DYNAMIC SPECTRUM ACCESS IN VEHICULAR AD-HOC NETWORKS (VANETS)

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Abstract: Vehicular Ad Hoc Network (VANET) is an emerging application of Intelligent Transport System(ITS) with a wide range of safety and non-safety applications. Data communication in VANET is challenging is due to its high mobility , short link lifetime, and frequent network fragmentation. These challenges demand efficient spectrum utilization for ensuring reasonable network performance. The use of Cognitive Radio (CR) can facilitate efficient spectrum utilization by Dynamic Spectrum Access (DSA). It allows the vehicles to use an existing road side network infrastructure without interfering its users.We point out the detailed procedure of evaluating the performance of DSA algorithms in CR-vanets using discrete-event simulation.

Keywords: vanet,dsa,cr-ahn

I. INTRODUCTION

The motivation behind our project is to showcase the use of DSA algorithm in the VANET scenario and prove that DSA incorporated VANET gives us an efficient and thorough output when compared to the case of an existing VANET scenario. In this project we implement the VANET scenario in the NS-2 Simulation Tool. We look forward to improvising on the feature of VANET by incorporating a CR-AHN as an extension tool to NS-2 so as to implement the spectrum sensing technique that previously could not be implemented. We also make use of the MATLAB tool so as to compare the sensing techniques and plot its efficiency.

Initially in this report we give an introduction to what is a CR-VANET i.e a DSA incorporated VANET. In the following chapters we explain about the Simulation tools we have used for our project. Then we move on to the working of this project and the details regarding its implementation. This chapter shows the flow of work of our project. The last part of the report involves the simulation results that were obtained on the completion of the project as well the comparison output.

II. VANET

Vehicle-to-vehicle communication is a very challenging topic in recent years. Vehicles equipped with devices capable of short-range wireless connectivity can form a particular mobile ad-hoc network, called a "Vehicular Ad-hoc Network"(VANET).

The existence of such networks opens the way for a large range of applications. We consider that two of the most important classes of such applications are those related to route planning and traffic safety. Most applications to be deployed on top of a VANET require some sort of data-dissemination model. This is a challenging problem, due to the unique characteristics of a VANET.Such a network has a very high degree of nodes' mobility and a very large scale. Network partitioning occurs frequently,making end to end communication impossible at times.

VANET uses cars as mobile nodes in a MANET to create a mobile network. A VANET turns turn participating car into a wireless router or node which allowing cars 100 to 300 meters of each other to connect and create a network with a wide range. As cars fall out of the signal range and drop out of the network, other cars can join in, connecting vehicles to one another so that a mobile network is created. It is estimated that the first systems that will be this technology are police and fire vehicles to communicate with each other for the purpose of security.

Vehicular Node (VN). Vanet-Vehicular Ad-Hoc Network is the network in which communication has been done between road side units to cars, car to car in a short range of 100 to 300 m. Existing authentication protocols to secure vehicular ad hoc networks raise challenges like as certificate distribution and revocation, avoidance of computation and communication bottlenecks, and reduction of the strong reliance on tamper proof devices. In VANET, vehicles will rely on the integrity of received data for deciding when to present alerts to drivers. This data may be used as the basis of control decisions for autonomous vehicles. If this information is corrupted, vehicles may present unnecessary or erroneous warnings to their drivers, and the results of control decisions based on this information could be even more disastrous.

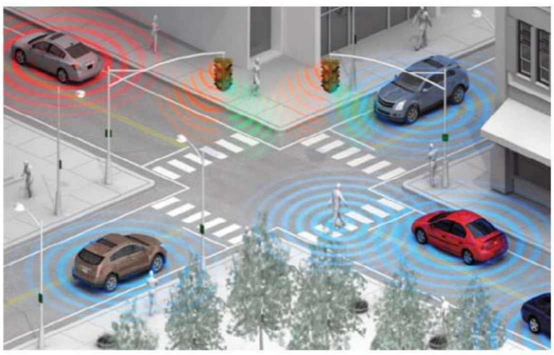

Fig 1. VANET Scenario

III. IMPLEMENTATION DETAILS

3.1VANET Scenario

We consider a roadside infrastructure-based single-radio multi-channel primary network having PUs and moving vehicles along the roads as SUs. These PUs and SUs share a set of orthogonal wireless channels. Thus the roadside Base Stations (BS) provide wireless communication channels to the PUs within its transmission area. The vehicles are only allowed to use the channels that are not being used by any PUs within their transmission range. For simplicity, we consider two entry point for vehicles in our simulation .Thus here, we allow vehicles to enter through the top and bottom horizontal roads (from right to left).

On the other hand, vehicles can leave the simulation area through the exit points.

We start by generating a set of vehicles moving through the roads. Then, at each time epoch, we track each vehicle's position, number of neighbour, neighbouring PUs, etc. Based on these information, we evaluate our simulation parameters.

Throughout their lifetime, each vehicle can communicate with its neighbouring vehicles. In our simulation, for each vehicle, we find out how many neighbouring vehicles are available for communication. We present the average number of neighbouring vehicles, averaged over the lifetime of each vehicles

3.2 Spectrum Sensing Techniques

Spectrum sensing helps to detect the spectrum holes (underutilised bands of the spectrum) providing high spectral resolution capability. Many different methods are proposed to identify the presence of signal transmission and can be used to enhance the detection probability.

3.2.1 Energy Detection Technique

Energy detector is the most popular way of spectrum sensing because of its low computational and implementation complexities. The receivers do not need any knowledge about the primary users. An energy detector (ED) simply treats the primary signal as noise and decides on the presence or absence of the primary signal based on the energy of the observed signal. If the secondary user cannot gather sufficient information about the PU signal, the optimal detector is an energy detector, also called as a radiometer. It is common method for detection of unknown signals. First, the input signal y(t) is filtered with a band pass filter (BPF) in order to limit the noise and to select the bandwidth of interest. The noise in the output of the filter has a bandlimited, flat spectral density. Next, in the figure there is the energy detector consisting of a squaring device and a finite time integrator. Finally, this output signal is compared to the threshold n in order to decide whether a signal is present or not. The threshold is set according to statistical properties of the output when only noise is present.

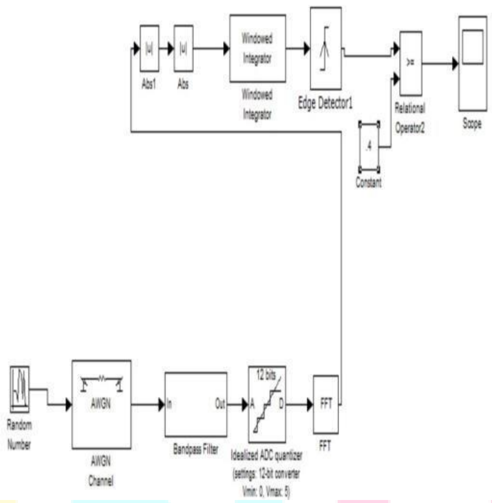

Fig 3. Block Diagram Energy detection

Result

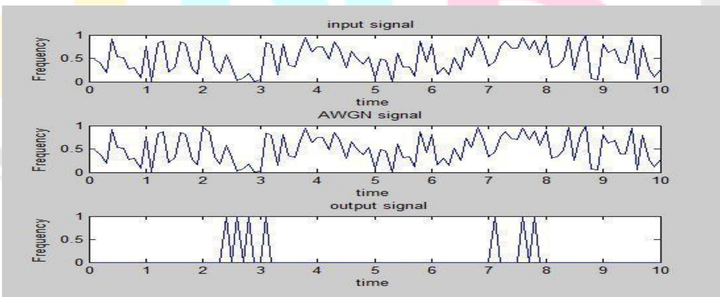

Fig 4. Output Of Energy Detection Technique

3.2.2 Matched Filter Detection Technique

We have some prior knowledge about the primary user's signal such modulationscheme used, signal shape; then a matched filter becomes the optimal choice for transmitter detection. This means if the pre knowledge of modulation scheme is not correct, the matched filter will perform poorly therefore, correct prior knowledge about the primary user's signal has to be ensured.

A matched fiter (MF) is a linear filter designed to maximize the output signal to noise ratio for a given input signal. In matched filter detection the secondary user has a priori knowledge of primary user signal is needed Matched filter operation is equivalent to correlation in which the unknown signal is convolved with the filter whose impulse response is the mirror and time shifted version of a reference signal. Matched fiter detection needs less detection time because it requires only O (1/SNR) samples to meet a given probability of detection constraint.

Eergy

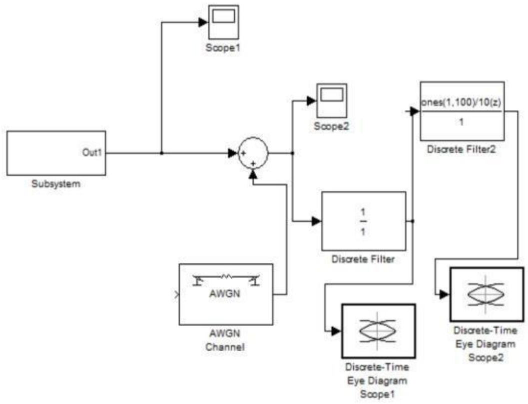

Fig 5. Block diagram Matched filter Detection

Result

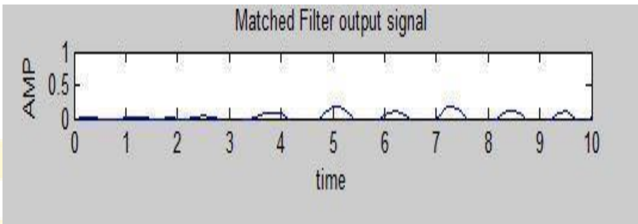

Fig 6. Output of Matched Filter Technique

3.2.3 Cyclostationary Detection Technique

Cyclostationary feature detection method is also called as spectral correlation method because it uses cyclic correlation function for detecting present of signal in a given spectrum. These process having periodicity in statistical property like mean, autocorrelation are cyclostationary . By using periodic statistics of primary user waveform, CR can detect random signal in presence of noise. And these features are extracted using spectral correlation function.Cyclostationary feature detection exploits the periodicity in the received primary signal to identify the presence of Primary Users (PU). The periodicity is commonly embedded in sinusoidal carriers, pulse trains, spreading code, hopping sequences or cyclic prefies of the primary signals. Due to the periodicity, these cyclostationary signals exhibit the features of periodic statistics and spectral correlation, which is not found in stationary noise and interference.

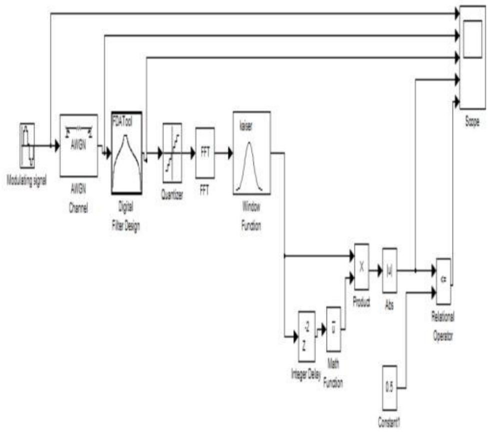

Fig 7. Block diagram of Cyclostationary Detection

Result

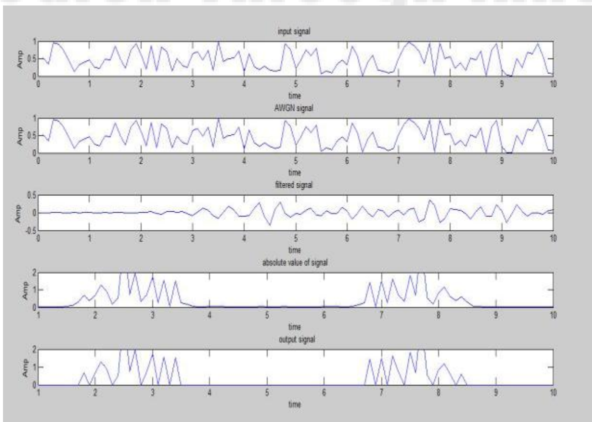

Fig 8. Output of Cyclostationary Detection Technique

3.3. CR VANET in NS-2

We consider a roadside infrastructure-based single-radio multi-channel primary network having PUs and moving vehicles along the roads as SUs. These PUs and SUs share a set of orthogonal wireless channels. We illustrate our design in Fig. 9. Here, the roadside Base Stations (BS) provide wireless communication channels to the PUs within its transmission area.

The vehicles are only allowed to use the channels that are not being used by any PUs within their transmission range. For simplicity, we consider entry points for vehicles in our simulation area . Here, we allow vehicles to enter through the top and bottom horizontal roads (from right to left). On the other hand, vehicles can leave the simulation area through the exit points.

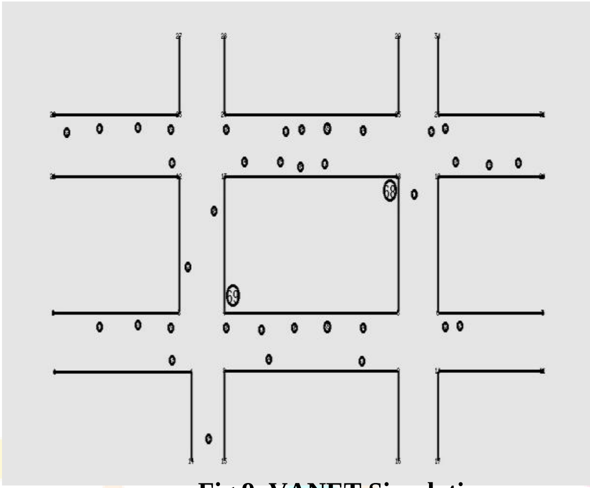

Fig 9. VANET Simulation

In case of a junction, vehicles take a probabilistic decision. We consider each direction equally likely for the vehicles. These junctions are marked in Fig. 4.7. We start by generating a set of vehicles moving through the roads. Then, at each time epoch, we track each vehicle's position, number of neighbour, neighbouring PUs, etc. Based on these information, we evaluate our simulation parameters .

3.3.1 Model Parameters

We place several primary BSs and Secondary BSs respectively for PUs & SUs. Besides, we mark the PUs by computers and SUs by vehicles. The arrival rates of the vehicles follow a Poisson distribution.In our scenario, the circles represent the coverage areas of PU BSs and the coverage area of moving SUs. The Channel Assignment decision is centralised, i.e., channels are assigned to vehicles by the base stations in the network. Each vehicle communicates with its nearest base station and share information regarding its channel access. Information include its current position, speed, direction, etc. Each base station assign channels to vehicles based on these information from all vehicles within its transmission range. Therefore, each base station maintains data structure to accommodate the following information :

(i) Position, speed, and direction of each vehicle within its transmission range.
(ii) Active vehicles (i.e., vehicles which are in transmission) and the corresponding channels being used for their communication.
(iii) Active PUs and the corresponding channels being used for their communication.

3.3.2 Simulation Settings

1. Antenna Model: Omni Directional Antenna
2. Radio Propagation Model: Two Ray Ground
3. Interface Queue Type: CMU PriQueue
4. No. of Nodes:70
5.Routing Protocol: DSR
6. X-axis Distance:2000
7. Y-axis Distance:1200
8. Simulation Time:20sec

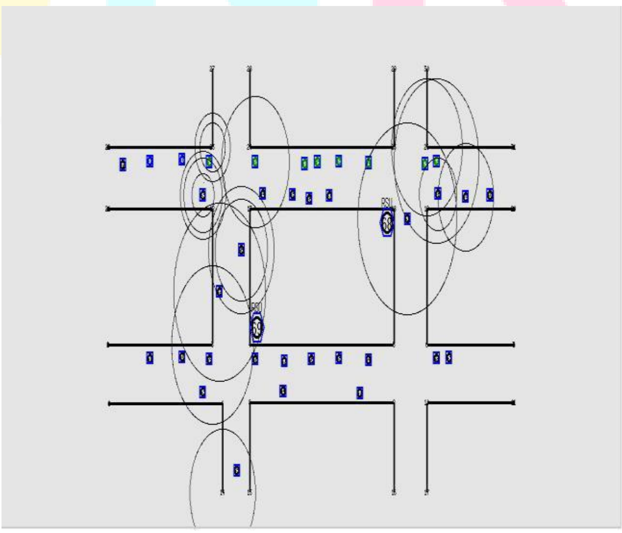

Fig 10. Communication Between PU and SU

In the simulation, we generate up to 70 vehicles. These vehicles arrive from the entry points maintaining the lanes.We control the flow of arrival rate of vehicles by following Poisson distribution. Afterwards, we track each vehicle for a simulation time of 20000ms. At each epoch, all BSs in the network assign channels to moving vehicles within their transmission range. Through the simulation time, we track route of each vehicle whether it is under any coverage area of base stations or not. Alongside, we also find that if any vehicles are assigned with channel or not. If they are assigned with any channel, we also find that under which base stations it is assigned. We apply a dynamic VANET topology where these moving vehicles have different travelling paths, arrival times, etc. These vehicles not only arrive at different times, they differ in their travelling paths due to the presence of junctions.

Here we depict two scenarios :
(i) High Density Traffic

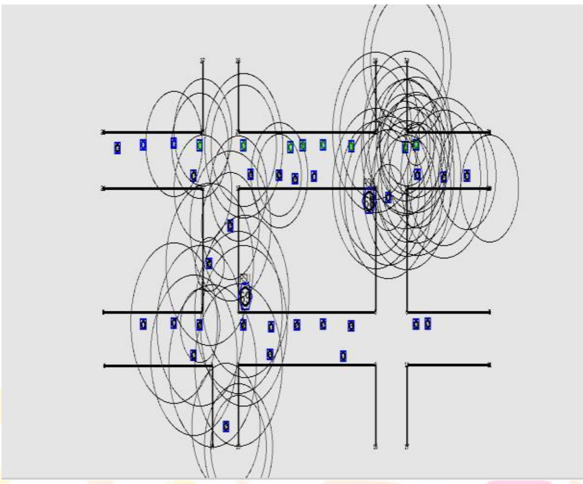

Fig 11. High Density Traffic

In this case we find many SUs trying to communicate with available PUs. Thus in these cases we have less packet delivery as we can't assign much channels to the requesting SUs.

(ii) Accident Scenario:

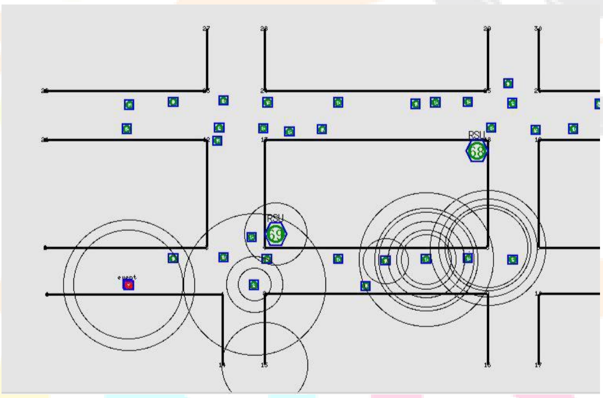

Fig 12. Accident Case

We show the case of collision that occurs between two vehicles and how the SU immediately transmits emergency message to nearby PU. This PU the alerts the vehicle approaching that lane about this case of accident.

IV. PERFORMANCE ANALYSIS

4.1. Comparison Result Of Spectrum Sensing Techniques

Energy detection has been adopted as an alternative spectrum sensing method for CRs due to its simple circuit in the practical implementation and no information requires about the signal needed to detect.

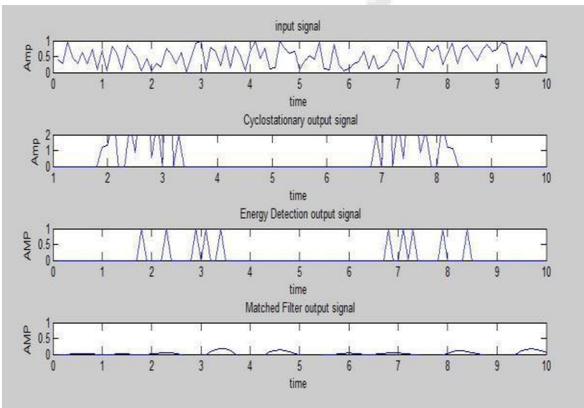

Fig 13. Comparison Of Output Signals

Figure 13 shows the difference in channel allocation of the three spectrum sensing techniques. Of the lot energy detection shows a better result as we get a sharper and clearer graph.

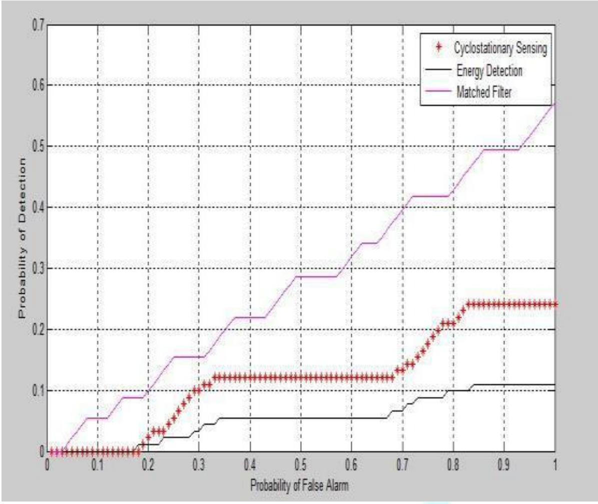

Fig 14. Probability of Detection vs Probability of False Alarm

Fig 14 plots the graph between the probability of detection and the probability of false alarm. It shows cyclostationary to be the most efficient in the case of detection.

But , due to the complexities experienced in the case of implementation of cyclostationary and matched filters , we make use of energy detection for the channel assignment process.

4.2. VANET Simulation Results

We initially present the frequencies we have considered for the spectrum sensing and assignment technique.

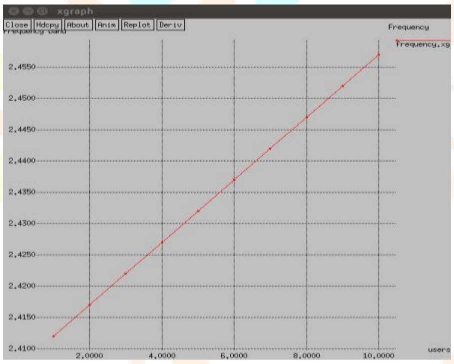

Fig 15. Frequency vs Users

The Figure 15 shows the frequencies that are being allotted to the 10 users (SUs) requesting for the free channel for transmission.
We also present our simulation results in terms of several standard Quality Of Service (QoS) parameters such as

1. Throughput
2. Packet Delivery Ratio (PDR)
3. Overhead.

(i) Network Throughput :

It refers to the amount of data transmitted across the network in a given time, usually measured in kilo-bytes per second (*Kbps*). At each run, we calculated the average network throughput by averaging the individual data rates of all CR users for a given topology.

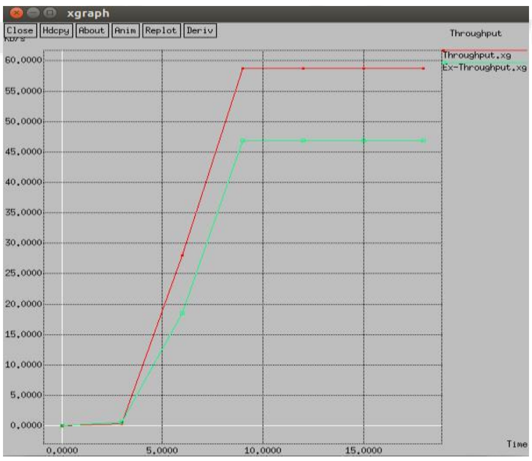

Fig 16. Throughput

(ii) Packet delivery ratio:

The ratio of number of packetsthat are successfully delivered to a destination compared to the number of packets that have been sent out by the sender, is referred to as packet delivery ratio.

This figure shows the packet delivery ratio plotted for units a time.

Fig 17. Packet Delivery Ratio

(iii) Overhead :

Increased data length of the security envelope leads to significant increases in channel load and thereby decrease in communication range. Two main sources of data length increasing exists. The first one is applied message encoding rule, e.g., binary . The second and even bigger source of message length variation caused by the security envelope is inclusion of optional data fields. .

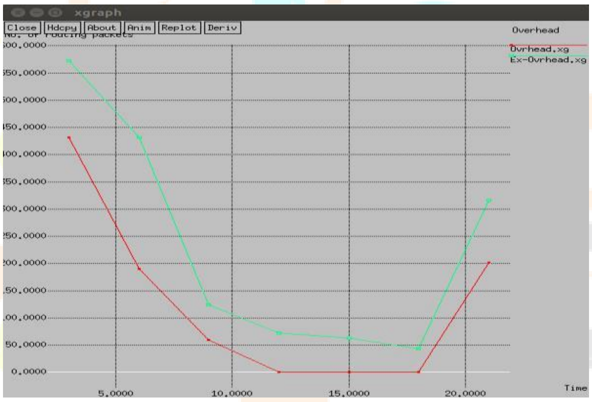

Fig 18. Overhead

V. REFERENCES

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