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Network Lifetime Enhancement for Wireless Body Area Networks

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Abstract:- The increasing use of wireless networks and the constant miniaturization of electrical devices have empowered the development of Wireless Body Area Networks (WBANs). WBAN is designed to operate autonomously by establishing a wireless communication link. Various medical sensors and appliances are attached or implanted inside and outside of a human body. The media access control (MAC) layer plays an important role in deciding the energy efficiency. We do the research on the adaptive energy efficient Medium Access Control protocol used in WBAN, so to increase the network lifetime. The proposed protocols show increase in common node remaining energy, cluster node remaining energy, BAN co-or node remaining energy and decreasing in delay. This is achieved because of dynamic duty cycle and priorities based message passing schemes.

Keywords:- Wireless Body Area Networks, Media Access Control, Wireless Local Area Network, Personal Digital Assistant, Sensor Media Access Control

I. INTRODUCTION

The increasing use of wireless networks and the constant miniaturization of electrical devices have empowered the development of Wireless Body Area Networks (WBANs). In these networks various sensors are attached on clothing or on the body or even implanted under the skin. The wireless nature of the network and the wide variety of sensors offer numerous new, practical and innovative applications to improve health care and the Quality of Life.

A Wireless Body Area Network (WBAN) is a special purpose sensor network used in the field of mHealth and telemedicine. It is designed to operate autonomously by establishing a wireless communication link. Various medical sensors and appliances are attached or implanted inside and outside of a human body. A WBAN system can offer following two significant advantages compared to patient monitoring system which currently exist. The first advantage is the mobility of patients due to use of portable monitoring devices. Second advantage is the location independent monitoring facility.

A WBAN will consist of a number of tiny sensor nodes and gateway node which are small intelligent devices. The gateway node is used to connect external database server. The gateway node could connect the sensor node to a range of telecommunication networks. These communication networks could be a standard telephone network, mobile phone network, a dedicated medical center/ hospital network or using public Wireless Local Area Network (WLAN) hotspots [1]. A WBAN can also take advantage of deployed mobile data networks such as 3G/4G data network to transmit patient data. A WBAN could allow a user to store its collected data on his/her Personal Digital Assistant (PDA) or iPod or any other portable devices. This data is then transfer to a suitable computer or a medical server. Fig. 1 shows the General Wireless Body Area Network Architecture [2].

Wireless Body Area Network (WBAN) sensors sense the data such as body temperature, blood pressure, ECG and so on. The Sensor nodes are usually programmed to monitor or collect data from the deployed area and pass the information to the base station for remote user access through various communication technologies.

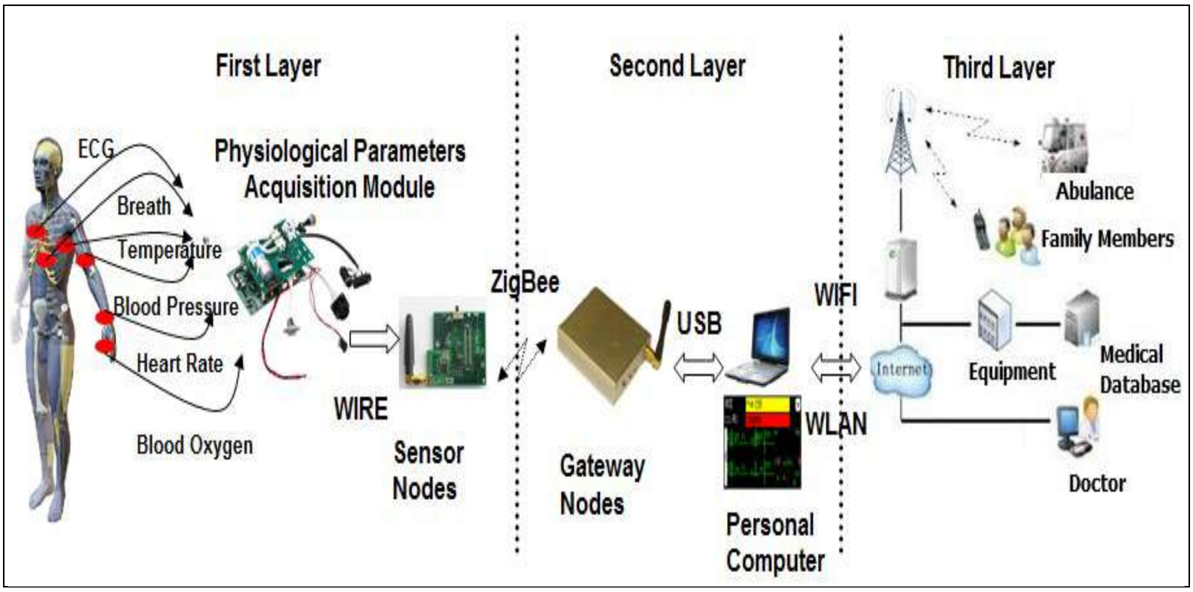

Fig. 1: General Wireless Body Area Network Architecture

II. RELATED WORK

Sensors and actuators are the key components of a BANs. They bridge the physical world and electronic systems. A body sensor node mainly consists of two parts: the physiological signal sensor(s) and the radio platform [3], to which multiple body sensors can be connected. A Wireless Body Area Network (WBAN) is a special purpose sensor network designed to operate autonomously to connect various medical sensors and appliances, located inside and outside of a human body [1]. Protocols for WBANs can span from communication between the sensors on the body to communication from a body node to a data center connected to the Internet [1]. Due to advancement of technology, and the decreasing size and cost of devices, it is possible to implement them in healthcare activities related to human. The application areas can be divided into two major categories – medical use, nonmedical use [4]. The medical applications can be of two types: wearable and implanted. The wearable medical devices and applications are: Temperature measurement, Respiration monitor, Heart rate monitor, Pulse oximeter, SpO2, Blood pressure monitor, pH monitor, Glucose sensor etc. The implantable medical devices are those that are inserted inside human body. These devices and their applications are: Cardiac arrhythmia monitor/recorder, Brain liquid pressure sensor, Glucose sensor, Endoscope capsule etc. [4] – [6]. The non-medical devices and their applications can be real-time video streaming using mp4 video player and real-time audio streaming using mp3 player and so on. There can also be scope for remote controlled applications, data file transfer, and sports and gaming applications [6], [7].

Communications in and around the human body is highlight a unique set of challenges in WBAN. Those are not present in other types of networks. At the physical layer, protocols need to take account of how the body reacts to RF communications and the complications therein [8]. The MAC layer controls the channel access, packet encoding, addressing and as such must achieve maximum energy efficiency and data throughput by the efficient management of these functions that energy wastage in existing MAC protocols [9] occurs from four major sources: excessive collisions, control packet overheads, idle listening, and overhearing. All contribute to network delay and energy inefficiency. In comparison to WSNs, the bandwidth available to WBANs is limited, likely to be shared with other local ISM band devices and is subject to physical layer attributes such as interference, fading, and attenuation due to the specific characteristics of the human body. The network layer is responsible for routing the data sensed by source sensor nodes to the data sink(s). It uses various localization scheme and algorithms. The application layer for a WBAN includes the application running on the node that may be specific to the sensor type as well as management, security, synchronization, and query type functions [10].

III. ADAPTIVE ENERGY EFFICIENT SMAC AND WISEMAC

SMAC

Wireless Sensor Network is special class of Wireless Communication; consist of large number of miniature battery operated sensor nodes. Those are distributed and do communication wirelessly. Due to small and inexpensive sensor node, they are widely used in many areas. Sensor Media Access Control(SMAC) was designed and developed for WBAN to prolong the life time and reduce energy consumption [11].

SMAC [12] is a robust medium access control protocol for wireless sensor networks. Owing to its success in significant reduction in energy consumption and its robustness, SMAC has been used in many wireless sensor networks. SMAC combines the features of both contentions based as well as time scheduled protocols. SMAC saves energy by requiring the nodes to periodically listen for any communication for a short interval and then allowing them to sleep, if the node is not involved in data communication, for the rest of a pre-determined duration (a *frame*) to conserve energy. Because of limited power supply, the main objective to design MAC protocol for WBAN is energy efficiency. SMAC is specially designed for WSN to reduce energy.

Wise MAC

Wise MAC is based on the preamble sampling technique [13]. This technique consists in regularly sampling the medium to check for activity. . All sensor nodes in a network sample the medium with the same constant period TW. Their relative sampling schedule offsets are independent. If the medium is found busy, a sensor node continues to listen until a data frame is received or until the medium becomes idle again. At the transmitter, a wake-up preamble of size equal to the sampling period is added in front of every data frame to ensure that the receiver will be awake when the data portion of the packet arrives [14].

The proposed protocols could collect the critical and non-critical data from different body sensor nodes in body area network. Reliability and Latency of the WBAN will depend upon the data transmission, which is extremely important. SMAC and Wise MAC are used to check and to maintain the energy efficiency and the data transmission in the millisecond or in nanosecond.

Following is the procedure for the working of the system

- Packets are sent from the source node to the sink node.
- Packets' inter-arrival times at the source node conform to an exponential distribution with mean value 10s.
- Packet size is fixed to 100 Bytes.
- Calculates the duration of transmitting this packet and starts a timer called sending timer with the duration timer.
- When the sending timer expires, proposed protocols knows the sending is over (the lower layer will not acknowledge this), then it sets the radio variable back to idle state.
- There are four radio states defined in proposed protocols, sleep, idle, transmitting, and receiving.
- Proposed protocols change the value of the radio state variable according to some events.

The proposed method is modification of the algorithms [15]. The novelty in the proposed method is to reduce energy consumption using the concepts of contention window which is adaptive to the different traffic conditions. Probability is calculated for possible transmission failure over a sufficient number of packets and contention window is adjusted accordingly to avoid the collision. A concept of dynamic duty cycle is used and it classifies the traffic into different groups depending on the type of traffic class. The protocol should adopt variable traffic loads and should minimize the power consumption and increase the power consumption of sensor node. The experimental result shows increase in common node remaining energy, cluster node remaining energy, BAN co-or node remaining energy and decreasing in delay.

Dynamic duty cycle algorithm

Algorithm scenario:

- Initialize lower and upper limit on utilization of node, sleeping delay and duty cycle and adjusting degree parameter.
- Calculate the utilization of node last period U. The utilization of node is depends on total time required to transmit, to receive and total time the node was idle.
- Calculate sleeping delay of communication D, which depends on number of packets and sleep time of node.
- Adjust duty cycle according to current traffic load. If utilization is high, i.e. traffic is heavy for current schedule to afford; therefore we increase the duty cycle by n%. Otherwise decrease the duty cycle.
- End

IV. EXPERIMENTAL RESULT

We take the inputs of the one node with the parameter of body temperature, blood pressure. These are the low power parameters, so according to that the total energy consumed for the receiver with its based station in time measure in the millisecond. The develop protocol is simulation with the help of NS 2.29 tool. In a 2-D square area, WBAN comprise of common sensor nodes, cluster heads, access points and BAN coordinator node was deployed. All these nodes are deployed randomly all over the area. Common nodes sense various parameters such as body temperature, blood pressure, ECG and audio. These nodes are associated with nearest cluster head and send the sensed data periodically. Cluster head disseminate data to access point according to data priority. Access point gets the data from all cluster heads and sends to coordinator according to their priority. The parameters considered are number of nodes equal to 35, topology and its size is 550 m × 550 m, initial energy of nodes 5 Jules, transmit and receiving power are 12mW and 4.5 mW respectively.

Fig. 2 shows data rates versus energy utilized for Common Node Energy Remain Comparison between SMAC and Wise MAC protocols. SMAC and Wise MAC achieve an average increases in remaining energy of 389 Jules and 104 Jules respectively. This is less than SMAC. As date rate increases remaining energy increases gradually. So it increases the life of common nodes.

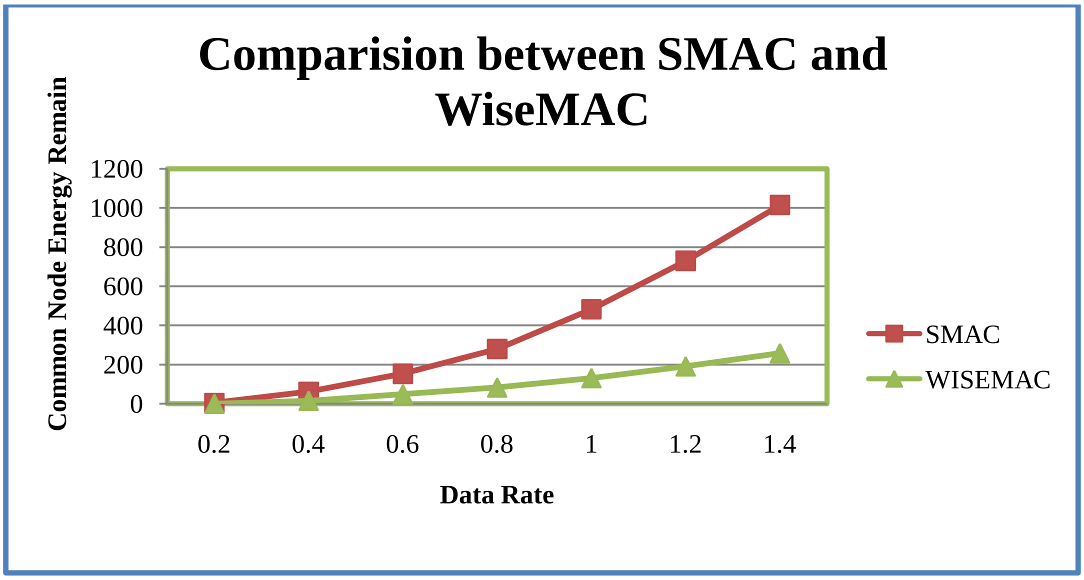

Fig. 2: Common Node Energy Remain - Comparison between SMAC and Wise MAC

Fig. 3 shows characteristics of the wireless Cluster Head Energy Remain between SMAC and Wise MAC. It is clear that while SMAC and Wise MAC achieve an average increases in remaining energy of 1597 Jules and 637 Jules respectively, for above sample data shown in Table 5.18. This is less than SMAC. As date rate increases remaining energy increases gradually. As compare to common node, cluster head remaining energy is more, because all variable data is passed through cluster head and access point. This point we implement priority queue for variable traffic such as emergency and normal data.

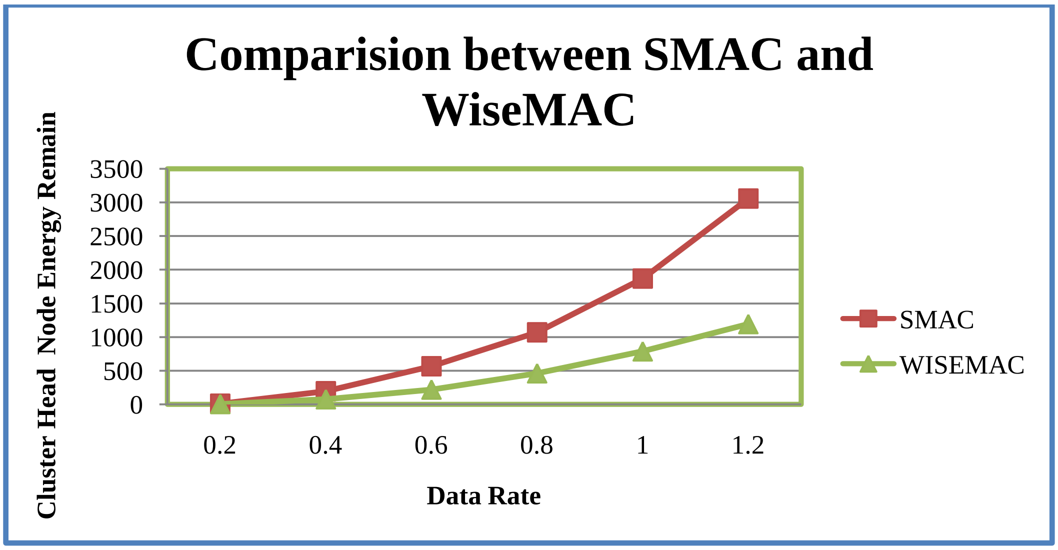

Fig. 3: Cluster Head Node Energy Remain - Comparison between SMAC and Wise MAC

Fig. 4 shows study of the wireless BAN Coor Energy Remain Sensor Node between SMAC and Wise MAC. It is clear that while SMAC and Wise MAC achieve an average increases in remaining energy of 149 Jules and 829 Jules respectively, for above sample data in Table 5.19. This is more than SMAC. As date rate increases remaining energy increases. As compare to common node and cluster head BAN Coor remain energy is more, because all variable data is passed through BAN Coor from cluster head and access point. This point we implement priority queue for variable traffic such as emergency and normal data.

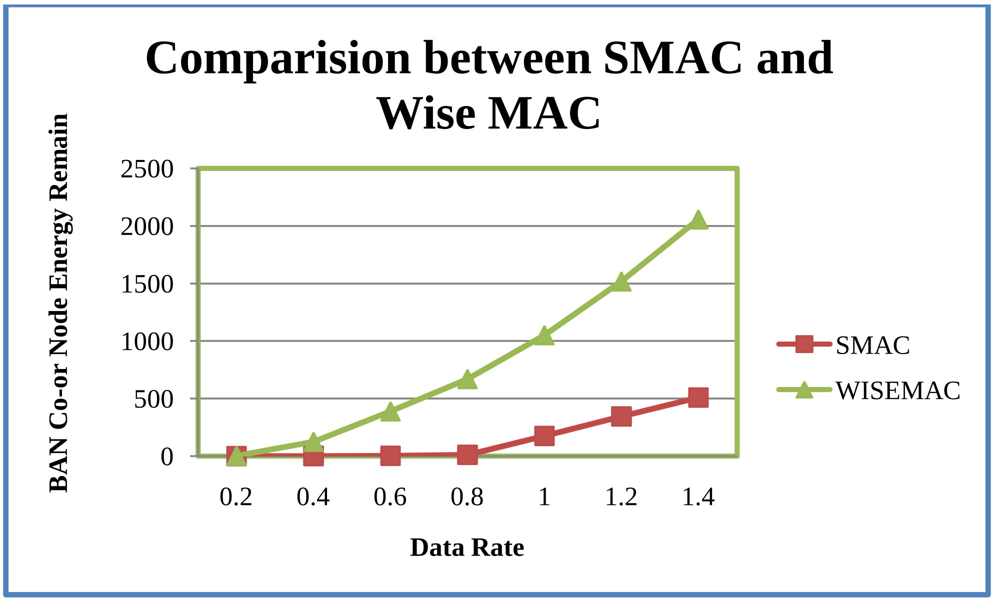

Fig. 4: BAN Co-or Node Energy Remain - Comparison between SMAC and Wise MAC

Fig. 5 presents a study of the Delay between proposed SMAC and WiseMAC. WiseMAC protocol offers more delay as compared to SMAC. As the data rate increases the delay decreases. This is a disadvantage of store and forward messaging strategy applied for sensor node. Common nodes always communicate to BAN Coordinator node via cluster heads. Cluster head aggregates the data received from various common nodes in that cluster and transmits it to the access point and then access point forward it to the BAN Coordinator node according to the priority, i.e. normal data or emergency data. Here in both point priority queue is implemented. Because of this delay is going to add at every step. Because of this delay parameter is increase. Table 5.23 shows the sample data value of delay.

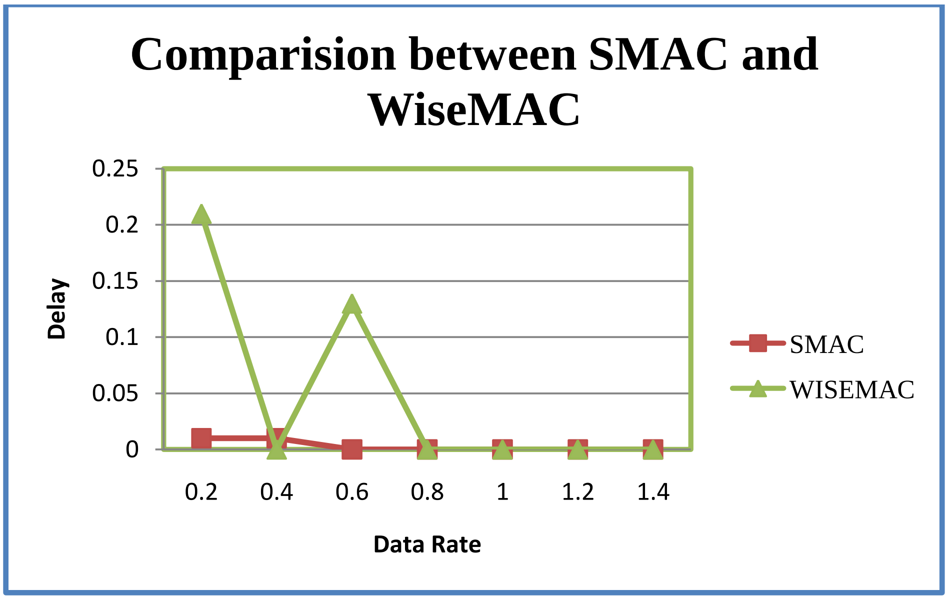

Fig. 5: Delay - Comparison between SMAC and Wise MAC

V. CONCLUSION

Low power consumption is the main requirement in wireless sensor network. In this research work, we attempted to develop an adaptive energy efficient SMAC and WiseMAC protocols for wireless body area network. The proposed protocols show increase in common node remaining energy, cluster node remaining energy, BAN co-or node remaining energy and decreasing in delay. This is achieved because of dynamic duty cycle and priorities based message passing schemes. The developed protocols can be used for wireless body area networks and patient monitoring systems.

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