MANET Routing Protocols for Real-Time Multimedia Applications

GHULAM YASIN
Hailey College of commerce, Faculty of Commerce, University of the Punjab, Lahore, Pakistan.
ghulam_yaseen@hotmail.com

SYED FAKHAR ABBAS
COMSATS Institute of Information Technology, Lahore Pakistan
syedfakhar15@gmail.com

S R CHAUDHRY
Department of Computer Science, COMSATS Institute of Information Technology, Lahore Pakistan.
Saqib.Chaudhry@ieee.org

Abstract: Mobile ad hoc network (MANET) is a self-directed system of mobile devices connected by wireless links. The node in MANETs moves in the region and modifies its locations by creating infrastructure less network without intervention of any network administrator. Varity of routing protocol for ad hoc network are probable. The main focus behind is to save resources (bandwidth) while using routing protocols. While deploying MANETs, a number of challenges involve like network scalability, Quality of services (QoS), energy utilization, security, privacy measures, bandwidth optimization and dynamic topology etc. In this paper an effort has been made to compare the performance of different routing protocols using multimedia application (video traffic). Protocols which are being analyzed in this paper are: AODV, DSR TORA and OLSR. The performance parameter includes Data Dropped, Delay, Load, Media Access Delay, Retransmission attempt and throughput.

Key words: *MANETs, AODV, DSR, OLSR.*

1. Introduction:

A wireless network is a rising new technology that will permit users to access services and information by electronic means, irrespective of their geographic location. Wireless networks can be divided in two kinds: *infrastructure network and Infrastructure less (ad hoc) networks*. Infrastructure wireless network is a network with fixed and wired gateways. A mobile host interrelates with base station within its communication radius. The mobile device move frequently when it is communicating with other mobile devices. Mobile ad-hoc network is an independent system of mobile nodes connected by wireless links; each node operates as an end system and a router for all other nodes in the network [1]. In wireless network configuration is quickly changing and delay, packet drop, security, lower bandwidth, load on network are import key factor in the network. Rouging decision, to design the protocol and to apply QoS is also challenging task for the network designers. MANETs support a lot of technologies in the modern era. Table 1 is brief description about network technologies supporting by MANETs.

Routing in MANETs is one of the major tasks to provide the network functionally to each device at any time; at any place. [2] MANETs differ with other network due to it has no central control mechanism , limited power capacity, to main the information on regular basis to transfer information. Different routing protocols for Ad-hoc network such as AODV, DSR, DSDV, ZRP, OLSR, and CGSR can be used to provide the consistent services to the mobile node [3].

Standards	Data rate	Frequency	Range	Power utilize
IEEE 802.11b	1, 2, 5.5 and 11 Mbit/s	2.4 GHz	25–100 m (indoor) 100–500 m (outdoor)	~30 mW
IEEE 802.11g	Up to 54 Mbit/s	2.4 GHz	25–50 m (indoor)	~79 mW
IEEE 802.11a	6, 9, 12, 24, 36, 49 and 54 Mbit/s	5 GHz	10–40 m (indoor)	40 mW, 250 mW or 1 W
Bluetooth	1 Mbit/s	2.4 GHz	10 m (up to 100 m)	1 mW (up to 100 mW)
UWB	110 – 480 Mbit/s	Mostly 3 – 10 GHz	~10 m	100 mW, 250 mW
IEEE 802.15.4	20, 40 or 250 kbit/s	868 MHz, 915 MHz or 2.4 GHz	10–100 m	1 mW
HiperLAN2	Up to 54 Mbit/s	5 GHz	30–150 m	200 mW or 1 W
IrDA	Up to 4 Mbit/s	Infrared (850 nm)	~10 m	Distance based
HomeRF	1 Mbit/s 10 Mbit/s	2.4 GHz	~50 m	100 mW
IEEE 802.16 IEEE 802.16a IEEE 802.16e	32 – 134 Mbit/s up to 75 Mbit/s up to 15 Mbit/s	10–66 GHz < 11 GHz < 6 GHz	2–5 km 7–10 km 2–5 km	Complex power control
Wi-Fi	54 Mbit/s	2.4 GHz	~30m	86.6mW

Table 1: Description of technologies supported by the MANETS

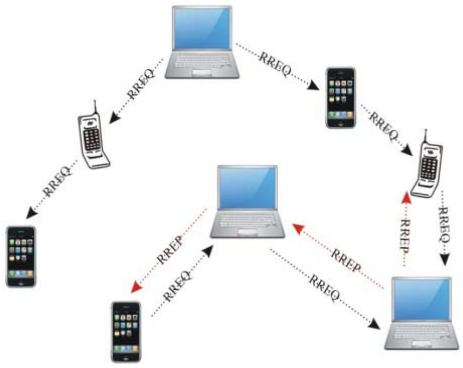

Fig.1: Infrastructure less Network

In figure 1 there are eight (8) mobile devices which are creating infrastructure less network to exchange information among them. Each mobile device will ask for routing path sending the route request and route reply packets. Objectives of routing mechanism in a MANET are to dig out the current network configuration to discover a route [4]. It is necessary to maintain route specifications while mobile device will alter its location within network.

MANETs is appropriate solution in daily life e.g. in business, outside the organization, using Wi-Fi technology, in Bluetooth technology etc. [5] [6] [7].This article is divided into the following sections. Section II is about explanation of AODV, DSR, ZRP, OLSR and TORA. Security in any network is key parameter to provide consistent and reliable services to the users.

We briefly talked about the consequences of attacks on two leading routing protocols AODV [8] and DSR [9]. Sections III narrated the major contributions of researcher in MANETs. Simulation model sketch, parameter selections and results are narrated in section IV. Section V showed the conclusion and future thinking for researchers.

1.1 Problem Statement

Ad hoc routing protocols in many scenarios are vulnerable to movement particularly in very large network. In ad hoc network route for data transmission is pre-established before the devices have to transfer data. While network topology is changing very fast and dynamically it is difficult to keep the route.

Major issues in ad hoc network are hidden node problem, security issue, Bandwidth-constrained, variable capacity links, Energy-constrained, network scalability, privacy measures etc. All these issues can be seen as one single word network performance. While measuring performance of ad hoc network, different protocols are implemented.

To ensure the performance different protocols must be analyzed using some simulation environment. After comparison the AODV, DSR, TORA and OLSR using multimedia application we can show the performance while transmitting video in MANETs. We will make comparison of the above protocols in simulation environment which will help to improve network performance.

2. Routing Protocols in MANETs:

In the modern era a lot of research and expansion is being done in the area of mobile ad-hoc networks (MANETs) as its application are in the field of education, engineering, business, social network, medical, Personal Area Networks etc. MANETs is providing a lot of sophisticated features to mobile devices; some of them are as under:(1) Dynamic topologies (2) Bandwidth constrained links (3) Energy constrained operation and (4) Limited physical security [10].

Hence, a highly adaptive routing method to deal with the dynamic topology is necessary. Many unicast routing protocols have been proposed for MANETs to achieve efficient routing [11] be done in many ways, but most of them are depending on routing plan and network arrangement.

According to the routing strategy, the routing protocols can be categorize as proactive and reactive routing , while depending on the network structure these are divided as flat, hierarchical and position based routing. Both the proactive and reactive protocols fall under the flat routing. Figure 2 shows the classification of proactive, re-active and hybrid routing protocols in MANETs.

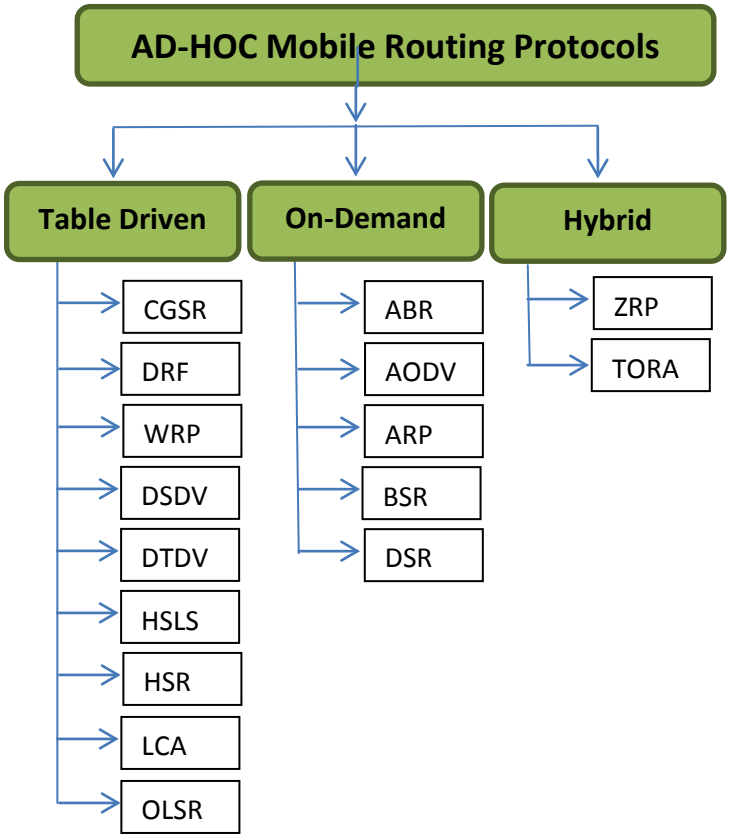

Fig.2: Classification of Routing Protocols

2.1. Proactive-Routing Protocols:

A proactive routing protocol is also called "table-driven" routing protocol. In proactive routing protocol, nodes in a mobile ad-hoc network incessantly evaluate routes to all accessible nodes and try to uphold reliable, up-to-date routing information in their routing tables. LCA, HSLS, DSDV, OLSR etc. are examples of proactive-routing protocols.

2.1.1 Optimized Link State Routing Protocol (OLSR):

OLSR is a table driven/Proactive routing protocol. This protocol provides pure optimization of link state for the MANETs. It reduces the size of control packet, maintains the flooding of the traffic etc. It stores and updates its routes to provide the updates routes when it is immediately required by the node without any delay. In OLSR, some applicant devices called the multipoint relays (MPRs), which are chosen and in charge to forward broadcast packets throughout the flooding procedure. This mechanism reduces the overhead of packet transmission while comparing to flooding producer.

2.2. Re-active Routing Protocols:

Reactive routing protocols for mobile ad hoc networks are also known as “on-demand" routing protocols. In a reactive routing protocol, routing paths are look for only when desirable. When a source node wants to send packets to the destination node but no route is available, it initiates a route discovery operation. It is initiated with RREQ packet, response is with RREP and while link is not available it is received RERR packet. Reactive routing protocols has less overhead, a unique feature, while reactive routing protocols have better scalability than proactive routing protocols. However, when using reactive routing protocols, source nodes may undergo from long delays for route probing before they can forward data packets. Figure 3 shows the classification of AODV showing the procedure of RREQ and RREP. Figure 4 shows the classification of DSR showing the procedure of RREQ and RREP. Hence these protocols are not suitable for real–time applications. The Dynamic Source Routing (DSR) [11] and Ad hoc On-demand Distance Vector routing (AODV) [11] are examples for reactive routing protocols. Figure 3 shows the general categorization of Ad-Hoc routing protocols.

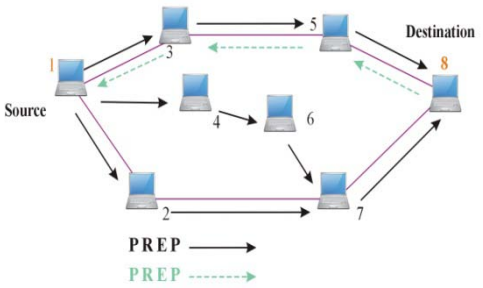

Fig.3: AODV Protocol

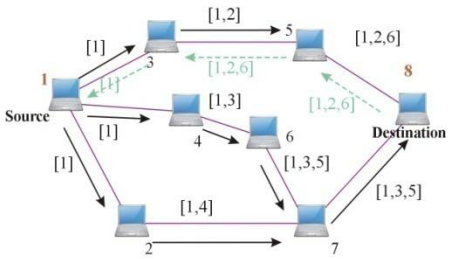

Fig.4: DSR Protocol

2.2.1. Ad Hoc on-Demand Distance Vector Routing (AODV):

It is a Source Initiated on Demand routing protocols used in VANET. In this protocol every vehicle maintains route information of every vehicle. It uses sequence number concept to acknowledge the entry update time and time stamp based concept for table entry. If a table entry is not used within a certain time limit, it will be deleted from table and if there is any breakage in linking with a vehicle to another vehicle, route error (RERR) packet is forwarded so that vehicle route is effectively updated in the routing table.

2.2.2. Dynamic Source Routing (DSR):

It is Source Initiated on Demand routing protocol used in VANET and is based on link state routing algorithm. When a vehicle wants to communicate data to another vehicle, firstly it finds route up to that vehicle. For route discovery, source vehicle initiates a route request (RREQ) packet in the network and other nodes forward the RREQ by changing their name as sender. Finally when RREQ packet reaches to the destination vehicle or to a vehicle having path to the destination vehicle, a route reply (RREP) packet is unicasted to the sender node. If the reply is not received, the source vehicle restarts aggressive discovery of route up to the destination vehicle.

2.3. Hierarchical Routing Protocols:

Typically, when wireless network size become larger, current “flat” routing method become inappropriate due to processing and link overhead. Efficient way to minimize this problem is to use hierarchical routing. Wireless hierarchical routing is based on the idea of organizing nodes in groups and then assigning nodes different functionalities inside and outside of a group. The Zone Routing Protocol (ZRP) [12], Zone based Hierarchical Link State routing (ZHLS) [13] and Hybrid Ad hoc Routing Protocol (HARP) [14] are examples for hybrid routing protocols.

2.4. Position Based Routing Protocols:

With the development of Global Positioning System (GPS) it is promising to give location information with accuracy in the order of a few meters. Position information can be used for directional routing in distributed ad hoc systems; the universal clock can provide global synchronize among GPS equipped nodes. In position based routing protocols the routing decisions are made on the basis of the current position of the source and the destination nodes. In this system no routing tables are maintained for routing. No addressing scheme is used to move packet from source to destination. Location Aided Routing (LAR) [15] and Distance Routing Effect Algorithm for Mobility (DREAM) [16] are examples of position based routing protocols which are suggested for mobile ad hoc networks. After some research routing method that use positional information scale well [17].

In all of the unicast routing protocols, the strength of the route is not concerned as a requisite for its selection. As a result, route disintegrate will normally arise, encourage by nodal mobility and or link failures as well as by changes in the communications transport quality viewed across the networks communications links. The latter is reason which is generated by signal interferences, fading and multi-path phenomena and other causes producing ambient and environmental noise and signal interference processes. While route breakups lead the common operation of upgrading routes that consume lots of the network resources and the energy of nodes. Many efforts have been made to design reliable routing protocols that enhance network stability. The among all the routing protocols here we discuss the two reactive type of protocols AODV & DSR one Proactive routing protocol which is OLSR and one Hybrid routing Protocol which is TORA.

2.4.1. Hybrid Routing Protocol:

The benefits of Reactive and Proactive protocols are combined in the hybrid routing protocol. Hybrid routing protocol are classified as Zone Routing Protocol (ZRP) and Temporally- Ordered Routing Algorithm (TORA).

2.4.2. Temporally Ordered Routing Algorithm (TORA):

TORA is a source-initiated and on-demand routing protocol in which link reversal algorithm is used. It has also functionality to provide loop free multipath route from a source to destination. In TORA each node keeps its one-op local topology. This algorithm has information and ability to find separation. It sustains less overhead and local reconfiguration of path results in non-optimal routes. TORA tries to obtain degree of scalability using flat routing algorithm. TORA has three main responsibilities: to establish, to maintain and to erase routes. The route establishment function is done only when a node requires a path to a destination but it has not any direct link to the destination. This process maintains a destination-oriented directed acyclic graph (DAG) using a query/update mechanism.

3. MANETs Routing Attacks

Security is important factor while designing of any network. MANET is secured when it ensured to the mobile node to guarantee the following security measures: privacy, integrity, accessibility, verification. It is important to note there is no central supervision unit and is more susceptible to cyber-attacks. Table 2 is about the explanation of some of the major attacks. In the preliminary design of AODV and DSR routing protocols; there is no consideration of security measures which make insecure MANETs to some extent.

Attacks on Mobile Ad hoc Networks
Passive Attacks
Active Attacks
Wormhole Attack
Black hole Attack
Byzantine Attack
Information Disclosure
Resource Consumption Attack
Routing Attacks
Session Hijacking
Repudiation
Denial of Service
Impersonation

Table 2: MANET's Attacks

4. Related Work

Researchers have done a lot of work on the MANETs protocols and working still to improve the security, standards and other important parameters of MANETs. Some of them are as under:

Y. -C. Hu et al [18] described the detection and protection technique against wormhole attacks, calling it packet lashes. In this paper TIK protocols is used to implements leashes.

V. Sharma et al [19] showed the performance of AODV and DSR with wormhole attack. He also showed performance of the above protocols without wormhole attacks. In the paper different parameters like throughput, jitter, data sent and received is showed.

G. K. Singh, Bindra, et al [20] investigated the recital of DSR and AODV routing protocols for low and high density random waypoint mobility model. In this paper authors have used the packet delivery, jitter, packet dropped ration, delay, packet delivery etc parameters to compare these two protocols in MANETs.

B. Cameron Lesiuk [21] has worked on ad hoc routing principals and detailed analysis of difference of traditional routing protocols. In this paper DSR, TORA and DSDV were discussed to show the comparison.

Khan, Zaman, Reddy [22] had worked on difference routing protocols and simulation results are shown by NCTUns networking simulator software. This paper calculated performance of routing protocols using different number of node which is multiple of 5.

Simulation time was 70 seconds and packet size was 1400 bytes.

S P Setty et.al [23] analyzed the performance of AODV routing protocol on differ nodes placement model such as Grid model, Random model and Uniform model using Qualnet network Simulator.
S R Chaudhry et al [24] investigates different on demand routing protocols of ad hoc network by simulations. Results show that the performance of AODV is better than DSR and TORA. In this paper authors have used the end-end delay, throughput and media access delay parameters to compare and to show the simulation results.

5. Simulation Model and Parameters

Routing Protocols	AODV,DSR, TORA and OLSR
No. of Nodes	50
Simulation area	100X100m
Simulation Time	600seconds
Channel type	Wireless channel
MAC protocol	802.11
Mobility model	Random Way Point(RWP)
Traffic type	Constant Bit Rate (CBR)
Packet Size	512 bytes
Channel bandwidth	10 Mbps
Transport protocol	UDP
Services	Video transmission
Transmitted power	.05

Table 3: Simulation Parameters

OPNET simulator is common network simulation to for network modeling and simulation. It permits tl users to structure; analyze the networks device protocols with elasticity and scalability. It also shov results in the form of graphics which may help the use to visualize the whole network and its results.

Fig.5: MANETS Scenario

Figure 5 shows 50 mobile nodes which show the network behavior as the nodes move within the network to analyze the performance of each protocol. While assessing the performance of a given scenario in the ad-hoc network mobile nodes move within network and establish MANET. In this mobility model we used Random waypoint. Using this mobility model modes are free to move to reach at random destination. Movement of the nodes is calculated by the algorithm. The simulation study of our work consisted of three routing protocols AODV, DSR, TORA and OSLR deployed over MANET using video transmission.

6. Results Analysis

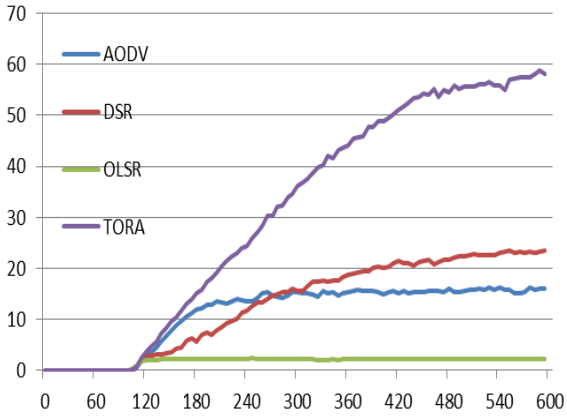

Fig.6: End-To-End Delay

It is observed that OLSR has the lowest delay. OLSR is a proactive routing protocol, which means that routes in the network are always ready whenever the application

layer has traffic to transmit. Periodic routing updates keep fresh routes available for use. The absence of high latency induced by the route discovery processes in OLSR explains its relatively low delay. With higher number of mobile nodes, the performance of OLSR competes with that of AODV. In the networks considered, OLSR had a consistent end-to-end delay due to its proactive characteristics.

On the other hand, AODV competes with DSR w speeds and is superior at high speeds. It has a cor t delay and outperforms DSR at higher speeds due e performance degradation in DSR. When the nun f nodes increased to 50, TORA suffers a sigr t degradation in its end-to-end delay. One reason e degradation in the end-to-end delay of TORA at er number of nodes is attributed to its route.

While OLSR exhibited very low delay. TORA had high delay in the high traffic network, and mobility did not have an effect on the delay. AODV had an improved end-to-end delay as the network grew whereas the speed did not have a noticeable effect on delay, and lastly DSR had a consistent end-to-end delay and suffered more delay as the network grew larger but speed did not have profound effects on the performance. The three reactive protocols exhibited high delays at higher loads due to the increase in route discovery requests.

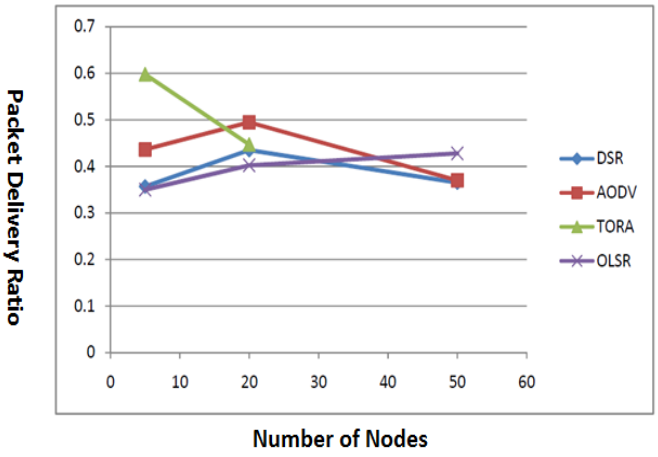

Fig.7: Packet Delivery Ratio

TORA delivered the highest number of packets with low speed and low number of traffic sources. However, this rapidly degraded from about 60% to about 44% when the number of sources increased to 20. Statistics for 50 traffic sources were not available due to the traffic implosion problem TORA suffers.

At low speeds, AODV outperformed both DSR and OLSR in the networks with 5 and 20 traffic sources. When the traffic sources increased to 50, the packet delivery ratio for AODV degraded significantly and was comparable to that of DSR. OLSR at this stage outperformed all the other protocols. We can attribute the improvement in the performance of OLSR in networks with higher number of traffic sources to its proactive nature.

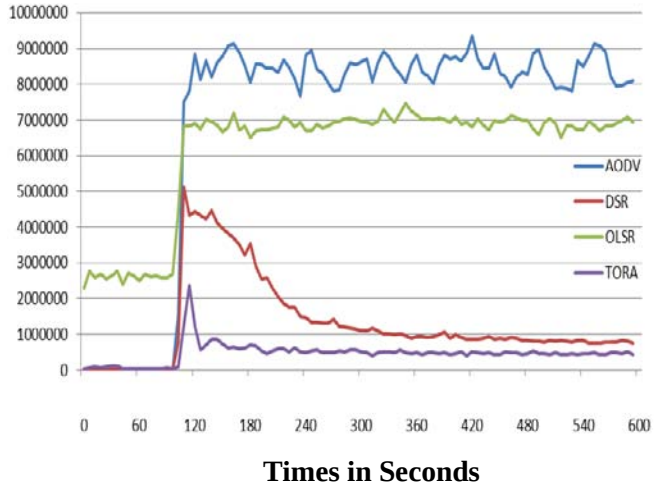

Fig.8: Throughput

In figure 8 it is observe that AODV by far outperforms all the other protocols. As AODV is a reactive (on-demand) routing protocol, uses route discovery process to cope with routes on demand basis. It uses routing tables for maintaining route information. It doesn't need to maintain routes to nodes that are not communicating. OLSR maintains consistent paths in the network causing a low delay. Since throughput is the ratio of the total amount of data that a receiver receives from the sender to the time it takes for the receiver to get the last packet, a low delay in the network translates into higher throughput.

OLSR may optimize the reactivity to topological changes by reducing the maximum time interval for periodic control message transmission. Furthermore, as OLSR continuously maintains routes to all destinations in the network, the protocol is beneficial for traffic patterns where a large subset of nodes are communicating with another large subset of nodes, and where the [source, destination] pairs are changing over time. The protocol is particularly suited for large and dense networks, as the optimization done using MPRs works well in this context. The larger and more dense a network, the more optimization can be achieved as compared to the classic link state algorithm.

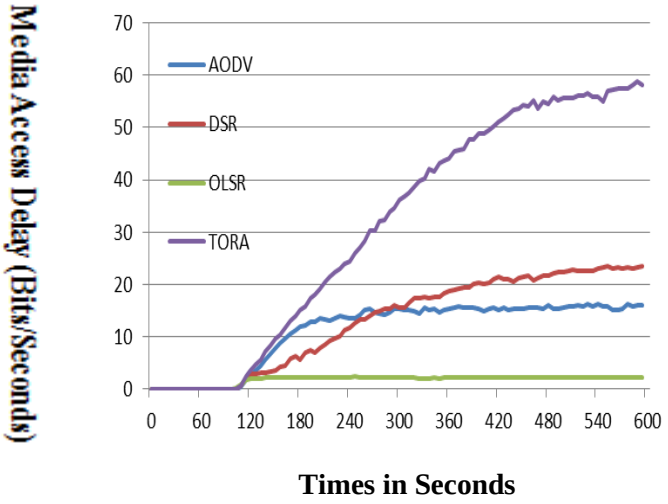

Fig.9: Media Access Delay

In figure 9 OLSR has very low media access delay and consistent as nodes increased from 20 nodes to 50. TORA had high delay in the high traffic network, and mobility did not have an effect on the delay. DSR had an improved end-to-end delay as the network grew whereas the speed did not have a noticeable effect on delay, and lastly AODV had a consistent media access delay and suffered more delay as the network grew larger but speed did not have profound effects on the performance. The three reactive protocols exhibited high delays at higher loads due to the increase in route discovery requests.

OLSR outperforms AODV, DSR and TORA in terms of end-to-end; media access delay, data delivery ration and throughput. Varying traffic volumes or speeds in the network, leaves OLSR superior in terms of end-to-end delay and throughput. OLSR build and maintains consistent paths resulting in low delay. The results in this study also confirm TORA's inability to handle rapid increases in traffic volumes. TORA performs well in networks where the volume of traffic increases gradually.

7. Conclusion

The simulation results shows the performance of AODV, DSR,TORA and OLSR using different parameters over MANET using multimedia application (video transmission) and analyze the performance of the network.

The study of these routing protocols shows that the OLSR is better than AODV, DSR and TORA in performance using parameters data dropped, end-to-end, packet delivery ration and media access delay. AODV performance is average while comparing with DSR and TORA. But overall performance of OLSR is likely better than AODV because TORA produces higher delay with decreasing mobility. This is due to increasing mobile nodes in the network.

As per analysis, we can conclude that OLSR protocol is best performer as compared to all other protocols and DSR protocol is the worst performer. In future this work can be extended to provide the support Video Conferencing, Real time remote surveillance system and MANET based Battlefield Communication System.

References:

[1] ANDREW S. TANENBAUM, "Routing in Ad Hoc Networks, Computer Networks", chapter 5, pp. 375-380 2011.

[2] Sree Ranga Raju, Kiran Runkana, Jitendranath Mungara, "ZRP versus AODV and DSR: A Comprehensive Study on ZRP Performance on MANETs", International Conference on Computational Intelligence and Communication Networks 2010.

[3] Shaily Mittal, Prabhjot Kaur, "PERFORMANCE COMPARISION OF AODV, DSR and ZRP ROUTING PROTOCOLS IN MANET'S", International Conference on Advances in Computing, Control, and Telecommunication Technologies 2009.

[4] Richa Agrawal, Rajeev Tripathi, Sudarshan Tiwari, "Performance Evaluation and Comparison of AODV and DSR under Adversarial Environment", International Conference on Computational Intelligence and Communication Systems 2011.

[5] Bulent Tavli "Mobile Ad Hoc Networks: Energy-Efficient Real-Time Data Communications", 2006.

[6] Azzedine Boukerche "Algorithms and Protocols for Wireless, Mobile Ad Hoc Networks", 2008.

[7] Mohammad llyas, Richard C. Dorf "The handbook of ad hoc wireless networks", 2003.

[8] C. Perkins, Royer, "Ad-Hoc On-demand Distance Vector Routing," Proc. 2nd IEEE Workshop on Mobile Computing Systems and Applications, WMCSA'99, pp. 90-100, 1999.

[9] D. Johnson, Y. Hu, D. Maltz, "The Dynamic Source Routing Protocol (DSR) for Mobile Ad Hoc Networks for Ipv4," Network Working Group, RFC 4728, 2007.

[10] S. Basagni, M. Conti, S.Giordano, I. Stojmenovic, Mobile Ad Hoc Networking, IEEE Press, Wiley, Interscience, 2004.

[11] Hadi Sargolzaey, Ayyoub Akbari Moghanjoughi and Sabira Khatun, ―A Review and Comparison of Reliable Unicast Routing Protocols For Mobile Ad Hoc Networks, IJCSNS International Journal of Computer Science and Network Security, VOL.9 No.1, pp. 186-196, January 2009.

[12] D. Johnson, D. A. Maltz, "Dynamic source routing in ad hoc wireless networks", in Mobile Computing (T. Imielinski and H. Korth, eds.), Kluwer Acad. Publ., 1996.

[13] C.E. Perkins and E.M. Royer. "Ad hoc on demand Distance Vector routing", mobile computing systems and applications, 1999. Proceedings. WMCSA " 99. Second IEEE Workshop on, 1999, p90 - p10.

[14] Z. J. Haas. "The Zone Routing Protocol (ZRP) for ad hoc networks", Internet Draft, Nov. 1997.

[15] M. Joa-Ng and I-Tai Lu, "A peer-to-peer zone-based two level link state routing for mobile ad hoc net-works", IEEE on Selected Areas in Communications, vol. 17, no. 8, pp.1415 1425, 1999.

[16] Navid Nikaein, Christian Bonnet and Neda Nikaein, "HARP - Hybrid Ad Hoc Routing Protocol", in proceeding of IST 2001: International Symposium on Telecommunications, Iran/Tehran 2001.

[17] Y. B. Ko and N. H. Vaidya. "Location Aid Routing (LAR) in mobile ad hoc networks", In Proc. ACM/IEEE MOBICOM, Oct. 1998.

[18] Y. -C. Hu, A. Perrig, and D. B. Johnson, "Wormhole Attacks in Wireless Networks," IEEE Journal on Selected Areas in Communications, vol. 24, no. 2, pp. 370-380, February 2006.

[19] V. Sharma and A. Baghel, "Analysis of AODV and DSR in Presence of Wormhole Attack in Mobile Ad-hoc Network," International Journal of Engineering Science and Technology, vol. 2, no.11, pp. 6657-6662, 2010.

[20] G. K. Singh, H. S. Bindra and A. L. Sangal, "Performance Analysis of DSR, AODV Routing Protocols based on Wormhole Attack in Mobile Ad-hoc Network," International Journal of Computer Applications,Volume 26– No.5, pp. 38-41, July 2011.

[21] B. Cameron Lesiuk, "Routing in Ad hoc Networks of Mobile Hosts", Department of Mechnical Enginnering University of Victoria, Victoria, BC, Canada, December 2, 1998.

[22] K U Khan, R U Zaman, A. Venugopal Reddy, "Performance Comparison of On-Demand and Table Driven Ad Hoc Routing Protocols using NCTUns", 10th International Conference on Computer Modeling and Simulation, 2008.

[23] S. P. Setty et. Al., "Performance evaluation of AODV in different environment", International Journal of Engineering and Technology Vol. 2(7), 2010.

[24] S R Chaudhry, A Al-Khwildi, Y Casey, H. Aldelou, H S Al-Raweshidy, "A Performance comparison of multi on-demand routing in wireless ad hoc networks," *Wireless And Mobile Computing, Networking And Communications, 2005. (WiMob 2005) , IEEE International Conference on,* vol.3, 16 Vol. 3, 22-24 Aug.2005.