# Energy-Efficient Direct Routing To Advance The Reliability In Wireless Body Area Network

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**Abstract: Wireless Body Area Networks (WBANs) are mainly designed to improve quality of life of the human beings. Reliable communication using multi-hop topology or via cluster head with minimum energy consumptions is one of the major issues in WBANs. Due to it, an efficient routing protocol is needed to transmit the data reliably. As the routing play an important role in WBANs to maintain the delivery of patient's data on time. A self-adapting routing protocol is required to find an optimal path in multi-hop routing or cluster based routing, in case of dead node. In this work, the concept of mobility has been considered. Two general routing approaches such as cluster-based routing and direct routing which are widely acceptable have been simulated and compared based on different radio models configurations. Simulation results showed that direct routing is much more reliable as compared to cluster-based routing.**

**Keywords: Cluster based routing, Direct routing, Energy-efficient routing, WBAN.**

## I. INTRODUCTION

WBAN follows a standard of IEEE 802.15.6 based on ultra-wide base -band, means to enable low power and limited range communication [1]. WBAN uses several transmission technologies like Bluetooth (IEEE 802.15.1), Zigbee (IEEE 802.15.4) and WLAN (Wireless Local Area Network) and all these technologies work on same band 2.4 GHz ISM [2]. Since, one of the main constraints in WBANs is their limited power supply. So, requirements of data rates and power in WBANs have been compared with other wireless technology, as shown in figure 1. According to that, WBANs require higher power efficiency as compared to other. The SNs in WBANs are capable of transmitting data in a wide range of data rates from 1Kbits/s to10 Mbits/s [1,2].

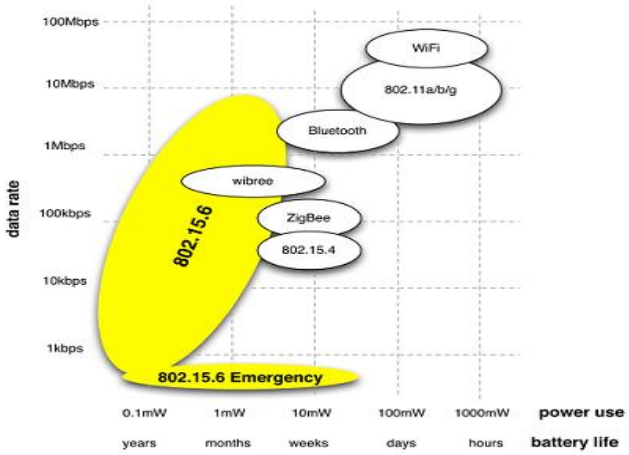


Figure 1: Data rate & power requirement in WBAN

Sensors in WBANs are a network of multiple battery operated devices having limited energy and computational capability, lacking of memory storage and scalability with a demand of continuous operation [3]. Though the technology used for communication in biosensors do not match exactly with

the conventional sensor network. In this owrk, we provide a brief review of the some existing routing protocol of WBANs, which would help in establishing the proposed work [1-12].

## II. LITERATURE REVIEW

In [1], authors design an improved routing protocol for effective data transmission and achieve even energy consumption in WBAN, called 'Even Energy Consumption and Back Side Routing Protocol (EECBSR)'. It considers the deployment of nodes on the front side as well as the back side of the human body. To overcome the various issues line link quality, delay and multi-hop energy consumption in WBANs, a fuzzy based routing algorithm called 'Optimized Fuzzy Based Swarm Routing (OFSR)' is proposed in [2]. The best node is selected in first round on the basis of fuzzy logic method and best route is selected by using the Ant Colony Optimization (ACO) technique to transmit the data. The modified version of ATTEMPT is proposed in [3], called New-ATTEMPT. It supports the heterogeneous network because nodes deployed on the human body with different data rate. A node with maximum cost function is selected as forwarder node to transmit the data to the sink node. In [4], a stable and reliable routing protocol is proposed for indoor environment named: Energy Aware and Stable Routing Protocol. To ensure the lowest energy consumption and reduce network traffic overhead, a stable link is selected to route the data to the sink node. In order to increase the lifetime of network and balance the energy consumptions of SNs, authors designed Weighted Energy Balanced Efficient routing algorithm in [5]. It is the improvement over dynamic routing algorithm (DRA), in which Dijkstra's algorithm is used to discover the shortest path. In [6], cross layer optimization performance is investigated based on real life example, by Samiya and others at the physical and network layers. The best route is selected at the network layer, according to the channel state information from the physical layer. To avoid the retransmission of partially damaged data frame, authors proposed an approach named Automatic Segment Repeat Request (ASRQ) for IEEE 80.15.4 based WBANs in [7]. A new mobility based temperature aware (MTR) routing protocol is proposed by authors in [8], using store and carry scheme. It also considered the frequent link break among neighboring nodes in the network, due to mobility. Two types of nodes are used named: static & dynamic. Static node fixed at the mid of the body, while dynamic nodes are attached to the different parts of the body like leg, arms etc. By combining two technologies such as VANET and WBAN in a vehicular environment, the authors in [9] have designed a prototype that can help to provide comfort and monitoring services for elderly/special people. Dong Liu et. al. [10] proposed a contention-oriented node sleeping MAC protocol for WBAN as an improvement of IEEE Std. 802.15.6 MAC protocol. The authors invoked a contention orientation mechanism as well as a node sleeping scheme, which yielded a fair and energy-efficient resource allocation and eliminated the direct packet collision between different contention levels. In this paper [11], a large-scale platform using the WBAN technology for the monitoring of patients in their homes, in nursing homes or in large hospitals is proposed. In this paper, Tanumay Manna et. al. [12] presented a WBAN that can be used to remotely monitor and store multiple physiological signals of patients.

In this work, comparative analysis for direct routing and cluster routing have been compared. The algorithms for cluster based routing and direct routing for WBAN are as follows.

## III. IMPLEMENTATION

In this algorithm, human body is lying on the bed is assumed for simulation. Ten nodes are implanted in or outside the human body. Movement of legs and hands has been considered in this case. All nodes have equal initial energy and similar processing and computation capabilities. Ten nodes are placed around the human body and BS is placed around waist as shown in figure 2.

*A. Algorithm for Cluster based routing*

The algorithm for cluster based routing is as follows:

Step 1: Initially, all SNs are deployed with equal power and computation capabilities on human body. Sink node is placed near the chest.

Step 2: Calculate the distance from sink node to the each SNs, using equation (1), given as follows:

$$\text{Distance}(i) = \text{sqrt}\left((SN(i).xd-(sink.x))^2+(SA(i).yd-(sink.y))^2\right) \quad (1)$$

Step 3: A route is selected with minimum hop count to transmit the data to the sink node and calculate the energy of each node using equation (2) in each round:

$$SA(i).E = SN(i).E - ((E_{TX})*(4000)+E_{mp}*4000*(distA^2)) \quad (2)$$

where,

$$distA = \text{sqrt}\left((SN(i).xd-(SN(node+1).xd))^2+(SN(i).yd-(SN(node+1).yd))^2\right)$$

$E_{TX}$: Energy consumed by transmitter to send the data.

$E_{mp}$: Energy consumed by amplifier.

Step 4: Steps 2-3 will be repeated until all SNs deplete their energy or number of rounds has been finished.

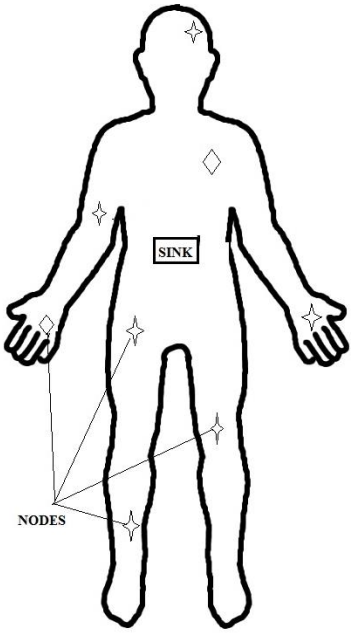


Figure 2: Nodes deployment in Human Body

*B. Algorithm for Direct Routing*

The flowchart for data transfer is shown in figure 3. The algorithm for direct routing is as follows:

1. Initially, BS is placed on 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. 1J and sink is considered to be a node that is having unlimited energy supply. We propose here a direct routing protocol is proposed to reduce packet loss as well as to improve QoS.
2. In round 1, All nodes will transmit the sensed data directly to BS.
3. Energy consumption will be calculated according to equation (2).
4. This process will be repeated until the whole network gets down or number of rounds finished.
5. Performance will be evaluated according to parameters like network lifetime, energy dissipation, no. of data packets sent etc.

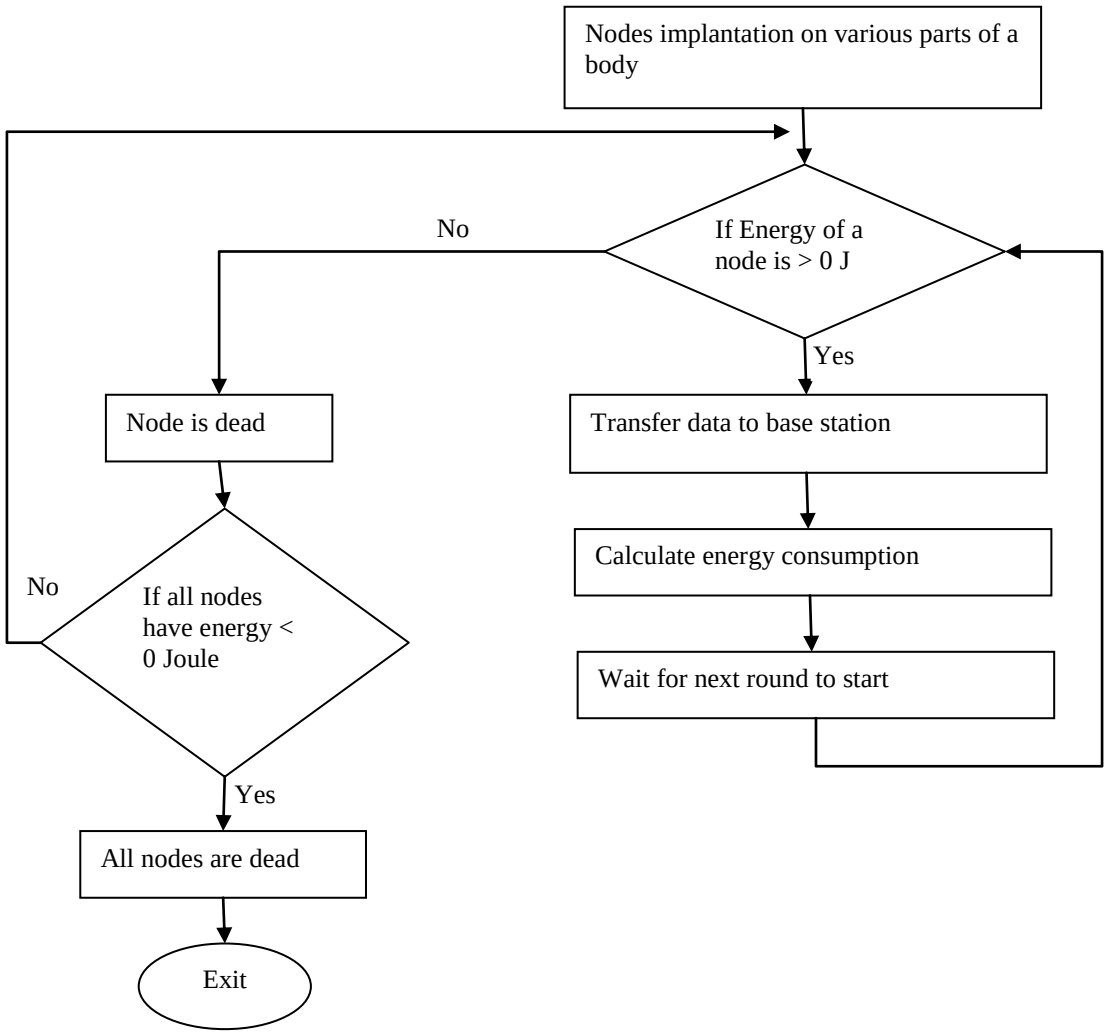


Figure 3: Flowchart of Data Transmission for Static and Mobile Nodes in Direct Routing

Two nodes (node on right hand and feet) in each routing technique will change their position due to body movement as simulation rounds increases. Initially, the nodes will be placed as shown in Figure 2. Assume after 50 rounds, nodes changed their position. For e.g. after 50 rounds, right foot have changed its position. After 100 rounds, hands have changed their position and so on. The concept of mobility is also considered in this work for direct routing as well as for cluster based routing.

Energy consumed for transmitting k-bit message for distance 'd', is given by:

$$Etx(k,d) = Etx\text{-}elec(k) + Etx\text{-}amp(k,d) \quad (3)$$

Where, $(k,d)=Eelec*k+\in amp*k*d^2$

And for receiving k-bit message, energy used is:

$$Erx(k) = Erx\text{-}elec(k) \quad (4)$$

$$Erx(k) = Elec*k \quad (5)$$

Where Etx is the energy consumed in transmission, Erx is the energy consumed by receiver, Etx-elec and Erx-elec are the energy required to run the electronic circuit of transmitter and receiver respectively. $E_{amp}$ is the energy required for amplifier circuit, while k is the size of packet.

*C. Simulation Setup*

First order radio model is used to simulate the comparison among direct and cluster based routing protocol. Table 2 provides the details of network parameters, which is used for simulation. The size of

packet which is to be transmitted is 4000 bits. The sink node is placed at the center. Initial energy of all SNs is taken as 1 J.

Table 1: Parameters of Radio Models

| **Radio Model** | **nRF 2401A** | **CC 2420** |
|---|---|---|
| $E_{TX}$(elec) | 16.7nJ/bit | 96.9 nJ/bit |
| $E_{RX}$(elec) | 36.1nJ/bit | 172.8 nJ/bit |
| $E_{amp}$ | 1.97nJ/bit | 271nJ/bit |

Table 2: Network Parameters (Radio Model nRF 2401A)

| **Parameters** | **Value** |
|---|---|
| Initial Energy, Eo | 1 J |
| Amplifier energy, Eamp | 1.97nJ/b |
| Transmitting Energy Etx(elec) | 16.7nJ/bit |
| Receiving Energy Erx(elec) | 36.1nJ/bit |
| Data Aggregation Energy($E_{DA}$) | 5nJ/ bit |
| Packet size (b) | 4000 bits |
| No. of Nodes(n) | 8 |

*D. Results*

In this work, two routing strategies such as direct and cluster based routing have been compared. First, we have considered eight nodes have been deployed on the body. Each nodes will have equal initial energy i.e. 1 Joule. The simulation parameters have shown in table 2.

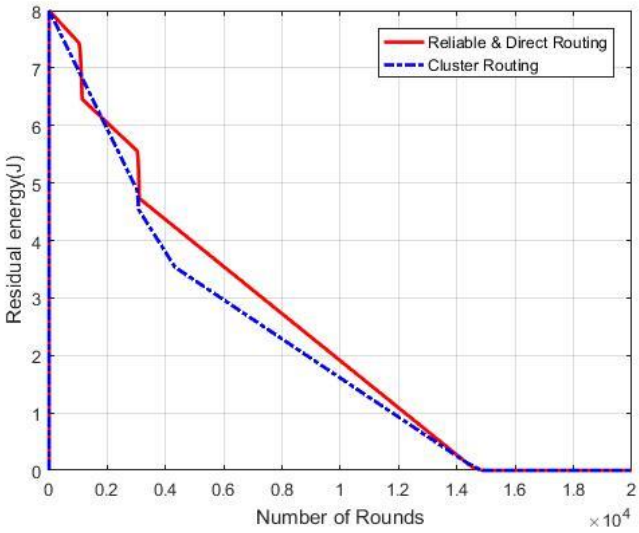


Figure 3 Comparative analysis of energy consumption between direct and cluster based routing

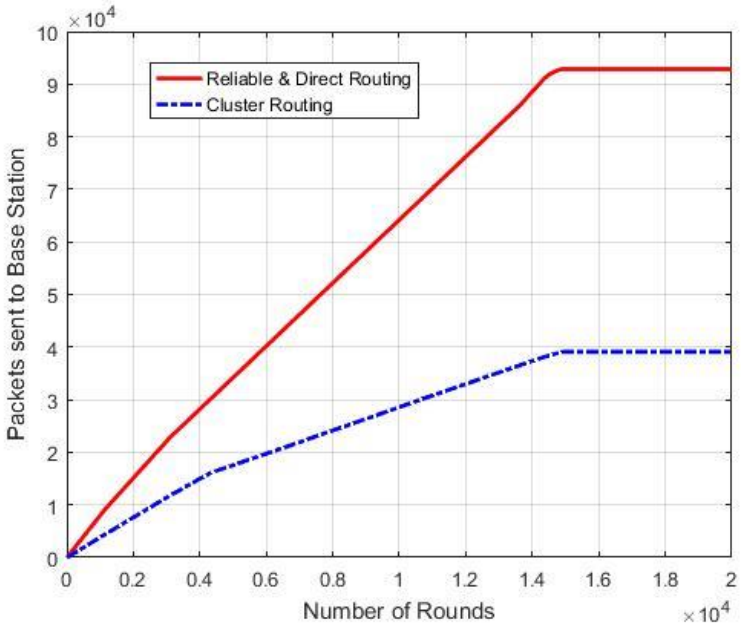


Figure 4 Comparative analysis of packets transfer to base station between direct and cluster based routing

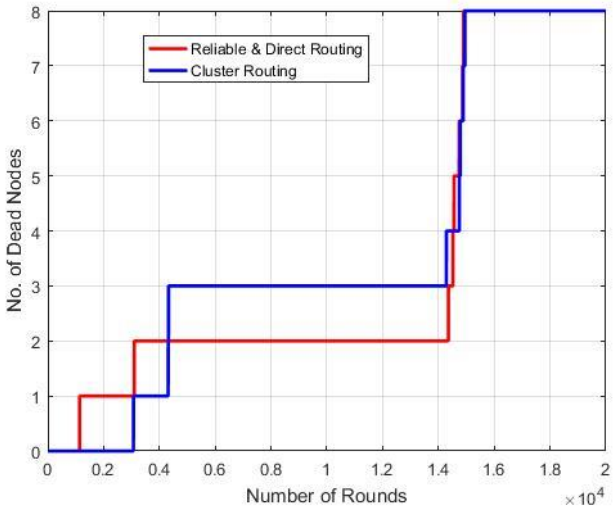


Figure 5 Comparative analysis of dead nodes between direct and cluster based routing

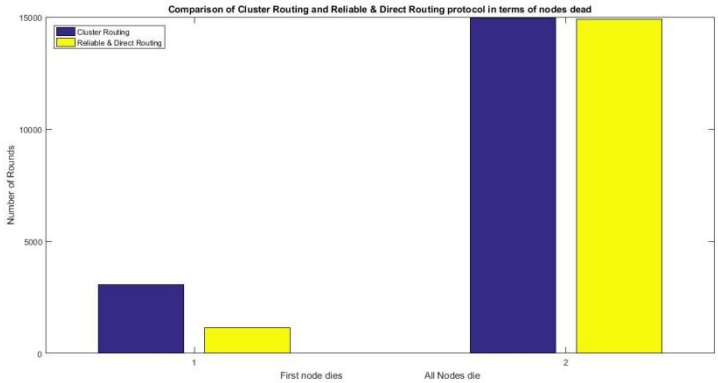


Figure 6 Comparative analysis of first and all nodes dead between direct and cluster based routing

Figure 3 depicts comparative analysis of energy consumption of nodes between direct and cluster-based routing. In direct routing technique, a SN who wants to transmit the data will remain

active and all other SNs will not participate in data transfer. while, in cluster-based technique, all the SNs will take part in data transfer. It can be observed from the figure 3 that balanced amount of energy have been consumed in direct routing, whereas in cluster-based routing the energy consumption is much more. Figure 4 showed comparative analysis of packets transfer to base station from nodes between direct and cluster based routing. In direct routing approach, every node will transmit the data directly to the base-station. While in cluster-based routing, a cluster head will be formed that will collect the data from other SNs, aggregate the data and transmit it to the base-station. Hence, the data transfer will be much more in direct routing approach as compared to cluster-based routing approach. Figure 5 depicts comparative analysis of number of dead nodes versus number of rounds between direct and cluster based routing. In direct routing approach, each node have to transfer their own data to the base-station. While in cluster-based routing approach, CH will collect the data from SNs and transmit aggregated data to BS. Still, the consumption of energy and dead nodes ratio is almost similar in both of the techniques. Figure 6 depicts comparative analysis of first node dead and all nodes dead in both of the techniques through bar graph.

## IV. CONCLUSION AND FUTURE WORK

Sensor nodes in WBANs are deployed with limited energy source, low range communication capability and limited storing capability. WBANs are required to operate properly for long duration of time without any battery recharge or replacement. Therefore, proficient energy efficient routing technique is a key requirement for WBANs in terms of stability period and throughput of the network. Due to high mobility nature of WBANs, stringent requirement on reliability and energy efficiency, routing approaches of WSNs cannot be used. In this work, the concept of mobility has been considered. Two general routing approaches such as cluster-based routing and direct routing which are widely acceptable have been simulated and compared based on different radio models configurations. Simulation results showed that direct routing is much more reliable as compared to cluster-based routing. It is clear from the results that energy consumption is similar in both of the routing approaches. But, the throughput is high in case of direct routing approach as compared to cluster routing approach. Also, in case of critical conditions, direct routing approach will work more efficiently than cluster-based routing approach.

In this work, the reliability of the network has been improved with the use of direct routing approach. Direct routing approach is also reliable in mobility of sensor nodes. But, security in WBAN is still a major concern. In future, security can be applied to make the WBAN secure.

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