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Stochastic Approach for Energy-Efficient Clustering in WSN

ByManpreet Kaur, Er. Rohit Bhullar & Er. Lokesh Pawar
Chandigarh University, India

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Keywords: WSN, ELEACH, EBCH, and CELEACH.

GJCST-E Classification : H.3.3, I.5.3

STOCHASTICAPPROACHFORENERGY-EFFICIENTCLUSTERINGINWSN

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Manpreet Kaur [α], Er. Rohit Bhullar [σ] & Er. Lokesh Pawar [ρ]

Abstract- Wireless sensor networks are self-organizing networks in which sensor nodes with limited resource are scattered in an area of interest to gather information. WSNs need to have effective node's energy management methods for stable and seamless communication. Power efficient clustering is done in WSN to prolong the life of the network. In WSN, many algorithms are developed to save energy of sensor nodes and to increase the lifetime of the network. This paper provides an energy efficient clustering algorithm inspired by prophet routing protocol to enhance the cluster based operation of the nodes. Adaptive learning is implemented for head selection for efficient communication. Simulation results confirm the efficiency of the mechanism.

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I. Introduction

Wireless Sensor Networks in which sensors behaves as a substitute of humans consists of small devices with very limited capabilities, called wireless sensor nodes that collect information from the environment by sensors, process the information, locally make decisions and wirelessly communicate with other nodes in the network. In wireless sensor networks, the large number of sensors is deployed over a wide range to inspect and collect the information regarding their environmental performance. Generally, the most important responsibility of those device nodes in WSN is to notice and collect WSN's environmental knowledge and to send its knowledge into WSN network's external finish users [1]. To detect and collect the data many routing protocols have been proposed which reduce load from network and extend the network lifetime. In WSN load can be balanced by using clustering algorithm. Most of the load maintaining algorithms assumes similar parameters like energy, load at nodes and clustering overhead. Thus, Cluster formation and cluster election is very important for data gathering, and clustering phenomenon is an essential part of the organizational structure.

LEACH is one of the first cluster-based routing protocols. But LEACH causes unequal partition of clusters in the network and don't allow reselection of cluster head during 1/p rounds. To overcome the drawbacks of LEACH new cluster head algorithms are introduced such as EBCHS introduces residual energy which is an important parameter in WSN to threshold calculation of cluster head selection. It allows reselection of cluster head during 1/p rounds. EBCHS increases lifetime of network better than the LEACH. Many other energy efficient algorithms are proposed to prolong the life of the network such as ELEACH, PEGASIS, PEACH, HEEP, HEED, etc. In routing algorithms, Multiple-sink topologies are also chosen due to limited battery power, capabilities and low communication range sensor nodes suffer from some disadvantages in single sink networks. Moreover, in WSN multi-sinks are used to increase the lifetime and enhance the performance of the network. EMCA, MRMS, and PBR such algorithms use the concept of multi-sinks to increase the lifetime of the network.

In our case, packet count between the sensors in a cluster is an important parameter: as it comes longer, the radio signal to communicate between two nodes must be more powerful, and more energy is consumed. Eventually, our goal is to save energy and to enable the WSN to live longer. The rest of the paper is organized as follows. Section II introduces some related work of clustering algorithms. In Section III we describe the clustering-related method of our CELEACH. Section IV describes various algorithms for proposed methodology and pseudo code. Section V presents network simulations and assumptions. Then we show simulation evaluation and performance comparison in Section VI and Section VII concludes this paper.

II. Related Work

Wireless Sensor Network consists of sensor nodes and many algorithms have been proposed to select a suitable cluster head for clusters, for communicating cluster headers with each other, etc. by many researchers. Ye XiaoGuo, Lv KangMeng, Wang RuChuan, and Sun Lijuan begin with the introduction of traditional routing protocols, classifications of routing protocols and proposed a novel adaptive load-balanced routing algorithm (ALB) based on minimum interference and cross-layer design principle in [3] and introduced the least interference path algorithm principle briefly, and the implementation of adaptive load-balanced routing algorithm is elaborated in detail. ALB algorithm could realize the prediction of network congestion and TCP can adjust the congestion window size self-adaptive according to the real-time status of link. The

Author α: Research Scholar, CSE Dept. CGC Gharuan, Mohali. e-mail: manpreet15dec@gmail.com.

Author σ ρ: Assistant Professor, CSE Dept.Chandigarh University, Mohali. e-mails: rohitbhullar.cu@gmail.com, lokeshpawar.cu@gmail.com

simulation results show that packet loss rate had been greatly improved and throughput rate had got a large scale enhancement (PP). It is not only avoiding the occurrence of link overload phenomenon, but also increased the network resource utilization rate and ensured data transmission reliable.

Tejal Irkhede, and Prachi Jaini begin with wireless sensor networks, frequently occurrence of failures in WSN and stated that load balancing is of great importance in wireless sensor networks because of the limited resource constraint and by keeping dynamic metrics such as network load, load balancing can be achieved and congestion can be avoided in [4]. They also stated that multipath routing decision in network layer has an important impact on the performance of WSN. The approach they take is to combine the ideas of clustering first and then traffic is evenly distributed in network. In clustering, each node takes part in cluster head formation. For load balancing in the network they improved the traffic splitting protocol. This approach helps in enhancing the total energy consumption. Common WSN experience shows that link congestion node failure frequently occur. This is because using single route in WSN would deplete the energy resources of involved nodes. Communication in WSN is depending on different parameters. Proposed method is considering two parameters load balancing and energy. Proposed protocol provides the better result than exiting E-leach protocol for total energy consumption. In future work, they will explore load balancing technique to avoid the congestion at nodes. They will evaluate more metrics like delay, jitter, bandwidth, packet delivery ratio.

In paper [1], Authors begin with the needs of WSN such as self Organizing Mechanism, Low-Powered Communication, Data Aggregation Mechanism and CH Rotational Selection and propose the CH self-selection mechanism based on nodes' energy value comparison algorithm to migrate these problems. In this paper authors compare energy consumed in LEACH, EACH and their propose algorithm EBCH. The first node dies at 357 in the case of LEACH and the spherical of initial node dead is 379 within the case of EACHS. Conversely, the spherical of FND is 478 within the case of EBCHS. However, Nodes square measure dead systematically when 490 rounds thanks to unequal energy consumption in LEACH and EACHS. But, EBCHS will maintain a standard network higher than alternative mechanisms by employing a minimum of 530 rounds.

Z. Xu, Yue Yin, Jin Wang and Jeong-Uk Kim proposed an Energy-efficient Multi-sink Clustering Algorithm (EMCA) for wireless sensor networks in [8] and stated that wireless sensor networks with single sink; the energy consumption of sensors near the sink or on the critical paths is too fast besides other disadvantages. In EMCA, residual energy plays a big role within the procedure of choosing cluster heads. Simulation results show that their projected rule consumes abundant less energy and owns longer network time period than the normal routing rule LEACH. For LEACH, the primary node that becomes invalid seems in 390th spherical, whereas EMCA has the primary inactive node in 503rd spherical. It is owing to the changes of cluster head roles considering nodes' residual energy, additionally because the main concentrate on diminution of energy consumption in EMCA that with efficiency prolongs the network time period.

A.Y. Al-Habashneh, M.H. Ahmed, and T. Husain had proposed three MAC protocols for the forest fire detection using WSN: P-CSMA/CA and Per-Hop Synchronization CSMA/CA are contention-based MAC protocols and the third one called Sensor-TDMA is a TDMA-based protocol in [2]. In paper [4], Author begins with brief introduction of clustering algorithms and their usage in many domains. Subsets are clusters of groups which share the similarities. The authors suggest that these algorithms are particularly use full in wireless sensor networks where there is data aggregation and energy cuts. In this paper clusters are assigned base stations of the network to spare energy and they can detect forest fire. A new approach of clustering in WSNs based on FFUCA method and on a metric measure of energy consumption. This algorithm can process large network easily with same cost and simple to use and clear organisation of nodes.

Andrei Gagarin and Sajid Hussain begin with transient introduction concerning WSN and provides a brand new heuristic approach to look for balanced and little weight routing spanning trees in an exceedingly network in [9]. This approach could be a modification of Kruskal's minimum spanning tree (MST) search rule and relies on a distributed search by graded clusters. It provides spanning trees with a lower most degree, an even bigger diameter and may be used for balanced energy consumption routing in wireless sensing element networks. In this, Author assumes that every link is employed specifically once in each directions in each of the information gathering or distribution communication rounds, consumed receiving energy of every node will be neglected with reference to its transmission energies in each of the communication rounds and every one transmissions over the links square measure assumed to possess knowledge packets of constant size. The approach will be enforced in parallel yet as a straightforward regionally distributed rule. Simulations of a sensible situation WSN square measure done supported the transmission energy matrix. The simulation results show that the proposed approach can extend the functional lifetime of a WSN in 3-4 times in terms of sensor transmission energy.

Ting Yang, ChunJian Kang, and Guofang Nan states that the simple graph theory is commonly employed in wireless sensor networks topology control but an inherent problem of small- granularity algorithms is the high computing complexity and large solution space needed when managing large-scale WSNs. So, they use hyper-graph theory to solve these practical problems and propose a spanning hyper-tree algorithm (SHTa) to compute the minimum transmitting power delivery paths set for WSNs converge cast. Variable scale hyper-edges represented as computing units limit solution space and reduce computing complexity in. Mutual backup delivery paths in one hyper-edge improve the capability of fault tolerance. With experiment results, SHTa computes short latency paths with low energy consumption, compared with previous algorithms. Furthermore, in dynamic experiments scenes, SHTa retains its robust transmitting quality and presents high fault tolerance.

There are three main contributions of [10]:

1. They present a novel hyper-graph model to abstract large-scale and high connectivity WSNs into a robust hyper-tree infrastructure.
2. They present a precise mathematical derivation that solves the "hyper-tree existence" problem.
3. SHTa is proposed to compute the delivery paths set, which is the minimum power transmitting converge cast hyper-tree.

III. Proposed Methodology

In the proposed methodology, the prime focus was on reducing the load on node which will in turn provide a good platform to improve upon a number of things such as better performance and long life of the network.

Now we had two major schemes to discuss and implement. Firstly EBCH i.e. Load distributing protocol in which residual energy is an important parameter and threshold calculations are used for cluster head selection. It allows reselection of cluster head during 1/p rounds and secondly CELEACH in which we combine the ideas of clustering first and then traffic is evenly distributed in network. For clustering, the concept of EBCH algorithm is used and for load balancing in the network we use prophet routing protocol's concept on the improved the E-leach protocol for total energy consumption proposed in [4].

Hereby, an energy efficient algorithm CELEACH is proposed to enhance the cluster based operation of the nodes and balance traffic load. First step of proposed work is deployment of the network that consists of 50 nodes equally divided in five clusters. Each cluster elects cluster head for efficient communication. In our proposed methodology, we assume that:

1. Network area is 400*400 sq.units
2. Number of nodes are 50
3. Initial energy of all the nodes is 500mj
4. Delay between subsequent 0.2 unit Packet, and
5. Packet Size is 5 bit.

In the paper that we taken as our base of work for tsp the Load distribution is done. But contrastingly the load distributed is not balanced as evident in the figure above that the data is split in different paths of equal capacity but if that data if not balanced it will cause congestion.

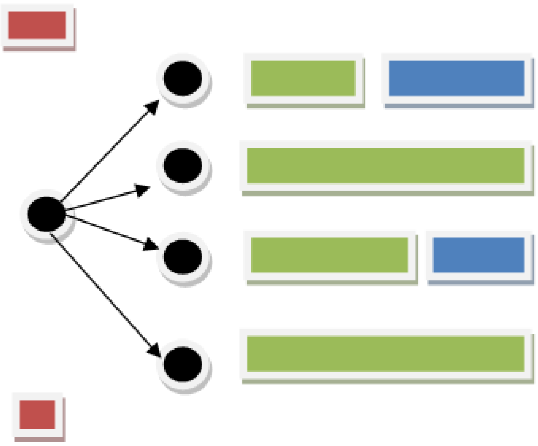


Figure 1

In figure 1, the green part is the travelling data, the blue part is empty slots and the red ones are which are waiting for slots to be free. This red part is the one which hinders the performance of the system. The problem is evident enough from the above scenario that the traffic that is distributed needs to be balanced immediately and for that purpose we have used CELEACH as explained in brief above in which our focus is on removing this unbalanced load on paths. EBCH improves the problem single path but the scope of improvement is still there in the multipath mechanism. For fulfilling the above stated purpose and for full filling the CELEACH mechanism we simulated the situation with equal distribution while EBCH was undertaken.

In figure 2, the packets which were earlier waiting for the slots to get free for the communication now are assigned to different paths which intern give the right solution for their communication over same paths which faced heavy congestion earlier, reduced but still prominent in case of EBCH but with now the situation is under control.

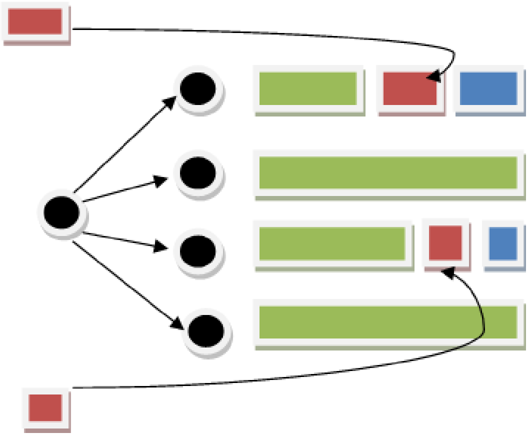


Figure 2

We also calculate average load, throughput, end to end delay, power left and power consumption in ELEACH and CELEACH algorithms. Description of calculations in brief is as given below:

- *Average load* is simply calculated by taking averages of all paths of *CELEACH* and *ELEACH*.
- *Throughput* is calculated by counting the number of packets needed for transmitting the same information.
- *End to End delay* is calculated by taking the sum of delay needed to send each packet.
- *Power left* is calculated as the power required to transmit one packet is known and number of packet send helps to calculate to total power in each case. Also the sleeping of nodes is considered.
- *Power consumed* is *100 - Power left*.

IV. Algorithm for Proposed Methodology

Three algorithms are designed for proposed methodology. First algorithm describes the whole procedure used to the cluster heads for clusters till the network is alive, second algorithm describes how the data is transferred from nodes to cluster head and from cluster head to base station, and third algorithm shows how the load is managed on the paths in the proposed methodology.

Algorithm 1: Election of CH

```
1. Deploy n nodes at random for the network.
   for n=1:50                        // n is number of nodes
   k= randint (1, 2, [53,348]);      // equation for node
                                     // deployment
2. Choose uniformly a part of nodes as cluster and elect
   one CH(Cluster Head) for each cluster as:
   ✓ let bcno is battery capacitor of each node and c is
     battery capacitor of CH.
   ✓ c= max(bcno)                    // node with maximum
                                     // battery power elected as
     CH
3. Repeat step 2 for each cluster to elect their CH.
4. CH will hold its position till its battery power is
   maximum than the threshold value.
5. Next CH will be elected by repeating step 2 to 5.
```

Algorithm 2: Data transfer

```
1. Both nodes send data to CH and CH transfer data to
   base station using multi paths.
2. Initially packet count is zero on each path.
3. If load on path is less than or equal to threshold

{
   Packet count increased by one
   Energy consumed (de)         // de is assumed
   energy
                                // used to transfer
                                // one packet count
 }

Else

 {
   Algorithm 3
 }
```

```
Algorithm 3: Load Balancing

1. If load is less than or equal to threshold
   {
                          // Do nothing
   }

   Else
   {
    Calculate extra load by subtracting threshold value
     from load

     Adjust extra load on the minimum loaded path
     {

      If extra load did not adjusted on other path
      Then: Send extra load on same path in next term
            Its packet count increased by two and
            Double of energy consumed (2de)
     }

   }
```

Pseudo code

```
Step 1: let load at 4 paths be L1, L2, L3 and L4.
Step 2: Start for loop path 1 >=4
Step 3: if (L1 > T) \\ T is the load threshold
Step 4: find difference in load D= L1 - T;
Step 5: if (L2 ' < T)
Step 6: put extra load to this path L2 = L2 ' + D; \\ L2 & L2 ' are the current and previous loads.
Step 7: end if condition;
Step 8: if (L3 ' < T)
Step 9: put extra load to this path L3 = L3 ' + D; \\ L3 & L3 ' are the current and previous loads.
Step 10: end if condition;
Step 11: if (L4 ' < T)
Step 12: put extra load to this path L4 = L4 ' + D; \\ L4 & L4 ' are the current and previous loads.
Step 13: end if condition;
Step 14: end if condition;
```

REPEAT THE STEPS 2 TO 14 FOR L2, L3 & L4 also.

V. Network Setup for Simulation

In this section, we mainly describe the simulations that are used to analyze and evaluate the performance of the proposed methodology. MATLAB was used to evaluate the ELEACH, EBCH and CELEACH algorithms via simulations. In wireless sensor networks, there are a lot of parameters to evaluate a clustering algorithm. In this paper, the packet count and average remaining energy of all nodes are chosen to compare the performance of the improved algorithm with ELEACH and EBCH.

We simulate E-LEACH, E-LEACH using EBCH and E-LEACH using CELEACH protocols by using the parameters defined in Table 1.

Table 1: Parametr of simulation

S.No.	Parameters	Values
1	Network size	400m X 400m
2	Initial Energy	500 mJ
3	Pd	100 mJ
4	Data Aggregation Energy cost	50pj/bit j
5	Number of nodes	50
6	Packet size	4000 bit
7	Transmitter Electronics	50 nJ/bit
8	Receiver Electronics	50 nJ/bit

VI. Simulation Analysis

During simulation, we compare the performance of our proposed algorithm with the performance of LEACH and EBCH algorithms. During deployment we divide 50 nodes in five clusters and each cluster is represented by different colors as shown in figure 3:

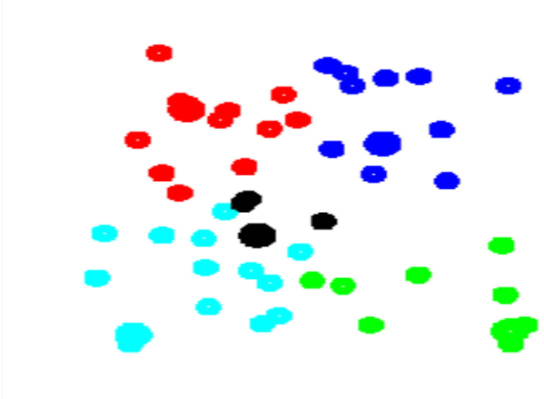
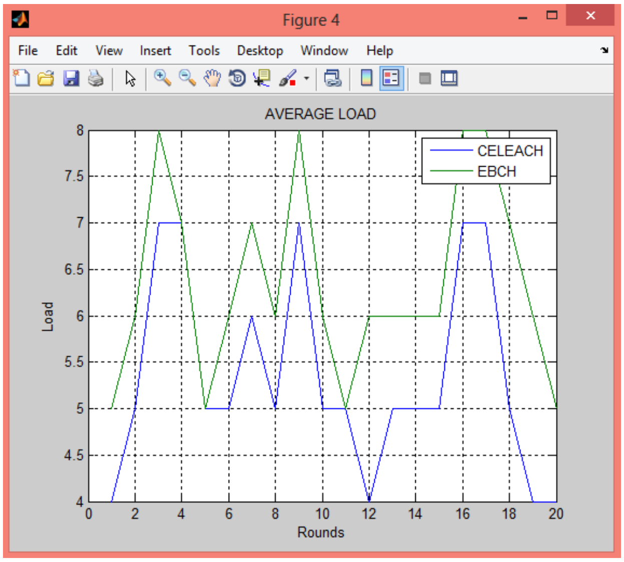


Figure 3

Simulations of E-LEACH using CELEACH in comparison with LEACH and E-LEACH using EBCH is being performed to observe the average load, power left, power consumption, end-to-end delay, average jitter and overall PDR or throughput.

Figure 4 shows that average load of E-LEACH using EBCH (Traffic splitting protocol) & CELEACH (Adaptive load balancing). Here the figure shown that the total no. of average load in E-LEACH using EBCH is higher than the total no. of average load in E-LEACH using CELEACH.

Figure 4



As CELEACH algorithm adaptively balanced the load in the network & gives better results in terms of network lifetime, end-to-end delay and throughput too.

Figure 5 shows that end to end delay comparison is higher in EBCH, lower in CELEACH and lowest in LEACH,

Figure 5

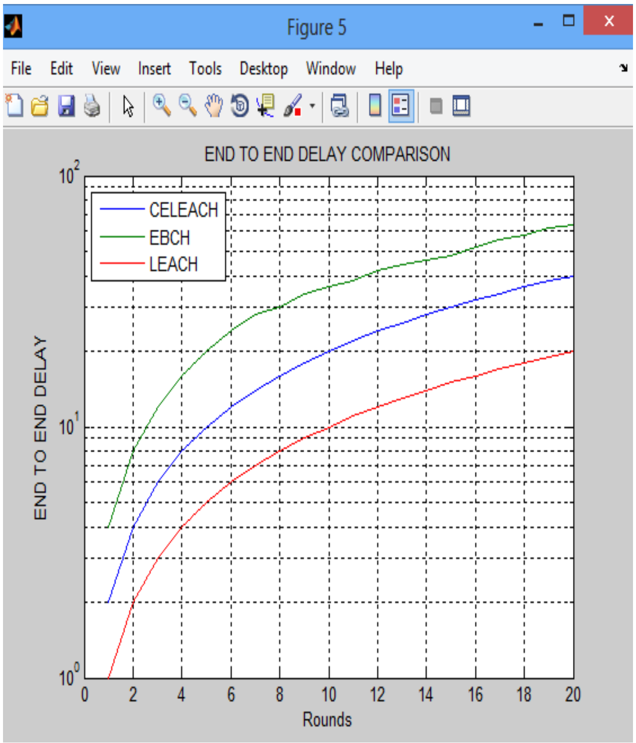


Figure 6 shows that throughput of E-LEACH using CELEACH is significantly greater as compared to LEACH and E-LEACH using EBCH. From this graph we see that the throughput of E-LEACH using CELEACH is more than the other two protocols because of adaptively load balancing in clustering and provide congestion free network,

Figure 6

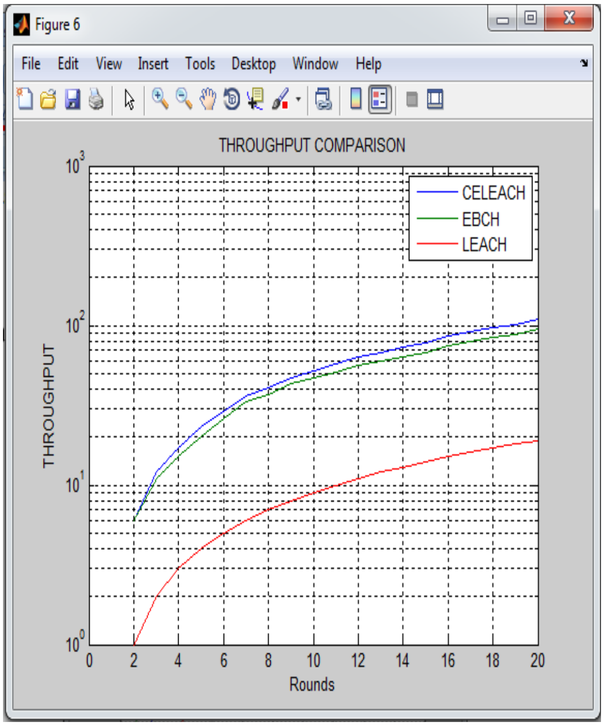
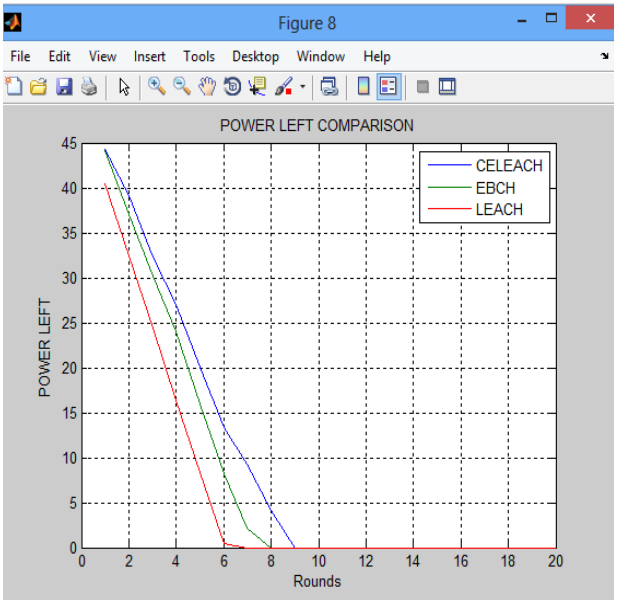


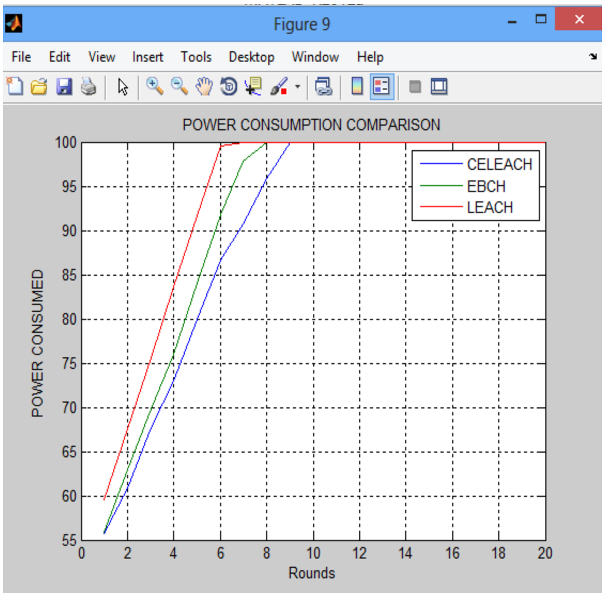
Figure 7 shows that power left comparison is less in LEACH as compare to CELEACH and EBCH,

Figure 7



and figure 8 also shows that the power consumption comparison is higher in LEACH as compare to CELEACH and EBCH.

Figure 8



Simulation results of LEACH, E-LEACH using EBCH and E-LEACH using CELEACH protocols by using the parameters defined in Table 1 are briefed in *Table 2:*

Algorithm	Network Survival Time	Through put (Max)	Jitter (Max)	E2E Delay (Max)
LEACH	7 rounds	10 bps	10 u	10 ms
EBCH	8 rounds	40 bps	6 u	30 ms
CELEACH	9rounds	50 bps	4 u	20 ms

Simulation results of LEACH, EBCH and CELEACH for various parameters while variation in nodes of the network.

a) Throughput Comparison

Table 3 compares throughput parameter in LEACH, EBCH and CELEACH and shows that the performance of CELEACH is getting better by increasing the number of nodes.

Table 3 : Throughput Comparison

No. of Nodes	LEACH	EBCH	CELEACH
50	10 bps	40 bps	50 bps
100	10 bps	40 bps	60 bps
150	10 bps	50 bps	70 bps

b) Jitter Comparison

Table 4 compares jitter parameter in LEACH, EBCH and CELEACH and shows that the performance of EBCH is getting better by increasing the number of nodes.

Table 4 : Jitter Comparison

No. of Nodes	LEACH	EBCH	CELEACH
50	10 u	6 u	4 u
100	10 u	5 u	4 u
150	10 u	5 u	4 u

c) Comparison of End to End Delay

Table 5 compares End to End Delay parameter in LEACH, EBCH and CELEACH and shows that there is no change by increasing the number of nodes.

Table 5 : Comparison of End to End Delay

No. of Nodes	LEACH	EBCH	CELEACH
50	10 ms	30 ms	20 ms
100	10 ms	30 ms	20 ms
150	10 ms	30 ms	20 ms

d) Comparison of Network Survival Time

Table 6 compares Network Survival Time in LEACH, EBCH and CELEACH and shows that the performance of CELEACH is getting better by increasing the number of nodes.

Table 6 : Network Survival Time's comparison

No. of Nodes	LEACH	EBCH	CELEACH
50	7 rounds	8 Rounds	9 Rounds
100	7 Rounds	8 Rounds	10 Rounds
150	7 Rounds	8 Rounds	11 Rounds

VII. Conclusion

In this paper, we proposed an optimized routing scheme for WSNs. The main focus was to provide the congestion free protocol. In our proposed scheme, Adaptive Load balancing is used in clustering. In E-LEACH using CELEACH, cluster heads are selected in each cluster on the basis of residual node energy. The E-LEACH using CELEACH scheme decrease the congestion in the network which make the WSN communication more energy efficient. The stability period of network and network lifetime have been optimized in our proposed strategy. Simulation results show that when compared with existing routing protocols CE-LEACH and ELEACH using EBCH, there is significant improvement in all these parameters.

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