Mobile Ad Hoc Networking Protocols' Evaluation through Simulation for Quality of Service

Nadia Qasim, Fatin Said, Hamid Aghvami

Abstract— *This paper evaluates quality of services for the mobile ad hoc network's routing protocols. It is seen that mobile ad hoc networks will be an integral part of next generation networks because of its flexibility, infrastructure less nature, ease of maintenance, auto configuration, self administration capabilities, and cost effectiveness. This research paper shows comparative evaluation within mobile ad hoc networks' routing protocols from reactive, proactive and hybrid categories. We have comprehensively analyzed the results of simulation for mobile ad hoc routing protocols for quality of services of end to end delay, media access delay, throughput and packet delivery ratio for optimized link state routing, temporary ordered routing algorithm and ad hoc on demand distance vector protocol. In mobile ad hoc networks, mobile nodes must collaborate with each other in order to interconnect, organize the dynamic topology as mobility cause route change and establish communication over wireless links. The simulation results showed the lead of proactive over reactive and hybrid protocols in routing traffic for dynamic changing topology. Proactive protocol, optimized link state routing, a protocol for building link tables for ad-hoc networks, can transmit traffic more rapidly though involve less processing speed in packet forwarding.*

Keywords: MANET, QoS, Routing Protocol, Wireless.

I. INTRODUCTION

Mobile ad hoc networks (MANETs) are rapidly evolving as an important area of wireless mobility. MANETs are infrastructure less and wireless in which there are several routers which are free to move arbitrarily and perform management of routes [2]. MANETs as shown in fig (1) have characteristics that network topology changes very rapidly and unpredictably in which many mobile nodes moves to and from a wireless network without any fixed access point where routers and hosts move, so topology is dynamic. MANET can have multiple hops over wireless links; also connection point to the internet may also change. It has to support multi hop paths for mobile nodes to communicate with each other. If mobile nodes are within the communication range of each other than source node can send message to the destination node otherwise it can send through intermediate node. Now-a-days mobile ad hoc networks have robust and efficient operation in mobile wireless networks as it can include routing functionality into mobile nodes which is more than just mobile hosts and reduces the routing overhead and saves energy for other nodes.

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Nadia Qasim is Researcher, Fatin Said is Member and Hamid Aghvami is Director of the Centre for Telecommunication Research, King's College London, Strand, WC2R 2LS, London, England, UK, phone: +44 (0)20 7848 2889, Fax +44 (0)20 7848 2664, {nadia.qasim, fatin.said, hamid.aghvami}@kcl.ac.uk.

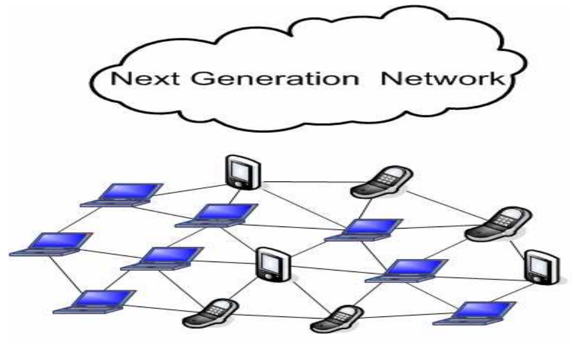

Fig 1: Mobile Ad Hoc Networks-MANETs.

Mostly mobile ad hoc networks are used in military communication by soldiers, planes, tanks etc, operations, automatic battlefields, emergency management teams to rescue[5], search, fire fighters or by police and replacement of a fixed infrastructure in case of earthquake, floods, fire etc, quicker access to patient data about record, status, diagnosis from the hospital database, remote sensors for weather, personal area network, taxi cab network, sports stadiums, mobile offices, yachts, small aircraft, electronic payments from anywhere, voting systems[6], vehicular computing, education systems with set-up of virtual classrooms, conference rooms, meetings, peer to peer file sharing systems[6], collaborative games with multi users.

Major challenges in mobile ad hoc networks are routing of packets with frequently mobile nodes movement, there are resource issues like power and storage and also wireless communication issues. As mobile ad hoc network consists of wireless hosts which may move very often. Movement of hosts results in a change of routes

II. MOBILE AD HOC NETWORK'S ROUTING PROTOCOLS

Mobile ad hoc network's routing protocols are characteristically subdivided into three main categories. These are proactive routing protocols, reactive routing protocols and hybrid routing protocols. Each category has many protocols and some of these protocols are shown in figure (2).

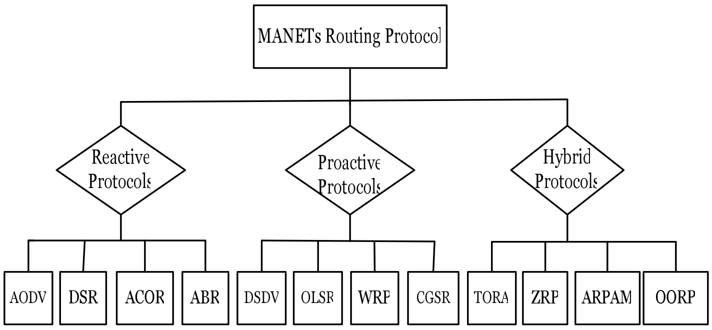

Fig 2: MANETs Routing Protocols.

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Proactive routing protocol maintains regular and up to date routing information about each node in the network by propagating route updation at fixed time intervals throughout the network, when there is a change in network topology. As the routing information is usually maintained in tables, so these protocols are also called *table-driven* protocols i.e. Ad hoc On Demand distance Vector protocol (AODV), Dynamic Source Routing (DSR), Admission Control enabled On-demand Routing (ACOR) and Associativity Based Routing (ABR). Reactive routing protocols establish the route to a destination only when there is a demand for it, so these protocols are also called *on demand* protocols i.e., Destination Sequenced Distance Vector (DSDV), Optimized Link State Routing (OLSR), Wireless Routing Protocol (WRP) and Cluster head Gateway Switch Routing (CGSR). When a source wants to send to a destination, it uses the route discovery mechanisms to find the path to the destinations by initiating route request. When a route are established, then route remains valid till the destination is reachable or when the route is expired. Hybrid routing protocols is the combination of both proactive and reactive routing protocols i.e. Temporary Ordered Routing Algorithm (TORA), Zone Routing Protocol (ZRP), Hazy Sighted Link State (HSLS) and Orderone Routing Protocol (OOPR). Proactive and reactive algorithms are used to route packets. The route is established with proactive routes and uses reactive flooding for new mobile nodes. In this paper we have compared MANETs routing protocols from reactive, proactive and hybrid categories, as we have used randomly one protocol from each categories as from reactive AODV, proactive OLSR, hybrid TORA; for simulation evaluation of quality of service factors.

A. Ad Hoc on Demand Distance Vector (AODV)

Ad hoc on demand distance vector protocol is reactive protocol. It constructs route on demand and aims to reduce routing load [1]. It uses a table driven routing framework, destination sequence numbers for routing packets to destination mobile nodes and has location independent algorithm. It sends messages only when demanded and it has bi-directional route from the source and destination. When it has packets to send from source to destinations mobile node (MN) then it floods the network with route request (RREQ) packets. All mobile nodes that receive the RREQ from neighbor or update message then it checks routing table to find out that if it is the destination node or if it has fresh route to the destination then it unicast route reply (RREP) which is routed back on a temporary reverse route generated by RREQ from source node, or else it re-broadcast RREQ.

B. Optimized Link State Routing (OLSR)

Optimized link state routing is a proactive routing protocol [9]. In which each node periodically broadcasts its routing table allowing each node to build a global view of the network topology. The periodic nature of the protocol creates a large amount of overhead. In order to reduce overhead it limits the number of mobile nodes that can forward network wide traffic and for this purpose it uses *multi point relays* (MPRs) which is responsible for forwarding routing messages and optimization for controlled flooding and operations. Mobile nodes which are selected as MPRs can forward control traffic and reduces the size of control message. Each node independently elects a group of MPRs from its one hop neighbors. MPRs are chosen by a node such that it may reach each two hop neighbor via at least one MPR. The MPRs are responsible for forwarding the control traffic generated by that node. All mobile nodes periodically broadcast a list of its MPR selectors instead of the whole list of neighbors. MPRs advertise link state information for MPR selection periodically in control messages. MPRs are also used to form a route from MN to destination node and perform route calculation. OLSR can forward packets if control traffic received from a previous hop has selected the current node as a MPR. Mobility causes route change and topology changes very frequently and topology control (TC) messages are broadcasted throughout the network. All mobile nodes maintain the routing table that contains routes to all reachable destination nodes. OLSR does not notify the source immediately after detecting a broken link and source node comes to know that route is broken when the intermediate node broadcasts its next packet.

C. Temporary Ordered Routing Algorithm (TORA)

Temporary ordered routing algorithm is hybrid protocol, which is distributed and routers only maintain information about adjacent routers [11]. During reactive operation, sources initiate the establishment of routes to a given destination on demand. Where in dynamic networks, it is efficient with relatively sparse traffic patterns; as it does not have to maintain routes at all the time. It does not continuously execute a shortest path computation and the metric used to establish the routing structure does not represent a distance. TORA maintains multiple routes to the destination when topology changes frequently. It consists of link reversal of the *Directed Acyclic Graph* (ACG). It uses internet MANET encapsulation protocol (IMEP) for link status and neighbor connectivity sensing. IMEP provide reliable, in-order delivery of all routing control messages from a node to all of its neighbors, and notification to the routing protocol whenever a link neighbors is created or broken. As TORA is for multihop networks which is considered to minimize the communication overhead associated with adapting to network topological changes by localization of algorithmic reaction. Moreover, it is bandwidth efficient and highly adaptive and quick in route repair during link failure and providing multiple routes to destination node in wireless networks.

III. SIMULATION SETUP

We have conducted extensive simulation study to evaluate the quality of service for various mobile ad hoc networks' routing protocols; reactive AODV, proactive OLSR, hybrid TORA. We have used OPNET 14.0 simulator to carry out simulation of MANETs routing protocols [7], which is used for network modeling and it has very fast event simulation engine.

A. *Mobility Model:* Mobile nodes in the simulation area move according to random waypoint model [5].

B. *Radio Network Interfaces:* The physical radio characteristics of each mobile node's network interface, such as the antenna gain, transmit power, and receiver sensitivity, were chosen to approximate the direct sequence radio [6].

C. *Media Access Control:* The distribution coordination function (DCF) of IEEE 802.1 1b was used for underlying MAC layer [6]. Default values are used for MAC layer parameters.

D. *Network Traffic:* In order to compare simulation results for QoS of each routing protocol, communication model used for network traffic sources is FTP.

E. *Traffic Configuration:* For traffic configuration, all experiments have one data flow between a source node to a sink node consisting of TCP file transfer session and TCP transmits packets with the highest achievable rate with reliable delivery [3].

IV. SIMULATION ENVIRONMENT

Simulation environment consists of 50 wireless mobile nodes which are placed uniformly and forming a mobile ad hoc network, moving about over a 1000 x 1000 meters area for 900 seconds of simulated time [2]. All mobile nodes in the network are configured to run Ad hoc On Demand distance vector protocol (AODV) or Temporary Ordered Routing Algorithm (TORA) or Optimized Link State Routing (OLSR) protocols and multiple FTP sessions. In our simulation studies, we have set different values for seed of the pseudo random number generator *(PRNG)* properly, so that each simulation will produce independent results, in order to affirm the independent replication method for analysis. We have collected AODV, TORA, OLSR related statistics and analyze these protocols as the network dynamics changes. Data points are represented in the graphs are averaged over 10 simulation runs, each with different seeds. All protocols have used Karn's algorithm for accurately estimating the round trip time for messages when using TCP. It is incorporated with transmission timeouts with timer backoff strategy which computes an initial timeout. If the timer expires and causes a retransmission, TCP increases the timeout generally by a factor of 2 as *new timeout = 2* timeout.* Parameters which are common to proactive, reactive and hybrid routing protocols are shown in Table 1.

Table 1: Common simulation parameters

Parameters	Value
Channel type	Wireless Channel
MAC Type	802.11 b
Data Rate	11 Mbs
Radio Propagation Model	Direct Sequence
AP Beacon Interval	0.02 Sec
Network Interface Type	Wireless Physical Layer
Buffer Size	256000
Link Layer Type	Data Link Layer
Large Packet Processing	Fragment
Packet Reception Power Threshold	-95
Transmit Power	0.005
Rx Group Config Selection Criteria	Distance & Path Loss Match
Wireless LAN	IEEE 802.11e capable
HCF for QoS Support	Promoted

Following tables show various parameters used specific to routing protocols during simulations' execution.

Table 2: Constants of IMEP used in the TORA simulation.

Beacon Periods	3 sec
Max Beacon Timer	9 sec
Max Tries	3 Attempts

Table 3: Constants used in the AODV simulation.

Route Discovery Parameter	Gratuitous Reply
Active Route Timeout	30 Seconds
Hello Interval	uniform (10,10.1)
Allowed Hello Loss	10
TTL Parameter	2

Table 4: Constants used in the OLSR simulation.

Hello Interval	2 sec
TC Interval	5sec
Neighbor Hold Time	6 seconds
Topology Hold Time	15 seconds
Duplicate Message Hold Time	30 seconds
Willingness	Willingness Always
Addressing Mode	IPv6

The AODV simulation parameters used are the same as in [2] except the active route timeout which was set to 30 seconds, the TORA parameters we have used are similar to those in [8]; moreover, the OLSR parameters we used are similar to those in [2]; OLSR's Hello interval and TC interval are set to 2. In OLSR's Hello interval and TC interval were set to 2 and 5 seconds respectively, its neighbor hold time is 6 seconds, and entries in topology table expire after 15 seconds. When we run AODV simulation then speed and results are improved by active route timeout, Hello interval and allowed Hello loss values. Figure (3) shows simulation scenario of AODV.

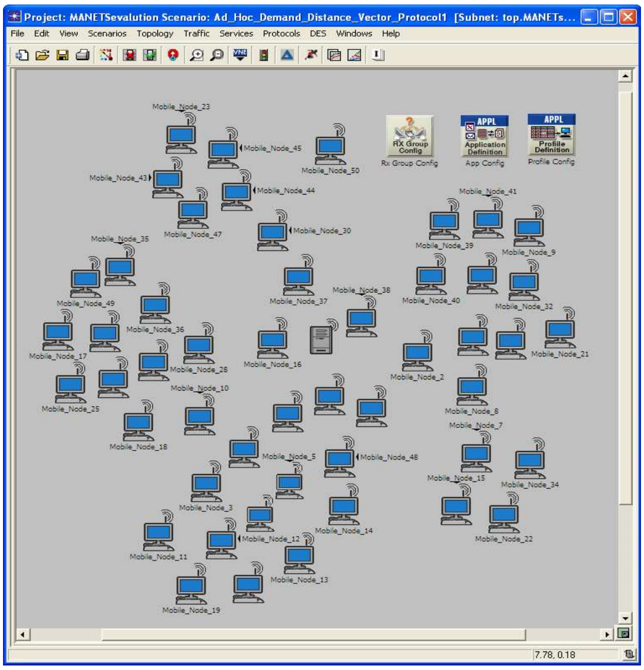

Fig 3: Ad Hoc on Demand Distance Vector Scenario.

These reduced FTP download and upload response times. As now the routes expire only after 30 seconds rather than 3 seconds. Also gratuitous reply and increased time to live (TTL) start values reduce route discovery frequency. Less routing traffic is generated because of increased Hello time interval for periodic Hello broadcasts and results in less congestion in wireless network.

TORA has dynamic networks with relatively sparse traffic patterns, when topology changes frequently. It has link reversal of the *Directed Acyclic Graph* (ACG) and IMEP for link status and neighbor connectivity sensing. Figure (4) shows simulation scenario of TORA.

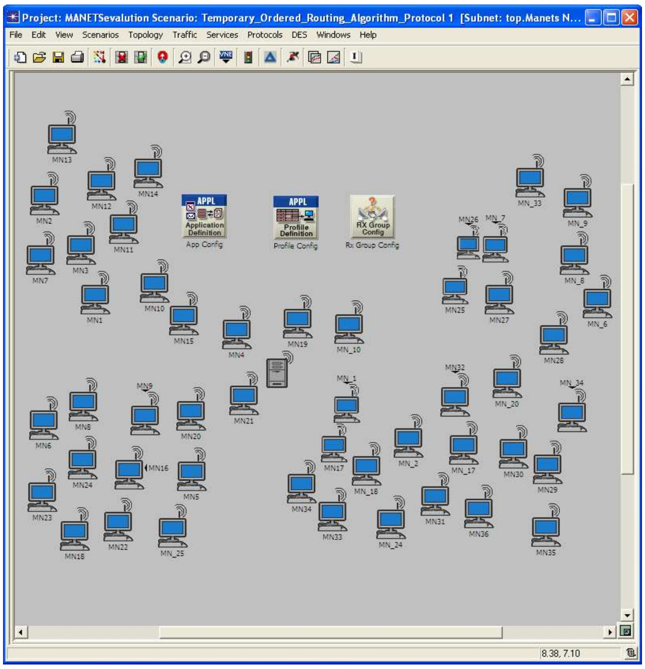

Fig 4: Temporary Ordered Routing Algorithm Scenario

In OLSR scenario as shown in figure (5), the mobile nodes in the network are grouped in clusters and each cluster of mobile nodes has MPR. The transmission range is 300 meters so that one hop is required for communication for the MN at other ends of the network. Mobile node in centre cluster can be accessed easily than nodes near boundary clusters. The willingness parameters for MPR are chosen to reduce the number of MPRs.

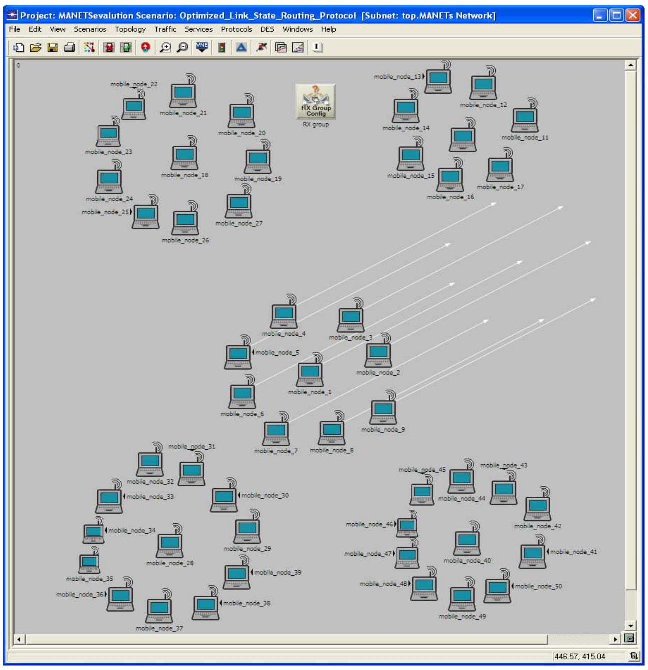

Fig 5: Optimized Link State Routing Scenario

If the willingness attribute are already set for some specific MNs then those nodes can guaranteed to be selected as MPR. The MPRs that are selected in each cluster are the MNs which have high willingness parameter. In that case all mobile nodes in wireless network have part of information about network topology and chosen MPR. When mobile nodes receive new topology information then MPRs are selected again and finally move towards stable state. We have five clusters each having its own five MPRs that move towards stable state. MPR mobile nodes in the network send topology control messages periodically. The numbers of MPR in network are directly proportional to the number of TC traffic sent. Each MN sends periodically Hello messages in the network that consists of list of neighbors and node movement's changes. When number of neighbors for each mobile node decreases in network. Therefore, the mobile nodes in centre cluster moves away; it results in the size of each hello message reduction [7].

There have been previous papers [2,3,6,8 and 10] to provide a comparative analysis of routing protocols for ad hoc networks, although those simulations used substantially different input parameters than ours. Yet, there has been no comprehensive evaluation study done to compare the performance based on categories of routing protocols, which are reactive, proactive and hybrid routing protocols. Specifically, the total simulation time was 900 seconds over which the performance statistics are collected. Another important difference between our study and previous studies was that we aim to evaluate the varying state behavior of routing protocols from different categories.

V. QUALITY OF SERVICES FACTORS

In our simulation study, quality of service evaluation is carried out by following performance factors:

A. *Throughput* is the total number of packets received by the destination.
B. *End to End Delay* is the average end to end delay of data packets from senders to receivers.
C. *Media Access Delay* is the media transfer delay for multimedia and real time traffics' data packets from senders to receivers.
D. *Packet delivery ratio* (PDR) is ratio between the number of packets received by the TCP sink at the final destination and number of packets generated by the traffic sources. Moreover, it is the ratio of the number of data packets received by the destination node to the number of data packets sent by the source node [4].
E. *Routing load* specifies the load over communications links for traffic flow.

VI. SIMULATION RESULTS

When the mobile ad hoc network simulations are run than result shows that all mobile nodes are in range of each other, no data packets experience collisions in presence of ftp traffic load and all mobile nodes are capable of sending packets. Hence, it shows that carrier sense and back off mechanisms of the 802.11b are working precisely. All results are obtained by averaging over 10 random mobility scenarios of mobile ad hoc networks.

Table 5: Simulation results over simulation time of 900 seconds.

Protocols	Average Number of Events Simulated	Average Speed
AODV	229,537	398,557 events/sec
TORA	199,354,5	544,829 events/sec
OLSR	143,571,00	232,943 events/sec

The most number of events are simulated by OLSR which are 143,571,00. Consequently, average number of events simulated by TORA and AODV are 199,354,5 and 229,537 respectively. On the other hand, high simulation speed for most of events simulated per seconds was observed in TORA routing protocol simulation runs that was 544,829 events per second, than it was in AODV and OLSR for about 398,557 and 232,943 events per seconds. These statistics shows that proactive protocol can simulate millions of more event than reactive and hybrid protocols.

A. Throughput

Throughput which is the number of routing packets received successfully by each routing protocol was shown in figure (6). When comparing the routing throughput packets received by each of the protocols, OLSR has the high throughput. Throughput is a measure of effectiveness of a routing protocol. OLSR receives about 1,950,000 routing packets at start of simulation time, then fluctuates for 60 seconds and gradually becomes stable around 1,600,200 data packets are received.

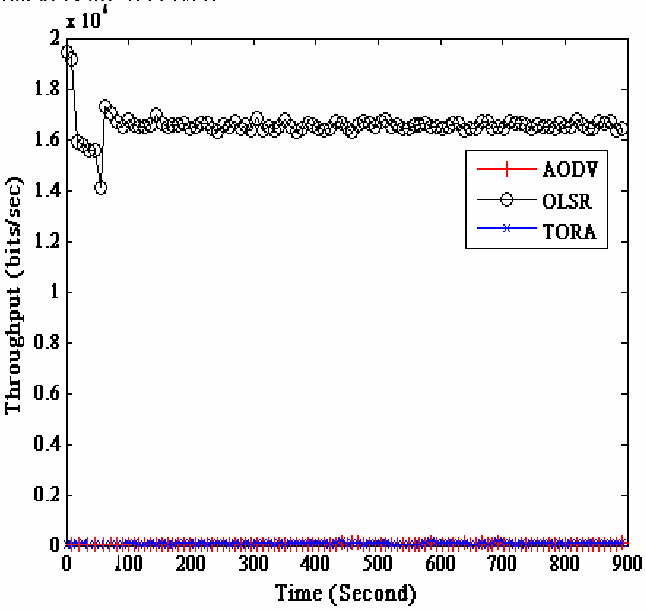

Fig6: Throughput for AODV, OLSR and TORA

In figure (7) AODV and TORA are plotted on the different scales to best show the effects of varying throughput. TORA's throughput increases IMEP's neighbor discovery mechanism, which requires each node to transmit at least 1 Hello packet per BEACON period (3 second). For 900 second simulations with 50 mobile nodes, this results in a maximum throughput of 1, 4500 packets. In reactive protocol AODV as the number of sources nodes increases than the number of routing packets received also increases to 8,000 packets as it maintains cache of routes in routing table to destination and unicast reply by reversing route generated by source node or re broadcast route request. Delivery of broadcast packets are not reliable at receiver as there cannot be reservation for the wireless medium at the receivers before transmitting a broadcast packet by exchange of request to send or clear to send (RTS/CTS) packets. The source nodes generate packets and broadcast packets which are received by many mobile nodes, so number of packets received is much higher than the number of packets sent. This difference does not exist in wired networks and shows fundamental limitation of wireless networks. Overall, proactive routing protocol has highest throughput in MANETs.

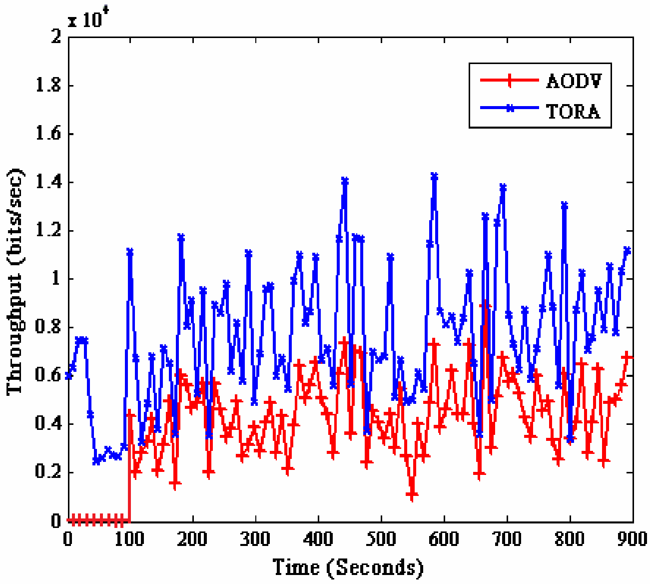

Fig7: Throughput for AODV and TORA

B. End to End Delays

Figure (8) shows that OLSR has lowest steady end to end delays which are about 0.0004 seconds. Further on, the end to end delay start to rise and fall abruptly in AODV and TORA therefore ends up in less end to end delays in AODV as compare to TORA that is around on average 0.0015 second

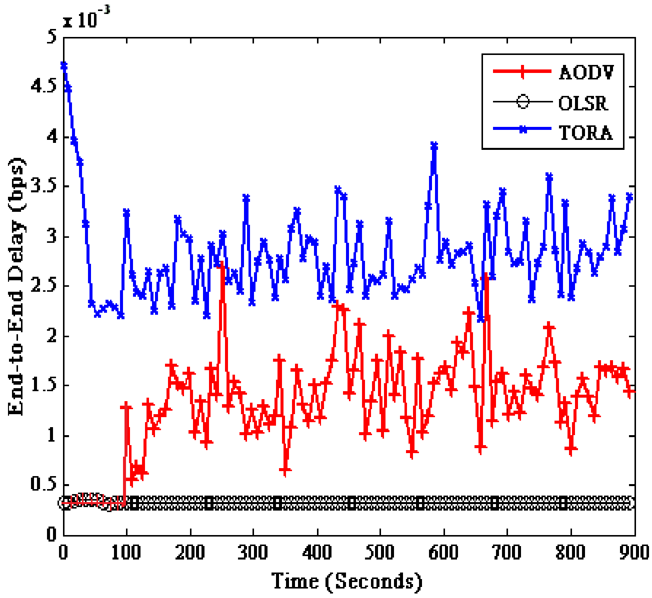

Fig 8: End to End Delay for AODV, TORA and OLSR

TORA have higher delays because of network congestion. As created loop where the number of routing packets sent caused MAC layer collisions, and data, Hello and ACK packets were lost that resulted in assuming that links to neighbors was broken by IMEP. Therefore, TORA reacted to these link failures by sending more UPDATEs, in turn that created more congestion as failure to receive an ACK from retransmitted UPDATEs was considered as link failure indication. Overall, OLSR has lowest end to end delays with high throughput.

C. Media Access Delay Details

In figure (9) we have plotted media access delay which is very important for multimedia and real time traffic; furthermore it is vital for any application where data is processed online. Media access delays are low for OLSR that is around 0.0001 second. However, the media access delay for AODV and TORA fluctuates more frequently but AODV fluctuates more frequently above and below its mean while TORA mainly around its mean, thus in both case fluctuation is higher and more frequent as compared to OLSR that remains steady over 900 seconds of simulation time.

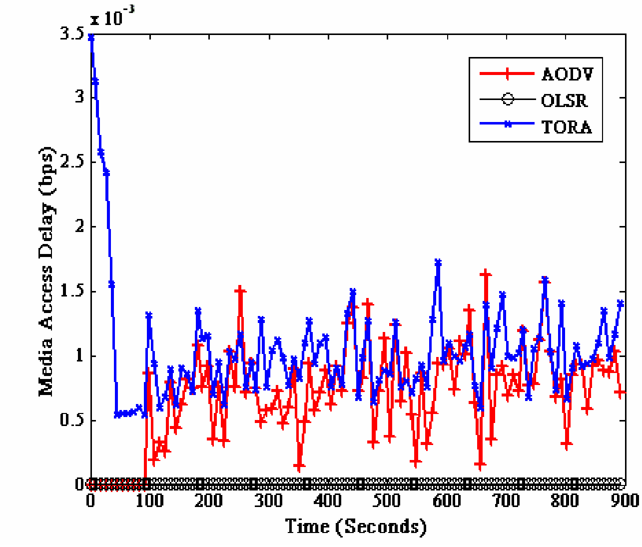

Fig 9: Media Access Delay for AODV, TORA and OLSR

D. Packet Delivery Ratio

The fraction of the originated application data packets by each protocol was able to deliver at varying time as shown in figur (10). As packet delivery ratio shows both the completeness and correctness of the routing protocol and also the measure of efficiency. We used packet delivery rate as the ratio of number of data packets received at the sink node to the number of data packets transmitted by source nodes having a route in its routing table after a successful route discovery. For all protocols packet delivery ratio is independent of offered traffic load, where routing protocols OLSR, AODV, TORA delivering about 81, 53.6 and 53.1 % of the packets in all cases. OLSR provides better packet delivery rate than all other routing protocols, on the other hand AODV has higher delivery ratio as compared to TORA. As packet delivery ratio indicates the loss rate which can be seen by the transport protocols that effects the maximum throughput of network. OLSR have MRPs for each cluster, which maintains routes for the group of destination, packets that the MAC layer is unable to deliver are dropped since there are no alternate routes.

In figure (11) we have used different scales of axes to show results of packet delivery ratio visibly for reactive and hybrid protocol. In AODV and TORA graph starts after hundred seconds because AODV and TORA takes time for computing route to receive data packets on destination as these protocols constructs route on demand whereas OLSR is a proactive routing protocol and uses routing table to send data packets at once. TORA in 50 MN wireless networks delivered around fifty three percentages of data packets over simulation time, TORA fall short to converge because of increased congestion.

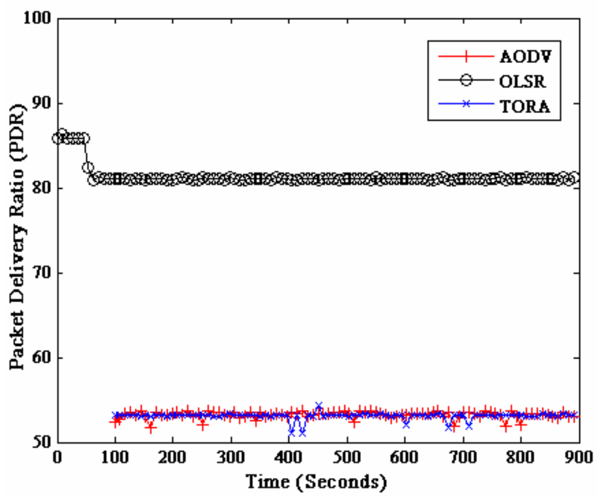

Fig 10: Packet Delivery Ratio for AODV, TORA and OLSR

In TORA mainly data packets are dropped because of short lived routing loops, which are part of its link reversal process. When the packet of next hop and previous hop are same then more data packets are dropped because the packets are looped until time to live expires or when loop exited; moreover data packets which are in loops interfered by broadcast UPDATE packet from neighbor mobile nodes which in turn can resolve routing loop. It was observed that packet delivery ratio was less in TORA than AODV. Moreover, routing protocols have differed in how much protocols can deliver packets to destination mobile node.

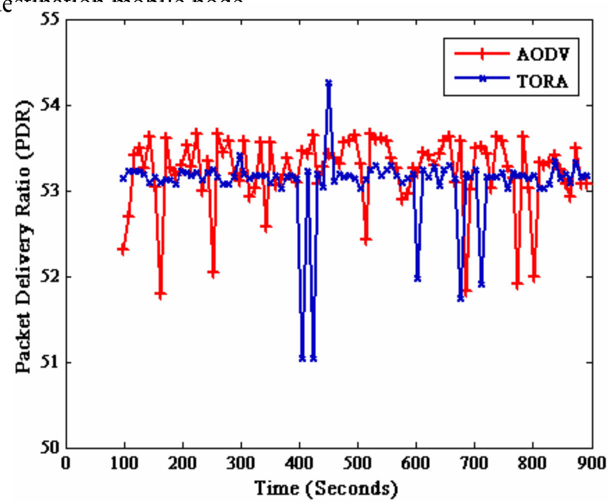

Fig 11: Packet Delivery Ratio for AODV and TORA

E. Routing Load Details

In figure (12) we have plotted routing load which is very significant to shows routing load over communications links. It is observed that the average routing load for OLSR is 58,000 bits per seconds. OLSR protocol shows increase in throughput even when the routing load is increasing over network. Moreover, OLSR apart from other protocol also experience 81% of packet delivery ratio, even under the high routing load. Whereas TORA and AODV protocols show decreased performance due to the increase in traffic load. Routing load for AODV and TORA fluctuates more frequently, but AODV experiences less routing load as compare to TORA that is around on average 3,000 bits per seconds and 8,000 respectively. With the exception of OLSR, AODV and TORA protocols show decreased quality of service due to the increase in routing load over the network.

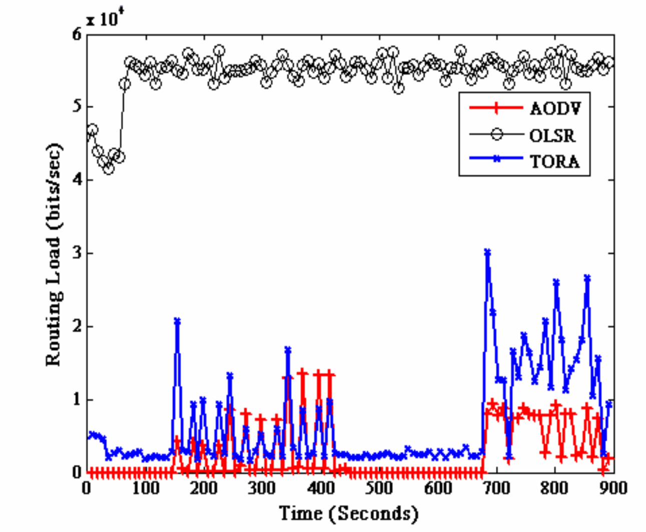

Fig 12: Routing Load for AODV, TORA and OLSR

F. Additional Results

Following are additional results which are observed during simulation. These results are specific to either of routing protocols used.

a. Average MPR Count

From figure (14), shows that he MPR count is instantly increasing at beginning of OLSR simulation, which is because

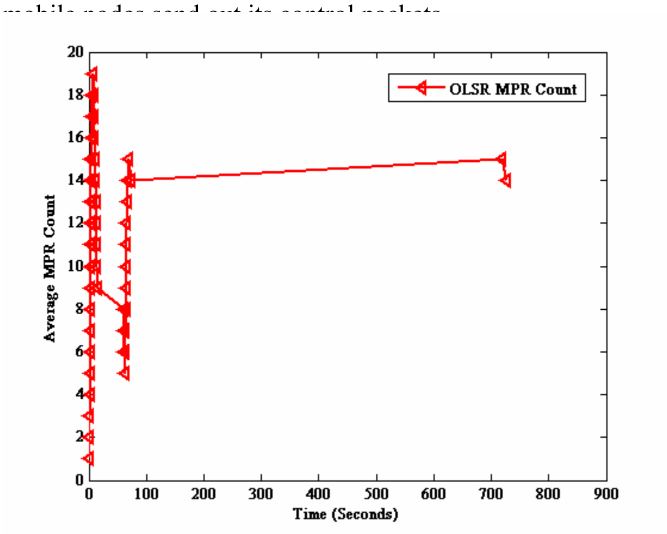

Fig 14: Average MPR Count in OLSR

Moreover, the mobile nodes broadcast the packet out to its entire neighbor's node by network flooding, which results in redundant broadcast traffic. After around 80 seconds when mobile nodes have selected its MPR set, then MPR count becomes stable for the rest of simulation time. Therefore, mobile nodes selected as MPR nodes forward the control traffic and reduces the total number of transmissions are needed to broadcast the information to all the mobile nodes.

b. Average Number of Hops

From the figure (13), the reactive protocol AODV offers a consistent hop count even under increasing routing loads. In AODV the intermediate mobile nodes uses unexpired route to the destination. When the new mobile node creates new route discovery processes, then intermediate mobile nodes learn shorter routes to destination, therefore it experiences on average consistent hop count of 2 hops as the route discovery flow increases

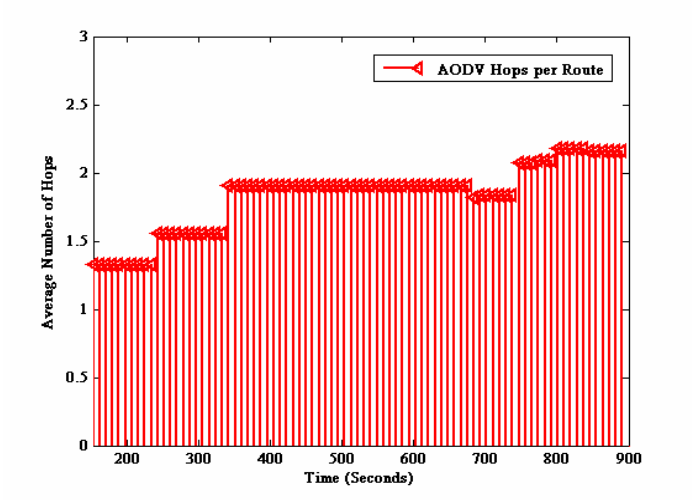

Fig 13: Number of Hops for AODV

c. Average Number of Traffic

Figure (15) shows that Hello and Topology Control (TC) traffic used by OLSR. At the start of simulation Hello traffic increase then it becomes stable around 32,000 bits per seconds. Hello messages traffic are propagated over simulation time so that mobile nodes can learn all its two-hop

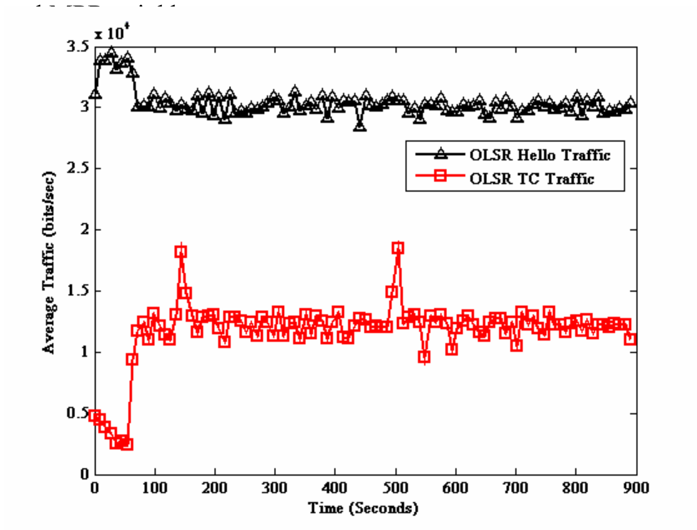

Fig 15: Average Traffic in OLSR

Hello messages are only broadcasted to neighbors and are not send out further. From the Hello messages, the mobile nodes know if it has been selected as a MPR, if so then it place the corresponding node in its 'MPR selector set'. In TC curve, it starts gradually and becomes stable around 14,000 bits per second. New TC message are used to propagate the changes in the network topology, when there has been mobile node's movement and new MPR has to be selected. When mobile node receives TC messages, it learns about the idle time from MPR selector sets and TC message mobile node's source. Therefore, OLSR can figures out the partial network topology, bandwidth and by using that information can calculate the routing table as well.

d. Average Control Traffic

TORA uses Internet MANET Encapsulation Protocol (IMEP) for its link status and neighbor connectivity sensing. In figure (16), TORA's IMEP control traffic is plotted. After 10 seconds of simulation time, control traffic abruptly decreases as neighbor connectivity sensing are carried out and becomes stable around 6,500 bits per second for IMEP control traffic received and 4,000 bits per second for IMEP control traffic sent. Moreover, difference is because sent traffic is broadcasted and received by many mobile nodes in wireless network where control traffic involves propagation of periodic Hello and TC messages together over the mobile ad hoc networks.

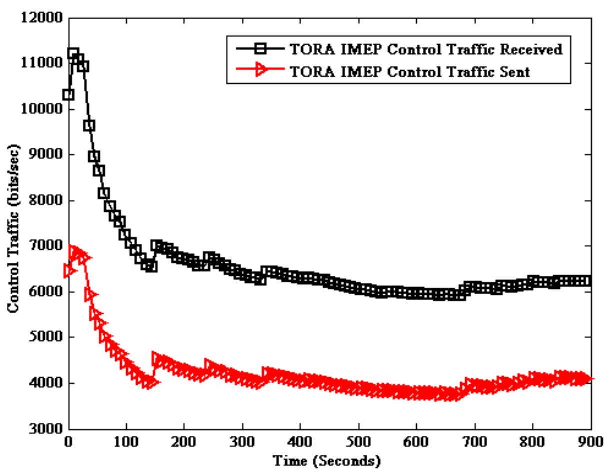

Fig 16: Control Traffic in TORA

e. Average Route Discovery Time

In figure (17), shows average route discovery time in AODV is average around 0.17 seconds where route discovery involves propagation of RREQ and path taken by RREP packets to flow over network.

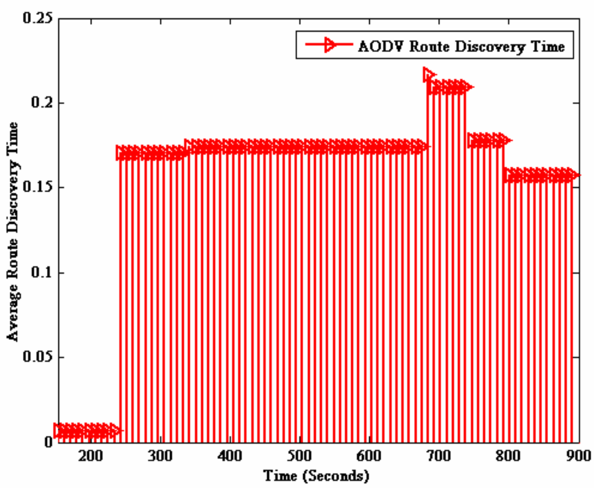

Fig 17: Average Route Discovery Time in AODV

VII. Conclusion

The mobile nodes' mobility management is key area since mobility causes route change and frequent changes in network topology, therefore effective routing has to be performed immediately. This paper makes contributions in two areas. Firstly, this paper have compared the performance of reactive ad hoc on demand distance vector protocol; proactive optimized link state routing protocol and hybrid temporary ordered routing algorithm protocol in mobile ad hoc networks under ftp traffic. Secondly, we have presented the comprehensive results of packet delivery ratio, throughput, media access delay, end to end delay and routing load over mobile ad hoc networks of fifty mobile nodes moving about and communicating with each other. The simulation results were presented for a range of node mobility at varying time. OLSR performs quite predictably, delivering virtually most data packets at node mobility. In [2] also shows that OLSR shows the best performance in terms of data delivery ratio and end-to-end delay. TORA, although did not perform adequate in our simulation runs in terms of routing packet delivery ratio, delivered over fifty three percentage of the packets. Since the network was unable to handle all of the traffic generated by the routing protocol and a significant fraction of data packets were dropped. As well as in [8]shows that the relative performance of TORA was decisively dependent on the network size, and average rate of topological changes; TORA can perform well in small network size but TORA's performance decreases when network size increases to 50 nodes. On the other hand, AODV performed better than TORA in most performance metrics with response to frequent topology changes. Finally, the overall performance of OLSR was very good when mobile nodes movement was changing over varying time. OLSR has high control traffic as compared to TORA as it searches for routes to destination more frequently. Despite the other routing protocols, OLSR protocol showed increase in throughput even when the routing load was increased. We have analyzed that all routing protocol successfully delivers data when subjected to different network stresses and topology changes. Moreover, mathematical analysis and simulation results both show that optimized link state routing protocol, from proactive protocol category, is a very effective, efficient route discovery protocol for MANETs.

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