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ANALYSIS OF ENERGY CONSUMPTION IN WIRELESS BODY AREA NETWORK USINGMAC PROTOCOLS (BASELINE AND SMAC)

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ABSTRACT

A Wireless Body Area Network (WBAN) is a short-range network that consists of a coordinator and a gathering of low-power sensors that can be embedded in, or attached to the human body. A WBAN can be used for a diversity of new uses which including online health control, home/health care, pharmacy, multimedia, and sports, among many more, all of which take advantage of the unrestricted mobility that WBANs can provide. In the medical industry, for example, a patient may be fitted with a WBAN of sensors that continuously track basic biological functions including temperature, blood pressure, heart rate, electrocardiogram (ECG), breathing, and so on. The patient does not have to lie in bed and can move around freely in the room or even leave the hospital for a short period of time. This increases the patient's feature of life while further lowering treatment costs. Furthermore, evidence gathered over a prolonged period of time and in the patient's natural habitat provides more useful knowledge, allowing for a more definitive and, in some cases, quicker diagnosis. Sensors connected to the human body are normally battery-powered devices with brief lifetimes. Institute of Electrical and Electronics Engineers (IEEE) 802.15.6 standard is the typical choice for low power ingestion and reliable short-range communication for Wireless Body Sensor Networks (WBSNs). The effects are demonstrated using the Omnet++ simulator and its Castalia extension for WBANs.

***KEYWORDS*:1**-WBAN. 2-Baseline MAC and SMAC. 3- IEEE 802.15.6. 4- Castalia. 5- Energy Efficiency.

1. INTRODUCTION

Healthcare is an upward apprehension in many countries. Medical researchers have forced to aspect for confidential health observing of patients via signs. The main purpose is to decrease patient appointments and prepare medical teams for regular inspections. One of the key areas of researches is minimizing energy ingestion of the device and communication tools. WBAN required minor system and little power consumption. An imperative part of the node's behavior is the Media Access Control (MAC) layer. MAC protocol is an energy efficient in WBAN so the major issue of WBAN is more power consumption. In order to protect the quality of service and prolong the net system life time of the sensor nodes devoted to or implanted in a human body and revision the act using IEEE 802.15.6 MAC. To improve the enactment of the network can be accomplished by using MAC layer. This layer establishes the node's access to the shared wireless channel. MAC layer is also in charge of to encounter the life period for the battery and has an important role to help protocol to realizing the QoS(Arefin, 2017).

The rest of the paper is schematized as follows: section 2 presents some related work. Section 3source of energy waste in WBAN. Section 4 explainMAC protocol for WBAN. Section 5 present IEEE 802.15.6 communication modes.Simulation results for packet delivery and energy consumptions are shown in sections 6.1 and 6.2 respectively. Finally, sections 7 concludes the work presented in this paper.

2. RELATED WORK

To study IEEE 802.15.6, many researches has been done. The authors in (El azhari, 2014) have analysed the performance of TMAC, IEEE 802.15.6 and IEEE 802.15.4 MAC protocols questioning about throughput, consumed energy and latency using Castalia (Boulis, 2013) as a simulating tool. The author's analysis suggests IEEE 802.15.4 outperforms IEEE 802.15.6 and TMAC with

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temporal deviation and GTS ON. Pooja et al. (Mrs, Mohnani, & Jabeen, 2016) studied the routing problem for WBANs. They used a batch ACK for validation of packet transfer to achieve a power efficient, reliable and secure wireless body area network. A new IEEE 802.15.6 MAC superframe structure has been developed by Sultana et al. (Sultana, Huq, Razzaque, & Rahman, 2019) to handle one type of information with unique priorities, eliminating transport delays as opposed to exclusive schemes. In (Ullah & Tovar, 2015), the authors presented an accurate model to calculate the QoS parameters, i.e. throughput, lengthening and the quantity of consumed energy of the IEEE 802.15.6 CSMA/CA protocol used in beacon-supported mode. A lossy channel model is used with saturated nodes communicating over a restricted range.In (Almazroa & Rikli, 2014), the authors have expected the general performance of WBAN through varying the scattering of slot and the data rates between a diversity of MAC access mechanisms used in IEEE 802.15.6 and by using Castalia simulation tool the performance of WBAN was calculated via the perceived effects of latency, power consumption and data packet breakdown.In (Goyal, Bhadauria, Patel, & Prasad, 2017), the authors proposed a TDMA-based MAC protocol for WBAN for energy efficiency and delay sensitivity to view physiological warnings such as ECG and EEG remotely.A survey on energy efficiency intrabody communication techniques for wearable devices(Igor Khromova September 2021)provides the two intrabody communication (IBC) methods, the equivalent body channel models and modeling methods are analyzed. The experiment was conducted in order to measure the BodyCom mobile module output power, the comparative analysis showed that the power consumption of the IBC proposed technique is 7 times lower than Bluetooth LE, and 14 times lower than ZigBee. The proposed technique can be applied in areas such as home and industrial automation, medical appliances, wearable devices, security, and internet of things.An empirical model of the IEEE 802.15.6 CSMA/CA protocol is provided by the authors in (Negra, Jemili, & Belghith, 2016) under non-saturated visitor conditions. To accomplish a higher throughput and the least interval, they calculated throughput, energy consumption, and suggested frame carrier time and enhanced area lengths.Reliability and Energy Efficiency Enhancement forEmergency-Aware WBANs (Marwa S., Feb. 2018)proposed two new TDMA based scheduling algorithms to improve the reliability and energy efficiency of WBAN. The results reveal that short slot lengths contribute to better performance. This is because a short slot gives nodes enough time to access the channel, while it reduces the probability that their links will experience deep fade in the channel. Consequently, other nodes with better links status will quickly use the channel. To improve network lifetime and restrict energy consumption of the sensors. The authors(Dr. Joy, 2020)contributed towards reducing the size of data to be transmitted by compressed sensing and selection of relay sensor based on sampling frequency, energy levels and sensor importance. Using the proposed methodology, it is possible to improve both reliability and energy-efficiency of WBAN data transmission.

3. SOURCE OF ENERGY WASTE IN WBAN

Transmitting, receiving and processing packets in wireless networks contribute to a large amount of energy consumption. The following list includes some scenarios that can cause increased energy consumption in the wireless network(Pruthviraj Rajaram Ghatge, June -2017).

- Overhearing: It occurs when the node gets the channel to accept the packets that are really meant for another WBAN nodes.
- Packet Collisions: collisions occur when more than one node try to pass on their packets using the shared wireless medium. All collided packets will be damaged and should all be retransmitted which increases the energy consumption.
- Idle Listening: the node doesn’t receive or send any data over the channel even when it is active.
- Packet Overhead: It comprises the control information in the packet header. The energy consumption will increase due to the additional bit in the packets.

4. MAC PROTOCOL FOR WBAN

The most important factor is energy efficiency characteristic of a decent MAC protocol in WBAN. It is highly desirable for WBAN devices to have battery lives of months or years without intervention. For instance, cardiac defibrillators and innovators have life time more than five years. Some applications might need battery life times of few of hours.

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For example, a swallowable pill containing a camera will need a battery life time of about 12 hours (Alam, 2014).To reduce the power usage, sources of energy expenditure (overhearing, packet collisions, idle listening and control packets) should be minimized.

The performance of WBAN, such as transmission delay, reliability, energy consumption and network throughput is closely related to MAC protocol. The design of MAC protocol plays a major role in the energy efficiency and reliability of WBAN. In WBAN medium access control is the usage of wireless channel and it has many important uses such as processing, conflict detection of nodes, priority control, allocation time slot and the transmission order of nodes. In traditional MAC protocol wireless sensor network cannot be directly applied to the WBAN. Many research have been done in order to design a new MAC to meet the characteristics and requirements of WBAN. Baseline and Scheduled MAC protocols based on IEEE802.15.6 for WBAN are presented and studied in this paper. These two protocol will expand the concert of the WBAN in relations of energy ingestion and throughput(Yuan, Zheng, Ma, Shang, & Li, 2019).

4.1BASELINE MAC PROTOCOL

IEEE802.15 Task Group 6 (BAN) was molded to draft a standard for MAC layer for WBANs that covers short range announcement within the locality of a human body. Task Group 6 drafted the baseline BAN MAC protocol which addresses the issues of WBANs inboth medicinal and non-medical uses are possible.

Baseline BAN MAC splits time into beacon stages. A beacon is a control frame broadcasted by the coordinator over which the nodes catch the statistics about the BAN, such as BAN ID, the distance of the beacon steps, the extent of each contact phase (CAP, RAP, EAP), and the pause of a time slot(Lu, Khan, & Iqbal, 2013).

4.2 SMAC PROTOCOL

Scheduled MAC protocol is an energy efficient protocol for health care and medical applications which provides less delay, increasing the network lifetime and higher packet reception rate. The SMAC chains the following three types of access method(Kaur, 2016):

1. Polling access method:Where there is no need to assign slots in superframe boundaries earlier than required, this approach is used. Where required, the hub assigns specific slots to gorgeous nodes only from the contemporary body. It then sends ballot instructions showing the number of prompt polled access slots open.

2. Contention access method: The slotted CSMA protocol is selected by the hub established on the PHY layer. When the beacon is turned on, the nodes are allocated unique slots at the start of each frame.

3. Scheduled access method: The node in this mode can get right of entry to the sure slots at each interval freely with the aid of sending the request to access channel messages to the hub.

5. IEEE 802.15.6 COMUNICATION MODES

1. Beacon mode with superframe: in this mode of operation, the coordinator sends beacons in active superframes. The active superframe can be followed by many inactive superframes each time where there is no arranged data transmission. The superframe construction, shown in Figure 1, is arranged into(S. Ullah, 17 OCTOBER 2018):

- EAP1 and EAP2 (Exclusive Access Phases)
- RAP1 and RAP2 (Random Access Phases)
- MAP (Managed Access Phase)
- CAP (Contention Access Phase)

High-priority or disaster traffic is moved via EAPs. Nonrecurring traffic is handled by RAPs and CAPs. Scheduled and unscheduled bilink portions, scheduled uplink and downlink portions, and Type I polled and pushed allocations are all performed during the MAP period .The length of Type I and Type II allocations is represented in terms of the transmission time and number of frames, respectively

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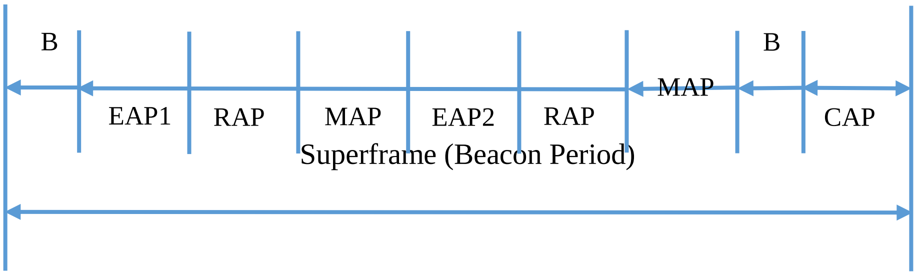

Fig.(1):- Superframe mode in beacon mode.

2. Nonbeacon mode with superframe: in this mode, the coordinator works in the MAP interval only, as shown in Figure 2.

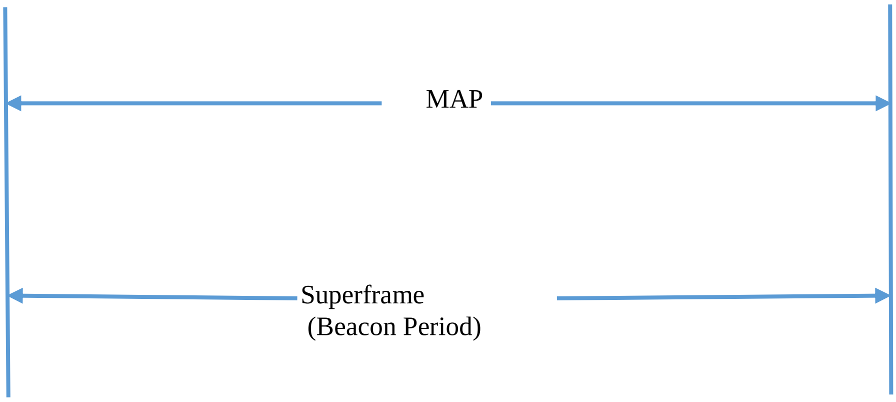

Fig.(2):- None-beacon mode with superframe.

3. Nonbeacon mode without superframe:in this mode,the coordinator offers unscheduled Type II polled or pushed allocation, or a combination of both as shown in Figure 3.

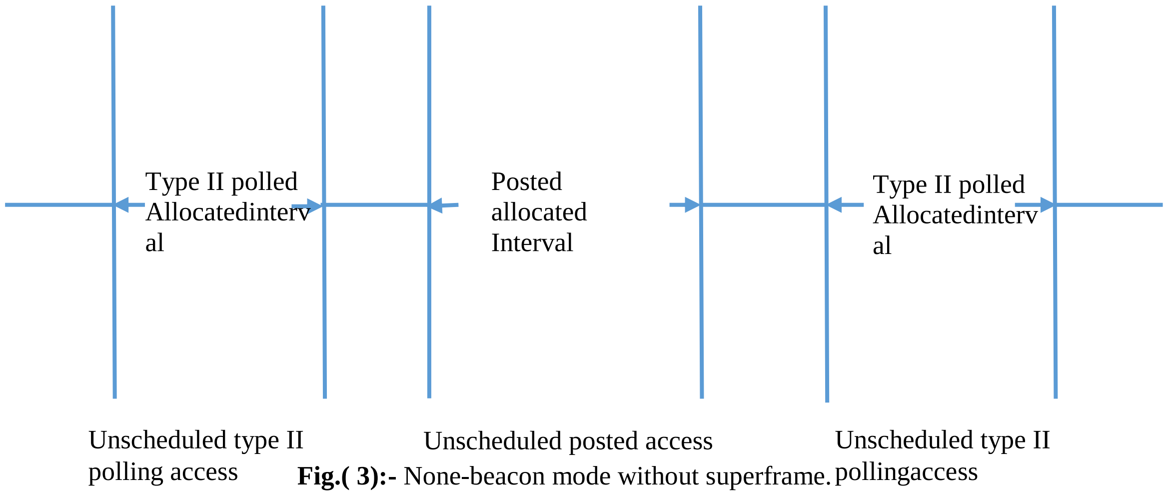

Fig.(3):- None-beacon mode without superframe.

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6. SIMULATION AND ANALYSES OF THE RESULTS

In our approach using Baseline MAC and Schedule Media Access Control (SMAC) protocols under the IEEE 802.15.6standard. Castalia is the simulation environment and a star topology is used with four source nodes and one coordinator. Packets commencing all the source nodes flow towards sink node. The main objective of simulationis to measure average energy consumption and packet rates by increasing the number of nodes and traffic load.

To estimate the performance of the Baseline and scheduled access MAC protocols, considered two scenarios to calculate average packet delivery ratio and total energy consumed.

In the first scenario, varying the number of nodes (5, 6, 8, 10) while keeping the rate of packets constant (10kbps).

In the second simulation scenario, keeping the number of nodes constant (five nodes) and changed data rate from (10 to 150 Kbps).

6.1Analysis of Packet Delivery

Figures 4 and 5 show how many packets wheresuccessfully delivered from source nodes to the destination node for both protocols.

In figure 4, it is detected from the results that Packet Delivery Rate (PDR) in SMAC is higher than Baseline MAC protocol. When the number of nodes is five, the sink node receives more packets, since there is greater chance for nodes to send their data without collision in a wireless shared channel.Increasing the number of nodes will cause heavy traffic load over transmission channel and the chances of collision between packets will increase which in turn will decrease the number of intact packets arriving at the destination node.

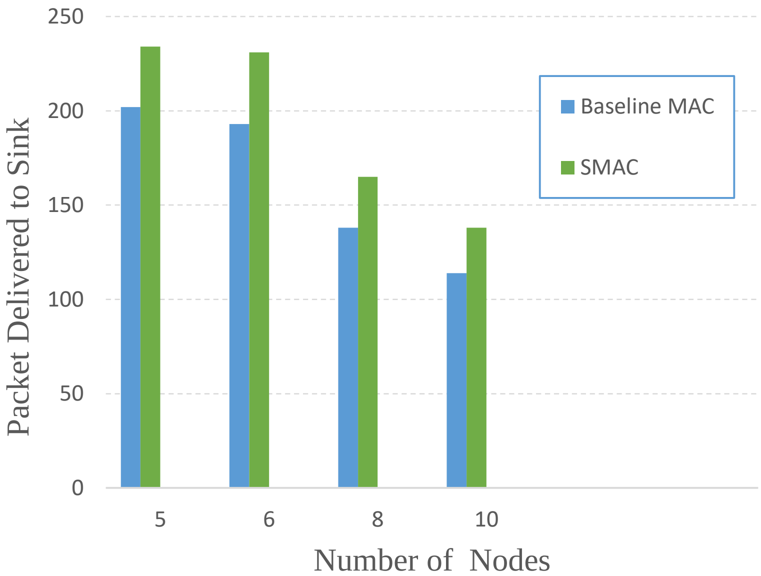

Fig.(4):- Packets delivery to sink node (varying number of nodes)

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In the second simulation scenario, the number of nodes was fixed while changing data rate from 10 to 150 kbps. More packets received by the sink in the SMAC than the Baseline MAC protocol as showed in figure 5.

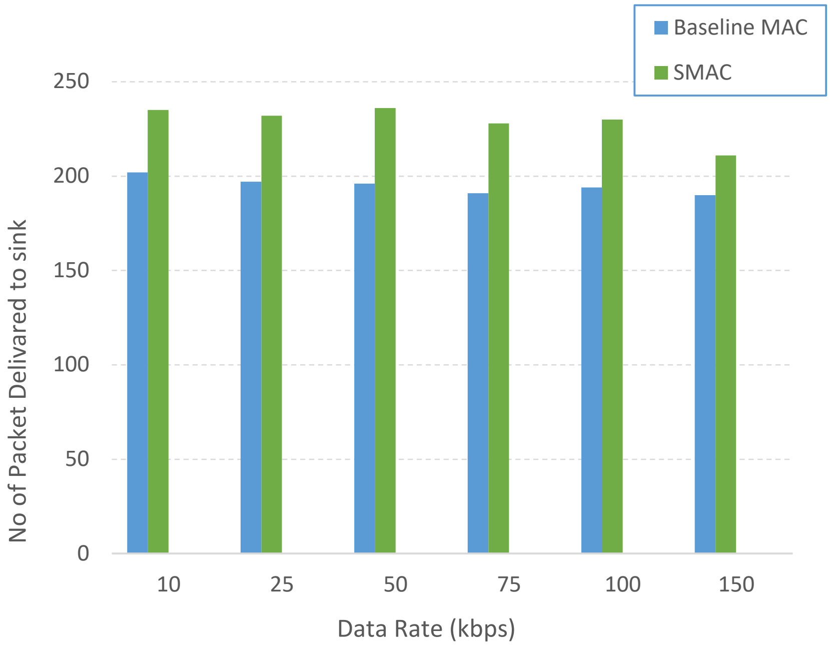

Fig.(5):- Packets delivered to sink node (varying data rates)

Figures 6 and 7 show the total number of packets delivered to the sink node in the first and second simulation scenario respectively. It is clear from these figures that SMAC outperforms baseline MAC in terms of packet delivery in both simulation scenarios.

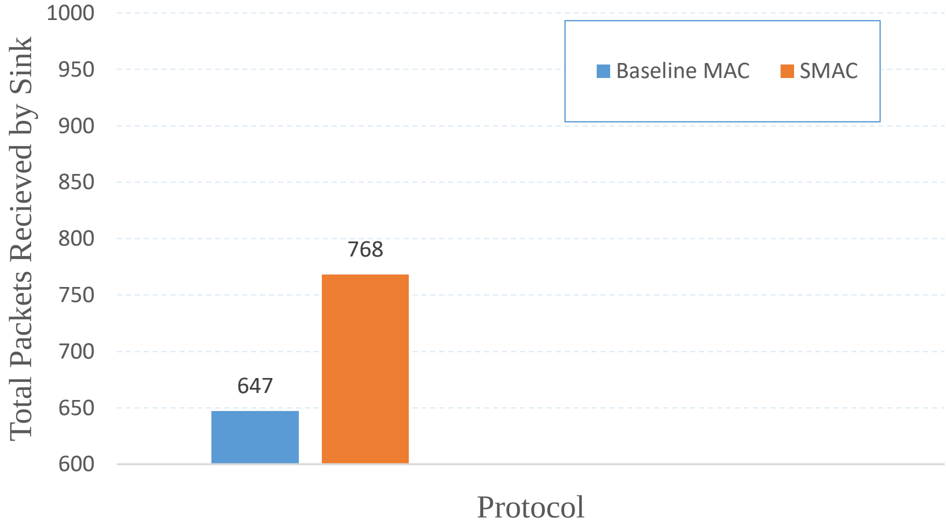

Fig.(6):- Total number of packets received by the sink node, first simulation scenario

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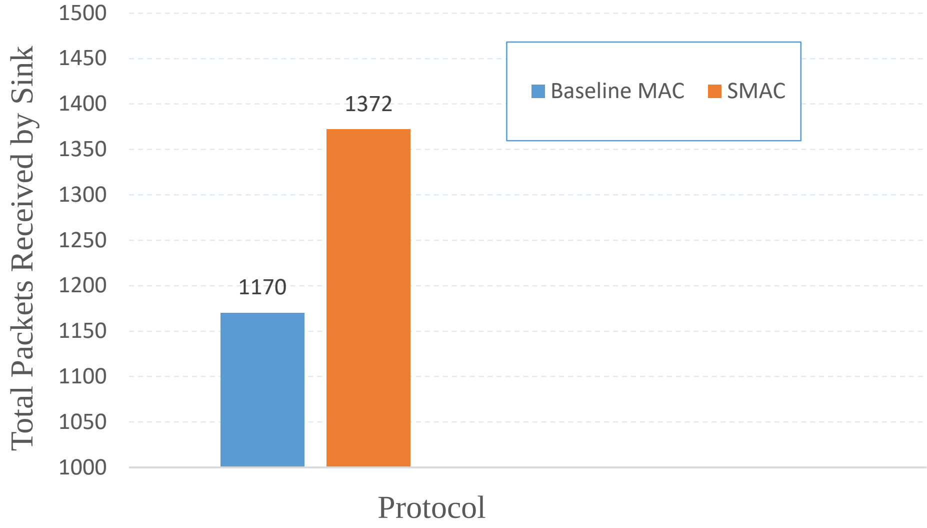

Fig.(7):- Total number of packets received by the sink node, second simulation scenario

6.2ANALYSIS OF CONSUMED ENERGY

In the first set of simulations,consumed energy when the number of nodes was changed (see figure 8which shows a small change in energy consumption when changing thenumber of nodes this is the advantage of using these two protoco ls)the results indicate that the average energy consumption of SMAC is less as compared with the Baseline MAC for any number of nodes.

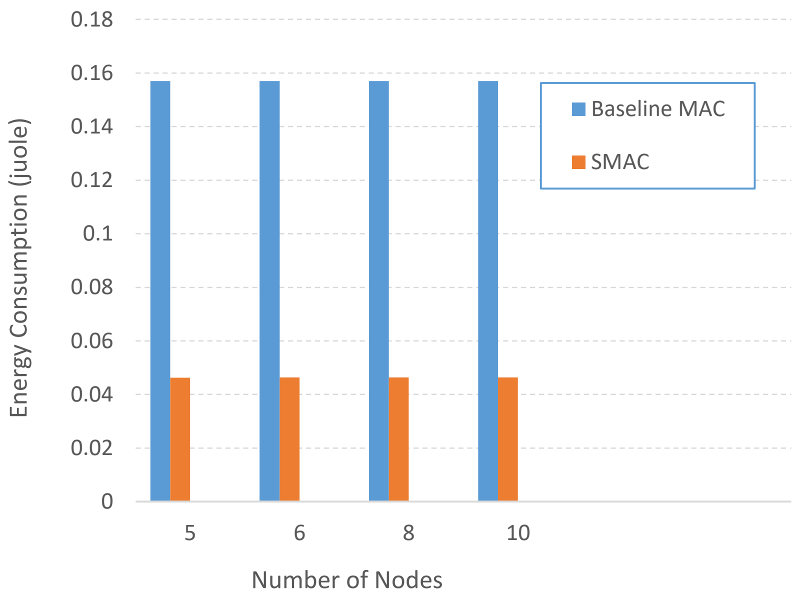

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Fig.(8):- Average energy consumption varying the number of node and constant data rate

For the second set of simulations, when the data rate was varied from (10 to 150 kbps). Figure 9, reveal that a lesser amount of energy consumption is used in SMAC than Baseline MAC. This is a significant improvement to extend in battery life of sensor nodes.

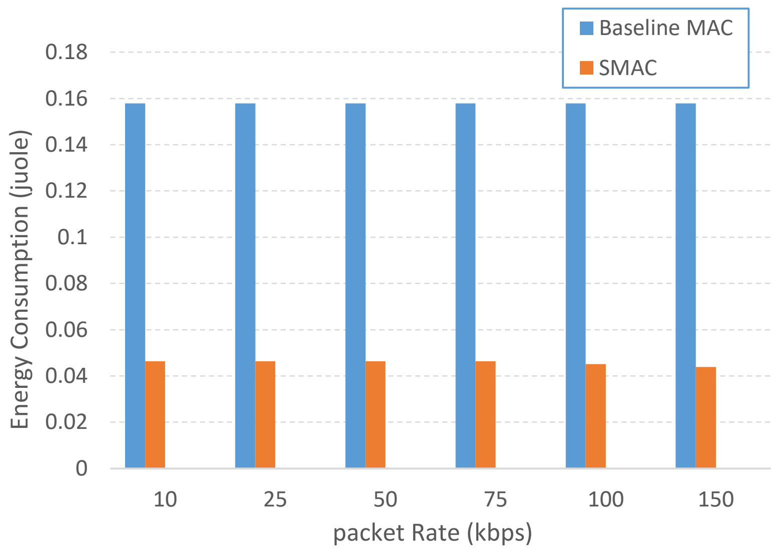

Fig.(9):- Average energy consumption varying the data rate and the number of nodes constant

Figure 10 shows the overall energy consumed for both protocols. It is clear that SMAC consumed less energy as compared to the Baseline MAC protocol.

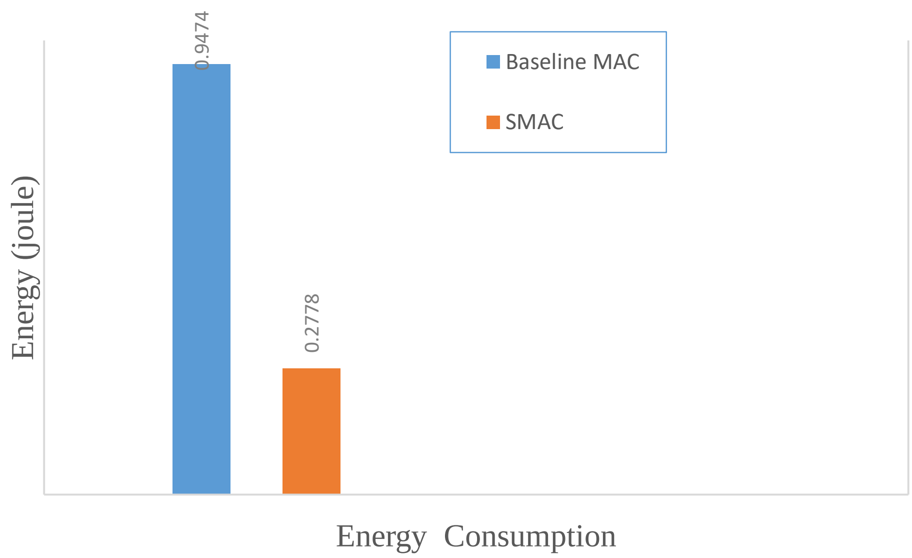

Fig.(10):- Overall energy consumption for baseline MAC and SMAC protocol.

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7. CONCLUSION

The impact of using WBSNs in medical care systems is increasing massively as a result of their ease of use, reliability, reduced cost and freedom. Many researchers have developed different ways for WBAN to monitor the human body. However, there are still many issues to be solved.

Main issue in WBAN is energy consumption. In this paper, using OMNET++ 4.6 with Castalia 3.2 as a WBAN simulator to test the performance of two protocols (Baseline MAC and SMAC)by varying number of nodes and data rates.

SMAC performed better than baseline MAC in terms of energy consumption and packet delivery rates.

SMAC achieved the highest number of packets as compared to Baseline MAC when varied the number of nodes and data rate 768 to 1372 packets and 647 to 1170 packets respectively. Also, the SMAC used an overall system energy of 0.28J while Baseline MAC consumed 0.95J.

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تحليل استهلاك الطاقة في شبكة منطقة الجسم اللاسلكية باستخدام بروتوكولات MAC (خط الأساس و SMAC)

الخلاصة

شبكة منطقة الجسم اللاسلكية (WBAN) هي شبكة قصيرة المدى تتكون من منسق ومجموعة من أجهزة الاستشعار منخفضة الطاقة التي يمكن دمجها أو توصيلها بجسم الإنسان. يمكن استخدام WBAN في مجموعة متنوعة من الاستخدامات الجديدة بما في ذلك التحكم في الصحة عبر الإنترنت ، والرعاية المنزلية / الصحية ، والصيدلة ، والوسائط المتعددة ، والرياضة ، من بين أشياء أخرى كثيرة ، وكلها تستفيد من التنقل غير المقيد الذي يمكن أن توفره شبكات WBAN. في الصناعة الطبية ، على سبيل المثال ، قد يتم تزويد المريض بجهاز استشعار WBAN الذي يتتبع باستمرار الوظائف البيولوجية الأساسية بما في ذلك درجة الحرارة وضغط الدم ومعدل ضربات القلب وتخطيط القلب (ECG) والتنفس وما إلى ذلك. لا يتعين على المريض الاستلقاء في السرير ويمكنه التنقل بحرية في الغرفة أو حتى مغادرة المستشفى لفترة قصيرة من الوقت. هذا يزيد من سمة حياة المريض مع تقليل تكاليف العلاج بشكل أكبر. علاوة على ذلك ، فإن الأدلة التي تم جمعها على مدى فترة طويلة من الزمن وفي الموطن الطبيعي للمريض توفر معرفة أكثر فائدة ، مما يسمح بتشخيص أكثر دقة ، وفي بعض الحالات ، أسرع. عادةً ما تكون أجهزة الاستشعار المتصلة بجسم الإنسان أجهزة تعمل بالبطارية ذات أعمار قصيرة. معيار معهد مهندسي الكهرباء والإلكترونيات 802.15.6 (IEEE) هو الخيار النموذجي لابتلاع الطاقة المنخفضة والتواصل قصير المدى الموثوق به لشبكات استشعار الجسم اللاسلكية (WBSNs). تم توضيح التأثيرات باستخدام محاكي Omnet ++ وامتداد Castalia الخاص به لشبكات WBAN.

الكلمات الداله : 1- شبكة منطقة الجسم اللاسلكية. 2-خط الاساس والجدول الزمني للتحكم في الوصول 3- معيار معهد مهندسي الكهرباء والإلكترونيات 802.15.6. 4- كاستاليا. 5- كفاءة الطاقة.

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