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Final Presentation Report

## Analysis of Wireless Mesh Network

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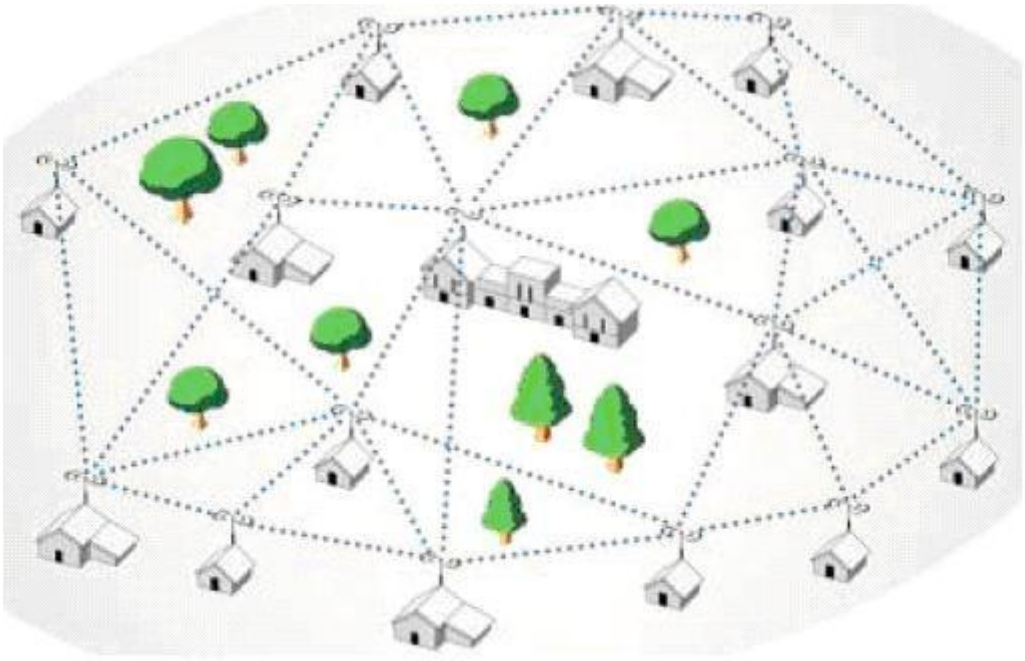
# Introduction:

Ad-hoc network is an autonomous system of independent wireless nodes which consist several hosts interconnected with the router without having any fixed architecture. The nodes in Ad-hoc network system can be arranged in any order. There is a great amount of work has been done in the research and development of new techniques and protocols in different kinds of Ad-hoc networks like Mobile Ad-hoc network (MANET), Wireless mesh network (WMN) etc. The mobile ad-hoc network could be very useful and have many advantages in term of cost and flexibility. MANET's can be very helpful in several applications such as medical, emergency response, data collection etc. dominated by Wi-Fi, architectures which mix mesh networking and ad-hoc connections are the beginning of a technology revolution based on their simplicity.

In recent years, the ad-hoc networks has becomes very popular and attracted many organizations and researchers who deals with wireless communication due to its unique availability feature. It provides a significant flexible environment of communication.

Beside the above flexibility, there are several questions that must be consider to make this architecture efficient and perform at its best. In this report we will discuss and explain some very important parameters in mobile ad-hoc network and wireless mesh network.

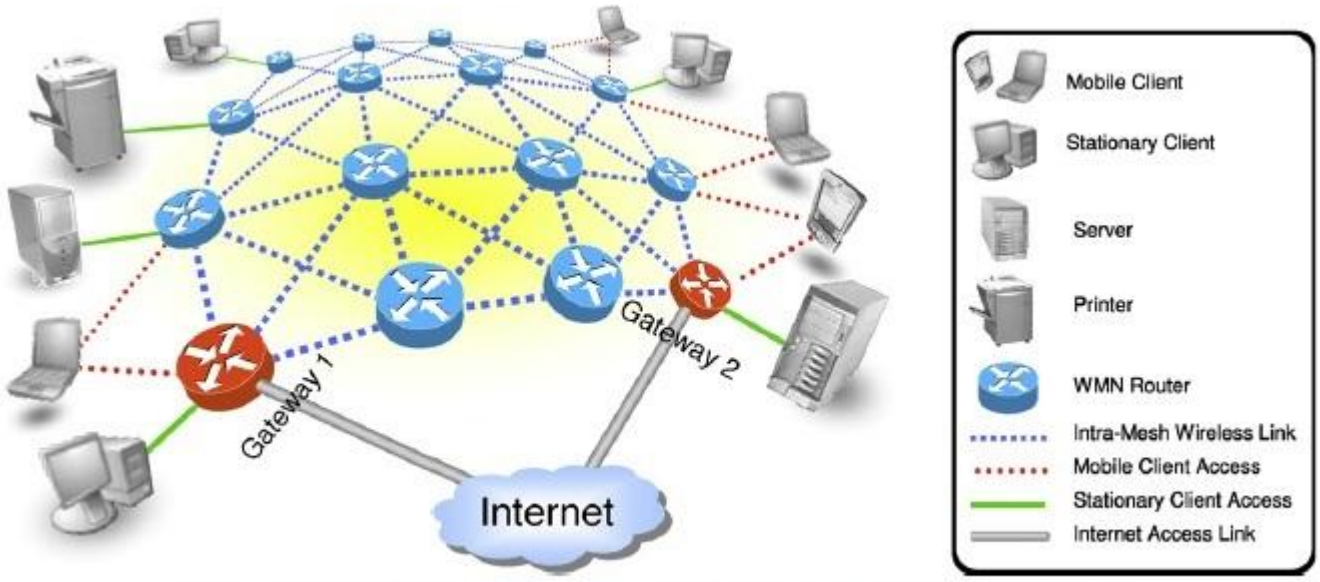


Source[1] Ad-Hoc Network

# Wireless mesh network (WMN):

A wireless mesh network (WMN) is a network that are created by the connection of wireless access points installed at every network user. It consists of mesh routers, mesh clients and gateways. Each network user is also a provider, which forwards data to the next node. The networking structure is decentralized and simplified because of each node need only transmit as far as the next node can. Wireless mesh networking allowed people who live in remote areas and small businesses operating in rural regions to connect their networks together for reasonable Internet connections. Nowadays WMNs are used widely and are rapidly undergoing progress. WMNs are widely used but, they face problem due to frequent link failures. To solve these failures many solutions have been proposed such as resource allocation algorithm, greedy channel assignment algorithm and fault tolerant routing protocols.

Wireless Mesh Networks (WMNs) are emerged as a concept to see the challenges in Future networks such as providing adaptive, reconfigurable and flexible architecture while offering less cost solutions to the service providers. Different old-style Wi-Fi networks, with access point (AP) connected to the wired network, but in WMNs they only require a subset of the APs to connect to the wired network. The APs which are linked to the wired network are called the Internet gateways (IGWs), On the other hand, the APs that do not have wired connections are referred as mesh routers (MRs). The MRs are connected to the IGWs by using multi-hop communication. Then IGWs provide a access to the conventional clients and interconnect ad hoc, sensor, cellular, and other networks to the Internet.




**Source[2]:** A wireless mesh network connecting several stationary and mobile clients to the Internet.

# Characteristics of wireless mesh network:

- **Mobility**: WMNs networks supports user mobility, it is necessary for the physical layer to support the shift in frequency and adapt to the fast fading conditions commonly associated with mobile users.

- **Link Adaptation**: When transmission conditions are not perfect (i.e., most of the time), a more robust modulation or error-correcting codes will be employed to restore the reliability of a link (at the expense of the bandwidth). Lots of new technologies (cellular systems, WLANs, WMANs) currently using such a link adaptation.

- **Multiple Transceivers**: If there is any availability of communication channel (i.e., multiple frequency channels, different orthogonal codes for CDMA, UWB, etc.) it is believable that a well designed MAC protocol can take benefit of having multiple transceivers to transmit and/or receive on different channels at the same time.

- **Directional Antennas**: Omni-directional antennas are inexpensive and simple to construct and handle; however, directional antennas allows wireless mesh networks(WMNs) to reduce the interference between simultaneous transmissions to improve the range and link budget and/or to reduce the transmission power. But, using directional antennas can significantly complicate the design of the upper layers.

- **Transceiver Performance**: At last, the transceivers should be able to switch quickly between the available channels, between transmitter and receiver mode and be able to quickly acquire synchronization. The efficiency of the transmission can be significantly lowered if preambles and inter-frame spacing are long, especially for short packets.

- **Link Quality Feedback**: Now, for wireless networks, link quality information can be successfully used in the higher layers for detecting handover imminence, capacity optimization, routing decision, etc. With the help of this information the efficiency of the upper layers can significantly improve.

- **Variable Transmission Power**: Being able to vary the power of the wireless transmitter can be seen as an extra degree of freedom for the link adaptation algorithm. Since, the “optimal” transmission power can be determined only using information from the upper layers (depending on the goal any of the following objectives can be improved by: minimize delay, minimize interference, maximize network capacity, etc.).

# WIRELESS MESH NETWORK ARCHITECTURES:

WMNs are of two types of nodes: mesh routers and mesh clients. The routing capability for gateway/repeater functions in a conventional wireless router, a wireless mesh router have additional routing functions to support mesh networking. To improve the flexibility of mesh networking, a mesh router is used with multiple wireless interfaces built on either the same or different wireless access technologies. If we Compared with a conventional wireless router, the wireless mesh router can achieve the same coverage with much lesser transmission power over multi-hop communications. Medium access control (MAC) protocol in a mesh router is improved with better scalability in a multi-hop mesh environment. The architecture of WMNs is classified into three main groups based on the functionality of the nodes:

- Infrastructure/Backbone WMNs.
- Client WMNs.
- Hybrid WMNs.

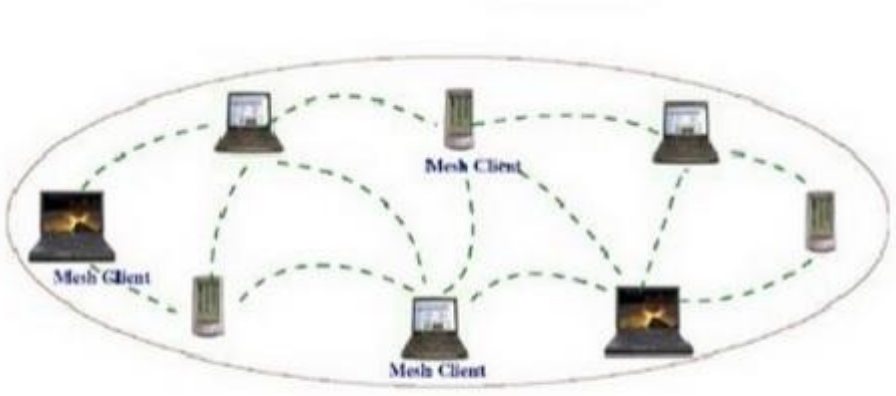
## • Infrastructure/Backbone WMNs:

The architecture is where dash and solid lines shows wireless and wired links, respectively. This type of WMNs which includes a mesh routers forms a infra structure for the clients that connect to them. The WMN infrastructure/backbone can be built by using various types of radio technologies, in addition to mostly used IEEE802.11 technologies. The mesh routers are capable of forming a mesh of self-configuring, self-healing links among themselves. With gateway functionality, mesh router can be connected to the Internet. This method also known as infrastructure meshing, which provides support to conventional clients and allow combination of WMN with existing wireless networks, through gateway/bridge functionalities in mesh routers. Conventional clients having Ethernet interface can be connected to mesh routers by Ethernet links. For conventional clients having the same radio technologies as mesh routers, they can directly communicate with the mesh routers. If we used different radio technologies, clients must communicate with the base stations who have Ethernet connection to mesh routers. Infrastructure/Backbone WMNs are usually used type. For example, neighborhood and community networks can be built using infrastructure meshing. Generally, the mesh routers are placed on the roof of houses in a neighborhood, which serve an access points for users along the roads and inside the homes. Typically, two types of radios are used in the routers, i.e., for the backbone communication and for user communication. Mesh backbone communication can be established by using long-range communication techniques including directional antennas.


Source[3]: Backbone WMNs

- Client WMNs:

Client meshing helps in providing peer-to -peer networks among client devices. In this type of architecture, client nodes organize the actual network to perform routing and configuration functionalities as well as providing end user applications to the customers. Therefore, a mesh router is not required for these types of networks. The basic diagram is shown in fig. In Client WMNs, a packet destined to a node in the network hops through multiple nodes to reach the destination. Client WMNs are usually formed by using one type of radios on devices. Moreover, the requirements on end-user devices is increased when compare to infrastructure meshing, since, in Client WMNs, the end - users must perform additional functions such as routing and self-configuration.




**Source[4]:** Client WMNs

- Hybrid WMNs:

This network architecture is the combination of client meshing and infrastructure. Mesh clients can able to access the network with the help of mesh routers as well as directly meshing with other mesh clients. On the other hand, the infrastructure provides connectivity to the networks such as the Internet, WiMAX, Wi-Fi, cellular, and sensor networks, the routing capabilities of clients also provide better connectivity and coverage inside the WMN. The hybrid architecture will be the most applicable case in our opinion.


**Source[5]:** Hybrid WMNs

# Differences between WMNs and general MANETs:

- **Gateways:** Mostly the WMNs are designed to provide connectivity to a distribution system (usually connected to the Internet). Therefore, they commonly have specialized nodes (the gateways) that helps in providing the connectivity to the distribution system.

- **Traffic pattern**: In WMNs, most of the traffic is expected to flow between the clients and the Internet (via the gateways). Generally, MANETs, the common assumption is that any node is equally likely to be the source or the destination of a traffic flow.

- **Mobility**: In most WMNs, nodes belong to two distinct categories: either stationary (e.g., rooftops, on lamp poles, etc.) or mobile, are capable of roaming in coverage area provided by the stationary nodes. In MANETs, it is assumed that all the nodes have homogeneous mobility characteristics.

# Advantages of Wireless Mesh Network:

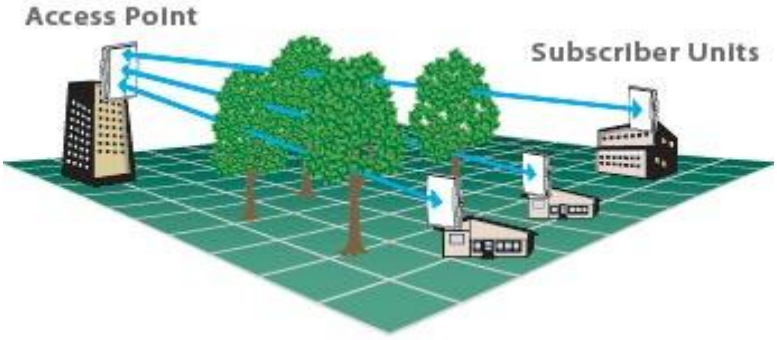
The advantages of wireless mesh network as compared to other networks are very important and also have great significance. While building a network, WMN offers a unique feature as compared to other networks.
• No use of wire
• Cost effectiveness is less
• More nodes, i.e. more speed
• Useful in Non Line of Sight (NLOS)
• No need for network administrator
• Data processing is fast
• Easy to install and uninstall
• Not require new Wi-Fi standard
• Tolerant to faults

To build a network without wire is a great advantage. In these days, bigger networks do not prefer to use of wire. Internet is a life example of this many networks are connected with each other wirelessly having a mesh topology, which in other words also called as seamlessly. Since it uses no wire that is why it is very cheap. It is very useful for that networks where there is no direct communication is possible between transmitter and receiver. That Type of communication is known as NLOS communication.

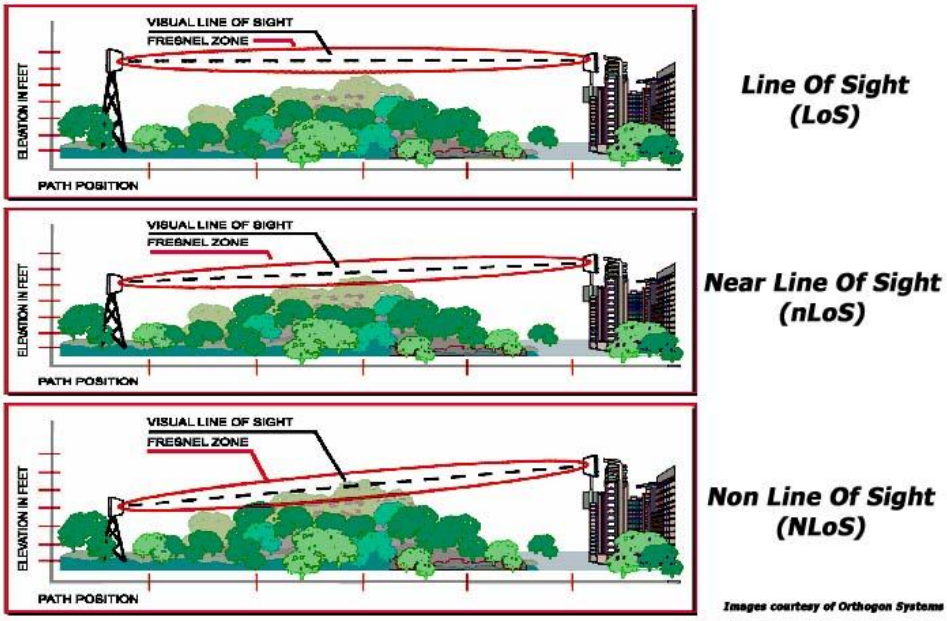
In WMN the nodes are automatically adjust themselves according to the condition; hence there is no need for the network administrator if there is any problem in the nodes or network. WMN nodes are able to communicate with their neighboring nodes as well as without going back to their central device, which increase its data processing speed. WMN nodes can easily installed or uninstalled depend on our requirement. Like all others, WMN also uses one of those standards. It is a new technology so it does not require any new Wi-Fi standard. WMNs are very much stronger to faults, if accidently, couple of nodes in a network fails, the communication will always keep on run.

- Non Line of Sight

NLOS is a term which is used for communication between transmitter and receiver where there is no hope getting direct path for data transmission. There are many obstacles between transmitter and receiver. The obstacles might be anything i.e. trees, buildings, mountains etc. When the transmitter sends any data, it reflect from these paths and then goes to the receiver. But, NLOS is extracted from the term line of sight (LOS) which exactly refers that there is a direct communication between transmitter and receiver, no single obstacles will be there between them. But in NLOS when data reaches to the receiver from different kinds of reflections it may face a weak signal at its end. This is called fading. But fading is no longer a very big issue now a days. It can be minimized easily and bring up to level zero. By increasing the strength of the signal at the transmitter side and increase the bandwidth of signal helps in to minimize/remove the signal fading. Bandwidth refers to the range of frequencies in a signal.




Source[6]: NLOS communication




Source[7]: NLOS communication

Increasing the range of frequencies will also increase the bandwidth of a signal. WMN is always a best suited option used for NLOS networks. WMN is a mesh network which prefers NLOS communication, so during the transmission of data from one end to another; the data strength varies when it reaches to the destination. Thus, WMN has the ability to automatically detect and handle this kind of problems. It also have capability to automatically increases the signal strength up to that level that it does not experience any kind of fading at receiver's side. Because WMN has alots of nodes in it, and that is why these nodes help to find a perfect signal at the receiver side. None of other network has the ability to do this.

- Seamless Communication

Seamless communication works on the basis of best connection anywhere anytime. In a WMN there are so many nodes present, and the function of seamless is to connect these nodes all the times at every conditions .User are not allowed to disconnect during the continuing communication which results handover management HO and location management. HO management refers to keep all nodes connected when the position or we can say direction will change. Location management refers to the network will find from which point the node is connected to it. Hence, WMN is best for NLOS networks, wirelessly mobile communication with some access points is also come under the category of NLOS communication. Because signal from the base station (BS) experiences different reflection from different things and then reaches mobile node. This means that this is another advantage of WMNs which is also provides seamless communication.

# Frequent link failure in WMN:

WMN is the network which is created via the connection of wireless access point. Wireless access points are installed at every node. WMN composed of mesh client, gateways and mesh routes. In this era, WMAs are used widely and they are rapidly undergoing process. As WMNs are widely used, they face problem because of frequent link failure. To beat this problem we have lots of solutions. They are resource allocation algorithm, greedy channel-Assignment and fault-tolerant routing protocol.

- Resource allocation algorithm: In this first we allocates the resources. They provide an optimal solution they needed the global configuration changes. The snag is they are not suitable when frequency failure occur.
- Greedy channel-Assignment: It changes the setting of just faulty links. The main problem in this is we must consider configurations of nearby nodes in mesh network along with faulty link.
- Fault-tolerant routing protocol: This can be used to avoid the faulty link. The best examples of this routing protocol are local rerouting and multipath routing. This routing protocol depends on redundant transmission. Redundant transmission requires the more amounts of network resources than the reconfiguration in link level network.

We can overcome from all these drawbacks with the help of autonomous reconfiguration system (ARS).

# AUTONOMOUS RECONFIGURATION SYSTEM (ARS)

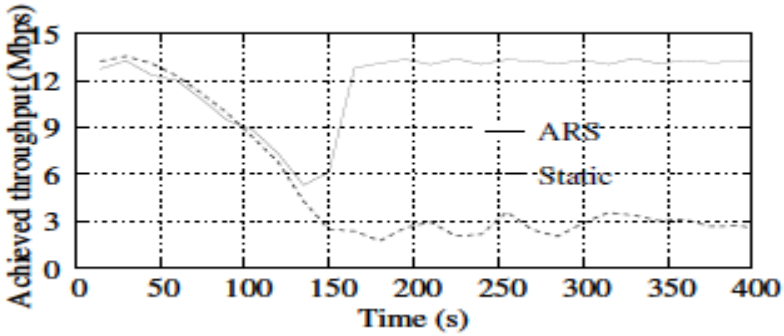
This allows a multi-radio WMN to autonomously reconfigure its local network settings from link. These settings are channel, radio and router assignment for real time recovery from the link failures. ARS consist of reconfiguration panel algorithm that identify the local configuration changes available for the recovery, while maximizing changes of healthy network settings. In detail, ARS initially search for the feasible local configuration changes available around the faulty area which is current channel and radio associations. Then by imposing current network setting as constraints, ARS identifies reconfiguration plans that require the minimum number of changes for the healthy network setting. After that by imposing current network setting as constrains, ASR identifies reconfiguration plans that require the least number of changes for the healthy network setting. Later, ARS also includes a monitoring protocol that enables a WMN to perform real time failure recovery in conjunction with the planning algorithm. The accurate link-quality information from the monitoring protocol is used either to identify network changes that satisfy applications, new QoS demand or ripple effect. Ripple effect is that which avoided the propagation of QoS failure to neighboring link. With the help of hybrid link quality measurement technique measure wireless link-conditions by monitoring protocol periodically by ARS running in each node.

- NECESSITY OF SELF-RECONFIGURABILITY

The most difficult task is to maintain the performance of WMNs in the dynamic link failures. In addition to this, this kind of link failures can be withstood even after maintain the performance by enabling WMNs to autonomously reconfigure channels and radio assignment in below examples:

- RECOVERING FROM DIMINISHING THE LINK QUALITY:

The quality of wireless links in WMNs can be decrease (link quality failure) because of severe interference from other co-located wireless network. Like Bluetooth, cordless phone and co-existing wireless networks operating on the same or adjacent channels cause significant and varying degrees of losses or collisions in packet transmission.




***Source[8] In this figure we illustrate that local links can recover from such link failure by switching the tuning channel of a link to other interference free channel***

- Satisfying dynamic QoS demands:

Links in some area may not be able to accommodate. The increasing QoS demand from end user because of spatial and temporal locality. Example links in conference room may have to relay too much data during the session. During the break time links outside room fail to support all present people voice-over-IP. Their channels re-associate with under-utilized channels those nearby. This help to avoid communication failure.

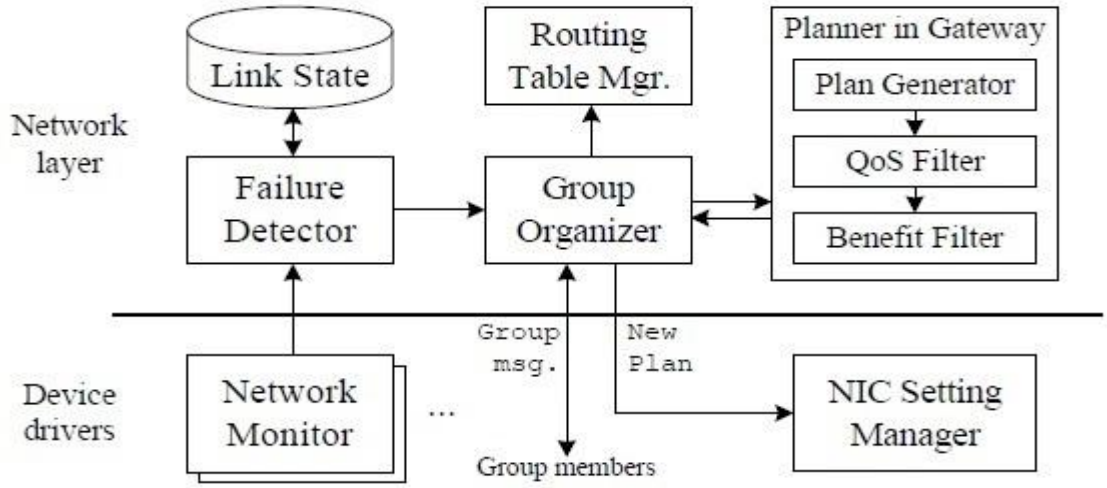
- Coping with heterogeneous channel availability:

Link in some areas may not be able to access wireless channels during spectrum locality because of spectrum regulation. For instance, some links in a WMN need to vacate current channels if channels are being used of emergency response near the wireless network. These kind of links can find and identify alternative channels available in same area.

## AUTONOMOUS RECONFIGURATION SYSTEM (ARS) ARCHITECTURE:

ARS comes up with a hook. With that ARS can capture and send the packets related to ARS similar to the group formulation data. Moreover it also have:

1. Network planner: - It will create the network reconfiguration plan in the gateway.
2. Group organizer: - This is liable for the formulation of local group in mash network.
3. Failure detector: - It communicate periodically with the network monitor and keep up-to-date link status.
4. Routing table manager: - It managed the state of the routing table.




**Source[9]:** ARS software architecture in each node

# AUTONOMOUS RECONFIGURATION SUPPORTS SELF-RECONFIGURABILITY

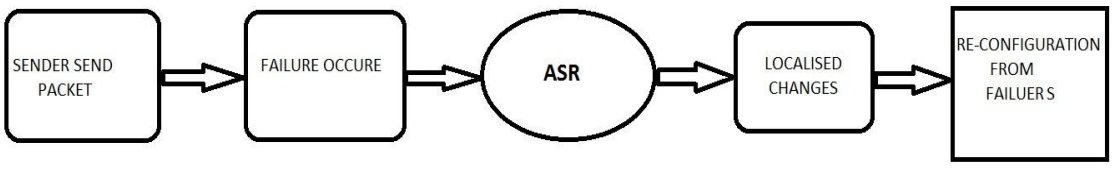
It supports self-reconfigurability after running on all nodes via the following features:

Cross-layer interaction: It actively communicates across the network as well as link layers for planning. This communication permits ARS to include a re-routing for reconfiguration planning in addition to link layer reconfiguration. With the help of routing protocol, ARS can also maintain connectivity during the recovery period.

- Autonomous reconfiguration via link-monitoring:
  It monitors exactly the quality of links of every node in a distributed manner and on the bases of measurements the given links' QoS constraints, ARS detects local link failures and autonomously initiates network reconfiguration.

- QoS-aware planning:
  It effectively identifies QoS must meet reconfiguration plan by:
  1. Estimate the QoS must meet the generated reconfiguration plans
  2. Obtain their expected benefits in channel utilization.

  Localized reconfiguration: On the bases of multiple channels and radio associations available, it produces reconfiguration plans that allow for changes of network configurations only in the surrounding area of link failures.



# ALGORITHM IN ARS:

**Algorithm** ARS Operation at mesh node $i$

(1) Monitoring period ($t_m$)
1: **for every** link $j$ **do**
2: measure link-quality ($lq$) using passive monitoring;
3: **end for**
4: send monitoring results to a gateway $g$;

(2) Failure detection and group formation period ($t_f$)
5: **if** link $l$ violates link requirements $r$ **then**
6: request a group formation on channel $c$ of link $l$;
7: **end if**
8: participate in a leader election if a request is received;

(3) Planning period ($M$, $t_p$)
9: **if** node $i$ is elected as a leader **then**
10: send a planning request message ($c$, $M$) to a gateway;
11: **else if** node $i$ is a gateway **then**
12: synchronize requests from reconfiguration groups $M_n$
13: generate a reconfiguration plan ($p$) for $M_i$;
14: send a reconfiguration plan $p$ to a leader of $M_i$;
15: **end if**

(4) Reconfiguration period ($p$, $t_r$)
16: **if** $p$ includes changes of node $i$ **then**
17: apply the changes to links at $t$;
18: **end if**
19: relay $p$ to neighboring members, if any

# IMPROVE THROUGHPUT OF WMN USING CSMA-CA TECHNIQUE:

The CSMA stands for Carrier Sense Multiple Access that employs collision avoidance (CA) to speed up the performance of the wireless mash networks. When any node or client connected with access point wish to interact with another node or client the following steps has used:

- The node sense the wireless medium or path which the node wants to communicates.
- If the node sense idle signal then if transfer the data to another node.
- When the node senses the busy signal then it waits the particular time.

When the transmission open then it transfers the whole data after it "Tear-down" the communication. The CSMA-CA does not sense the hidden node that's why we will import the feature of RTS-CTS mechanism to solve the hidden node problems.

# TEST MODEL:

In this section we are trying to improve the interference between the communicating nodes. The interference effect the electromagnetic waves on physical layer. It affects the bit alteration which results to packet drop. We define the orthogonal channels so we calculate the channel interference in the medium access layer. The equation for interfering signals:

$$\mathbf{ETX=1/\ df\ *\ dr}$$

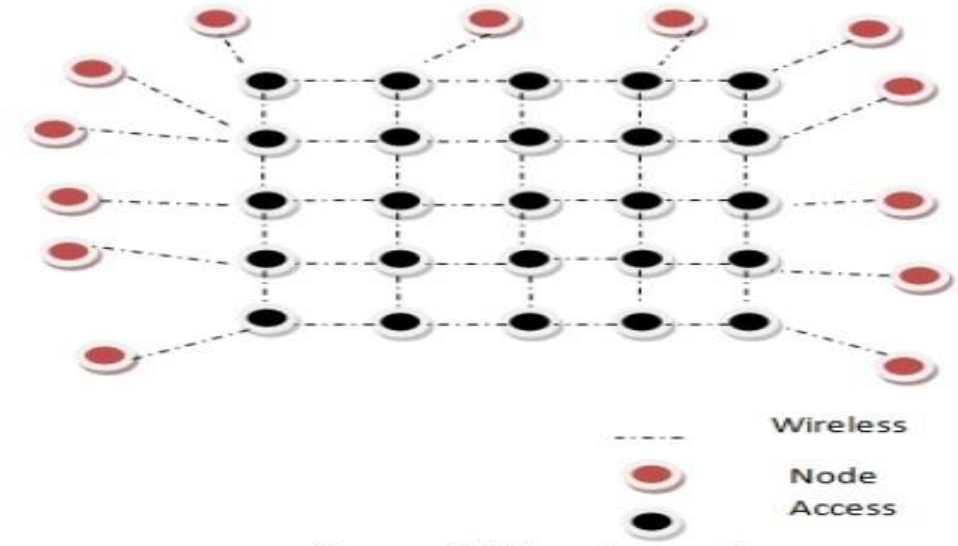
The df and dr related to reverse delay ratio that finds from the expected transmission time. The expected transmission calculates from the source node when delivered the packets to the destination node. Since we calculate the expected transmission time from the expected transmission rate that in which number of packets delivered on the link. If we have 1KB packets with transmission rate is 2 then the outcome will be multiplied with the expected transmission. The proposed method also measured the path loss (Pa) with a distance of two nodes (d). The value of the transmitter power is constant.

$$\mathbf{Pa=Cd-\eta}$$

The interference will be higher than the radius of the total network. The η specifies delay that measures the difference between the packet time receiving and transmission from one node to another. This equation solves the power level of two nodes.

# TEST SCENARIO:

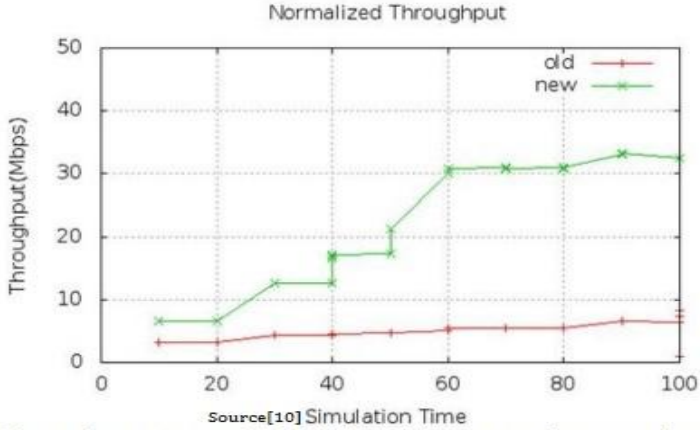
In networking industry, we use Access points to route data. It help us to create WLAN network. Basically the access point transmit traffic to and from the end users, it is also being used in mobile Ad Hoc network to connect themselves. The efficiency and effectiveness of forwarding the data in the entire network is to hold and keep the connectivity between the networks towards users within its supporting and covered area. If there are two users within the coverage range of each other, than there will be a virtual link between them. Multi radio wireless mesh network primarily focus to maintain topological connectivity. FTP and CBR are the supported traffic types. 25 nodes square grid is the topology of all networks in the simulations. The simulation network has been configuring as square grid access point and all the 13 nodes as mesh clients. The bandwidth form client and access points are 11Mbps and 54mbps respectively. It means in the standard configured on the side nodes and standard configuration on client side 802.11b and 802.11a respectively. The ratio between communication and interference range is 2. All nodes in multi-channel networks equipped with 2 radios. Initially we randomly choose 4 pair of nodes from 13 nodes and assign each pair with a different CBR UDP flow. The flow rate is selected as a 2Mbps. 1KB is the packet size, flow runs for 70 seconds and the distance is 20 meter.




Source[9]: Square Grid based scenario

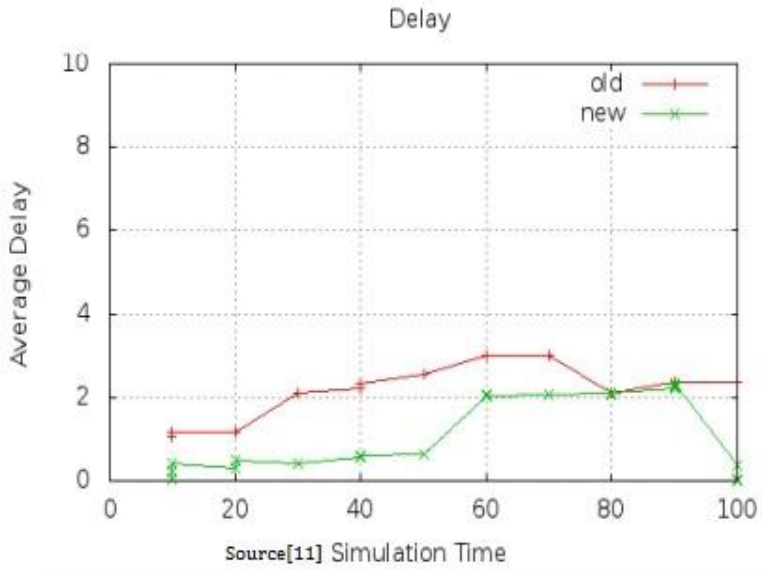
# RESULTS:

The Medium Access Control (MAC) protocol plays important part in moderating access to decrees the collision while keeping fairness. The aim is to maximize the overall network throughput and decrease the end-to-end delay or in term of fairness.




Source[10] Throughput comparison between previous and proposed approach

The collision free environment permits for higher throughput and improves error performance of the system. Each client initiate the data and forwarded data to another client. The multi ratio multichannel applies on different client and access point to achieve the higher throughput with least delay. If the channel is only 1 then the achieved throughput is less and the delay per channel is more. In the experiment the number of client are 13 and the matrices for 5X5 for access points. The delay corresponding to each client is very less because of dynamic reassignment of channel is randomly assigned channel to each client.




Delay comparison between previous and proposed approach

# Conclusion:

AODV protocol able to deliver mostly whole original data packets in the local network in the correct manner and this protocol has very little routing overhead. At the time client communicate with another client on the same link, this leads to changes in communication pattern as well as the increase in routing packet overhead. The routing mechanism is used to examine the nodes with the help of CSMA-CA technology. CSMA-CA calculate the currently used routes automatically for transmission of data. CSMA-CA gives us the advanced solution for network, operational integrity and optimized network efficiency.

# Routing Protocols for Wireless Mesh Network:

Wireless mesh network is technically considered as one of the type of mobile ad-hoc networks. But there are some differences between them. In wireless mesh networks, all the traffic starts from the gateways and ends up on gateway. 2nd in wireless mesh networks, all the nodes are clearly separated from each other in the form of mobile node. On the other hand MANETs are linked with mobile ad-hoc networks.

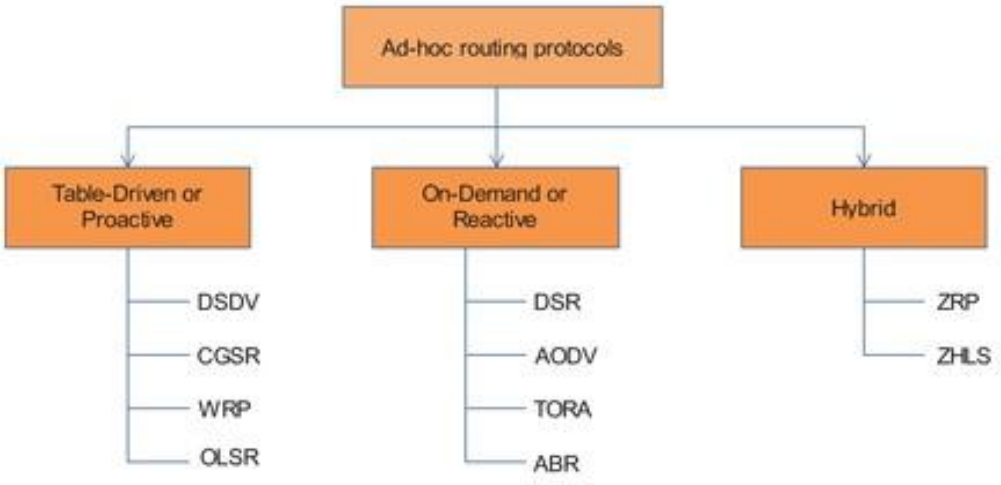
MANETs routing protocols can be used in wireless mesh networks. In addition, wireless mesh networks are new technological networks which are similar to MANETs. It provides connection to an infrastructure node which plays vital role for providing broadband internet access. Another best feature of wireless mesh network is wireless local area network (WLAN). Routing is the key and basic attribute and fundamental feature of wireless mesh network. The routing protocols have the clear effects on the behavior and performance of the wireless mesh networks. So it is extremely important in selection of suitable routing protocol which will increase the efficiency and performance of the network.

- Some of the basic effects of routing protocols in WMNs:

1. It creates synchronization between nodes.
2. They are responsible to strength the network architecture.
3. They are helpful to make connection between nodes.
4. They plays a vital role in providing quality of service (QoS) in terms of bandwidth utilization. Delay, throughput.

## Routing protocols can be classified in:

1. Proactive Protocols.
2. Reactive Protocols.
3. Hybrid Protocols.




**Source[12]: Ad-Hoc Routing Protocols**

- Proactive Routing Protocol:

Using proactive routing approach, the route information is periodically exchanged between hosts (e.g. DSDV, OSLR). The routing paths are established to all the destination nodes regardless of whether or not the routes are needed to transmit data. They are also called table-driven methods. Continuously evaluate routes to all reachable nodes and maintain consistent, up-to-date routing information. Thus the main advantage of proactive protocols is that nodes can quickly obtain route information and quickly establish a path. The whole network should, in theory, be known to all nodes. This results in a constant overhead of routing traffic, but no initial delay in communication.

- Reactive Routing Protocol:

In reactive approach limit the exchange of route information, building routes only towards nodes involved in higher layers communication and routes are established on demand. (e.g AODV, DSR, and TORA). Reactive methods are also called on-demand methods. The route discovery process is initiated when the source node requires a route to a destination node. The discovery procedure terminates either when a route has been found or no route available after examination for all route permutations. In mobile networks active routes may be disconnected due to node mobility. In WMNs node mobility is very minimal, so reactive routing protocols have better scalability than proactive routing protocols.

# Simulate the performance of WMN protocols:

In this report we will discuss and simulate different proactive and reactive protocols to determine that which has better performance in wireless mesh network. For this purpose, we selected three widely use protocols ( AODV, DSR and OLSR) to run the simulation.

- Design Parameters

There are various parameters that are available in WMNs and they are also termed as performance metrics or design parameters. Every parameter has its own importance. These parameters are named and described below. These design performance metrics are used for the evaluation of routing protocols. These design parameters have a great impact on overall performance of a communication network. We dealt with the first three performance metrics of a network i.e. delay and throughput. These three performance metrics are evaluated with respect to routing protocols to see the performance. The descriptions of all the design parameters that are useful in WMNs are as follows.

• Delay
• Throughput

- Delay (End to End Delay):

Time taken by a bit of data in a network to flow from one to another node is known as delay or end to end delay. The unit of delay is second. In different kinds of networks delay is a major concern, every network has some kind of delay in it, but it is always practiced to reduce the delay in a network as low as possible. Delay in a network is a mixture of several kinds of delays which are Processing Delay (PDe), Queuing Delay (QD), Transmission Delay (TD) and Propagation Delay (PD). The end to end network delay does not include the queuing delay as network delay has no concern with it and mathematically it is written as follows:

$d_{end\text{-}end} = N [ d_{trans} + d_{prop} + d_{proc} ]$

Where

$d_{end\text{-}end}$ = end to end delay

$d_{trans}$= transmission delay

$d_{prop}$= propagation delay

$d_{proc}$= processing delay

- Throughput :

The rate at which the data is transferred from one node to another node in a communication network is known as throughput. The unit of throughput is bits/sec. Throughput is usually referred with a symbol λ. It is acceptable if all the nodes in a network send data at a rate of $\lambda > 0$ bits/sec to the destination node.

# Simulation Environment Used:

Simulation environment used in this report is OPNET. It stands for Optimized Network Evaluation Tool. It is a very sophisticated tool and gives very user friendly Graphical User Interface (GUI). It is used especially for network simulations which includes the research and development of the networks. OPNET is among the leading simulators these days. Most of the other networking tools do not have so much vast library like this OPNET has. In this tool we can have a deep understanding of routing protocols, network devices and network scenarios in a very efficient manner. The good thing about OPNET is that it has the ability to simulate each and every happening of a system.

- Division of Simulation Work

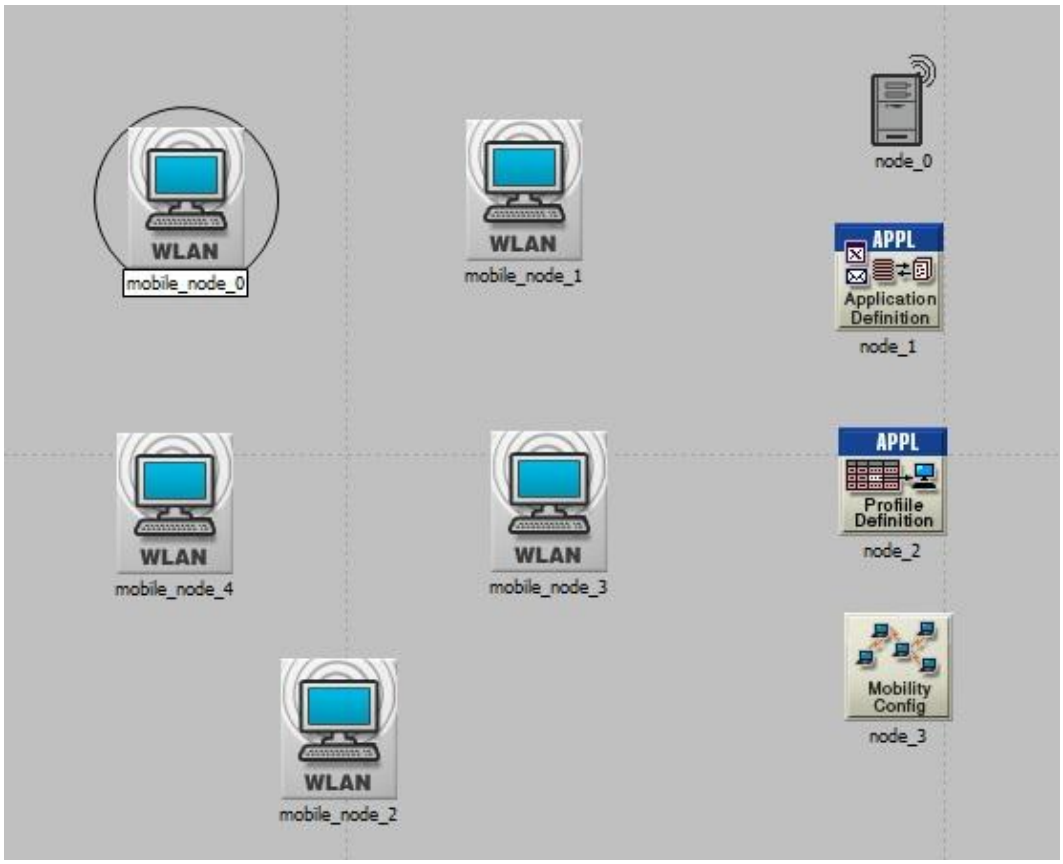
While we carried out in a simulation tool like OPNET, we divided the whole work into two levels ( as we use the free academic version of Opnet with restrictions to only use 20 nodes maximum). The two levels are

• Highest Level (20 nodes)
• Low Level (5 nodes)

# First Scenario:

We made first scenario in which we used 5 mobile nodes from the object palette window of OPNET and pasted all of them in the workspace window. For these 5 mobiles there had to be one server, so we took one fixed wlan_server from the object palette. These nodes were being pasted in the campus network size of 1000 x 1000 meters. Once all the mobile nodes and fixed node server have been pasted on a workspace window, IPv4 addressing was assigned automatically to all nodes. After this we drag application configuration and profile configuration from object palette to workspace window. All the attributes of these two configuration contain mostly the number of rows, speed in meters/seconds and pause time in seconds. So these settings must be done according to the requirement. The FTP was selected as traffic and FTP was set to High Load FTP traffic. After doing all the configurations to a network now it's time to deploy the configured profile which can be done by clicking Protocol tab in OPNET workspace window and selecting the Deploy Defined Application. Mobility Configuration was also dragged into workspace window, all its necessary attributes had been set and then random mobility was set to MANET as a profile. Before running simulation, individual statistics had been selected from where we can choose protocols and wireless LAN etc.

## AODV, DSR and OLSR Protocols with 5 mobile nodes:




AODV, DSR and OLSR Scenario with 5 mobile nodes.

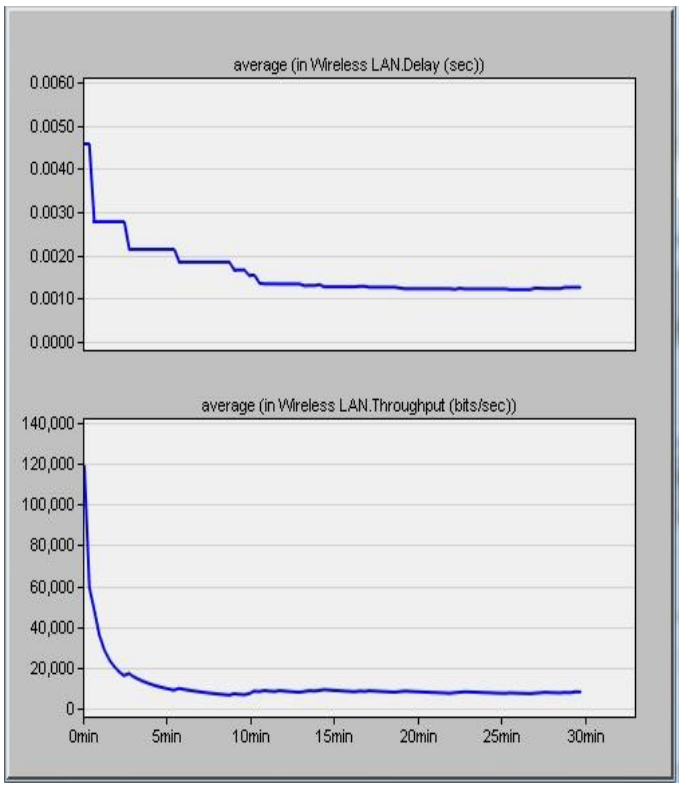
# Second Scenario:

Similarly we made our second scenario in which have increased the number of mobile nodes from 20. This scenario was made by clicking scenario → new scenario option when all the necessary steps of scenario 1 have been completed. All the settings in this scenario remained same like it had in the first scenario, only the number of nodes was increased. In this scenario also, the protocols are tested against the three parameters.

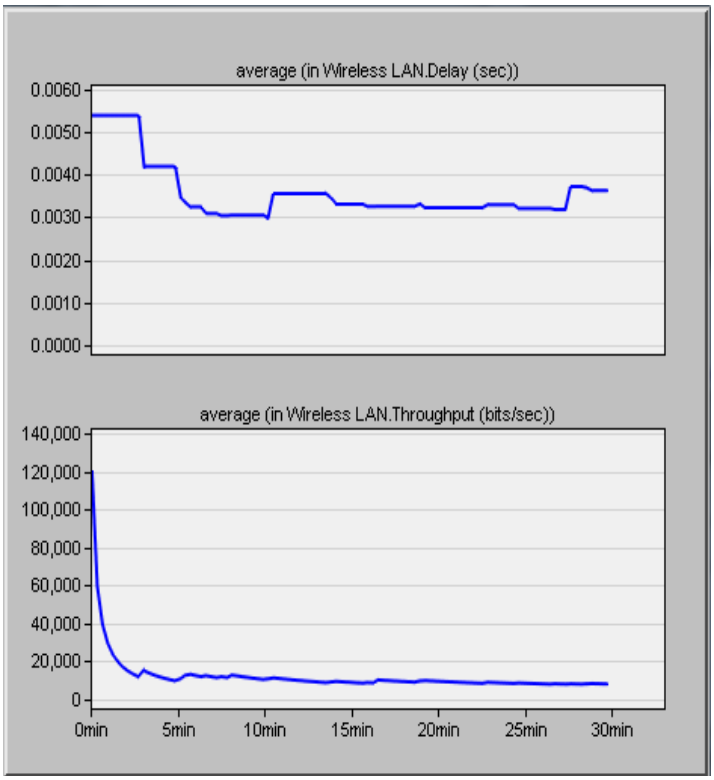
## AODV, DSR and OLSR Scenario with 20 mobile nodes:


AODV, DSR and OLSR Scenario with 20 mobile nodes

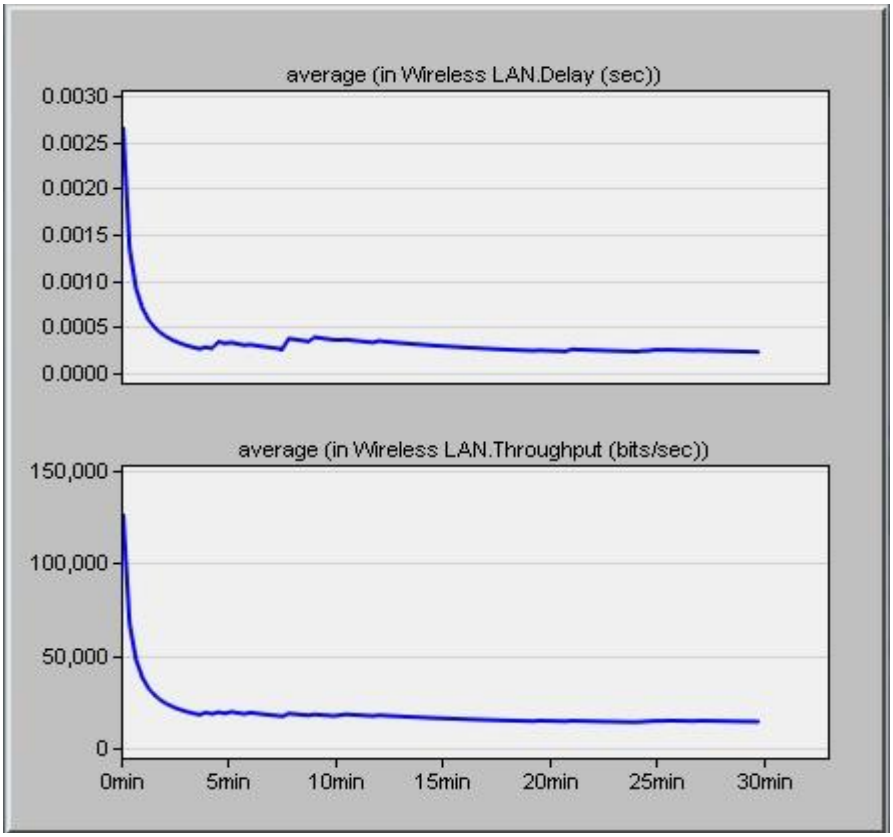
# Simulation Results with 5 Nodes ( AODV, DSR, OLSR):




Delay and throughput AODV 5 nodes

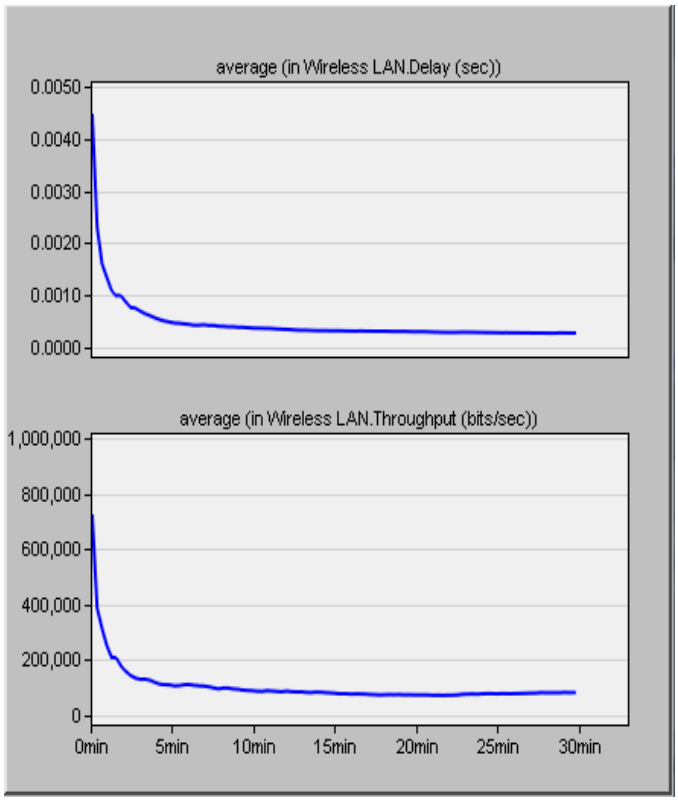



Delay and throughput DSR 5 nodes

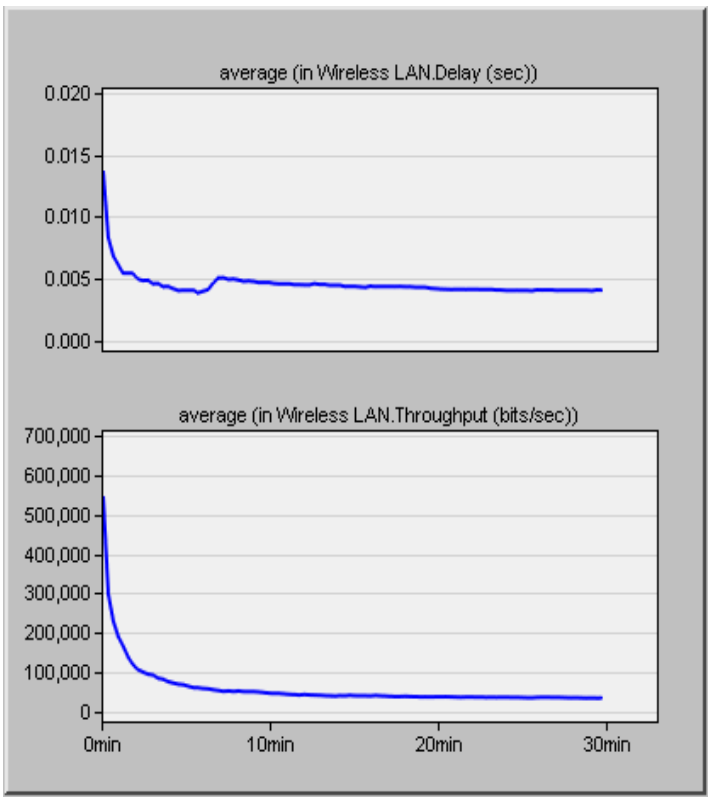



Delay and throughput OLSR 5 nodes

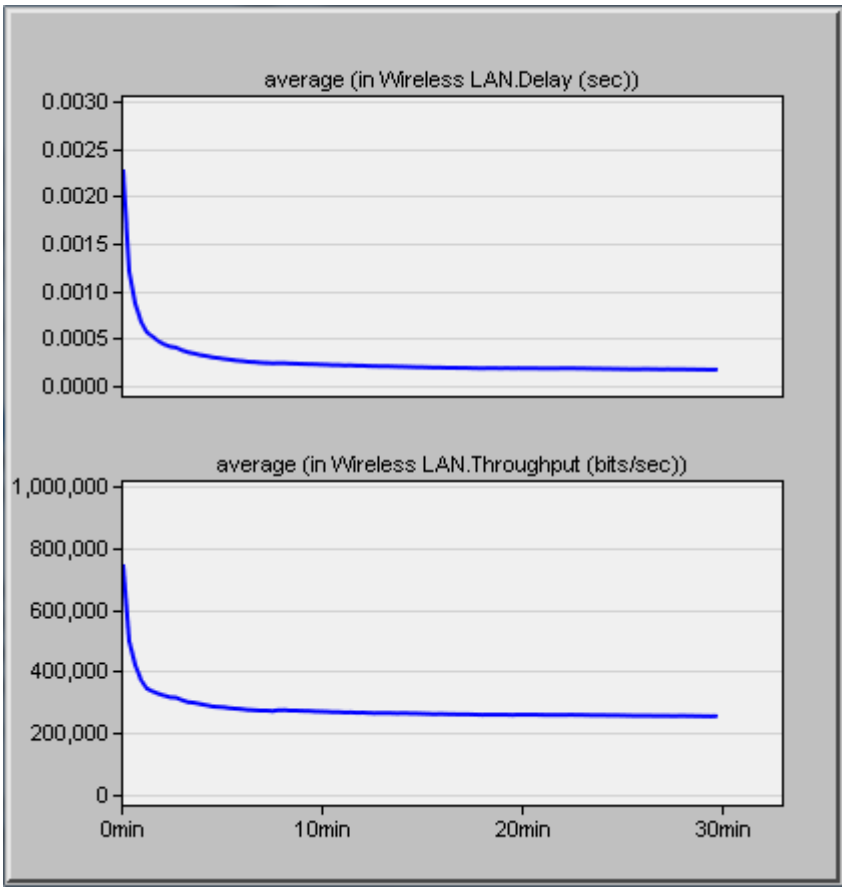
# Simulation Results with 20 Nodes ( AODV, DSR, OLSR):




Delay and throughput AODV 20 nodes



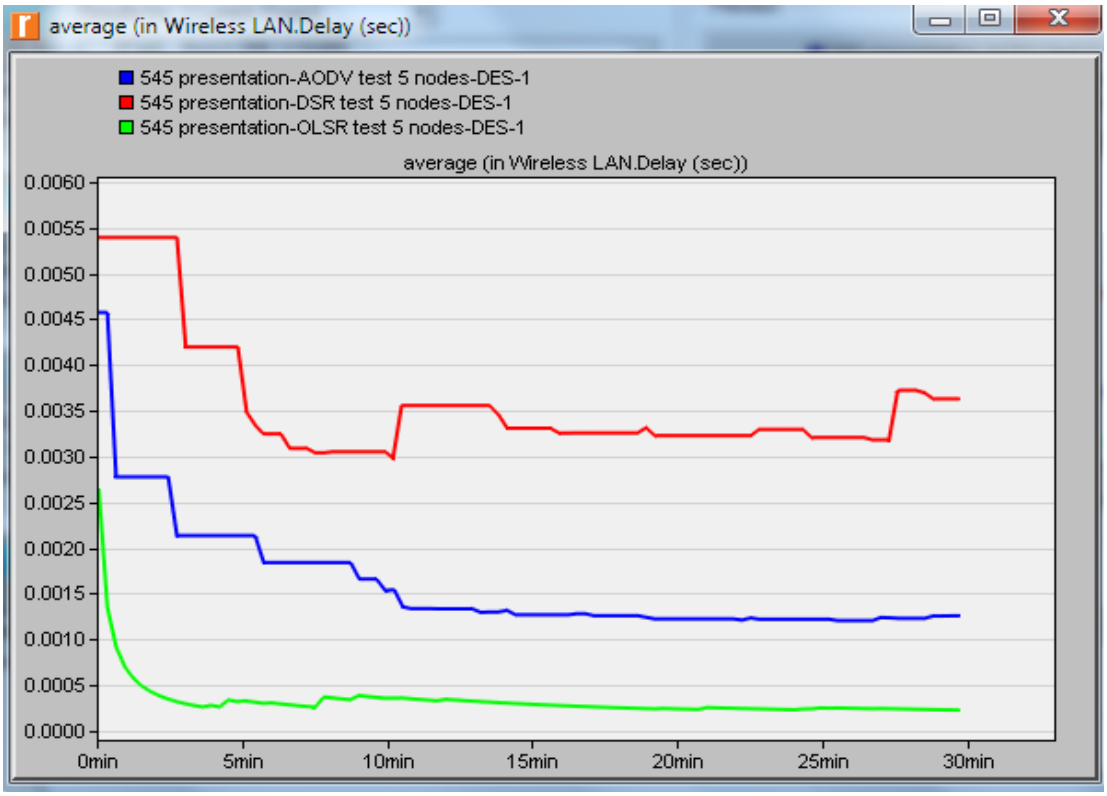

Delay and throughput DSR 20 nodes



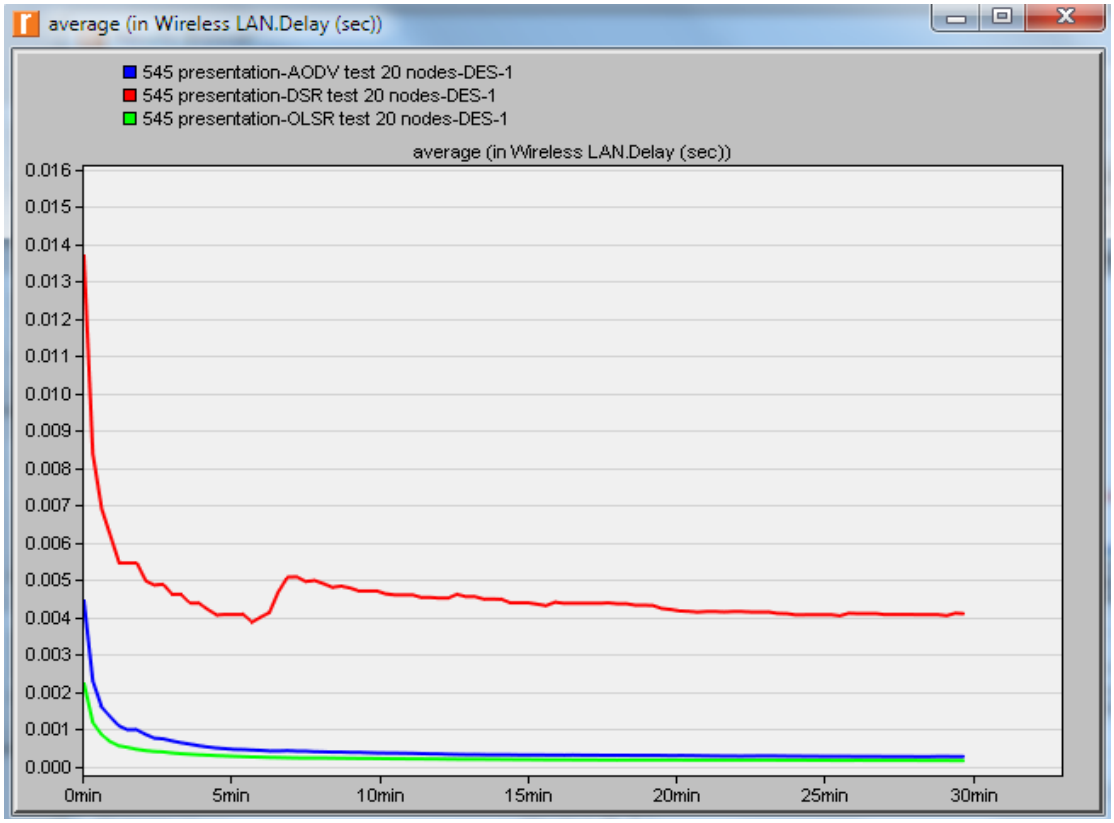

Delay and throughput OLSR 20 nodes

# Comparison & Statistical information:

Delay when we used 5 nodes (AODV, DSR, OLSR).

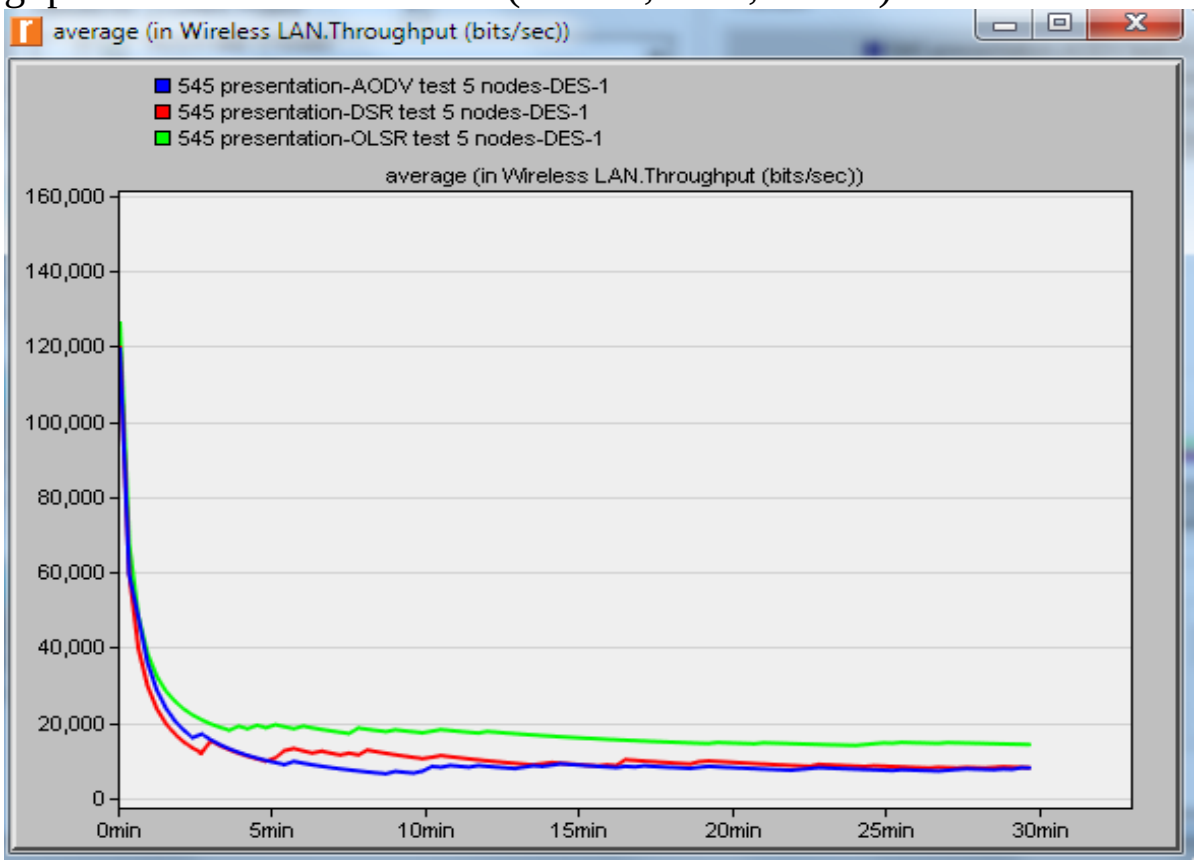



Delay with we use 5 nodes ( AODV, DSR, OLSR)

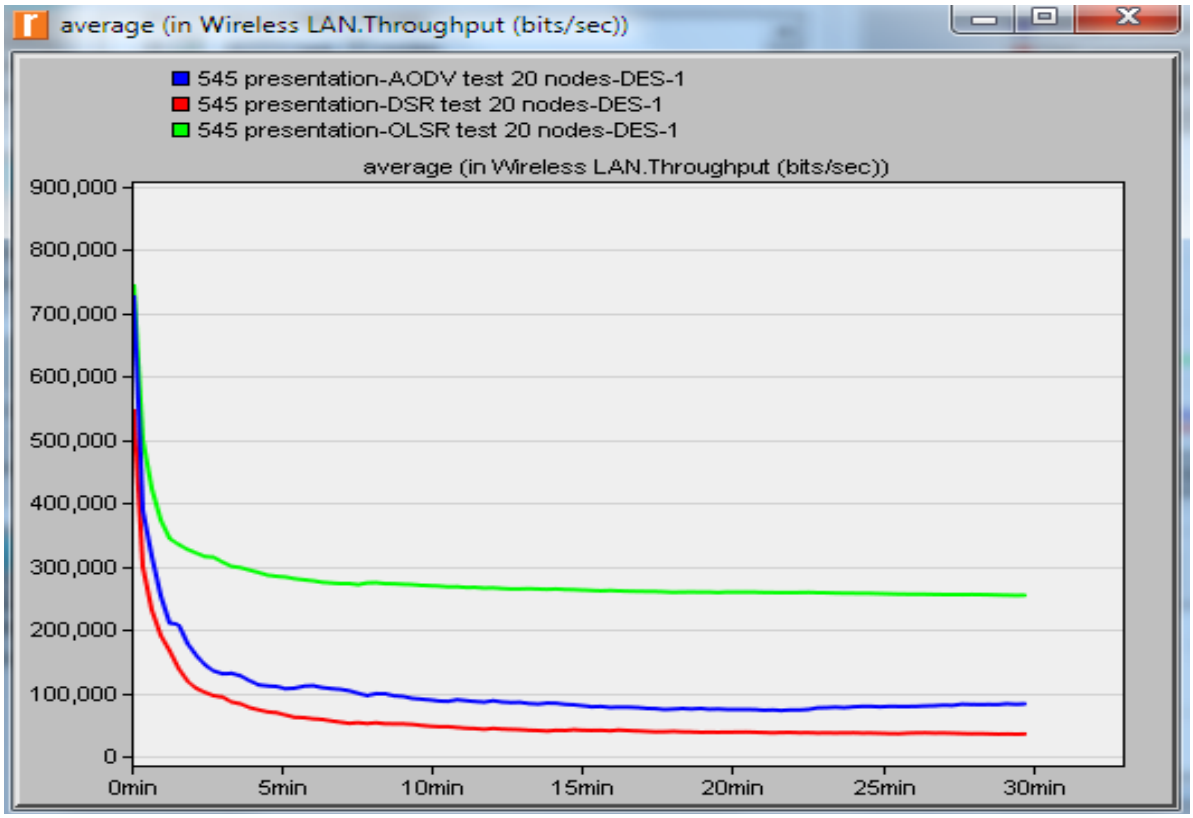



Delay with we use 20 nodes ( AODV, DSR, OLSR)

Throughput when we used 5 nodes (AODV, DSR, OLSR):




Throughput with we use 5 nodes ( AODV, DSR, OLSR)




Throughput with we use 20 nodes ( AODV, DSR, OLSR)

# Conclusion:

## Delay for 5 and 20 nodes ( AODV, DSR, OLSR):

The simulation study of this report reveals that, Optimized Link State Routing (OLSR) protocol works better than Ad-hoc on-demand Vector (AODV) and Dynamic Source Routing (DSR) protocols regarding end to end delay when we used 5 and 20 nodes for each protocol.

## Throughput for 5 and 20 nodes ( AODV, DSR, OLSR):

Once again Optimized Link State Routing (OLSR) protocol works better than Ad-hoc on-demand Vector (AODV) and Dynamic Source Routing (DSR) protocols regarding throughput when we used 5 and 20 nodes for each protocol.

So on the basis of above simulations we can clearly see that the OLSR is outperforming protocol in our case. Two out of three routing protocols are reactive (AODV and DSR) while OLSR is proactive protocol. The traffic we used in our simulation was FTP. Traffic is distributed to all nodes in each scenario in equal amount. From our simulation we can conclude that DSR is a very slow routing protocol as it has taken lot of time while simulating each scenario (5 and 20), OLSR does not take so much time. The feature of OLSR pace is its less delay due to its pre determined route quality, it can process data from node to node without taking much time. On the other hand DSR has large delay, which means it takes so much time in processing the data from one node to another. Throughput is the rate at which data is processed from node to node which has a great importance in any network, so that routing protocol is always needed which gives best throughput and in our simulation OLSR is providing best throughput.

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