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ENHANCING ENERGY IN WBAN THROUGH COGNITIVE RADIO NETWORKS

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Abstract — Wireless Body Area Networks (WBAN) provides to measure various physiological and biological data and monitor human body functionalities. In this study, a cognitive radio based coordinator node is designed for Wireless Body Area Networks. Cognitive Radio is capable of connecting various wireless access points with perception and adaptation features. A simulation model has been developed for implementing cognitive radio enabled body area network for analyzing remote health monitoring system for humans. The prominent parameters such as user speed, access point delay, and connection cost are taken into account when selecting the wireless access point. A supervised machine learning technique called Particle Swarm Optimization (PSO) is adapted in the proposed model for improving Energy efficiency and reducing transmission delay in CR enabled WBAN. Simulation is performed using MATLAB and results indicate that the use of proposed PSO for WBAN performs efficiently compared to traditional methods based on MAC protocols.

Keywords — Wireless Body Area Network, Cognitive Radio Network, Body Sensor Network, Routing Protocols.

I. INTRODUCTION

1.1 WBAN

Wireless body area network for health monitoring is used to reduce the expense of healthcare due to continuous monitoring of the patient. It is used for providing the real time scenario and diagnoses of diseases [1][2][3]. WBAN gather information from different sensors for providing secure data communication, low power consumption, prevention and early risk detection and sharing the information to the doctors, also provide greater mobility and flexibility to the patients.

1.2 MBAN

Medical body area network is used for the purpose of measuring and recording the parameters inside the body that provide care and safety for the patients [4][5]. MBAN spectrum provide a cost effective way for monitor the patients health including the sensing parameters such as blood glucose, body temperature and electrocardiogram readings. MBAN technology is used to provide healthcare facility to improve the quality of the patient to reach the critical levels.

Advantages of MBAN

It is used for allowing the patient monitoring throughout the hospital to increase the comfort zone [6][7].

Ease of transport for allowing patients to re locate in different clinics.

1.3 Energy Efficiency

Energy efficiency is the first goal to achieve in WBANs since sensor nodes are small and battery operated. For long time patient monitoring, it is an obligatory goal to play down energy dissipation at Level 1 as much as possible. Multiple and dynamic power management schemes can be used to prolong lifespan of sensor nodes. In WBANs, sensor node's transceiver is one of the dominant energy dissipation source [8][9]. Optimization of Physical (PHY) and MAC layer processes result in reduced power consumption of transceiver. PHY layer has some limitation for power optimization. However, MAC layer provides higher level of energy savings by introducing multiple transmission scheduling schemes, optimal packet structure, smart signaling techniques and enhanced channel access techniques.

1.4 Organization

In this paper we are going to tell about the literature survey made regarding the WBAN and Cognitive Radio Networks. How the wireless body area network is applied using CR network and by using PSO algorithm to calculate the energy efficiency for the proposed system.

II. LITERATURE REVIEW

2.1 WBAN Challenges

The recent technological advances in integrated circuits, wireless communications, and physiological sensing allow miniature, lightweight, ultra-low power, intelligent monitoring devices. A number of these devices can be integrated into a Wireless Body Area Network (WBAN), a new enabling technology for health monitoring. Using off-the-shelf wireless sensors we designed a prototype WBAN which features a standard ZigBee compliant radio and a common set of physiological, kinetic, and environmental sensors [10][11][12]. We introduce a multi-tier telemedicine system and describe how we optimized our prototype WBAN implementation for computer-assisted physical rehabilitation applications and ambulatory monitoring. The system performs real-time analysis of sensors' data, provides guidance and feedback to the user, and can generate warnings based on the user's state, level of activity, and environmental conditions. In addition, all recorded information can be transferred to medical servers via the Internet and seamlessly integrated into the user's electronic medical record and research databases.

2.2 CR Enabled WBAN

Cognitive radio (CR) is a paradigm for opportunistic access of licensed (primary) parts of the electromagnetic spectrum by unlicensed (secondary) users. This emerging technology is aimed at improving the efficiency of wireless resource usage. In medical environments, CR has big potential to solve interference problems caused by the scarcity of spectrum allocated to medical applications. Hospital environments such as the operating room (OR) offer challenging scenarios 13[14] to spectrum managers, in which CR is a viable solution to ensure electromagnetic compatibility (EMC). A recent trend in medical practice is the use of wearable wireless medical sensors. These devices are being introduced in unlicensed bands, where the usual concepts of primary and secondary users do not apply. This paper discusses some of the alternatives for implementing CR in such particular environments. A short survey of CR for hospital environments is also presented, highlighting the differences with the scenarios in which wireless sensors are used.[3]

2.3 Machine Intelligence in WBAN

Fostered interest in human health & technological developments has increasingly paved way to (WBAN) Wireless body area network. With broader capabilities it focuses is to play a vital role for the improvement of human health. In this research paper, we propose to Conceptualize & optimize medical data using PSO in virtual doctor server (VDS) in existing WBAN architecture. Existing architecture of WBAN consists of: wireless sensor, wireless actuator node, wireless central unit, a virtual doctor server (VDS) and wireless Personal Device (PD). Personal Digital Assistant (PDA) or smart phone can be used as PD. Based on the existing architecture mentioned above VDS will keep the historical data about the patient, optimize the data using PSO, generate advices, inform to take rescue action and can provide first aid assistance instructions on patient or any of his close relative’s PDA's. VDS can further be used to improve security & develop potential solutions for secure network for WBAN system.[15].

Table 1. Comparison of Existing System

Title of the paper	Problem Definition	Technique	Limitation
A wireless body area network of intelligent motion sensors for computer assisted physical rehabilitation.	A wearable Wireless Body Area Network (WBAN) of physiological sensors integrated into a telemedical system holds the promise to become a key infrastructure element in remotely supervised, home-based patient rehabilitation.	ZigBee Radio	Reliability
Cognitive radio for medical wireless body area networks.	The trend of Wireless Body area networks with cognitive radio is towards the implementation in unlicensed frequency bands.	Ultra Wide Band Technology (UWB)	Interference problems are created due to scarcity of spectrum and large no of collocated devices.
Modeling and Optimizing Wireless Body Area Network Data using PSO in Virtual Doctor Server.	The literature on wearable sensors and devices for monitoring human activities which aims to improve quality of human life with the Architecture of WBAN integrated with the advantage of VDS & data optimization using PSO.	Particle Swarm Optimization	Design issues like Durability, Power supply issues, element constrain.

III. SYSTEM ARCHITECTURE AND IMPLEMENTATION

3.1 Energy Efficiency in CR Enabled BAN

A CR-based WBAN system may consist of wearable or implantable sensor nodes that sense the biological information from the human body and transmit to a fusion or sink device via relay sensor nodes. Once the patient information is at the sink, it can be accessed by the medical research center for analysis, as well as by the medical specialist for the medication. These sensors that gather biological information from the human body are tiny and low power and detect medical signals such as electrocardiogram, photplethysmogram, lectroencep halogra phy, pulse rate, pressure and temperature. As low power consumption, tiny size and low latency are three essential requirements of the body area network to determine the life time of the sensor nodes, their suitability to be worn by the patient or implanted inside the human body and effective healthcare monitoring respectively, thus, it is desirable to use a wireless platform that will provide low power consumption and transmit over longer distance with less power. Keeping in view these stringent requirements of WBAN, each sensor is armed with CR, thus termed as CR-based WBAN [16][17].

With the help of CR, each sensor node can sense the spectrum to find out the available/empty channels. Those channels that are unoccupied by the PUs are considered as empty. Each sensor node can select the best channel that suits its quality of service requirements in terms of bandwidth, latency and error rate. Because CR can select any channel out of the available/empty channels, it can reconfigure its operating parameters such as transmission power, error coding scheme, modulation scheme, etc. in accordance with the conditions of the selected channel.

3.2 Energy Calculation

In CR network as mentioned earlier, there are two types of users, that is, SU and PU. In CR-based WBAN, all the sensors, whether collecting biological information or relaying the information, work as SU, and every radio other than these sensors will be considered as PU. SU can occupy a channel only if it is idle, that is, unoccupied by PU. If an SU communicates over a channel and a PU comes back over the channel, collision occurs between SU and PU, hence loss in the SU data packet. While selecting a channel for SU communication, we need to take the PU activity into consideration.. Let T_0 and T_1 be the mean PU Absent and PU Present, respectively, then the probability of PU absence (H_0) and probability of PU presence (H_1) can be stated as follows

$$\mathbf{H}_{0=}\frac{T_0}{T_{0+T_1}} \text{ ------------- } (1)$$

$$\mathbf{H}_{1=}\frac{T_1}{T_{1+T_0}} \text{ --------------- } (2)$$

If a PU appears during SU communication on a channel, this will lead to a collision between SU and PU. It is assumed that even if a collision between SU and PU occurs just for the duration [18][19] of a single bit, the whole packet is considered to be corrupted. To account for the error due to collision between PU and SU, we need to compute the probability of collision occurrence, also known as packet error rate due to collision between SU and PU, denoted by E_r. The E_r can be calculated

$$\boldsymbol{E}_{r=1-e\frac{l_{s+l_h}}{r\times T_0}} \text{ ---------------- } (3)$$

Where Ls is size of the packet, L_h is the size of the packet header; r is the data rate of SU transmission and To is the mean time when the channel is empty.

Path loss represents the gradual power reduction in the electromagnetic signal as the signal propagates through the wireless channel. In order to measure the signal to noise ratio (SNR) between the transmitter and receiver, we need to estimate the path loss. Several path loss models have been previously established for approximating signal attenuation. The relationship between transmitted power (Pow_t) and received power (Pow_r) can be expressed as follows:

$$\mathbf{Pow_r = Pow_t C} \left(\frac{d_0}{d}\right)\boldsymbol{\gamma} \text{ --------------- } (4)$$

where γ is the path loss exponent, C is the constant and d0 is the reference distance. The assumption is that C, d0 and γ are the same for all hops. After calculating the Signal Noise Ratio for the channel between data sensors and the first level of relaying sensors, the SNR of channel between two nodes that are i hops away from each other is [20].

$$\mathbf{SNR_i = SNR} \times (\boldsymbol{\gamma_i})\boldsymbol{\gamma} \text{ , i=1, 2… ---(5)}$$

IV MACHINE INTELLIGENCE ALGORITHM

A.
B.

4.1 PSO Algorithm

It was proposed by Eberhart & Kennedy in 1995, the Particle Swarm Optimization (PSO) algorithm was an outcome of the observations on foraging behavior of birds and their collective intelligence. While foraging for food, a bird communicates and shares information with their other companions. Therefore, according to their personal best experiences and the swarm's best experiences, birds keep

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modifying their trajectory to find food for each individual as early as possible. Hence, the swarms of birds start their flight towards the same direction. Analogous to Genetic Algorithm (GA), PSO algorithm can generally be used for optimization problems. Whilst, the difference between GA and PSO is, here (each particle in the PSO) has its own memory; it shares the information with neighbors then adjusts its behavior to align with the swarm's best experiences. These three features enable PSO to convergence rapidly and reach a good solution.

```
for each particle i = 1, ..., S do
  Initialize the particle's position with a uniformly distributed random vector: xi ~ U(blo, bup)
  Initialize the particle's best known position to its initial position: pi ← xi
  if f(pi) < f(g) then
      update the swarm's best known  position: g ← pi
  Initialize the particle's velocity: vi ~ U(-|bup-blo|, |bup-blo|)
while a termination criterion is not met do:
  for each particle i = 1, ..., S do
    for each dimension d = 1, ..., n do
      Pick random numbers: rp, rg ~ U(0,1)
      Update the particle's velocity: vi,d ← ω vi,d + φp rp (pi,d-xi,d) + φg rg (gd-xi,d)
    Update the particle's position: xi ← xi + vi
    if f(xi) < f(pi) then
      Update the particle's best known position: pi ← xi
      if f(pi) < f(g) then
        Update the swarm's best known position: g ← pi
```

Fig 3: PSO Algorithm

4.2 Body Node Coordinator(BNC)

Wireless body area networks (WBANs) are intelligent wireless monitoring systems, consisting of wearable, and implantable computing devices on or in the human body. They are used to support a variety of personalized, advanced, and integrated applications in the field of medical, fitness, sports, military, and consumer electronics. In a WBAN, network longevity is a major challenge due to the limitation of the availability of energy supply in body nodes. Therefore, routing protocols can play a key role towards making such networks energy efficient. In this work, we exhibit [21][22] that a routing protocol together with an effective body node coordinator (BNC) deployment strategy can influence the network lifetime eminently. Our initial work shows that the variation in the placement of a BNC within a WBAN could significantly vary the overall network lifetime. This motivated us to work on an effective node placement strategy for a BNC, within a WBAN; and thus we propose three different BNC placement algorithms considering different features of available energy efficient routing protocols in a WBAN. Our simulation results show that these algorithms along with an appropriate routing protocol can prolong the network lifetime by up to 47.45%.

4.3 Simulation Setup

To analyse the energy in BAN network the PU and SU nodes are initialized to evaluate the energy among BAN sensors from the transmitter to the receiver by setting up the following parameters Ls , Lh, r , N (no of nodes) , T_0.

Table 2. Simulation Paramters

Parameters	Values
Ls	512 bits
N	5
Lh	30 bits
T_0	0.8
r	8 Kbps
T_0 i=1, 2, 3…	Mean idle time for links in i^{th} route

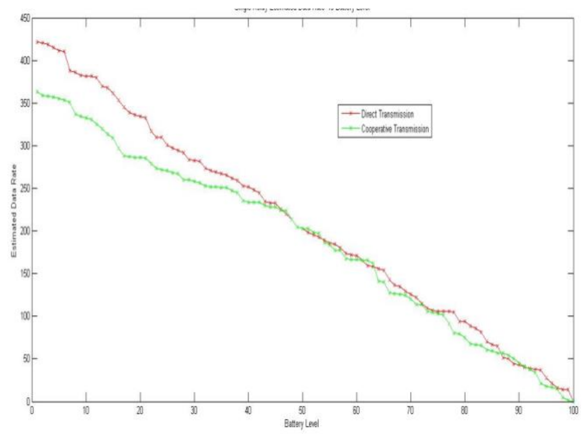

Fig 4 : Data Transfer Rate Vs Energy

By the above calculated result the energy is minimized and simulations are made by removing the noise in the signal received using Signal to noise ratio (SNR).

V. CONCLUSION

From this project we conclude that the energy utilization of the hardware can be reduced and also the speed of deduction of the attacks will increased by using the coordinator node in the proposed WBAN which is designed with cognitive radio capabilities for adopting any access point around. It can be seen from the analysis of the results that coordinator node can sort the data and choose the best access point for sending them to the destination within the best performance. For minimization of energy utilization CR-WBAN is enabled with SNR and the final simulations are calculated to improve energy optimization by providing proper information to the user quickly.

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