Advances in Computer Science and Information Technology (ACSIT)
p-ISSN: 2393-9907; e-ISSN: 2393-9915; Volume 3, Issue 3; April-June, 2016, pp. 187-193

http://www.krishisanskriti.org/Publication.html

Performance Evaluation of Mobility Model against Routing Protocols in Mobile Ad Hoc Networks

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Abstract—*Ad hoc networks consist of hosts interconnected by routers without a fixed infrastructure and can be arranged dynamically. A mobile ad hoc network (MANET) is an autonomous system of mobile routers (and associated hosts) connected by wireless links - the union of which forms an arbitrary graph. With the growing of the Internet application, audio, video and multimedia has been playing a key role in wireless network. In this paper we evaluate the performance of ad hoc routing protocols i.e AODV (Ad hoc On-demand Distance Vector), OLSR (Optimized Link State Routing) and GRP (Gathering Based Routing Protocol) under Random Way Point and Vector Mobility model by undertaking three parameters such as delay, network load, and throughput. Simulation results by the OPNET 14.5 is also showed that OLSR proactive routing protocol is the best suited for MANET networks in with multimedia data in real time environment.*

Keywords*: MANET, AODV, OLSR, GRP, Mobility Models and OPNET.*

1. INTRODUCTION

A MANETs can be defined as a system of autonomous mobile nodes that communicate over wireless links without any preinstalled infrastructure. MANETs are useful in places that have no communications infrastructure or when that infrastructure is severely damaged. Mobile ad hoc network is a type of ad hoc network that can change locations and configure itself on the fly. In ad hoc networks every communication terminal communicates with its partner to perform peer to peer communication. Such a network may operate in a standalone fashion, or may be connected to the larger Internet. In ad hoc networks every communication terminal (or radio terminal RT) communicates with its partner to perform peer to peer communication. If the required RT is not a neighbour to the initiated call RT (outside the coverage area of the RT), then the other intermediate RTs are used to perform the communication link. This is called multi-hope peer to peer communication. In MANET every node finds the route by route request. Routing protocol plays a crucial role to send the data from source to destination that discovers the optimal path between the two communication nodes. Each protocol has its own rules (algorithm) to finds the route or maintenance the route. There are various routing protocol proposed by researchers. MANETs [1] are facing various challenges for e.g. No central controlling authority, Mobility models, limited power ability, continuously maintains the information required to properly route traffic. Mobility models are also a factor that puts a deep impact over the performance of a MANET and need to be concerned. There are many type of routing nodes in MANET are shows in the figure 1.

MANET routing protocols are traditionally divided into three categories which are Proactive Routing Protocols, Reactive Routing Protocols, Hybrid.

The most popular routing protocols in MANET are AODV (reactive), OLSR (proactive), and GRP (hybrid). Reactive protocols find the routes when they are desired. Proactive protocols are table driven protocols and discovery best routes before they need it. And finally hybrid routing protocols offer an efficient framework that can concurrently draw on the strengths of proactive [2] and reactive routing protocols [3]. Proactive algorithm also known as Time Driven Routing algorithm, workout routes in the background independent of traffic demands. Each node uses routing information to store the location information of other nodes in the network and this information is then used to move data among different nodes in the network. In networks utilizing a proactive routing protocol, every node maintains one or more tables representing the entire topology of the network. Reactive protocols also known as On Demand Routing Protocols, establish routes between nodes only when they are required to route data packets. There is no updating of every possible route in the network instead it focuses on routes that are being used or being setup.

When a route is required by a source node to a destination for which it does not have a route information, it starts a route discovery process which goes from one node to the other until it arrives at the destination or a node in between has a route to the destination.

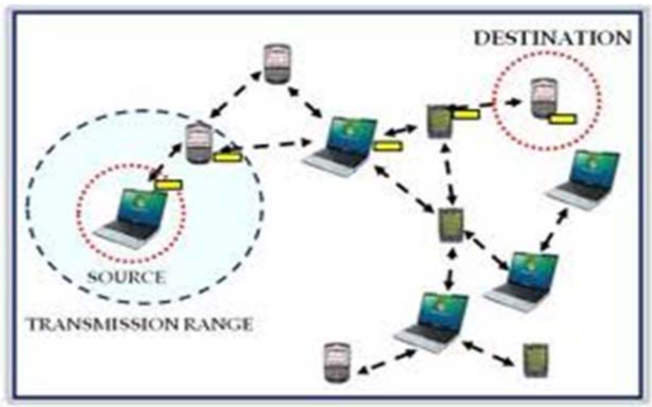

Fig. 1: Mobile Ad-hoc Network

Examples of reactive protocols are Ad-Hoc on Demand Distance Vector Routing Protocol (AODV) [10]. In this paper, we focus on two MANET routing protocols AODV, OLSR and GRP. We consider three parameters to evaluate the performance of these routing protocols: Throughput, Delay, and Network Load by multimedia application.

The rest of this paper is planned as follows. In section 2 we briefly describe the routing protocols in MANET. In Section 3 presents related work. In section 4 the Simulation environment and research Methodology used for evaluation of the said protocols and traffic. In Section 5 we analysis our simulation results and observations. Finally, section 6 concludes the paper.

2. ROUTING PROTOCOLS IN MANETS

Ad-hoc on demand distance vector (AODV)

AODV [4] is based upon on-demand routing protocol. Its provides on-demand route discovery in MANET. When the nodes need to send data to the destination, if the source node doesn't have routing information in its table, route discovery process begins to find the routes from source to destination. Route discovery begins with broadcasting a route request (RREQ) [5] packet by the source node to its neighbours. RREQ packet comprises broadcast ID, two sequence numbers, and the addresses of source and destination and hop count. The intermediary nodes which receive the RREQ packet could do two steps: If it isn't the destination node then it'll rebroadcast the RREQ packet to its neighbours. Otherwise it'll be the destination node and then it will send a unicast replay message, route replay (RREP), directly to the source from which it was received the RREQ packet. When the source node wants to create a new route to the destination, the requesting node broadcast an RREQ message in the network [6]. The hop count of the RREQ is incremented by one. The neighbour node will check if it has an active route to the destination or not. If it has a route so it will forward a RREP to the source node A. If it does not have an active route to the destination it will broadcast the RREQ message in the network again with an incremented hop count value. When a link is failed an RERR message is generated. RERR message contains information about nodes that are not reachable. The IP addresses of all the nodes which are as their next hop to the destination.

All the routing information about the network is stored in the table. The routing table have these route entries; (i) destination IP address, (ii) Destination Sequence Number (DSN), (iii) Valid Destination Sequence Number flag (iv) other state and routing flags (e.g., valid, invalid, repairable being repaired) (v) network interface (vi) hop count (number of hops needed to reach destination) (vii) next hop (viii) the list of precursors and lifetime (Expiration time of the route).

Optimized Link State Routing Protocol (OLSR)

The OLSR [7] is a table driven protocol. It usually stores and updates its routes so when a route is needed, it present the route immediately without any initial delay. In OLSR, some candidate nodes called multipoint relays (MPRs). Multipoint Relay (MPR) nodes broadcast route packets. These MPR nodes can be selected in the neighbor of source node. Each node in the network keeps a list of MPR nodes.

Multi-Point Relays (MPR) [8] are used to avoid unnecessary broadcast of packet retransmissions, moreover only partial link state is flooded to provide the shortest path route. This MPR selector is obtained from HELLO packets sending between in neighbour nodes. These routes are built before any source node intends to send a message to a specified destination. Each and every node in the network keeps a routing table. This is the reason the routing overhead for OLSR is minimum than other reactive routing protocols and it provide a shortest route to the destination in the network. There is no need to build the new routes, as the existing in use route does not increase enough routing overhead. It reduces the route discovery delay.

Gathering-based routing protocol (GRP)

Gathering-based Routing Protocol [8] combines the advantages of Proactive Routing Protocol (PRP) and of Reactive Routing protocol (RRP). Supporting the delay sensitive data such as voice and video but it consumes a great portion of the network capacity. While RRP is not suitable for real-time communication, the advantage of this approach is it can dramatically reduce routing overhead when a network is relatively static and the active traffic is light. However, the source node has to wait until a route to the destination can be discovered, increasing the response time.

The goal of the proposed routing protocol (GRP) [9] is to rapidly gather network information at a source node without spending a large amount of overheads. It offers an efficient framework that can simultaneously draw on the strengths of PRP and RRP. The procedures of GRP are described below.

A source node broadcasts a destination query (DQ) packet to its neighbours [10]. The DQ packet is continuously forwarded into each node's neighbours until the destination is reached. It is simply implemented by the conventional flooding process of RRP (as in DSR or AODV). That is, the DQ packet plays the same role of route request (RREQ) packet of RRP so that it consists of the address of the source, the destination node's address, and the sequence number. When the DQ packet reaches the destination, the destination node broadcasts a network information gathering (NIG) packet to its neighbours. The structure of NIG packet is similar to that of DQ packet, but it additionally contains link reversal flag (LRF) for resolving deadlock and variable-length payload for recording/gathering the network information.

3. RELATED WORK

We also studied performance evaluation of AODV, OLSR and GRP protocols, in that study various QoS parameters used were throughputs, end-to-end delay and network load. But a real evaluation of performance of protocols must also describe the degree of variability in packet arrivals, which can be caused by network congestion (bursts of data traffic), timing drift or because of route changes. Zhou et al. [11] that consists of ns multicast sessions. Each multicast session has one source and p destinations. Each source sends identical information to the p destinations in its multicast session, and the information is required to be delivered to all the p destinations within D time-slots. Assuming the wireless mobiles move according to a 2-D independently and identically distributed mobility model, then propose a joint coding/scheduling algorithm achieving a throughput. Our simulation results suggest that the same scaling law also holds under random walk and random waypoint models.

Each multicast session has multiple destinations, so the probability that a packet is within the transmission range of its destination(s) is higher than that in the unicast scenario. On the other hand, in the multicast scenario, the information needs to be transmitted reliably from the source to all its destinations, which requires more transmissions than that in the unicast scenario. Due to the broadcast nature of wireless communication, all mobiles in the transmission range of a transmitter can simultaneously receive the transmitted packet. In the unicast scenario, only one mobile (the destination of the packet) is interested in receiving the packet. In the multicast scenario, all the destinations belonging to the same multicast sessions are interested in the packet. Thus, one transmission can result in multiple successful deliveries in the multicast scenario, which can increase the capacity of MANETs. Liu et al.[12] represent the throughput delay trade off in a mobile ad hoc network (MANET) operating under the practical reference point group mobility model and also a general setting of node moving speed. We determine the regions of per node throughput and average delay and their trade off that can be achieved in such a network. The results in this paper help us to have a deep understanding on the fundamental performance scaling laws and also enable an efficient throughput delay trade off to achieve in MANET with correlated mobility. For both the regime of v=0 and v>0 we developed upper bond and lower bond for per node throughput delay tradeoffs. When v=0 all the group settings are static and the group region associated with each group remains unchanged over the time. For the regime of v>0 we consider a random direction model for group centre mobility, where each group centre moves across the network at a speed. Nodes belonging to a group need to concurrently reside in the disk area centred at the group centre and follow the i.i.d. mobility in the disk area during each time slot. Wang et al.[13] investigate the impact of an adaptive rate communication model on capacity-delay tradeoffs in MANETs under classical mobility models. Specifically, we adopt a well-known adaptive rate model called the generalized physical model .The mobility of nodes is characterized by two broad classes of practical mobility models and they are hybrid random walk models and discrete random direction models. The two models generalize many mobility models studied in the literature, including the random walk, Brownian, and random way point models. For each mobility model, we derive the optimal delay for the optimal per session unicast capacity (that of constant order Qð1Þ) under the generalized physical model, depending on the individual parameters of mobility models. In particular, the adaptive feature of link rate under the generalized physical model results in a significant decrease in the optimal delay for the optimal capacity; more precisely, both the optimal capacity and optimal delay can be simultaneously achieved, while there is no improvement for the random way-point model. There are having some limitations. There remain gaps between the lower and upper bounds on capacity and delay for some regimes. It is necessary to derive tight bounds in the whole regime and provide more complete and conclusive results. In order to concentrate on stressing new insights of the impact of rate adaptation, we constrained the strategies to the type of simple threshold-based two-hop relaying schemes in this work. An important work is to extend our results by adopting some advanced relay techniques, such as replication and network-layer cooperation policies. We only considered unicast sessions in this work. It should be interesting to extend our results to other traffic sessions, e.g., multicast, broadcast, converge cast, any cast and many cast.

Gandhi et al. [14] analyse the effect of one mobility models and average end to end delay is very less and remains almost same for all the nodes in case of DSDV. The performance of AODV has less end to end delay compared to ZRP but degrades with increase in the number of nodes. Overall, ZRP has higher end to end delay compared to other two protocols. AODV has an excellent performance over DSDV and ZRP. Average jitter of ZRP becomes quite high as network size increases. It is also observed that average jitter of ZRP degrades in high density of network. AODV gives best throughput. DSDV has lower performance in 75 nodes compared to ZRP. Average throughput of ZRP decreases when the no of nodes increase in network. Data packet delivery fraction of AODV is the best as compared to DSDV and ZRP. PDF of ZRP degrades consistently with increase of number of nodes in the network. AODV performs well in all parameters.

4. SIMULATION ENVIRONMENT AND RESEARCH METHODOLOGY

We used Network Simulation OPNET (optimized Network Engineering Tool) Modeler version 14.5 in our evaluation. The OPNET is a discrete event driven simulator . It simulates the network graphically and its graphical editors mirror the structure of actual networks and network components. The users can design the network model visually. The modeler uses object-oriented modeling approach. The nodes and protocols are modeled as classes with inheritance and specialization. The development language is C. The simulation is performed to evaluate the performance of routing protocols with the vector mobility issue at FTP traffic. Therefore, different simulation scenarios consisting of 50 nodes for AODV OLSR and GRP is considered. The nodes were randomly placed within certain gap from each other in 3.5×3.5 km office environment for 50 nodes. The constant FTP traffic is generated in the network explicitly i.e. user defined via Application configuration and Profile Configuration. Every node in the network was configured to execute AODV, OLSR and GRP respectively. The simulation time was set to 15 minutes and all the nodes were configured with defined mobility in space.

The following Performance Metrics has been used for evaluating the performance of various MANET routing protocols:

Network Load: The statistic represents the total data traffic (in bits/sec) received by the entire WLAN BSS from the higher layers of the MACs that is accepted and queued for transmission

End-to-end Delay: Represents the end to end delay of all the packets received by the wireless LAN MACs of all WLAN nodes in the network and forwarded to the higher layer. This delay includes medium access delay at the source MAC, reception of all the fragments individually, and transfers of the frames via access point, if access point functionality is enabled.

Throughput: Represents the total number of bits (in bits/sec) forwarded from wireless LAN layers to higher layers in all WLAN nodes of the network.

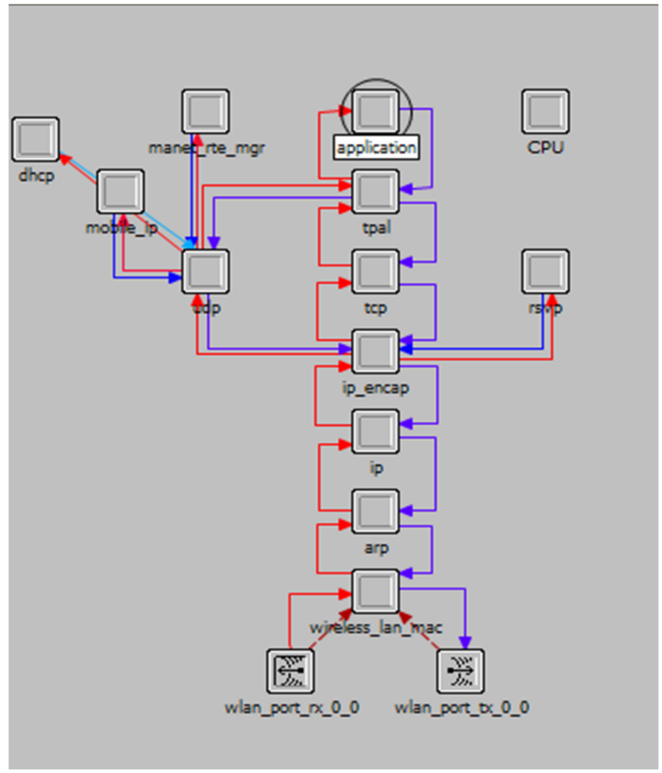

Fig. 2: Simulation of MANET system in OPNET

Table 1: Simulation Parameters

Statistic	Value
Simulator	OPNET 14.5
Routing Protocols	AODV,OLSR and GRP
Data rate	11 Mbps for 802.11
MANET Nodes	50 nodes
Scenario Size	3.5 *3.5 km
Voice frames per packets	One
Simulation Time	15 minutes
Application Traffic	Multimedia
Channel Type	IEEE 802.11 Wireless channel
Performance Parameters	Throughput, Delay, Network Load

Routing Protocol – AODV, OLSR and GRP. When there are no direct links between the sender and receiver, packets must pass through other nodes in the network to reach their destination. This multi-hop routing is implemented using routing protocols. Determines routes from each node to every other node in the network.

It allows the users to design and study communication networks, devices, protocols, and applications with flexibility and scalability. It simulates the network graphically and its graphical editors mirror the structure of actual networks and network components. The simulation multimedia MANET application nodes with parameters are summarized in figure 2.

Fig. 3: Simulation Network with 50 nodes with GSM codecs

OPNET modeler 14.5 is used to investigate the performance of routing protocols AODV, OLSR and GRP with varying network sizes, data rates, and network load. We evaluate three routing protocol with three parameters and show of these applications is estimated beside the quality of service requirements using the voice and wireless LAN metrics and based on the results it is clear that multimedia quality speech has shown the maximum QoS standards when compared to the other scenarios.

5. SIMULATION RESULT AND OBSERVATIONS

We carried out simulations on OPNET simulator [20]14.5. The results show differences in performance between considered routing protocols, which are the consequence of various mechanisms on which protocols are based. We carried out our simulations with 50 nodes [21].

Figures 4, 5 and 6 depicts the throughput, delay and network load of this network with respect to total simulation time which is taken as 15 minutes for which the simulation was run. In this simulation, the networks is set to 50 nodes, the voice traffic with variable bit rate and constant bit rate, the data transmission rate is 11 Mbps, IEEE 802.11 Wireless channel and the simulation time is 15 minutes

A. Throughput:

In this figure 4 show that throughput in OLSR is the higher than AODV and GRP. OLSR performs better from both AODV and GRP setups of 50 nodes in vector mobility model. The throughput for OLSR is much higher in the start 2,500,000 bps but it shows a slight slump at the end 2,300,000 bps in vector mobility.

OLSR gives the best performance as throughput from both AODV and GRP in vector mobility model for 50 nodes, because VBR files provide variable output as data per time segment and VBR permits more complex segments for media files due to variable bit rate encode video data or sound more correctly .The available bits are more flexibly due to throughput which comes out under OLSR other than two protocols. The network throughput of AODV and OLSR becomes low with the increase of the node number. The reason is that OLSR and AODV have different strengths and weaknesses when it comes to node mobility in MANETs. Unlike wired networks, the topology in wireless ad hoc networks may be highly dynamic, causing frequent path breaks to on-going sessions. When a path break occurs, new routes need to be found.

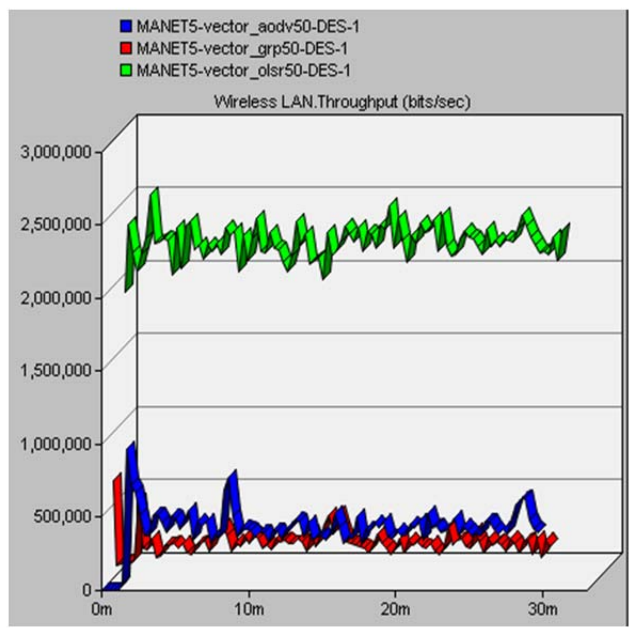

Fig. 4: Throughput comparison in routing protocols with 50 nodes using vector mobility model

B. Delay:

Again OLSR outperforms both in figure 5 AODV and GRP in terms of end to end delay experienced in the network. It is observed that OLSR consistently shows the minimum delay. In both vector mobility as well multimedia application. OLSR shows minimum delay and AODV shows average delay and GRP shows maximum delay.

In vector mobility model initially OLSR shows delay of 0.0004 sec in the beginning and maximum delay of 0.007 sec in the 50 nodes of vector mobility.

OLSR is a proactive protocol this may be explained by the factor that, it has a faster processing at intermediate nodes. When a packet arrives at a node, it can immediately be forwarded or dropped because OLSR protocol proactively holds routing information to all destinations in its table, regardless the topology changed. OLSR shows up to 50 nodes at the end 0.0005 sec delay.

In this setup AODV shows much higher maximum delay of 0.0028 sec than OLSR but lower than GRP in the 50 nodes of vector mobility. At the end it shows delay 0.0010 sec but it was quit higher than OLSR.

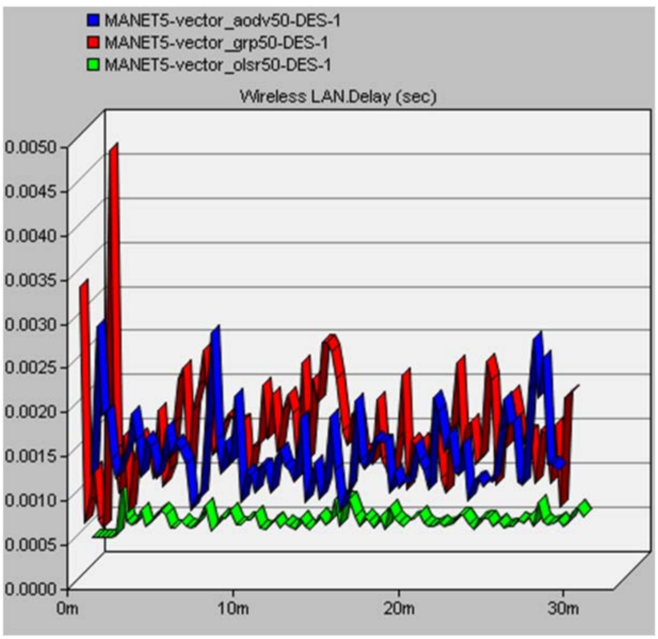

Fig. 5: Delay comparison in routing protocols with 50 nodes using vector mobility model

C. Network Load

According to Figure 6 network load of OLSR [7] is highest, AODV is low after end of simulation time.

OLSR shows 5,25,000 bps maximum load initially, while it move in the 50 nodes shows 2,51,000 bps at the end of vector mobility than AODV and GRP, because OLSR have proactive nature and required all routing table towards its destination. Initially it shows the load on the network with maximum level but, it decreases at end.

AODV shows medium or average load as compare to OLSR, because it act as reactive in nature and established a connection on demand. It shows initially and maximum load 432,000bps and at the end it shows 110,000bps in the 50 nodes of vector mobility.

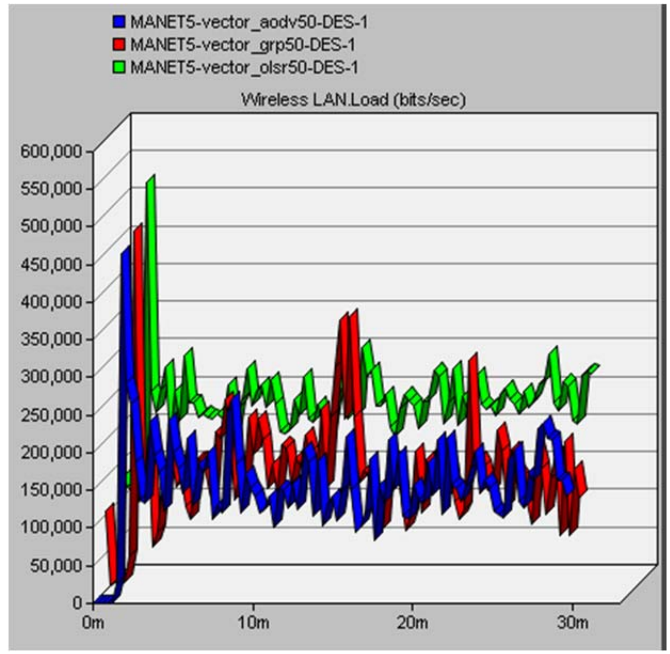

Fig. 6: Network Load comparison in routing protocols with 50 nodes using vector mobility model

GRP shows maximum load 450,000bps at the beginning and decrease minimum load at the end 1,00,000 bps in the 50 nodes of vector mobility, because GRP is a hybrid protocol , reassembling itself when required.

6. CONCLUSION

In this paper, according to simulation study of this work has been done for three routing protocols AODV, OLSR and GRP deployed over MANET using multimedia traffic. As the results for real environment of MANET is shows that OLSR in vector mobility have greater maximum throughput than AODV and GRP in different simulation parameters. The reason behind that vector mobility avoids unrealistic behavior and also remembering current state and partial changes allow. It can be easily implemented its positional updates as well as prediction opportunity and GRP shows hybrid nature as proactive as well as reactive nature for mobility models. In vector mobility shows high throughput as compare to others, because vector mobility works on prediction mobility whereas random way point mobility and other having fixed and well defined path and speed variances as min speed or max speed and showed that OLSR proactive routing protocol is the best suited for MANET networks against the vector mobility model with multimedia data in real time environment.

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