DESIGN OF ENERGY EFFICIENT WBAN FOR ENERGY HARVESTING

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Abstract: In this paper we focus on achieving the QoS requirements in WBAN when node would be powered by the human energy harvesting. And detection is improved better quality of data is available for usage and as the battery cannot be removed time and again so the battery power needs to be enhanced. This approach prioritizes the packets and the more important packets are transmitted effectively. As the accommodation in the queue gets better clinically critical data packets having high priority are made available to the doctors. We aim to achieve better detection ability of the data by the sensor and also increase the life of battery. The main feature of the approach is that the battery is powered for the body movements itself and the packets or the more critical and prior data is taken. Not only we are able to detect more important events but the transmission of packets is also done in better way.
Keywords: Body Nodes, Energy Harvesting, Quality of Service (QoS), Wireless Body Area Network (WBAN), Power Aware Management, Wireless sensors

1. INTRODUCTION

Wireless Body Area Network (WBAN) is made up of several medical aids working together in collaboration with the network mainly for the clinical utilities. These medical devices are popularly called as BNs (Body Nodes). These nodes when implanted in various parts of the body have different functionality and normally aimed for the diagnosis of certain medical changes in the body. As the nodes are sometimes implanted inside the body also, so their maintenance and longevity must be ensured so that the health to be monitored is not put in the risk. Though sometimes the nodes can be external also which are carried in the wallets, bags or pockets [1].The implanted sensors are also surfacing. There must be a proper collaboration between the nodes and the server for where the medical data is intended. Furthermore the nodes must be handy and have longer life because the nodes can't be easily replaced [2]. The battery which powers the wireless nodes and also enables the communication by providing the energy.

The explored technique of energy harvesting from the human body movements itself can prove to be quite promising, because without connecting to any other external device using the technique of scavenging the energy from human body for operation of nodes [3]. The various activities such as running, walking can generate power required for transmission by the battery. The energy collected from the nodes can be stored in inbuilt battery which can be chargeable and without any need of external charging. The smooth functioning of the nodes can be ensured. Not only collecting the energy for the functioning of nodes, the delay in the transmission of the packets, also needs to be addressed because the packets are having critical importance in the health of the patient and require proper timely transfer. Also increasing the throughput is one of the aims to be accomplished [4]. The energy that is harvested from the body and stored in the battery. The use of harvested energy can be ensuring the smooth functioning of the Body Nodes [7]. There is the concept of Energy Neutral Operations (ENO) also, which gives a prolonged life to the battery [5].

Focusing on the priority of the messages which are to be sent is another critical functioning which is required in the proper functioning of the body nodes. Because of much of the power is used for the message detection of non priority energy collected would be wasted; the life critical message should be saved and sent. Also the detection capability of nodes must be enhanced and the important message should be saved.

Several works have been dedicated for the energy management in the nodes[9-10]. but there is still a long way which would render the nodes properly feasible in the human body. Although many works focus on several parameters still the priority of data packets and battery longevity are long way to go which we have tried to address.

2. RELATED WORKS

Many works have been dedicated to address the various problems of QoS in the Wireless body area networks. In a work IEEE 802.15.4 was used, its super frame structure aimed at queue and traffic control[11]. Another method utilized Low Latency Queuing along markov chain for managing long range traffic.Gur game approach used for enabling the system to work in low states and harsh environment[12].Some works dedicated for the telemedicine using IEEE 802.11 and Express

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Dual channel mechanism[13-14]. Another author who aimed at saving of energy with low data loss by using the dynamic voltage scaling and modulation[15]. Ernesto Ibara proposed a method of PEH QoS aware management of energy, implemented on the WBAN for the detection efficiency[7]. Authors Shanshau Jian worked using XML for the Qos specifications for WBAN[16].

3. CONTRIBUTION
In the paper we have worked on the human energy harvesting model[7] which used the scarce energy collected from the movements of the body and have added some of the modifications and have used algorithm to address the problem of power energy harvesting aware management and also the congestion of data queue and the aggregation of the packets and scheduling.
To test the performance of the scheme the simulations have been done on various activities such as running, cycling, walking and relaxing to check the detection efficiency along with the throughput.

4. DESIGN
The important parts of WBAN that we consider contain body node, the network coordinator and the server.
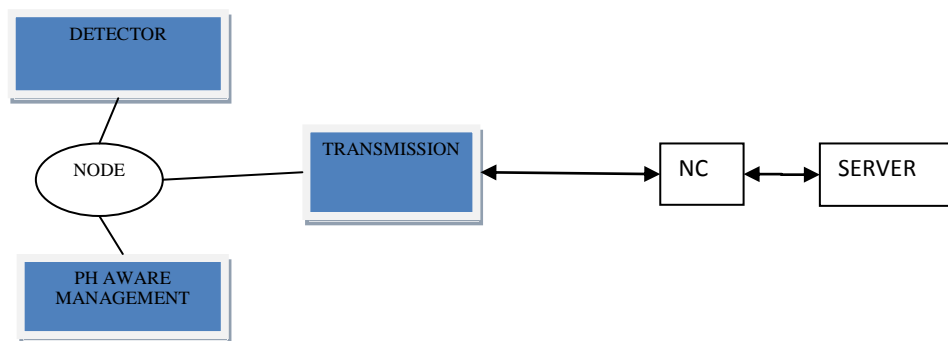

Fig. 1. Design of WBAN

The WBAN design would be having following main parts:
The Major design features of WBAN contain following parts-
Node: Node is apart which can be attached on or off the body and contains three further parts:
Detector- A sensor which would detect various signals that are important and all the other transitions.
Transmitter- Node has another important part which will transmit the signals to and from the node and the external network coordinator.
Power harvester- It is battery module of the sensor, and the energy that is harvested will be stored and used to run the functionality of other parts also.
Network Coordinator: It can be device which will be personal to the user and the data from the node will be sent to the server with help of this coordinator.
Server: The information collected would be given to the server and clinically important data available to the doctor for proper monitoring of the patient.

5. ALGORITHMS
Following algorithms were used in our system
Energy Harvesting Aware Algorithm
if (PBT $\geq$ PDN + PTM) then
TURN THE DETECTOR ON
if (ZPK $\geq$ ZTM AND ZPK $\geq$ 1) then
TURN TRANSMITTOR ON
TRANSMIT ZTM PACKETS
else
TURN TRANSMITTOR SLEEP
end if
else if (PBT < PDN + PTM) then if (PBT $\geq$ PDN) then
TURN DETECTOR ON
TURN TRANSMITTOR OFF
else
TURN DETECTOR OFF
TURN TRANSMITTOR OFF

end if
end if
In the aware energy harvesting algorithms the energy is collected from the human movements and the performance needs to be monitored in the energy harvesting conditions. Body nodes energy would be divided into two major parts. The power required for detection PDN and PTM for the transmission [8] PBT is the energy in battery. If the energy in battery is more than the collective power required for detection and transmission then detector will be turned ON. And ZPK (No. of packets in queue) are more than ZTM (packets to be transmitted) the transmitter would be turned on and detector OFF.

Detection Module Algorithm
if (ZPK > 0) then
for(i=0: ZPK) do
if (Dq (i) $\geq$ Dmax && packetPriority <= 1) then
DELETE DATA PACKET i
else if (Dq(i) < Dmax && packet priority <=0)
DELETE DATA PACKET i
end if
end for
end if
if Event Detected then if (ZPK < MSC) then
STORE PACKET IN DATA QUEUE
SET PRIORITY OF DATA ON EventType
else if (ZPK == MSC) then
DELETE OLDEST PACKET WITH packetpriority $\leq$ 1
STORE NEWEST PACKET IN QUEUE
SET PRIORITY OF DATA
end if
end if
To improve the detection ability the packets are assigned with priority and the packets with less priority and the duplicates one would get deleted. The old packets which are consuming the queue space would be deleted and the new packets with set priorities would be added when MSC   (maximum storage capacity) of the queue is achieved.

Aggregation and Scheduling Algorithm
COMPUTE PTM FOR SINGLE PACKET and CHECK PBT and PACKETS IN DATA QUEUE
If (ZPK = 1) and (ZBT $\geq$ ZDN + ZTM) then
ZPK=1
START COMMUNICATION OF PACKETS else if (ZPK > 1)
then
if(PBT $\geq$ PDN + PTM) then
Compute ZTM
FIND PTM TO MOVE ZTM if (ZPk $\geq$ ZTM)
then
REMOVE THE STALEPACKETS
Set Zcur = 0
for Zcur = 0 to Size (Zq) Repeat
Set Data Current = Data [Zcur];
List Duplicates = Find Element (ZQ, Data [Zcur])
DELETE ZQ [duplicates]
end for
else if (ZPK $\leq$ ZTM) then
RECOMPUTE ZTM
COMPUTE PTM REQUIRED TO SEND ZTM
MAKE PACKETS OF SIZE ZTM
START DATA TRANSMISSION
end if end if
end if
The aggregation and the scheduling of the data packets is very important. The PTM (Power for transmission) is computed and also power in the battery. If the number of packets in queue are equal to the capacity that can be transmitted then the communication is started. ZTM (No. of packets to be transmitted) are computed and also energy is checked. The stale packets are removed. The Date column is added along with the packet and checked ZQ and Zcurrent are matched and duplicate packets are deleted and if no. of packets are less than to be transmitted and wait and make the bundles of similar sized packets for efficient transmission.

6. PERFORMANCE EVALUATION

We have developed OMNET ++ simulator which implements an algorithm in basic WBAN. We consider that there is a simple battery with no energy storage and connected with energy harvester. The elements detected by the sensor are converted into the data packets and stored in buffer. We study the performance of previous PEH QoS and also our enhanced system . We measure the detection efficiency, the length of data queue, the aggregation , the throughput and the packet delay.

Simulation Results

Detection Efficiency
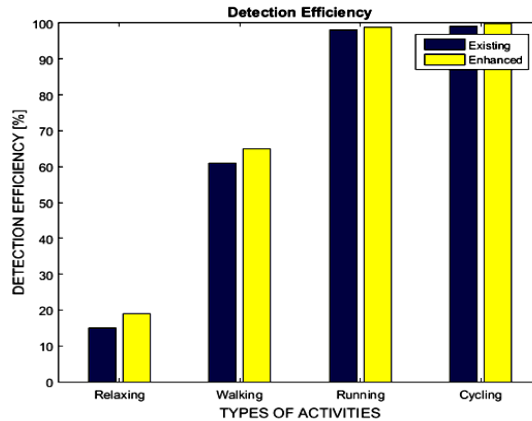
Fig. 2. Detection Efficiency in various activities

Detection efficiency is the number of events that are detected over the total number of events that have actually occurred.

The Fig. 2 presents the result of simulation for the detection efficiency of the body node for the PEH QoS and our enhanced system. We can see that the efficiency increased by at least 2% in case of relaxing and walking and also in high intensity activities such as running.
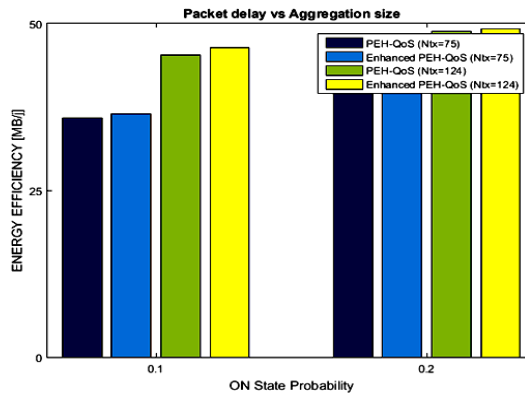

Fig. 3.Packet delay vs Aggregation size

Energy Efficiency is the total bits that were actually transmitted over the total energy consumption.

The Fig. 3 shows the energy efficiency when packets were aggregated in the size 75 and 124. When the packet size Ntx was 75 more bits of data were transferred and so was the case when the size was 124. The results shown are in two probabilities 0.1 and 0.2.

Data queue length is the size of the queue that how many packets are stored in the data queue and the storage efficiency is defined as the number of events that are stored as compared to what were detected.

Fig. 4 depicts the behavior of the queue when time is initialized at zero ms packets start to accumulate and when there is enough energy the packets are transmitted. Enhanced system provides better queue management as the data and priority vise packets are sorted, sent and discarded so the battery also works for useful transmissions enhancing its power also. Packets of more importance are sustained for longer time giving away stale and duplicate ones.
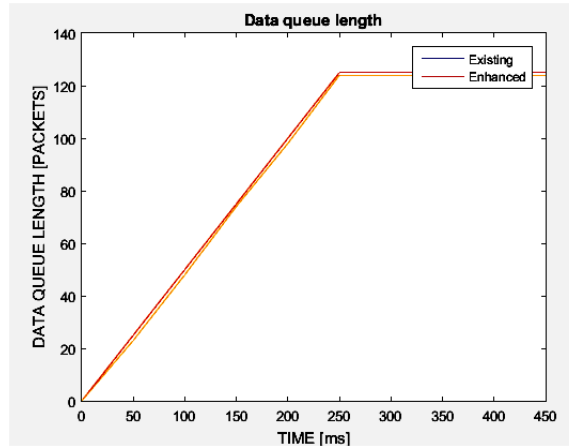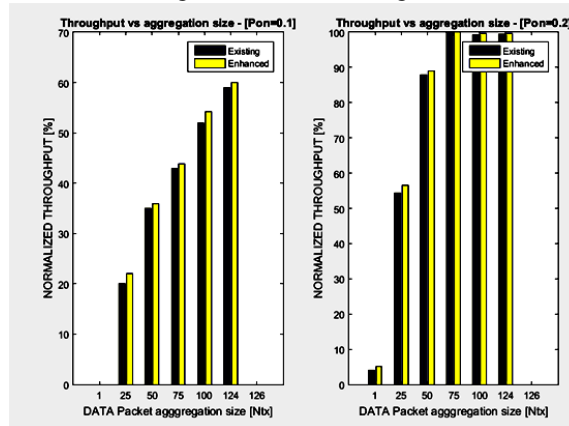
Fig. 4. Data Queue length

Fig. 5. Throughput vs aggregation

Normalized throughput is the number of bits that are successfully transmitted as compared to what bits are generated.
The figure 5 shows that on the on state probability 0.1 our enhanced system achieves higher normalized throughput when the number of packets was 124. And also the probability was 0.2 then also the results were better.
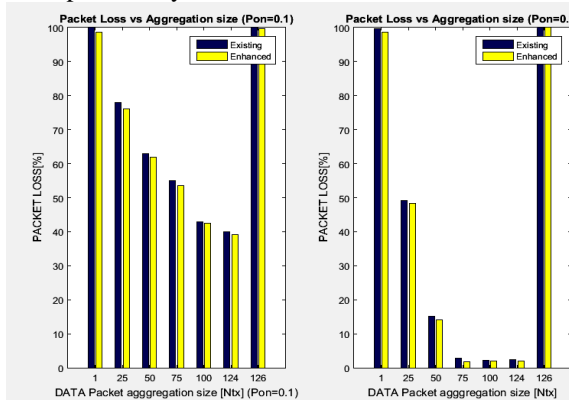

Fig . 6. Packet loss vs Aggregation size

Packet loss is the proportion of the packets of data which due to lack of energy were lost or also because the queue was saturated. The Fig. 6 shows that the relation between the packet loss with the aggregation size in two different probabilities. Packet loss was lesser in the enhanced system and when the aggregation size crossed 124 the loss was more but low in our proposed system also similar results were witnessed at 0.2.
Packet delay is defined as the total time between the generation of the packets and the arrival at the network node. Fig 7 depicts that the percentage of the lost packets is little low in the enhanced system in the packet size 75 and 124.
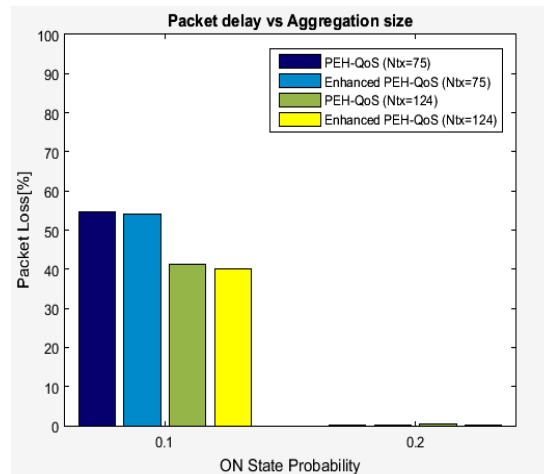
Fig. 7. Packet delay vs aggregation size

7. CONCLUSION AND FUTURE SCOPE

In this paper we have introduced an approach for WBAN run by the human energy harvester . The node performance is improved and provide an efficient method to improve the WBAN by using energy harvested from the body itself. As such the body nodes do not have to be removed again and again the longevity of the node is also improved. In future this work can be carried forward for further enhancing the limits of WBAN.

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