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Design and Development of a Network Based Signal Analysis Model for Real Time Applications for Abnormality Prediction in Human Body

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***Abstract*—** There are many diseases that are needed to be identified quickly. So there are the chances that some people have to send the recorded heart ECG signals to quickly assure the abnormality in their body. Today the technology has advanced so much that people can send their signals over the network. People prefer to send their signals over the network instead of going to the destination as to speed up the transmission. When a signal is to be transmitted over the network, it is first converted into smaller parts called packets. Thus, the signal in the form of packets, then transmit through various intermediate nodes or the routes coming in the path from source to destination. There are the chances of distortions in the signals due to loss of packets while moving over the network.

In this paper, the packet losses or distortions that are introduced in transmission have been analyzed. The number of packets that are lost and the effect of this packet loss on the signal transmission are studied. Random packetization is done to analyze further results. The network simulator NS2 is used for this purpose and results are analyzed using NS2 which provides both wired as well as wireless transmission. The performance of reactive routing protocol AODV under TCP and UDP agents and traffic generators FTP and CBR respectively are compared.

***Keywords*—** ECG signal; NS2; NS2 agents; routers; routing protocols.

I. INTRODUCTION

Computer network enables the connection between various nodes. In computer networks, computing devices allows transmission of data through these nodes by providing the links between them. These links can be wired i.e., that uses the physical cables to transmit the data, or can be wireless [1] i.e., that do not use any cable to transmit the data. To transmit the packets over the network it will be much better to use the wireless network as the data has to be transmitted through the large distant computing devices. So, it is better to use wireless networks. The wireless nodes form a network dynamically to exchange information among each other without using any existing network. They create their own routes according to their requirement to reach the destination. The packets are free to move dynamically from one node to another which acts as routers and route the data packets that are not within the direct communication [2-5]. The packet loses can take place due to the damaged hardware, it may be due to hardware low capacity or due to bottlenecks in the hardware, there may be the network congestion as in the network many packets can be moving, sometimes there can be bugs in the network devices due to which the packet loss can take place [6].

Simulation of wireless network has been done using NS2. The packet loss has been analyzed with the help of network simulator Application layer protocols like FTP take messages from user and then transmit it to the transport layer protocols like TCP, UDP which divides that message into small parts called segments and transmit it to the lower layers by attaching necessary error and flow control information, and then passes the segment to the lower layer.

Many parameters like biomedical images [7], videos [8], messages, etc can be transmitted in the network and their performances can be evaluated. These packets thus, are related to the biomedical signals, in this paper as they are important part of the humans for the diseases to be cured. So, they are needed to send through the network so that they can reach faster to the destination that can help the person to identify the disease in earlier stages. There are many biomedical signals but this paper analyses the ECG signals of different Kilobytes. They are used as the data packets in the network and transmitted from source to destination. ECG is the electrical manifestation of heart activity recorded from the body surface. ECG signals can be recorded easily with surface electrodes on the limbs or chest. The ECG is the most commonly used biomedical signal. Original investigations on recording of the human ECG were conducted by Waller and Einthoven in the late 1800s and the early 1900s. The following waves and time intervals describe some important characteristics of the ECG signal. Fig. 1 depicts the electrocardiogram in which the QRS-complex reflects the contraction of the right and left ventricles. In a normal heart, the QRS complex lasts for about 70–110 m sec and is a sharp bi- or tri-phasic wave. The first negative deflection is the Q-wave, and the first positive is the R-wave, while the negative deflection subsequent to the R-wave is the S-wave. The P-wave reflects the sequential

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contraction of the left and the right atria. The T-wave reflects ventricular relaxation and extends about 300msec after the QRS-complex. The PQ-interval is the time interval from the onset of atrial activation to the onset of ventricular activation. The length of the PQ-interval is only weakly dependent on the heart rate. The Qt-interval is the time interval from the onset of the ventricular activation to the completion of ventricular recovery. This interval is normally dependent on the heart rate; it becomes shorter at more rapid rates [9-12].

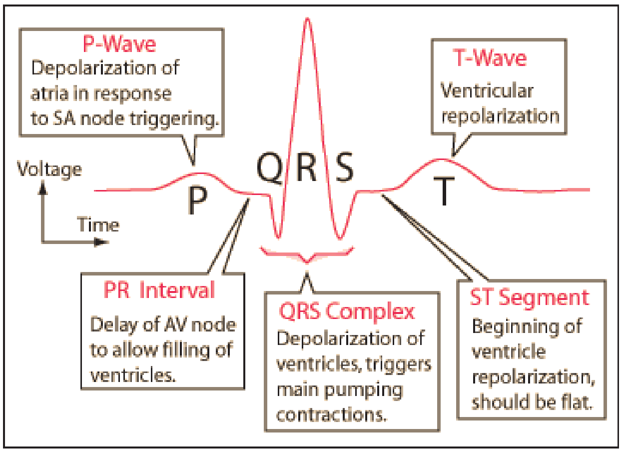

Fig. 1: Electrocardiogram (ECG) [13]

II. NETWORK SIMULATOR-2 (NS2)

NS2 was developed by University of California at Berkeley. Network Simulator-2 is popularly used for ad-hoc networking community. It is open source software used for evaluating the network. Wireless networks have several unique characteristics compared to wired communication. Wireless links are dynamic as compared to wire lines since they are subject to time and location dependent signal attenuation, reflection, refraction, diffraction, and interference. Another disadvantage of wireless links is limited bandwidth. MANET has to respond quickly to a high degree of topological changes in the network and still it has to maintain routes, and at the same time it has to control excessive traffic. In wireless networks, providing TCP traffic is very difficult task. A lot of research has been carried out in few years, to provide TCP traffic in the wireless networks. So, it is important to study that which routing protocol works well in wireless communication using TCP traffic. The various routing protocols used in MANETs are three types such as Reactive and Proactive protocols.

Proactive Protocols are table driven routing protocols in which, all the route information is maintained in routing table. The Packets are transferred over the network in the manner in which the routes are predefined in the routing table. The packet moves faster in this case but the routing overhead is greater because all the routes need to be defined in the table before transmitting the data and packets. Some the proactive routing protocols are DSDV, OLSR (Optimized Link State Routing), etc.

Reactive Protocols maintains only the routes that are currently in use thereby reducing the burden on the network as only the available routes is in use at any time. These types of protocols are also called as On Demand Routing Protocols where the routes are not defined before for routing. A Source node calls for the route discovery to generate a new route whenever a transmission is to be done. Some of the reactive protocols are DSR, AODV, etc. Ad hoc On-Demand Distance Vector Routing (AODV) maintains a routing table in which it maintains only a single entry instead of multiple entries that are maintained by DSR. So, AODV is most preferred routing protocol that is to be used in this paper. The main objective of a transport layer is to perform two main functions that are: flow control and error control. Transport layer protocols divide the message into number of segments. The segments are then transferred to the network layer which determines the route through which packets are sent from source to destination [14]. The transport layer protocols are called as agents. The data traffic is generated by two agents in NS2 namely UDP and TCP. TCP traffic is a trustable, connection-oriented. It generates packet and send it to the TCPsink attached to the destination node and in return TCPsink sends ACK packets to the source. But in case of UDP, the ACK packets are not sent back. It generates connectionless traffic and send to the null agent attached to the destination of source node connected to UDP. Now, these agents are attached to the application layer protocol which takes the message and send to agents for further transmission. TCP adjusts the rate of transfer with the network so, its send rate is not constant. Thus, CBR (Constant Bit Rate) is normally connected to UDP and FTP with TCP agent. In NS, the traffic source does not transmit actual data, but it sends message to the underlying agents that it has some data to send to the destination node and then agent just knowing how much data to transfer, creates packets and send to destination node [15-17]. Mobile Ad-hoc Network (MANET) is a network, in which the nodes are not fixed. Every node in the network performs functions as the routers. They discover the routes themselves for the other nodes to transmit the message to the destination. If there is no direct route between the destination and source they create routes between them. The most widely used and popular protocols proposed for MANETs are AODV, DSR, and DSDV which comes under the two types that are: proactive and reactive protocols [18-19].

The scripts that are written in NS2 are called TCL scripts. NS2. NS2 consists of two languages: C++ and Object-oriented Tool Command Language (OTCL). C++ is used for internal mechanism that is for backend programming and OTCL for frontend. The C++ and OTCL are linked together using TCLClasses (TCLCl). The outputs generated are two files: output trace file which contains the information of every packet and NAM (Network Animator) which runs the

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simulations and shows the results graphically [20]. Fig. 2 describes the architecture of the NAM.

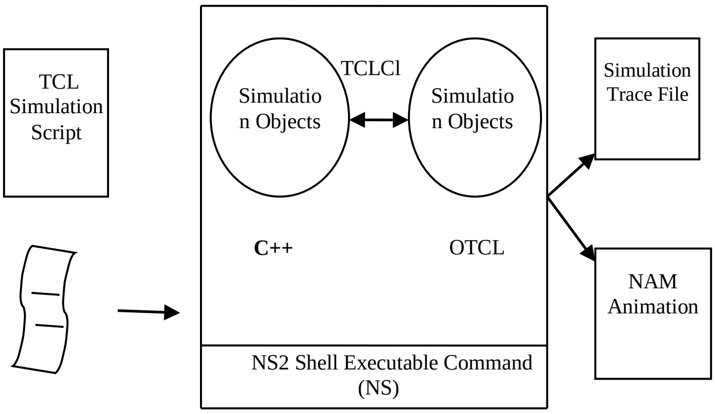

Fig. 2: NAM Architecture

III. METHODOLOGY

This section is based on the performance evaluation of different protocols in NS2 and then the results are applied to the ECG signals. NS2 is installed in windows with the help of Cygwin which provides the environment of linux in windows and helps to run NS2 in windows. Different simulations are made to evaluate the performances. Based on the simulations, the effect of the packet loss on the ECG signal is identified. Different distorted views are seen in the ECG signals before the transmission and after the transmission. Then random packetization is done to improve the results as if it is considered that the signal is sent again if there is more distortion and the lost packets at first time are recovered in second time transmission. The procedure of the proposed research is explained in Fig. 3 and the steps are explained below.

1. TCL script: Tool Command Language (TCL) is the scripting language used in NS2 to write the simulation which one need to run. It is written in NSG 2.1 which is the NS2 scenario generator. The program is saved in the Cygwin folder. The two forms of outputs are generated that are the trace file and other is NAM (Network Animator) which runs the simulations and give the results graphically.
2. Trace file is generated which contains all the traces of the packets as it is written in script to trace all the contents of the output to the file.
3. From the generated trace file, packet loss is calculated.
4. Then an ECG signal is taken and it is divided into small parts to form packets. Let us say, ‘m’ packets are generated.
5. Of the ‘m’ packets, say ‘L’ packets are dropped or lost. This is calculated by the packet loss generated in simulation.
6. For the lost packets, the values of ECG signal is put zero.
7. The resulted graph is generated.

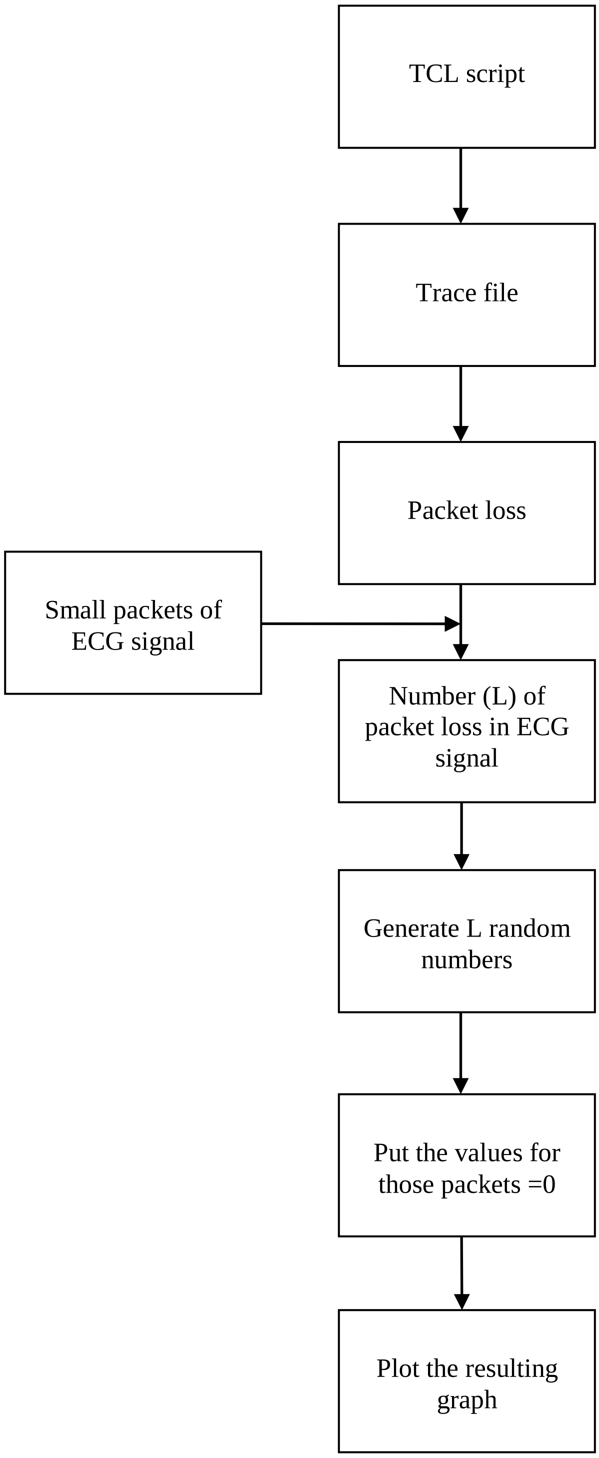

Fig. 3: Flow Chart of the proposed methodology

IV. RESULTS AND DISCUSSIONS

A. *Simulation Scenarios*

NS2 simulator is used in all scenarios. We examine the results using two traffic generators that are TCP and UDP. The

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different scenarios are detailed in TABLE I.

TABLE I. Various simulation parameters

Parameter	Value
Simulator	NS-2.35
Platform	Windows
Antenna	Omni Antenna
Node Deployment	Random
Routing Technique	AODV
Number of nodes	10,30,50
Size of packets	1000 Bytes
Traffic type	TCP,CBR
Packet rate	1 Mbps (in case of CBR)
Simulation time	Seconds

B. *Traffic: TCP*

In this simulation scenario, TCP agent is attached with the source node and on the other side it is attached with the application layer protocol FTP. On the receiver end, the node is connected with the TCPsink and the traffic transfers from TCP agent at the source end to the TCPsink at the destination. There are further three scenarios for TCP that are on the basis of the variation in the number of nodes. This permits to compare the assessment of these protocols under different scenarios. So, total number of nodes is varied. The queue limit is taken as 10. The routing protocol is AODV. Total simulation time is taken as 50s. The packet size is considered as 1000 kilobyte. The numbers of nodes considered for the simulation are 10, 30 and 50. 10 nodes scenario is shown in Fig 4.

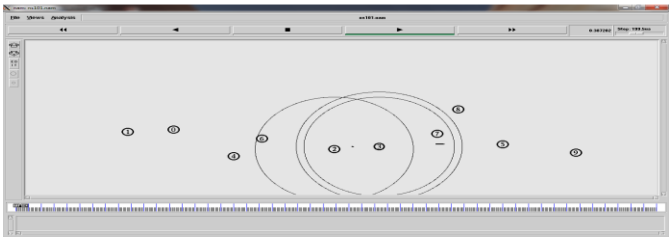

Fig. 4: Packets moving from node 1 to node 9 in TCP

In Fig. 4, packets are moving from node 1 to node 9 where node 1 is the source node and TCP is connected with it and TCPsink is connected with node 9. The nodes are forming their own routes to transfer data from source to destination. Fig.5 shows the packet loss in the simulation scenario of the same scenario shown in Fig.4.

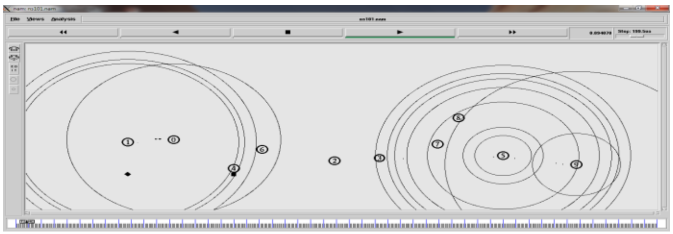

Fig. 5: Illustration of packet drop in TCP

TABLE II shows the total packet sent from source, dropped packets and the packet loss in case of TCP.

TABLE III. Parameters values in case of TCP

Parameter measured	10 nodes	30 nodes	50 nodes
No. of packets send	469	887	389
No. of dropped packets	87	333	127
Packet loss	0.18	0.37	0.32

C. *Traffic: UDP*

In this simulation scenario, UDP agent is attached with the source node and on the other side it is attached with CBR. On the receiver end, the node is connected with the NULL and the traffic transfers from UDP agent at the source end to the NULL at the destination. There are further three scenarios for UDP that are on the basis of the variation in the number of nodes. The other parameters are same as in TCP except one set packet rate here as UDP send rate is constant and the packet rate can be fixed as per requirement. The numbers of nodes considered for the simulation are 10, 30 and 50. 10 nodes scenario is shown in Fig 6.

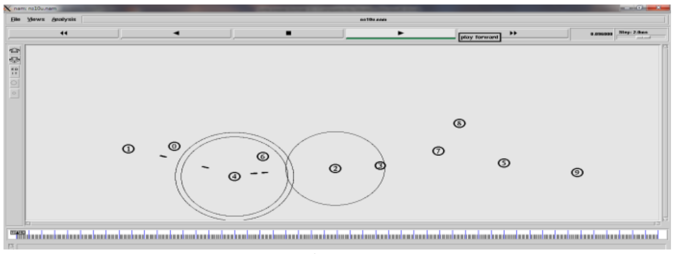

Fig. 6: Packets moving from node 1 to node 9 in UDP

In Fig.6, packets are moving from node 1 to node 9 where node 1 is the source node and UDP is connected with it and NULL is connected with node 9. The nodes are forming their own routes to transfer data from source to destination with the help of AODV routing protocol.

Fig. 7: Illustration of packet drop in TCP

Fig.7 shows the packet loss in the simulation scenario. In case of UDP, the packet losses are more as compared to TCP. Then the packet loss is calculated. TABLE III shows the total packet sent from source, dropped packets and the packet loss in case of UDP.

TABLE IIIII. Parameters values in case of UDP

Parameter measured	10 nodes	30 nodes	50 nodes
No. of packets send	68	392	1477
No. of dropped packets	56	316	1237
Packet loss	0.82	0.80	0.83

Since these results are not efficient so the signals are sent twice and random packetization is done to improve the results.

B. ECG signal

ECG signal are taken which are of different kilobytes. They are converted into small packets. The simulated packet loss is then used to calculate the lost packets in the signal. Random numbers are generated to identify the lost packets. The graphs are plotted before and after the transmission to study the effect on ECG signal that transfers through the network.
The signal of 164 Kb is taken and the performances are evaluated for each simulation scenario. The packet loss that is calculated in the above scenario is used for these signals. The lost packets in the ECG signals for different scenarios are detailed in the table. Single random packetization is done to generate the lost packets for the given packet loss but to improve the results the signal is sent twice. So we chose the lost packet in second round by random packetization. Thus, double random packetization is done for all the scenarios to see the effect on the transmission of signals. Following are tables showing packet losses of signal of 164 kb when the total number of nodes are 655. TABLE IV shows the packet losses in case of single random packetization and TABLE V shows the packet losses in case of double random packetization.

TABLE IVV. Table showing lost packets after single random packetization in case of 164 kb signal

Traffic	10 nodes	30 nodes	50 nodes
TCP	121	246	214
UDP	539	528	549

TABLE V. Table showing lost packets after double random packetization in case of 164 kb signal

Traffic	10 nodes	30 nodes	50 nodes
TCP	27	94	64
UDP	441	425	457

Fig. 8 shows the original and distorted views of TCP after single randomization and Fig. 9 shows the original and distorted views of TCP after double randomization in case of 164 Kb of signal.

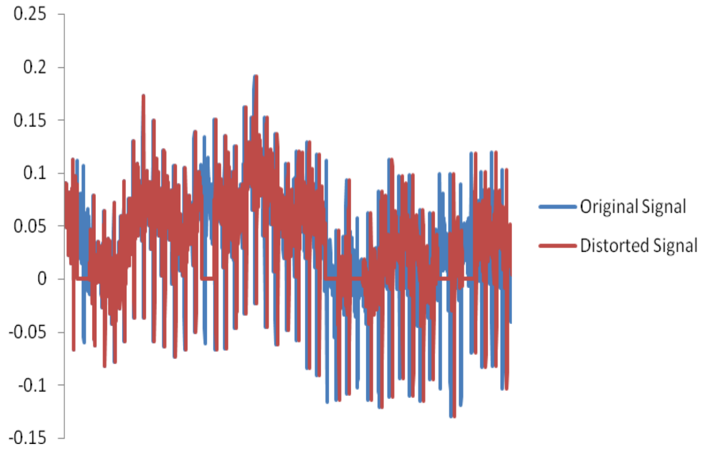

Fig. 8: Graph showing signal before transmission and after transmission in TCP after single random packetization

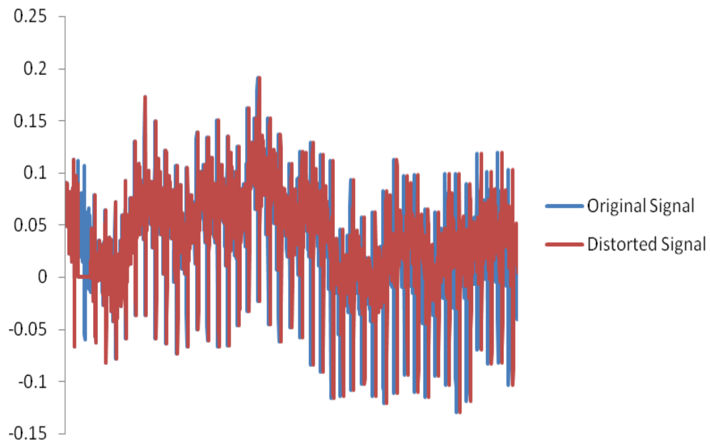

Fig. 9: Graph showing signal before transmission and after transmission in TCP after double random packetization

TABLE VI and TABLE VII are showing packet losses of signal of 14.2 kb, when the total numbers of packets are 36.

TABLE VI. Table showing lost packets after single random packetization in case of 14.2 kb signal

Traffic	10 nodes	30 nodes	50 nodes
TCP	6	14	12
UDP	30	29	30

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TABLE VII. Table showing lost packets after double random packetization in case of 14.2 kb signal

Traffic	10 nodes	30 nodes	50 nodes
TCP	1	6	3
UDP	23	22	25

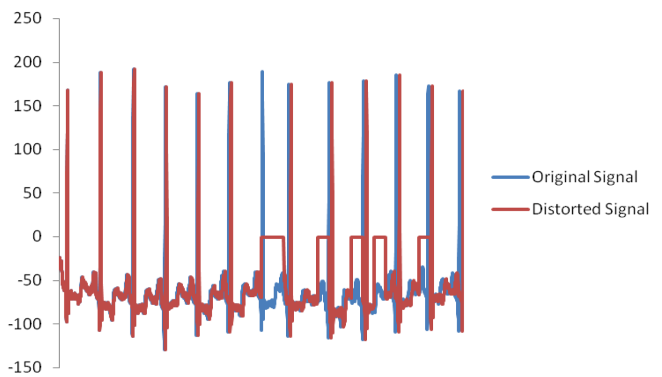

Fig. 10: Graph showing signal before transmission and after transmission in TCP after single random packetization

Fig. 10 shows the original and distorted views of TCP after single randomization and Fig. 11 shows the original and distorted views of TCP after double randomization in case of 14.2 Kb of signal.

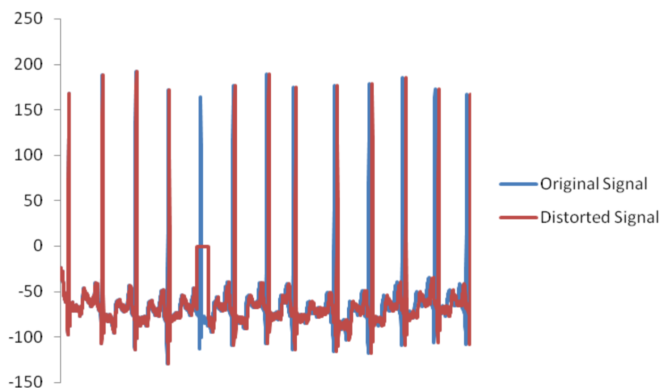

Fig. 11: Graph showing signal before transmission and after transmission in TCP after double random packetization

V. CONCLUSION

In this paper, the behavior of TCP and UDP agents of transport layer has been analyzed. The results are carried out by varying the number of nodes. This is done by simulating the number of nodes using NS2. The packet loss calculated for the simulation is used to study the effect on ECG signals if they transmit over the network. Various operations are carried out for different signals of varying sizes. The graphs are plotted for different cases which clearly show the impact of ECG signal transmission on network. It is noticed that TCP works much better than UDP. The results are more efficient when the signal is sent twice or it can be said that after the double random packetization, the signals loss is minimum.

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