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Application of Routing Metrics in Wireless Network

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Abstract*— The wireless Ad-hoc network consists of wireless nodes communicating without the need for a centralized administration, in which all nodes potentially contribute to the routing process. A user can move anytime in an ad hoc scenario and, as a result, such a network needs to have routing protocols which can adopt dynamically changing topology. To accomplish this, a number of ad hoc routing protocols have been proposed and implemented, A mobile ad hoc network (MANET) consists of mobile wireless nodes. The communications between these mobile nodes are carried out without any centralized control. MANET is a self organized and self configurable network where the mobile nodes move arbitrarily. The mobile nodes can receive and forward packets as a router. Routing is a critical issue in MANET and hence the focus of this thesis along with the performance analysis of routing protocols. We compared three routing protocols i.e. AODV, DSR and OLSR. The simulation tool will be OPNET modeler (14.5V). The performance of these routing protocols is analyzed by three metrics: delay, routing discovery, and jitter. All the three routing protocols are explained in a deep way with metrics. The comparison analysis will be carrying out about these protocols and in the last the conclusion will be presented, that which routing protocol is the best one for mobile ad hoc networks.

Index Terms—**Delay, Routing Discovery, and Jitter, MANET, opnet, AODV, DSR, OLSR.**

I. INTRODUCTION

MANET stands for Mobile Ad hoc Network. It is a decentralized autonomous wireless system which consists of free nodes. MANET sometimes called mobile mesh network, is a self configurable wireless network. A MANET consists of mobile nodes, a router with multiple hosts and wireless communication devices. The wireless communication devices are transmitters, receivers and smart antennas. These antennas can be of any kind and nodes can be fixed or mobile. The term node referred to as, which are free to move arbitrarily in every direction. These nodes can be a mobile phone, laptop, personal digital assistance, MP3 player and personal computer. These nodes can be located in cars, ships, airplanes or with people having small electronic devices. Nodes can connect each other randomly and forming arbitrary topologies. Nodes communicate to each other and also forward packets to neighbor nodes as a router. The ability of self configuration of these nodes makes them more suitable for urgently required network connection. For example in disaster hit areas where there is no communication infrastructure. It is greatly desired to have a quick communication infrastructure. MANET is the quick remedy for any disaster situation. MANET is a spontaneous network. It is useful when dealing with wireless devices in which some of the devices are part of the network only for the duration of a communication session. The MANET working group (WG) within the Internet Engineering Task Force (IETF) works specifically on developing IP routing protocols topologies. To improve mobile routing and interface definition standards for use within the Internet protocol suite.

After huge research work on MANET, still it does not have a complete form of Internet based standards. The identification of experimental Request for Comments (RFCs) since 2003 is used. In these RFCs the questions are unanswered concerning of implementation or deployment of these routing protocols. But these proposed algorithms are identified as a trial technology and there are high chances that they will be developed into a standard. Extensive research work in this area is progress with major studies on different routing protocols such as Ad hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), Temporarily Ordered Routing Algorithm (TORA) and Optimized Link State Routing (OLSR) . Along with the standardization of routing and interface solutions for mobile networking support through Internet Engineering Task Force (IETF) MANET Working Group WG.

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Aims and Objectives

There are two basic groups of routing protocols, Proactive MANET protocol (PMP), Reactive MANET Protocol (RMP), and whereas the third one is derived from both of these and called as Hybrid MANET Protocol. The Proactive MANET protocol is generally called table driven protocol and it detects the network layout periodically. It tries to maintain the routing table at every node which is used to detect a most feasible route to the destination from the source with less delay. Proactive MANET protocols provide good reliability and low latency for deciding a route but these protocols are not suitable for the nodes moving with high speed as the routing information cannot be updated in the routing table. If a node is not moving, then its routing table information is updated continuously. It causes more traffic overhead wastage of network resources such as bandwidth. Another drawback is the unsuitability for large scale MANETs. Reactive MANET Protocol is called on-demand routing protocol and finds the route when a source node requests to communicate with the other. On-demand approach is suitable for the nodes with high mobility and nodes that transmit data rarely. The main drawback of reactive routing protocols is that the source node broadcasts the routing requests in the whole network and it waits for the responses. This route discovery procedure causes significant delay and makes them less suitable for real time traffic. Hybrid MANET Protocol integrates the merits of Proactive and Reactive Protocols. Zone routing protocol (ZRP) and two zone routing protocols (TZRP) are the examples of hybrid of MANET protocol.

Reactive Routing Protocols

Reactive routing protocols are called on-demand routing protocols so these routing protocols are called when they are needed and the routes are built. These routes can be acquired by sending route requests through the network. Disadvantage of this algorithm is that it offers high latency in searching a network. We will consider AODV and DSR in this thesis report and the simulation analysis will be presented in the fifth chapter.

1- AODV (Ad hoc On-demand Distance Vector)

AODV is an on-demand routing protocol. The AODV algorithm gives an easy way to get change in the link situation. For example if a link fails notifications are sent only to the affected nodes in the network. This notification cancels all the routes through this affected node. It builds unicast routes from source to destination and that's why the network usage is least. Since the routes are build on demand so the network traffic is minimum. AODV does not allow keeping extra routing which is not in use. If two nodes wish to establish a connection in an ad hoc network then AODV is responsible to enable them to build a multihop route. AODV uses Destination Sequence Numbers (DSN) to avoid counting to infinity that is why it is loop free. This is the characteristic of this algorithm. When a node send request to a destination, it sends its DSNs together with all routing information. It also selects the most favorable route based on the sequence number.

There are three AODV messages i.e. Route Request (RREQs), Route Replies (RREPs), and Route Errors (RERRs) . By using UDP (user datagram protocol) packets, the source to destination route is discovered and maintain by these messages. For example the node which request, will use its IP address as Originator IP address for the message for broadcast. It simply means that the AODV not blindly forwarded every message. The number of hops of routing messages in ad hoc network is determined by Time-To-Live (TTL) in the IP header.

When the source node wants to create a new route to the destination, the requesting node broadcast an RREQ message in the network .In the figure 3-2 the RREQ message is broadcasted from source node A to the destination node B. The RREQ message is shown by the black line from source node A to many directions. The source node A broadcasts the RREQ message in the neighbor nodes. When the neighbor nodes receive the RREQ message it creates a reverse route to the source node A. This neighbor node is the next hop to the source node A. The hop count of the RREQ is incremented by one. The neighbor 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. The figure 1 shows the procedure for finding the destination node B. The RREQ message is flooded in the network in searching for finding the destination node B. The intermediate nodes can reply to the RREQ message only if they have the destination sequence number (DSN) equal to or greater than the number contained in the packet header of RREQ.

The intermediate nodes forward the RREQ message to the neighbor nodes and record the address of these nodes in their routing cache. This information will be used to make a reverse path for RREP message from the destination node, it is shown in the below figure 1. The destination node B replies with RREP message denoted by the dotted orange line, the shortest path from destination B to source A. The RREP reached to the originator of the request. This route is only available by unicasting a RREP back to the source. The nodes receiving these messages are cached from originator of the RREQ to all the nodes.

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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).

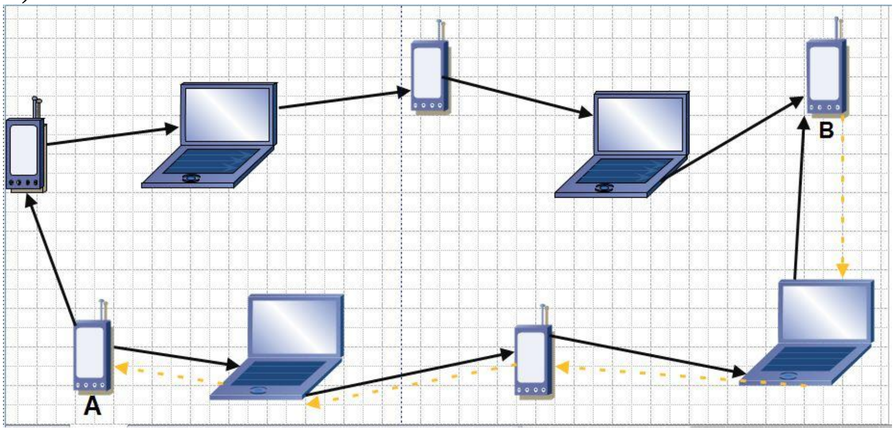

Fig 1 .RREQ and RREP messages in MANET using AODV

The main advantage of this protocol is having routes established on demand and that destination sequence numbers are applied to find the latest route to the destination. The connection setup delay is lower. One disadvantage of this protocol is that intermediate nodes can lead to inconsistent routes if the source sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number thereby having stale entries. Also multiple Route Reply packets in response to a single Route Request packet can lead to heavy control overhead. Another disadvantage of AODV is unnecessary bandwidth consumption due to periodic beaconing.

2- DSR (Dynamic Source Routing)

Dynamic Source Routing Protocol is a reactive routing protocol and is called on demand routing protocol. It is a source routing protocol that is why it is a simple and an efficient protocol. It can be used in multi hop wireless ad hoc networks. The DSR network is totally self organizing and self configuring. The protocols is just compose of two mechanisms i.e. route discovery and route maintenance. The DSR regularly updates its route cache for the sake of new available easy routes. If some new available routes were found the node will directs the packet to that route. The packet has to know about the route direction. So the information about the route was set in the packet to reach its destination from its sender. This information was kept in the packet to avoid periodic findings it has the capability to find out its route by this way. DSR has two basic mechanisms for its operation i.e. route discovery and route maintenance. In route discovery, it has two messages i.e. route request (RREQ) and route reply (RREP). When a node wishes to send a message to a specific destination, it broadcast the RREQ packet in the network. The neighbor nodes in the broadcast range receive this RREQ message and add their own address and again rebroadcast it in the network. This RREQ message if reached to the destination, so that is the route to the specific destination. In the case if the message did not reached to the destination then the node which received the RREQ packet will look that previously a route used for the specific destination or not. Each node maintains its route cache which is kept in the memory for the discovered route. The node will check its route cache for the desired destination before rebroadcasting the RREQ message. By maintaining the route cache at every node in the network, it reduces the memory overhead which is generated by the route discovery procedure. If a route is found in that node route cache then it will not rebroadcast the RREQ in the whole network. So it will forward the RREQ message to the destination node. The first message reached to the destination has full information about the route. That node will send a RREP packet to the sender having complete route information. This route is considered the shortest path taken by the RREQ packet. The source node now has complete information about the route in its route cache and can starts routing of packets. Figure 3-3 shows the route discovery procedure. Here we have four nodes i.e. A, B, C and D such as node A is the source and node D is destination. When node A wish to send a data packet to the node D, It will first check its route cache that whether it has direct route to node D or not. If node A does not have a direct route to node D, then it will broadcast a RREQ message in the network. The neighbor node B will get the RREQ

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message. First node B will check its route cache that whether it have a direct route to the destination node D or not, If it finds a route to the destination node D. So it will send a RREP message to the source node A. In the reply of that message the source node A will start sending the data packets (DP) on the discovered route. If it didn't discover the route from node B to node D so it forwards the message RREQ to the next node C and store the route AB in the cache. The process is going on until the RREQ message reached to destination node D. The destination node D caches the routes AB, BC and CD in its memory and sends a RREP message to the source node A.

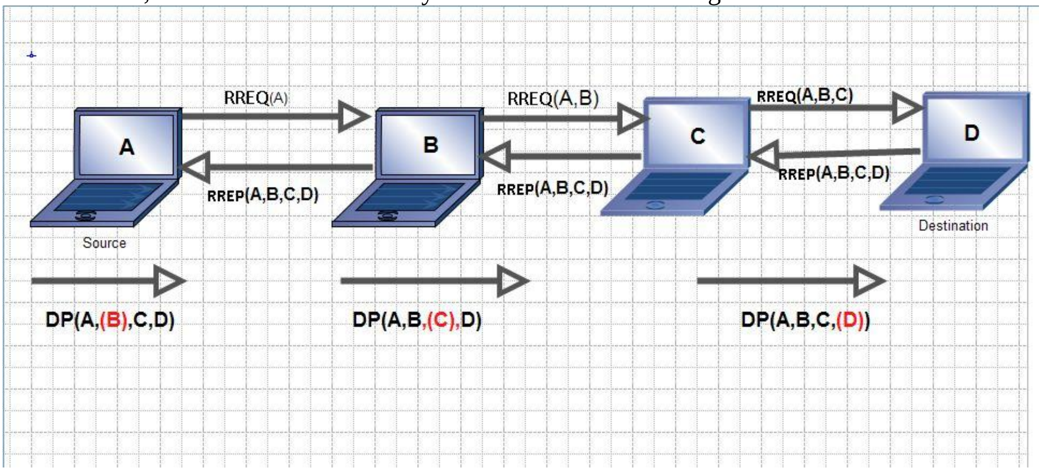

Fig 2 : Route discovery procedure in MANET using DSR

The next mechanism is the route maintenance. The route maintenance uses two kind of messages i.e. route error (RERR) and acknowledgement (ACK). The messages successfully received by the destination nodes send an acknowledgement ACK to the sender. Such as the packets transmitted successfully to the next neighbors nodes gets acknowledgement. If there is some problem in the communication network a route error message denoted by RERR is transmitted to the sender, that there is some problem in the transmission. In other words the source didn't get the ACK packet due to some problem. So the source gets the RERR packet in order to re initiate a new route discovery. By receiving the RERR message the nodes remove the route entries. In figure 3-4 four nodes are shown i.e. A, B, C and D. The node A sends a message to destination node D. The message goes on up to the node C, while receiving the ACK message up to node B. When the node C forward the RREQ message to the node D and it does not receive the ACK message from node D. The node C recognizes that there is some problem in the transmission. So the node C sends a RRER message to the source node A. Which in return search for a new route to the destination node D.

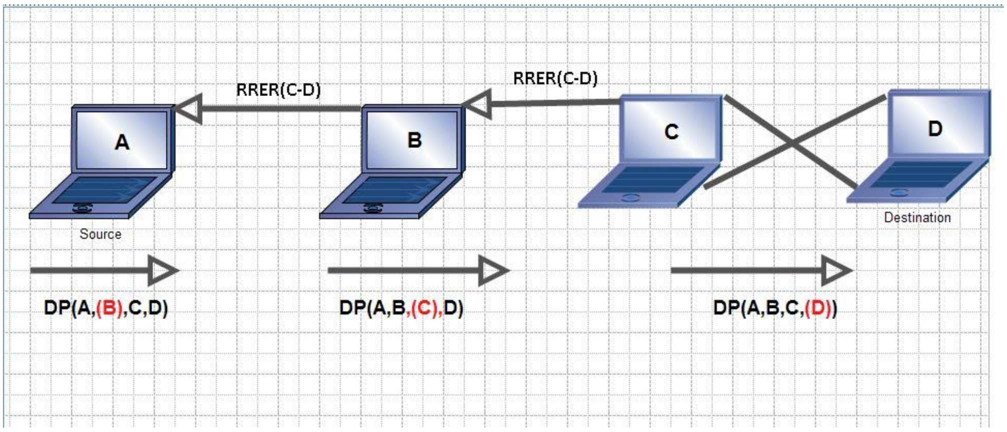

Fig 3: Route maintenance procedure in MANET using DSR

Proactive Routing Protocols

The routing information about all the nodes is build and maintained by the proactive protocols. The proactive routing protocols are independent of whether or not the route is needed. Control messages are transmitted with periodically intervals. Even if there is no data flow still control messages are transmitted. Because of these control messages proactive routing protocols are not bandwidth efficient. There are many advantages and disadvantages of proactive routing protocols. One of its advantages is that the nodes can easily get routing information, and it easily

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starts a session. The disadvantages are, too much data kept by the nodes for route maintenance, when there is a particular link failure its reform is too slow.

1-OLSR (Optimized Link State Routing)

It is a proactive routing protocol and is also called as table driven protocol because it permanently stores and updates its routing table. OLSR keeps track of routing table in order to provide a route if needed. OLSR can be implemented in any ad hoc network. Due to its nature OLSR is called as proactive routing protocol. Multipoint relay (MPR) nodes are shown in the given figure 3-5. All the nodes in the network do not broadcast the route packets. Just 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. This MPR selector is obtained from HELLO packets sending between in neighbor 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.

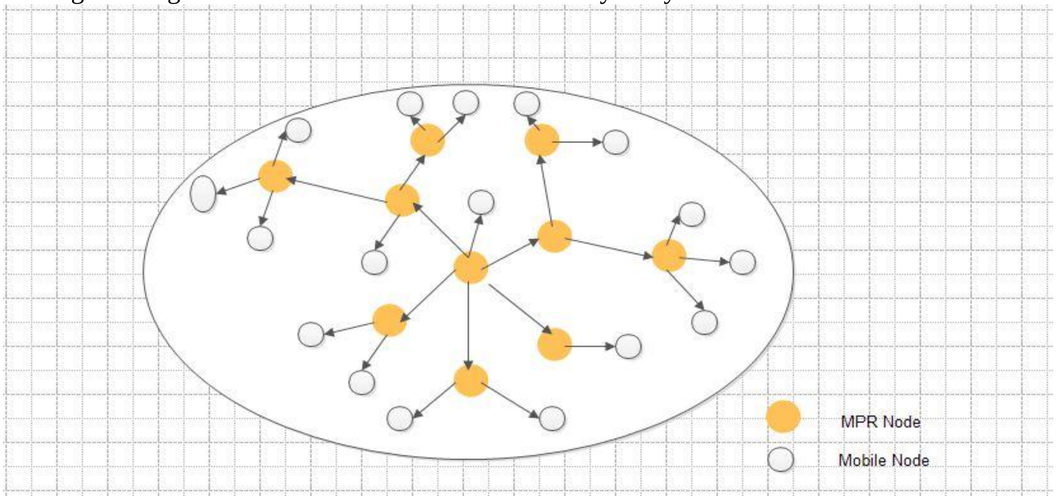

Fig 4: MPR node sends the TC message

Nodes in the network send HELLO messages to their neighbors. These messages are sent at a predetermined interval in OLSR to determine the link status. Here we can understand this by Figure 3-6. If node A and node B are neighbors, node A sends HELLO message to B node. If B node receives this message, we can say the link is asymmetric. If now B node sends the same HELLO message to A node. This is the same as first case, called asymmetric link. Now if the two way communication is possible then we can call it symmetric link, as shown in below Figure 3-6. The HELLO messages contain all the neighbor information. This enables the mobile node to have a table in which it has information about all its multiple hop neighbors. A node chooses minimal number of MPR nodes, when symmetric connections are made. It broadcast topology control (TC) messages with information about link status at predetermined TC interval. TC messages also calculate the routing tables. In TC messages MPR node information are also included.

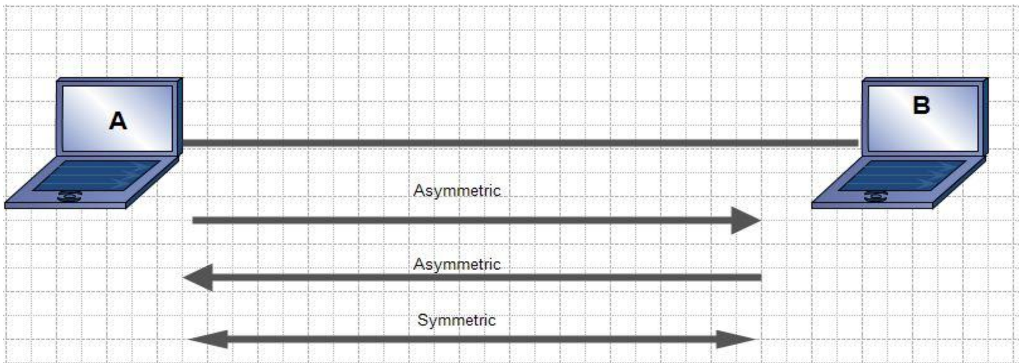

Fig 5: HELLO messages in MANET using OLSR

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Figures and Tables

Table 1: PARAMETERS OF SIMULATION

Simulation time	1 hours
Simulation area	100*100 m
Application traffic	Voice application
Number of nodes	6 mobile node.
Performance parameter	Routing discovery ,delay, jitter
Routing protocols	AODV, OLSR, DSR
Start-finish time	Actual data taken from site: http://crawdad.cs.dartmouth.edu/meta.php?name=cambridge/haggle/imote

Fig.6: Simulation scenerio

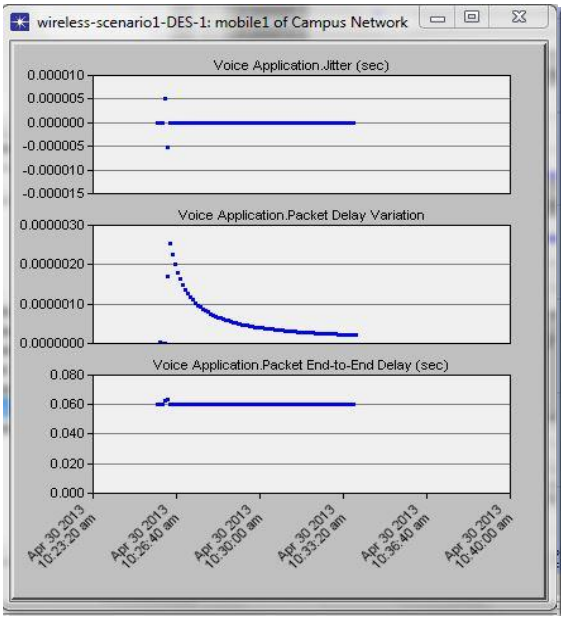

Fig.7 AODV

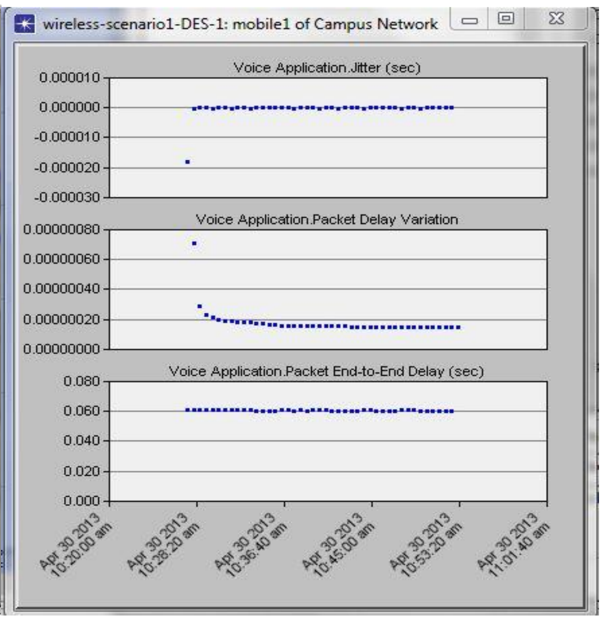

Fig.8 DSR

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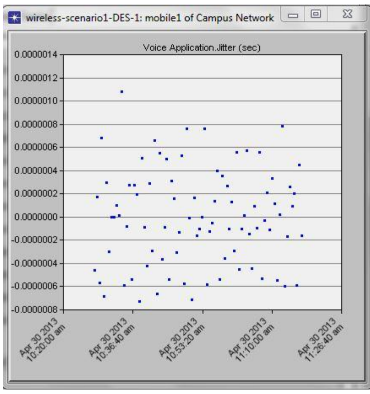

Fig.9 OLSR part A

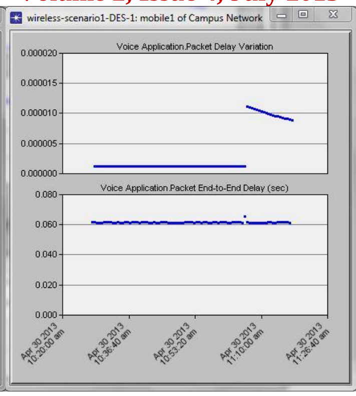

Fig.9 OLSR part B

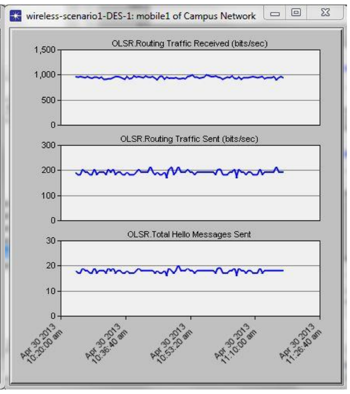

Fig.9 OLSR part C

Table 2: Performance QOS of different Routing protocols

Protocols	End –to –End delay	Jitter
AODV	0.065	121-121=0
		121to464=21.43
DSR	0.070	121to121 = 0.00000125
		121to 464= 343.00008
OLSR	0.60	121to 121= 0.0000056
		121to 464=343.000002

A. Abbreviations and Acronyms

AODV: **Ad hoc On-demand Distance Vector, DSR: Dynamic Source Routing, OLSR: Optimized Link State Routing,** MANET: Mobile Ad hoc Network

B. Equations

$$J(i)= j(i-1)+|D(i,i-1)|-j(i-1)/16 \text{……(1)}$$

$$d_{end-end} = N[d_{trans}+d_{prop}+d_{proc}] \text{…….(2)}$$

where

dend-end= end-to-end delay

dtrans= transmission delay

dprop= propagation delay

dproc= processing delay

N = path

II. CONCLUSION

Our Paper report is mainly consists of two studies, one is analytical study and other is simulation study. From analytical study we concluded that routing protocols in new modern area of telecommunications, internet systems and in seamless communication play prominent role to develop better communication between end users. Different routing protocols have different attributes according to their environmental scenarios. The selection of suitable protocol according to the network definitely increases the reliability of that network, for example in case of mobile ad hoc networks routing protocols should be loop free according to this report . Categorically it has been analyzed that there are two categories of routing protocols used in mobile ad hoc networks that are reactive routing protocols and proactive routing protocols, both categories have their own usage, so the selection of these categories in ad-hoc networks is very important. The simulation study of my report consisted of three routing protocols AODV, DSR and OLSR deployed over MANET using voice traffic analyzing their behavior with respect to three parameters, delay, jitter and routing discovery. Our motive was to check the performance of these three routing protocols in MANET in the above mentioned parameters. The selection of efficient and reliable protocol is a critical issue. In this simulation work we get two kind of results, one is the simulation graphs and other is the concluded average statistical data from these graphs. it can be seen that which routing protocol perform well. From the above analysis of routing protocols, the OLSR outperforms the two AODV and DSR protocols in terms of delay, the OLSR

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perform well than AODV and DSR in delay. The AODV puts low load than OLSR and DSR respectively. To minimize the delay variations, a jitter buffer are implemented which temporarily stores arriving packets.

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