Improved ELBPQA Protocol for Clock Synchronization in Wireless Body Area Network

Anuja, Paras Chawla, Sukhpreet Singh

ABSTRACT---A network that is designed to sense the conditions of human body and pass the sensed information to base station is called wireless body area network. Due to such unique property of the network channel sensing and energy consumption are the major issues. In this research, channel sensing in wireless body area network is studied. The protocol called ELBPQA is proposed which assign priority to the data for the transmission. To improve performance of ELBPQA protocol, the clocks of sensor nodes are synchronized using time lay technique. The improve ELBPQA protocol and ELBPQA protocol, are compared in terms of throughput, packetloss and number of dead nodes. The performance of proposed protocol is high as compared to ELBPQA protocol.

Keywords—ELBPQA, Clock Synchronization, time lay, WBAN.

INTRODUCTION

A radio frequency based wireless technology through which the nodes are interconnected with sensor or actuator capabilities placed within or on the human body is called WBAN (Wireless Body Area Network). The body functioning of humans and the properties surrounding them are monitored by the body sensors which act as nodes in these networks. The regions such as entertainment, sports, military, and first aid and so on include the deployment of WBANs. For health care professionals as well as patients, high flexibilities and cost saving options are provided when WBAN is deployed within medical monitoring and other health applications. In comparison to the current electronic patient monitoring systems, two significant benefits are provided by WBAN systems [1]. The mobility of patients using portable devices is permitted which is known as the first benefit. Further, a mobile SBAN can search and identify one appropriate communication network for transmitting data to a remote database server. This means that being an autonomous device, the location independent monitoring facility can be provided by this network which is its second advantage [2]. For transmitting the data, WBAN also connects itself to the internet. Either on or closer to the individual, a hub device is placed with which the body sensors installed in human body communicate. Important properties of human body such as blood pressure, and temperature are measured by the body sensor and then the measured data is sent to the hub. Another longer-range network might be used by hub device to communicate with others [3]. The data of body sensors is forwarded to the body coordinator in BAN. In WBAN, the body coordinator behaves as a router and also communicates with other devices present in the network. The mobile devices are deployed in the network which helps in transmitting information from the human body to the external world. It is possible to use the routing techniques for WSN for establishing communication among two of these devices [4]. There can be centralized or distributed kind of communication architecture included in these devices.

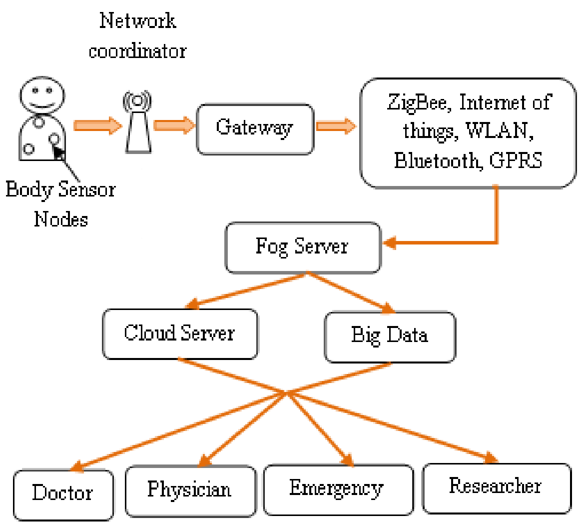

Figure 1: Architecture of WBAN

On the basis of data transmission process which aims to improve the quality of service (QoS), the overall architecture of WBAN is shown in figure 1. Certain advantages like improvement of throughput and reliability, reducing the delay and failure are included in an effective WBAN data transmission process [5]. However, when transmitting the emergency medical data, certain issues like unscheduled traffic loads, lack of prioritization, limited data rate and short distance arise.

The current routing protocols are not well suitable for WBAN due to their typical properties. Monitoring the real-time patient monitoring system is the major objective of Medium Access Control (MAC) protocols designed for WBAN [6]. Highly energy efficient protocols which provide collision-free transfer are introduced. The scheduled and random access protocols are the two broader categories

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among which all the MAC protocols are categorized. By accepting packet delay and packet loss, high quality of service is provided by scheduled access protocols. Only once a message to transmit the data is received by the node the resources are allocated to the communicate nodes in case of random access protocols [7]. Better efficiency is achieved at varying traffic load. The protocol in which the transmission channel contention is absent since deterministic delay is ensured with it along with no packet loss is called Scheduled TDMA MAC Protocol. An on-demand access protocol which can be used in short range communications for the specially designed networks is called Random Access MAC Protocol (RA-MAC). The master-slave architecture which is based on the scheduled transmission approach is called polling MAC protocol [8]. For avoiding any contention probability, central controller is provided in this protocol. A duty-cycling protocol in which the node is open for limited time known as active time is called TMAC protocol. Depending upon the traffic load of the network, the duty cycle can vary. The protocol which includes fixed duty cycle is called SMAC. Better efficiency is achieved for varying data rates included in WBAN [9]. A protocol which uses two different techniques named CSMA/CA or TDMA is called ZigBee MAC. Average output is achieved if CSMA/CA scheme is used in this protocol. However, maximum extent of power consumption is reduced if TDMA scheme is used. Another type of MAC protocol which uses CSMA/CA scheme is called baseline MAC [10]. Throughput achieved here is average even when energy consumption is not average. Another energy-efficient protocol which provides higher efficiency and minimizes the delay within normal as well as emergent packets is called QS-PS MAC.

The wireless body area network is the decentralized type of network in which wireless nodes can join or leave the network. The channel sensing is the efficient approach which can maintain quality of service in the network. The various MAC protocols are proposed in the previous research for the efficient channel sensing. The TDMA is the reliable protocol which can provide efficient channel sensing in the network. The TDMA protocol works, on the basis of time slots which are assigned to every node in the network for the communication over the wireless channel. Due to decentralized nature, clocks of the sensor nodes are not well synchronized which leads to TDMA does not work efficiently and it leads to packet loss in the network. The efficient clock synchronization scheme is required for WBAN for channel sensing.

Literature Review

Wen Huang, et.al (2015) proposed a medium access control (MAC) layer protocol such that the inter-WBAN interference could be handled [15]. A coordinator and multiple sensor nodes were included in every WBAN. In case when multiple nodes were forwarding data to their coordinators at one time, interference could occur. On the basis of perceived interference level, the proposed protocol was able to adjust the frame length using coordinator in adaptive manner. For minimizing the sensing power consumption of sensor nodes, a sensing mechanism was designed here. Also, for providing multi-channel and QoSsupport, the extension of protocol was discussed here. It was seen that the proposed approach was highly effective as per the simulation results.

Xin Qi, et.al (2015) studied about the energy harvesting wireless body area network (EH-WBANs) which faced link scheduling related issues [16]. In these networks, sensor devices provide heterogeneous energy harvesting mechanisms as well as temporally variant data rates. Adaptive TDMA-based protocol (AT-MAC) was proposed in this paper for increasing the channel utilization with lifetime operation. For the remote monitoring of physiological signals, this proposed protocol was used to perform communication in an EH-WBAN. It was seen that for realizing the lifetime operation within EH-WBANs, the proposed protocol acted as a promising candidate.

Raoua Ben Hamouda, et.al (2017) proposed a high-level model initially, named as Statistical frame based TDMA protocol (STDMA) for body area networks [14]. The TDMA bus arbitration was utilized by this protocol in which temporal aspect modeling was also required. Further, at a high level abstraction, a formal validation of various relevant properties was proposed here. This research used the generation of timed automata components and real-time model checker was used to perform verifications for this protocol.

SoumenMoulik, et.al (2017) proposed a research which aimed to maximize the probability of reliability in WBANs. For this, an adaptive MAC-frame payload tuning technique was proposed [13]. The parameters of standard MAC protocol were tuned effectively such that the reliability of sensor nodes could be increased. Finally, it was seen that if payload was tuned appropriately with proposed algorithm, low rate and low power IEEE 802.15.4 could be applied effectively in WBANs. For critical node in WBAN, the proposed protocol provided around 70% of increment in reliability.

Ambigavathi.M et.al (2018) proposed a novel ELBPQA (Energy Efficient and Load Balanced Priority Queue Algorithm) using which the critical data could be transmitted using minimum possible delay in WBAN [11]. High, medium and low priorities were provided in this research. The hardware scheduler was used to schedule and transmit the data on the basis of priority. It was seen through the experimental results that in terms of power consumption, delay and throughput, the performance of proposed approach was known to be better.

Xin Yang, et.al (2018) proposed a new MAC layer protocol through which the energy efficiency of WBANs could be improved along with increase in their lifetime [12]. Particular merits from collision avoidance and TDMA approaches were extracted and merged with CSMA for designing a hybrid technique. Further, at the personal station side, the important transmission overhead was allocated. For improving the energy efficiency, a novel awaiting order state was designed for the sensor nodes. Around 6 to 15% of reduction in energy consumption was achieved as per the results achieved from simulation results.

RESEARCH METHODOLOGY

The standard IEEE protocol is used to transmit the data along with a designed protocol named ELBPQA. Scheduling the packets on the basis of priority of data packets is the major aim of this protocol. By identifying the generated location, the verification of data received from personal computers is done initially. The classification of packet is done on the basis of data priority if it originates from local location. If any packet is being received from a certain remote location, its severity is verified. The scheduling of packet in the queue is done on the basis of condition. In order to process the incoming packet, four various types of queues are maintained which are high priority, medium priority, low priority and normal data queue. Further, the packet can be prioritized by the scheduler and for further processing it will be forwarded into the hardware scheduler. As shown in figure 2, four queues are available in this configuration, which are high, medium, low and normal. Any of the queues is assigned the packets. The types of packets assigned to any queue are determined with the help of access lists. If the packets are held for a long time, they are forwarded by the scheduler to the queue with higher priority. If there are no packets in the high priority queue, the queue with medium priority can be processed. Similarly, packets included in the queue with least priority are processed in case if the queues with high and medium priorities do not have any packets.

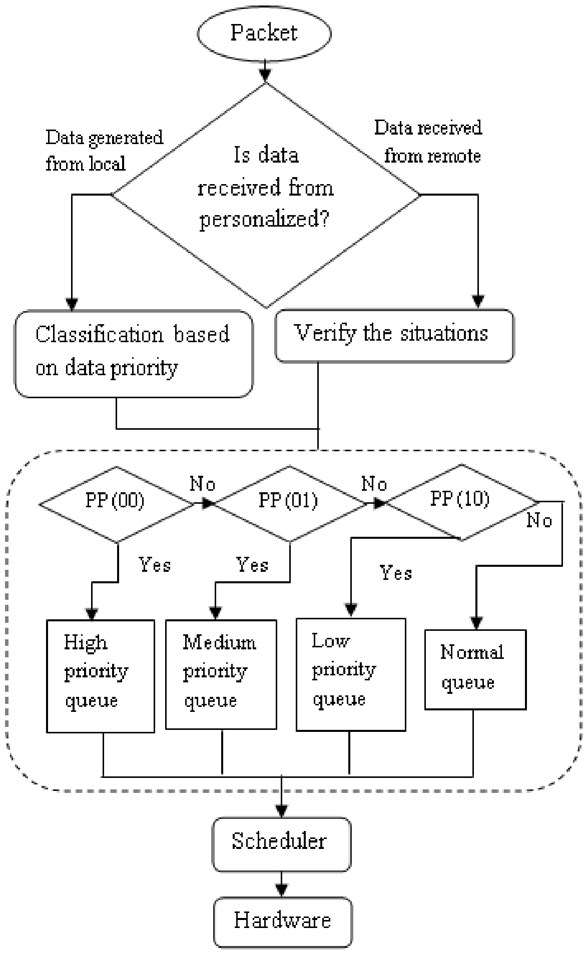

Figure 2: Layout of ELBPQ Algorithm

Priority Classification: Here, depending on how severe is the data traffic, the data packets are scheduled. Certain categories are assigned for this scheduling, which are explained below:

Packet Priority 1 (PP1): The class with the highest priority which aims to support any kinds of emergency actions is PP1. Any kinds of emergency conditions are only to be processed with emergency actions. Due to its acyclic nature that has low recurrence rate, PP1 is always critical. Particularly, for this traffic, more reliable routes need to be provided.

Packet Priority 2 (PP2): The medium priority data which supports extremely critical and serious situations is included in this class. The cyclic or acyclic serious traffic which has high recurrence rate is represented here.

Packet Priority 3 (PP3): For periodic monitoring this priority is considered. One or more packets are transmitted during each particular interval. The packets are prioritized as high, medium and low depending upon their conditions.

The ELBPQ assign the priority to the data based on the type of data. To improve the efficiency of ELBPQ algorithm, the approach of clock synchronization is proposed I this work. The time lay is the technique is applied with the ELBPQ protocol to synchronize clocks of the sensor nodes. In the clock synchronization process, will be taken place by the scheduler which is one hop to base station. The scheduler will send the clock synchronization message to all sensor nodes. The sensor nodes receive message and present its clocks to the scheduler. The scheduler will calculate average time and send average time to the sensor nodes. The sensor nodes, the adjust its clocks according to the average time. The time lay technique leads to synchronization of clocks of sensor nodes.

Proposed Algorithm

Input: Sensor nodes
Output: Synchronization of sensor nodes
Begin
1. Deploy network with the finite number of sensor nodes
2. Define scheduler in the network which forward information to base station
3. Clock synchronization
3.1 Scheduler sends the clock synchronization message to all nodes in the network
3.2. Sensor nodes present its clocks to the scheduler
3.3. The scheduler calculate average time based on the sensor node time
3.4 As per the average time, the clocks are adjusted by the sensor nodes.
4. Step 3 repeats until clocks of the sensor nodes get synchronized
5. Assign priority to the data packets for the classification at the scheduler
End

RESULTS AND DISCUSSION

The proposed methodology is implemented in MATLAB. The eight number of sensor nodes are used for the information sensing which sense information and pass it to

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base station. The two scenarios are implemented and compared in terms of certain parameters. In the existing scenario, the priority to the data is assigned for the transmission to base station. In the proposed scenario, the clock synchronization process is initialized which can synchronize clocks of the sensor nodes. The parameters which can used for the performance analysis are number of dead nodes, number of packet dropped, throughput, energy consumption and delay

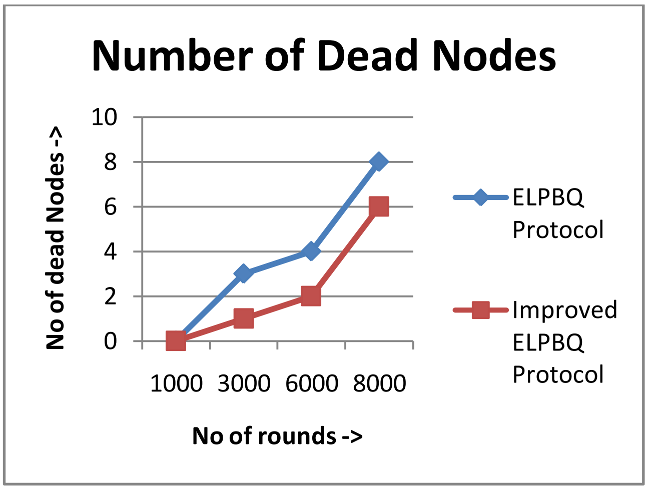

Fig 3: Number of dead Nodes

Figure 3 shows the comparison of ELPBQ protocol with the improved ELPBQ protocol for the performance analysis. The improved ELPBQ protocol has less number of dead nodes as compared to ELPBQ protocol

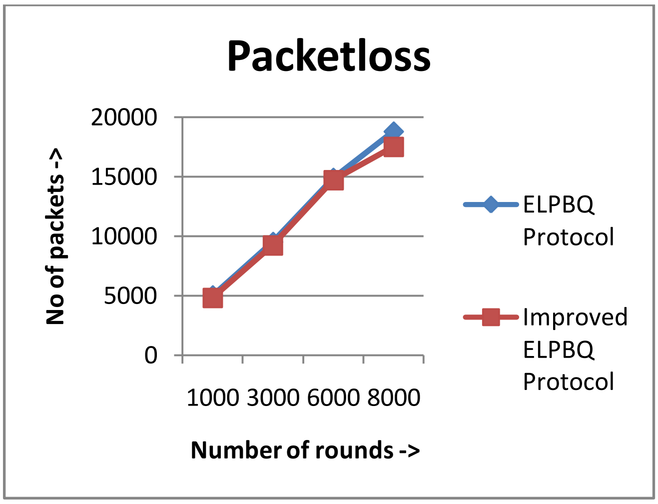

Fig 4: Packetloss Comparison

Figure 4 shows the comparison of packet loss of ELPBQ protocol with improved ELPBQ protocol. Due to clock synchronization in the network, the packetloss of improved ELPBQ protocol is low as compared to ELPBQ protocol

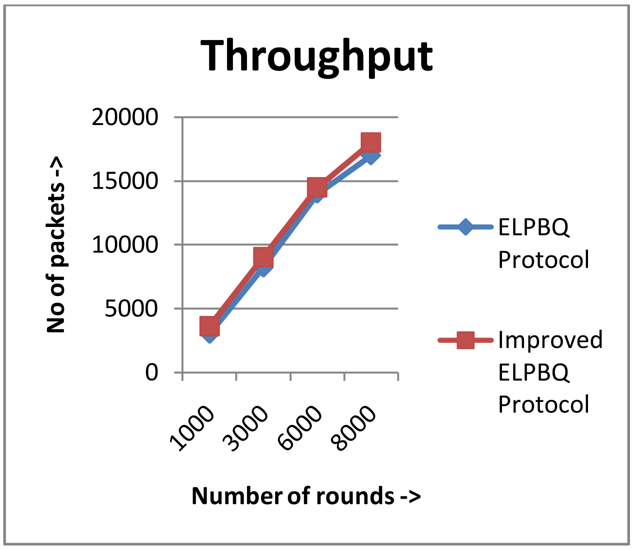

Fig 5: Throughput Comparison

Figure 5 shows that in comparison to the improved ELPBQ protocol, the throughput of existing ELPBQ protocol is less. In the improved ELPBQ protocol, synchronization of clocks of sensors is done which increase throughput of the network as compared to ELPBQ protocol.

CONCLUSION

In this work, it is concluded that wireless body area network has major issue of channel sensing and lifetime. The ELPBQ is the protocol which can prioritize the data according to its type which is given to scheduler for the classification. In this work, the ELPBQ is improved using time lay for the clock synchronization. When the ELPBQ protocol is improved for the clock synchronization then the performance of ELPBQ get increased in terms of throughput, packetloss and number of dead nodes. In future, the approach will be proposed which improve security of the improved ELPBQ protocol.

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