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Energy Efficient Cross- Layer (EECL) Approach for WBAN using Hybrid Protocol

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ABSTRACT: Wireless Body Area Networks (WBANs) has a broad application in the field of health care such as disease analysis, diagnostic monitoring and tracking, etc. With techniques like single and multi-hop through relay node and opportunistic schemes help in increasing the life time of the network. In case of wireless sensor networks (WSN) the most prominent issue to be tackled is the energy consumption. In wireless network communication loss of data i.e., packet loss and collisions are high. So as to prolong the networks lifetime it is important to increase the life of all the network nodes. Hence developing an energy efficient algorithm is a challenge. Protocols have to be efficient in selecting a route for retransmitting the data when the range falls beyond the threshold value. An hybrid LEACH (Low-Energy Adaptive Clustering Hierarchy) algorithm for WSN is presented in this paper to tackle the issue of on-demand, traffic and emergency situations. We also discuss on the application of WBAN using examples. Through the proposed discussion we conclude that there is a need for optimized solutions for both on and in-body network sensors.

Keywords: Energy–Efficiency, Hybrid LEACH Protocol, Wireless Body Area Networks (WBANs).

Abbreviations: ADV, Advertisement; BER, Bit Error Rate; BS, Base Station; CSMA, Carrier Sense Multiple Access; CDMA, Code Division Multiple Access; CH, Cluster Head; CM, Non- Cluster Head Nodes; EECL, Energy-Efficient Cross Layer; Join-REQ, join request; LEACH, Low-Energy Adaptive Clustering Hierarchy; MAC, Medium Access Control; Nco, Number of nodes collided; Nds, Nodes sends data to CM; TDMA, Time Division Multiple Access; WBAN, Wireless Body Area Network; WSN, Wireless Sensor Network.

I. INTRODUCTION

BAN (Body Area Network) is commonly found in a medical field to collect biomedical signals and monitor vital signal information. BAN stands for Body Area Network and it is also called as WBAN (wireless body area network). BAN is a wireless network that includes wearable devices that can either be placed in the human body or mounted on human body. BAN refers to the wireless network technology that is wearable. The purpose of inventing BAN is to transmit the data received from wearable devices and to transmit it to a WLAN or internet. These wearable devices can also interchange data within themselves too [1].

WSNs are a group of sensor nodes that work together to monitor the environmental conditions, and also to collect data about a certain location. It needs to have nodes that can configure on its own. In this case routing strategies and security is a concern to be researched upon [2]. In previous study the drawbacks were energy consumption, network throughput, end to end delay and congestion control [12]. The proposed system EECL and LEACH protocol approach was introduced to overcome the loss of energy during the data transmission. This paper mainly focuses routing protocol issues. There are numerous approaches and algorithms proposed for routing protocols among which the hierarchical approaches like a hybrid LEACH are well known. This paper aims to identify the most efficient and suitable approach for WBAN. Since wireless sensor nodes operate on batteries, the sending and receiving of data consumes the majority of the energies and thus minimizing the lifetime of the network. This paper proposes a new concept that evenly distributes the cluster heads and hierarchical protocols are used to reduce energy use by minimizing transmissions to the Sink station. Hybrid LEACH is a cluster based routing algorithm that helps to minimize energy consumption [3]. This work is designed with Section II presenting the related works, Section III introduces the proposed protocol with Clustering Hierarchy proposed system model, Section IV defines the Low-energy adaptive clustering hierarchy (LEACH), Section V discusses the simulation of the proposed protocol and Section VI deals with the conclusion of the paper.

II. RELATED WORK

A wireless sensor network is framed with several sensor nodes that are economical and can monitor the environmental condition in a given surrounding. While considering difference between a simple wireless network and a wireless sensor network the latter is sensitive towards the energy utilization. Energy optimization is a crucial and essential factor in the case of wireless sensor networks [4]. There are several other techniques that replace the LEACH-C algorithm where the residual energy of the nodes, and also the size of the cluster is considered in creating a cluster structure.

The modified LEACH-C algorithm is compared with random LEACH and Max Energy LEACH, or any other LEACH-C algorithm to analyze its load balancing efficiency and distribution of cluster heads [5]. The network layer uses the energy from the physical layer and based on this energy level it is decided whether to drop the packets or immediately forward the packet or delay it if the battery level is too low. The energy management schemes can be classified into transmission management schemes, battery management schemes and system power management schemes [6]. This work also considers minimizing noise and inaccuracies in data using Kalman filter also the shortest path between one to another node is identified to maintain efficiency in utilizing the energy [7]. Due to limited resources and limited energy levels it is difficult to maintain a strong security protocol during transmission of data. However there are some security mechanisms that are proposed for wireless sensor networks. With the advantage of using Hybrid LEACH also provides security terms to the network. The dynamic nature of communication in Hybrid LEACH makes it complicated to apply the existing security solutions [8]. The projected OE-LEACH (An Optimized Energy economical LEACH algorithmic program for WSNs) to reinforce the performance of the LEACH Protocol, cut back time delay and energy consumption [10]. The proposed work uses CASTALIA simulator and OMNET++ provides energy efficiency in collecting a patient data. In data link layer, MAC (Medium Access Control) protocols specific to WBAN help in energy efficiency [11]. The techniques of node replacement, combination of genetic algorithm in the effectiveness of fault node algorithm is used and for creating a route path of sensor node, grade diffusion algorithm are used [13]. In the study macro cells multi –tier architecture, different types of licensed small cells, relays, and device-to-device (D2D) networks will be adopted by 5G systems to serve with different quality-of-service and energy-efficient manner [14]. In this analysis, a cross layer style methodology was adopted to style associate degree energy economical routing protocol entitled "Position Responsive Routing Protocol" (PRRP). The outcomes show a significant improvement in the WSN regarding energy efficiency and the overall performance of WSN [15].

III. PROPOSED SYSTEM MODEL

Clustering Hierarchy. Hybrid LEACH follows a hierarchical protocol where the nodes transport data to cluster heads. These cluster heads collect data so as to gather and condense the data and finally forwards to the sink station also called as base station. The cluster heads are decided upon stochastic algorithm at each round. The hybrid LEACH approach assumes that all the nodes are radio powerful and they can reach the base station directly or thinking that the cluster head to near to the base station. Using the radio power at all times will actually waste energy.

Once a node is ranked as cluster head it will not become a cluster head another time until P rounds. Here P refers to desire percentage of cluster heads. Hence, each node will have 1/P probability of getting a chance to become a cluster head again. At every round the nodes selects a cluster node that's close, and becomes a member of that cluster group. Once the cluster groups are formed the cluster head prepares a schedule for all nodes to perform transmission of data. The nodes that are not a cluster head will contact the cluster head through TDMA (Time Division Multiple Access) fashion based on the schedule prepared by cluster head. In this design the nodes use less energy to communicate with the cluster head and keep its radio on only during its time slot. Hybrid LEACH also implements CDMA (Code Division Multiple Access) for different clusters to have different CDMA codes thereby reducing the interference between the clusters.

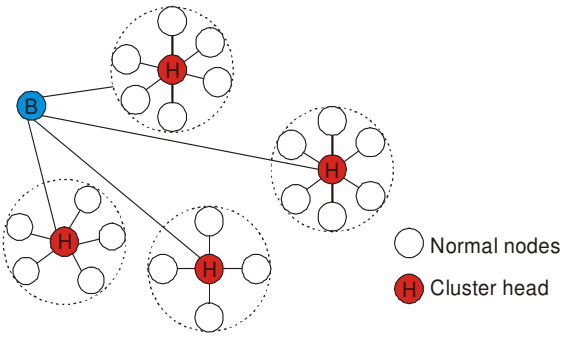

Fig. 1. Cluster Formation in hybrid LEACH.

The hybrid LEACH approach divides all nodes as cluster groups, and each cluster group has a cluster head that is selected on random basis. There is no central node to control the cluster head selection and hybrid LEACH follows a distributed algorithm to select cluster heads. In distributed algorithm each node makes its own decision if it can become a cluster head or not.

System Model. Hybrid LEACH follows cluster base protocol where the nodes are classified as clusters. These cluster groups have a cluster head. Nodes in the cluster transmit data to that group cluster head, and it in turn sends it to the base station. This approach makes it possible to allocate energy to all sensors nodes in a homogeneous behavior. The cluster head selection is a dynamic in nature in hybrid LEACH, and it keeps rotating among different sensors, so that, energy shortage of a single node does not happen [9]. WBAN infrastructure designed for medical application is shown above.

Here traffics in WBAN are organized into On-demand, Normal and Emergency traffic. (1) Normal traffic refers to the traffic that occurs under normal conditions where there are no time-critical and on-demand events. (2) On-demand traffic refers to the traffic that occurs when a coordinator or doctor wants certain information for diagnostic purpose. (3) Emergency traffic occurs when the predefined threshold is exceeded and it must be accompanied in less than one second. Emergency traffic occurs at any situations and not on regular intervals. It is unpredictable too.

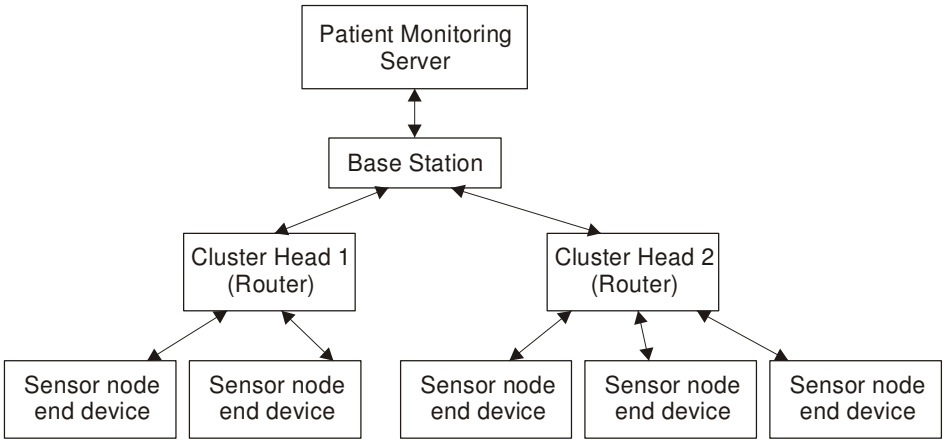

Fig. 2. WBAN Infrastructure for Medical Applications.

The flow characteristics of sensor are mentioned below:
(a) The nodes are connected with their respective Cluster Head (CH).
(b) The CH's are connected to each other.
(c) The Base station (BS) can connect to all CH's.
(d) The individual nodes cannot connect to each other.
(e) The sensor nodes will not be able to connect to the CH through BS etc.
(f) The information from the monitor station passes through the BS, CH to reach the end node.

IV. LOW-ENERGY ADAPTIVE CLUSTERING HIERARCHY

Cluster Set-up Phase: Hybrid LEACH is designed mainly to minimize energy consumption in WSN and minimize time delay is transmitting data and increase network lifetime and network stability period. This is achieved by concentrating on the nodes that do not have data to be sent on regular basis. In such as a situation data is available to the node only when the event is triggered. So in scenarios where no event occurs these sensor nodes need not be active in the channel. Energy is consumed in having the node in the idle state too; hence the proposed method uses slots where the nodes do not have data to transmit. In the proposed approach slots are not assigned to these idle nodes, and these free and useless slots are converted into useful slots. Thereby reducing the energy consumed by idle listening and decreases the waiting time of nodes and nodes get more than one slot in a frame. The overall process works in a round model and each round has two phases namely: Steady State Phase and Cluster Set-up Phase. Cluster set-up phase is divided into two parts cluster head selection and cluster formation.

Cluster Head Selection: Based on the present energy level the nodes announce its probability value of becoming a cluster head to the base station. The node that has the highest probability becomes the cluster head for that round. Once the cluster head is decided it broadcasts an ADV message called as Advertisement message that includes two fields node's ID and distinguishable header with control information using CSMA (Carrier Sense Multiple Access) and MAC (Medium Access Control) protocol. Now all the nodes to decide its cluster head depending on the received signal strength of the cluster head. To have balanced energy consumption among nodes, cluster head keeps changing based on the random number that is picked up by the nodes between 0 to 1. The number below the threshold value T (n), is termed as the cluster head.

$$T(n)=\begin{cases}\left(1-p\left(rmod\frac{1}{p}\right)\right)^{p}, if n \in G\end{cases} \quad (1)$$

Here, p stands for probability of cluster head selection; r for current round and the term G represent the nodes that are not cluster heads in the previous 1/p rounds.

Cluster Formation: Once the cluster head is selected the non-cluster head nodes transmit a Join-REQ (join request) to the cluster heads using CSMA and MAC protocol. This message includes Node's ID, Cluster Head ID and distinguishable header with control information. This message is sent by the node based on the receiving signal strength of ADV message that the cluster head sends. By this method, the clusters are formed.

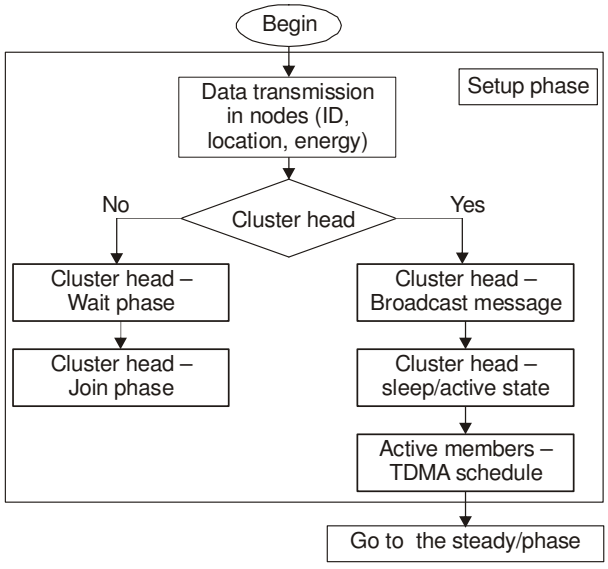

Fig. 3. Process flow diagram in set-up phase of hybrid LEACH Protocol.

The above figure demonstrates the working procedure for the proposed system. Once the lifetime of the node ends, the results are broadcasted.

Steady State Phase: The Hybrid LEACH protocol follows a distributed algorithm to form clusters and Base Station is not involved in this process. Stochastic algorithm is followed in every round to decide if the node can become cluster head. This algorithm also responsible for cluster head node selection and notification of non-cluster head nodes. This phase is classified into three parts namely:

(i) Advertisement
(ii) Cluster set-up
(iii) Transmission schedule creation

The algorithm is proposed aiming that no single node gets the chance of becoming a cluster head. The cluster head selection process is based on a random number selection. Selection of random number is generated by sensor nodes which hold value range between 0 and 1 the threshold value is estimated as below:

$$T(n) = \begin{cases} \frac{p}{\left(1-p\left(r \bmod \frac{1}{p}\right)\right)}, if n \in G \\ 0, \text{ otherwise} \end{cases} \quad (2)$$

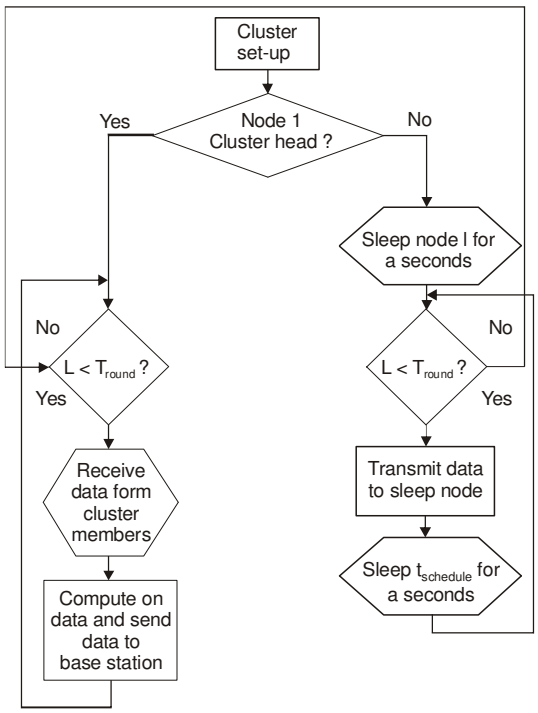

Fig. 4. Flow-chart of Steady State Phase in HYBRID LEACH Protocol.

Here p stands for cluster head probability, r for the current round and G represents nodes that are not cluster heads in the last 1/p rounds.

To reduce energy cost, steady state phase is designed with several frames, which means set-up phase has extended time limit than steady state phase. Therefore, over a period, the system moves back again into set up phase and initiates another round and chooses a new cluster head.

To decrease the interface among various clusters, different CDMA code is used to communicate for each cluster. Here BS refers to base station, CH as cluster head, CM are non-cluster head nodes, Nco as the number of nodes collided, Nds as nodes that have data to send out of CM, Nan is the number of slots not allocated and t is timer.

Algorithm: Steady State Phase using Proposed Method

Proposed EECL (Energy-Efficient Cross-Layer) approach

Step 1: Initialize: N→ Number of nodes in WSN.
Step 2: Check I ≠ N length do
Time_sensing = Time of transmitted (tr) - received packets(pr).
Step3: Switch
Case 1: node _status= ideal
No. of packet receive in node *i*
Case 2: node _status =transmit
Calculate: transmit power.
Calculate: node distance and
BER (Bit Error Rate)
Calculate: Received Power
Calculate: Current Energy
Step4: Check: *if* (Current_Energy> Threshold) && (node*i+1_BER>=0.5*)*then*
Forward : All the received packet to the node *i + n* with BER <0.5
Calculate: energy consumption in node
else
Forward : All the received packet to the node *i + n* with Min_distance or node *i + 1*
Step 5: Check:
energy consumption in node<= threshold
if (Slot _time >0) *then*
node _status = sleep
else
node _status = ideal
Step 6: end

Energy Calculation In Hybrid Leach Protocol: To calculate energy in the hybrid LEACH Protocol.

The nodes that communicate with each other and with the base station are within the communication range.

– The Base or the Sink Station is located at the center of the network.
– Energy dispersion is being neglected here.
– All the nodes in the network are of same capability.
– Therefore, the energy that is needed to transmit k-bit message at a distance d is -

$$E_{Tx}(k,d) = \frac{k*E_{elec} + k*E_{fs}*d^2 d<0}{k*E_{elec} + k*E_{amp}*d^4 d\geq 0} \quad (3)$$

Meantime the nodes calculate their BER and broadcast it to others using Hello message during routing information exchanging process.

The BER was modeled using the following equations:

$$P_{BER} = 1-(1-P_{e\frac{B}{F}})\,(1-T)^{n-1} \quad (4)$$

$$T = \frac{2(1-2P_{BER})}{(1-P_{BER})(w+1)+P_{BER}W(1-2P_{BER}{}^{n})} \quad (5)$$

$$P_{BER} = P_{e\frac{B}{F}} + + P_c - P_{e\frac{B}{F}}.P_c \quad (6)$$

$P_{e\frac{B}{F}}$ → the probability of error of bit/frame

T → the given time slot

W I → the initial window size.
Case1: ideal

$$P_{\text{ideal}} = (1-T)^n \quad (7)$$

Case 2: transmit

$$P_{\text{transmit}} = \text{n T}(1-T)^{n-1} \quad (8)$$

Case 3:

$$P_c = 1 - P_{\text{ideal}} - P_{\text{transmit}} \quad (9)$$

V. RESULT AND DISCUSSION

Matlab R2014a (Matrix Laboratory) is used to execute simulation process to compare the results of hybrid LEACH and the improved hybrid LEACH algorithms. The above methods are compared based on total energy consumption of nodes, and the overall lifetime of the network. Lifetime of the network refers to the time from beginning of the simulation until the last node in the network dies. As we are aware that the energy factor is limited in WSN it plays as an important indicator in deciding the lifetime of the network. The simulation circumstances considered in this work are:

1. The sensor nodes are distributed randomly across the square region.
2. The nodes hold a fixed location after it is deployed. These nodes are homogeneous in nature with unique ID number until its life in the network and the energy factor is limited.
3. The base station or the sink station holds a fixed location and is placed in the center of region.
4. Single-hop and multi-hop techniques are used for the nodes to communicate with the sink station.
5. Wireless transmitter power can be adjusted. Since the energy factor is limited in WSN, energy consumption is a crucial factor that indicates the performance of the network.

Assumption:

Table 1: Simulation environment parameters.

Parameters	Parameters
Area 500*500	Packet size 4500bits
Nodes number 500	Eelec 60nJ/bit
Initial Energy 1J	Radio electronics energy, = 50nJ/bit
CH proportion P=8%	Average Data rate= 25 kbps,
BS location (100,100)	

Simulation Parameter: The simulation scenario consists of 200 nodes that are distributed randomly in the square area that measures to 200m * 200m. The base station holds the center of the region with coordinates as (100, 100). The term network lifetime defines the start time of the simulation and ends until the last node in the network dies. The network lifetime in case of WSN can be divided into stable and unstable period. Stable period refers to the lifetime between the beginning of the simulation till the first node dies and unstable period is the time from the first node's death till the end of simulation. If in case some nodes start to die then the entire network operation gets spoiled and unstable, hence longer the stable period better is the network performance. In case of hybrid LEACH protocol, cluster heads are responsible for communication as well as data fusing or data collection. These cluster heads are randomly chosen and Fig. 5 denotes randomly distributed cluster heads die at very early stage due to low energy and long distance to the base station. The fig.6 represents the data rate between the nodes, which is determined by the distance between nodes. By having secondary cluster heads for these clusters help to continue the communication with the other nodes, and also to continue with data fusing. In this case energy load is balanced among the cluster heads, and eliminates early death of these cluster heads and resulting in stable period of the network lifetime to be prolonged. In Fig. 7 the energy efficiency is shown.

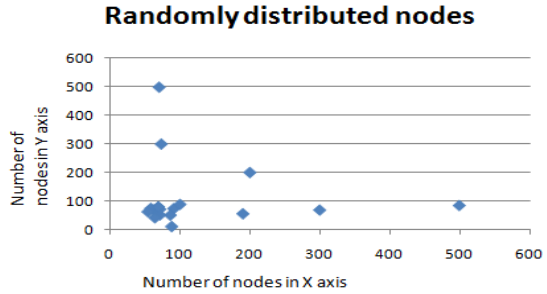

Fig. 5. Randomly distributed nodes.

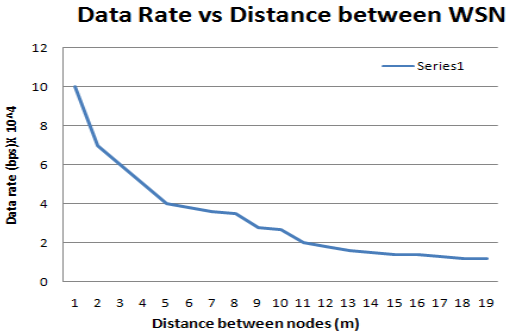

Fig. 6. Data Rate vs Distance between nodes.

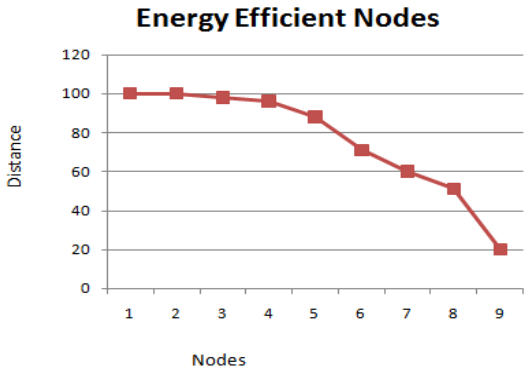

Fig. 7. Data Rate vs Energy Efficient between WSN.

VI. CONCLUSION AND FUTURE WORK

With the random selection of cluster head in hybrid LEACH protocol can cause some cluster heads with less energy or their distance to the base station is far. Due to these factors the cluster heads may die soon. To tackle this issue a modified algorithm of hybrid LEACH protocol is projected to balance this energy

consumption of the cluster heads. The improved algorithm is tested in MaTLab (Matrix Laboratory) environment for simulation and the results say that the life of the network and energy consumption is optimized than the hybrid LEACH protocol.

REFERENCES

[1]. Arutselvan, B., & Maheswari, R. (2013). Improving reliability and energy efficiency using packet splitting based on CRT forwarding technique and Kalman filter in wireless sensor networks. In *2013 International Conference on Information Communication and Embedded Systems (ICICES)* (pp. 701-705). IEEE.

[2]. Ouafaa, I., Mustapha, E., & Salah-ddine, K. (2017). A new secure solution for clustering in wireless sensors networks based on LEACH. In *2017 International Conference on Engineering and Technology (ICET)* (pp. 1-5). IEEE.

[3]. Patel, N. R., & Kumar, S. (2017). Energy efficient cross layer approach for Wireless Ad-hoc Network. *International Journal of Applied Engineering Research*, *12*(17), 6330-6337.

[4]. Sharma, R., Sohi, B. S., & Mittal, N. (2017). Hierarchical Energy Efficient MAC protocol for Wireless Sensor Networks. *International Journal of Applied Engineering Research*, *12*(24), 14727-14738.

[5]. Gill, R. K., Chawla, P., & Sachdeva, M. (2014). Study of LEACH routing protocol for Wireless Sensor Networks. In *International conference on communication, computing & systems,* 196-198.

[6]. Budhiraja, R., & Singh, S. (2014). An Improved LEACH-C Algorithm for Energy Efficiency in WSN Routing, *International Journal for Scientific Research & Development, 2*(7), 607-610.

[7]. Ullah, S., Khan, P., Ullah, N., Saleem, S., Higgins, H., & Kwak, K. S. (2010). A review of wireless body area networks for medical applications. *arXiv preprint arXiv:1001.0831*. Vol. *2*, No. 8, pp 797-803.

[8]. Gupta, V., & Doja, M. N. (2018). H-leach: Modified and efficient leach protocol for hybrid clustering scenario in wireless sensor networks. In *Next-generation networks* (pp. 399-408). Springer, Singapore.

[9]. Vishwakarma, S. (2015). An analysis of LEACH Protocol in Wireless Sensor Network: A Survey. *International Journal of Computer Science & Engineering Technology*, *6*(3), 148-154.

[10]. Gambhir, S. (2016). OE-LEACH: An optimized energy efficient LEACH algorithm for WSNs. In *2016 Ninth International Conference on Contemporary Computing (IC3)* (pp. 1-6). IEEE.

[11]. Kalaiselvi, K., & Cerli, A. A. (2017). A pragmatic implementation of energy efficiency in the wireless body area network using CASTALIA. In *2017 International Conference on Inventive Computing and Informatics (ICICI)* (pp.6-8). IEEE.

[12]. Huynh, D. T., & Chen, M. (2016). An energy efficiency solution for WBAN in healthcare monitoring system. In *2016 3rd International Conference on Systems and Informatics (ICSAI)* (pp. 685-690). IEEE.

[13]. Mali, S., & Sharma, R. (2015). Fault Node Recovery algorithm for wireless Sensor Network. *International Journal of Electrical, Electronics and Computer Engineering*, *4*(2), 99-103.

[14]. Mahtato, R. K., & Sharma, P. (2018). A Review 5G using Millimeter Wave in Ultra-Reliable Machine-to-Machine Communications, 7(2): 01-06.

[15]. Niharika, Yadav, H., & Agrawal, C. (2019). A Review of Enhancing Energy Efficiency of Wireless Sensor Network. *International Journal of Electrical, Electronics and Computer Engineering*, *8*(1), 46-49.

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