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Energy Efficient System for Wireless Sensor Networks using Modified RECHS Protocol

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Abstract— The area of wireless sensor networks (WSNs) is one of the emerging and fast growing fields in the scientific world. This has brought about developing low cost, low-power and multi-function sensor nodes. Prolonged network lifetime, scalability, node mobility and load balancing are important requirements for many WSN applications. Clustering the sensor nodes is an effective technique to achieve these goals. Cluster-based routing protocol is currently a hot research in wireless sensor network. In this paper, we have added additional criteria for the selection of cluster heads in a Redundant and Energy-efficient Cluster head Selection Protocol (RECHS) and compared results with Energy Aware Low Energy Adaptive Clustering Hierarchy (EA-LEACH) protocol. This modified RECHS significantly increases the lifetime, reliability of the network. Simulation results show that comparison between two methods (Modified RECHS and EA- LEACH) for LEACH protocol on the basis of network lifetime (stability period), number of cluster heads are present per round, number of alive node are present per round and throughput of data transfer in the network.

Keywords- *Wireless sensor network; Clustering algorithm; Redundant and energy-efficient clusterhead selection(RECHS); Stability period; LEACH protocol; EA-LEACH protocol*

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I. INTRODUCTION

A wireless sensor network is a collection of sensor nodes with limited power supply and constrained computational and transmission capability. Due to the limited transmission and computational ability, and high density of sensor nodes, forwarding of data packets takes place in multi-hop data transmission. Therefore routing in wireless sensor networks has been an important area of research in the past few years.

The sensor nodes run on non-rechargeable batteries, so along with efficient routing the network should be energy efficient with efficient utilization of the resources and hence this is an important research concern. Advances in wireless technologies and evolution of low cost sensor nodes have led to introduction of low power wireless sensor networks. Due to multiple functions and ease of deployment of the sensor nodes it can be used in various applications such as target tracking, environment monitoring, health care, forest fire detection, inventory control, energy management, surveillance and reconnaissance, and so on[1]. The main responsibility of the sensor nodes in a network is to forward the collected information from the source to the sink for further operations, but the resource limitations [2], unreliable links between the sensor nodes in combination with the various application demands of different applications make it a difficult task to design an efficient routing algorithm in wireless sensor networks.

Considering the unique features of low power wireless sensor networks, routing in WSN is much more challenging compared to traditional wireless networks such as ad-hoc networks [3, 4]. It has its own characteristics: such a nodes energy cannot be added, a large number of data redundancies in networks. AL-Karki et.al [3] classified the existing routing protocols in wireless sensor networks in two different perspectives, network structure and protocol operation. Hierarchical routing protocols were proposed to increase the scalability of the network and make the network energy efficient through node clustering. Clustering algorithms are recognized as the most effective organization. Many clustering algorithms in various contexts have been proposed [5,6,7,8].

In this paper, we have added additional criteria for the selection of cluster heads in a Redundant and Energy-efficient Clusterhead Selection Protocol (RECHS) and compared results with Energy Aware Low Energy Adaptive Clustering Hierarchy (EA-LEACH) protocol[9] that significantly increases the lifetime, reliability of the network.

In the Modified RECHS, selection criteria for cluster heads are weighted by remaining energy of a node and the average hops from all the ordinary nodes to the cluster heads in the network as well as we have added other criteria to select random number of cluster heads (within 1 to 6).

II. RELATED WORKS

We have studied a number of clustering algorithms in various contexts. Heinzelman et al have proposed a distributed algorithm for micro sensor networks in which the sensors select themselves as clusterheads with some probability and broadcast their decisions [5]. This algorithm allowed only 1-hop clusters to be formed and had brought the convenience of communication. For the nodes which are far away the clusterhead need considerable energy to transmit data to clusterhead, such nodes will soon run out of battery power and premature be death. The lifetime of the network will reduce, and it is not conducive to expand the sensor networks.

Heinzelman et al have also proposed LEACH-C (LEACH-Centralized)[5] . It uses a centralized algorithm to form clusters. A non-autonomous cluster head selection is again the main disadvantage of this algorithm. Moreover, LEACH-C requires location information of all nodes of the network. Location information requires additional communication among the nodes. Lindsey et al present an interesting chain-based algorithm to solve the problem of collecting data from a micro sensor network [10]. M. J. Handy et al have proposed a deterministic clusterhead selection algorithm [11].There is a modification of the threshold equation T (n). This algorithm only considered the selection of the majority of clusterheads, but for the problems of that some clusterheads are selected unreasonable and clusterheads are far away from the cluster nodes are not resolved. Then some Multi-hop routing clustering algorithms are proposed [6,12,13,14]. The way of cluster node transmit data to clusterhead is not single-hop, but multi-hop by other cluster nodes. Multi-hop clustering routing algorithm solves the problem from the cluster nodes which far away clusterhead to the clusterhead in Communication.

The algorithm proposed in this paper uses conditional probability and the number of hops to choose clusterhead and redundant clusterhead. In addition to this, we have also changed the criteria of selection of cluster heads at each round. The clusterheads selected are not random but are chosen depending upon the available energies of the nodes. In other words, out of the total number of nodes, those nodes which have maximum energies available have a higher priority to become the clusterheads. So, the clusterheads are chosen as evenly as possible which can only be achieved if at each round base station the available energy of each and every node. On the one hand, clusterheads are distributed in a more reasonable position, energy consumption will be decreased, and the network lifetime will be extended. On the other hand, the new protocol would solve the problem that the clusterhead fails or be damaged by attackers. The reliability and security of network have been improved.

III. Modified Redundant and Energy efficient Clusterhead Selection Protocol algorithm (Modified RECHS)

We will propose a Modified Redundant and Energy efficient Clusterhead Selection algorithm. In Modified RECHS, we first select initial clusterheads using random selection and optimal numbers (within 1-6) algorithms. After that we select initial redundant clusterheads and then compare the two nodes. The node which has better performance will be selected as clusterhead and other node will be as redundant clusterhead in current round.

A. *Selection of Initial Clusterhead*

In RECHS, we use a random selection algorithm with a condition that adds two parameters: Ecurrent and Emax. Ecurrent is node remaining energy, Emax is node initial energy. For a node S, S generates a random number rand (s) from 0-1, rand (s) multiply by a factor which representing the remaining energy level of a node be as the new random number rand '(s):

$$rand'(s) = rand(s)*(1-E_{current} / E_{max})$$

There is inverse relationship between remaining energy of a node and new random number. The probability of a node to become a clusterhead is greater if rand '(s) is less than the threshold T(s). If rand '(s) is bigger than threshold T(s), node S will be as the ordinary node.

B. *Additional Criteria for Selection of Clusterheads in RECHS algorithm*

Neither very less nor very large number of clusters are required to have a stable network. The number of clusters always has an optimal value at which the network is most stable. It is found from the study of [15] that the optimal value of clusters is given by

$$k_{opt} = \frac{\sqrt{N}}{\sqrt{2\Pi}} \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \frac{M}{d^2_{toBS}}$$

where,

k_{opt} is optimal number of clusters(cluster heads),
N is the number of nodes,
M is the length of the region,
εf_s and ε_{mp} are the characteristics of the transmitter amplifier,
d_{toBS} is the distance between the base station and clusterhead.

Along with this condition, we introduce a modification by restricting number of clusterheads to within 1 to 6 so that reduction in energy consumption of the nodes in the wireless sensor network is possible.

C. *Selection of Initial redundant cluster head*

Besides the initial clusterhead, we will select a second node in the cluster that the node has more energy than other nodes except the initial clusterhead in the cluster as the initial redundant clusterhead.Initial clusterhead and initial redundant clusterhead both have chance to be clusterhead.

D. *Determination of cluster head and redundant clusterhead*

In RECHS, we compare initial redundant clusterhead with initial clusterhead in their remaining energy and the sum of hops from other nodes to the two nodes.

- Formulae to calculate weights of energy and hops:
  C_{k1} = red-hop/(red-hop + init-hop);
  C_{k2} = init-hop/(red-hop + init-hop);
  C_{e1} = E(CHvec(ii))/(E(CHvec(ii))+E(RCHvec(ii)));
  C_{e2} = E(RCHvec(ii))/(E(CHvec(ii))+E(RCHvec(ii)));

- Formulae to determine cluster head and redundant clusterhead:
  $C_1 = C_{k1}*C_{e1}$;
  $C_2 = C_{k2}*C_{e2}$;

By comparison, we choose the node with optimal performance as the clusterhead in this round, and the rest node will become the redundant clusterhead.e.g., if $C_1 > C_2$ initial clusterhead is clusterhead (within cluster) for current round otherwise redundant clusterhead is clusterhead for current round.

IV. Simulation Results

To validate the performance of modified RECHS, we will compare parameters of EA-LEACH and Modified RECHS as:

A. *Performance Parameters of EA-LEACH and Modified RECHS:*

MATLAB Simulator: 100-node random network; Eo=0.5J per node; Eelec = 50nJ/bit; εamp = 100pJ/bit/m2; Nbits= 4000 bits; Base Station:(50,150); Area= 100 m2

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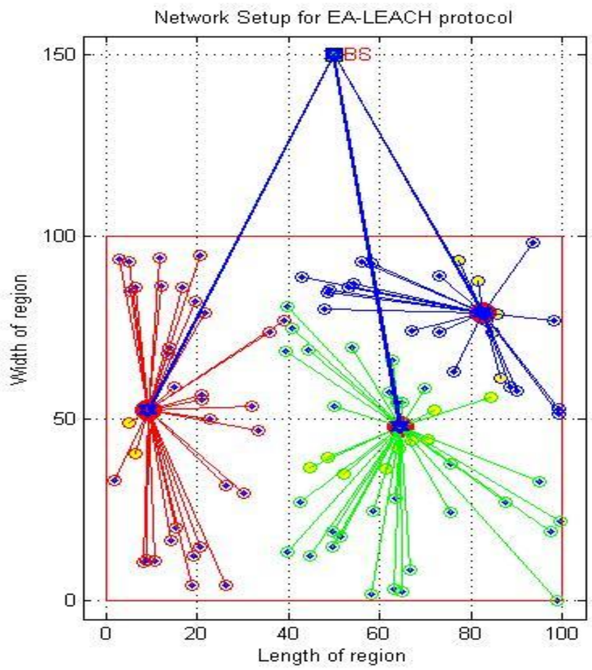

Figure 1. Simulation result of the sample networks with base station

MATLAB Simulator: 100-node random network; Eo=0.5J per node; Eelec = 50nJ/bit; εamp = 100pJ/bit/m2; Nbits= 4000 bits; Base Station:(50,150); Area= 100 m2

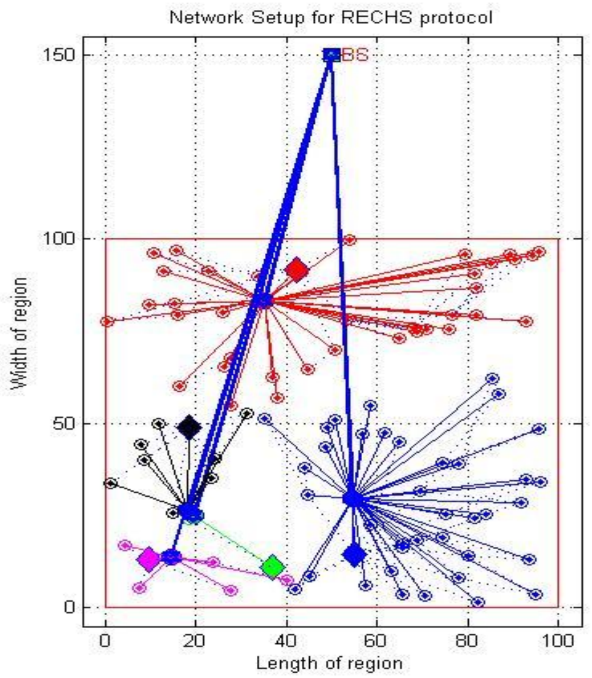

Figure 2. Simulation result of the sample networks with base station

B. Simulation results of Comparison of EA-LEACH and Modified RECHS:

Comparison on the basis of Number of Alive Node Vs Round:

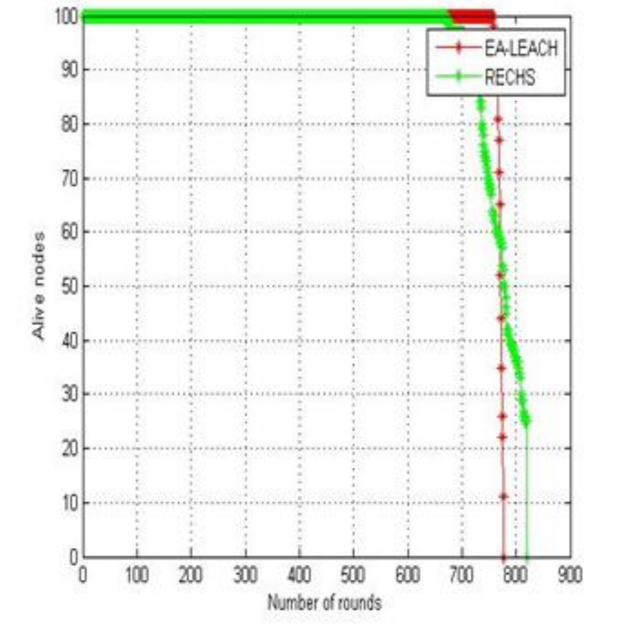

Figure 3. Simulation result of stability period

In above figure result shows that in both methods, number of alive node is 100 till end of 670th round. After first node dead, other node dies very slowly as round increases in modified RECHS method where as in EA-LEACH node dies very fast.

Comparison on the basis of Residual Energy Vs Round:

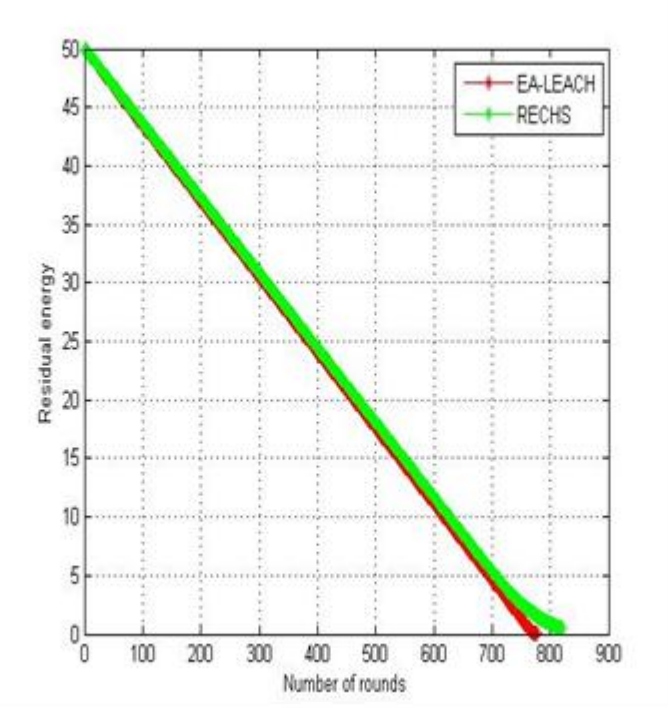

Figure 4. Simulation result of residual energy of system with number of rounds

In above figure, result shows that In both method, Residual energy decays as round increases. In modified RECHS method Residual energy is greater than zero even after end of 800th round.

Comparison on the basis of Number of Clusterhead Vs Round:

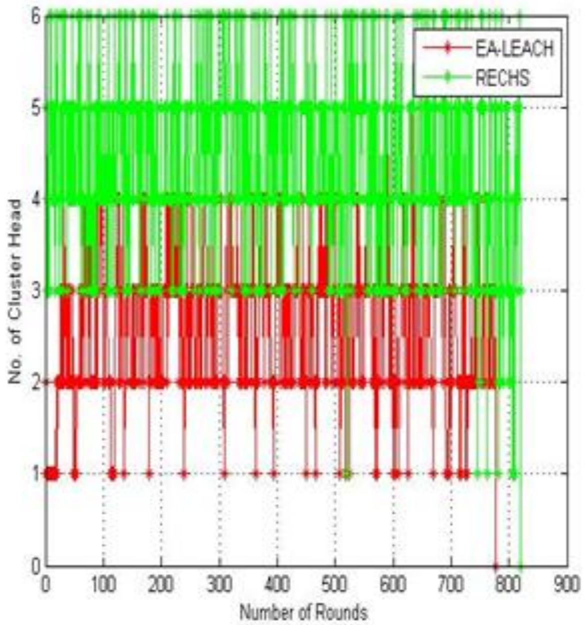

Figure 5. Simulation result of number of clusterheads with number of rounds

In above figure, result shows that in RECHS method, Number of clusterhead per round mostly lies between 3 to 6. In EA-LEACH method, Number of clusterhead per round mostly lies between 2 to 6.

Comparison on the basis of Number of Packet Sent To BS Vs Round:

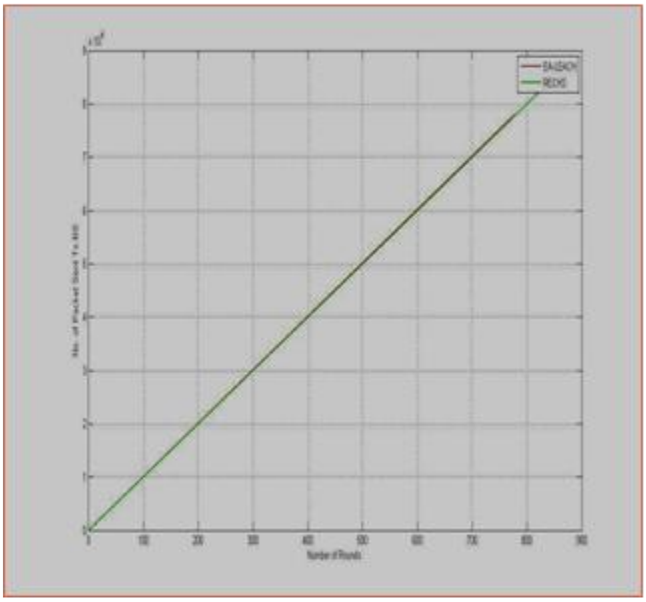

Figure 6. Simulation result of Packets received at the base station with number of rounds

In above figure, result shows that number of Packet sent to Base Station per round is nearly same in both method. Number of Packet sent to Base station is more in RECHS method as ompare to EA-LEACH method.

Comparison on the basis of Network Lifetime:

Result Shows that

EA-LEACH: First node died at 759 round
EA-LEACH: Communication possible till at 777 round
RECHS: First node died at 672 round
RECHS: Communication possible till 821 round

V. CONCLUSION

Modified RECHS has better performance than EA-LEACH in terms of throughput and Network life time. Network stability period is more in case of EA-LEACH. In EA-LEACH method, we utilized full energy of all nodes for data transfer. This is not possible with RECHS method. As per application requirement, we can modify LEACH protocol by one of these methods to get optimum output from wireless sensor network.

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