A Case Study on MANET Routing Protocols Performance over TCP and HTTP

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Abstract

Mobile Ad-Hoc Network (MANET) is a wireless network without infrastructure. Self configurability and easy deployment feature of the MANET resulted in numerous applications in this modern era. Efficient routing protocols will make MANETs reliable. In this thesis, to find out the efficient routing protocol for routing, we have considered four different aspects scalability, mobility, network load and TCP delay to analyze the performance of DSR, OLSR and AODV routing protocols. HTTP traffic is used over the network designed for our analysis. Performance metrics Throughput and Delay are used for the performance analysis. In our simulation results, none of the protocols we selected have shown best performance in all the four different aspects considered. We conclude the efficiency of a network can be achieved by choosing the best suitable protocols based on the network requirement.

Keywords: Mobile Ad-Hoc Network, Mobile Ad-Hoc Routing Protocols, Delay, Throughput.
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<td>Ad hoc On-demand Distance Vector</td>
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<td>CBR</td>
<td>Constant Bit Rate</td>
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<td>DSDV</td>
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<td>WG</td>
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INTRODUCTION

Mobile Ad-hoc Network (MANET) is a wireless system that comprises mobile nodes. It is usually referred to a decentralized autonomous system. Mobile nodes engaged in MANET often work as client/servers. Nodes in the network can be either fixed or mobile. Mobile nodes include laptop, mobile phone, MP3 player, home computer or personal digital assistance. Nodes may be located on ships, airplanes or land, irrespective of their location as they can participate in communication. Self connectivity and easy deployment of MANETs makes it apt for emergency, surveillance situations and rescue operations.

MANET routing protocol noticed experimental Request For Comments (RFC) since 2003. Implementation and deployment of the protocols have not properly addressed by RFCs, but the routing protocol algorithms proposed were identified as trial technology with the high probability that will result into a standard. Enormous research work have been focused on different routing protocols such as Dynamic Source Routing (DSR), Optimized Link State routing(OLSR), Temporarily Ordered Routing Algorithm (TORA) and Ad hoc On-demand Distance Vector (AODV), for their development and standardization of routing support by MANET Working group(WG) of Internet Engineering Task Force (IETF)[24].

MANET gradually exploited the wireless communication world as the common means for human communication. Devices are configured with Wi-Fi cards as hotspots in many places such as universities, offices, airports and hotels. It stood as a major source for communication in this modern world. This challenged the researchers around the world to enforce their research in developing MANET. In such advanced communication network, routing plays a key role as it is one of the major aspects to route the data in network. Different protocols have been proposed so far by many researchers. This exploration of wireless devices lead the path to focus our study on the large networks where hosts involved in the network engage to communicate each other in Ad hoc fashion.

PROBLEM STATEMENT

MANET performance is sensitive to mobility, scalability and traffic load, thus variation in this aspects will affect the performance of MANET, this may result in either
increment or decrement on overall efficiency of the network. So to examine the different protocol performance while the amount of traffic and speed of nodes varies even plays a crucial role in efficient traffic routing. Now the important aspect is whether varying the network size, node speed and traffic load will improve the performance of the Protocols.

So far Research studies on performance analysis of MANET routing protocols have shown distinctive results, based on the different network conditions such as traffic type, parameters, network size and by using different simulators.

Many researchers intensively worked in analyzing the performance of MANET routing protocols focusing on Constant Bit Rate (CBR) traffic, File Transfer Protocol (FTP) traffic, User Datagram Protocol (UDP) traffic and Transmission Control Protocol (TCP) traffic etc. But MANET being one of the most usable and reliable network for communication with distinct applications in universities, offices, airports and hotels etc. In such user applications good HTTP performance is required, to enable the web based applications. So it is necessary to investigate the performance of chosen MANET routing protocols DSR, OLSR and AODV over HTTP traffic as this plays a key role in MANET applications.

1.2 Aim of the thesis

“The goal of this thesis is to analyze the MANET routing protocols DSR, OLSR and AODV performance over HTTP traffic with respect to scalability, mobility, network load and TCP delay aspects”

1.3 Contribution

In our thesis one of the major contributions will be to analyze the performance of the existing protocols DSR, OLSR and AODV, confined to web traffic with performance metrics Delay and Throughput by using OPNET simulation. Secondly, in designing and implementing the network scenarios by varying number of nodes, mobility of nodes and traffic loads to examine the protocols performance and to identify the optimal protocol in routing. Finally, as web traffic (HTTP) uses TCP as its transport protocol, we are also concentrating an impact of traffic at two different layers application layer and transport layer to analyze the performance of MANET routing protocols. This perspective of problem provoked us to put forth our following research challenges.
1.4 Research Challenges

[1] To find out the Scalability effect on MANET routing protocols performance.
[2] To analyze the delay and throughput based on varying traffic load over the network.
[3] To observe the impact of nodes mobility over the throughput and delay.
[4] To analyze the selected MANET routing protocols over HTTP traffic and to find the protocol that plays optimal role in routing.

1.5 Hypothesis

We have assumed that the traffic type used while communicating with MANET routing protocols effect the performance of the MANET routing protocols. This unique assumption needs to be verified by conducting simulations over the selected MANET routing protocols DSR, OLSR and AODV in context to meet our research challenges framed above. OPNET modeler 14.5 is used to perform the simulation as stated below

- Network size is varied in different simulation scenarios and the performance of MANET routing protocols is analyzed.
- Two simulations scenarios with HTTP heavy traffic and HTTP light traffic are developed to observe the behavior of MANET routing protocols performance.
- Speed of the nodes is varied in different simulation scenarios and performance metrics delay and throughput are analyzed, to observe the mobility effect on MANET routing protocols performance.
- Finally the performance of DSR, OLSR and AODV protocols in routing is analyzed by using TCP delay, in two different scenarios HTTP heavy traffic and HTTP light traffic.

1.6 Scope of the Thesis

MANET routing protocols are generally classified in three categories namely proactive, reactive and hybrid. Ad hoc routing protocols exhibiting both reactive and proactive protocols are called hybrid routing protocols. Our thesis work is focused only on reactive protocols DSR, AODV and proactive protcol OLSR. In this thesis we will conduct a performance evaluation of the protocols DSR, OLSR and AODV in MANET. We will observe the effect of these protocols on MANET performance while using HTTP traffic.
Analysis of this protocols and Algorithm design issues will not be focused. Energy consumption of the routing protocols while performing our evaluation and the pause time for the mobile nodes used in our thesis will not be considered. As pause times assigned to the nodes will also have the impact over the performance of network, as the nodes engaged in communication will stop at the assigned pause time and then takes a new random destination. Thus consideration of pause time will affect the analysis of our chosen protocols in our chosen aspects scalability, mobility, network load and TCP delay. Hence pause times are set constant for all the scenarios.

1.7 Thesis Outline

This thesis document is divided into eight main chapters. First chapter gives the introduction of the topic and states the problem and our research challenges. Second chapter gives the background and the related. Chapter three gives the overview of MANET and its applications. Chapter four shows an insight into the ad-hoc routing protocols particularly DSR, OLSR and AODV. Fifth chapter explain the TCP and HTTP. In six chapter it will explain about the simulation tool and its working. Seventh chapter will be the results and analysis chapter here it explains the performance analysis of the protocol DSR, OLSR and AODV in four aspects scalability, mobility, network load and TCP delay. Eighth chapter contains conclusion and future work.
2 BACK GROUND & RELATED WORK

Expeditious features of MANET are easy deployable, decentralized and needs no infrastructure resulted in rapid growth of its applications. In these ad-hoc networks routing plays a crucial role. Several routing protocols are proposed by the researchers to make an efficient routing over MANET. Routing protocols plays a major role in performance of the MANET. This aspect encouraged researchers to analyze the routing protocols under various network conditions and to find their impact over MANET performance.

Reactive routing protocols DSR, AODV and Proactive routing protocol OLSR were analyzed, using the performance metrics, data delivery ratio and end-to-end delay. CBR traffic is used to make a performance analysis of the selected protocols. Results concluded that proactive routing protocol OLSR is having better performance than reactive routing protocol DSR and AODV. The poor performance of reactive protocols is due to the high possibility of buffer overflow and packet drops over network layers [12].

Multiple scenarios are developed by varying the number of nodes to analyze the performance of AODV, DSR and OLSR protocols. TCP variants, TCP Tahoe, Reno and New Reno are used in the performance analysis. Throughput for the selected protocols while using the TCP variants chosen decreases by increasing the network size. High delay was noticed in DSR and TORA protocols. Congestion window reaches the maximum for TORA than DSR and AODV this is because of low buffer space to manage the incoming data on all the three variants of TCP. [5].

DSR, OLSR, TORA and AODV were analyzed by using the FTP traffic, 50% packet loss was noticed and UDP traffic result in higher packet delivery. None of the protocols selected shown better performance, but the protocols are best in terms of throughput. In case of high capacity links proactive protocols outperforms reactive protocols where as reactive protocols outperforms proactive in case of low capacity links [13].

Random mobility and scalability aspects were used to analyze the performance of the AODV, OLSR and TORA routing protocol. OPNET modeler 14.5 is used for simulation. Throughput analysis of the selected protocols concluded TORA shows poor
throughput than AODV and OLSR. AODV resulted in good efficiency over heavy traffic than OLSR and TORA [15].

The conclusion of the above research works shows that the performance of protocols varying diversely, based on different network conditions under different simulation environments. This is due to type of traffic, number of nodes, rate of mobility etc. Considering this fact as a key point, we have taken initiation to perform our research on well known MANET routing protocols namely DSR, OLSR and AODV in case of HTTP (web traffic) as this rely on TCP as its transport protocol, we are also concentrating the impact of traffic at two different layers application layer and transport layer in analyzing the performance of selected MANET routing protocols.
3 **OVERVIEW OF MANET**

Mobile Ad hoc Network (MANET) is a Wireless Ad-Hoc Network technology. Mobile nodes in the network will act as clients and servers [1]. Figure 3.1 shows the decentralized MANET consisting of mobile nodes functioning as routers along with the respective mobile nodes.

![Ad-Hoc Wireless Network](image)

**Figure 3.1 Ad-Hoc Wireless Network**

### 3.1 MANET Characteristics

- MANETs do not have any central authority or fixed infrastructure, unlike the traditional network makes MANET decentralized system.
- MANETS connects themselves by discovering the topology and deliver the messages themselves makes MANET a self configuring network.
- Mobile nodes in the MANET are free to take random movement. This will result frequent changes in the topology, where alternative paths are found automatically.
They use different routing mechanisms in transmitting the data packet to the desired nodes by this it exhibits dynamic topology.

- MANET usually operates in bandwidth-constrained variable-capacity links. That results in high bit errors, low bandwidth, unstable and asymmetric links results in congestion problems.

- Power conservation plays a key role in MANET as the nodes involved in this network generally uses exhaustible battery/energy sources this makes MANETS energy-constrained.

- Finally, Mobile wireless networks are more vulnerable to eavesdropping and interception. Network control will increase the robustness of the failure, rather than centralized network dispersion [2].

### 3.2 MANET Applications

Self reconfiguring, easy deployment, decentralized and infrastructure independent nature of MANET makes befit for communication.

- Formerly, MANET was used for military applications for communication where the data units/armed soldiers engaged in the battle field such as fighter planes, tankers, missile ships etc no matter air, water or land irrespective of their place and location.
- MANETs are widely used at locations where the fixed infrastructure for communication has been destroyed or impossible situations such as earthquake, flood, fire explosions plane/air crash and the areas of disaster and natural calamities.
- MANETs are playing a vital role in crowd control and surveillance.
- Flexibility of the MANET advanced its usage in the business applications such as conferences, file transfers and web application and home-automation such as to lock and unlock the doors and to operate the lights remotely.
- Other applications include easy of fight check-in procedures and traffic management [3, 4].
HTTP applications of MANET include numerous web applications used by people in different sectors and organizations.

Example: students in a university uses HTTP requests to access their educational pages, passengers uses web application in order to book their travel tickets.
4 **Ad Hoc Routing Protocols:**

Routing protocols are usually engaged to determine the routes following a set of rules that enables two or more devices to communicate with each other. In an ad hoc network routes are enabled in between the nodes using multi-hop, as the propagation range of the wireless radio is limited [5]. The nodes engaged in traversing the packets over MANET are not aware of the topology of the network. Routing protocols discovers the topology by receiving the broadcast messages from its neighboring nodes in the network and respond to accordingly. Routing protocols are classified based on the different routing strategies.

- Pure distance vector algorithms are followed by the protocols Distributed Bellman Ford, Routing Internet Protocol. Due to the poor result of these algorithms new protocols are proposed with improvement enhancing the current algorithms, such as Least Resistance Routing (LRR), Distance Sequence Distance Vector (DSDV) protocol and Wireless Routing Protocol (WRP).

- Link state algorithms are used in the protocols Fisheye State Routing (FSR) protocol, Global State Routing (GSR) protocol, Optimized Link State Routing (OLSR) protocol, Source Tree Adaptive Routing (STAR) protocol etc.

- On demand routing protocols find routes on demand i.e., when traffic arrives to the protocol for routing. No prior routes are configured and it is not necessary to exchange the routing tables frequently. A route request packet is used by source to find a route before communication is initiated. The best route is found by a route selection algorithm. Several protocols follow this strategy i.e., Ad Hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Temporarily Ordered Routing Algorithm (TORA), Lightweight Mobile Routing (LMR) etc.

- Global Positioning System (GPS) in this routing algorithm protocols use the position of the nodes in traversing the packets. Protocols using this routing algorithm are Flow Oriented Routing Protocol (FORP), Distance Routing Effect
Algorithm for Mobility (DREAM), Greedy Perimeter Stateless Routing (GPSR) [5].

4.1 Overview of Routing Protocols

4.1.1 Proactive (Table Driven) Routing Protocols

Proactive routing protocols maintain the routing information of all the participating nodes and update their routing information frequently irrespective of the routing requests. Proactive routing protocols transmit control messages to all the nodes and update their routing information even if there is no actual routing request. This makes proactive routing protocols bandwidth deficient, though the routing itself is simple having this prior updated routing information. The major drawback of proactive protocols is the heavy load created from the need to flood the network with control messages [6].

4.1.2 Reactive (On Demand) Protocols

Reactive protocols establish the route only when it is required unlike the proactive protocols these protocols do not update their routing information frequently and will not maintain the network topology information. Reactive protocols use the connection establishment process for communication [7].

Few pitfalls are noticed in these reactive protocols such as these are generally have high latency in searching the network. In finding the routes if there is excessive flooding over the network with route request packets it may result in network clogging [8].

4.2 Dynamic Source Routing (DSR) Protocol

Dynamic source routing protocol (DSR) is a reactive protocol that is known as simple and efficient, specially designed for the multi-hop mobile ad hoc network. Often called “On-demand” routing protocol as it involves determining the routing on demand unlike the pro-active routing protocols that has periodic network information. Network
nodes use multiple-hops to communicate, DSR protocol plays a key role in determining and maintaining all the routing automatically as the number of hops needed changes at anytime and the mobile nodes involved may leave or join the network. DSR protocol involves two major mechanisms to establish the routing process. These are route discovery and route maintenance [16].

4.2.1 Route Discovery

Route discovery is the process of DSR uses to find the route and to transmit the data from a source to destination where the source node is unaware of the destination route.

For example, in fig 4.2.1,

1. Initially node 'Y' transmits 'RREQ' (Route Request) will usually be received by all the participating nodes in the network.
2. This Route request contains information about the source and the destination along with unique request identification (id = 1 and id = 2 respectively in the considered figure).
3. RREQ even maintains the information about all the intermediate nodes passed by while reaching the destination.
4. Once the destination receives the RREQ packet then it will send the 'RREP' (Reply Route) to the source node 'Y'.
5. ‘RREP’ contains a copy of the route information of the RREQ then the source cache information to use in further communication process[16].
4.2.2 Route Maintenance

DSR protocol implements the route maintenance mechanism while communicating the packets from source to destination. But when the communication link between the source and the destination is broken or else a change in network topology is noticed, it will lead to failure of the communication between source node and destination node. In this scenario DSR protocols uses the route mechanism, to detect any other possible known route towards the destination to transmit data. If the route maintenance fails to find an alternative known route to establish the communication then it will invoke the route discovery to find the new route to destination [16].

Disadvantage:-

One of the major disadvantages of DSR protocol is in implementing the route discovery process. Source will transmit the RREQ messages to all the neighboring nodes to find the route to destination. It is fair and good when there are few nodes in the network, it will easily find a route and it can receive a RREP message from the desired destination. But if in case the network size is very high and participating nodes are
numerous, then there will be a possibility to have so many routes to the destination. It may result in the reply storms this may cause collision of packets and it may increase the congestion at the nodes while sending reply[17].

### 4.3 Optimized Link State Routing (OLSR) protocol

OLSR protocol is a proactive protocol used in mobile ad-hoc networks. It is often called table-driven protocol as it maintains and updates its routing table frequently.

OLSR exchanges the topology information always with other nodes. Few nodes are selected as MPRs (Multi point relays). MPRs are responsible for transmission of broadcast messages during flooding and generating link state information. MPRs technique used in OLSR protocol will reduce the message overhead and even minimize the number of control messages flooded in the network.

Nodes maintain the information of neighbors and MPR's, by sending and receiving HELLO messages from its neighbors. This will help in determining the link formation illustrated in the fig 4.3.3.

- Node N1 transmits the HELLO message to node N2 and then the message received by node N2 from node N1 can be called asymmetric link.
- If this HELLO message is retransmitted by the node N2 to node N1 then the resulting link even called as asymmetric link.
- Finally the resulted bidirectional link is known as a symmetric link.
- Symmetric link formation will help the nodes to choose MPRs.
- MPRs will send the topology control (TC) messages containing the information about link status and MRP node information [18].

![Hello Message - Asymmetric](image1.png)

![Hello Message- Asymmetric](image2.png)

![Symmetric Link](image3.png)

**Figure 4. 2.3** OLSR Symmetric link formation
4.4 Ad Hoc On-Demand Distance vector (AODV)

Mobile nodes in the ad hoc network are dynamic and they use multi-hop routing by using Ad-Hoc On-Demand Distance Vector algorithm. AODV will not maintain the routes unless there is a request for route.

Mobile nodes respond to the any change in network topology and link failures in necessary times. In case of the link failures the respective defective nodes are notified with the message, and then the affected nodes will revoke the routes using the lost link. This will help AODV to avoid the Bellman-Ford “counting to infinity” problem and then its operation is known as loop-free.

AODV uses Destination Sequence Numbers (DSN) for every route entry. DSN is created by the destination this DSN and the respective route information have to be included by the nodes while finding the routes to destination nodes. Routes with the greatest DSN are preferred in selecting the route to destination.

AODV uses the message types Route Request (RREQ), Route Replies (RREP) and Route Error (RERR) in finding the route from source to destination by using UDP (user datagram protocol) packets [19].

A typical AODV protocol follows the following procedure while routing.

- A source node intending to communicate to a destination it generally uses the RREQ constituting the source address and the broadcast ID address to its neighboring nodes to find the route to destination,

- This broadcast ID is incremented for every new RREQ. Once a neighbor notice a destination route it will respond with RREP to the source
- If the destination route is not found then it will re-broadcast the RREQ to its corresponding neighboring nodes by incrementing hop count.

- In this process a node participating in communication may receive the numerous copies of the broadcast packets in the pool of transmissions from all the corresponding nodes.

- Then the node cross check the broadcast ID of the request if the broadcast ID is new and have not received so far by the particular node then it will process the request if not the node drops down the superfluous RREQ and avoids the rebroadcast [14].
5 TCP & HTTP

5.1 Transmission Control Protocol

Transmission Control Protocol (TCP) represents to the transport layer of the OSI reference model. Transport layer is responsible for transmitting the data. Flow control, error control and division of chunks of application data into segments appropriate to the layers below which is done by the transport layer.

TCP uses a virtual connection. It means a logical connection is established before transmitting the data. TCP operates at a higher level with the end systems like Web browser and Web server. Applications of TCP include FTP, HTTP, streaming media and E-mail.

TCP in data transmission uses requests for the lost packets and rearranges the out of order packets and minimizes the network congestion. This makes TCP efficient in accurate packet deliver. But sometimes, this will result in long delays usually in seconds using requests for lost packets [20].

5.2 Web Traffic (HTTP)

Hyper Text Transfer Protocol (HTTP) plays key role in the communication of Web browsers with Web servers this will ensure the secure communication by avoiding eavesdroppers and counterfeits. HTTP standards are not confined to fixed information exchange. Indeed it is capable in storing and exchanging any kind of information. Hypertext Markup Language (HTML) provides set of rules in creation of web pages, where as HTTP is skilled in transferring remote printing instructions, multimedia objects and program files etc. HTTP laid base foundation for all network based computing with the extensive use of Web browsers and the due to the omnipresence of internet and for its flexibility. Several protocols are involved in communication over internet every protocol is confined to its own layer performing its own functions. HTTP is an application protocol that lies in the application layer. In figure 5.1 we can see the layers involved in a communication.
HTTP follows the process in fig 5.1 for communicating data. Generally it has two systems communications. The first communication system is Web Browser can be seen in figure 5.1 and the second communication system is Web Server can be seen in figure 5.2.

At the application layer if an HTTP application got needs to transmit a message it will pass it to the lower layer protocols Transport protocol (TCP), Internet Protocol (IP) and Network technology consecutively as shown in fig 5.1 until it will depart the system. HTTP constructs the message to transmit and then it will pass over to TCP, where the message is processed by certain information and it results in creation of TCP segment. This TCP segment works as an envelope to the message constructed by HTTP, this envelope will make sure to transmit the mail and then TCP segment is forwarded to IP layer, here IP process engages in adding further information to the current TCP segment. Resulting in another envelop and it so called as IP datagram. Thereafter it will be
transferred for the protocol implementation that is controlling the system network technology. Here some additional information is added and that leads the message to leave the system in the form of network packets/frames.

This HTTP message will then arrive to the application layer of Web server passing over the protocol stack from the lower layer until it reaches the application layer where all the concerned respective information in the HTTP message is removed in respective protocol layers flowingly network packet will be transferred as IP datagrams and then to TCP segments and finally HTTP message will arrive at the HTTP application layer. The pictorial representation of Web Server communication system can be seen in figure 5.2 [21].

![Communication System (Web Server)](image)

Figure 3.2 Four protocols layers used in HTTP exchange by Web Server [21]
6 SIMULATION DESIGN & IMPLEMENTATION

Designing an efficient network plays an important role in this world and then it is even essential part to check the performance of the designed network, which will be a difficult task in a real time application. For this many network simulators have been designed so far among the most reputed are OPNET (Optimized Network Engineering Tool) Modeler and NS2 (Network Simulator) OPNET Modeler is not a open source product it needs license to access it provides GUI and consists of predefined models, protocols and algorithms and supports with lot of documentation it is specially used for commercial purpose. NS2 is an open source simulating tool it is combination of C++ & Otcl with less document support specially used by developers [22].

6.1 Simulation Platform

OPNET (Optimized Network Engineering Tool) Modeler 14.5 is used for the design and implementation of our thesis work. OPNET is a network simulator that provides virtual network communication environment. It is prominent for the research studies, network modeling and engineering, R & D Operation and performance analysis. OPNET plays a key role in today’s emerging technical world in developing and improving the wireless technology protocols such as WiMAX, WiFi, UMTS, etc, Design of MANET routing protocols, working on new power management systems over sensor networks and enhancement of network technologies such as Ipv6, MPLS etc., [23].

6.2 Why OPNET Modeler?

- Provides virtual real time environment with GUI.
- Good for performance study of existing systems based on users conditions.
- Helpful in evaluation of designs for new network models and architectures
- Easy for understanding the network behavior in various scenarios.
- Pre defined network models and design exists for user education and development purpose.
- Very flexible and easy graphical interface to view the results.
OPNET is reliable, robust and efficient.

6.3 How OPNET Works?

Working of OPNET generally divided into four parts, model design, applying statistics, run simulation and then to view results and to analyze the results, if the results are not correct then it has to be re-modeled and then to apply new statistics. The basic working flow of OPNET can be seen in the flow chart below fig 6.1.

![Workflow of OPNET](image)

**Figure 4.1 Workflow of OPNET**

6.4 Model Design

In designing the model initially, we have to run OPNET modeler and then to create a blank scenario from the start-up-wizard soon we will see the work space. Here in the work space we will design our network by using the required network entities for our design. All the required entities such as Application configuration, Profile configuration, Mobility configuration, Server, Nodes these entities will be taken from the object palette to our project work space. We can see an example of network model designed over workspace in the fig 6.2.
6.5 Application configuration

Application configuration is used to specify/choose the required application among the available applications such as FTP, HTTP, Email, Database, Print etc. We can create a name for our choice and give the relevant description in creating new application. In this thesis we have used two web application HTTP performing heavy browsing and light browsing.
6.6 Profile Configuration

Profile configuration will be used to create user profiles; these profiles can be specified on different nodes in the network designed to generate the application traffic. While configuring profiles, applications that are defined in the application configuration are used. In this thesis, we have created two profiles: HTTP Heavy and HTTP Light, based on the applications chosen in the application configuration. With these profiles, we can restrict the nodes to a specified profile based on user design requirements.

6.7 Mobility Configuration

Mobility configuration is used to specify mobility models to the nodes in the network and provides parameters that will control the movement of nodes such as speed, start time, stop time, etc. In this thesis, we have chosen 10 meters/sec and 28 meters/sec speeds respectively based on our simulation scenario requirements. Start time at 10 sec, mobile nodes have a trajectory of movement 500 meters max, and we have not taken the pause time into consideration. We have chosen random waypoint mobility as this will make sure that mobile nodes are configured with mobility; it is widely used mobility model in Ad hoc networks.

6.8 Server

It is a WLAN server mobile node with applications running over TCP; it will support one underlying IEEE 802.11 and its connection at 2 Mbps. In the server, we can define the supported services based on the user profiles; they may support FTP, Email, and HTTP, etc., on the client. In our thesis, we have set HTTP as supported services in the server as our clients rely on the profiles HTTP.

6.9 Nodes

Nodes are workstations with client-server applications running over TCP/IP and UDP/IP; this will support underlying WLAN connection at 1 Mbps, 2 Mbps, 5.5 Mbps, and 11 Mbps. Here for the nodes, we can define the trajectory in designing the model as per the requirement for our model design; we have chosen VECTOR trajectory. And we
can assign the routing protocol to be used by the nodes for routing. In our thesis we have used DSR, OLSR and AODV routing protocols. We can assign the start time and end time in our design start time is chosen to start at the start of simulation and end time is chosen to end at the end of the simulation. We can specify the mobility profile defined in the mobility configuration to model the mobility over the nodes. In our design we have specified random way point mobility model. Generally mobile nodes engaged in a network move randomly and takes random destinations, moreover random mobility model is more appropriate for simulation studies.

6.10 Applying Statistics

To specify the statistics that has to be collected during a discrete event simulation we have to choose from the ‘choose individual DES statistics’ can be found in workspace pop-up menu. Statistics need to be applied for a designed model is basically two type’s global or scenario-wide statistics and object statistics. Global statistics will be collected from the whole network model designed and the object statistics will be collected over nodes. These statistics can be applied to a network model based on the user requirement for his design. In our design for our analysis we have chosen global statistics of Wireless LAN that include delay, throughput and TCP delay in analyzing the performance of the protocols chosen on our modeled scenarios.
7 RESULTS & ANALYSIS

7.1 Category-1

7.1.1 Impact of Scalability on MANET routing protocols performance

Fig 7.1 Delay for DSR, OLSR and AODV 10 nodes

Fig 7.2 Throughput for DSR, OLSR and AODV with 10 nodes.

Fig 7.3: Delay for DSR, OLSR and AODV with 50 nodes

Fig 7.4: Throughput for DSR, OLSR and AODV with 50 nodes.
In this Scenario simulation environment is modeled in OPNET 14.5 modeler with DSR, OLSR and AODV routing protocols. The performance of the protocols is measured in terms of throughput and delay parameters. The average time taken by the packet in order to traverse the network is named as delay where as the total amount of the data received by the receiver from the sender until the end of last packet transmission is known as throughput.

To observe the effect of scalability over MANET routing protocols we have developed two simulation scenarios each scenario constitute 10 nodes and 50 nodes respectively as this two scenarios contain low and high number of nodes, this scenarios can be helpful for us to examine our analysis using DSR, OLSR and AODV routing protocols in the campus area of 1000 meters x 1000 meters.

Initially, first scenario is developed using 10 nodes with DSR, OLSR and AODV routing protocols to analyze their performance over HTTP traffic. After finishing the simulation setup the designed model is simulated for 10 minutes and then results are collected.

In figure 7.1, we can see that the simulation results for 10 nodes reactive protocols DSR and AODV showing quite high delay compared to proactive protocol OLSR as the reactive protocols using the cache causing the higher delay.

In figure 7.2, The simulation results for the 10 nodes on DSR, OLSR and AODV protocols over HTTP traffic shows that the throughput for the OLSR routing protocol is higher than that of DSR and AODV routing protocols, it is because the OLSR protocol is independent of the traffic and network density compared to the reactive protocols DSR and AODV.

The reactive routing protocols DSR and AODV observed to have more delay compared to the proactive routing protocol OLSR, as the reactive protocols the source nodes generally broadcasts the routing requests in the whole network and keeps waiting for the responses this makes reactive protocols to show up quite much delay. High delay is noticed in the DSR routing protocol compared to AODV and OLSR is because of the
high packet size in DSR this will results in large routing overhead packet in the payload of the packets in DSR.

Second scenario is developed using 50 nodes with DSR, OLSR and AODV routing protocols over HTTP traffic and the designed model is simulated for 10 minutes and then results are collected to analyze the delay and throughput parameters.

In figure 7.3. The simulation result for the 50 nodes shows that approximately constant delay was observed by the OLSR protocol where as DSR protocol shown higher delay than AODV and OLSR protocols respectively. Initially, an aggressive increment in the DSR protocol is observed than AODV and then the delay observed to decrease gradually in both DSR and AODV protocol and further it has not shown the major variance. The better performance of reactive protocol AODV than the reactive protocol DSR is due to hop by hop initiation by AODV protocol on increasing number of sources this results in less delay in case of AODV than DSR protocol. The approximate constant delay noticed in the OLSR protocol is due to the proactive nature. The maintenance and regular update of the OLSR routing table helps OLSR protocol to use the available routes efficiently and the low latency of the route discovery process will result in low delay in OLSR protocol.

In case of throughput from Figure 7.4 we can see that DSR and AODV protocols shown less throughput than OLSR routing protocol. The high value of the throughput in OLSR protocol is due to its proactive characteristic it will always engage in maintaining and updating its routing information with all the participating nodes in the network this will result in the reduction of over head. And even the independency over network traffic and network density will also helps OLSR protocol to have higher throughput.

7.2 Category 2
7.2.1 Impact of Network Load on MANET routing protocol performance

In this scenario simulation environment is modeled in OPNET 14.5 modeler using DSR, OLSR and AODV routing protocols to analyze the chosen protocol performance on varying network load.
In the simulation environment two scenarios are developed separately with two different profiles HTTP heavy load traffic and HTTP light load traffic respectively this implies number of HTTP requests given by the users in the network designed will be higher in HTTP heavy load than HTTP light load traffic, 50 nodes were considered in each scenario with a constant speed of 10 meters/second(M/S), and pause time is not considered in this network environment in analyzing the protocol performance and is set to constant[0] and then each protocol performance is observed on two different loads using the performance parameters throughput and delay the behavior of protocols is analyzed.

![Fig 7.5: Delay for DSR protocol over HTTP heavy load and low load.](image1)

![Fig 7.6: Throughput for DSR protocol over HTTP heavy load and low load.](image2)

![Fig 7.7: Delay for OLSR protocol with heavy load and low load](image3)

![Fig 7.8: Throughput for OLSR protocol with HTTP heavy load and low load](image4)
7.2.2 DSR protocol performance on varying Network Load

Initially simulation environment is modeled as per above network conditions using DSR protocol. In figure 7.5, we can see the delay for the DSR protocol for HTTP heavy load traffic and HTTP light load traffic. DSR protocol shows higher delay when subjected to HTTP heavy load traffic than compared to HTTP light load traffic. The initial delay caused in the DSR protocol both in the high traffic and low traffic is quite high due to the reactive active nature that it needs to find the routes for transmitting the data and when it receive the data for transmission it will result in such incremental delay, and then it is observed to decrease gradually and finally stay constant. On the whole our simulation result shows that DSR show high delay in case of heavy traffic than low traffic.

In fig 7.6, we can observe the throughput for the DSR protocol for HTTP heavy load and HTTP light load traffic. DSR protocol shows higher throughput when subjected to low load traffic than high load traffic. In case of low load DSR protocol show an aggressive increment initially and then it gradually decreases and finally it maintains a constant throughput, whereas in case of heavy load DSR protocol observed to increase the...
throughput gradually unlike the low load traffic and finally it remains constant. On the whole the throughput of the DSR protocol when subjected to HTTP heavy load traffic is quite less than compared to HTTP light load traffic. This is due to change in topology DSR protocol experiences heavy traffic and it is possible to see new destinations to route the traffic and even breakage of existing links, generally DSR protocol maintains the cache routes and in this case DSR protocol routes the traffic to the stale routes resulted due to breakage of links and this makes the heavy loss of packets resulting lower throughput on increasing network load,[25] further it will implement the route discovery process to establish the new routes and then performs re-transmissions this results in excessive delay.

This simulation results confined to the above mentioned network conditions shows DSR protocol performance is poor when the HTTP traffic load increases.

7.2.3 OLSR protocol performance on varying Network Load

Secondly, Simulation environment is developed using 50 mobile nodes moving with constant speed of 10 M/S, as we are not considering the pause time it is set to constant [0] and then OLSR protocol performance is analyzed on subjecting to two different network load HTTP heavy load and HTTP low load traffic respectively with the performance metrics delay and throughput.

In figure 7.7, we can observe the delay for the OLSR protocol on HTTP heavy load and HTTP low load. Our simulation results show that OLSR protocol when subjected to low and and heavy load it has shown very little variation in the delay. We can observe from the graphs OLSR protocol shows quite less delay in case of heavy traffic than in case of low load traffic initially and finally it shows in both the heavy and low load cases almost same delay approximately with a slight difference.

In fig 7.8, we can observe the throughput of the OLSR protocol on HTTP heavy load and HTTP low load. Our simulation result shows that OLSR protocol when subjected to HTTP heavy load and HTTP low load it shows almost same throughput with slight variation. OLSR protocol due to its proactive nature it will always maintains and updates its routing table this will help the OLSR protocol to follow its routing in order to direct the traffic to the destination efficiently though there is increase in network load.
This simulation results for the designed model considering the conditions mentioned above shows that OLSR protocol on HTTP heavy load and HTTP low load almost similar performance.

7.2.4 AODV protocol performance on varying Network Load

Finally, Simulation environment is developed using 50 mobile nodes moving with constant speed of 10 M/S, as we are not considering the pause time it is set to constant [0] and then AODV protocol performance is analyzed on subjecting to two different network load HTTP heavy load and HTTP low load traffic respectively with the performance metrics delay and throughput.

In figure 7.9, we can see the delay for the AODV protocol when subjected to HTTP heavy load and HTTP low load. Our simulation results show that AODV protocol shows less delay under heavy HTTP traffic load than compared to the HTTP low traffic load. Initial delay for the AODV protocol is quite high in case of HTTP low load than HTTP high load, the delay for AODV in case both HTTP heavy and low load it decreases gradually and maintains a constant delay.

In figure 7.10, we can see the throughput for the AODV protocol when subjected to HTTP heavy load and low load. Our simulation result shows that AODV protocol shows gradual increment in the throughput in case of HTTP heavy load and even HTTP low load. Finally we can notice high throughput by the AODV protocol on HTTP heavy load than compared to HTTP low load.

This simulation results for the AODV protocol on above mentioned network conditions shows that AODV protocol under HTTP heavy load outperforms HTTP low load. AODV protocol unlike the DSR protocol it will not maintain any cache routes and on changing network topology it will setup new routes by the time, this will help AODV protocol to avoid loss of packets and excessive delay thus AODV protocol on HTP heavy load outperforms HTTP low load.
7.3 Category 3

7.3.1 Impact of Node Mobility on MANET routing protocols performance

In this scenario simulation environment is modeled in OPNET 14.5 modeler using DSR, OLSR and AODV routing protocols to analyze the chosen protocol performance on varying network nodes speed over HTTP traffic.

To observe the effect of mobility over MANET routing protocols two simulation scenarios were developed each scenario constitute 50 mobile nodes with nodes speed 10 M/S and 28 M/S respectively using DSR, OLSR and AODV routing protocols in the campus area of 1000 meters x 1000 meters.

Initially, simulation environment is developed by using 50 mobile nodes with 10 M/S speed and then using the performance metrics delay and throughput DSR, OLSR and AODV protocols performance are analyzed.

Fig 7.11: Delay for DSR, OLSR and AODV protocols over 10 M/S speed.

Fig 7.12: Delay for DSR, OLSR and AODV protocols over 28 M/S speed.
7.3.2 Delay analysis for DSR, OLSR and AODV on 10 m/s and 28 m/s speeds

In figure 7.11 and figure 7.12, we can see the delay for DSR, OLSR and AODV protocols for the nodes moving with a speed of 10 M/S and 28 M/S respectively.

On comparing the graphs we can observe that delay for DSR protocol gradually increases and then it remains constant in case of nodes moving with 10 M/S speed where as the delay for DSR protocol when the nodes moving with 28 M/S shows a very high increment in delay. Our simulation results shows that DSR protocol shows low delay in case of low node speed than higher speed, this results in poor performance of DSR protocol in case of network nodes moving with higher speeds. In this aspect, mobility of the nodes results change in position of the destination node. It will then initiates the route maintenance process to find out the new routes as it noticed change in network topology. But due to the mobility of all the participating nodes it may not possible to find the alternate routes to the destination by route maintenance mechanism. Thus it implements re-establishment of route discovery mechanism to find the new routes to the destination.
nodes for efficient data transmission and this results higher delay on increasing the node speed.

In figure 7.11 and figure 7.12, we can see the delay for the OLSR protocol for nodes moving with 10 M/S and 28 M/S respectively.

We can notice that the delay for the OLSR protocol approximately constant for the nodes moving with 10 M/S speed where as the delay for OLSR protocol when the nodes moving with 28 M/S even show approximately same delay and even stays constant. On comparing the graphs for OLSR delay in case of 10 M/S and 28 M/S we can see that there is no significant variation in delay. Our simulation results show that OLSR protocol shows same delay on varying the nodes speeds, this result in same performance by OLSR protocol on varying the nodes speed. OLSR protocol unlike the reactive protocols, it will maintains and updates its routing table frequently, this will help OLSR protocol to maintain consistent paths. OLSR protocol exchanges hello messages with its neighboring nodes and forms symmetric links though there is variation in nodes speeds and by this it can make successful routing, thus mobility of nodes shows less impact over the performance of OLSR protocol.

In figure 7.11 and figure 7.12, we can see the delay for the AODV protocol for nodes moving with 10 M/S and 28 M/S speed respectively. The delay for the AODV protocol when subjected to 10 M/S nodes speed its delay gradually decreases and then after it stays constant where as the delay observed for the AODV protocol on 28 M/S node speed it gradually increasing. On comparing both the graphs for AODV protocol delay in case of 10 M/S is quite less than that of delay in case of 28 M/S. Our simulation results show that AODV protocol show higher delay on increasing the nodes speed.

7.3.3 Throughput analysis of DSR, OLSR and AODV on 10 m/s and 28 m/s speeds

In figure 7.13 and figure 7.14, graphs shows the throughput for the DSR, OLSR and AODV protocols for the nodes moving with the 10 M/S and 28 M/S respectively.
On comparing the fig 7.13 and 7.14 we can see that the throughput for the DSR protocol is high for the nodes moving with the 10 M/S speed than the nodes moving 28 M/S speed. The throughput for the AODV protocol even show higher in case of nodes moving with 10 M/S speed than that of nodes moving with 28 M/S speed. But the OLSR protocol shown differently than DSR and AODV protocols, OLSR protocol shown quite higher throughput for the nodes moving with speed 28 M/S that that of the nodes moving with 10 M/S speed.

Finally for simulation results conclude proactive routing protocol OLSR shows higher throughput on increasing the nodes speed than that of reactive protocols AODV and DSR protocols respectively, this is due to the reason we have discussed above in case of delay analysis.
7.4 Category-4

7.4.1 Impact of TCP over the Routing Protocols performance

In this scenario DSR, OLSR and AODV protocols performance is analyzed using TCP Delay over HTTP low load traffic and HTTP heavy load traffic respectively.

To observe the impact of TCP Delay in analyzing the MANET routing protocols performance, we developed two simulation scenarios each scenario constitute 50 mobile nodes with HTTP low load and HTTP heavy load respectively using DSR, OLSR and AODV routing protocols, in the campus area of 1000 meters x 1000 meters.

Initially, simulation environment is developed for the each protocol separately for two cases and then simulated every scenario for 10 min and then results are collected.

![Fig 7.15: TCP Delay for DSR, OLSR and AODV protocols over HTTP low load.](image1)

![Fig 7.16: TCP Delay for DSR, OLSR and AODV protocols over HTTP heavy load.](image2)

7.4.2 Impact of TCP Delay on AODV Performance

In figure 7.15 we can see the TCP Delay for the AODV protocol when subjected to HTTP low load traffic. Our simulation results show that TCP Delay for the AODV
protocol increases initially and then it reaches a maximum of 1.60 sec and then it decreases gradually and remains constant at 0.64 sec. Where as in figure 7.16 we can see the TCP Delay for AODV protocol when subjected to HTTP heavy load traffic we can notice that the TCP Delay for AODV protocol increases and reaches a maximum of 0.57 sec and then the TCP Delay decreases slightly and stays constant at 0.49 second.

On comparing both figure 7.15 and figure 7.16 our simulated results for the AODV protocol on HTTP heavy load and HTTP low load concludes AODV protocol shows less TCP Delay when subjected to HTTP heavy load than HTTP low load.

7.4.3 Impact of TCP Delay on OLSR Performance

In fig 7.15 we can see the TCP Delay for the OLSR protocol when subjected to HTTP low traffic. Our simulation results show that TCP Delay for the OLSR protocol initially increases and then it reaches to a maximum of 0.96 sec and then it decreases gradually and remains constant at 0.35 sec. Where as in fig 7.16 we can see the TCP Delay for OLSR protocol when subjected to HTTP heavy load traffic we can notice that TCP Delay for OLSR protocol gradually increases initially and reaches a maximum at 0.94 sec and then it decreases gradually and stays constant at 0.60sec.

On comparing both figure 7.15 and figure 7.16 our simulated results for the OLSR protocol on HTTP heavy load and HTTP low load concludes OLSR protocol shows less TCP Delay when subjected to HTTP low load than HTTP heavy load.

7.4.4 Impact of TCP Delay on DSR Performance

In figure 7.15 we can see the TCP Delay for the DSR protocol when subjected to HTTP low traffic. Our simulation results show that TCP Delay for the DSR protocol initially and then it reaches to a maximum of 0.37 sec and then it decreases gradually and remains constant at 0.16 sec. Where as in figure 7.16 we can see the TCP Delay for OLSR protocol when subjected to HTTP heavy load traffic we can notice that TCP Delay for DSR protocol gradually increases initially and reaches a maximum at 0.54 sec and then it decreases gradually and stays constant at 0.40sec.
On comparing both figure 7.15 and figure 7.16 our simulated results for the DSR protocol on HTTP heavy load and HTTP low load concludes DSR protocol shows less TCP Delay when subjected HTTP low load than HTTP heavy load.

Finally we conclude, reactive protocols shown variation in TCP delay than compared to proactive protocol on varying the traffic load. Variation in TCP delay in case of reactive protocols on varying the traffic load is due to the reactive nature of the protocols, while transmitted the data usually these reactive protocols results in link breakages that may be due to heavy traffic/node mobility/congestion and results in loss of packets. As TCP rely on accurate delivery than timely delivery. It will not send the acknowledgement to the source unless and until it will receive the packets in right order, then it results initiation of Retransmission Time Out (RTO) and re transmits the packets considering the packets or lost [25]. Thus reactive protocols show variation in TCP delay than proactive protocols.
In this thesis we have performed performance analysis on MANET routing protocols DSR, OLSR and AODV protocols focusing on scalability, mobility, network load and the impact of TCP delay. Throughput and delay parameters are used to analyze the protocols.

Our simulation results focusing on scalability in analyzing the performance of our chosen protocols conclude that on varying the number of nodes OLSR protocol outperforms AODV and DSR protocols respectively.

In case of network load it was observed that on varying the network load from HTTP light load traffic to HTTP heavy load traffic the performance of DSR protocol has seen the poor performance where as the performance of the OLSR protocol noticed similar performance in both the scenarios but AODV protocol under HTTP heavy load outperforms HTTP low load.

In case of mobility it was observed that on varying the nodes speed proactive routing protocol OLSR outperforms the reactive protocol AODV and DSR protocols even at higher nodes speed.

Finally our performance analysis is performed based on TCP delay, for this we have taken HTTP heavy load traffic and HTTP light load traffic into consideration to simulate the scenarios and to collect the TCP Delay results, in this we noticed that DSR protocol shown less TCP Delay in case of HTTP low load than HTTP heavy load and even OLSR protocol shown less TCP delay in case of HTTP low load than HTTP heavy load but AODV protocol shown less TCP delay in case of HTTP heavy load than HTTP low load.

Finally, based on our simulation results collected using our network conditions we conclude that the performance of the network rely on the network conditions and we confirm that the efficiency of a network can be achieved by choosing the best suitable protocols based on the network requirement as our results show performance variation on changing the network conditions.
Future work for this thesis could be to have an insight into the protocols performance and to standardize routing protocols for different network conditions. Yet many factors such as impact of pause times, multi speed network, power capacity of nodes, different mobility models, implementation of multiple profiles with multiple applications on different mobile nodes, and impact of defective nodes on the network performance. Need to be considered to improve the performance of MANET.
## APPENDIX A

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AODV</td>
<td>Ad hoc On-Demand Distance Vector Routing</td>
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<td>DREAM</td>
<td>Distance Routing Effect Algorithm for Mobility</td>
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<td>DSN</td>
<td>Destination Sequence Numbers</td>
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<tr>
<td>DSR</td>
<td>Dynamic Source Routing</td>
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<tr>
<td>FORP</td>
<td>Flow Oriented Routing Protocol</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<td>GPSR</td>
<td>Greedy Perimeter Stateless Routing</td>
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<tr>
<td>HTML</td>
<td>Hypertext Markup Language</td>
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<tr>
<td>LMR</td>
<td>Lightweight Mobile Routing</td>
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<tr>
<td>MPR</td>
<td>Multi Point Relay</td>
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<td>OLSR</td>
<td>Optimized Link State Routing</td>
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<tr>
<td>OPNET</td>
<td>Optimized Network Engineering Tools</td>
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<td>RREP</td>
<td>Route Reply</td>
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<td>RREQ</td>
<td>Route Request</td>
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<tr>
<td>RERR</td>
<td>Route Error</td>
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<td>STAR</td>
<td>Source Tree Adaptive Routing</td>
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<td>TC</td>
<td>Topology control</td>
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<tr>
<td>TORA</td>
<td>Temporarily Ordered Routing Algorithm</td>
</tr>
<tr>
<td>TTL</td>
<td>Time-To-Live</td>
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REFERENCES:


