IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Vol. 8, Issue 8, August 2019

Development of Energy Efficient Wireless Body Area Network (WBAN) based on Modified CPMAC Protocol

Shraddha Nagar[1], Navneet Agrawal[2]

M. Tech, Scholar, Department of ECE, CTAE, MPUAT, Udaipur, India[1]

Assistant Professor, Department of ECE, CTAE, MPUAT, Udaipur, India[2]

Abstract: 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). 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 studied which assigns priority to the data for the transmission. The ELBPQA protocol assign priority to data packets but clocks of the sensors are not synchronized which affect its efficiency. To improve performance of ELBPQA protocol, the clocks of sensor nodes are synchronized using time lay technique. The improved ELBPQA protocol and already existing ELBPQA protocol, are compared in terms of throughput, packet loss and number of dead nodes. The performance of proposed protocol is high as compared to ELBPQA protocol. It is analyzed that when the clocks of sensor nodes are synchronized then the Packet Delivery Ratio is optimized up to 8%, power consumption is reduced by 5%, delay is reduced up to 5% and throughput is improved by 10%.

Keywords: Time-lay, Clock Synchronization, ELBPQA, WBAN

I. INTRODUCTION

There are several challenges being faced when the human body is monitored within the medical health applications due to which wireless sensing network is applied. The common concept of data acquisition is found when examining the human body within the studies of biomedical signals [1]. Responses are given by a human body depending upon the scenario in which it is available. On the body of a patient, various sensors are deployed strategically such that all of the features can be monitored. Thus, a Wireless Body Area Network (WBAN) is generated through this. The functions of a body are monitored using a number of portable, autonomous and miniaturized sensor nodes in WBAN [2]. Within the natural physiological states, the health of patients is monitored without causing much affect on their normal actions through WBAN. The deployment of WBAN is done depending upon the radio frequency. Here, there is an interconnection amongst the small nodes of the network. A radio frequency based technology in which the small nodes are interconnected with each other using sensing unit or actuator capabilities is called WBAN. For providing support to several medical and non-medical applications, the nodes operate in close vicinity or within the human body. The physiological data is achieved from sensor nodes of WBAN with the help of medical bands [3]. The interference is minimized and the coexistence of sensor nodes with other network devices that are deployed within the medical centers is increased by selecting an appropriate medical band. The medical gateway wireless boards are utilized by the multi-hopping approach for transmitting the collected data to remote stations [4]. In medical science and human healthcare applications, the usage of WBAN has been appreciated at high level. Also within the biomedical and other scientific regions, a certain level of contribution is provided. Further, within the non-medical areas like personal entertainment or clients electronic devices, these applications have been spreading on huge scale. A technology through which the fitness and health of patients can be monitored and controlled through automated devices is called Body Area Network (BAN). Several low powered devices known as sensor nodes are linked with each other and to a Micro-Controller Unit (MCU) to perform certain emergency actions [5]. To ensure that the important data is transmitted from one node to another radio transceivers are available in these networks instead of wired connections which speed up the performance. There are two methods in which the coordinator can function. Either the data is transmitted to a health care monitoring system through the gateway or the self control hub is included that performs local monitoring. Wireless MCU has been designed lately to improve the performance of networks. WBANs are deployed within several application areas today due to the several advantages they provide. It is possible to provide remote monitoring of data, provide interface for diagnostics, and provide health treatment in hospitals with the help of W-Health Care BANs [6]. The continuous monitoring of patients and providing them the appropriate medication is possible through these

applications. For monitoring purposes, there is no need for the patients to be connected to larger technologies anymore. The interplanetary communication was the base on which the concept of Delay or Disruption Tolerant Networks (DTNs) originated. A continuous end-to-end link was assumed to exist amongst the distant devices and local control center when providing communication to distance satellites [7]. Amongst two communication partners, common occasional links exist which result in huge disruptions and thus longer delays within the complete chain of communication. There are some traditional protocols such as TCP or UDP which are applied for communication. However, higher delays and disruptions cannot be handled by these protocols since the permanent and stable end-to-end topologies that are not available within the outer space are a major factor on which they depend [8]. However, reliable and secure communication is provided by DTN protocols which are proposed lately by researchers. Amongst two communication partners a dependable hop-by-hop communication is established when there is a physical radio link present amongst any two partners.

II. LITERATURE REVIEW

Ambigavathi.M et.al (2018) presented a new scheme for the transmission of critical data by ensuring the least delay in networks [9]. This approach uses the IEEE 802.15.6 standard for developing Energy Efficient and Load Balanced Priority Queue Algorithm (ELBPQA). As per the location, the packet obtained from personalized device was classified primarily. The packet will be scheduled on the basis of deadlines if the packet is received from remote area. High, medium and low priority, are the three different levels in which priority is provided. The hardware scheduler is used to schedule and transmit the data on the basis of priority. It was seen through the evaluations that the performance of propose research algorithm was better in terms of several parameters.

Ping Zhang et.al (2018) proposed [10] Multi-functional secure Data Aggregation scheme (MODA). In this research, the author specifically used homomorphic scheme to work on cipher text aggregation and end-to-end security. In this study, Random selected encryption Data Aggregation (RODA) and COmpression based Data Aggregation (CODA) were two newly approaches. These approaches were considered as advanced and developed techniques. The function of RODA was to decrease communication cost at the margin of lesser and extra security on the leaf node where as the purpose of CODA was the decrease in communication cost by lowering the rate of accuracy. The researcher concluded from the obtained results that the superior performance results could be achieved by proposed approach in comparison with other existing approaches.

Ashwini Umare, et.al (2018) introduced a novel routing protocol based on cluster for Wireless Body Area Networks. The Genetic Algorithm [11] was utilized for the optimization of proposed approach. Darwinian Principle of Natural Selection was the inspiration of Genetic Algorithm. Genetics proved one of the most significant optimization methods. The proposed GA based scheme for WBANs produces much improved outcomes were produced by the introduced approach in comparison with other existing protocols in terms of several factors such as life span of network, formation of cluster head, power exhaustion and network throughput. The proposed approach may be modified in future through the consideration of different body positions. In future, security system can be applied for ensuring safe data transferring.

Srinivas Doddipalli, et.al (2018) presented a planar Ultra Wide Band (UWB) antenna with the slotted substrate for WBAN applications [12]. This antenna is constructed with an advanced elliptical shaped radiator was utilized for the construction of this antenna. In this antenna, slots on the patch surface and a curved shape imperfect ground plane with adapted substrate shape were etched. At higher frequencies, the return loss performance was improved by new substrate arrangement. The proposed antenna occupies the minimal area was occupied by the proposed antenna which was 646.88mm2. The wide frequency range from 2.94 GHz to 17.6 GHz was covered by the proposed antenna in comparison with other existing structures. For achieving improved performance characteristics, the effect of different slots and design parameters was scrutinized. In the fabrication tolerance, the architecture was good. This design showed total bandwidth of 14.66 GHz.

Thanadol Tiengthong, et.al (2018) investigated the assessment of power delay feature of UWB transmission waveform for WBAN with human corpse [13]. The investigational model, VNA and biconical antennas were utilized for investigation. At the receiver end, the delay feature of transmission waveform was evaluated using expansion of friis' transmission formula, rectangular pass band waveform and power delay report. The investigational outcomes demonstrated power delay profile. These outcomes depicted the effect of UWB transmission waveform on human body. The UWB transmission effected human body in terms of reflection and shadowing. The postures of the human body will be taken into account in near future.

Abhilash Hegde, et.al (2017) presented a concise review on inferior layers of WBAN system with the help of a simulation tool called Castalia [14]. The results achieved from approach evaluated the requirement for WSNs over wired networks. These results also provided necessary outcomes for the utilization of WBAN in health applications efficiently. In WBANs, the proposed approach also provided quality of service with energy restriction in sensors. This phenomenon assisted in the deployment of several equipment with inexpensiveness and high competence.

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
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III. RESEARCH METHODOLOGY

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.

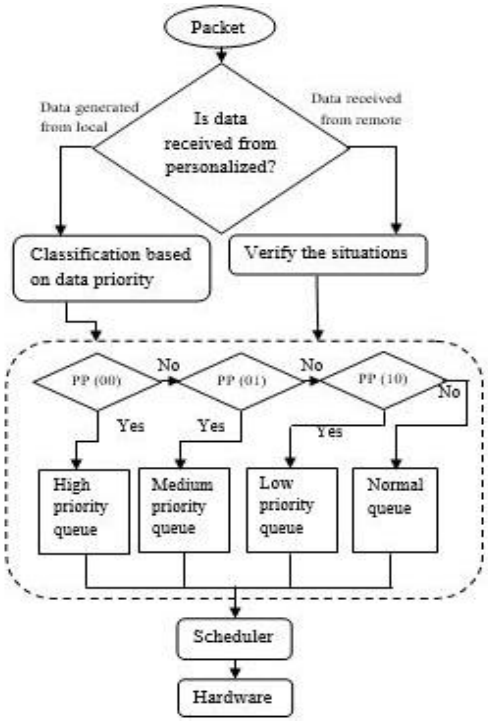

Figure 1: Layout of ELBPQ Algorithm

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 in 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, 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

IJARCCE

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IV. RESULTS

The proposed research is implemented in MATLAB and the results are evaluated by comparing proposed and existing techniques in terms of various performance parameters. The formulas for the calculations of parameters are described below:-

1. **Packet Delivery Ratio: -** The PDR defines the ratio of packets which are transmitted and received at the base station.

$$\textbf{PDR} = \frac{\textit{Number of Packets received}}{\textit{Number of Packets Send}}$$

2. Average Delay: - The average delay calculate the delay of the packets while transmitting data from source to destination. Average Delay = Time of packet received – Time of packet sent

3. Power Consumption: - It calculate the power consumption which is consumed while transmitting data. Power consumption = No. of packets transmitted * per unit energy.

4. Throughput: - The throughput defines the number of packets transmitted by number of packets send per unit energy.

$$\text{Throughput} = \frac{\textit{Number of Packets received}}{\textit{Number of Packets Send}} * \textit{time}$$

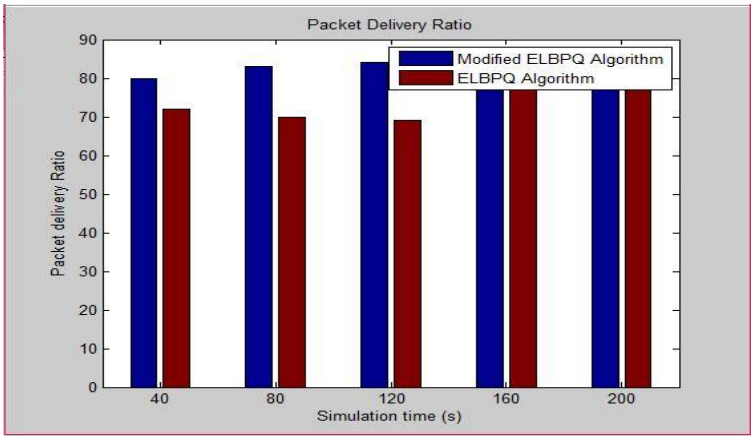

Figure 2: Packet Delivery Ratio

Table I: Packet Delivery Ratio

Simulation time (s)	Existing algorithm [9]	Proposed Algorithm
40	70	81
80	71	86
120	69	83
160	68	83
200	70	82

As shown in figure 2, the packet delivery ratio of proposed protocol and existing is compared for the performance analysis. The packet delivery ratio of the proposed technique is high as compared to existing technique.

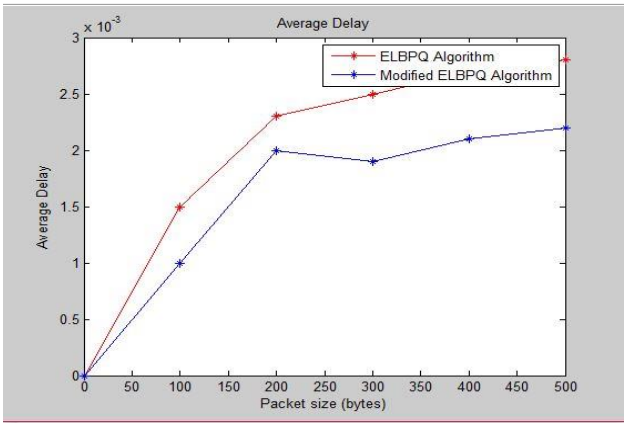

Figure 3: Average Delay

DOI 10.17148/IJARCCE.2019.8812

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Vol. 8, Issue 8, August 2019

Table 2: Average Delay

Packet Size (bytes)	Existing algorithm (ms) [9]	Proposed Algorithm (ms)
50	1.6	1
200	2.4	2
300	2.5	1.9
400	2.6	2
500	2.8	2.4

As shown in figure 3, the average delay of the proposed technique and existing technique is compared for the performance analysis. The average delay of the proposed technique is less as compared to existing technique.

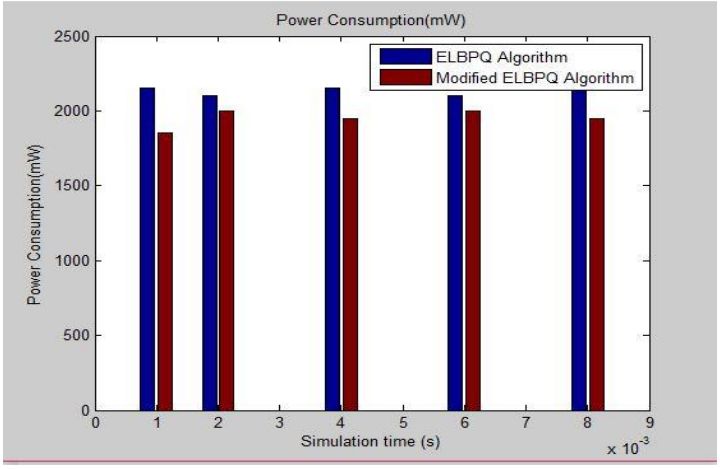

Figure 4: Power consumption

Table 3: Power Consumption

Simulation time (s)	Existing algorithm (mW) [9]	Proposed Algorithm (mW)
0.001	2200	1900
0.002	2100	2000
0.004	2200	1900
0.006	2000	1800
0.008	2300	1800

As shown in figure 4, the power consumption of the proposed technique and existing technique is compared for the performance analysis. The power consumption of the proposed technique is less as compared to existing technique.

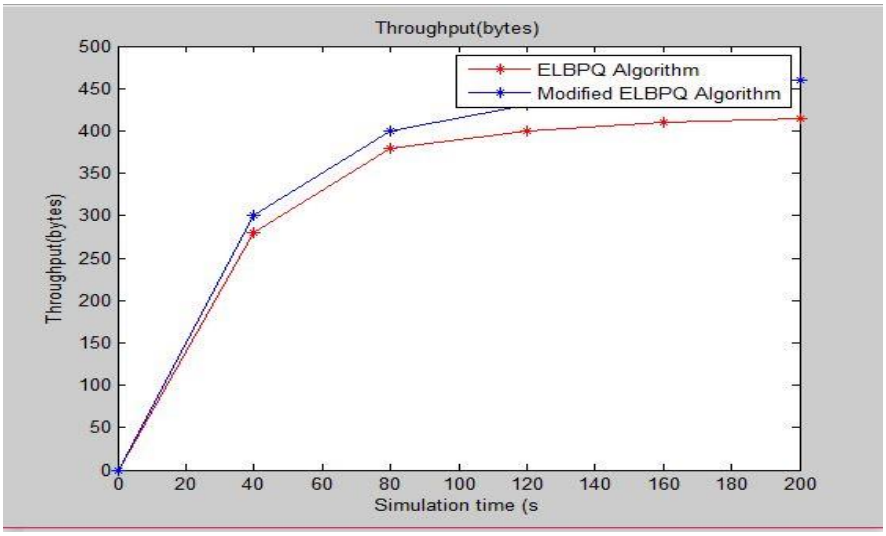

Figure 5: Throughput Analysis

DOI 10.17148/IJARCCE.2019.8812

Table 4: Throughput Analysis

Simulation time (s)	Existing algorithm (bytes) [9]	Proposed Algorithm (bytes)
40	280	300
80	380	410
120	390	440
160	410	450
200	410	460

As shown in figure 5, the throughput of proposed protocol and existing is compared for the performance analysis. The throughput of the proposed technique is high as compared to existing technique.

V. CONCLUSION

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). In comparison to the current electronic patient monitoring systems, two significant benefits are provided by WBAN systems. In this work, it is concluded that wireless body area network has major issue of channel sensing and lifetime. The ELBPQ is the protocol which can prioritize the data according to its type which is given to scheduler for the classification. In this work, the ELBPQ is improved using time lay for the clock synchronization. When the ELBPQ protocol is improved for the clock synchronization then the performance of ELBPQ get increased in terms of throughput, packet loss and number of dead nodes. In future, security improvement can be proposed for improved ELBPQA protocol.

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