Behavior Analysis of TCP Traffic in Mobile Ad Hoc Network using Reactive Routing Protocols

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ABSTRACT
A wireless Ad Hoc network is a collection of mobile nodes that form a dynamic, autonomous network. Nodes communicate with each other without depending on any infrastructure. Hence, in these networks each node acts as a host and as a router. Routing protocols in wireless ad-hoc networks are divided into three groups of proactive (Table-Driven), reactive (On-Demand), and hybrid routing protocols depending on their method of acquiring information from the other nodes in unicast routing classification. In this paper study of reactive routing protocol AODV and DSR has been presented. We have done in-depth analysis of AODV and then compared it with DSR. Performance of TCP is very different in MANET than the same in wired network. We have analyzed TCP performance in terms of parameters like delay, segment delay and retransmission attempt in both AODV and DSR protocol by using file downloads via FTP (File Transfer Protocol). Number of nodes and mobility has significant impact on the performance and QoS of AODV and DSR. We have used different scenario in order to check performance with respect to different parameters and mobility model. OPNET simulator has been used for simulation purpose.

General Terms
AODV, DSR, TCP, DELAY

Keywords
Behavior analysis of TCP, comparing AODV and DSR protocol.

1. INTRODUCTION
A wireless Ad Hoc network is a collection of mobile nodes that form a dynamic, autonomous network. Nodes communicate with each other without depending on any infrastructure (e.g. access points or base stations) [3]. Hence, in these networks each node acts as a host and as a router.

2. AD HOC ROUTING
Network topology in Ad Hoc networks, changes frequently and unpredictably. Such a highly dynamic nature of network, makes routing difficult and complex between mobile nodes. As routing is very important in communication between mobile nodes, study of routing protocols has become area of interest for many. Based on Routing information update mechanism, routing protocols in wireless ad-hoc networks are divided into three groups of proactive (Table-Driven), reactive (On-Demand), and hybrid routing protocols. [3]

In proactive routing protocols, each node periodically distributes routing tables throughout the network. The main disadvantages of such protocols are the large amount of routing overhead generated for maintenance and at the time of link failure, reestablishing the network is slower. The main advantage of these protocols is that a source node can get a routing path immediately if it needs one [6] [3]. DSDV (Destination-Sequenced Distance-Vector Routing) and OLSR (Optimized Link State Routing Protocol) are proactive routing protocols.

In reactive routing protocols, the nodes obtain the necessary path only when it is required using connection establishment process. The main advantage of such protocol is less routing traffic being generated in network and faster route discovery which is very essential in Ad hoc networks. The disadvantage is that the node has to initiate route discovery process before sending the data if it does not have prior information about the same. AODV, DSR (Dynamic Source Routing, TORA (Temporally-Ordered Routing Algorithm) are reactive routing protocols.

In hybrid routing protocols, the merits of both proactive and reactive routing protocols are combined. The initial establishment of the routes is done with some proactively prospected routes and then additionally activated nodes are served on-demand through reactive flooding. The disadvantage of such protocols is dependence of the advantage on amount of nodes activated [6]. ZRP (Zone Routing Protocol) is a hybrid routing protocol.

3. AD HOC ON-DEMAND DISTANCE VECTOR (AODV) ROUTING PROTOCOL
Ad-Hoc On-Demand Distance Vector (AODV) routing protocol is one of the most efficient reactive routing protocol. AODV routing algorithm is suitable for dynamic self-starting network as needed by users who want to use ad hoc networks. Whenever a source is required to send data to destination , then only it initiates request for route discovery. Thus it uses an on demand approach for finding routes. AODV uses a novel concept of sequence number for each node which results into loop free route discovery. In AODV single route request may receive multiple route reply but the use of sequence number helps to find out the latest information about the route which is very important in dynamic and rapidly changing network topology. Route discovery is mainly accomplished with flooding of RREQ packet by source in the network. Expanding ring search Algorithm is used to limit the initial flooding control traffic.

Route maintenance is carried out by intermediate node by using Hello messages. Whenever a link breakage is detected, local repair is carried out by intermediate node by finding alternate route. Routing table is maintained distributed that is all the intermediate nodes contain routing information for a particular route in their routing table.

Route discovery is accomplished in AODV by defining control packet, RREQ(Route Request), RREP(Route Reply), and RERR(Route Error). These message types are received via UDP, and normal IP header processing is applied.

Whenever a source node wants to send data to destination and does not have valid route to destination in its routing table, it initiates route discovery by sending RREQ. Each RREQ contains destination sequence number – last known sequence number for the destination, destination IP address, source sequence number and source IP address. It also contains RREQ ID which identifies each RREQ uniquely originating from a source. RREQ ID is incremented each time a new RREQ message is sent. RREQ also contains hop count which shows the number of hops from source node to the node handling the request. The source node sends RREQ to its neighbor i.e. nodes directly reachable and in its radio range. Further this request is then forwarded by intermediate nodes to their neighbors, and so on, until either the destination or an intermediate node with a "fresh enough" route to the destination is found. Destination sequence number is utilized by AODV to ensure loop free routes. So, if intermediate nodes have a route to the destination whose corresponding destination sequence number is greater than or equal to that contained in the RREQ packet, they can reply to it. During the process of forwarding the RREQ, intermediate nodes record the address of the neighbor from which the first copy of the broadcast packet is received in their route tables. Thus, they establish a reverse path [5]. Each time Source waits for the reply for predefined time interval and if reply not received from destination or any other intermediate node, new request is sent with incremented RREQ ID. Such retries goes on with increased wait time for reply. This is basically done to limit initial flooding of routing traffic into the network. This technique is known as expanding ring search. Figure 1 shows the propagation of RREQ across the network. Here node N1(source) sends RREQ to its neighboring nodes N2, N3 and N4. They further sends to N5, N6, N7 and finally to N8 (destination).

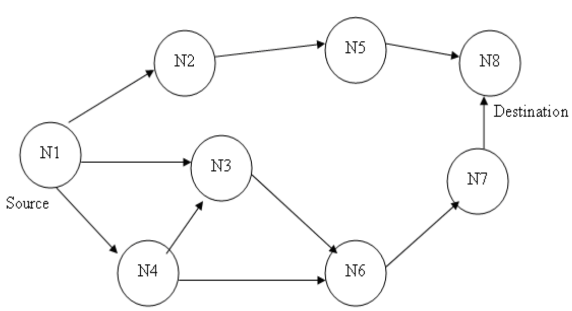

Fig. 1: Propagation of RREQ [5]

RREP contains destination IP address, destination sequence number, source IP address and life time - the time for which nodes receiving the RREP consider the route to be valid. After the RREQ reaches the destination or an intermediate node with a fresh enough route, it responds by a route reply (RREP) packet that unicast to the neighbor which first received the RREQ packet and routes back along the reverse path [5]. Thus the routing information is stored in routing table which is distributed in all the intermediate nodes sending RREP. In this way the routing table is distributed among all the nodes in the route. The distance of source from destination is recorded in hope count field of RREP.

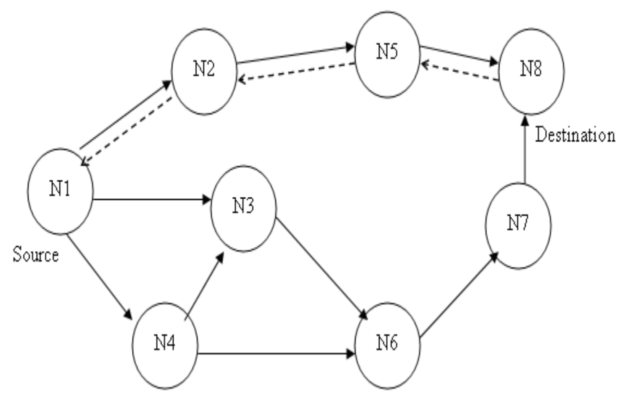

Fig. 2: Path of the RREP to the source

Hello messages to neighboring are used by nodes to maintain such established route. If no reply received within specified time due to the node in the network moved out of coverage area, places and the topology is changed or the links in the active path are broken the node is declared as unreachable. The intermediate node that discovers this link breakage propagates an RERR packet that contains unreachable destination IP address and unreachable destination sequence number. Then, the source node re-initializes the path discovery if it still has data to send and desires the route [6].

4. DYMANIC SOURCE ROUTING (DSR) PROTOCOL

Dynamic Source Routing is another on-demand routing protocol that is based on the concept of source routing. This means that each routed packet must carry a complete and ordered list of nodes in its header through which the packet passes. Hence, intermediate nodes do not need to maintain up-to-date routing information in order to route the packets they forward [3]. The protocol consists of two major phases: route discovery and route maintenance. When a source node wishes to send a packet to a destination, it obtains a source route by the route discovery mechanism [3]. At first, a source node consults its route cache to determine whether it already has a route to the destination. If it does not have a route to destination, it initiates route discovery by broadcasting a Route Request packet. It is then answered by a Route Reply packet when the Route Request reaches either the destination itself, or an intermediate node which has an unexpired route to the destination in its route cache [3][5]. Figure 3 illustrates the building of the route record during the route discovery operation.

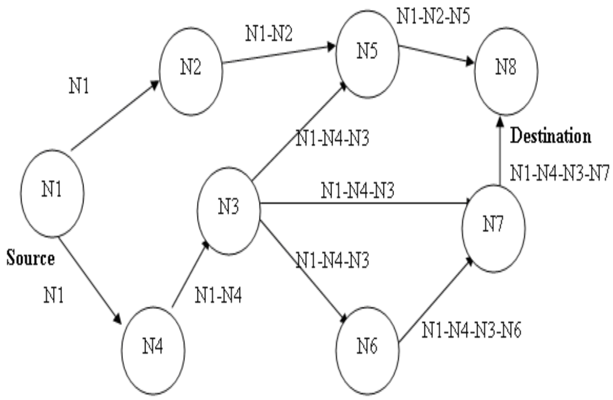

Fig. 3: Building of the route record during the route discovery [5]

Route maintenance is a mechanism that uses Route Error packets and acknowledgments. Route Error packets are generated to notify the source node that a source route is broken. When a Route Error packet is received, the node removes the hop in error from its route cache. In addition to route error messages, the correct operation of the route links verify with acknowledgment message [5]. Figure 4 shows the propagation of route reply with the route record in the network.

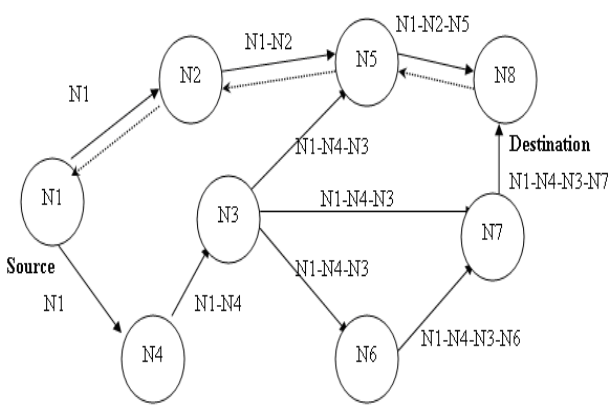

Fig. 4: Propagation of route reply with the route record [5]

5. COMPARISON BETWEEN AODVAND DSR

DSR and AODV both initialize the route discovery on demand to establish the route dynamically when they are no efficient route from source node to destination node. Routing information in DSR is stored in routing cache while in AODV it is stored in distributed routing table in the intermediate node of route. Because of the same, there exist several differences between DSR and AODV. When a source node sends a packet the packet of DSR contains the information of all nodes while AODV has only the information of destination node. The routing discovery of AODV is divided to reverse route establishment and forward route establishment, all the links are expected to be symmetric which is not required by DSR. DSR is based on the dynamic source routing; the routing information of DSR will be significantly more than that of AODV. While AODV may bring greater network overhead since it mainly relies on the flooding routing method. DSR can make full use of the routing cache to respond to all the RREQ packets getting to the destination nodes through only one routing discovery. In AODV, the destination node will responds only to the first arrived RREQ packet and ignores the following RREQ packets. Since the routing table of AODV maintains only one table entry for each destination node, when the intermediate nodes find the route is broken, the only way is to drop the packets. DSR neither have the explicit routing mechanism to terminate the outdated routes in routing cache nor choose the latest route when there are many optional routes. However, when there are optional routes, AODV can choose the latest route according to the serial number of destination node. The RERR packet in DSR will be sent back to the source node along the route passed by the data packets which encounter the broken link. The nodes that use this broken link are not in the route passed by these data packets, cannot be notified. However, by using the upstream node list in AODV, the RERR packet can get to all nodes which use this broken link. In case of increased mobility, due to stale cache and high overhead, DSR's performance degrades compared to AODV.

6. SIMULATIONS AND RESULTS

6.1 Performance Analysis Of AODV And DSR

Both these protocols are used in Ad hoc network widely. As discussed earlier in section 5. there does difference exists between these two protocols. To compare and validate the above difference, various simulation scenarios created in OPNET for AODV and DSR routing protocols. Same kind of network characteristics like bandwidth, no of nodes, mobility and traffic was selected for each pair of scenario. One by one mobility and number of nodes were increased in the network and performance measured for both the protocols.

As shown hereunder we have selected a 3000 x 3000 meters campus area for simulation purpose. 15 mobile nodes with random waypoint mobility was selected. Nodes start moving after 150 seconds of simulation in random fashion in selected network with a constant speed of 5 meters / second. Application phase starts after 30 seconds. Source is a mobile node, which sends 10 requests of 1024 bytes each. Destination is FTP mobile server which replies to source with 25 response packets of size 1024 byte each.

To compare the performance between the two protocols, following QoS parameters are selected:

6.1.1 Routing traffic received

As shown in the figure 6 the routing traffic received is more for AODV compared to DSR. The reason for AODV having higher routing traffic received is on route discovery; it receives multiple route replies for a single request. Route discovery in

AODV is accomplished by flooding the network while DSR also uses its cache route in case of route failure.

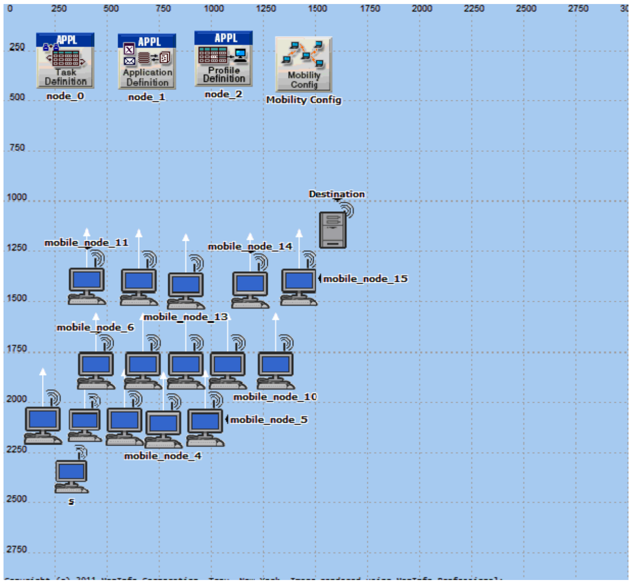

Fig. 5. Network topology

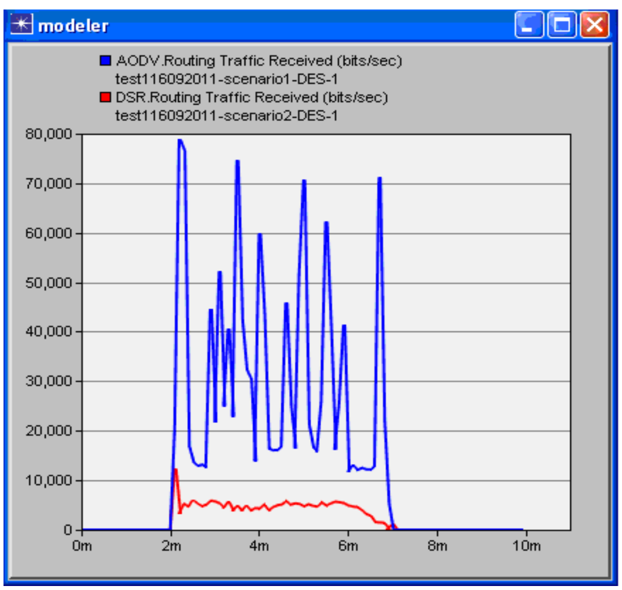

Fig. 6: Routing traffic received

6.1.2 Data dropped:

Because of node mobility, data drop is higher in DSR compared to AODV. The same results into better throughput for AODV compared to DSR. DSR takes longer time to establish route

6.1.3 Throughput

As shown in the figure 8, WLAN throughput is higher for AODV compared to DSR. Though DSR performs well in lower mobility by using its cached route but the same turns into lower performance when mobility increases and stale route problem occurs i.e. DSR sends data to a route which is no longer valid. AODV maintains only one route per destination and in high mobility environment route discovery is faster and hence the throughput is higher.

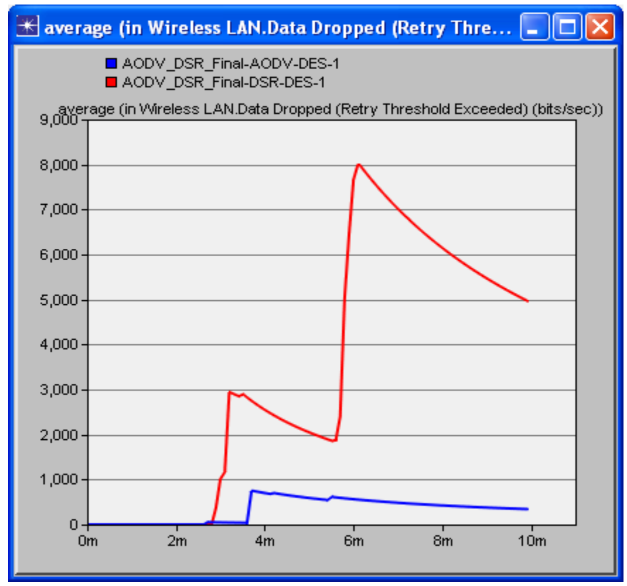

Fig. 7: WLAN data dropped

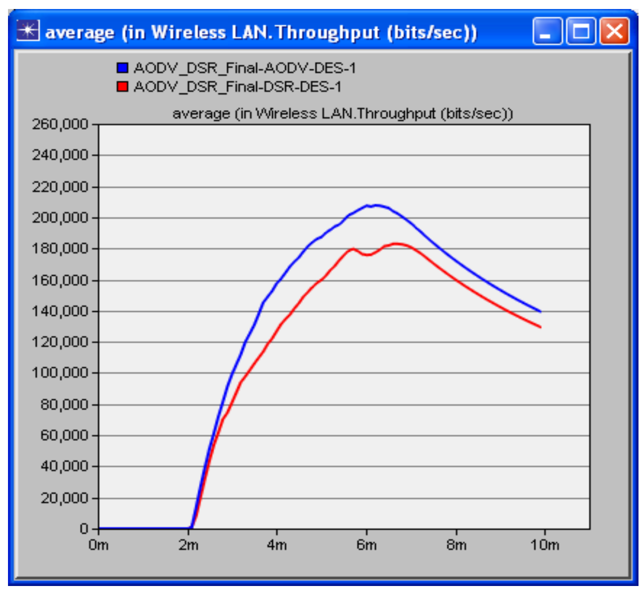

Fig. 8: WLAN Throughput

6.2 Performance of TCP in MANET

TCP was originally designed for wired networks. Now using TCP in MANET has several challenges. In the presence of the high error rates and intermittent connectivity characteristics of wireless links, TCP reacts to packet losses as it would in the wired environment so it drops its transmission window size before retransmitting packets, initiates congestion control or avoidance mechanisms such as slow start and resets its retransmission timer. These measures result in an unnecessary reduction in the link's bandwidth utilization, thereby causing a significant degradation in performance in the form of poor throughput and very high interactive delays. Therefore, route changes due to mobility can have a detrimental impact on TCP performance.

6.2.1 Delay in TCP

Delay is time measured in seconds from the time an application data packet is sent from the source TCP layer to the time it is completely received by the TCP layer in the destination. This

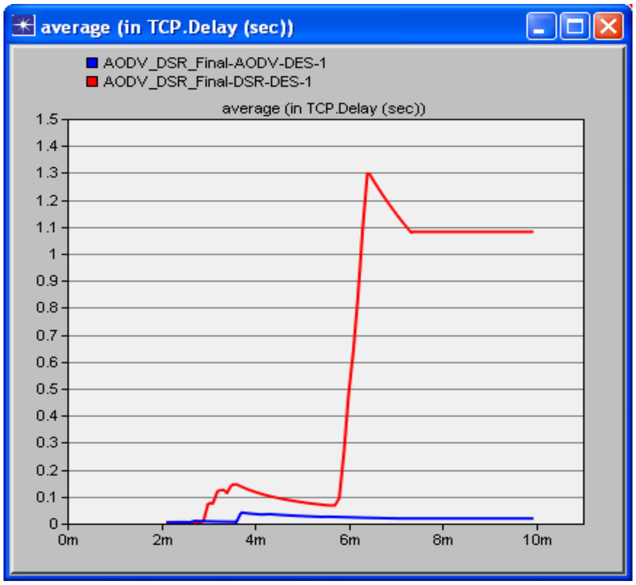

Fig. 9: TCP Delay

delay includes the protocol processing time, the queuing delay at node and MAC contestation delay. As clearly shown in the figure 9, delay in DSR is higher compared to AODV. In DSR header of each data packets will carry the routing information which will increase the length of packet and also the time delay for processing and queuing. The benefit of caching routes in DSR is completely lost in the present case as mobility increases. Caching of several routes for destination helps in low mobility where in source switches to such cached routes in case of route failure. This significantly reduces the possibility to restart a route discovery process. But in stressful situation i.e. when number of nodes and speed is higher, it is more likely that all cached routes are already invalid and thus increasing the delay.

6.2.2 TCP Segment delay:

It is measured from the time a TCP segment is sent from the source TCP layer to the time it is received by the TCP layer in the destination node. AODV performs better compared to DSR. Initially AODV has more delay but as the time goes on it performs far better than DSR.

6.2.3 Retransmission attempt:

AODV requires a lot of retransmission attempts before it can successfully transmit data. When a source first gets a RREQ message for a destination, and if it does not have the route for the requested destination, it broadcasts the message and increases the height of the node. In this way it tries to transmit the message until it gets the destination. Once the destination is found retransmission attempts decreases. This is very clear in the figure 11, where in initially retransmission attempts are higher but decreases significantly after route is established.

The same is not followed in DSR which is clear from the figure 11.

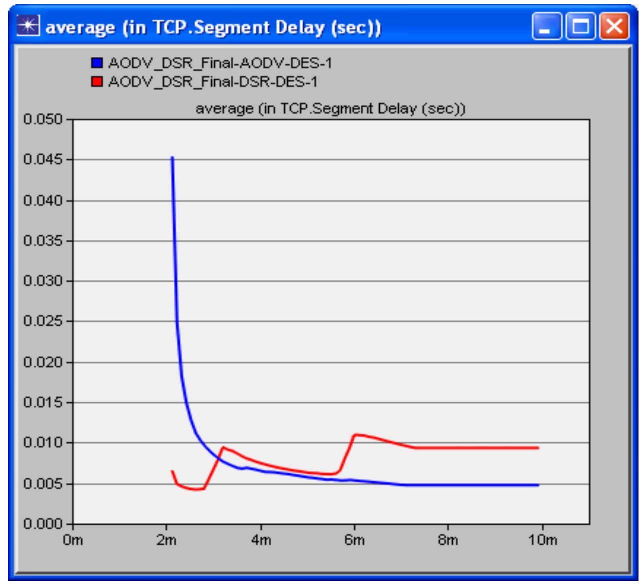

Fig. 10: TCP Segment delay

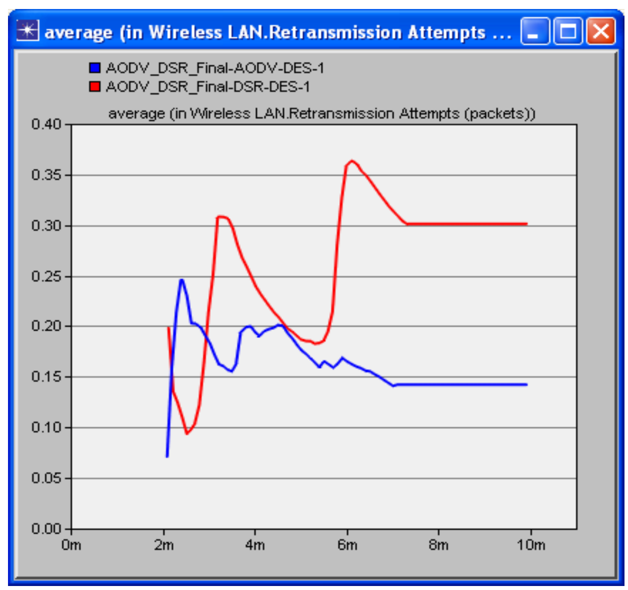

Fig. 11: Retransmission attempt

7. CONCLUSION

Based on the above results we can conclude that performance of AODV and DSR is dependent on various variables and environmental conditions like topology, node mobility, node density, type of traffic etc. For route discovery, AODV sends many small routing control packets, while DSR sends less but bigger control packets during transmission of data packets. All this results into making DSR more useful in smaller networks with less mobility and AODV more appropriate in ad hoc networks with a higher mobility and higher data transfer rate. As stated earlier and shown in the results, TCP performance in MANET is a challenge. Moreover the performance is also affected by the routing protocol used. TCP performance in AODV is better than that in DSR.

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