Cluster Head Selection Algorithm for Wireless Sensor Networks

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ABSTRACT
Wireless sensor network is a collection of sensor nodes, each node is coupled with irreplaceable power source and limited resources. In order to prolong network lifetime several cluster based routing protocols are proposed. However, due to the different power levels and transmission distances from each Cluster Head (CH) to the Base Station (BS) there occurs unequal and high energy depletion in the CH. In this paper, we have proposed a novel approach to select CHs, which is called as Efficient Cluster Head Selection (ECHS).This approach minimizes the energy depletion. This is done by selecting the CH with maximum residual energy node and less transmission distance between the CH and BS. Castalia simulation results shows that proposed approach is more energy efficient, and hence it is more effective to fulfil the major demands of the wireless sensor networks which prolongs the network life time.

Keywords
WSN; Cluster; LEACH; Energy; ECHS; ERA; Energy Efficiency; Timer; Cluster Head.

1. INTRODUCTION
Wireless sensor network (WSN) consists of a group of low power and low cost embedded device (sensor nodes) used to monitor physical and environmental condition such as temperature, humidity, sound, fire etc. WSN should be managed wisely to prolong the network lifetime because sensors are coupled with limited and non-rechargeable energy source. Energy efficient algorithms can be improved at each layer of communication protocol suite to overcome most challenging issues of WSN i.e. energy conservation of sensor node to increase network lifetime.

Cluster based routing protocol attracts significant attention among the different categories of routing protocol. In order to conserve energy sensor node can be grouped into clusters. Clustering is a process where sensor nodes are organized into distinct groups called cluster. One representative is selected from each cluster known as cluster head and remaining nodes become cluster members (CMs). Each sensor node must become a member of single cluster. CH receives data from its members, aggregate it and forwards data to the sink node. Many clustering algorithms like LEACH, LEACH C and EEE LEACH are proposed but these protocol randomly select CH which results in increased energy consumption and does not guarantee about the placement of CH. On the other hand, TB LEACH and ERA are timer based cluster head selection algorithm. In these algorithms timers are generated randomly or by using node residual energy. Timer based cluster head selection algorithm perform well then the random selection of CH.

In this paper we propose a new efficient cluster head selection algorithm, called ECHS for a cluster based WSN that takes care of all above mentioned issues. In our approach, initially Base Station (BS) broadcast hello message to all the nodes. After receiving the hello message each node calculates the quality of a signal from received signal strength. To become a CH, each node starts its own timer which depends on the residual energy and the quality of a signal calculated at initial stage. The rest of the paper are organized as follows. We have reviewed some related work in Section II. Radio energy model used in this study is presented in Section III. The proposed algorithm is explained in Section IV. We present result and analysis in Section V. Conclusion from work is in Section VI.

2. RELATED WORK
LEACH stands for Low Energy Adaptive Clustering Hierarchy proposed by Heinzelman et. al.. It is a popular distributed hierarchical clustering, in which CHs are selected using randomized rotation techniques which distributes energy load evenly among the all sensor nodes [1]. Main drawback of LEACH is high depletion of energy in the CH because of different transmission distance from CH to BS. If a CH is located far from the BS it depletes the energy faster than the CH located closer to BS. Another drawback of LEACH is that the node having low energy level has the same probability of becoming a CH as compare to the node having high energy level. This effects the lifetime of a network.

EEE LEACH (Energy Efficient Extended LEACH) is another clustering technique in which two sets of CHs are selected Set 1. Cluster Head (CH) and Set 2. Member Cluster Head (MCH). CH collects information from its members, aggregates the information and forwards it to the nearest MCH, which efficiently reduces the transmission distance and achieves the low power consumption [2]. But the CH selection process is same as LEACH i.e. randomized rotation techniques.

TB-LEACH (Timer Based – Low Energy Adaptive Cluster Head) uses a timer based cluster head selection algorithm for LEACH. It forms a well distributed clusters without using global knowledge of the network and selects constant number of CHs [3]. In the cluster head election process it assigns the random time interval to every nodes. Node having the minimum time interval become the CH because its timer expires first. To maintain a constant number of cluster head it uses counter. Without considering the energy level of a node TB-LEACH assigns random time interval to each node. If a node having a low energy level receive a minimum time interval its timer expires first and becomes the CH. Therefore, TB-LEACH CH selection process is not optimal.

In ERA (Energy Aware Routing Algorithm) cluster heads selections are based on residual energy of a node and cluster formation is based on intra cluster distance [4]. ERA selects CHs by initiating a time interval for each node which depends on its residual energy. All cluster member join CHs by

considering its residual energy and distance to the CH. Each nodes independently sets its timer for CH selection camping. Node with high residual energy obtain minimum time interval and expires first in CH selection camping.

3. NETWORK ASSUMPTION AND MODEL

We assume a homogenous set of sensor nodes deployed in network field. These sensor nodes are energy constrained. After deployment, all the sensor nodes become static. The base station is located outside the network field and it is also static.

The energy model of the WSN is adopted from [1], total energy used by transmitter to send a k-bit message over a distance d is given by

$$E_T(i,j)=E_{elec}K + \varepsilon_{amp}kd^2 \quad \text{----------(1)}$$

Where ε_{amp} is the energy constant for the radio transmission and E_{elec} is the energy per bit. $E_{elec}K$ is the energy used to run the circuitry to handle the k bit and $\varepsilon_{amp}kd^2$ is the energy for transmitter to send k bits over distance d. The energy spent with the transmission of the message increases if the distance d and number of bit k increases.

Energy consumed in receiving the k bit data by node j is given by

$$E_R(k)=E_{elec}*k \quad \text{----------(2)}$$

4. PROPOSED APPROACH

The proposed ECHS scheme achieve major demands of the wireless sensor network i.e energy conservation by selecting the cluster head which has less transmission distance to BS and has high residual energy. It also avoids unnecessary large number of CH in a network by selecting CH dynamically. ECHS selects CH in such a way that it covers all the regions of the network and no two CHs are selected within its communication area. ECHS scheme works in network set up phase to select the best suitable node to become a cluster head.

4.1 Clustering

Initially at network deployment stage, sink node broadcast the hello message to all the sensor at maximum power level. After receiving the hello message each sensor node compute signal quality based on the received signal strength. It also helps to calculate the distance to the base station. Each sensor node sets its individual timer independently before nodes starts the campaign for CH selection. Let t(*i*) be the timer of node *i* which is derived as follows

$$t(i)=\frac{Em(i)-Er(i)}{Em(i)} \times \frac{1}{q} \quad \text{……..…..(3)}$$

Where q is the signal quality computed based on the received signal strength of hello message for sink node, where $E_r(i)$ is the residual energy and $E_m(i)$ is the initial maximum energy of the sensor node *i*. The sensor nodes with higher residual energy and greater signal quality will be selected as CH since its timer expires first. When the timer expires node *i* declare itself as a CH and broadcasts a CH announcement message. If the node *j* receives the advertisement message it withdraws CH candidature and becomes the non-cluster head for that communication round. After receiving the CH advertisement message node *j* updates the neighbour CH information and its received signal strength value. Each non-cluster head chooses its nearest cluster from the neighbour CH list based on the largest received signal strength. After that it sends the join message to the CH.

Algorithm: Cluster Head selection algorithm

/*Cluster Head Selection*/
1. **if** (sink node) **then**
2. Broadcast (hello message) in the range Maximum;
3. **end if**
4. **if**(!sink node) **then**
5. **for** each node *i*
6. **if(** node *i* receives Hello message) **then**
7. calculate RSSI;
8. calculate signal_quality;
9. T(*i*)=((Em(i)-Er(i))/Em(i))X(1/q)
10. **end if**
11. **end for**
12. **if** (t(*i*) == 0) **then**
13. node *i* broadcast(CH advertisement);
14. **end if**
15. **if** (node *j* receives CH advertisement message) **then**
16. node *j* cancel its CH candidature and becomes non CH node;
17. update Neighbor CH(*j*);
18. **end if**
19. **if** (node j is non CH node and receives a CH advertisement message) **then**
20. update Neighbor CH(*j*);
21. **end if**

/*Cluster Formation*/

22. **for** each non CH node *j*
23. sort neighbor CH(j) base on received signal strength;
24. select CH having largest received signal strength;
25. node j send join message to CH;
26. **end for**
27. **end if**

Pseudo code for clustering algorithm

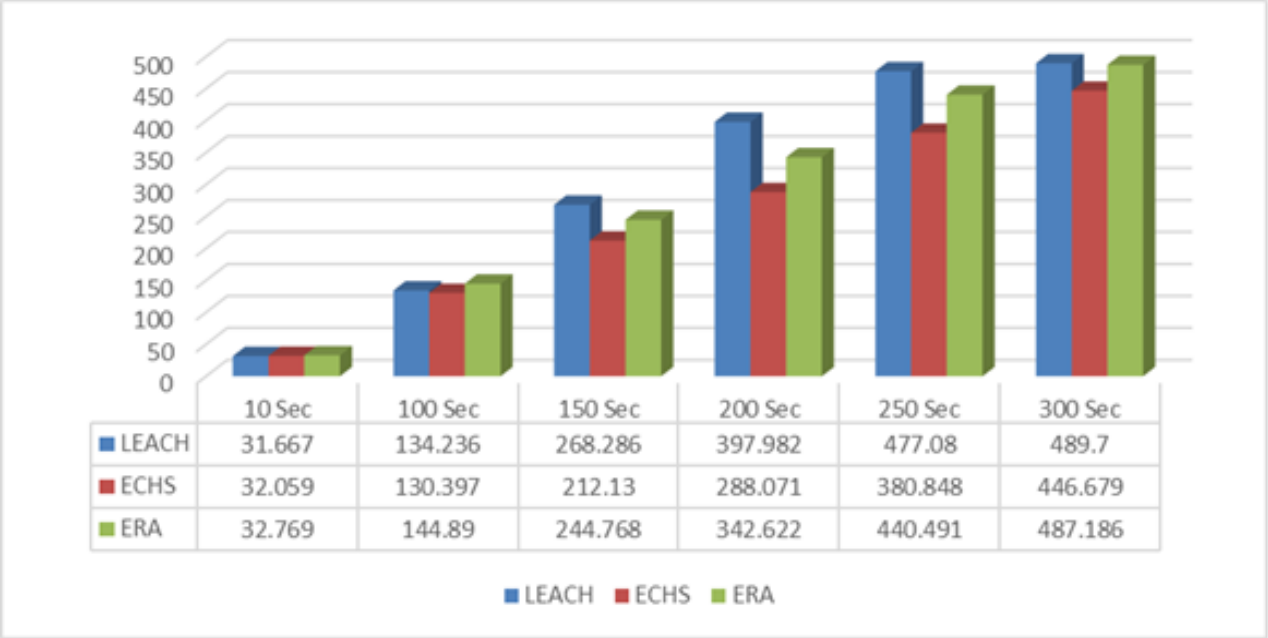
Table 1. Parameter Used in Simulation

Sl. No.	Parameters	Bottom
1	Routing Protocol	LEACH, ECGS,ERA
2	Network Size	50x50 m
3	Data Packet size	500 bits
4	Initial energy per node	10 J
5	Tx and Rx energy	50nJ/bit
6	Amplifier energy (e_{fs})	10 pJ/bit/m^2
7	Amplifier energy (e_{mp})	0.0013 pJ/bit/m^4
8	Control message size	100 bits
9	Simulation Time limit	300 sec

5. RESULTS AND DISCUSSION

To evaluate the performance of ECHS algorithm we simulate ECHS, LEACH and ERA. We deploy 50 nodes using random uniform distribution into the network of size 50 x 50 m. To model our algorithm we use Castalia simulator. Figure 1 shows the energy consumed by each protocol. The LEACH consumes more energy as compared to the ECHS and ERA. Both ECHS and ERA CH selection process is based on timer. But the outcome of ECHS is better than ERA.

Figure 2 shows the initial stage of all the three CH selection scheme. At the beginning of the selection scheme, all nodes consumes almost equal amount of energy but as the simulation time increases the energy consumption varies between all the three schemes. Figure 3 shows result of each node captured at 150 sec. The nodes which uses LEACH consumes more energy as computer to others.



	10 Sec	100 Sec	150 Sec	200 Sec	250 Sec	300 Sec
LEACH	31.667	134.236	268.286	397.982	477.08	489.7
ECHS	32.059	130.397	212.13	288.071	380.848	446.679
ERA	32.769	144.89	244.768	342.622	440.491	487.186

Fig. 1: Energy consumed by LEACH, ECHS and ERA

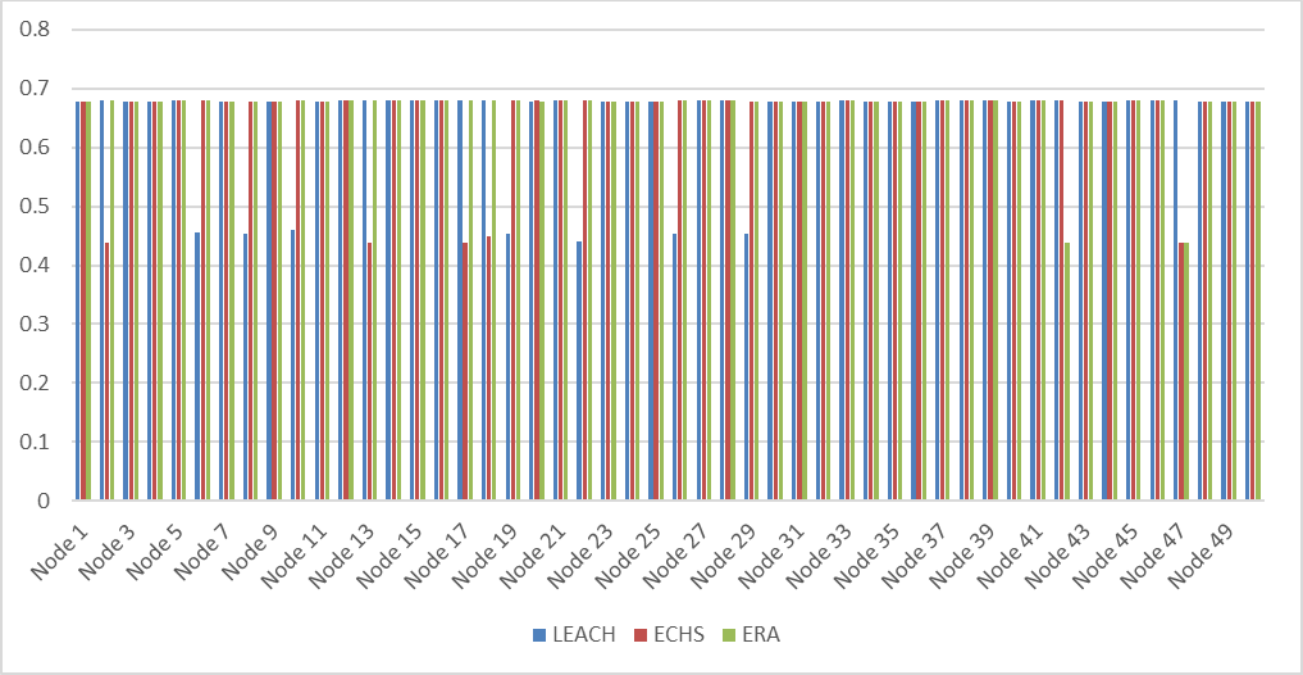


Fig. 2: Energy consumed by each node using LEACH, ECHS and ERA (simulation time 10 Sec).

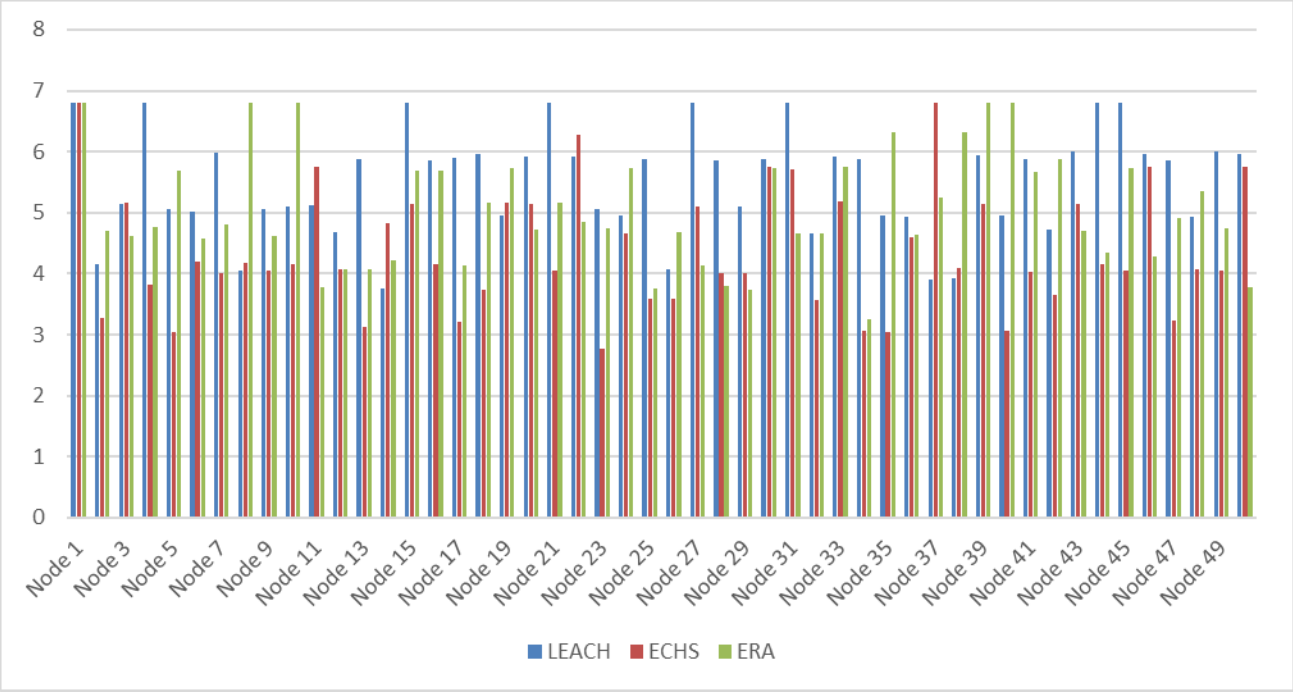


Fig. 3: Energy consumed by each node using LEACH, ECHS and ERA (simulation time 150 Sec).

6. CONCLUSION

The main challenge in the development of wireless sensor network is to conserve energy. In this paper we have presented novel approach towards energy efficient cluster head selection scheme for wireless sensor networks called ECHS. It produces a uniform distribution of cluster head across the network. In each communication round ECHS tries to select a CH which has more residual energy and less communication distance to the base station. Our simulation model results shows that ECHS is energy efficient and it prolongs network lifetime.

7. REFERENCES

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