

Comparison of Efficient Energy Harvesting Routing Algorithm using IEECBSR Protocol and Compared with EECBSR in Wireless Body Area Network

K.Divya¹, C. Senthilkumar^{2*}

¹Research Scholar, Department of Biomedical Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamilnadu, India. Pincode: 602105.

²Project Guide, Department of Biomedical Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamilnadu, India. Pincode: 602105.

Abstract

Aim: The main aim of this research is the efficient cluster based routing protocol which minimizes the energy consumption in remote medical applications for WBAN by robust and efficient Improved Even Energy Consumption and Back Side Routing (IEECBSR) is proposed and compared with Even Energy Consumption and Back side routing (EECBSR) protocol.

Materials and Methods: In IEECBSR protocol the energy consumption is achieved using Cost function (CF) selection parameters such as distance, residual energy and Innovative hop count are used. The forwarder node selection enhances the efficiency of the routing protocol in WBAN. In this work there are two groups in which each group has 20 sample sizes ($n=20$) collected by varying numbers of rounds and it was calculated by calculator. Net with pre-test power of 80% (G-power). To evaluate the effectiveness of the IEECBSR protocol in terms of Residual energy and Packet Drop Ratio

Results: Simulation results show that IEECBSR protocol has performed better than EECBSR Protocol in terms of residual energy and Packet drop ratio. The proposed IEECBSR protocol increased (3.1%) in residual energy and decreased (2.8%) in packet drop ratio compared with EECBSR protocol. The sample T-test also shows that there is a significant difference in IEECBSR and EECBSR protocol values in terms of residual energy and packet drop ratio ($p < 0.05$).

Conclusion: Depending on the experimental results and independent statistical t-test shows that proposed IEECBSR protocol has achieved higher performance when compared to EECBSR protocol.

Keywords: Forwarder node, End-to-end delay, Network stability, packet drop ratio, WBANs, Throughput, Innovative hop count, Residual energy.

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INTRODUCTION

A new type of network known as Wireless Body Area Networks has emerged as a result of advancements in communication technology and sensors (WBANs). It has gained popularity as a result of its low cost, vast application, and ability to be monitored remotely. (R, Latha, and Vetrivelan 2020) WBANs are a type of invasive or non-invasive personal computing device that may be worn or implanted and are intelligent, small in size, low in cost, low in power, and light in weight. (Abidi, Jilbab, and Mohamed 2020) These sensor nodes with limited battery energy not only impose performance drawbacks, but also depletes quickly, limiting the service availability. (Hamalainen 2014) WBAN has many applications like online health monitoring, remote health care systems. (Khan et al. 2021) and (Qu et al. 2019).

Over the past 5 years, nearly 100 articles have been published in IEEE Access and 98 articles are published in Science Direct related to EECBSR protocol for WBAN. (Velez and Miyandoab 2019) In WBAN the cluster based routing algorithm brings a new way to enhance the energy consumption of the forwarder node. In this scheme CF is calculated using various parameters such as SNR, transmission power, distance between nodes, total available energy, but the coverage area is less in this scheme which leads to inefficient CF selection methodology. (Bizon et al. 2017) proposed CF based routing scheme for WBAN, in this methodology residual energy is considered for CF selection and this scheme is not suitable for WBANs environment, due to high energy consumption in the routing

process. It illustrates that a sensor node which is capable of harvesting energy, acquires energy from various sources present in the surrounding environment such as body temperature, motion, vibration, ambient light etc, and converts it into usable energy (Mosavat-Jahromi, Maham, and Tsiftsis 2017). (Egwuche et al. 2020) developed a strategy that focuses on path loss, network life-time, end-to-end delay, and packet delivery ratio resolution. Sensor nodes are located in several parts of the human body. (Vaidyanathan 2014) and (Kanoun 2018) illustrated various applications of WBAN such as military applications, health care systems. Our team has extensive knowledge and research experience that has translate into high quality publications (Bhansali et al. 2021; Jayanth et al. 2021; Sudhakar, Ravel, and Perumal 2021; Sathiyamoorthi et al. 2021; Deepanraj et al. 2021; Raju et al. 2021; Arun Prakash et al. 2020; Kamath et al. 2020; Shanmugam et al. 2021; Rajasekaran et al. 2020; Adhinarayanan et al. 2020; Rajesh et al. 2020; Aurtherson et al. 2021)

This literature survey includes that mostly the CF selection depends on Proximity distance and residual energy of the sensor nodes. These parameters are not efficient to select the CF effectively. Hence IEECBSR protocol is proposed, which selects the CF using various parameters such as distance, residual energy and Innovative hop count.

MATERIALS AND METHODS

The research work was done in the Department of Biomedical and Engineering at Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamilnadu, India. Two groups are required for this study. Group one consists of IEECBSR protocol and group two represents EECBSR protocol (Herrera 2016). The sample size was calculated by using a sample size calculator finding the mean and standard deviation. The sample size was 20 per group 80% of the pre-test power (G-power) used for this study. A PC with Ubuntu OS by VMware workstation and NS2 simulator software was used for execution of the project. The ns run command was given to execute the code in TCL script.

IEECBSR Protocol

The clustering based routing algorithms are used to improve the performance of the WBAN routing protocol by enhancing the sensor nodes battery power in the network. The IEECBSR protocol uses innovative cost function (CF) selection parameters such distance, residual energy and Innovative hop count.

The various steps involved in the forwarded node selection are described below.

Step 1: All the sensor nodes are deployed in a human body and formed WBAN.

Step 2: All the sensor nodes calculate their values using CF based forwarder node selection parameters such as distance, residual energy and Innovative hop count.

Step 3: The node which contains the maximum value that node becomes the Forwarded node

Step 4 : The CF aggregates the information from the sensor nodes using Hello and Reply message within the cluster and other sensors in the network.

Step 5: The Forwarded node routes the information to the server using the shortest routing path.

EECBSR Protocol

The EECBSR protocol used the following parameters to select CF selection parameters such as residual energy, distance between nodes to sink. The selected CF forwards the information to the sink using the easiest routing path.

STATISTICAL ANALYSIS

The statistical analysis was carried out using the SPSS tool. The significance is calculated using Independent t-test. It was performed for the five dependent variables such as residual energy and packet drop ratio. The independent variables are the number of nodes and distance. Using the SPSS software the standard deviation, standard error of mean were also calculated.

RESULTS

Table 1 shows experimental results of data analysis of the IEECBSR protocol under varying number of rounds and residual energy with reference to packet delivery ratio. Experimental results of IEECBSR protocol under varying number of rounds (0 to 16000) in terms of residual energy (achieved highest value 7.7 when the number of rounds is 800 and achieved lowest value 1.2 when the number of rounds is 16000).

Table 2 shows the experimental results of the IEECBSR protocol under varying number of rounds (0 to 16000) in terms of packet drop ratio (achieved lowest value 0.15 when the number of rounds is 800 and achieved highest value is 2 when the number of rounds is 16000).

Table 3 Group statistical analysis of IEECBSR protocol and EECBSR protocol. Residual energy Mean value is 4.3650 in IEECBSR protocol. Packet drop ratio Mean value is 0.6445 in IEECBSR.

Table 4 Shows the independent sample T-test calculation of IEECBSR protocol and EECBSR protocol. The Residual energy and packet drop ratio are statistically significant ($p < 0.05$)

DISCUSSION

Figure 1 shows a comparison of residual energy in IEECBSR with EECBSR protocol under varying number of rounds and the residual energy is increased by 3.1% due to the routing based forwarded node selection. Figure 2 represents comparison of packet drop ratio of sensor nodes battery power in IEECBSR with EECBSR protocol. Under varying number of rounds the packet drop ratio minimized by 2.8% due to the position of the node. Figure 3 shows the bar chart representing the comparison of IEECBSR protocol and EECBSR protocol in terms of residual energy and achieved 3.1% higher residual energy when compared with EECBSR protocol. X axis: IEECBSR protocol vs EECBSR protocol, Y axis: mean residual energy of detection ± 1 SD. Figure 4 illustrates that the bar chart representing the comparison of IEECBSR protocol and EECBSR protocol in terms of 2.8% packet drop ratio when compared with the previous protocol of EECBSR X axis: IEECBSR protocol vs EECBSR protocol, Y axis: Mean packet drop ratio ± 1 SD

Comparison of energy efficiency of IEECBSR protocol and EECBSR protocol is studied. The number of rounds of the proposed protocol is varied from 0 to 16000. The residual energy is increased by 3.1% in IEECBSR as shown in Fig 1. The packet drop ratio is decreased by 2.8% in IEECBSR protocol with EECBSR protocol under varying number of rounds as shown in Fig 2. By independent sample t-test calculation the residual energy and packet drop ratio is statistically significant ($p < 0.05$) by SPSS software shown in Fig 3 and Fig 4. The proposed IEECBSR protocol has better performance in efficient routing when compared with the EECBSR protocol with reference to the stimulation results.

Modification made in this research is that the forwarder node selection depends on multiple parameters such as distance, residual energy and Innovative hop count. (Yousaf *et al.* 2016) and (Kanoun 2018) This paper has similar research which uses the EECBSR (Even Energy Consumption and Back Side Routing) protocol to improve the performance of the network routing in WBAN. (Ghamari *et al.* 2016) in this paper the the authors used gateway

nodes between the forwarder node for long distance communication which oppose the methodology of IEECBSR protocol which uses an angle as a forwarder node selection parameter (Thabit et al. 2019). (Mosavat-Jahromi, Maham, and Tsiftsis 2017) this scheme opposes the findings, in that the gateway node is used between two clusters to achieve energy efficiency.

The main limitation of this paper is high end-to-end delay is present in the network due to the CN and SCN selection procedures. In future the security of the scheme needs to be improved to achieve the efficient routing scheme.

CONCLUSION

The proposed IEECBSR protocol has better simulated outputs when compared to EECBSR protocol in terms of residual energy increased by 3.1%, packet drop ratio is increased by 2.8% and also the sample T-test also shows that there is a significant difference in IEECBSR and EECBSR protocol values in terms of residual energy and packet drop ratio ($p < 0.05$).

DECLARATION

Conflict of Interests

No conflict of interest in this manuscript.

Author Contribution

Author KD was involved in Methodology creation, simulation, data collection, data analysis, Manuscript writing. Author CS was involved in conceptualization, guidance and critical review of manuscript.

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TABLES AND FIGURES

Table 1. Experimental results of IEECBSR protocol and compared with EECBSR protocol under varying number of rounds (0 to 16000) in terms of Residual energy (achieved highest value 7.9 when the number of rounds is 800 and achieved lowest value 0.1 when the number of rounds is 16000).

Number of rounds	IEECBSR	EECBSR
800	7.9	2.6
1600	7.5	2.2
2400	6.4	2.1
3200	6.2	1.9
4000	5.9	1.6
4800	5.7	1.4
5600	5.1	0.48
6400	4.8	0.45
7200	4.3	0.4
8000	2.7	0.24
8800	2.3	0.2
9600	2.1	0.18
10400	1.7	0.14
11200	1.6	0.13
12000	1.5	0.12
12800	1.3	0.1
13600	1.1	0.08
14400	0.8	0.05
15200	0.5	0.02
16000	0.1	0.01

Table 2. Experimental results of IEECBSR protocol and compared with EECBSR protocol under varying number of rounds (0 to 16000) in terms of packet drop ratio (achieved lowest value 0.17 when the number of rounds is 800 and achieved highest value is 2.5 when the number of rounds is 16000)

Number of rounds	IEECBSR	EECBSR
800	0.17	1.4
1600	0.19	1.6
2400	0.27	2.4

3200	0.38	3.5
4000	0.4	3.7
4800	0.41	3.8
5600	0.42	3.9
6400	0.44	4.1
7200	0.48	4.5
8000	0.49	4.6
8800	0.51	4.8
9600	0.52	4.9
10400	0.54	5.2
11200	0.57	5.4
12000	0.59	5.6
12800	2.1	5.8
13600	2.2	5.9
14400	2.3	6
15200	2.4	6.1
16000	2.5	6.2

Table 3. Group statistical analysis of IEECBSR protocol and EECBSR protocol. Residual energy Mean value is 3.4750 in IEECBSR protocol. Packet drop ratio Mean value is 0.8940 in IEECBSR.

	Group	N	Mean	Std.Deviation	Std. Error mean
Residual energy	IEECBSR	20	3.4750	2.51184	0.56166
	EECBSR	20	0.7199	0.87564	0.19580
Packet drop ratio	IEECBSR	20	0.8940	0.84328	0.18856
	EECBSR	20	4.4700	1.43604	0.32111

Table 4. Shows the independent sample T-test calculation of IEECBSR protocol and EECBSR protocol. The Residual energy and packet drop ratio are statistically significant($p < 0.05$).

		Levene's Test for Equality of variances		T-test for Equality of Means						
		F	Sig	t	df	Sig.(2-tailed)	Mean Difference	std.Error Difference	Lower	Upper
Residual Energy	Equal variances assumed	39.49	<0.001	4.632	38	<.001	2.755	0.59481	1.5509	3.959
	Equal variances not assumed			4.632	23.55	<.001	2.755	0.59481	1.5262	3.983
Packet drop ratio	Equal variances assumed	4.19	<0.001	-9.603	38	<.001	-3.57	0.37238	-4.3298	-2.822
	Equal variances not assumed			-9.603	30.71	.001	-3.57	0.37238	-4.3357	-2.816

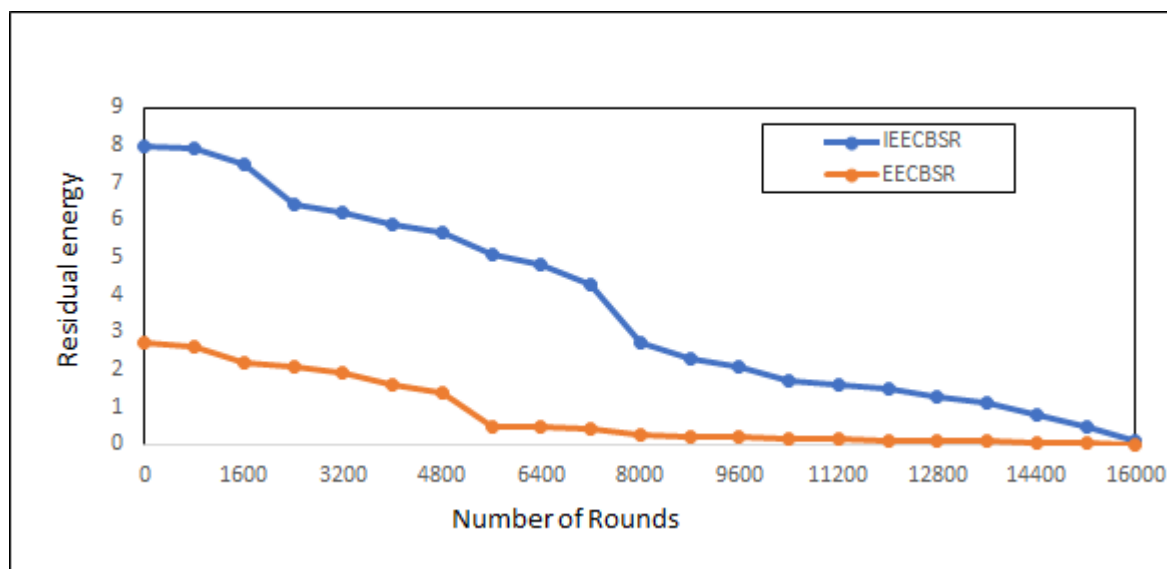


Fig. 1. Comparison of residual energy in IEECBSR protocol with EECBSR protocol. Under varying number of rounds the residual energy is increased by 2.8% due to routing based forwarder node.

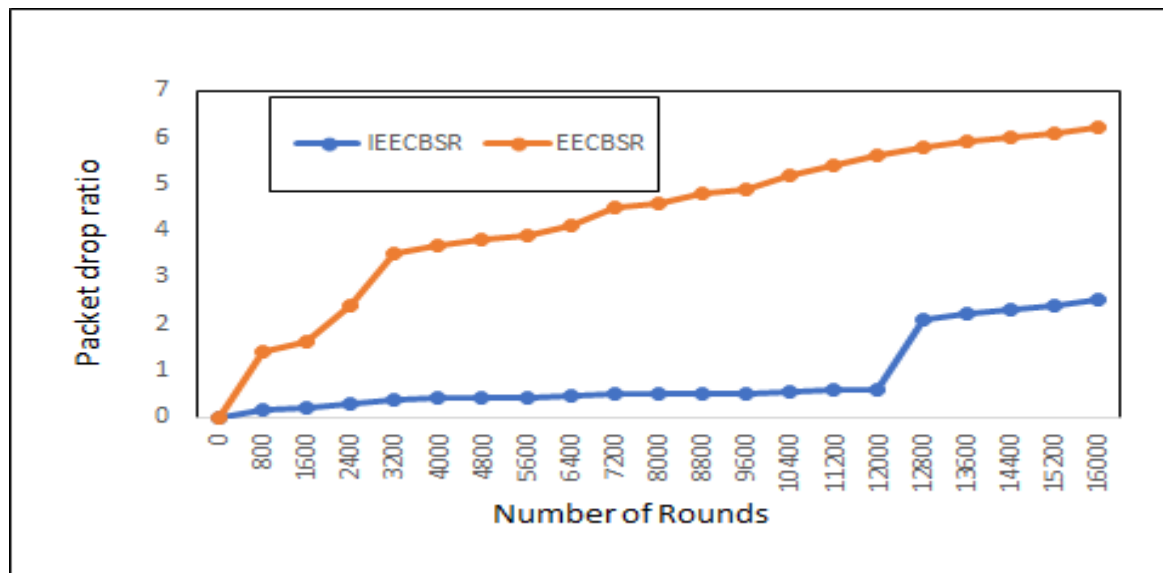


Fig. 2. Comparison of packet drop ratio in IEECBSR protocol with EECBSR protocol. Under varying number of rounds the packet drop ratio is decreased by 3.4% due to routing based forwarded nodes.

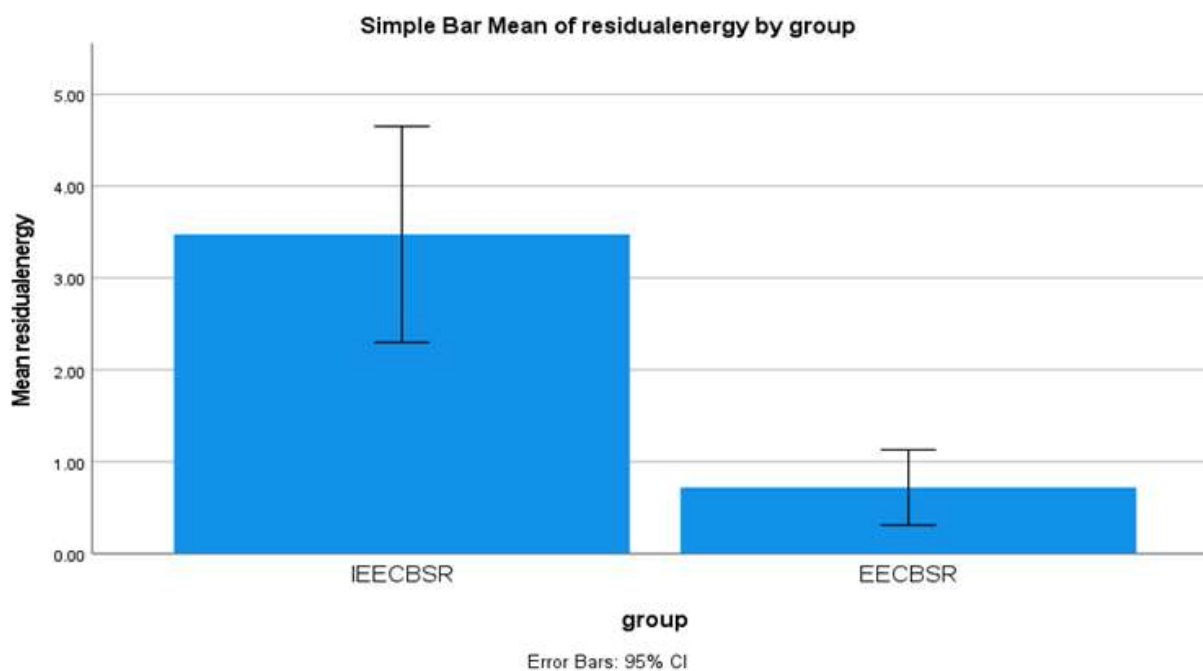


Fig. 3. Bar chart representing the comparison of IEECBSR protocol and EECBSR protocol in terms of Packet Drop Ratio. The IEECBSR protocol achieved a 2.8% increased residual energy when compared with the EECBSR protocol. X Axis: IEECBSR protocol vs EECBSR protocol, Y Axis: Mean residual energy of detection \pm 1 SD.

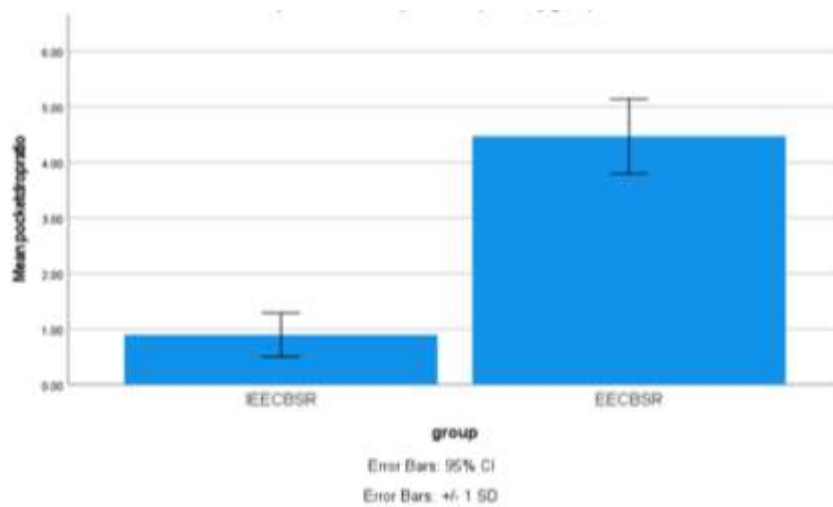


Fig. 4. Bar chart representing the comparison of IEECBSR protocol and EECBSR protocol in terms of Packet Drop Ratio. The IEECBSR protocol achieved a 3.4% minimized packet drop ratio when compared with the EECBSR protocol. X Axis: IEECBSR protocol vs EECBSR protocol, Y Axis: Mean residual energy of detection \pm 1 SD.