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ENERGY EFFICIENT AND RELIABLE DATA TRANSFER ROUTING IN WIRELESS BODY AREA SENSOR NETWORKS

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***Abstract**: Wireless body area network, WBAN, is a network designed by low-power devices that are located on, in or around the human body and are used to monitor physiological signals and motion for medical, personal entertainment and other applications and purposes In Wireless Body Area Network, Sensor nodes are typically powered with battery, which have insufficient life time. Even though renewable energy sources like solar energy or piezo-electric means are used as supplementary energy in WSNs, it is still some degree of reserve to consume energy judiciously. Proficient energy routing is thus a key requirement for a trustworthy design of a wireless sensor network. We propose a reliable, power efficient and high throughput routing protocol for wireless body area networks (WBANs). We use hierarchical routing to minimize energy consumption and maximizing network lifetime. Selection of cluster head is based on distance and residual energy to maximize network lifetime. Simulation results shows that proposed protocol named EERR enhance the network stability period and nodes stay alive for longer period. Longer stability period contributes high packet delivery to sink which is major interest for continuous patient monitoring. Simulation has been done in MATLAB and results are compared with existing hierarchical protocol such as M-ATTEMPT.*

***Keywords:** WBAN, Hierarchical routing in WBAN, wireless body area network.*

1. INTRODUCTION

Advancements in wireless technology born a new generation of WSN which is suitable for networking on the human body or in the human body. For data transfer among sensor nodes a point to point topology or multi-hop topology is used in these networks. In wireless body area network, only few sensors are used which are implanted in body or positioned on the body. These tiny sensors placed on patient’s body measure vital signs like blood pressure, Glucose level, and pulse rate etc. These measured values are then forwarded to the medical server or doctor to further analyze the patient’s condition. Wireless sensors provide continuous monitoring of patient at remote place. Use of topology depends on the application, for example to measure the postures of an athlete require a multi-hop topology. The sensed data is exchange among sensor nodes and then it reaches to base station or sink. Sensors can be implanted or placed on the athlete’s body. One of the major applications of WSN technology is monitoring of human health [2]. Wireless body area network, WBAN, is a network formed by low-power devices that are located on, in or around the human body and are used to monitor physiological signals and motion for medical, personal entertainment and other applications and purposes [1], Fig.1. Healthcare applications have attracted researcher’s attention because of the increasingly aging population prone to age-related diseases and could often benefit from continuous monitoring of physiological signals [2]. The use of WBANs may enable ubiquitous healthcare and could lead to proactive, and even remote, diagnostic of diseases in a nearly stage. Moreover, a WBAN may contain an actuator, which based on measurements and settings, can automatically release medicine or other agents. An example being an actuator to supply insulin to a patient with diabetes under the appropriate conditions. Additionally, WBANs provide health monitoring without interfering the patient’s everyday activities. For real-time applications where the caregiver needs to receive information about the patient’s health on a continuous basis, the WBANs should provide, among other characteristics, reliable communications that are relatively insensitive to link or node failures [3]. However, patient mobility increases the probability of packet loss, and it is preferred that the packet error rate should be kept less than1% [4]. Moreover, the WBANs must transmit at low power to protect the patients against harmful health effects associated with the radiofrequency (RF) emissions. Thus, the specific absorption rate (SAR) should be low [5]. SAR is the rate at which the RF energy is absorbed

ISSN 2320-6802

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by a body volume or mass. Due to this limitation on the specific absorption rate, it is not possible to increase the transmission power beyond a certain level to overcome the transmission loss of the packets. To increase the network's throughput and reliability in the presence of packet losses and avoid single points of node or link failures, the author extend Cooperative Network Coding (CNC)as proposed in [6] to networks where there are many sources, many relay nodes and many sinks/destinations. The relays and sinks act as multiple-input-multiple-output (MIMO) nodes [7].

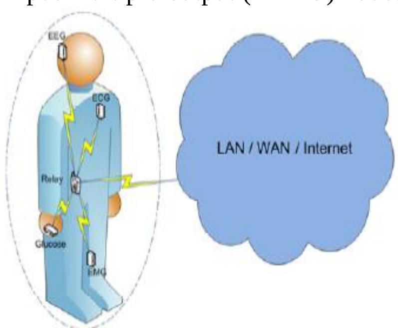

Figure 1: Wireless Body Area Network

2. LITERATURE REVIEW

In [1], the author implant devices are used to measure biological parameters and transmit their results to remote off-body devices. As implants are characterized by strict requirements on size, reliability and power consumption, applying the concept of cooperative communications to wireless body area networks (WBANs) offers several benefits.

In [2], Author describes Wireless body area networks (WBANs) offer many promising new applications in the area of remote health monitoring. An important element in the development of a WBAN is the characterization of the physical layer of the network, including an estimation of the delay spread and the path loss between two nodes on the body. This paper discusses the propagation channel between two half-wavelength dipoles at 2.45 GHz, placed near a human body and presents an application for cross-layer design in order to optimize the energy consumption of different topologies.

In [3], the emerging of wireless body area network has profound impacts on our daily life, such as pervasive medical supervision and outdoor exercises, and the large scale application of wireless body area network can effectively reduce higher cost burden owing to the aging society and long term healthcare for the chronic illness.

This paper presents [4] the WBAN transceiver that satisfies all of the requirements for IEEE 802.15.6 applications. The transceiver is optimized to the WBAN sensor nodes by removing the XO and any off-chip external components for reducing the cost, size, and power consumption by efficient duty cycling.

In paper [5] The author's addressed the topology design problem for Wireless Body Area Networks, proposing a novel and effective model based on mathematical programming that determines (1) the optimal number and placement of relay nodes, (2) the optimal assignment of sensors to relays, as well as (3) the optimal traffic routing, taking accurate account of both the total network cost and energy consumption. The model can be used to minimize both the total energy consumption and the network installation cost, while ensuring full coverage of all sensors.

3. METHODOLOGY

1. Initially, we have set base station a fixed position at human body and nodes are setup in a particular region on different parts of body like on legs, hands, heart etc. and each have equal energy i.e. 0.5 J. We propose here a Hierarchical Routing Protocol to reduce packet loss and we also use one-hop routing to improve quality of service. One hop routing is used for nodes that will transfer important data for the human body like heart rate and ECG. Initially, all nodes have equal energy. So, there is no cluster head.

2. In round 1, Cluster Head will be created according to probability condition i.e. according to minimum distance from base station and residual energy. The residual energy is the energy that a nodes must have to send the aggregated data to the Base Station which can be calculated as,

Residual Energy:

$$(1.5*((ETX+EDA)*(b)+ Eamp*b*(distance * distance))) \quad (1)$$

where,

ETX: Energy consumed by Transmitter to send data.

EDA: Data Aggregation Energy

Eamp: energy consumed by transmit amplifier.

b= Data Bits need to transfer

distance: Distance from a particular cluster head or base station

3. After election of cluster heads, remaining Nodes will find out their respective cluster head according to the minimum distance. Nodes will elect a node as their cluster head if it is nearest as compare to other cluster heads.

4. Then, Nodes sends the data to their respective cluster heads and energy consumption will be calculated according to equation.

$$ETX*(b) + Eamp*b*(min\_dis * min\_dis); \quad (2)$$

where,

ETX: Energy consumed by Transmitter to send data.

Eamp: energy consumed by transmit amplifier.

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b= Data Bits need to transfer
min_dis: Distance from a particular node to cluster head.

5. Cluster Head will aggregate the data and send it to the base station and energy consumption will be calculated for each node and cluster heads according to following equation:

1.5*((ETX+EDA)*(b) + Eamp*b*(distance * distance)) (3)

where, ETX: Energy consumed by Transmitter to send data.
EDA: Data Aggregation Energy
Eamp: energy consumed by transmit amplifier.
b= Data Bits need to transfer
Distance: Distance from a particular cluster head or base station

6. In round 2, the nodes will become cluster heads according to cost function i.e. according to minimum distance from base station and threshold energy.

Cost Function (i) = distance (i) /Residual Energy (i) (4)

Cost function value ensures new forwarder in each round

7. After selection of cluster heads, Nodes sends the data to their respective cluster heads, that will be selected according to the minimum distance of a particular node from cluster heads and energy consumption will be calculated according to above equations.

8. Cluster Head will aggregate the data and send it to the base station and energy consumption will be calculated according to above equations.

9. This process will be repeated until the whole network gets down or number of rounds finished.

10. Performance will be evaluated according to parameters like network lifetime, energy dissipation, no. of data packets sent etc.

4. IMPLEMENTATION AND RESULTS

Due to the fact that clustering protocols consume less energy, these protocols for WSNs have gained extensive acceptance in many applications. Many on hand WSN protocols use cluster based scheme at manifold levels to minimize energy expenditures. CH in most cluster based protocol is selected based on a probability. In this report, our goal is to design a routing protocol that will reduce packet loss as well as energy consumption.

4.1 Minimum Energy Consumption Radio Model

A great number of radio models are presented in literature. We use first order radio model as proposed in [2]. This radio model considers d the separation between transmitter and receiver and d2 loss of energy due to transmission channel.

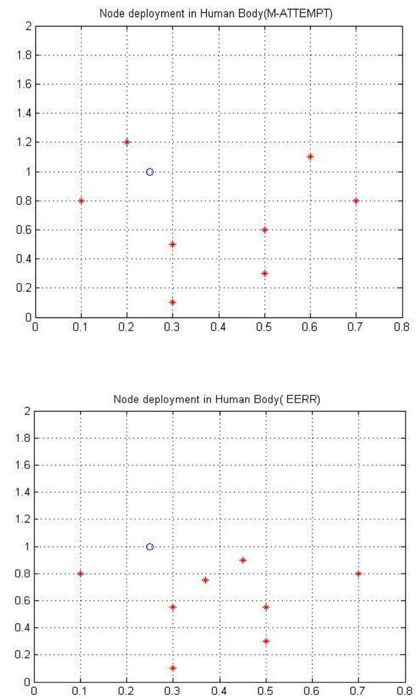

Figure 2: Node deployment in Body (M-ATTEMPT VS EERR)

Table 1: Radio Models

Radio Model:	nRF 2401A	CC 2420
Etx(elec)	16.7nJ/bit	96.9 nJ/bit
Erx(elec)	36.1nJ/bit	172.8 nJ/bit
Eamp	1.97e-9 j/b	2.71e-7 J/b

The energy required to transmit a data packet of k bits to a distance d and to receive a data packet of d bits the radio consume, respectively, the following energies:

ETx(b; d) = Eelec x b + Eamp x b x d^2 (3)

ERx(b) = Eelec x b (4)

b is the data-bits and d is the distance between nodes and cluster head or cluster head or base station.

Table 2: Network Parameter Value

Initial Energy,Eo	1 J
Amplifier energy,Eamp	2.71e-7 J/b
Transmitting Energy,Etx(elec)	96.9 nJ/bit
Receiving Energy, Erx(elec)	172.8 nJ/bit
Data Aggregation Energy, Eda	5nJ/ bit
Packet size(b)	4000 bits
No. of Nodes	8
Implementation tool	MATLAB 7.6

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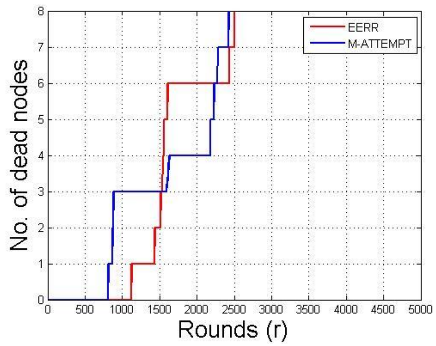

Figure 3: No. of Rounds vs No. of nodes dead

Figure 3 shows comparison of M-ATTEMPT and EERR technique in terms of number of nodes dead. From figure 3 it is observed that, initially M-ATTEMPT protocol loses its nodes quickly as compared to EERR protocol. The EERR protocol will utilize energy much better much better as compared to M-ATTEMPT.

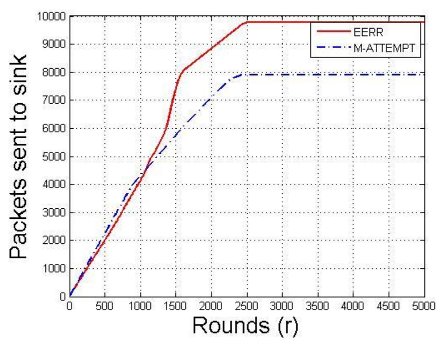

Figure 4: No. of Rounds vs Data sent to Base Station (SINK)

Figure 4 shows how much data will be sent from nodes to base station. From figure 5 it is observed that, in M-ATTEMPT protocol data sent to base station is relatively less as compared to EERR protocol.

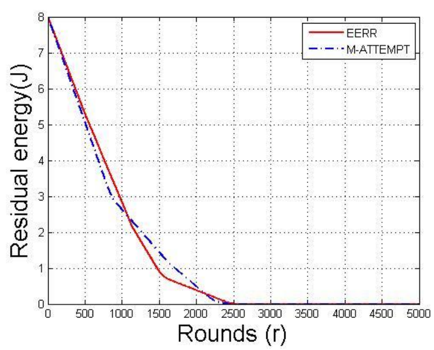

Figure 5: No. of Rounds vs Residual Energy

Figure 5 shows the comparison between M-ATTEMPT and EERR technique in terms of residual energy of the network. Initially, the EERR routing technique shows better stability in terms of energy consumption.

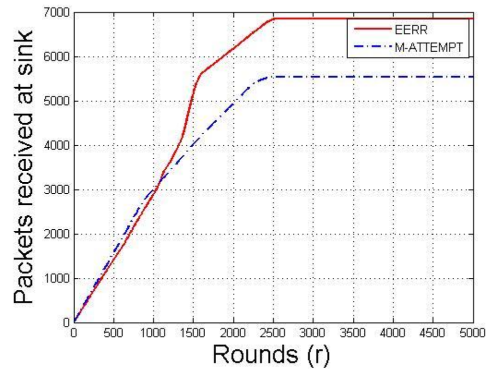

Figure 6: No. of Rounds vs Data received at Base Station (SINK)

Figure 6 shows how much data is received by base station. From figure 6 it is observed that, in M-ATTEMPT protocol data received at base station is relatively less as compared to EERR protocol.

5. CONCLUSION AND FUTURE WORK

In this work, the EERR routing protocol which is hierarchical routing as well as single-hop routing with the whole control to the base station. In EERR routing technique, the base station first collects information about the logical structure of the network and residual energy of each node. So, with the global information about the network base station does cluster formation better in the sense that it has information about the residual energy of each node. Finally, the EERR protocol is compared with already developed routing protocol M-ATTEMPT by the help of MATLAB. A comparison between two is done on the basis of energy dissipation with time, data packet sent and the system lifetime of network. System lifetime is basically for how long the system works. There are still some challenging issues we have to investigate for our prototype system to form a real medical supervision system. One important issue is to make the system more comfortable and easily portable, and the Android application must be implanted into the smart phone to carry out the actually test. Another important issue is optimization of network schedule mechanism for compounding medical data transmission.

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