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Priority based data transmission for wireless body area network

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ABSTRACT

Wireless Body Area Sensor Network (WBASN) or Wireless Body Area Network (WBAN) is a growing field in healthcare applications. It enables remote monitoring of patient's physiological data through wireless communication. It is composed of sensor network which collects physiological data from the patient. There are several issues concerning WBAN such as security, power, routing protocol to address QoS metrics (reliability, end-to-end delay, and energy efficiency), etc. The focus of the study is the issue on different QoS metrics. There were several QoS aware routing protocol that has been proposed which implements multiple queues for different types of data. However, one issue on multiple queue system is starvation, end-to-end delay, and reliability. The study proposed an efficient priority queue-based data transmission that improves the end-to-end delay, reliability, and queuing delay of QoS aware routing protocol. It can be seen from the simulation that the proposed algorithm decreases the end-to-end delay of the system and improves the reliability of the system in sending priority packets.

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1. INTRODUCTION

Wireless communication technologies enables healthcare services to provide patient real-time monitoring [1] including diagnosis and therapeutic monitoring [2, 3]. Wireless Body Area Sensor Network (WBASN) or Wireless Body Area Network (WBAN) [4-6] is an emerging trend in healthcare applications [7, 8] which consists of networks of biosensors or medical sensors like electrocardiography (ECG), electroencephalogram (EEG), temperature sensor, blood pressure sensor, etc. These biosensors transmit phsysiological data into a coordinator, e.g. a personal digital assistant (PDA) or smart phones. WBAN allows continuous monitoring of patient's physiological data such as blood pressure, ECG, pulse rate, etc. This enable doctors to monitor abnormal behavior from patient's physiological data. Furthermore, patient monitoring outside the hospital and providing medical assistance to remote areas are made possible through WBAN.

Biosensor are categorized in three types; in-body biosensor, on-body biosensor, and off-body biosensor [9]. These biosensor nodes are low-power battery operated devices [10], therefore, biosensor nodes should transmit data at a minimum power because making a battery replacement is quite challenging especially to the implanted biosensors. The study on [11], make used of time slot reduction technique in sending data thereby reducing the energy consumption of sensor nodes; however, it resulted in the increase of communication delay. Due to the heterogeneity of these biosensor nodes, each node demands different level of quality of service (QoS) to ensure data quality and reliability, and efficiency [12, 13]. Thus, developing an efficient QoS protocol is very challenging considering that different QoS metrics are addressed by different modules [14].

Several QoS aware routing protocol that has been proposed such as Routing Service Framework (RSF) which prioritized routing services and provides QoS for users; however, there is a high overhead due to the control packet [15]. Reinforcement Learning based routing protocol with QoS support (RL-QRP) is proposed by [16] to find optimal routing policy using machine learning approach; however, this approach only works with small scale networks and can't achieve global optimization on large networks. LOCALized Multi-Objective Routing (LOCALMOR) protocol takes into consideration the traffic diversity of a network, latency, residual energy, and reliability; however, it doesn't take into account the energy efficiency and scalability of the network [17]. Data-centric Multi-objectives QoS aware routing protocol (DMQoS) improves the delay and reliability of the nodes offering data-centric QoS but the energy consumption also increases thereby reducing the battery lifetime [18, 19]. With the limitation of DMQoS on energy consumption, Energy aware Peering Routing protocol (EPR) was proposed by [20]. EPR addresses the limitation of DMQoS using the "hello packet" to choose the next hop on the neighboring nodes. QoS aware Peering Routing for Delay sensitive data (QPRD) and QoS aware Peering Routing for Reliability sensitive data (QPRR) are proposed to improve the delay and reliability of the network, and have lower energy consumption [21, 22]. The QPRR performs better than EPR and DMQoS in terms of energy consumption and end-to-end reliability. [23] also proposed a QoS aware routing protocol which focuses on improving the energy efficiency of WBAN by considering the number of packet loss and energy wastage caused by idle listening.

These studies on different QoS aware routing protocol showed significant improvement in different QoS metrics; however, it can also be seen from these studies that there is still a need for further optimization to achieved better performance in terms of reliability, data quality, end-to-end delay, and energy efficiency. QoS aware routing protocol uses modular approach which includes delay module, MAC receiver module, routing service module, hello protocol module, packet classifier module, QoS aware queuing module, MAC transmitter module which deals with different QoS metrics. However, the study will only focus on enhancing the QoS aware queuing module. QPRR, QPRD and DMQoS protocol used different queues for different types of packets such as ordinary packets (OP), reliability service packets (RSP), critical data packets (CP), and delay-driven packets (DP).

These types of packets have corresponding priority levels wherein OP has the lowest priority and CP having the highest priority. Since the queuing model caters to numerous simultaneous packets of different priorities this may lead to starvation issue. Starvation often occurs when lower priority packets are block by a higher priority packet leading to increase in transmission delay by the QoS aware routing protocol. QPRR, QPRD and DMQoS protocol address starvation by the method called "aging" wherein lower priority packets will increase priority over time. However, when higher priority queue fails to send the data within the allotted time, the packet will become a lower priority packet for a period of time before it can be considered as service packet and be inserted to the higher priority queue again, which can also increase the end-to-end delay. The study proposed to enhance the QoS aware routing protocol for WBAN by introducing an efficient priority queue-based transmission that lessens the queuing delay and end-to-end delay. Moreover, the efficient priority queuing algorithm have an error handling mechanism to ensure reliability.

2. RESEARCH METHOD

In this project we create a network topology. It is of consists n- sensor nodes, 1- server, and 1-sink as shown in Figure 1. All nodes have a data to transfer with flag values. The flag values are [1-4]. The flag values are specify the priority of the data like the 1-OP, 2-RP, 3-DP, 4-CP. Based on the priority of the packet it will make a separate queue. Then, perform the data transmission based on queue. If, any data loss occurred, the system reconstruct the queue, based on the priority of the data. Again perform the data transmission, based on priority queue as shown in Figure 2. We plot the result graph for end-to-end delay vs. No. of nodes, queuing delay vs. No. of nodes, and reliability vs. No. of nodes. NS3 simulator was used to perform simulations for comparing the performance of the proposed enhanced QoS aware protocol based on alternative queuing.

The proposed enhancement focuses on the modification of QoS aware queuing into priority-based queue data transmission. The QoS aware queuing classifies the packets as ordinary packets, delay sensitive packets, reliability service packet, and critical packets. The QoS aware queuing module prioritizes the higher priority packets during transmission. The lower priority packet will only be sent if the higher priority queue is empty. Furthermore, if the higher priority queue fails to send the packet during transmission the packet will be sent to the lower priority queue and wait some time before it will be having a higher priority. The proposed architecture aims to solve the starvation issue on the QoS aware queue by introducing an alternative queuing system. The proposed algorithm will create a separate queue that will hold the different classification of packets. The alternative queue will still follow the priority scheduling wherein the CP will still have the highest priority and the OP having the lowest priority. This method will eliminate the issue on starvation on multiple queue system by giving each packet to use the shared resources. The error handling mechanism will ensure that the packet will not be drop immediately even if error occurs. The system will check and notify the scheduler if the first batch of packets has been completed. If the scheduler is empty, then the proposed system will notify the QoS aware queuing to release the next batch of packets.

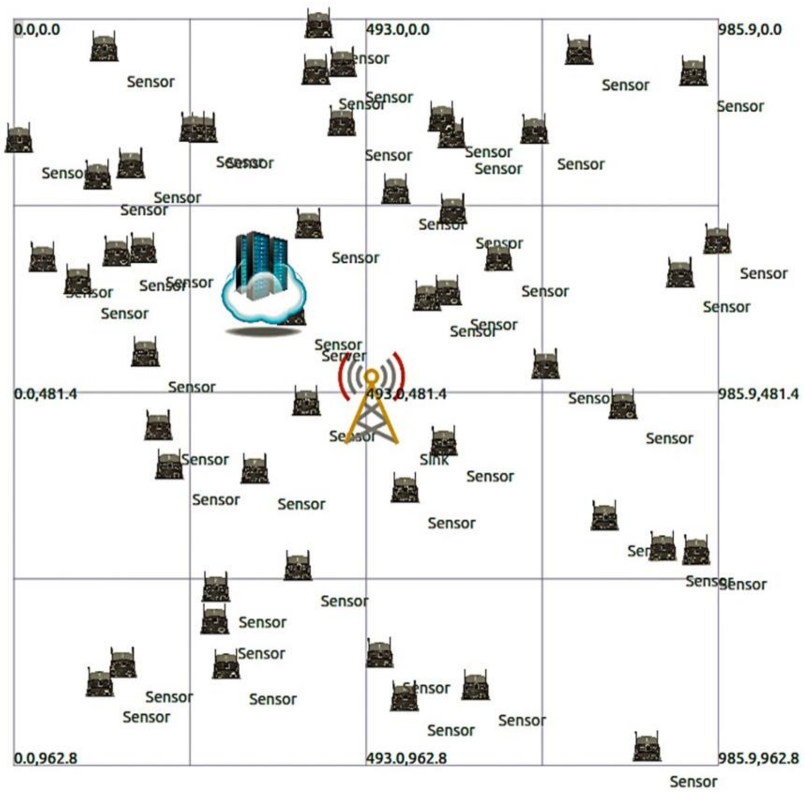

Figure 1. Network Topology of the system

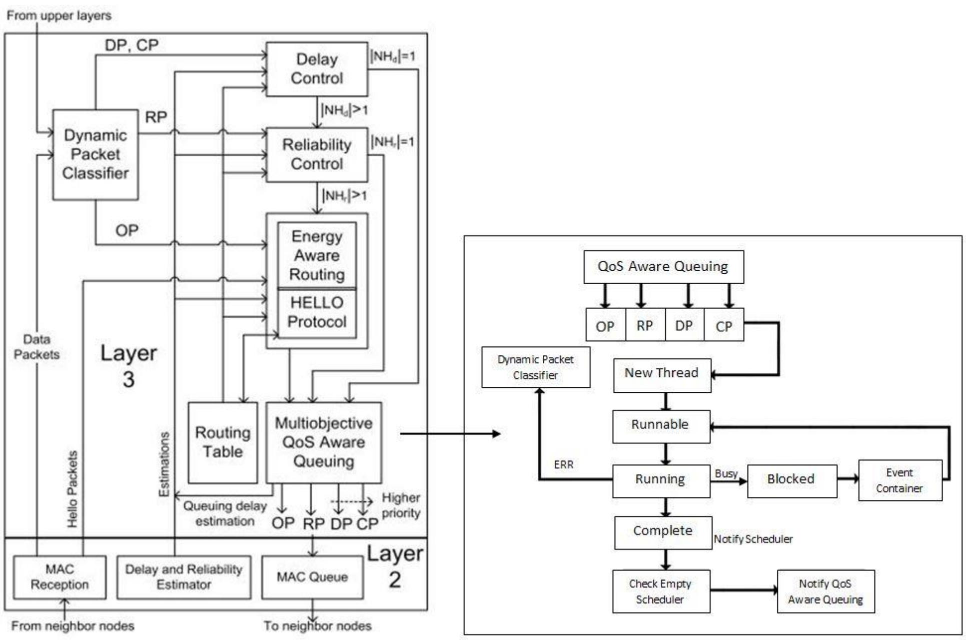

Figure 2. Priority based queue data transmission architecture

3. RESULTS AND ANALYSIS

This section presents the simulation results using NS3 Simulator in terms of QoS metrics such as queuing delay, reliability, and end-to-end delay. The results are compared with the existing QoS aware routing algorithm such as DMQoS [18] and QPRR [21].

Algorithm of the proposed priority-based queue data transmission

Dynamic Packet Classifier
Input Packet p
for each receive *p* **do**
    Determine p.Priority
    if (*p.Priority*==OP) **then**
        opQueue.push(p)
    else if(p.Priority==RP) **then**
        rpQueue.push(p)
    else if(*p.Priority*==DP) **then**
        dpQueue.push(p)
    else if(*p.Priority*==CP) **then**
        cpQueue.push(p)
    end if

create new queue
    nQueue[size=4]
    nQueue(getPacket(opQueue[head]),getPacket(rpQueue[head]), getPacket(dpQueue[head]),getPacket(cpQueue[head]))

Priority transmission
for each *p* **on** *nQueue* **do**
    transmit
        if(**transmit**==FAILED) **then**
            send p to dynamic packet classifier
        else
            if(*nQueue.empty*==TRUE) **then**
                create new queue
        end if
end for

The dynamic packet classifier determines the priority of each packet coming in the system. It enqueues packet *p* in its corresponding queue. The system then generates new priority queue by getting the head of each queue (OP, RP, DP, CP). This priority queue was transmitted based on packects priority accordingly.

3.1. Queuing Delay

The average queuing delay is the time the packet waits in the queue before it can be transmitted to the next node. The average waiting time of the data packets in the queue is computed as shown in (1).

$$W\_q = \lambda/\mu(\mu - \lambda) \quad (1)$$

Where: L_q is the length of queue and W_q is the waiting time in the queue, λ is the inter arrival time (Poison distribution), μ is the service time (exponential distribution). It can be seen from Figure 3 that the proposed priority based queue transmission performs better than DMQoS in terms of queuing delay, however, it can be seen that the QPRR is better because QPRR only consider two (2) types of priority which is OP and RP.

3.2. End-to-end delay

The end-to-end delay is the time taken for packet to be sent from source to the destination. The end-to-end delay of the system is shown on (2).

$$D\_Total = D\_Tx + D\_prop + D\_q + D\_ack \quad (2)$$

where: D_Total is the total delay (end-to-end delay), D_Tx is the transmission delay, D_prop is the propagation delay, D_q is the queuing delay, D_ack is the acknowledgement delay.

Based on Figure 4, the end-to-end delay of the proposed priority-based queue transmission is lesser than that of DMQoS and QPRR. It implies that the proposed system transmits the packet from a source to destination faster than the existing QoS aware routing protocol.

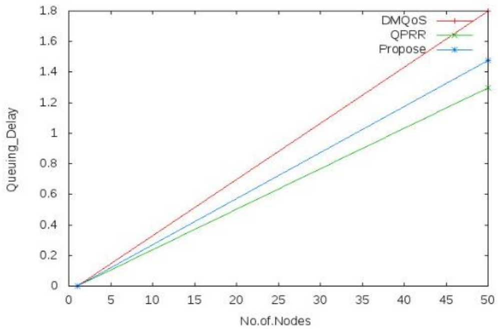

Figure 3. Queuing delay

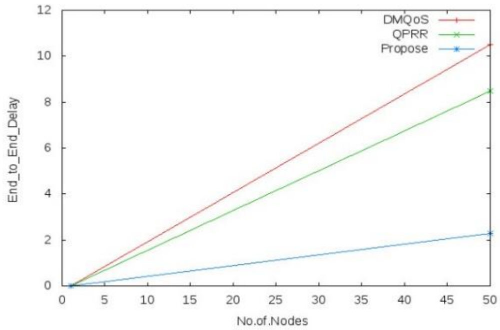

Figure 4. end-to-end delay

3.3. Reliability

WBAN packets are sensitive to packet loss during transmission. To minimize the packet loss on the link, the system uses retransmission on the link. Therefore, the reliability on the on the network increases as the reliability on the link or node increases. The reliability on the node is calculated using exponentially weighted moving average (EWAD) given by (3).

$$L\_R=(1-\gamma)\ L\_R+\gamma\ Tx\_succ/Tx\_total \qquad (3)$$

where: Tx_succ is the number of successful transmitted packets, Tx_total is the total number of transmitted packets, and γ = average weighting factor.

Figure 5 shows the simulation result for the reliability of the system. The proposed architecture sends data more reliable than DMQoS and QPRR. This implies that the data from the sensor nodes reaches the destination without loss. The proposed archicture overcomes the issues on data loss and startvation of multiple queues. This is because the proposed architecture has an error mechamism that reconstruct the queue based on the remaining priority if data loss occurs.

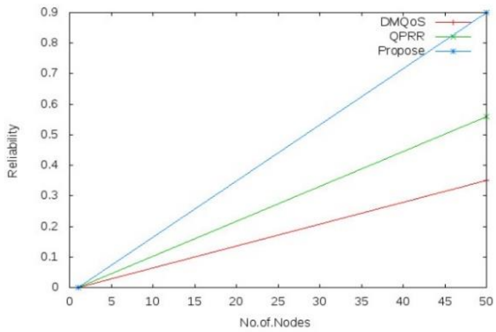

Figure 5. Reliability

4. CONCLUSION

A priority-based queue transimission has been proposed to enhance the QoS aware routing protocol in terms of end-to-end delay, reliability, and queuing delay. NS3 simulator was used to evaluate the proposed enhancement to the QoS aware routing protocol. The output of the simulation shows that the study performs better than DMQoS and QPRR in terms of end-to-end delay, reliability, and queuing delay.

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