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PERFORMANCE-ORIENTED COMPARATIVE ANALYSIS OF MOBILITY-BASED ROUTING PROTOCOLS IN FANET, MANET, AND VANET AD HOC NETWORKS USING OPNET MODELER FOR FTP AND WEB APPLICATIONS

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Abstract

In FANET (Flying ad-hoc network), VANET (Vehicular ad-hoc network), MANET (Mobile Ad-hoc Network), the phenomena routing happens without the support of infrastructure. To accomplish these tasks, the nodes used to act as both router and the host. The design of routing protocol is very complex and challenging, because of the unpredictable varying topologies in these ad-hoc networks. In this paper the performance of the three ad-hoc networks are analysed in terms of its response from the network parameters such as delay, throughput, media access delay, load, retransmission attempts network loads and throughputs. The simulation is carried out in riverbed modeler academic edition 17.5. In this paper, based on simulation results, the routing protocols are categorized in terms of performance for the network parameters. Also the performance of routing protocols is analysed based on its individual performance on the network parameters.

Keywords—FANETs; VANETs; MANETs; UAVs; Drones; Routing-DSR, AODV, OLSR, GRP, TORA

1 Introduction

In the past few decades the development of adhoc network systems has taken a wide role in the field of communication. This leads to the advancement in mobile adhoc networks, vehicular adhoc networks and flying adhoc networks. Also for the past couple of years, accessing and communicating became important challenge among the nodes of adhoc network. This provides a platform for the high demand for wireless communication technologies which can enable data communication services between air and ground links. The components or vehicles should be integrated with it to execute certain applications or missions. For this it is essential that the nodes in those adhoc networks should have good coordination among each other under the guidance of protocols. The routing protocols plays vital role in the applications or missions to be accomplished. [1]

In the adhoc networks the mobile host[MANET], vehicles[VANET] and unmanned aerial vehicles[FANET] communicate and coordinate each other with many challenges. Because based

on the architecture and protocol the individual node must as act as relay to transfer the packets from source to destination. The main objective of this paper is to help the developers of MANET, VANET and FANET to effectively select the topology based routing protocols to implement the communications among various nodes in the adhoc networks. To do this, it is required to compare the routing protocols performance. It is very much important to consider the mobility of nodes which are highly dynamic and random in nature also they can take any direction without centralized control which is infrastructure less network. In this paper to analyse and to compare the performance of adhoc networks, five different protocols from the topology based approach are considered and simulated in OPNET and analysed. [2]

This paper is organized as follow: Section II characterizes the Related works; Section III characterizes the Methodology with the Challenges in the Selection and Deployment of Routing Protocol and the types of protocols; Section IV presents the Simulations; Section V points out Results; Section VI Finalizes with several conclusions Section VII gives References and Section VIII gives Biography. After discussing network architecture, various Topology based routing techniques, and taxonomy of routing protocols in adhoc networks, the routing protocols qualitatively compared in terms of their performance.

2 Related works

The Mobile ad-hoc network consists of autonomous wireless devices with self-configuring characteristics without any centralised infrastructure. MANET devices are free to move independently. The network can be set at any place and at any time. The nodes are small and light equipment. This network is self-configuring. [3] vehicular ad-hoc network and flying ad-hoc network are the sub categories of MANET. The mobility change is very high in FANET and VANET than MANET [4]. In VANET, vehicle to vehicle as well as vehicle to the pre-installed infra structure communication is established. VANET supports multi hop communication for vehicles out of range. On board unit is a device which is responsible to collect and process data from various sensors moreover it is also responsible to communicate with other vehicles and infrastructure. Road side unit is an infra structure for the communication between the cars. [5]

FANET stands for flying ad-hoc network. Networks which operate in a flying object are called as FANET. The FANET network is highly dynamic fast changing. They could be created in terms of helicopters, planes, drones or UAV's. But now drones are much popular. Many drones can be communicated and coordinated together. There are two types of popular topology as like star [easily deployable] and mesh [attractive]. Lack of suitable algorithm for data routing is the major issue to be addressed in this network. FANET supports the flying unmanned aerial vehicle or drone to exhibit real time communication and to achieve their targets with the support controlling station. Crisis, natural disaster, military combat zones, and package delivery are few areas where flying drones / UAV's dominates as applications [6]

Each UAV should know the position of others to avoid collision. The UAV's can communicate with others, based on Intra plane, ground station, ground server and VANET

techniques. A network of UAV performs operations beyond the country for disaster through their cameras. They talk each other and send signal to ground station. Ground networks may be stationary or VANET or Control stations [7]. A satellite or ground base station is used for communication. Communication link is established between the UAV and infrastructure. Designing of system composed of more UAV's becomes complicated. The communication is done by few UAV linked to ground station and others with its colleague [8].

The above limitations are overcome by a Multi UAV system by configuring a FANET network. All UAV will constitute adhoc communication whereas a subset of UAV will be connected with the ground station / Satellite. The synchronization and relationship of FANET is very important in FANET [9]. Includes UAV + person who controls the system, Star topology is used by the Multi UAV system to get connected with base station. UAV's which are nearby ground can correspond with base station, others with space station. Higher range of communication is highly mandatory as in the case of FANET than MANET and VANET. The flying ad-hoc network is a special form of MANET. It doesn't mean that all Multi UAV systems are called as FANET unless it satisfies ad-hoc network. Among the Ad-hoc networks. The following are the most important communication architectures of FANET.In unmanned Air vehicle Adhoc network, the Backbone UAV acts as an Intermediater between other UAV's in the network and groundstation. The speed and the direction of the available UAV's must be similar in this network to get connected with the ground station through back bone UAV [10]. In **Multi**-Group UAV Ad hoc network two backbone UAV's are responsible for the intra as well as inter group communication in associated with the ground station. This is more suitable for the cases where huge numbers of UAV's are involved for some specific missions [12].

In multi-layer UAV the lower layer is utilized for communication between the UAVs and the upper layer is utilized for communication between the spine UAVs of all the connected bunches and the ground station [13].

3. Methodology

The challenges in the selection and deployment of routing protocol are as follows,

- The requirement of protocol must be adaptive.
- Large area must be covered;
- It should also have multicasting facility.
- Reconfigurable for the varying mission based on the application.

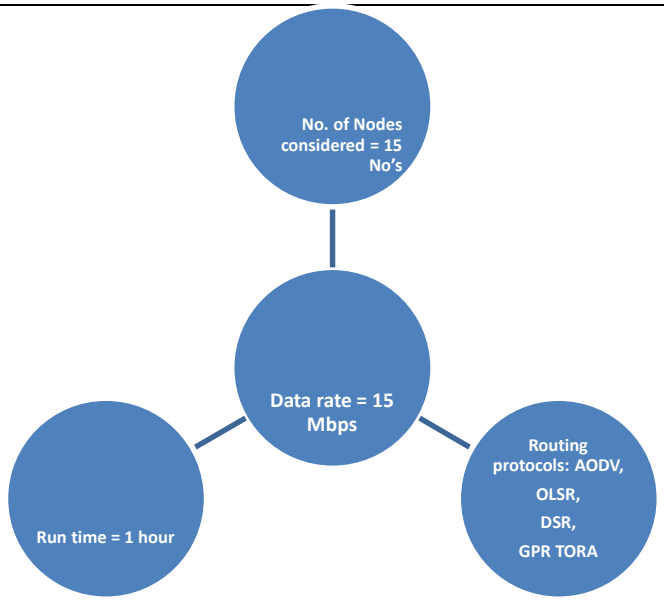
The Key issues during the selection of Routing Protocols are follows,

- The relative position of nodes keeps changing
- Network is not only moving, but nodes also moving

- Possibility of malfunctioning at the network
- The intermittent link may also change based on constraints
- Frequent link breakage
- Prone to malfunctioning
- High power requirements
- Very complex
- Physically prone to environmental effects wind and rain.
- Routing
- Path Planning
- Quality of service [13]

In this paper in order to do the comparison among the performance of routing protocols in the ad-hoc networks viz…. MANET, VANET and FANET, OPNET modeller is used as a simulator. The following list out the features of OPNET [14],

- Optimized Network Engineering Tools
- Network simulation tool
- Friendly graphical user interface (GUI)
- Animation
- Provides Hundreds of protocol
- Object-oriented modeling
- Hierarchical modeling environment
- Integrated GUI debugging and analysis tool
- Highly efficient simulation engine [15].



Identification of actual problem, modelling the network based on the identification, perform the process simulation and finalizing the results are the approaches of OPNET simulator, based on the actual problem identified modelling of the network is done. The next step is the process

Figure 1: Parameters generalized for 3 Networks	of simulation and finally the result computation. File transfer protocol(FTP) and web are the two parameters considered for the purpose of simulation. For the parameter FTP load is managed in the same way for HTTP, heavy browsing is considered [11] and the parameters are shown in figure 1.

Following characteristics maintained same for both FTP & Web applications, Operation mode is set as serial(Ordered), Start time as Constant (100), Duration(seconds) as End of simulation, File transfer protocol and web are the two parameters considered. In FTP, the load is maintained at medium for 3 adhoc networks in the same way for HTTP heavy browsing is taken. The following Figure 3. illustrates the screen shot for the configuration of the most important parameter mobility. Speed (m/s)– Constant (50),Pause time (seconds) – Constant (0),Start time (seconds) – Constant (15),Stop time (seconds) – End of simulation.4.Simulation and results

Based on the identified problem, the three ad-hoc networks are modelled and simulated for one hour. Figure 2 set shows screen shot for the configuration of multi UAV's in OPNET modeler. As discussed in the previous section, the total number of UAVs and the configuration of application, profile and mobility parameters are considered and deployed. It's quite important to deploy the application based on the assumption made in the application and profile configurations.

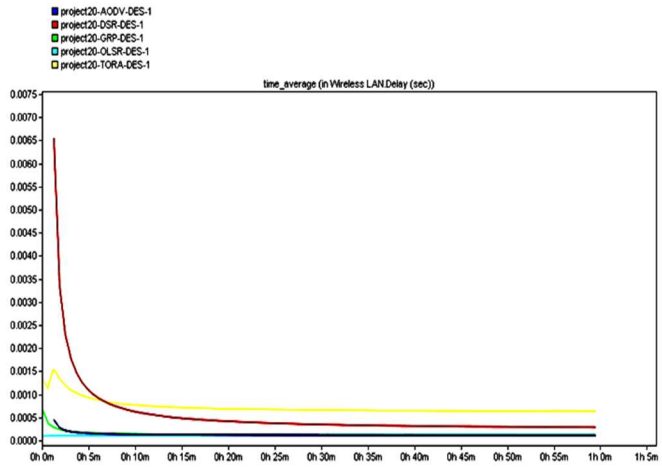


Figure 3: Delay in FANET

In Figure 3, the simulation screen shot of the parameter delay in FANET is presented. Delay is defined as the latency consumed by the packets to reach destination from the source.Based on the simulation,OLSR addresses the minimum delay among others. Temporally ordered routing algorithm holds maximum delays (approximately related to the saturation level) in the routing terminology.AODV GRP also performs well as like OLSR.

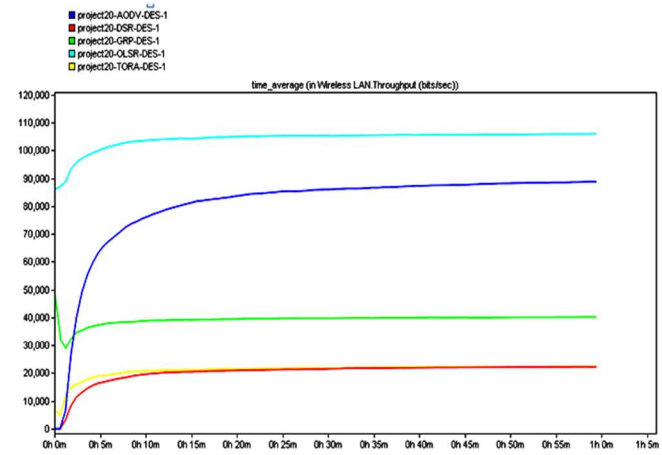


Figure 4: Throughput in FANET

Figure 4 shows the simulation screen shot of the parameter Throughput in FANET.In data transmission, network throughput is the amount of data moved successfully from one place to another in a given time period. As per the simulation result, OLSR shows the best performance with approximately 100000 bits/sec. Though the AODV starts near to 100 bits/sec but slowly it reaches the saturation level around 80000 bits/sec (approximately). TORA maintains the level around 20000 bits/sec(approx.).

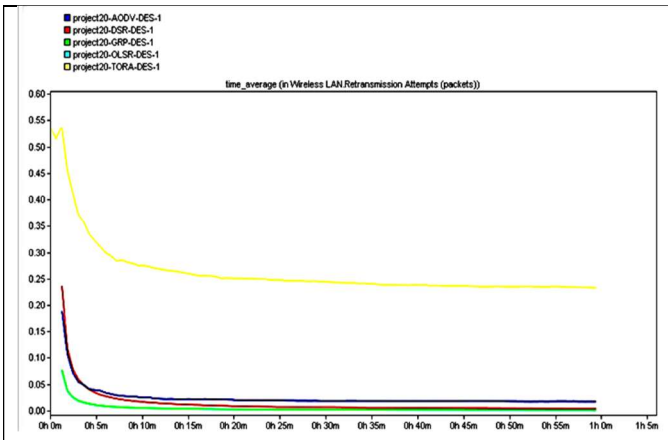


Figure 5: Retransmission attempt in FANET

Figure 5 illustrates the simulation screen shot of the parameter Retransmission attempts in FANET. Retransmission attempt is one of the basic mechanisms used by protocols operating over a packet switched computer network to provide reliable communication. Based on the simulation GRP finds its first position as best and the routing protocol TORA the least. All the other routing protocols find their positions in between the best and least.

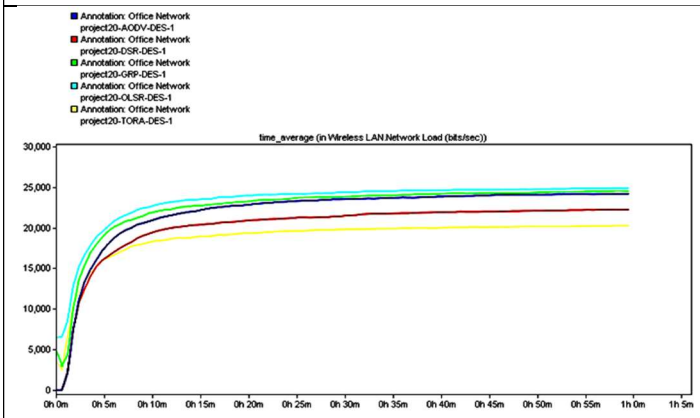


Figure 6: Network Load (bits/sec) in FANET

Figure 6 presents the simulation screen shot of the parameter Network Load in FANET. This is the amount of data (traffic) being carried by the network. The routing protocol OLSR perfoms well and carries approximately 25000 bits/sec. TORA holds the least position by showing the traffic load as approximately 18000 bits/sec,all the other protocols finds their respective positions in between.

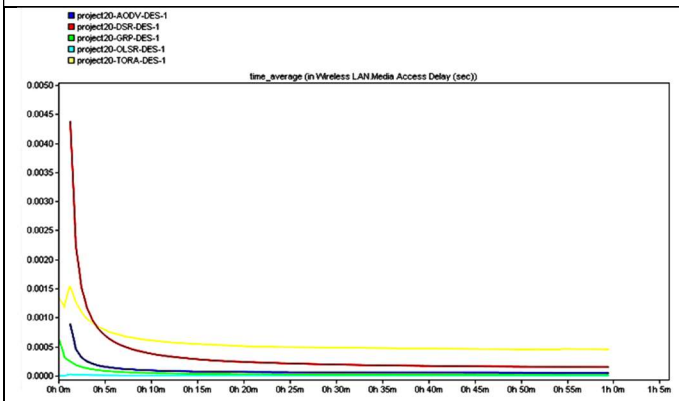


Figure 7: Media access Delay in FANET

Figure 7 clarifies the simulation screen shot of the parameter Media access delay in FANET. This is the time taken from when the data reaches the MAC layer until it is successfully transmitted out on the wireless medium. Based on the simulation,OLSR and DSR and even AODV addresses the minimum delay among others.Temporally ordered routing algorithm holds maximum delays in the routing terminology.

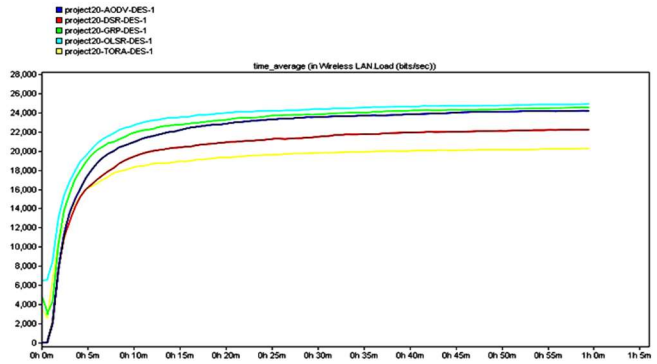


Figure 8: Load (bits/sec) in FANET

Figure 8 presents the simulation screen shot of the parameter Load (bits/sec) in FANET. It refers to the traffic carried out by the network.The routing protocol OLSR perfoms well and carries approximately 24000 bits/sec. GPR holds the second position by showing the traffic load as 23000 bits/sec and TORA the least around 18000 bits per sec.

Figure 9 illustrates the screen shot for the configuration of modern vehicles in OPNET modeler. As discussed earlier, the total number of modern vehicles and the configurations for application, profile and mobility parameters are deployed as per the requirement considered for FANET.

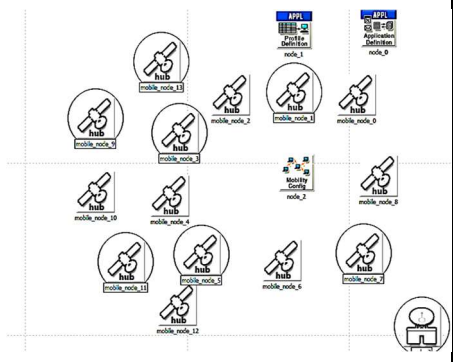


Figure 2: Configuration of UAV in OPNET

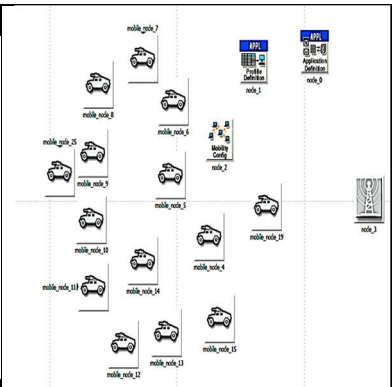


Figure 9: VANET configuration in OPNET

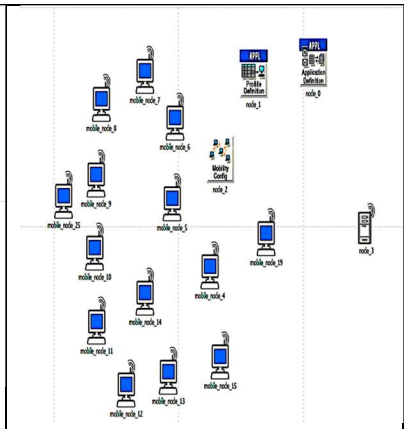


Figure 16: MANET configuration in OPNET

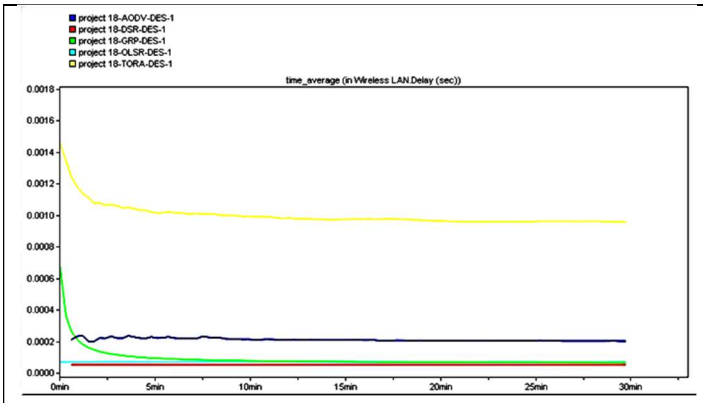


Figure 10: Delay in VANET

Figure 10 illustrates the simulation screen shot of the parameter Delay in VANET. This is defined as the latency consumed by the packets to reach destination from the source.Based on the simulation,Dynamic source routing ,GRP and OLSR addresses the minimum delay among others. Temporally ordered routing algorithm holds maximum delays as .0010 seconds in the routing terminology. Though GRP starts at 0.0006 second but after 2.5 minutes,the performance reaches it stability level at .001sec.AODV holds .002 sec delay.

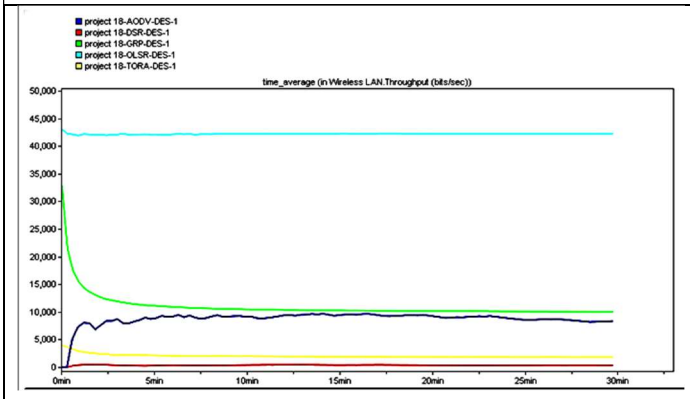


Figure 11: Throughput in VANET

Figure 11 presents the simulation screen shot of the parameter Throughput in VANET.As per the simulation result, OLSR shows the best performance with 43000 bits/sec, Though the routing protocol GRP starts at 12000 bits/sec but slowly it reaches the saturation level around 14000 bits/sec (approximately). AODV maintains the level around 10000 bits/sec (approx.). Also TORA maintains 2500 bits/sec. DSR holds the least throughput value and it maintains the throughput value of 100 bits/sec.

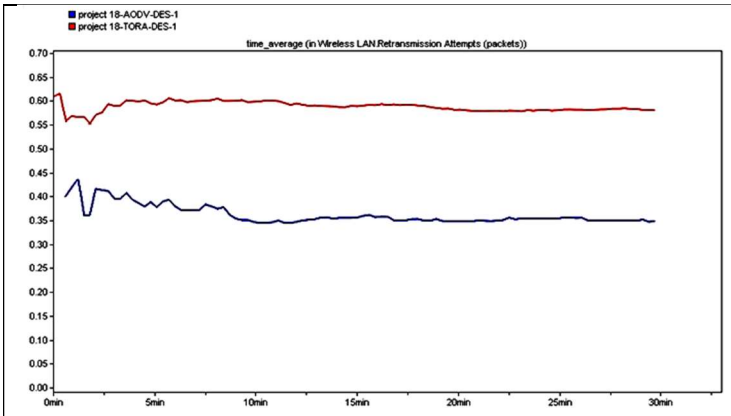


Figure 12: Retransmission Packet in VANET

Figure 12 explains the simulation screen shot of the parameter Retransmission Packet in VANET Retransmission attempt is one of the basic mechanisms used by protocols operating over a packet switched computer **network** to provide reliable communication. Based on the simulation AODV finds its first position as best and the routing protocol TORA the next.

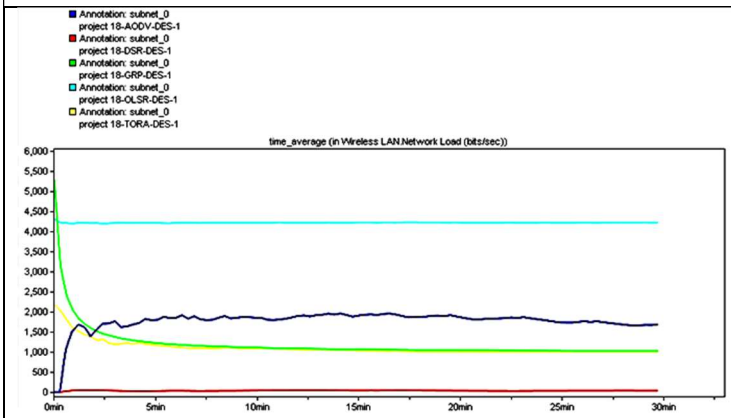


Figure 13: Network load (bits/sec) in VANET

Figure 13 presents the simulation screen shot of the parameter Network load (bits/sec) in VANET: The routing protocol OLSR perfoms well and carries approximately 4250 bits/sec.Though GRP starts at 5000 bits/sec,it could reach its saturation level around 1250 bits/sec.AODV starts around 100 bits/sce but after 2 min its shows a performance of managing approximately 1500 bits/sec.TORA maintains 1400 bits/sec. and DES perfoms least as zero.

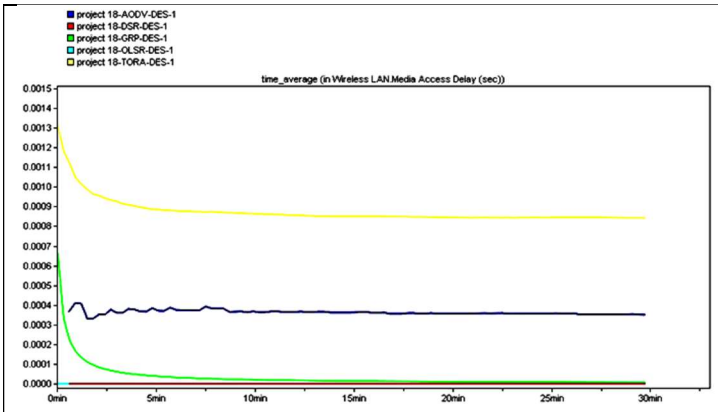


Figure 14: Media access delay in VANET

Figure 14 shows the simulation screen shot of the parameter Media access delay in VANET: Based on the simulation,OLSR and DRS addresses the minimum delay among others.Temporally ordered routing algorithm holds maximum delays in the routing terminology. GRP and AODV holds the positions after DSR.

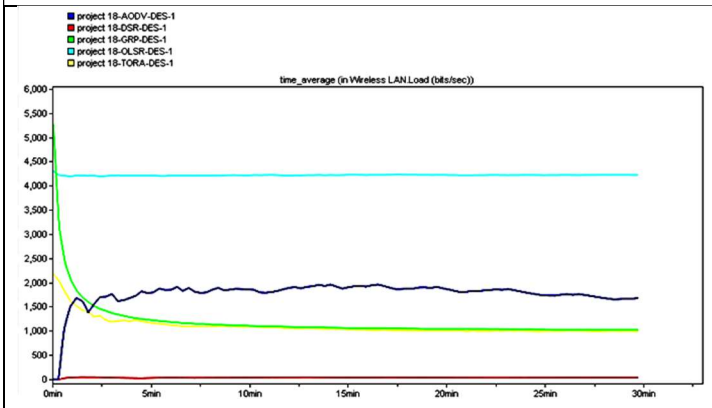


Figure 15: Load (bits/sec) in VANET

In Figure 15 the simulation screen shot of the parameter Load (bits/sec) in VANET is seen. The routing protocol OLSR perfoms well and carries approximately 4250 bits/sec. TORA shows the traffic load as 1000 bits/sec,GRP as 1250 bits/sec,AODV approximately 2000 bits/sec and DES perfoms least as zero.

Figure 16 set up the screen shot for the configuration of modern mobiles in OPNET modeler. As discussed earlier, the total number of mobile units and the configurations for application, profile and Mobility parameters are deployed as per the requirement considered for FANET and VANET.

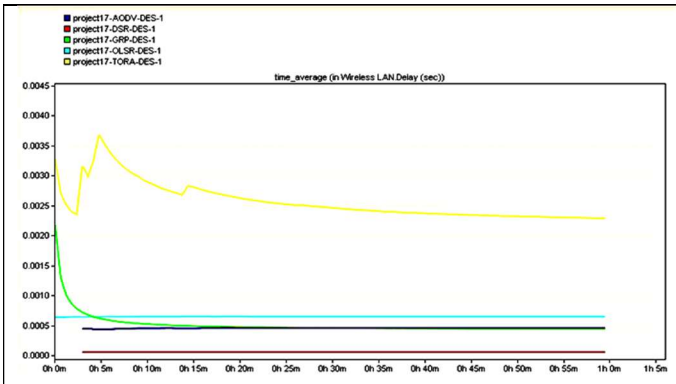


Figure 17: Delay in MANET

Figure 17 clarifies the simulation screen shot of the parameter Delay in MANET.Based on the simulation,Dynamic source routing addresses the minimum delay among others.Temporally ordered routing algorithm holds maximum delays as .0030 seconds in the routing terminology.AODV,OLSR and GRP holds the positions after DSR.

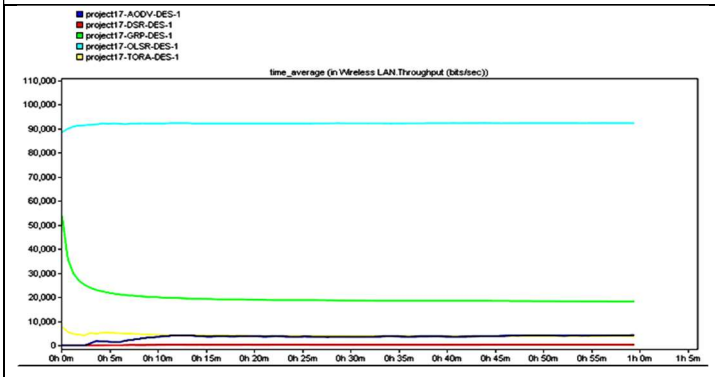


Figure 18: Throughput in MANET

Figure 18 presents the simulation screen shot of the parameter Throughput in MANET. As per the simulation result, OLSR shows the best performance with 90000 bits/sec, Though the routing protocol GRP starts at 50000 bits/sec but slowly it reaches the saturation level around 20000 bits/sec (approximately).TORA maintains the level around 9000 bits/sec (approx.). Also AODV starts their throughput value around 100 bits/sec, but after 5min it slightly increases and reaches 5000 bits/sec. DSR holds the least throughput value and it maintains the throughput value of 100 bits/sec.

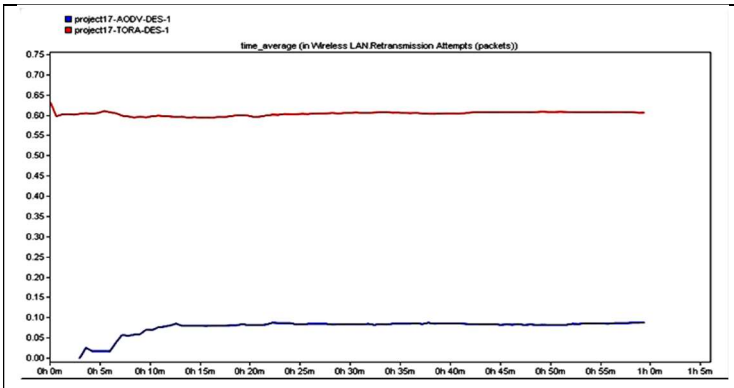


Figure 19: Retransmission Packet in MANET

Figure 19 shows the simulation screen shot of the parameter Retransmission Packet in MANET. Based on the simulation AODV finds its first position as best and the routing protocol TORA the next.

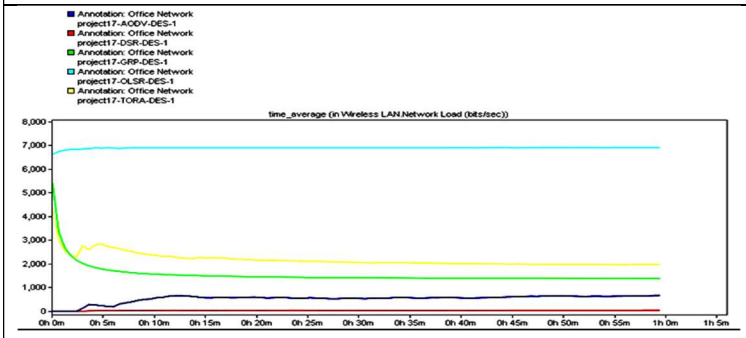


Figure 20 : Network load (bits/sec) in MANET

Figure 20 depicts the simulation screen shot of the parameter Network load (bits/sec) in MANET. The routing protocol OLSR perfoms well and carries approximately 4250 bits/sec. TORA holds the second position by showing the traffic load as 2800 bits/sec,GRP by 2000 bits/sec,AODV approximately 1000 bits/sec and DES perfoms least as with its load around 100 bits/sec

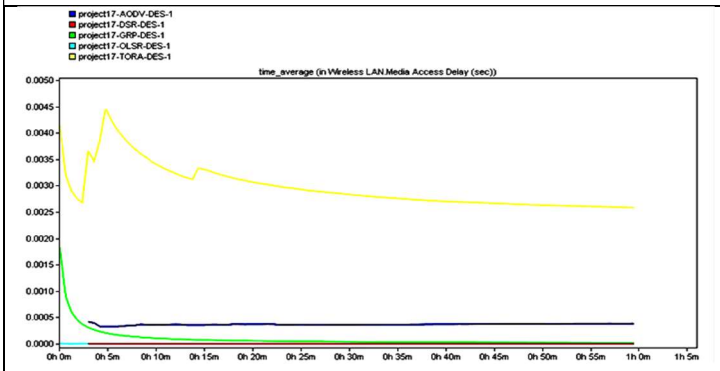
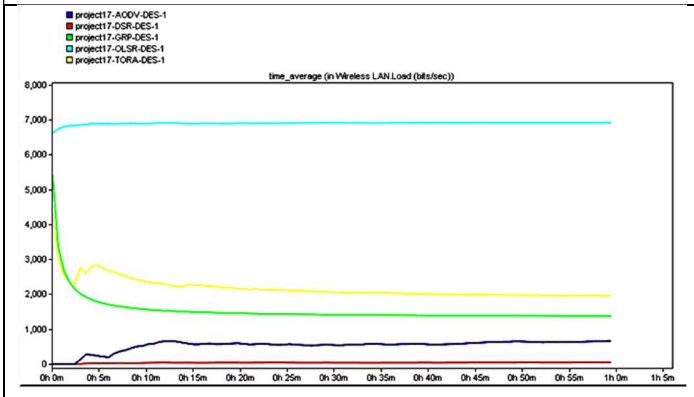


Figure 21: Media access Delay in MANET

Figure 21 describes the simulation screen shot of the parameter Network load (bits/sec) in MANET: Based on the simulation,OLSR and DRS addresses the minimum delay among others.Temporally ordered routing algorithm holds maximum delays in the routing terminology.

	GRP and AODV holds the positions after DSR
 **Figure 22: Load (bits/sec) in MANET**	Figure 22 records the simulation screen shot of the parameter load (bits/sec) in MANET. The routing protocol OLSR perfoms well and carries approximately 6900 bits/sec. TORA holds the second position by showing the traffic load as 2500 bits/sec,GRP by 1800 bits/sec,AODV approximately 1000 bits/sec and DES perfoms least as with its load around 100 bits/sec.

The following table 1,table2 and table 3 clearly mention about the Best and least performed routing protocol for the various Network parameters in MANET,VANET and FANET.

Table 1: Routing Protocols Results in MANET Network

Network Parameters	Best Performed Routing Protocol	Least Performed Routing Protocol
Delay	DSR	TORA
Load	OLSR	DSR
Throughput	OLSR	DSR
Media Access delay	OLSR	TORA
Network load	OLSR	DSR

Table 3: Routing Protocols Results in FANET Network

Network Parameters	Best Performed Routing Protocol	Least Performed Routing Protocol
Delay	OLSR	DSR
Load	OLSR	TORA
Throughput	OLSR	DSR
Media Access delay	OLSR	DSR
Network load	OLSR	DSR

Retransmission attempt	AODV	TORA

Retransmission attempt	GRP	TORA

Table 2: Routing Protocols Results in VANET Network

Network Parameters	Best Performed Routing Protocol	Least Performed Routing Protocol
Delay	DSR	TORA
Load	OLSR	DSR
Throughput	OLSR	DSR
Media Access delay	TORA	DSR
Network load	OLSR	DSR
Retransmission attempt	AODV	TORA

Based on the analysis made, it is found that for the network parameter Delay, the routing protocols simulation results of MANET and VANET is quite similar. Throughput analysis illustrates that, both the best and the worst performed Routing protocols of FANET shows same as like VANET and MANET As per the comparative analysis, It is found that the for the network parameters like Media access delay, Load, Network load and retransmission, the routing protocols OLSR performed well.

6. Conclusion

Based on the analysis of the Table 1, for MANET the routing Protocol OLSR shows good performance in the network parameter such as Load, throughput, media access delay and network load, but for delay and retransmission attempt criteria, DSR and AODV shows its best. The Routing protocol TORA shows least performance in the network parameter such as delay, media Access delay, retransmission attempt and DSR shows worst performance in the parameters load, throughput and network load.

The Table 2 for VANET, routing Protocol OLSR shows good performance in the network parameter such as load, throughput, media access delay and network load however for delay and retransmission attempt criteria, DSR and AODV is the best. The Routing protocol TORA shows least performance in the network parameter such as delay, retransmission attempt and DSR shows worst performance in load, throughput, media Access delay, network load. With respect to the analysis of Table 3, the routing Protocol OLSR shows good performance in the network parameters delay, load, throughput, media access delay and network load, but for retransmission attempt criteria, GRP is the best. The Routing protocol TORA shows least performance in the

network parameter such as load, retransmission attempt and DSR shows worst performance in delay, throughput, media Access delay, network load It is observed in FANET, VANET and MANET simulation, OLSR shows better performance than other routing protocols DSR shows it least performance.

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