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A COMPREHENSIVE STUDY OF VARIOUS ON DEMAND ROUTING PROTOCOLS IN MANETS

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ABSTRACT

In MANETs (or Mobile Ad-hoc Networks), mobile devices undergo dynamically varying network topology. AODV, DSR and AOMDV ad- hoc routing protocols use single route reply along reverse path. Rapid change of topology causes the route reply to the source node to fail i.e. after a source node sends several route request messages; the node obtains a reply message, especially on high speed mobility. This increases communication delay and power consumption as well as decreases the packet delivery ratio. In this paper an attempt has been made to compare the performance of three prominent on demand reactive routing protocols for MANETs i.e. Ad-hoc On Demand Distance Vector (AODV), Dynamic Source Routing (DSR) protocol and Ad-hoc On-demand Multipath Distance Vector (AOMDV) routing protocol. The performance of these routing protocols is analyzed on various performance metrics and are simulated using NS-2 Network Simulator.

KEYWORDS: *MANETs, Routing Protocols, AODV, DSR and AOMDV*

I. INTRODUCTION

A network of sensor nodes using peer-to-peer communication [6] without an AP (Access Point) is called an ad- hoc network. The nodes in an ad hoc network are limited by power, memory, band width and computational constraints. Such networks provide cheap communication without fixed infrastructure. Hence, they are very useful in disaster recovery, collaborative computing, rescue operations and military surveillance.

A wireless network is a connection of computers or nodes through radio signal frequency. These nodes exchange data as and when required. A MANET or a Mobile Adhoc Network is a network of nodes that are mobile or free to move in a particular region of operation to gather physical data like temperature, humidity, vibrations, location, etc. However an important should not be forgotten that such networks do not have a central access or access point, as discussed earlier.

This paper discusses the performance of three on demand MANET protocols, which are AODV, DSR and AOMDV. The remaining sections of this paper are divided in a systematic manner to give a better understanding of the basic routing protocols. Section II contains the Literature Survey that deals with the various classification of routing protocols for MANETs. Section III gives the introduction of the AODV, DSR and AOMDV protocols.

II. LITERATURE SURVEY

Routing Protocol

Routing is the act of moving information from a source to a destination. A MANET includes many challenges and issues such as Dynamic topologies, Frequency of updates or network overhead, energy, speed, routing and security. In wireless ad hoc networks, a central issue is how to improve the system throughput and delay with low link cost [10]. The routing protocol is required whenever there is need to transmit data from the source to the destination with minimum link cost and shortest distance.

Classification of Routing Protocols for Ad-Hoc Networks

- **Proactive Routing Protocols**

Proactive routing protocols are table driven protocols [3] which usually use link state routing algorithm to flood the link information across all the available nodes. Such link state algorithm stores a copy of the network information and link costs for all the known nodes in the network. Thus we can conclude that link state routing algorithm is more reliable. These are more complex, less bandwidth-intensive and memory-intensive.

In these protocols, each node maintains routing information to every other node in the network. The routing information is usually kept in number of different routing tables. These tables are periodically updated if the network topology changes. The difference between these protocols exists in the way the routing information is updated, detected and type of information kept at each routing. Some of the most used on proactive routing protocols are Destination Sequenced Distance Vector (DSDV) and Wireless Routing Protocol (WRP) [2].

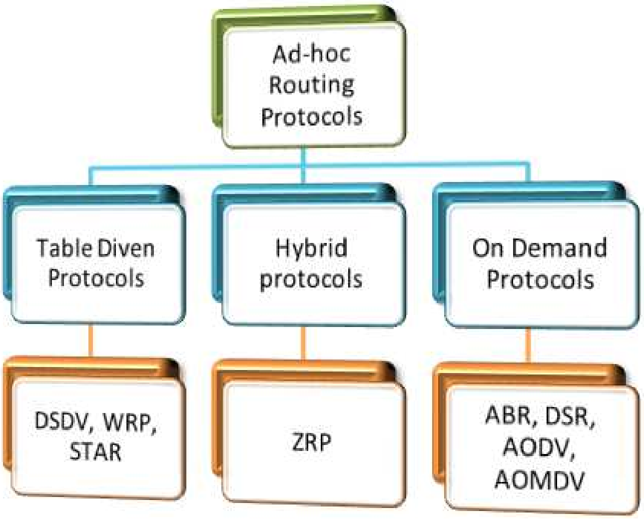

Figure 1: Routing Protocol in MANETs- An Overview

- **Reactive (On Demand) Routing Protocol**

Reactive routing protocols are on demand routing protocols which invokes the route discovery process to find the route to the destination. It employs the process of flooding in the network. Reactive protocol requests for the route in an on demand manner. The Route Request (RREQ) packets are flooded in the entire network. Unlike in table driven protocols, the nodes in Reactive routing Protocol does not necessarily need to update the routing information. Some examples of the on demand routing 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 Routing Protocol**

    - Hybrid routing protocols is a combination of both table driven and on demand routing protocols. Routing in hybrid routing protocol is initially established by some proactive (table driven) routes and then is flooded by the on demand routing protocol through the nodes in the network. Zone Routing Protocol (ZRP) is an example of such a hybrid protocol.

- **AODV(Ad-Hoc On Demand Distance Vector) Routing Protocol**

The adhoc on demand distance vector (AODV) routing protocol is an on-demand routing protocol as all routes are discovered only when needed and are maintained as long as they are being used. AODV has multicasting and uncasing routing protocol property within a uniform framework. *Source node, destination node* and *next hops* are addressed using *IP addressing.* AODV floods the route request (RREQ) packets in the entire network and receiving route reply (RREP) to find the available routes. To determine the updated routing information and to prevent routing loops, AODV uses sequence numbers maintained at each destination. Sequence number for both destination and source are used. The route reply (RREP) message is unicasted back to the source that sent the message RREQ. The route error (RERR) message is sent to notify other nodes of the network about the loss of the link. HELLO messages are used to detect the neighboring nodes of the network.

The routing table contains the information of the next hop to the destination and a sequence number which is received by the route request (RREQ) packet to its neighbours. The RREQ has following fields:

< source_addr, source_sequence_number, broadcast_id, dest_addr, dest_sequence_number, hop_cnt >

A route reply (RREP) packet is sent in a reply to the source of the RERR packet which contains the following fields:

<source_addr, dest_addr, dest_sequence_number, hop_cnt, lifetime>

There are two stages in the AODV protocol: route search stage and route maintenance stage. The main feature of the AODV is to update the state of every node. Routing table expires when the route is not used. The route search stage consists of:

- Route Request (RREQ)
- Route Reply (RREP)

Route maintenance stage consists of

    - Data
    - Route update
    - Route Error (RERR)

Route Search Stage

The figure 2(a) below shows the process of route discovery by broadcasting the RREQ packets and flooding the entire network. The node that receives the RREQ packet sends the RREP packet which is unicasted backwards to the source node. When the RREP packet reaches the source node it indicates that a route from source to the destination has been established and the source node can now start the transmission of data. If a route request (RREQ) is lost during transmission then the source node again broadcasts the RREQ packets using the route search mechanism.

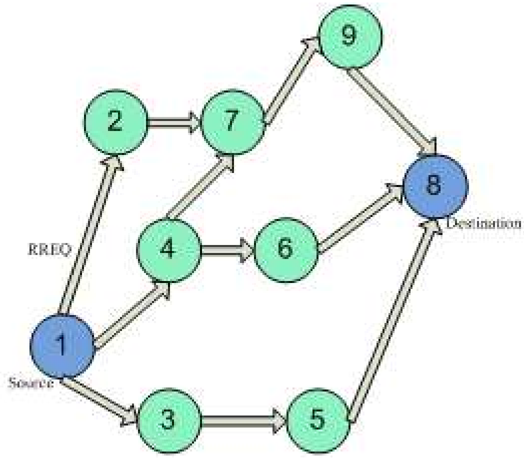

Figure 2(a): The Route Request (RREQ) Flooding for Route Discovery

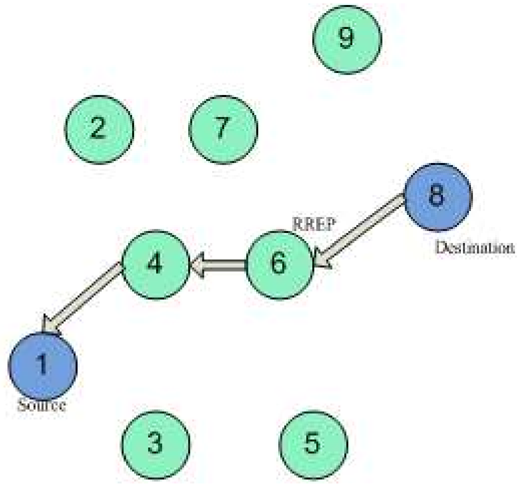

Figure 2(b): The Route Reply (RREP) Unicast for Route Discovery

Route Maintenance Stage

When a route is discovered between a source node and destination node then this route is to be maintained as long as they are needed by the source node. If the source node is in motion in active session then it can again use the route discovery process to find a new route to the destination. When the route discovery process fails due to the motion of the source node or any other nodes in the network then a route error (RERR) message is sent to the affected active nodes. These nodes send the RERR to their predecessor nodes until the source node is reached. When the RERR packet is received by the source node then it halts the sending of data and reinitiates the route search process by flooding the RREQ packets again in the network. If an intermediate node loses connectivity with its next hop, it sends a Route Error (RERR) message and broadcasts it to the neighboring nodes and the entry of the destination in the routing table is marked as invalid by setting the distance to infinity. This is explained in Figure 3 below:

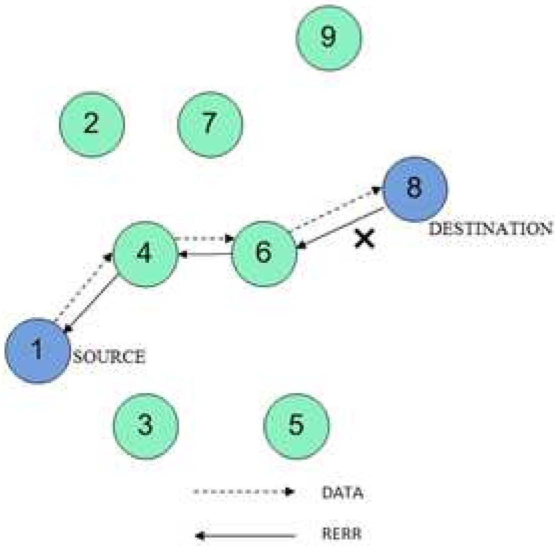

Figure 3: Route Maintenance Stage in AODV

- **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.

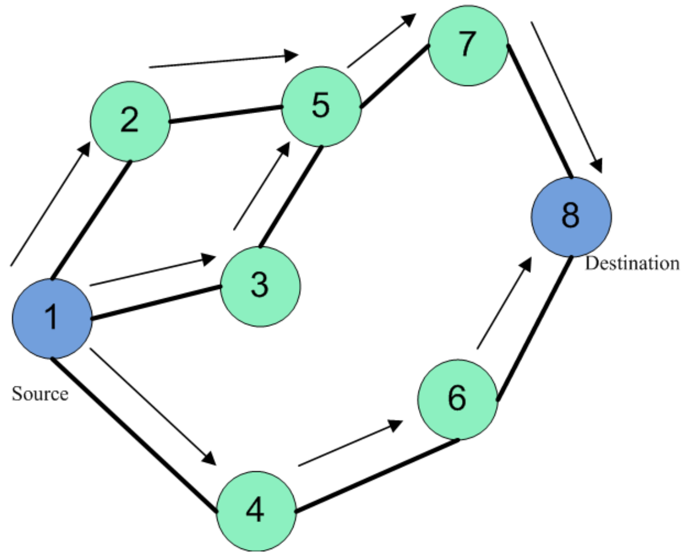

Figure 4a: Propagation of Route Request (RREQ) Packet

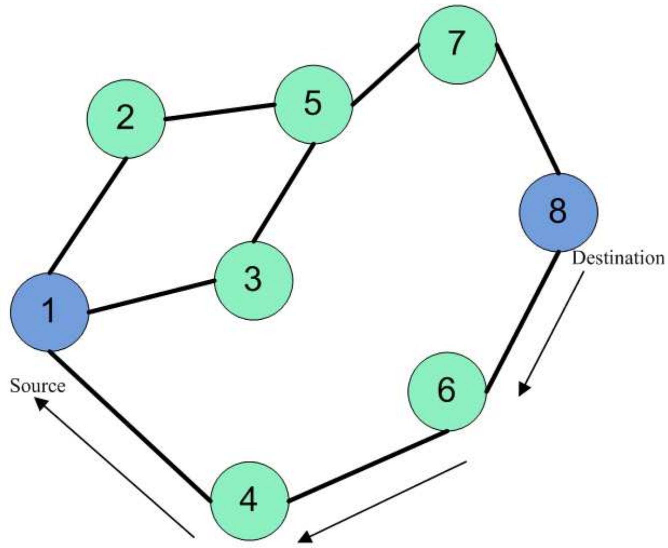

Figure 4b: Path Taken by the Route Reply (RREP) Packet

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

Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV) [11] protocol is an extension to the AODV protocol for computing multiple loop-free and link disjoint paths [12]. 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 [12]. 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 [12]. 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

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 [13] 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

- **Packet Delivery Ratio:** 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

- **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

- **Throughput:** Throughput is the ratio of the number of total packets successfully delivered to individual destination nodes over 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. The Simulation environment for the simulation of the above mentioned reactive protocols is given in table 1.

Table 1: Simulation Environment

SPECIFICATIONS	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

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 ratio, end to end delay and throughput are calculated for AODV, AOMDV and DSR. The results are analyzed below with their corresponding graphs.

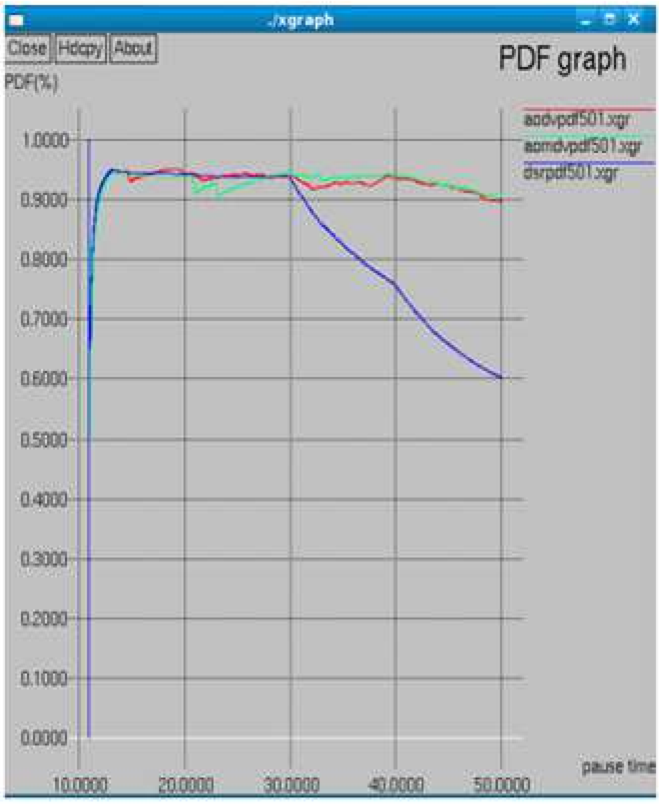

Figure 5a: Packet Delivery Fraction/Ratio Characteristics for AODV, AOMDV and DSR Routing Protocols

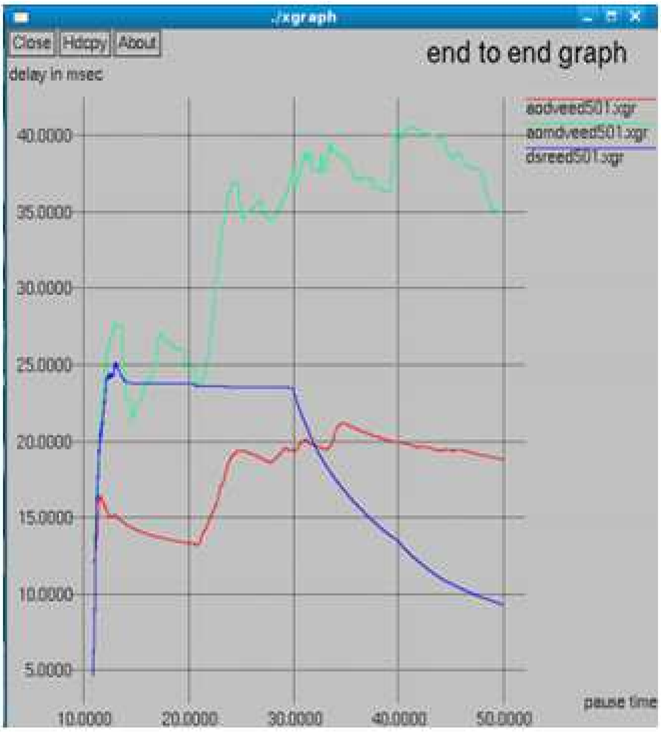

Figure 5b: End to End Delay Characteristics for AODV, AOMDV and DSR Routing Protocols

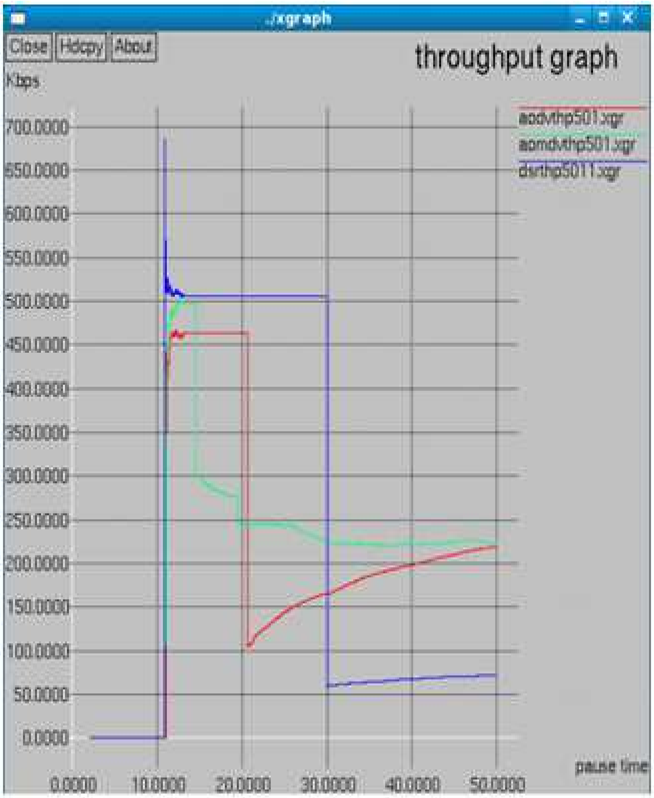

Figure 5c: Throughput Characteristics for AODV, AOMDV and DSR Routing Protocols

VI. ADVANTAGES AND DISADVANTAGES

There are less packet overheads in AODV routing protocol which serves as a great advantage over other protocols and it supports both unicast and multicast transmissions of packets even for the nodes which are in constant motion.

AODV employs destination sequence number for each route which increases the overall end to end delay. AODV does not allow security which may enable attacks from unknown nodes of other MANETs.

VII. CONCLUSIONS

This paper analyzed the performance of AODV, AOMDV and DSR protocols using NS-2. The comparison is made on three performance metrics that are End-to End Delay, Packet Delivery Ratio and the Throughput of the system. We conclude that AOMDV gives better performance as compared to AODV and DSR in terms of packet delivery ratio and throughput but worst in terms of end-to-end delay. Also the DSR routing protocol is best in terms of end-to-end delay in both static and dynamic networks.

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