Trace File Analysis To Obtain Congestion Window, Throughput And PDR

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Abstract

The use of wireless networks have led to a recognizable evolution in the area of wireless Body Area Networks (WBANs).With the help of WBAN a patient's state of health can be repeatedly monitored without affecting his day to day activities. A wide range of technologies have played a significant role in supporting WBAN applications which includes telemedicine, remote monitoring and ambient assisted living by focusing on particular quality of service requirements. In this project, the QOS parameters like delay and throughput will be improved compared to existing protocols with the help of a simulator(NS2).We will collect values from the present database and transmit it via the internet such that it will have minimum delay and throughput, so that the packet without any loss of data can be collected at the hospitals.

Keywords: Throughput; PDR; Trace-files; Congestion window; WBAN.

1. INTRODUCTION

In the field of health care rapid developments were made with the assistance of wireless body area networks WBAN. The growing demand for high quality and instant simplified services in health care have led to utilisation of information and communication technology in different ways. There are lot of factors which have impact on WBAN applications which are more evident with the new results showing health impact on quality issues, so it is very important to have a hold on problems mostly related to implementation. Proper implementation requires a good service quality for all the parameters in consideration in which the delay and the throughput play an important role. In order to improve the health technologies it is very important to scale up the QOS parameters in WBAN. To accelerate the transformation of our health care systems and to achieve affordability and quality for all in the near future QOS improvement plays a significant role. Wireless Body Area Network(WBAN) is a variant of wireless communication technologies, that connects independent nodes which can explore and detect a appropriate network to communicate and send data to a distant database server. These nodes are capable of sensing, gathering the human body signs.

We can implement the process with various simulation tools like omnet++,netsim,ns2 but we prefer ns2 for demonstration as it is a free source software. WBAN signals are mainly used in medical fields to transmit data like heart rate i.e. EC,EEG, Blood Pressure(BP),body temperature and sometimes sugar levels in the blood.By taking up this project we would like to reduce the probability of the same happening by improving the QoS of WBAN signals by using the Ns2 simulator, thereby try to improve the efficiency of the quick response care in emergency situations.

2. Related Works

Research works related to WBAN are quite large in number. Some of the works are listed as follows-This paper address the improvement of energy efficiency and service quality in a new wireless body area network architecture. This architecture is developed with dual sink nodes to reduce energy consumption and delay in this proposed work a new persistent media access control protocol is defined which can perceive the importance of perceptual data[1];Each WBAN comprises of a coordinator and multiple sensing nodes. When twhenhese nodes simultaneously transmit interference occurs. In order to avoid interference in wireless body area networks CSMA/CA is implemented at the coordinator level.The coordinator automatically adjusts its frame length to avoid interference [2];A comparison between the performance of AODV and DSDV for UDP and TCP is made and evaluation of their performance is carried out in similar simulation conditions. Here AODV performs better than DSDV and DSR[3];This research aims to solve the problem of energy consumption by a sophisticated classification scheme which categorises the data into normal, semi-urgent and urgent. this also provides a method for medical sensors that can send packets during a gateway failure[4];A mac protocol defined in this paper aims to meet the requirements and increase power consumption rate which increases rapidly as the number of nodes goes high.In order to effectively and objectively evaluate the MAC protocol it is compared with 802.15.6 protocol[5];In this paper Virtual Group formation architecture based on time instances.The way data is being transmitted from a source patient node to the destination node which is the doctor or nurse's mobile device through WLAN is one of the fastest approaches. For a particular time interval the data gets updated automatically[6].

3. METHODOLOGY

Topology :

The proposed topology consists of nodes acting as sensors along with intermediate node depending on distance and a final node acting as data base. These sensors are body sensors that are used to capture data like pulse, blood pressure, sugar and temperature. The data is captured based on requirement and the data will be transmitted to the database of the nearest hospital. This topology tries to meet real time situations as close as possible.The topology is implemented using Network Simulator (NS-2).

Queueing:

In general, class of object that has the ability to hold and perhaps mark or discard packets as they travel in a particular simulated topology is called a Queue. Here we use Drop Tail type of queueing. It is a simple queuing mechanism where routers use it to drop excess packets. In this mechanism, all packets are considered identical and given equal importance, so when the queue reaches its utmost capacity, all the new packets entering are are not taken until the queue has adequate area to allow the upcoming traffic payload. When the queue is full, the router discards all the packets hence dropping of the tail mechanism. This dropping of packets will make the sender enter into a slow-start phase, which will reduce the value of throughput and hence increasing the congestion window.

Routing Protocol:

The routing protocol can help the node find the required path and maintain the route for a certain time level until the target node has obtained the data packet from the source node. Routing protocols constitute an important part of mobile ad hoc networks. The routing protocols are available in three types which are active, passive, and mixed. The table-driven routing protocol is proactive, where every node constantly updates the table consisting of the routing information of other nodes, which helps to detect the route to the target node. In this paper, on-demand protocols are used, also known reactive routing protocols . Here, the mobile node consists only of information on the active path. According to the request of the source node to send the data packet, the reactive routing mechanism will find the path to the target node. Reactive routing includes protocols such as AdHoc on-demand multipath distance vector (AOMDV),Ad-Hoc on-demand distance vector (AODV) and dynamic source routing (DSR). Hybrid routing is a combination of both and location identification routing algorithms such as Gathering Routing Protocol (GRP) and Temporally Ordered Routing Algorithm (TORA).

DSDV Routing protocol:

Destination Sequenced Distance Vector (DSDV), basically it is a routing protocol which is based on the hop-by-hop mechanism. This protocol requires periodical update on broadcast routing at each nodes. This algorithm is based on the table-driven scheme, which is comparable to the scheme of modified Bellman-Ford routing .The network has nodes all the nodes are destined to have a routing table to keep the track of all the entries at the destination and need to have count on the hop required to achieve that particular destination. Their should be a sequence number at the entry to determine previous and old entries. Every node associated in the network periodically sends updated labels with consistently increasing even sequence numbers throughout the network to announce its position.

The latest available broadcasts consist of information regarding destination, hop count required to attain target, the details of the sequence number received with respect to destination, details with respect to the latest sequence that is specific about broadcast. The frequently selected path is basically the one which has its sequence number to be the most recent one. On the reception of this particular information by the nodes surrounded around the source node, heseneighbour nodes realize that they short of a hop with regard to transmitting one and hence try to accumulate this information in their respective DV. Each node keeps track of the following hop for each accessible target in their vector table. It is always the path having the utmost sequence number is chosen over other paths i.e. the latest path is used. On determining Y cant be reached by its neighbouring X and hence X helps to find a new path to it by a infinite method metric. The recent sequence number will help find all the new path in order to update it.

802.11 Standard:

802.11 is an IEEE protocol under the 802 protocol that specifies the LAN protocol. IEEE 802.11 defines protocols in the physical and data layers (especially the MAC layer). This protocol implements CSMA/CA. The protocol is usually used in the frequency range of 2.4GHz, 5GHz and 60GHz.Various sub-protocols are defined in 802.11, inclusive of 802.11a (that supports up to 54Mbps bandwidth when using 5GHz) and 802.11b (supports up to 11Mbps bandwidth when using 2.4GHz range), and is only supported by DSSS (direct spread spectrum sequence). This paper uses 802.11e, which is an improvement of 802.11a and 802.11b. It provides QoS functions, including data prioritization. The range it supports is the traditional 2.4GHz range. We know that the higher the frequency range, the faster the data transmission rate, thereby reducing sensitivity[9].

There are three parts in the MAC frame structure of the CSMA/CA protocol which are uplink, downlink and beacon, as seen in the figure. Beacon is responsible for synchronizing and defining the structure of the frame. The message in the beacon will consist of information of synchronization and transmission line up for all of the nodes inside the WBAN, also the transmission duration required for a particular frame is indicated by the duration field , during which the channel will be kept busy. Other nodes and coordinators set their network allocation vector(NAV) by keeping a track of the duration field in the wireless medium , which specifies for how long it should refrain from accessing the channel. The transmission information that is passed from coordinators to the receptor nodes is present in the downlink section, inclusive of both unicast as well as broadcast data. The uplink section consists of the contention access period(CAP) and the contention-free period(CFP). During CAP, nodes compete for an opportunity to transmit using a mechanism of slotted CSMA/CA. Meantime, in CFP, the coordinator manages the slot allotment for the receptor nodes i.e, the guaranteed time slots(GTS).The CSMA/CA protocol regulates the length of the frame and also changes the length accordingly, while in the downlink, coordinator puts together the CAP and CFP based upon the present characteristics of traffic.

Radio Propagation Model:

The received signal power of each data packet is predicted by the Radio propagation model which is applied in NS. At the lowest basic layer of every wireless node, there is a reception threshold. After receiving the data packet, if its signal power is lower than the reception threshold, it is considered as an error and discarded by the MAC layer. So far, NS has three types of propagation models, namely the two-ray ground reflection model, free space model 1 and the shadow model. We used a two-ray ground reflection model. There are two paths in two ray ground reflection model namely the direct path and the ground reflection path. The results show that, compared with the free space model, the model offers a more precise prediction over long distances.

Antenna type:
The antenna can be either Omni-directional or directional , we are using Omni-directional antenna as it is a WBAN application. Omni-directional antenna can transmit signals in any direction. The directivity of the antenna is given by:

$$D \approx 10\log10(101.5/HPBW-0.0072HPBW2)dB. \quad (1)$$

where HPBW is half power beam width.

Other considerations:
Wireless PHY defines the network in the physical layer. It allows nodes to transmit and receive in the physical layer. For tracing the packets in each layer of the network we have trace options. Router trace(RTR) traces the packet in network layer, whereas Agent trace(AGT) traces the packet in transport layer, MAC trace (MAC) traces packet in Data Link layer .the nodes can be stationary or mobile in a wireless environment, if the nodes are mobile and we would want to trace their movement,movement trace will serve the purposely type LL is an abbreviation for link layer.It is accountable for flow of packets from network to mac layer and mac layer to physical layer.It is also possible to specify the queue length with the help of ifqLen command.

4. Prioritization

To guarantee QoS is fulfilled by coordinating QoS mechanisms to the network, this permits separation of various sorts of traffic. The frames that show up in the MAC layer are segregated dependent on priorities. This is done with the assistance of medium access parameters, each having a different AC value.[7].The classification mechanism differentiates different user priorities into different packets. This allows the network in identification and separation of the different types of traffic into flows or a group of flow.

802.11e uses two ways to control air-time. It uses EDCA for prioritization and using HCF for scheduling. EDCA or Enhanced Distribution Channel Access uses multiple Access Categories (AC) each of which is given a contention window (CW) specific to it. Attribution Inter-Frame Space (AIFS) and Transmit Opportunity (TxOP) supports QoS enhancement method. The time that every client holds up after every transmission is constrained by Arbitrary Inter Frame Space Number (AIFSN). Its range defaults from 2 voice-slots to 7 voice-slots. The back-off interval which is utilized when the channel is occupied is irregular and is constrained by Contention Window (CW). The default esteems for Background and Best Effort min and max CW are twice as that for video while it is four times as that of voice.By default, Background and Best Effort min and max CW are twice as long as those used for Video and four times those used for Voice. AIFSN and CW are the parameters used for scheduling the packets. AIFSN is Arbitration Inter-Frame Space Number, CW belongs to CWmaxand CWminand the AFIS for the ithpacket is calculated using:

$$AIFSi = SIFS + AIFSNi \times Timeslot \quad (2)$$

SIFS is the Short Inter-Frame Space and is defined as the spacing that is provided before the acknowledgement is transmitted.HCF or Hybrid Coordination Function is characterized as the capability for a 802.11 radio to push various frames when transmission is on the RF medium.
A Power Save (PS) is a 802.11e extension which diminishes power utilization by letting the customers or applications sleep between transmissions, accordingly, saving battery life. This convention alters PS for better by permitting better control to applications or clients while snoozing, yet at the same time requests receive data.

WBAN categorises packets as Normal, Emergency and On-demand. The data that is requested by a doctor or coordinator is called On-demand, this category usually contains diagnostic information which is launched on demand. This is additionally characterised as continuous (for surgical events) and discontinuous (for timely disclosure). Emergency packets are the packets generated by nodes on a regular basis but are unpredictable. Nodes initiate traffic as emergencies at the point when they surpass a predefined threshold. Normal packets are those packets in which traffic of data is in normal condition without time criticality or event requests. These include packets that are transmitted at regular intervals and are used in medical conditions such as neurological diseases, gastro-intestinal and cardiac disorders and detection of oncological diseases. Data in these packets are collected and processed by the coordinator. These packets are assigned a packet subtype and a user priority (UP).PS is responsible for mapping these packets to access categories of WLAN protocols, thereby mapping WBAN categories to WLAN's ACs. The mapping module maps the three WBAN groups to WLAN categories. The packet type with the highest user priority will be mapped to the highest numbered AC which is then given the highest priority. The highest UP which is 7 is given to Emergency followed by UP 6 to Normal traffic. The lowest priority between these WBAN categories is given to On-Demand packets as they correspond to normal physiological parameters. Mapping module maps UPs to their corresponding WLAN AC. Based on the UP, the ACs assigned to Emergency was AC 3 while to Normal was AC 2 and so on. Non-medical data is given the lowest priority of all and is therefore mapped to AC 0.

After mapping the packets with the mapping module, the packets have to be transmitted through the network. There are two ways to transmit information. The first method is to directly transmit every WBAN frame that arrives at the MAC layer. The second method is an indirect one in which the WBAN frames are aggregated i.e. WBAN frames are combined to a WLAN frame such that the maximum Degree of Aggregation (DoA) will be the maximum payload size defined by 802.11e. This WLAN/WBAN Bridge gathers and consolidates datagram frames from the WBAN hubs and then transfers this to the medical server. Once packets are ready to be transmitted they have to be queued and scheduled before transmitting it through the network. The scheduling system of flows has to be such that when a packet is chosen from a chosen queue the QoS is met at all times.[8]

5. Simulation and Results

The simulation was conducted using NS-2 on linux based ubuntu and the results namely throughput, end to end delay,for overall network or for a specific node is obtained and analysed. Simulation was done for 7 nodes consisting of 4 sensor nodes, intermediate nodes and the database node. Initially the parameters for wireless sensor nodes were set. After the code is written we obtain trace files for the congestion window and the trace file for the whole event. Weanalyse the trace files to obtain congestion window, PDR and throughput. The trace file format is given below-

The first column represents the event type;it can be s,r,d,f for sent, received, dropped and forwarded respectively. The time is represented in the second column .The node number is given in the third column. The fourth column indicates the AGT to specify the Transport layer(e.gtcp)packet, MAC if a packet is from the MAC layer ,or RTR to specify the route packet. Sometimes it is IFQ for drop packet. Fifth column is the global sequence number of packets(not tcp sequence).The sixth column provide the details of the packet type(e.g. udp,tcp or ack).Seventh column represents the packet size in the form of bytes.In the eighth field, the details of Media access layer is given by square brackets with four numbers .The first hexadecimal number states the required time in seconds to send the datagrams through the wireless medium.The second one stands for the Media access identity of source node, third number is for receptor node. The fourth number,800,defines ETHERNETTYPE_IP which is a media access type. The next number of the second square bracket in the ninth column represents the Internet Protocol transmitting and receiving addresses, then the Time To Live (TTL) of the packet(In our file it is 32).The tenth column where third bracket specifies the tcp details as sequence number and acknowledgement number respectively.

The NAM window shows the simulation.Here we have 4 sensor nodes as tcp source nodes which generate the raw data.we set an actuator node as tcp/sink node .Then we may have a router node which is also given by tcp/sink node and finally the sink node.The sensor node data is added to the actuator and from the actuator the data travels to the final sink via a router node.A comparison of the values is given in the table below-

The table gives us the information about how the values of simulation vary with the time range. For our research, we have only considered the number of sending events, number of receiving events and the number of receiving events occurred when agent trace is on.

Congestion Window:

Congestion Window (cwnd) is a TCP state variable which controls the quantity of data a TCP can push into the network environment before obtaining a response is called a congestion window. In the following graph X-axis specifies time in ms and Y-axis specifies no. of MSS.MSS refers to maximum segment size. the congestion window is divided into three phases, i.e, slow start phase, congestion voidance, congestion detection. In slow start phase ,we set the size of congestion window equal to Maximum Segment Size (1 MSS).When acknowledgement is obtained the size of the congestion window size is increased by 1MSS.In this phase size of congestion window increases exponentially .In congestion avoidance phase the size of congestion window linearly increased to avoid the congestion. After obtaining every acknowledgement (ACK), the size of the congestion window is incremented by 1.In congestion detection phase ,when the loss of packets is observed, there is going to be a sharp decrease from the peak value. This may be due to time-out or by obtaining three identical ACKs.

For slow start phase,

$$\text{CWND size} = \text{CWND size} + \text{MSS} \tag{3}$$

For congestion avoidance phase,

$$\text{CWND size} = \text{CWND size} + 1 \tag{4}$$

Packet DeliveryRatio;

Packet Delivery Ratio is the ratio of packets or datagrams received to the total packets sent..This is determined by summing up the send and receive events from the trace file.Hence, the formula is given by:

$$\mathbf{PDR} = \Sigma\, \mathbf{R} / \Sigma\, \mathbf{S} \tag{5}$$

By this method we obtained the PDR as 98%.

Throughput; Throughput is the number of packets received successfully in unit time and it is defined in bits per second. Here we calculate the throughput by summing up send and receive events when either the packet is AGT type or MAC type and dividing by the time. Hence formula is given by:

$$T=(\Sigma S-\Sigma R)/(\text{start time-stop time}) \quad (6)$$

The throughput obtained for this method was 370KBps.

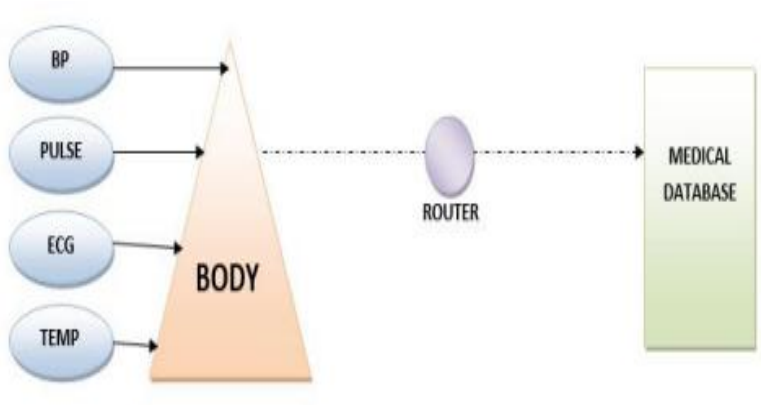

Figure 1. Block Diagram

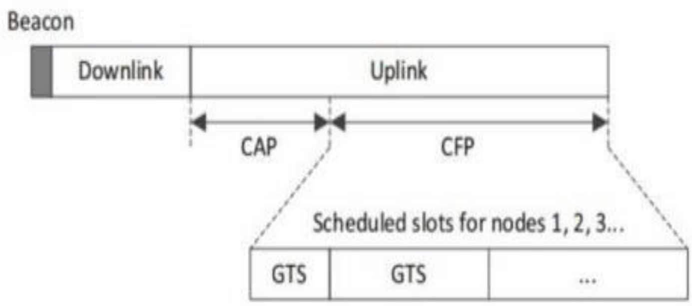

Figure 2. MAC Frame Format.

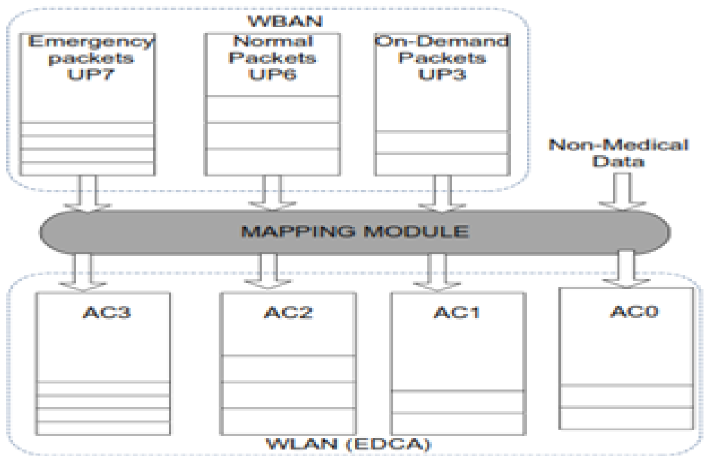

Figure 3. Prioritization in WBAN

```
s 5.068195427 _0_ RTR --- 44 tcp 100 [0 0 0 0] ------- [0:0 4:0 32 4] [12 0] 0 0
r 5.071539488 _6_ AGT --- 32 tcp 210 [13a 6 5 800] ------- [5:1 6:0 32 6] [4 0] 1 0
s 5.071539488 _6_ AGT --- 45 ack 40 [0 0 0 0] ------- [6:0 5:1 32 0] [4 0] 0 0
r 5.071539488 _6_ RTR --- 45 ack 40 [0 0 0 0] ------- [6:0 5:1 32 0] [4 0] 0 0
s 5.071539488 _6_ RTR --- 45 ack 60 [0 0 0 0] ------- [6:0 5:1 32 5] [4 0] 0 0
r 5.074763541 _6_ AGT --- 36 tcp 210 [13a 6 5 800] ------- [5:1 6:0 32 6] [5 0] 1 0
s 5.074763541 _6_ AGT --- 46 ack 40 [0 0 0 0] ------- [6:0 5:1 32 0] [5 0] 0 0
r 5.074763541 _6_ RTR --- 46 ack 40 [0 0 0 0] ------- [6:0 5:1 32 0] [5 0] 0 0
```

Figure 4. Trace File Format

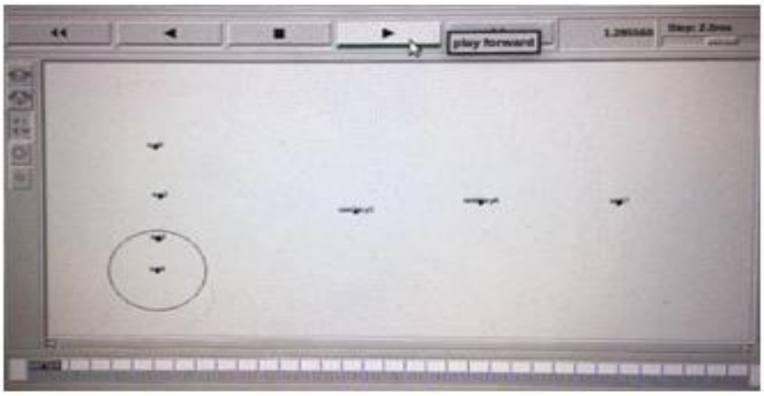

Figure 5:NAM Window

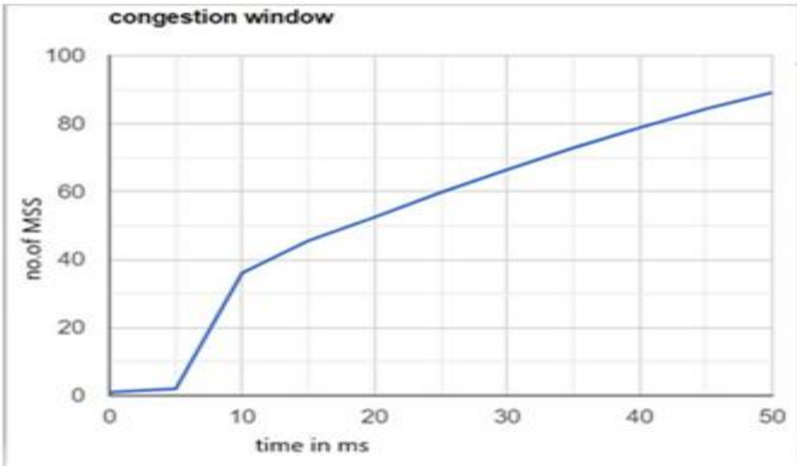

Figure 6:Graph of Congestion Window

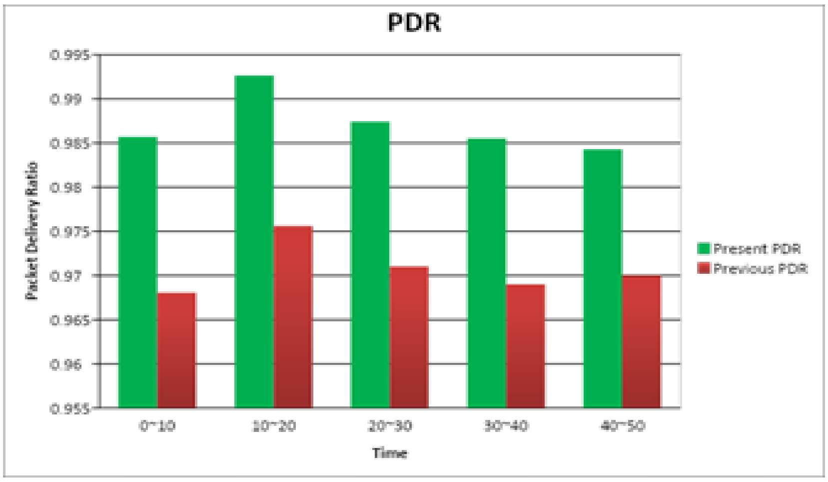

Figure 7:Graph of PDR vs. Time

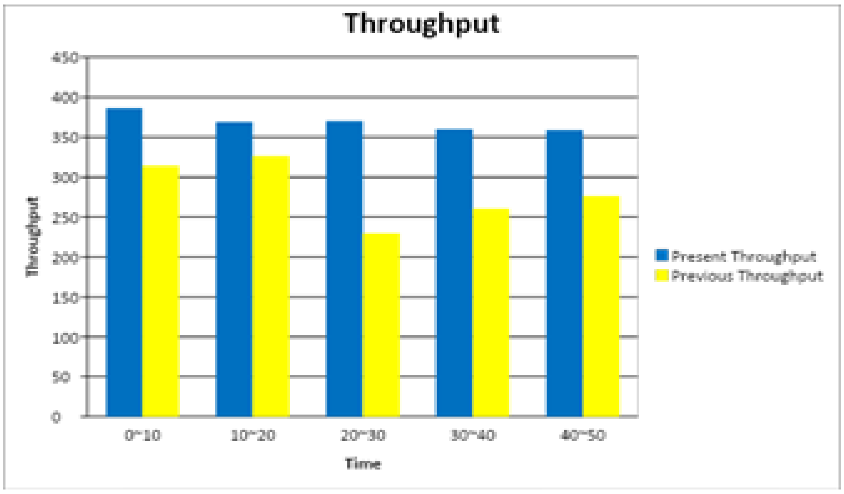

Figure 8:Graph of Throughput vs.Time.

Table I. Node configuration parameters and specifications.

Node Configuration Parameters	**Specifications**
Routing	Ad Hoc Routing DSDV
LL_type	LL
MAC_type	802_11
Queue type	DropTail
Queue length	50
PHY_type	Wireless
Channel Type	Wireless Channel

Propagation Type	Two Ray Ground
Antenna Type	Omni Antenna
Agent Trace	ON
Router Trace	ON
Maximum Packet Size	150
Number of Nodes	7
Simulation Time	50ms

Table II. Comparison of TCP packets vs. Time

Range	Time of first TCP packet	Time of last TCP packet	No. Of send events	No.of receive events	No.of receive events with agent trace
0-10	5	10.99	4788	4720	2312
11-20	11	20.99	7924	7866	3683
21-30	21	30.99	7500	7406	3698
31-40	31	40.99	7312	7206	3594
41-50	41	49.99	6575	6472	3224

7. CONCLUSION

This paper implements a WBAN with CSMA/CA using 802.11e protocol. The congestion window of the network is analysed. This paper also suggests a prioritization method that can be implemented in the network so as to achieve the QoS parameters in the network,which in this case is Throughput and Packet Delivery Ratio.The total number of sent and received packets is found using the trace file over the time interval and the corresponding Packet Delivery Ratio (PDR) and Throughput is calculated as 0.9874 and 370.993kbps respectively. Thus, concluding that the PDR and Throughput values have been improved from previous works.[15].This paper limits its research to PDR and throughput but it is possible to measure other QoS parameters like delay, bandwidth and energy with the same process.

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