contains the path from the source to the destination. Once the response packet (or the destination's request packet) arrives at the source, the source can add the new route into its cache and begin transmitting packets to the destination. Similar to AODV, DSR also employs a route maintenance procedure based on error messages, which are generated whenever the link layer detects a transmission failure due to a broken link. Compared to proactive routing protocols, DSR shares similar advantages and disadvantages as AODV. Unlike AODV, each packet in DSR carries route information, which allows intermediate nodes to add new routes proactively to their own caches. Also, DSR's support of asymmetric links is another advantage compared to AODV.



(a) Propagation of request (PREQ) packet



(b) Path taken by the Route Reply (RREP) packet

E. Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV)

Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV) [17] protocol is an extension to the AODV protocol for computing multiple loop-free and link disjoint paths [18]. The routing entries for each destination contain a list of the next-hops along with the corresponding hop counts. All the next hops have the same sequence number. This helps in keeping track of a route. For each destination, a node maintains the advertised hop count, which is defined as the maximum hop count for all the paths, which is used for sending route advertisements of the destination. Each duplicate route advertisement received by a node defines an alternate path to the destination. Loop freedom is assured for a node by accepting alternate paths to destination if it has a less hop count than the advertised hop count for that destination. Because the maximum hop count is used, the advertised hop count therefore does not change for the same sequence number [18]. When a route advertisement is received for a destination with a greater sequence number, the next-hop list and the advertised hop count are reinitialized. AOMDV can be used to find node-disjoint or link-disjoint routes. To find node-disjoint routes, each node does not immediately reject duplicate RREQs. Each RREQs arriving via a different neighbor of the source defines a node-disjoint path. This is because nodes cannot be broadcast duplicate RREQs, so any two RREQs arriving at an intermediate node via a different neighbor of the source could not have traversed the same node. In an attempt to get multiple link-disjoint routes, the destination replies to duplicate RREQs, the destination only replies to RREQs arriving via unique neighbors. After the first hop, the RREPs follow the reverse paths, which are node disjoint and thus link-disjoint. The trajectories of each RREP may intersect at an intermediate node, but each takes a different reverse path to the source to ensure link disjointness [18]. The advantage of using AOMDV is that it allows intermediate nodes to reply to RREQs, while still selecting disjoint paths. But, AOMDV has more message overheads during route discovery due to increased flooding and since it is a multipath routing protocol, the destination replies to the multiple RREQs those results are in longer overhead

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III. SIMULATION TOOL (NETWORK SIMULATOR 2)

Network Simulator (Version 2), widely known as NS2, is simply an event driven simulation tool that has proved useful in studying the dynamic nature of communication networks. Simulation of wired as well as wireless network functions and protocols (e.g., routing algorithms, TCP, UDP) can be done using NS2 It consists of two simulation tools. The network simulator (ns) contains all commonly used IP protocols. The network animator (nam) is use to visualize the simulations. Ns-2 [20] fully simulates a layered network from the physical radio transmission channel to high-level applications The simulator was originally developed by the University of California at Berkeley and VINT project the simulator was recently extended to provide simulation support for ad hoc network by Carnegie Mellon University (CMU Monarch Project homepage, 1999).

NS2 consists of two key languages: C++ and Object-oriented Tool Command Language (OTcl) while the C++ defines the internal mechanism (i.e., a backend) of the simulation objects, the OTcl sets up simulation by assembling and configuring the objects as well as scheduling discrete events (i.e., a frontend). As shown in figure The C++ and the OTcl are linked together using TclCL After simulation, NS2 outputs either text-based or animation-based simulation results. To interpret these results graphically and interactively, tools such as NAM (Network AniMator) and XGraph are used

IV. METRICS FOR PERFORMANCE COMPARISON

Some important performance metrics can be evaluated:-

A. ***Packet delivery fraction*** — the ratio of the data packets delivered to the destinations to those generated by the CBR sources. It specifies the packet loss rate, which limits the maximum throughput of the network

B. ***End-to-end Delay***- This metric represents average end-to-end delay and indicates how long it took for a packet to travel from the source to the application layer of the destination. It includes all possible delay caused by buffering during route discovery latency, transmission delays at the MAC, queuing at interface queue, and propagation and transfer time. It is measured in seconds

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

The first two metrics are the most important for best-effort traffic. The routing load metric evaluates the efficiency of the routing protocol. Note, however, that these metrics are not completely independent. For example, lower packet delivery fraction means that the delay metric is evaluated with fewer samples. In the conventional wisdom, the longer the path lengths, the higher the probability of a packet drops. Thus, with a lower delivery fraction, samples are usually biased in favor of smaller path lengths and thus have less delay.

V. SIMULATION RESULT AND ANALYSIS

As already outlined we have taken three On-demand (Reactive) routing protocols, namely Ad hoc On-Demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR) and Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV). The mobility model used is Random waypoint mobility model because it models the random movement of the mobile nodes We ran the simulation environments for 50 sec for one scenario with pause times varying from 0 to 50 second. Packet delivery fraction, end to end delay and throughput are calculated for AODV, AOMDV and DSR. The results are analyzed below with their corresponding graphs

From studying the figure Fig 5.1we note that at pause time 0 sec; DSR has a better PDF value when compared to AOMDV and AODV for each set of connections. But AOMDV gives better performance with increasing pause time. At pause time 50 sec, AOMDV has best PDF value compared to AODV, DSR for both scenarios

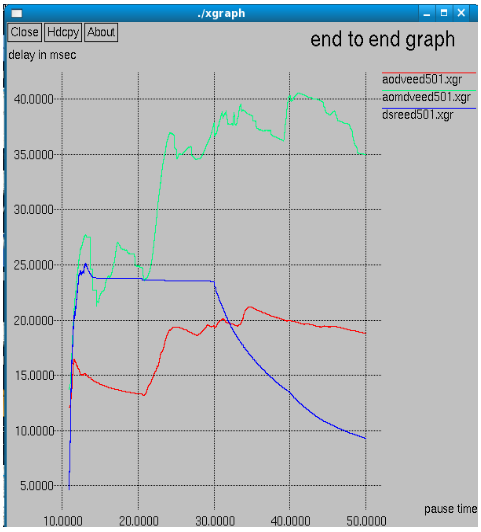
From studying the figure Fig 5.2 for throughput, we note that at pause time 0 sec, DSR has a better throughput when compared to AOMDV and AODV for each set of connections. But with increasing pause time, average throughput of AOMDV is better compared to AODV, DSR for each set of connections

From studying the figure Fig 5.3 DSR has better end to end delay from AOMDV and AODV protocols. AODV has worse end to end delay when compared to AOMDV and DSR in both scenarios.

Simulation environment is as follows:

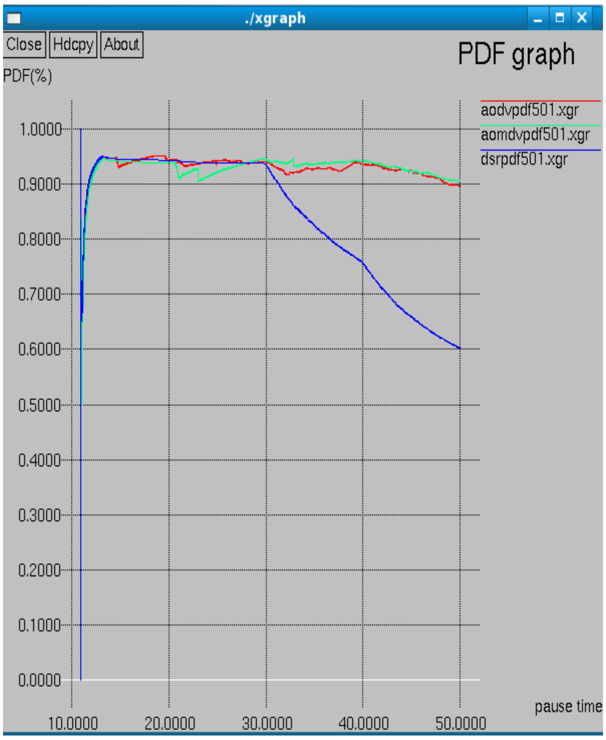
PARAMETER	VALUES
SIMULATOR	NS 2.34
ANTENNA TYPE	OMNIDIRECTIONAL
SIMULATION AREA	1000X1000
NUMBER OF NODES	50
PAUSE TIME	50 SEC
PACKET RATE	512 kbps
TRAFFIC TYPE	CBR,UDP,TCP

A. end to end delay



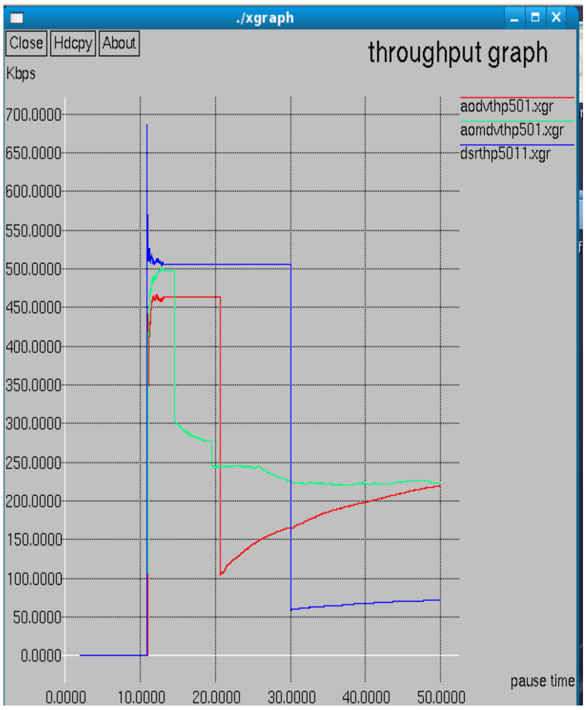
5.1 Comparison of AODV, AOMDV and DSR on basis of end to end delay at maximum connection 50

B. packet delivery fraction



5.2 Comparison of AODV, AOMDV and DSR on basis of PDF at maximum connection 50

C. throughput



5.3 Comparison of AODV, AOMDV and DSR on basis of Throughput at maximum connection 50

VI. CONCLUSION

This paper evaluated the performance of AODV, AOMDV and DSR using ns-2. Comparison was based on the packet delivery fraction, throughput and end-to-end delay. We concluded that in the static network (pause time 50 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.

REFERENCES

1. Performance Comparison of Mobile Ad-hoc Network Routing Protocol‖, International Journal of Computer Science and Network Security (IJCSNS), VOL.7 No.11, pp. 77-84 November 2007.
2. Mobile Ad hoc network (MANET), www.ietf.org/html.charter/manetcharter
3. D. Bertsekas and R. Gallager, Data Networks, 2nd ed. (Prentice Hall, Upper Saddle River, NJ, 1987).
4. G. Pei, M. Gerla, and T.-W. Chen, “Fisheye State Routing: A Routing Scheme for Ad Hoc Wireless Networks,” Proceedings of the IEEE ICC 1 (June 2000): 70–74.
5. C. E. Perkins and P. Bhagwat, “Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers,” Proceedings of the ACM SIGCOMM 1994 Conference (August 1994): 234–44.
6. H. Ehsan and Z. A. Uzmi (2004), “Performance Comparison of Ad HocWireless Network Routing Protocols”, IEEE 8th International Multitopic Conference, Proceedingsof INMIC, pp.457 – 465, December 2004.
7. V. Park and S. Corson, “Temporally Ordered Routing Algorithm (TORA) Version 1, Functional specification”, IETF Internet draft, http://www.ietf.org/internet-drafts/draft-ietf-manet-tora-spec-01.txt, 1998.
8. D. B. Johnson and D. A. Maltz, —Dynamic Source Routing in Ad Hoc Wireless Networks, Mobile Computing, Chapter 5, pp. 153-181, Kluwer Academic Publishers, 1996
9. J. Broch, D.A. Maltz, D. B. Johnson, Y-C. Hu, J. Jetcheva,

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"A performance comparison of Multi-hop wireless ad-hoc networking routing protocols", in the proceedings of the 4th International Conference on Mobile Computing and Networking (ACM MOBICOM '98), pp. 85-97, October 1998.
10. Md. Golam Kaosar, Hafiz M. Asif, Tarek R. Sheltami, Ashraf S. Hasan Mahmoud, "Simulation-Based Comparative Study of On Demand Routing Protocols for MANET", available at http://www.lancs.ac.uk, Internaional Conference on Wireless Networking and Mobile Computing, Vol. 1, pp. 201 – 206, December 2005.
11. C. Hedrick, Routing Information Protocol, Request for Comments 1058, June 1988.
12. C.E. Perkins, E.M. Royer, Ad-hoc on-demand distance vector routing, in: Proceedings of the 2nd IEEE Workshop on Mobile Computing Systems and Application.Evolution and future directions of the ad hoc on-demand distance-vector routing protocol by Elizabeth M. Belding-Royer and Charles E. Perkins
13. C.E. Perkins, E.M. Belding-Royer, S.R. Das, Ad hoc On-Demand Distance Vector (AODV) Routing, IETF Internet Draft, draft-ietf-manet-aodv-13.txt, Work in Progress.
14. C.E. Perkins, E.M. Royer, S.R. Das, M.K. Marina, Performance comparison of two on-demand routing protocols for ad hoc networks, IEEE Personal Communications Magazine, special issue on Ad hoc Networking 8 (1) (2001)
15. S. Gwalani, E.M. Belding-Royer, C.E. Perkins, AODVPA: AODV with path accumulation, in: Proceedings of the IEEE Symposium on Next Generation Internet (NGI), Anchorage, AK, May 2003
16. M. Marina, S. Das, On-demand multipath distance vector routing in ad hoc networks, in: Proceedings of the International Conference on Network Protocols (ICNP), Riverside, CA, November 2001
17. H.D.Trung, W.Benjapolakul, P.M.Duc, "Performance evaluation and comparison of different ad hoc routing protocols", Department of Electrical Engineering, Chulalongkorn University, Bangkok, Thailand, May 2007
18. Z. J. Haas and M. R. Pearlman, "The Performance of Query Control Schemes for the Zone Routing Protocol," ACM/IEEE Trans. Net. 9 (August 2001)
19. The VINT Project, The network simulator - ns-2. http://www.isi.edu/nsnam/ns/
20. ad hoc networks technologies and protocol by prasant mohapatra university of california, davis srikanth v. krishnamurthy university of california, riverside
21. Wireless Networking by Praphul Chandra, Daniel M. Dobkin, Alan Bensky, Ron Olexa, David A. Lide, and Farid Dowla ISBN: 978-0-7506-8582-5
22. Network Routing Algorithms, Protocols, and Architectures by Deepankar Medhi and Karthikeyan Ramasamy
23. Luke Klein-Bernd, ―A Quick Guide to AODV Routing‖, National Institute of Standards and Technology, US

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