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Effective implementation of Energy Aware Routing for Wireless Sensor Network*

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Abstract

The Wireless Sensor network has placed its inevitable position in monitoring and surveillance purpose. The remote and unattended condition of Wireless Sensor network seeks a new energy efficient algorithm. Enhancing the lifetime of Wireless sensor network has become the primary need to prolong the network lifetime. This paper envisage the increase in lifetime of nodes by properly selecting the cluster head based on the residual energy state and total number of frames transmitted to the sink. The role of sensor node is modelled as Finite State machine and realized as markov process. The process helps in scheduling the role of the sensor node and in the process of cluster head selection. Lifetime enhancement is achieved by selecting optimal cluster head among eligible cluster members. The proposed algorithm outperforms the other algorithms in terms of lifetime and throughput when compared to other protocol. The results supports that Energy aware routing increases the lifetime of the network and serves as the better solution for energy consumption.

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Keywords: Wireless Sensor Network (WSN), Energy aware routing (EAR), Finite state machine (FSM)

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1. Introduction

The Wireless Sensor Network (WSN) has wide range of applications in the field of surveillance, monitoring, consumer electronics, remote monitoring of patients etc.[1].The functionalities of sensor network are increasing day by day with advancements in technologies. The size of the sensor node is reducing, with the increase in applications. However, miniaturization of the sensor node influences the size of the battery [2]. The storage capacity of the battery is reduced as the size of the sensor node is reduced. The sensor network consists of group of sensor nodes which are deployed in the region of interest.

The nodes are deployed in the remote environment, which is hardly possible for the humans to replace the node. The capacity of the battery is limited due to the size of the sensor node. Thus, the energy management with the available resources has become the major constraint of sensor network. The lifetime of the sensor network depends on the lifetime of each individual node. Each sensor node plays a major role in increasing the survivability of the network.

The clustering mechanism in sensor network enables efficient transmission of information from end nodes to the sink. The selection of cluster head reduces the congestion due to data transmission from all nodes and data loss. Many energy efficient clustering and routing protocols are available which concentrate in improving the lifetime by considering the residual energy of the battery[3]. Hence the energy efficient routing should perform without compromising the size of the battery.

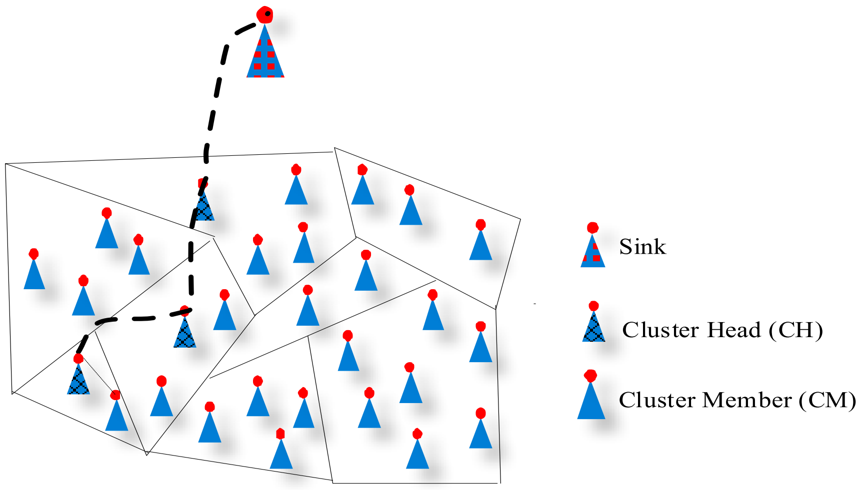

Fig. 1 Wireless Sensor Network (WSN) architecture

2. Related works

In [4] the battery friendly schemes are proposed by considering the internal battery characteristics. In [5] the expected residual energy of a node is determined which is the predicated remaining energy for a node to be cluster head. The estimation of lifetime of the node by considering battery characteristics is discussed in [6]. The battery characteristics such as self-discharge, discharge rate, ageing effects are analyzed to estimate the lifetime of the node. The mathematical model is proposed by measuring battery parameters under different environmental conditions. Though, many clustering schemes are proposed, improper clustering may isolate the nodes from cluster head [7]. These nodes consume more energy for communication hence an energy-efficient algorithm is proposed in[8] especially considering the isolated nodes. The optimum sleeping and censoring technique is addressed in for minimizing energy dissipation and maximizing network lifetime for cluster-based sensor network. The survey on energy-efficient routing protocols is discussed in[9] which elaborates the strength and weakness of different routing protocols. The proposed algorithm concentrates in solving the energy hole and utilizing the energy of the batteries to the utmost level.

3. Energy Aware Routing(EAR)

This section presents the proposed EAR algorithm for improving energy efficiency. The CH selection is based on the residual energy and the number of frames a node sends to the sink. The energy of the node (E) is compared with the energy states E1, E2, and E3. The E1 is said to be high energy state, E2 is medium energy state and E3 is considered as low energy state. When the energy of the current cluster head reduces below E2, a re-election is claimed. For the node, which has the energy level greater than E1, the total number of frames that can be transmitted to the sink is calculated.

The node which can send maximum number of frames , when compared with other nodes is selected as cluster head. The corresponding node can perform sensing, transmitting and transceiving operation. Fig 2 illustrates the Finite State Machine (FSM) of the proposed architecture. The Cluster Head selection is done based on the residual energy of the node. When the node energy is less than E_{min} the node is allowed to sleep without disturbing the network.

If the energy level of the node (E) is greater than E2 and less than E1, the total number of frames that can be transmitted to the sink is calculated. However, the node with higher probability can only perform transceiving operation. The Finite State Machine is simulated using markov model.

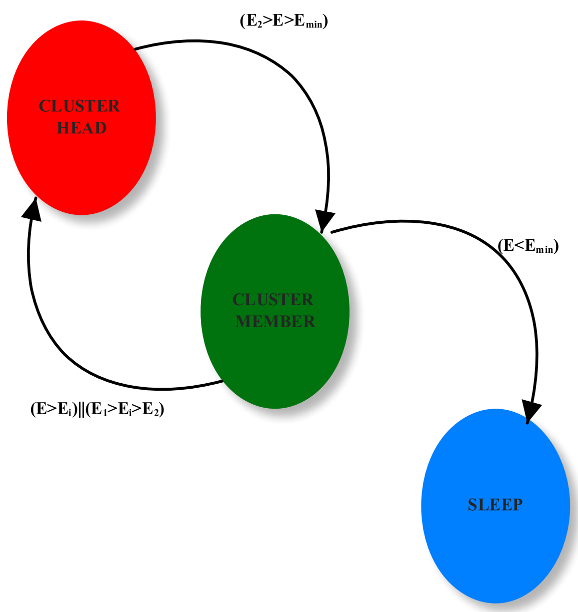

Fig. 2 Finite State Machine (FSM)

3.1. Markov model

The FSM proposed in Fig 2 is realized as markov model. The markov model is a memory less model, the state transition between states is only based on the present state.The probability P of transition from one state to other is represented by the matrix. The Pr11 indicates probability of transition from states in FSM after r steps.

$$P = \begin{array}{c} \\ S1 \\ S2 \\ S3 \end{array} \begin{array}{c} \begin{array}{ccc} S1 & S2 & S3 \end{array} \\ \begin{pmatrix} Pr11 & Pr12 & Pr13 \\ Pr21 & Pr22 & Pr23 \\ Pr31 & Pr32 & Pr33 \end{pmatrix} \end{array}$$

4. Algorithm

```
INPUT:  Residual energy (E1, E2, E3), distance
OUTPUT: Optimal Cluster Head
Begin Process:
        if(E<E2)
                {
                        claim reelection;
                        broadcast( re election request to all current cluster members);
                        accept request from nodes having energy E>E2;

                                        if(E>Ei)
                                          compute total number of  frames that can be transmitted to sink NFi
                                                considering (sensing, transmitting, transceiving);
                                         else if(E1>E>E2)
                                          computer total number of frames that can be transmitted to sink NFi
                                                considering (transceiving);
                                        end if

                                                broadcast new CHid to all cluster members;
                        resign CH;
                }
        else
                        proceed CH;
        end if
end process
```

Fig. 3 Energy Aware Routing algorithm

5. Simulation Preliminaries

The following prelims are considered for validating the proposed algorithm.

Table 1 Network parameters and values.

Prelims

Parameters	Value
Network Size	500× 500 m2
Number of nodes	200
Base station location	(250,750)
Eelec	50nJ/bit
Efs	10pJ/bit
Initial energy	5J
Probability of becoming a CH	0.1
Data message size	2000 bytes
Header bytes	50 bytes

6. Results and Discussion

The scenario is simulated under the constraints shown in Table 1. The proposed EAR algorithm is simulated using MATLAB . It is compared with LEACH and LEACH-C algorithm. The algorithm is simulated as per the algorithm given in Fig 3.

6.1. Assumptions made in simulation

- All sensors are deployed in the ROI.
- All nodes are energy constrained.
- The nodes are either a Cluster Head (CH) or Cluster Member (CM).
- All nodes are static in nature.

Fig 4 represents the survivability of different algorithms. The comparison is made between three protocols viz; LEACH, LEACH-C and proposed EAR. The proposed EAR algorithm is found to have increased lifetime when compared with other two algorithms. The EAR shows better survivability after

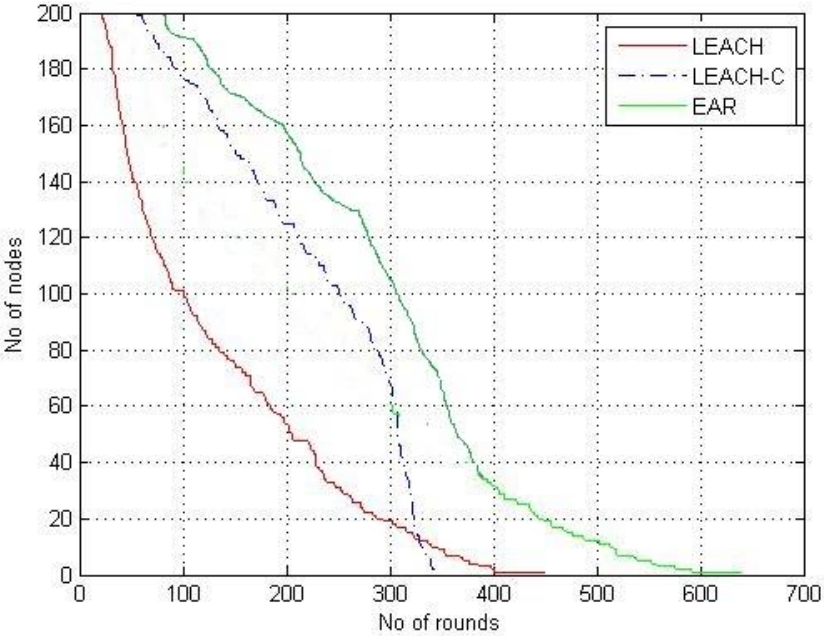

Fig. 4 Survivability of LEACH, LEACH-C and EAR routing algorithms

Apart from improved lifetime, the EAR algorithm also serves as the solution for energy hole problem and hot spot issue. The Cluster formed by network can be viewed through VORONOI plot. Fig 5 shows the Voronoi plot of proposed EAR algorithm. The unequal clustering is observed as the size of the cluster near the sink is small. This reduces the energy hole problem, thereby increasing the network lifetime.

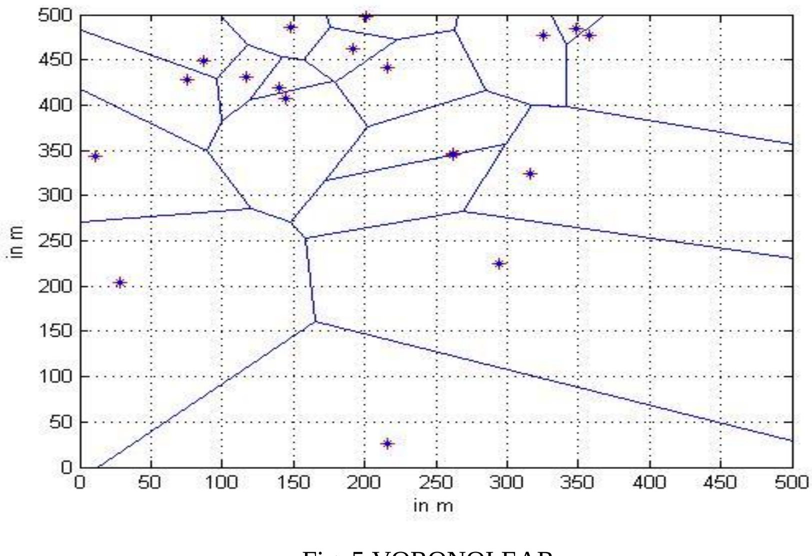

Fig. 5 VORONOI EAR

The EAR algorithm elucidates increased throughput when compared to LEACH protocol.

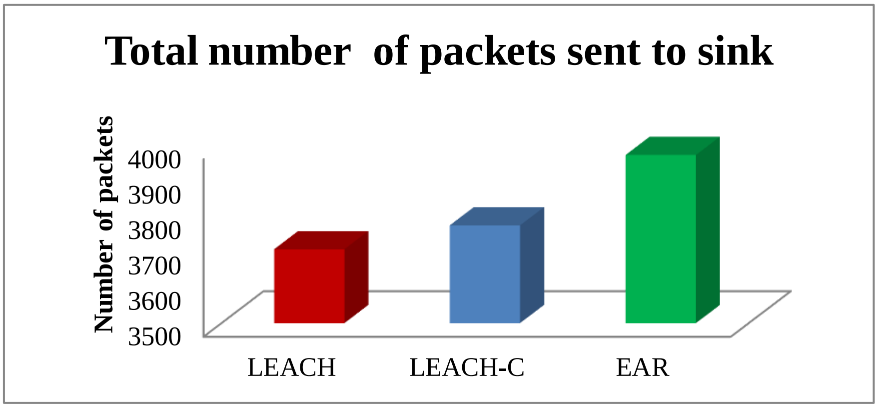

Fig. 6 Total number of packets sent to sink.

7. Conclusion

The problem of energy hole, Hot Spot and enhanced lifetime is addressed in this paper. The result supports that EAR algorithm improves network lifetime with increased throughput. The clustering is unequal exhibiting smaller cluster near sink and larger cluster avoiding energy hole attack and Hot Spot problem. Future enhancement of this paper includes analysing the increased throughput and other metrics of the network with increased scalability.

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