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Energy-efficient routing transmission for IoT based wireless body sensor network for health care monitoring system

M. Sree Chandana
Dept. of ECM, KoneruLakshmaiah Education Foundation, Vaddeswaram, Guntur, India, 522502
*Corresponding author email: sreechandana598@gmail.com, krraocse@gmail.com

K. Raghava Rao
Dept. of ECM, KoneruLakshmaiah Education Foundation, Vaddeswaram, Guntur, India, 522502

D. Sateesh Kumar
Dept. of Mathematics,KoneruLakshmaiah Education Foundation, Vaddeswaram, Guntur, India, 522502

G. Balaji Prakash
Dept. of Mathematics, Aditya College of Engineering, Surampalem,Andhra Pradesh, India, 533437

***Abstract*---**Body Sensor Networks are very useful in medical services for theidentification ofhealth concerns.In the human body, heterogeneous sensor nodes are used to measure data such as blood glucose, pulse,ECG, etc.Sensors are placed on patients to continually monitor their health status.Patients' smart gadgets with web access serve as gateways tothe internet of things-based WBANs.With the increasing usage of IoT-based body sensor networks, a large volume of health data traffic will develop, necessitating the need for a high consumption efficiency system for radio resource management.One of the most essential parameters in Energy Efficient Routing Transmission (EERT) design for the Internet of Things is reducing energy usage and longer network lifespan by sensor nodes using ad hoc networks. Data from sensor nodes is sent to a sink node via intermediary nodes. End-users can use the information accessible in the sink node for additional analysis.The remaining energy balances energy usage across nodes, and the distance parameter assures effective delivery of packets to the base station.Depending on the outcomes of data packet queuing up, a technique for arranging data packet transfers for medical applications with delay limits is being

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considered. The simulation results reveal that our suggested approach has a prolonged network lifetime, which aids in the high delivery of packets to the sink, which is essential for continuous healthcare monitoring.

***Keywords*---**data packet, heterogeneous, sensor nodes, internet of things (IoT), energy efficient routing transmission (EERT).

Introduction

With the population aging, present medical facilities will be unable to meet the future health needs of the elderly and patients. Because of financial constraints, jobs, and other factors, most patients are unable to cover the costs of long-term hospitalization, even if their health has to be monitored in live time or regularly [1]. The body sensor networkis comprised of several intelligent elements such as sensors, nodes, and actuators. This network is intended to interact with the human body and its environment.Wearable biosensors are a subset of WBANS or devices put in the human body, with a concentration on the size of such devices and low-power wireless communication among them [2].Those sensor-equipped nodes can organize medical warnings of interest, such as ECG data, blood pressure, blood sugar, temperature, voluntary and involuntarily movement or activity assessments, outward the processing and broadcasting of the collected information [3].The Internet of Things (IoT) is a new technology paradigm that has attracted the interest of several study disciplines in recent years.As the need for Sensor Networks e-health services grows, its capability is further strengthened by providing greater safety and confidentiality to users' data through additional confidentiality, and availability characteristics.

It allows people to live better by offering low-cost, flexible usage, and minimal event maintenance [4].Moreover, the lack of proper data sharing security in such a networking architecture permits rogue users to carry out illegal activities on sensitive health data. There is a considerable loss of confidential data and user confidentiality, with serious consequences for patients. If a patient suffers from a heart attack, body sensors (positioned on or within his/her body) can recognize it. As a result, customer and data safety on a network connection is critical, permitting a doctor to start treatment right away [5,6].To ensure the security of the WBANs system, an efficient security architecture is required. Authentication and secrecy are two of the most critical security challenges that must be handled in WBANs. Encryption and digital signatures are commonly used to solve authentication services [7].Furthermore, while transmitting medical data, the most crucial factor to consider is the quality of service given for the data transfer. This necessitates the use of a promising indication that must report a greater priority above non-emergent indicators [8].

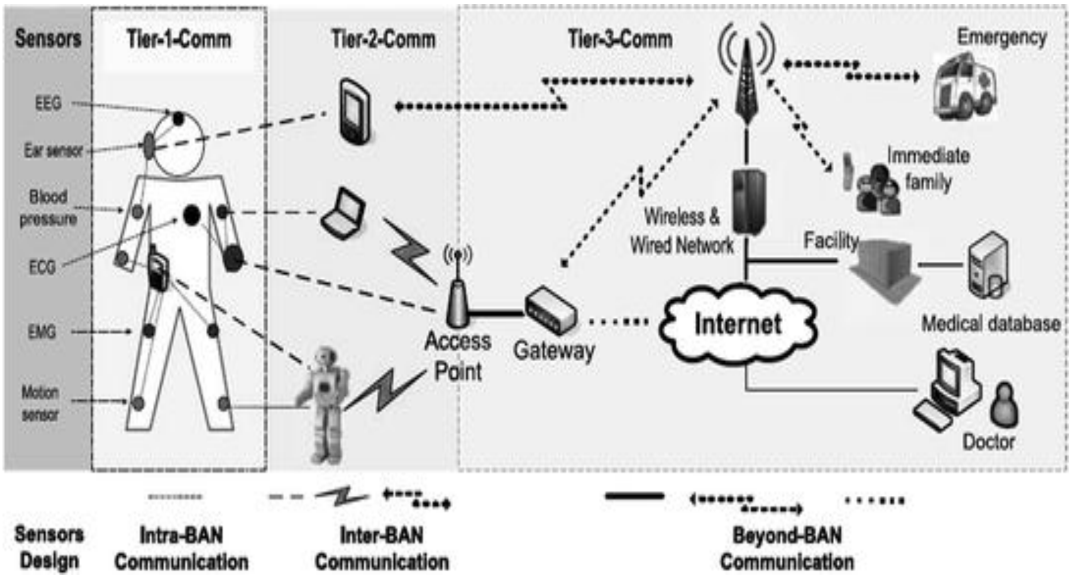

Fig 1. Healthcare IoT based Body Sensor Networks

Patients are observed by a physician from the hospital using WBAN technology. In the case of a dangerous situation, the data is quickly transmitted to the hospital through MAN, LAN, and so on, ensuring that the patient arrives on time. With the aid of WBAN, it is now possible to remotely monitor the actions of a human body and provide vital information through the internet [9].The duration of transmission of distinct data packets in WBANs was believed to be homogenous in attributes, which is not realistic and does not seek to decline network health, thus theefficiency of beyond-WBAN distribution routing may be less than optimum.In data, we described a scheduling algorithm for setback priority WBAN transmissions. In the proposed version, sensory data from medical signals generated by the body come at random at every entrance through Intra-WBAN links[10].

Related Work

The authors of [11] presented a thermally aware routing system. The node with the shortest hop or the shortest distance to the sink is chosen. Once this parent node is thermally heated, the child node chooses the best path to the base station, and the parent node sits idle until it recovers to standard and communication is reestablished. [12] suggested a way to reduce energy use. They set up a few non-sensing, specialized nodes with an extra source of energy. This strategy reduces node energy usage and increases network longevity; however, the added equipment required for the cost of the network is increased by relay nodes.The node is routed for transmission via TDMA (Time Division Multiple Access). A node closeserves as a forwarder node, collecting information from the member nodes. However, the parent node's energy soon depletes due to the influx of data from the child node. A technique for identity in personal area networks was presented as trustworthy [13].In [14], the authors presented a popular protocol for WBAN termed SIMPLE: stable increased-throughput multi-hop protocol for link efficiency.

To identify which nodes, perform best in terms of dependability and throughput, the protocol applies a cost function. In comparison to the M-ATTEMPT approach, this method delivers improved network stability and a longer network lifespan.In [15], a similar strategy was presented. The Transmission Power Control (TPC) method was also employed. When a node's connection quality deteriorates, an Automatic Repeat Request is sent, which retransmits the dropped packet. Retransmission of missed packets improves network performance at the cost of increased energy usage.This article [16]employs the SYLPH (Services layers over light physical devices) concept. It's a paradigm of provider design. The goal of this strategy was for resources to be dispersed among numerous WSNs and to run independently on various wireless devices. This type can connect a variety of networks utilizing various wireless technologies.In [17], the authors presented a routing scheme for BAN throughput enhancement. The residual energy of each node and the cost function for selecting a transmitting node is calculated using the distance between the sink and all nodes in the network. It is demonstrated that distance substantially impacts network performance, but residual energy has a minor impact.

In this paper [18], the author proposes several techniques for assuring security in medical systems. One of the challenges with maintaining patient data is confidentiality. It was proposed to use Ciphertext Policy Attribute-Based Encryption (CP-ABE). According to the access policy, Encryption and decryption of patient data are done. Data can be kept in a server after it has been encrypted. As a result, anybody can get similar data, but only the user's access policy can decode it.This [19] author's system was based on an infrared (IR) sensor. An IR-based monitoring system was deployed in the residence to record the patient's mobility as well as other parameters such as physical activity, and accessibility level. The support vector data description approach was utilized to distinguish between normal and pathological behavior. To categorize the behavioral traits, the behavior classifier approach was utilized.offered to reduce the risks of a bio-medical sensor inserted in a human's body overheating. The Thermal aware routing protocol (TARP) assures equitable temperature diffusion amongst all nodes by considering the temperature. TARP has certain restrictions, such as network longevity, packet loss, and transmission reliability [20].The temperature-aware and energy-optimized (TAEO) routing protocol is suggested, which not only addresses the thermal issues and hot spot problem but also improves longevity. Analytical simulations are run, and the results show that the network lifetime is less, energy conservation, and temperature management are all superior to state-of-the-art WBAN protocols[21].For personal area networks, the energy-aware and stable routing protocol (EASR) is used. The ESR method was created for body networks that are mostly utilized for scattered communication in a hospital context. An objective approach was used to develop energy-efficient paths with secure links to approach the static coordinator[22].

Proposed Methodology

Our proposed approach has a prolonged duration.Nodes remain active for a longer length of time while using the least amount of energy.High throughput is enabled by a long stability period and minimal node energy consumption.When a sink node moves out of the radio range, it employs a relay node to gather information from sensors. The wireless communication between the sink and the sensor nodes is severed when the sufferer moves with his hands in the opportunistic protocol. Link failure requires more energy from sensor nodes and actuators, resulting in the loss of essential and critical data.The overall system model employed in the study of the suggested procedure is briefly described in this section. It covers the network architecture, radio model, and path loss model used in wireless data packet transmission.In general, eight sensors are adequate to monitor the vital characteristics of a patient. In our study, we have picked eight sensors that must be attached to a patient's body; these sensors are ECG, EMG, glucose, blood pressure, temperature, lactic acid, acceleration, and location.We suggest a new technique to reduce energy use while increasing throughput.All sensor nodes are sending information to the base station via the forwarder node. Sensor nodes choose the shortest and most energy-efficient path to the sink node. The suggested effort centered on determining the best path for data transmission.

The proposed Energy Efficient Routing Transmission methodology will operate in the following manner: The number of nodes, a base station node, the distance between each sensor node and the sink node, the distance between each node andsurrounding nodes, and the starting energy of each sensor node.

$$distance_{(a,bs)}=\sqrt{(x_a - x_{bs})^2 + (y_a - y_{bs})^2} \quad (1)$$

where x_a is the node of origin and y_a is the destination node; x_{bs}&$y_{bs}$are the base station node coordinates.

Choose a neighborthe sensor's connectivity with the base station node.The distance between each sensor node and its neighbor node is determined.

$$distance_{(a,i)}= \sqrt{(x_a - x_i)^2 + (y_a - y_i)^2} \quad (2)$$

where x_i and y_i are neighbor nodes.

In WBAN, a multi-hop communication paradigm is recommended to reduce energy usage while increasing throughput. To balance the energy, a forwarder node must be chosen. This may be accomplished by computing the cost function of all nodes.

Transmission model

The energy consumed by the sensor's electronic system is described by a radio model. The first-order radio concept was used in our research.

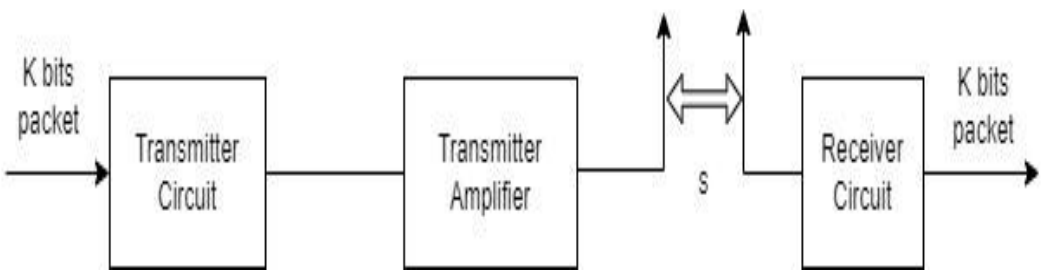

Fig 2. Transmission model

The transmission model characterizes the energy relationships between the transmitter and reception for sending a data packet of 'm' bits size across a distance of's'as given in Equations 1 and 2.

$$E_T(m,s)= E_{T\_Ele}* m + E_{T\_Am} * m * s^2 \quad (3)$$
$$E_R(m,s) = E_{R\_Ele}* m \quad (4)$$

Where E_T represents the energy spent by the transmitter and E_R represents the energy consumed during data packet reception. The energy consumption of the transmitter electronic circuit, transmitter amplifier section, and receiver electronics circuit is denoted as E_{T_Ele}, E_{T_Am}, and E_{R_Ele} respectively. A data packet's bit count is represented by'm', while the distance between a transmission and a reception is represented by's.'The signal is attenuated in the transmission line, and its effect may be integrated by incorporating the path loss.The route loss coefficient parameter 'n' is added since the data link is the human body, which gives attenuation to the energy function.The energy usage is computed as follows.

$$E_T(m,s)= E_{T\_Ele}* m + E_{T\_Am} * m * s^2 * n \quad (5)$$

Table 1
Simulation Parameters

Parameters	**Value**
E_{T_Ele}	$16.7* 10^{-9}$
E_{R_Ele}	$36.1* 10^{-9}$
E_{T_Am}	1.97
Nodes	8
Sink position	Waist of the body
Initial Energy	0.5J
Total rounds	8000
Data packets	4000 bits

Path Attenuation

The definition of path attenuation is the drop in power level as a result of the signal decreasing while theinformation is transferred from its origin to its recipient (measured in dB).This can be caused by a variety of events such as changes in the propagation surface of the wavefront, refraction, reflection during signal transmission, or the existence of an object in the path.The propagation context in the WBAN is not static, and human positions, body mobility, and garments can all impact transmission. A straightforward model of pathattenuation that is affected by distance and frequency is given by

$$PA = PA_0 + 10n\log_{10}\frac{s}{s_0} + X\sigma \quad (6)$$

where 'PL' stands for received power, 's' stands for the distance between transmitter and receiver, 's_0'stands for reference distance, and'n' stands for the path loss coefficient parameter, whose value is determined by the network environment. The standard deviation is 'σ' and 'X' is a Gaussian random variable.

The power received at the reference distance s_0' is denoted by 'PA_0,' 'λ' is the wavelength

PA_0 = $10\log_{10}(\frac{4\pi s_0}{\lambda})^2$ (7)

PA = $10\log_{10}(\frac{4\pi s_0}{\lambda})^2 + 10n\log_{10}\frac{s}{s_0}$ (8)

Multihop selection

We presented a multi-hop strategy for the body sensor network to save energy while improvingthroughput. In this part, we provide the Criteria for a node to become a parent or provider.This multi-hoping technique chooses a different forwarder every round to balance energy utilization among sensor nodes and minimize energy utilization.The base station is aware of the terminals' Identity, location, and remaining energy status.Sink calculates the cost function of all nodes and sends it to all nodes.As a forwarder, it is preferable to use a node with a low-cost function.All of the adjacent nodes band together and relay data to the access point.Data is gathered and sent to the base station by the nurturing node.Because the forwarder node has the most leftover energy and travels to the base station, it takes minimal energy to transport data to that location. Cardiac and insulin monitoring nodes communicate with the sink directly and are not engaged in data transfer.The cost function is given as follows

$$\text{Cost Function} = \frac{Distance\ between\ the\ node\ i\ and\ sink}{Residual\ Energy} \quad (9)$$

Network Topology

This system utilizes eight sensors to track the human body.The waist is the location of the sink node.ECG, EMG, glucose, blood pressure, temperature, lactic acid, acceleration, and location are examples of these sensors. Figure 1 depicts the position of these sensors. Sensor nodes are represented by a red circle, while sink nodesare representedby a green rectangle.It is assumed that each node can handle the same amount of electricity. The data from the ECG and glucose sensors (nodes 1 and 2, respectively) is sent to the sink node via single-hop propagation.

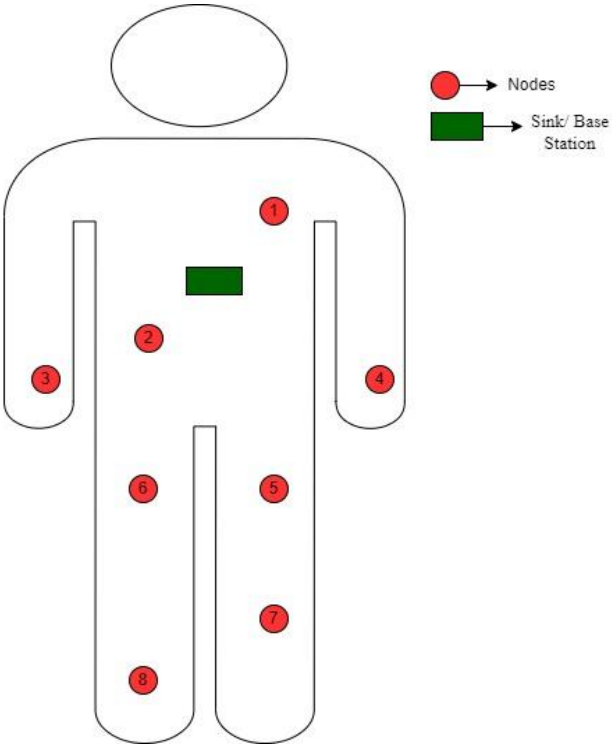

Fig 3. Node deployment

Each sensor node is fixed in its position.The energy of each sensor node is spread evenly.Every sensor in the constructed network is aware of the distance between itself and its neighbors and the distance between itself and its sink node.

Simulation and Analysis

The principal approach for carrying out the work in this study is simulation. Simulation gives the needed convenience, time, and cost savings to achieve the research's objectives.Simulation is a frequently used approach for simulating dynamic real-world systems. The model simulates a genuine system, allowing researchers to investigate multiple systems using simulation tools and emulators that operate on computers. In this work, simulation is utilized to examine the effects of several parameters on signal transmission in WBAN.

Network Lifetime

The length of time requires for the network to start up until the final node ends or dies.The proposed novel cost function for selecting the provider node plays a vital role in balancing the energy usage among the nodes.In every round, a new forwarder selectsbased on the cost function that has already been calculated. Here we observed that at 2175 roundsdead nodes are 3 for TARP and TAEO. From 2176 to 7033 rounds both TARP and TAEO dead nodes remainthe same. From there onwards TAEO dead nodes increases to 5. Whereas for TARP dead nodes start to increase to 5 from round 7161. Till round 3971 EASR the dead nodes are zero.

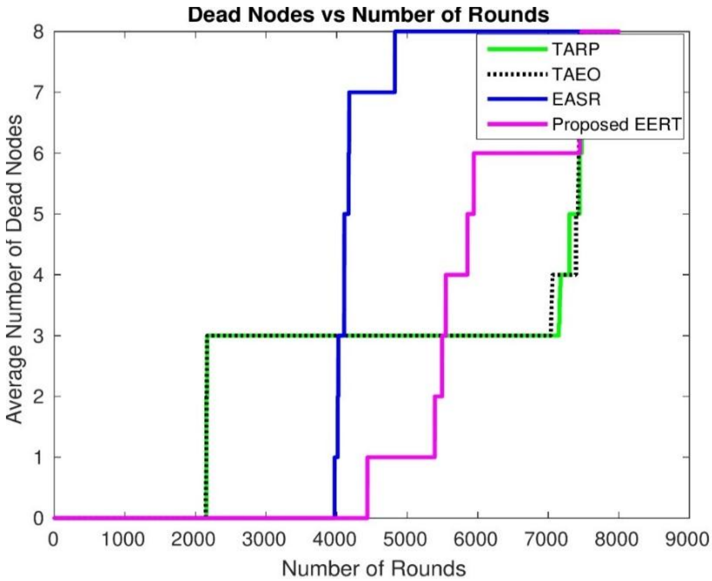

Fig 4. Network Lifetime for TARP, TAEO, EASR, and Proposed EERT

For EASR the number of dead nodesincreases to 7 nodes at round 4178. In the proposed EERT, till round 4437, the number of dead nodesremains zero.From 4438 to 5391 rounds the number of nodes that have died is one. The number of dead nodes has increased to 5 from the 5391 rounds. Fig 4 explains that the proposed EERT has a longer network lifespan than TARP, TAEO, and EASR, as the first node dies considerably later in EERT.This is because, in EERT, transmission occurs once the nodes are close together and contain a considerable amount of remaining energy.

Throughput

Fig 5 tells the packet that arrived at the sink successfully is referred to as throughput.Because of the extended network lifespan, more packets are sent to the body coordinator via the proposed EERT, i.e., the sink. Because WBAN contains crucial patient information it necessitates a procedure with the fewest packet drops and the greatest amount of successful information received at the base station. Here EERT has high throughput than other methods. The number of active nodes influences how many packets are transmitted to the sink.Increased network performance is achieved by having more active nodes send more packets to the sink.As a result, the major reason for the decline in throughput is a shorter time of stability.

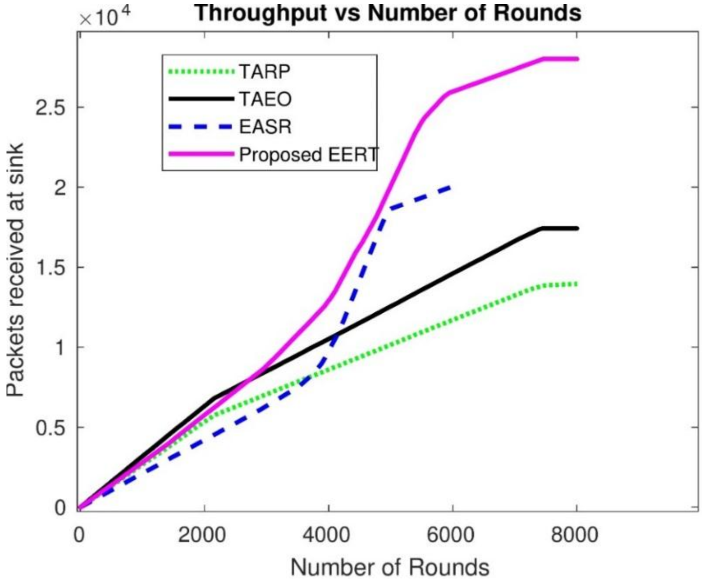

Fig 5. Throughput vs Number of Rounds

The packets received for EERT and TAEO methods are identical until 2955 rounds, after which there is a significant variance in the packets received. Proposed EERT receives 28015.8 packets overall, but TAEO receives 17425.4 packets total. Whereas TARP and EASR number of packets received same up to 3555 roundsthereafter there is a change in received packets. For EASR totalof 19883.2 packets were received whereas for TARP 13933.2 packets are received. proposed method EERT selects the forwarding node more efficiently which leads to a longer network lifetime and greater throughput.

Residual Energy

Figure 6 depicts the network's energy usage in terms of residual energy**.**The suggested model has a multi-hop architecture, each remote node uses a forwarder node to send data to the sink.Using the previously indicated cost function, the forwarder node is selected.The selection of a suitable forwarder in each round helps to preserve energy.Moving packets to the base station, our multi-hop design uses a new forwarder node in each cycle, limiting overburdening of a certain node.Because of the lower number of dead nodes, the proposed EERT approach saves energy more efficiently than existing techniques in terms of residual energy.According to simulation data, the EERT method uses minimal energy for up to 70% of the simulation period.This means that more nodes will have enough energy to deliver more packet data to the sink during the stability period. It also increases throughput on the network.Several TARP, TAEO, EASR nodes,exhaust prematurely due to high traffic loads.

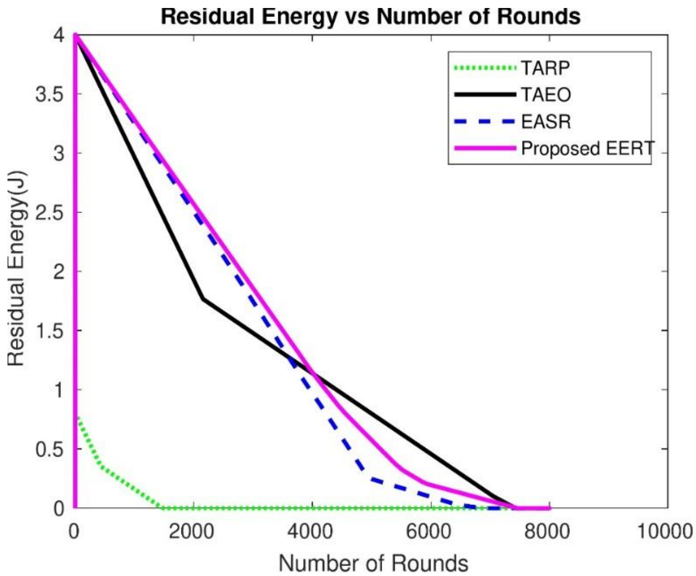

Fig 6. Residual Energy vs Number of Rounds

Path Attenuation

Figure 7 depicts the route loss behavior of various sensor nodes.To determine the route loss of each sensor, a standard frequency of 2.4 GHz was used for the simulation research. Initially, we can observe that EASR and EERT function well until 2000 cycles, after which TARP and TAEO fall dramatically as a portion of the structure dies sooner.Because methods with a longer stability period have more live nodes, the aggregate path attenuation is extremely visible.The reason for this is that multi-hop transmission lowers the distance traveled, resulting in little path loss.

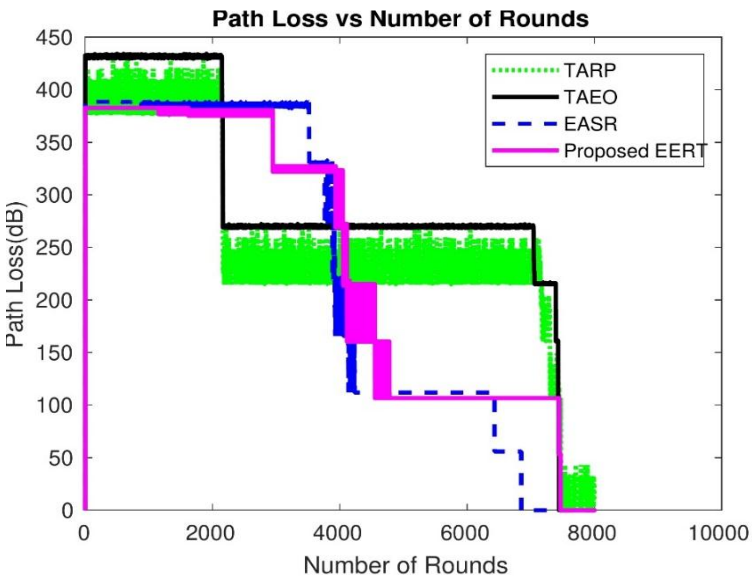

Fig 7. Pathloss(dB) vs Number of Rounds

Delay

Fig 8 depicts variation in delay as a function of transmission cycle count. The usage of multi-hop routing is recommended in WBAN's path loss reduction approach for energy efficiency.Whether it's simultaneous WBAN communication or not, network delays must be addressed, especially when dealing with emergency data.

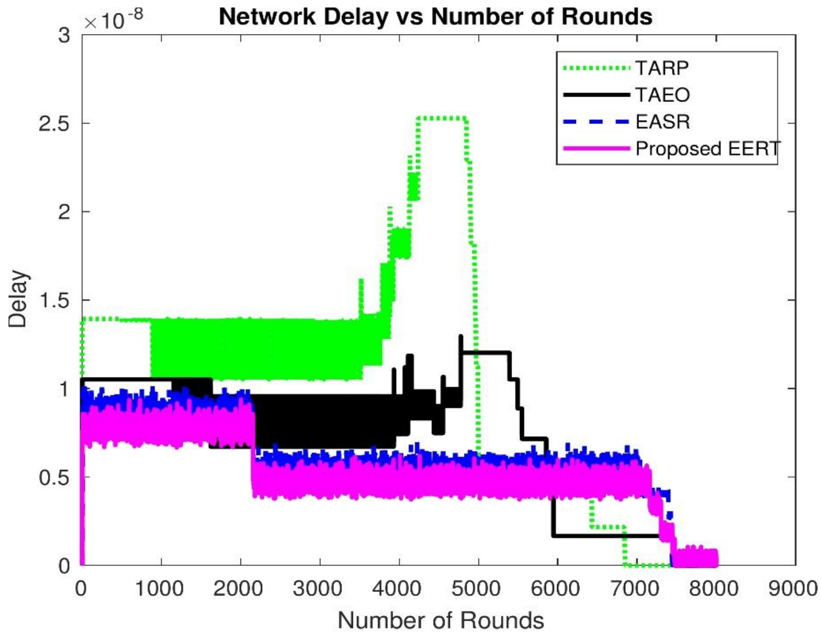

Fig 8. Network Delay vs Number of Rounds

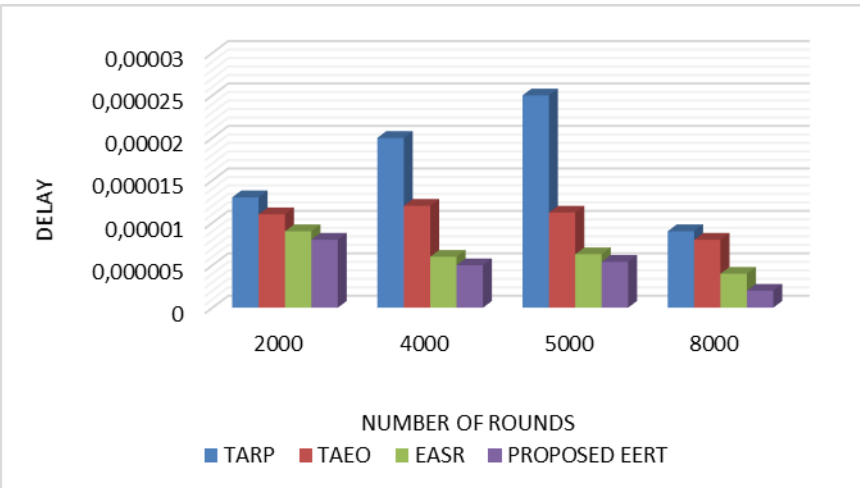

Fig 9. Delay vs Number of Rounds

WBANs that coexist and transfer messages at thesame time in a heavily populated area with high mobility produce significant network interference, resulting in transmission or association waiting time delays.The suggested approach has a faster response time than TARP, TAEO, and EASR.

Packets sent to the sink

Fig 10shows that packets sent to the base station in TARP are 19932 at the 8000thround, whereas for TAEO 24902 packets are sent to the sink at the 8000th round. For EASR 29913 packets are sent and for proposed EERT 40021 packets are sent to the base station. So, most of the packets are sent to the sink from the proposed EERT method.

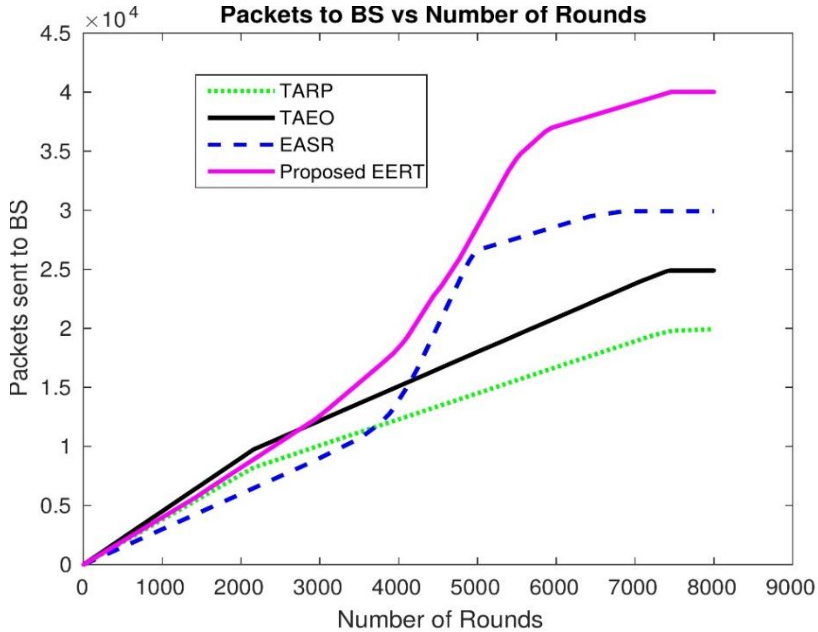

Fig 10. Packets sent to BS vs Number of Rounds

Conclusion

This paper presents a body sensor network for healthcare that has both energy efficient andthroughput routing systems.It is achieved by defining a new cost function that is based on the separation between a node's length and its dissipated energy.In comparison to TARP, TAEO, and EASR methods, we can conclude that the suggested EERT method has superior performance and stability. According to our simulation results, the proposed approach increases network stability and packet delivery to the base station, Throughput and also reducesPath lossand Delay which increases the gateway for the usage of IoT-based body sensor networks.In addition to network security, future WBAN will require advancements in energy efficiency and management, channel usage, and more durable design materials that comply with the high-frequency spectrum, low SAR devices.

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