Performance Comparision of LEACH, SEP and DEEC Protocol in Wireless Sensor Network

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***Abstract*— Wireless Sensor Network is the network of power-limited sensing devices called sensors. Wireless sensor network is differ from other networks in terms of optimization of amount of energy because when these sensors sense and transmit data to other sensors present in the network, considerable amount of energy is dissipated. Various routing algorithms are proposed to limit the powers used by the wireless sensors. Hierarchical routing protocols with the concept of clustering like LEACH and SEP and DEEC are already best known for maintaining energy efficiency. In this paper, we will compare these three protocols in terms of packet transmission, energy dissipation and number of nodes alive and stability period and we will discuss the advantage and disadvantage of these protocols under various conditions.**

Keywords- **Wireless Sensor Networks, Stability period, LEACH protocol, SEP protocol, DEEC protocol**

1. INTRODUCTION

Wireless Sensor Network (WSN) is a system composed of wireless sensors deployed in a region to sense various types of physical information from the surroundings [1]. The information sensed by these sensors (or nodes) is then processed and has been sent to Base Station (BS) for assessment.

WSNs are used for various applications like habitat monitoring, military surveillances, forest-fire detections, transport monitoring, etc. Since the nodes are wireless and tiny, these can be deployed with ease, even in remote areas and hilly terrains. However since the nodes are dense and monitoring of these nodes is very complicated, Particularly in the cases when the nodes are distributed in the regions where the physical intervene of the human being is not possible .The network once established, keeps on sensing the information and the energy of the nodes keep on dissipating whenever, they receive some information and send it further to other nodes or BS.A number of routing protocols have been proposed to make nodes more energy efficient. Dense nature of this sensor create the situation when the redundant information is transferred to the base station, along with this the energy of the nodes is also dissipated. To overcome from these problems various clustering algorithms were proposed. The whole network of nodes is divided into a number of clusters; the data aggregation is performed within the cluster and then transmitted to the BS. Clustering helps in reduction of redundancy and improvement over the lifetime of the network [2]. The LEACH [4] and SEP [5] and DEEC [3] are such clustering protocols. The rest of the paper is organized as follows:

In section 2, we review the related works in this field. Section 3 will depict the energy model that could be used by the sensors. Section 4 contains simulation results to compare all the three under various performance measure matrices. Finally, in section 5, we present the conclusion.

CH Selection Based on

(a) **Initial Energy:** Initial energy of all sensor nodes

(b)**Residual Energy**: The remaining energy of every node after every round.

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(c)**Energy Consumption Rate:** The energy dissipated in sensing information, sending information to base and energy associated with cluster formation

(d)**Average Energy of the Network**

2. REVIEW OF CLUSTERING ALGORITHMS FOR WIRELESS SENSOR NETWORK

1. LEACH (Low Energy Adaptive Clustering Hierarchy) LEACH [4] is one of the most popular clustering algorithms. The main idea behind leach is to form clusters based upon the signal strength of the sensors. Some of the nodes are randomly chosen as the cluster heads(CH) and a node is assigned to the CH based upon the signal strength received by that node from the CH. CHs have to do a lot more work than the normal nodes, hence they dissipate a lot more energy and may die quickly. In order to maintain a stable network, CHs keep on rotating, in every round. So, a node which had become CH may not get an opportunity to become CH again before a set interval of time.

A node can become the cluster head for the current round if its value is less than the threshold T(n) where T(n) is given by –

$$T(n) = \begin{cases} \dfrac{P}{1 - P * (r \bmod \frac{1}{P})} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

P is the percentage of cluster heads, r is the rth round, G is the set of nodes which are not cluster heads in the last 1/P rounds.

Advantages:

- LEACH is completely distributed. LEACH does not require the control information from the base station, and the nodes do not require knowledge of the global network in order for LEACH to operate.
- LEACH reduces communication energy by 8 times as compare to direct transmission and minimum transmission-energy routing.

2. SEP (Stable Election Protocol)

SEP [5] was an improvement over LEACH in the way that it took into account the heterogeneity of networks. In SEP, some of the high energy nodes are referred to as advanced nodes and the probability of advanced nodes to become CHs is more as compared to that of non-advanced nodes.

Advantage:

- SEP does not require any global knowledge of energy at every election round.

Limitations:

- The drawback SEP method is that the election of the cluster heads among the two type of nodes is not dynamic, which results that the nodes that are far away from the powerful nodes will die first.

3. ***DEEC (Distributed Energy Efficient Clustering)*** In DEEC [3] protocol all nodes use the initial and residual energy level to define the cluster heads. DEEC estimate the ideal value of network lifetime to compute the reference energy that each node should expend during each round. In a two-level heterogeneous network, where we have two categories of nodes,m.N advanced nodes with initial energy equal to Eo.(1+a) and (1 – m).N normal nodes, where the initial energy is equal to Eo. Where a and m are two variable which control the nodes percentage types (advanced or normal) and the total initial energy in the network Etotal.

•The value of Total Energy is given as

$$Etotal = N.(1-m).Eo + N.m.Eo.(1+a) \qquad (1)$$

•The average energy of rth round is set as follows

$$E(r) = \frac{1}{N} Etotal(1 - R) \qquad (2)$$

R denotes the total rounds of the network lifetime and is defined as

$$R = \frac{Etotal}{ERound} \quad (3)$$

• ERound is the total energy dissipated in the network during a round, is equal to:ERound = L(2NEelec +NEDA + kEmpd^{4}toBS+NEfsd^{2}toCH) (4)

k: number of clusters
EDA: data aggregation cost expended in the cluster heads
dtoBS : average distance between the cluster head and the base station
dtoCH: average distance between the cluster members and the cluster head.

• Because we are assuming that the nodes are uniformly distributed, we can get:

$$dtoCH = \frac{M}{\sqrt{2k\pi}}$$

$$dtoBS = \frac{0.765\ M}{2}$$

Advantages:

- DEEC does not require any global knowledge of energy at every election round.
- Unlike SEP and LEACH DEEC can perform well in multi-level Heterogeneous wireless network.

Limitations:

- Advanced nodes always penalize in the DEEC, particularly when their residual energy reduced and become in the range of the normal nodes. In this position, the advanced nodes die rapidly than the others.

3. ENERGY MODEL ANALYSIS

In this paper, we are analyzing three protocols – LEACH, SEP and DEEC-based on the energy dissipation model shown in the following figure –

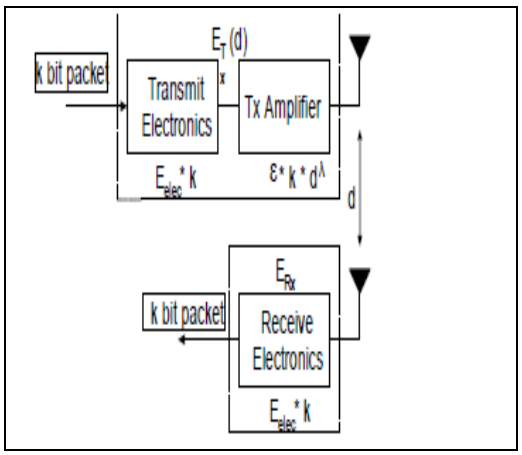


Figure 1: Energy dissipation diagram

For a particular node, the energy is dissipated because of receiving and transmitting. The energy expanded in transmitter to transmit k-bit message is given by –

$E_T(k,d) = (E_{elec} * k) + (E_{fs}*k*d^2)$
if $d<=d_0$

$(E_{elec} * k) + (E_{mp}*k*d^4)$
if $d>d_0$

- Eelec is the energy dissipated to run the electronics circuits
- k is the packet size
- Efs and Emp are the characteristics of the transmitter amplifier
- d is the distance between the two communicating ends.

Energy dissipation to receive a k-bit message is given by-

$E_R(k) = E_{elec} * k$

The values of radio characteristics are –

E_{elec} = 50 nJ/bit
E_{fs} = 10 pJ/bit/m^2
E_{mp} = 0.0013pJ/bit/m^4

In addition to above energy expansions, a CH also dissipates energy because of data aggregation. The data aggregation energy EDA has the value of 5nJ/bit/signal.

4. SIMULATION RESULTS

We have carried out a number of experiments and used them for the comparison of LEACH, SEP and DEEC for various performance metrics. Simulation results on MATLAB depict that DEEC has better stability period and less energy dissipation per round.

A. Network Settings

We are using a 100*100 region having 100 sensor nodes placed randomly. The probability of advanced nodes is kept as 0.2, so the number of advanced nodes is 20. The packet size is considered to be of 4000 bits. The various parameter values taken for experiments are shown in the following table –

Parameter	Value
E_{elec}	50 nJ/bit
Efs	10 pJ/bit/m^2
Emp	0.0013 pJ/bit/m^4
EDA	5 nJ/bit/packet
E_0	0.5 J
K	4000 bits
Kopt	3
Popt	0.1
N	100
A	1
M	0.2
D	30
Network size	100*100
Base Station Location	(50,50)

We have measured performance on the basis of following measurements:

(i) Stability Period is the period (or round) up to which all nodes are alive. This period lies between rounds 1 to the round at which the first node dies.
(ii) Instability period is the period between the first dead node and last dead node. This period should be kept as small as possible.
(iii) Energy dissipation
(iv) Different values of heterogeneity

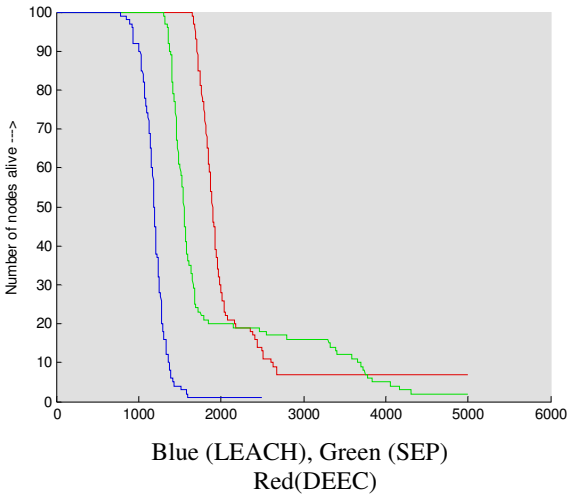


Figure 2: Number of Nodes alive Vs Number of rounds

From the figure 1 it is clear that the DEEC is more stable than the SEP and LEACH as the first node dead in DEEC after LEACH and SEP shows stability period of DEEC is prolong than the LEACH and SEP.

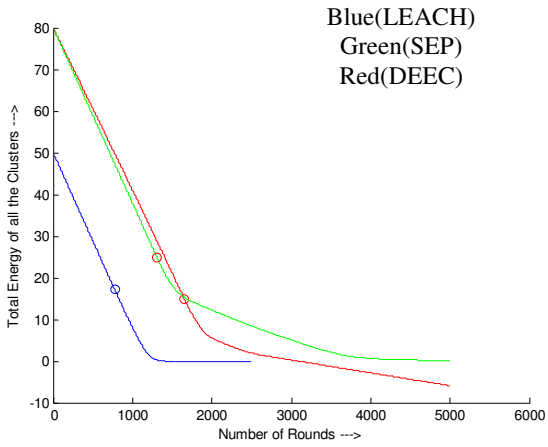


Figure 3: Energy dissipation diagram of LEACH ,SEP and DEEC

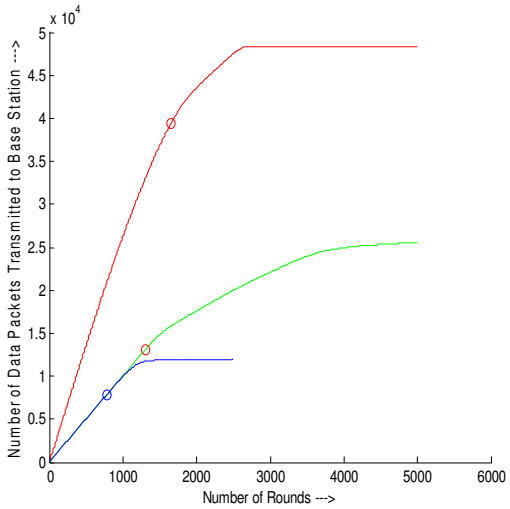


Figure 4: Number of Data packets transmitted to base station Vs Number of rounds

We can see from the figure 4 that the packets transferred to the base station are large in DEEC as compare to SEP and LEACH.

Comparison of SEP and DEEC under Heterogeneous Environment: Simulation results shows that the DEEC outperforms the SEP in heterogeneous environment .DECC is more stable than SEP when we varying the value of a from 0.5 to 5(Figure 5) and value of m from 0.1 to 0.9.(Figure 6).Simulations shows that the stability period of DEEC is prolong as compare to SEP.

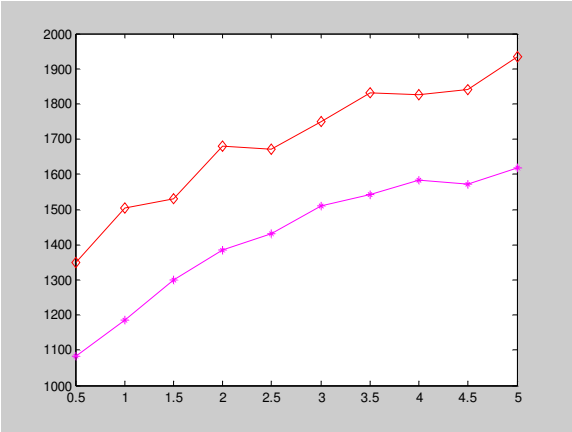
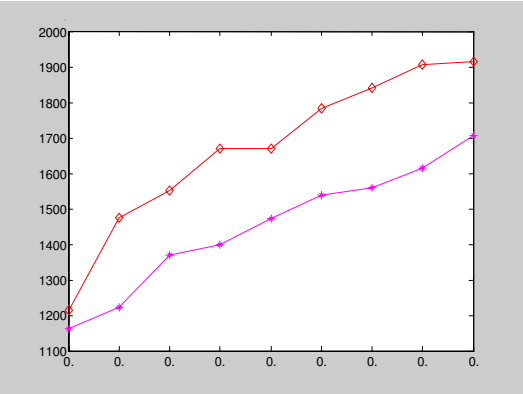


Figure 5: Round first node dies when a is varying.



Red (DEEC), Cyan (SEP)

Figure 6: Round first node dies when m is varying.

5. CONCLUSION

We had compare the LEACH SEP and DEEC protocol under various performances metric through simulation. The performance of the three protocols are judged under the various performance metric .Simulation results shows that DEEC outperforms the two .The table(1) shows the comparison of three protocols under various performance metrics.

Table 1.Comparision table for LEACH, SEP and DEEC

performance criteria	LEACH	SEP	DEEC
Heterogeneity level	Not present	Two	Multilevel
Cluster Stability	Lower than SEP and DEEC	Moderate	High
Energy Efficient	Low as compare to SEP and DEEC	Moderate	High
Cluster head Selection criterion	Based on Initial and Residual Energy	Based on Initial and Residual Energy	Based on Initial , Residual and Average Energy of the network
Network Lifetime	Lower than SEP and DEEC	Moderate	Prolong Network Lifetime than SEP and LEACH

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