OriginalArticle

Dynamic Clustering Mechanism for Mobile Patient Monitoring System in WBAN by Minimizing Energy Consumption using ITHE Protocol and Compared with THE Protocol

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Abstract

Aim: The aim of this study is to minimize the energy consumption in sensors in wireless body area networks by using ITHE protocol (Improved Temperature Heterogeneity Energy) compared with THE (Temperature Heterogeneity Energy) protocol. **Materials and Methods:** In this research uninterrupted communication with minimized energy consumption is achieved using Clustering mechanism with a mobile patient monitoring system in WBAN. The energy consumption is achieved using efficient coordinator node (CN) and Serving coordinator node (SCN) selection using various parameters such as Innovative node position,distance and residual energy of the sensor nodes.The sample size of each group is 20 (n=20) collected by varying the number of rounds and it was calculated by calculator.Net with pre-test power of 80% (G-power). **Result:** Simulation results show that ITHE protocol has performed better than THE Protocol in terms of throughput and energy consumption respectively. The proposed ITHE protocol achieved (2.3%) higher Throughput and (19%) lower energy consumption compared with THE protocol. The sample t-test shows that there is a significant difference in ITHE and THE values in terms of energy consumption and throughput ($p<0.05$). **Conclusion:** Depending on the experimental results and independent statistical T-test shows that proposed ITHEprotocol has achieved higher performance when compared to THE protocol.

Keywords: Wireless Body Area Network, Routing, Energy consumption, Coordinator node, Bandwidth, Throughput, Innovative node position.

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INTRODUCTION

Recent developments in sensor nodes with IOT, mobile patient monitoring have very much flexibility to create an efficient routing in WBAN. Nowadays Wireless body area networks (WBANs) are very important in mobile health monitoring that too in this COVID 19 scenario. WBAN consists of multiple sensors which are placed in various positions of the human body to measure various values such as ECG, EEG, temperature etc(Selem et al. 2019). The sensed information is communicated to the medical server over a wireless channel (Jabeen, Ashraf, and Ullah 2021). (Li et al. 2018) it shows the energy consumption of the nodes in the wireless body area network, it is improtant in nowadays because of network technologies such as wireless body area network has been used in different applications including the healthcare applications like providing convenience to monitor the patient healthcare remotely (Kumar, Tomar, and Chaurasiya 2019) and increasing data security. WBANs able to ubiquitous connection to the worldwide network, but they also necessitate support from a variety of software implementations, including remote operations (Pramanik, Nayyar, and Pareek 2019), database processing (Rathore et al. 2016), and a user interface whereas these solutions must be energy consumption and have minimal impact on the routing process(Tavera et al. 2021).

Mostly 89 articles were published in the IEEE access and 77 articles in the Science directly related to the Aware Routing Protocol for WBAN IoT health Application. (Bilandi, Verma, and Dhir, n.d.)proposed the schemer using clustering, in this scheme the coordinate node selection depends on the sensor node to wirelessly transfer sensed data to the Coordinate node, which wirelessly transmits it to the medical server on a regular basis. The parameters are temperature level, bandwidth and residual energy. These are the parameters used to select the coordinate node in the sensor for the wireless body area network. (Chowdhury 2021). (Khan, Rahman, and Khan 2016) THE protocol employs the energy consumption of the nodes to balance the information in the sensor network, and the number of rounds is determined by the node size. In this THE protocol, however, the coordinate is chosen at random and the Coordinate node acts as a serving node for its closest node and neighbor node. It has been positioned distant from the Coordinate node, making it impossible to collect data from the sensor nodes on a constant basis.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)

From this literature review, CN and SCN are used to avoid disconnectivity in sensor nodes in WBAN. Most of the previous protocol then CN and SCN nodes are selected using following parameters such as temperature level, bandwidth and residual energy. But these parameters are not sufficient to select the CN and SCN. Hence the ITHE protocol is proposed to achieve lower energy consumption and higher throughput using efficient CN and SCN selection criteria such as Innovative node position, distance, bandwidth and residual energy of the sensor nodes

MATERIALS AND METHODS

The research was carried out in the Department of Biomedical Engineering at the Saveetha School of Engineering, Saveetha Institute of Medical and Technical Science, Saveetha University, Tamilnadu, India. Two groups are required for this study. Group one consists of ITHE protocol and group two represents the THE protocol. 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) (Adhikary, Choudhury, and Chattopadhyay 2016) used for this study. A PC with Ubuntu OS by VM ware 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.

ITHE Protocol

In the mobile patient monitoring system consists of many sensors which mainly depend on battery power for its performances, it is very difficult often to change these sensor nodes battery, hence the energy consumption of the sensor nodes are very important and challenging. Hence the ITHE protocol is proposed to minimize the energy consumption and maximize the throughput in WBAN.

In ITHE protocol uses CN and SCN selection criteria such as bandwidth, Innovative node position, distance and residual energy of the sensor nodes.

In a cluster based approach all the sensor nodes save the Id and location of the nearest CN node and broadcast a brief information packet that includes the energy status, node Id and the location of the closest CN. Coordinate nodes send a confirmation message. The energy consumption of Coordinate nodes is estimated in order to increase sensor node stability.

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

STEP 1 : All the sensor nodes are deployed in various places of a selected patient using WBAN.

STEP 2 : The clusters are formed and the sink gathers all the required details such as node id, position, residual energy, distance.

STEP 3: The CN and SCN node is selected using various parameters such as bandwidth Innovative node position,distance and residual energy of the sensor nodes.

STEP 4: The node which contains the highest value becomes the CN and SCN.

STEP 5: The CN gathers all the information from the cluster members and forwarded to SCN.

STEP 6: The SCN routes the information to the sink or doctor server wirelessly.

THE Protocol

The THEprotocol selects the CN node using various parameters such as residual energy, node temperature. The coordinator node is used to gather the information from the cluster members and route it to SCN. The SCN receives the information from CN and routes the information to the destination end.

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 two dependent variables such as energy consumption, throughput. The independent variables are node coverage area and angle. Using the SPSS software the standard deviation, standard error of mean were also calculated (Deepak and Babu 2014).

RESULTS

Table 1 shows experimental results of data analysis of the ITHE protocol under varying number of rounds and throughput with reference to energy consumption. Experimental results of ITHE protocol under varying number of rounds (0 to 14000) in terms of throughput (achieved highest value 3.4 when the number of rounds is 14000 and achieved lowest value 0.2 when the number of rounds is 700).

Table 2 shows the experimental results of the ITHE protocol under varying number of rounds and energy c with reference to throughput. Number of rounds (0 to 14000) in terms of energy (achieved highest value 0.23 when the number of rounds is 700 and achieved lowest value 0.03 when the number of rounds is 14000).

Table 3Group statistical analysis of ITHE protocol and THE protocol. Throughput Mean value is 0.2268 in ITHE and the energy is 0.31270. The standard deviation value of energy consumption is 1.39846 and throughput value in the standard deviation value is 0.10143.

Table 4 shows the independent sample T-test calculation of ITHE protocol and THE protocol.The energy consumption and throughput are statistically significant ($p<0.05$).

DISCUSSION

Figure 1 shows a comparison of throughput in ITHE with THE protocol under varying number of rounds and the throughput is increased by 2.3% due to the routing based coordinate node selection. Figure 2 represents comparison of Energy Consumption of sensor nodes battery power in ITHE with THE protocol. Under varying number of rounds the energy consumption is minimized by 19% due to the position of the node. Figure 3 shows the bar chart representing the comparison of ITHE protocol and THE protocol in terms of throughput and achieved 2.3% higher throughput when compared with THE protocol. X Axis: ITHE protocol vs THE protocol protocol, Y Axis: Mean throughput of detection ± 1 SD. Figure 4 illustrates that the bar chart represents the comparison of ITHE protocol and THE protocol in terms of 19% lower energy consumption when compared with the previous protocol of THE X Axis: ITHE protocol vs THE protocol protocol, Y Axis: Mean energy consumption of detection ± 1 SD.

Modification made in this research is that the coordinate node selection depends on multiple parameters such as Innovative node position, distance and residual energy of the sensor nodes, which selects the CN and SCN efficiently. (V, Suresh, and Benakop 2020) proposed clustering protocol which supports the proposed scheme in this methodology the CN nodes selection depends on the residual energy of the node. (Saha and Anvekar 2017; Sharma, Ryait, and Gupta 2016) proposed similar findings which support this research scheme using various parameters to select the cluster head. (Shahbazi and Byun 2020) and ((Saha and Anvekar 2017; Sharma, Ryait, and Gupta 2016) these papers have similar routing protocols in order to improve the performance of coordinate nodes in sensors in the WBAN. (David et al. 2021) proposed lightweight dynamic clustering opposes the proposed scheme using dynamic clustering.

The limitations of this study is security of the routing scheme is less and mobility of the nodes consumes more energy compared to a stable scheme. In future the AES cryptography algorithm will be included to improve the security.

CONCLUSION

The proposed ITHE protocol minimized energy consumption by 19% and increased throughput by 2.3% when compared with THE protocol. The energy consumption and throughput is statistically significant ($p<0.05$) using SPSS software's independent sample T-test calculation. According to simulation data, the ITHE protocol output performs better than the THE in terms of efficient routing.

DECLARATION

Conflict of Interests

No conflict of interest in this manuscript.

Author Contribution

Author KS 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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Table 1. shows experimental results of data analysis of the ITHE protocol under varying number of rounds and throughput with reference to energy consumption. Experimental results of ITHE protocol under varying number of rounds (0 to 14000) in terms of throughput (achieved highest value 3.4 when the number of rounds is 14000 and achieved lowest value 0.4 when the number of rounds is 700).

No of rounds	ITHE	THE
700	0.4	0.1
1400	0.8	0.3
2100	1.5	0.6
2800	2	0.13
3500	0.4	0.18
4200	2.5	0.21
4900	2.8	0.23
5600	2.9	0.26
6300	2.9	0.29
7000	3	0.29
7700	3.2	0.31
8400	3.4	0.33
9100	3.4	0.33
9800	3.4	0.33
10500	3.4	0.33
11200	3.4	0.33
11900	3.4	0.33
12600	3.4	0.33

13300	3.4	0.33
14000	3.4	0.33

Table 2. shows the experimental results of the ITHE protocol under varying number of rounds for energy consumption and throughput. Number of rounds (0 to 14000) in terms of energy (achieved highest value 0.23 when the number of rounds is 700 and achieved lowest value 0.03 when the number of rounds is 14000).

No of rounds	ITHE	THE
700	0.23	3.9
1400	0.3	3.8
2100	0.16	3.4
2800	0.15	2.6
3500	0.2	2.3
4200	0.17	2
4900	0.13	1.5
5600	0.11	1.2
6300	0.01	0.8
7000	0.05	0.4
7700	0.3	0.2
8400	0.2	0.1
9100	0.09	0.1
9800	0.09	0.08
10500	0.08	0.07
11200	0.07	0.06
11900	0.06	0.05
12600	0.05	0.04
13300	0.04	0.03
14000	0.03	0.02

Table 3. Group statistical analysis of ITHE protocol and THE protocol. Throughput Mean value is 0.25780 in ITHE and the energy is 0.3088. The standard deviation value of energy consumption is 0.13812 and the throughput value in the standard deviation value is 1.15292.

	GROUP	N	MEAN	Std.deviation	Std.error mean
	ITHE	20	2.4970	1.15292	.25780

Throughput	**THE**	20	.2935	.10143	.02268
Energy	**ITHE**	20	.1215	.13812	.03088
	THE	20	1.1100	1.39846	.31270

Table 4. shows the independent sample T-test calculation of ITHE protocol and THE protocol.The energy consumption and throughput 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**
Throughput	Equal variances assumed	41.92	<.001	8.514	38	<.001	2.20350	.2588	1.679	2.727
	Equal variances not assumed			8.514	19.29	<.001	2.20350	.2588	1.662	2.744
Energy	Equal variances assumed	45.90	<.001	-3.146	38	.003	-.98850	.3142	-1.624	-.3523
	Equal variances not assumed			-3.146	19.37	.005	-.98850	.3142	-1.645	-.3316

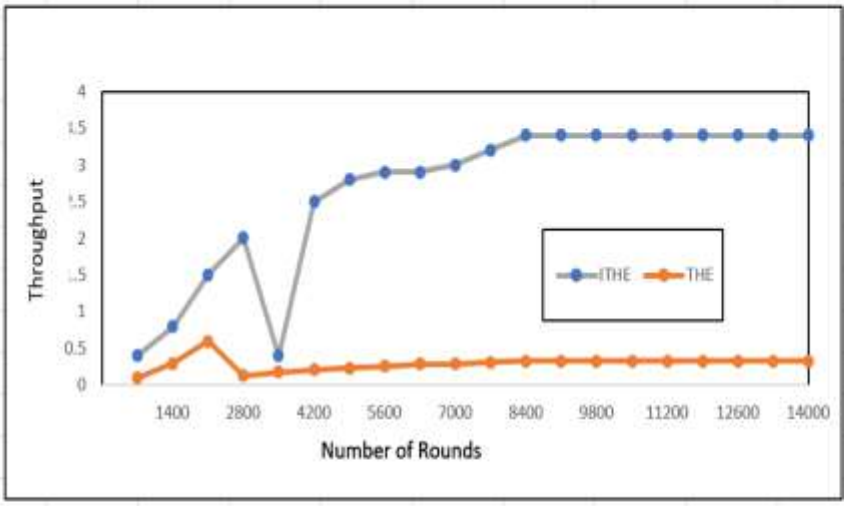

Fig. 1. Comparison of Throughput in ITHE with THE protocol under varying number of rounds and the throughput is increased by 2.3% due to the routing based coordinate node selection.

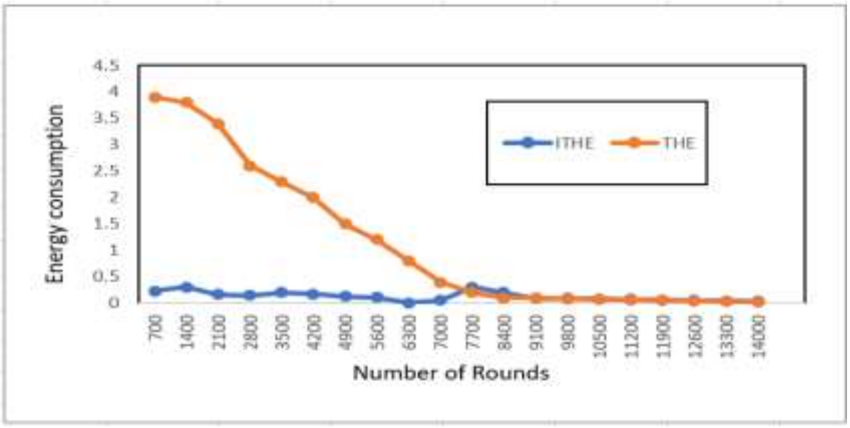

Fig. 2 Comparison of Energy Consumption of sensor nodes battery power in ITHE with THE protocol. Under varying number of rounds the energy consumption is minimized by 19% due the position of the node, node id etc are parameters for efficient Coordinate node selection which reduces the node energy consumption.

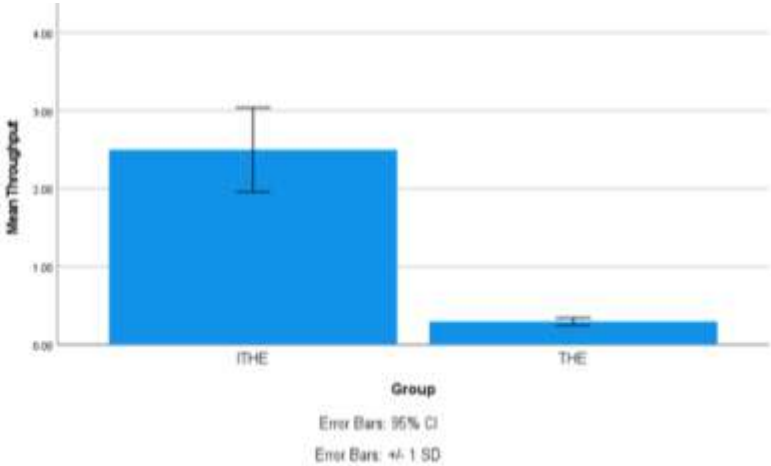

Fig. 3. Bar chart representing the comparison of ITHE protocol and THE protocol in terms of higher throughput is 2.3% when compared with the previous protocol. X Axis: ITHE protocol vs THE protocol, Y Axis: Mean throughput of detection ± 1 SD.

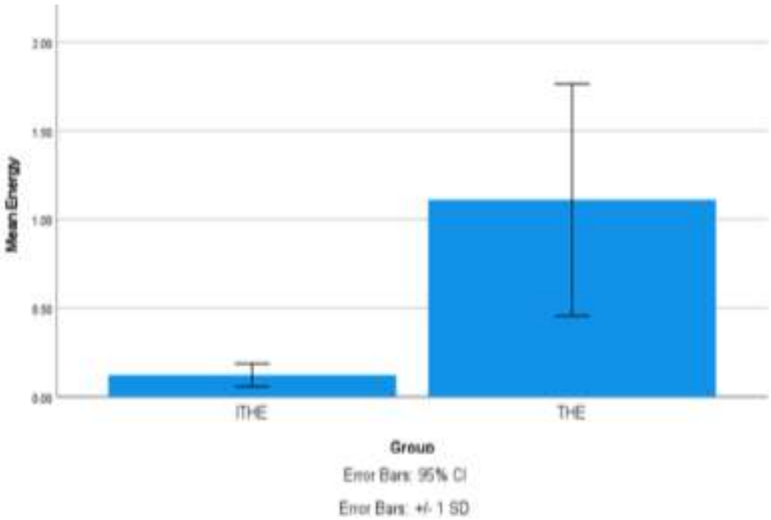

Fig. 4. Bar chart representing the comparison of ITHE protocol and THE protocol in terms of 19% lower energy consumption when compared with the previous protocol of THE. X Axis: ITHE protocol vs THE protocol, Y Axis: Mean energy conception of detection ± 1 SD.