

ENERGY EFFICIENT MULTI HOP ROUTING USING GENETIC ALGORITHMS FOR WIRELESS SENSOR NETWORKS

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ABSTRACT. A group of large number of Sensor Nodes (SNs) communicates with each other in Wireless Sensor Network (WSN) and used to monitor its surrounding. One of the major limitations of WSN is constrained battery of node. In case of battery depletion; battery cannot be replaced or recharged as SNs are deployed in unattended environment. In literature major research work on WSN include design of energy efficient protocols that can effectively utilize battery power of node thereby improving network lifetime. In this paper, the proposed method for WSN is energy efficient multi-hop routing based on Genetic Algorithms (GA) E2MHR-GA. Proposed protocol E2MHR-GA perform LEACH based clustering and multi-hop routing with use of GA fitness function. Fitness function requires estimating inter-cluster distance, number of cluster members and remaining energy to achieve routing among Cluster Head (CH) and Base Station (BS) through multi-hops. Simulation conclude that E2MHR-GA protocol improve the network lifetime as compared to LEACH protocol.

1. INTRODUCTION

WSNs is collection of large number of SNs used to sense its surrounding. Due to its sensing ability, WSNs is used in the wide range of applications including habitat monitoring, battlefield surveillance, wildlife supervision dense forest

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fire reporting, volcanic fields monitoring, etc. Nodes transmit its sensed information to CH which further send aggregated data of its member SN to BS. One of the major limitations of WSN is constrained battery of node. In case of battery depletion; battery cannot be replaced or recharged as SNs are deployed in unattended environment [1-3]. Major of the research work in literature of WSN focus on design of energy efficient protocols that effectively utilize battery power of node. LEACH [4] is most popular energy efficient clustering protocol of WSN which select CH based on probability and threshold value. Many energy efficient routing protocol [5] for WSN discussed in literature is based on LEACH protocol. One of the assumptions of LEACH protocol is that CH directly communicate with BS. But limitation of this assumption is that when size of network increases; which significantly increases separation among CH and BS, results more energy utilization of CH and reduced network lifetime. To address this limitation of LEACH many improvements of LEACH protocol has been proposed that assume multi-hop communication [6] between CH and BS as shown in figure 1.

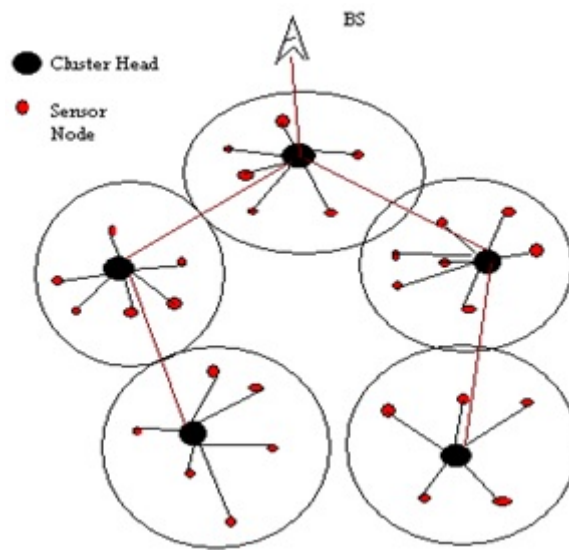


FIGURE 1. Multi-hop LEACH [6]

In this paper the proposed protocol E2MHR-GA performs LEACH based clustering and multi-hop routing with use of GA fitness function. Fitness function estimates inter-cluster separation, number of cluster members and remaining

energy to perform multi-hop routing among CH and BS. The paper highlights are as follows: Section 2 contributes related work. Protocol E2MHR-GA is proposed and discussed under section 3. Section 4 discusses results of simulation followed by section 5 for conclusion and future work.

2. RELATED WORK

To improve the energy efficiency of WSN many GA based routing protocols has been discussed in literature. Genetic Algorithm [7] solves the optimization and search problems with genetic process of biological evolution. [Nayak et. al] [8 ga1] presented GA-LEACH multi-hop routing protocol. In GA-LEACH protocol CH is elected based of based on fitness function. Input parameters of fitness function are distance and energy cost. Distance cost is summation of distance of SN to CH and CH to BS. Energy of SN and total residual energy of all SNs find energy cost. In each round elected CH transmits aggregated data to its neighbor CH in multi-hop fashion. This transmission process repeats until aggregated data reaches to BS.

[Tarun et. al.][9] proposed GA based routing GADA-LEACH protocol which makes use of GA to select CH. Authors introduced the concept of intermediate SNs to draw a path among CH and BS to ease the communication. To select CH, fitness function is calculated by considering factors like energy level of all SNs and CHs, separation of CHs to its member SNs and BS, number of nodes registered with CH and total number of CHs. Elected CHs transmit aggregated data of its members to either relay node or BS which has shortest distance to it. [G.Yao et. al] in [10] proposed ROS-IGA protocol that define the fitness function for the identification of a preferred route between SN and BS. Energy Consumption, Nodes Location, Accrued separation, and the energy level present at any SN are the contributory aspects to draw a path. Pourzaferani et. Al[11] suggested a routing algorithm based on the cluster head distribution and load balancing. This routing algorithm divides the whole network into cells. The optimal number of SNs and CH selection was defined using genetic algorithm. Low speed of genetic algorithm faced problems when dealing with large networks. Speed of clustering is increased with K-means algorithm.

Bhola et. al. [12] presented an energy efficient routing protocol LEACH along with genetic algorithm known as O-LEACH. LEACH protocol is used to convert

the sensor nodes into CH and the cluster heads are responsible for collection and size reduction of data and then pass it to the intended node. Further, genetic algorithms used its fitness function to draw the optimized route. Simulation concludes that the reduction in the rate of energy consumption using O-LEACH by 17.39% Energy consumption and the total transmission delay id with O-LEACH is decreased by 64.97% and 45% respectively in comparison with LEACH protocol.

Shokouhifar et. al. [13] proposed LEACH- LPR from LEACH protocol with a feature to predict energy and to maximize the network lifetime. Independent variables are estimated at their optimized level with the help of genetic algorithm. The dynamic fitness function was argued by considering the features of the application. The simulation showed that this proposed hybrid algorithm can effectively stable the energy exhausted by SNs and extend the network lifespan. The LEACH-LPR performs well with reference to the network lifetime in comparison to basic LEACH and its variants LEACH-DT, LEACH-EP. The gain received was 82% improved for network lifespan from LEACH, LEACH-EP, and LEACH-DT protocols.

3. PROPOSED PROTOCOL

3.1. Network Model. In proposed energy efficient multi-hop routing based on Genetic Algorithms (GA) E2MHR-GA protocol following assumptions are made:

- SNs are randomly deployed in squared region.
- BS is position at center of network.
- BS and SNs are stationary.
- BS and SNs are aware about location of each other.
- SNs are homogeneous.

3.2. Energy Model. E2MHR–GA Protocol uses following energy model. Transmission energy is $L_{T,X}(L, d)$ [14] for transmitting an L–bit data to a distance d, is given by Equation 3.1 and 3.2.

$$(3.1) \quad L_{T,X}(L, d) = L * E_{elec} + L * \epsilon_{fs} * d^4 \quad \text{if } d \geq d_0$$

$$(3.2) \quad L * E_{elec} + L * \epsilon_{fs} * d^2 \quad \text{if } d < d_0,$$

where E_{elec} is the electronic energy.

While receiving, the radio expands energy according to Equation 3.3:

$$(3.3) \quad E_{R,X} = L * E_{elec}$$

$E_{R,X}(L)$ is receiving energy of node required for receiving L bit packet.

3.3. Routing Process. The proposed E^2 MHR–GA Protocol works in following 2 phases:

i) CH selection phase: Objective of this phase is to select the CHs among the randomly deployed SNs in sensing area. LEACH protocol is used to select CHs. LEACH protocol works in several rounds and number of CHs in each round depends on the probability value p . A random number is produced and elected as CH if random value is less than threshold value as shown in following equation 3.4.

$$(3.4) \quad \begin{aligned} TH(n) &= \frac{P}{1 - P(r \bmod \frac{1}{P})} \quad \text{if } n \in S \\ TH(n) &= 0 \quad \text{otherwise.} \end{aligned}$$

In steady phase, SN communicates to its CH. CH transmit cumulated data to next CH selected through fitness function as described in route formation phase.

ii) Route Formation Phase: To transmit aggregated data of its member SNs, CH select next CH based on the fitness function. Fitness function of CH is function of $c_f = f(No, Energy, Dist)$ which is calculated as Equation 3.5.

$$(3.5) \quad c_f = \frac{Energy}{No * Dist},$$

where Energy is battery power of CH, No is the member SNs of CH and Dist is inter-cluster distance.

To route the packet CH select its neighbor CH with highest fitness function. It can be analyzed from equation 3. 5 CH with higher battery power, shorter distance and less number of registered node has higher fitness function. This multi-hop routing process continues till aggregated data reaches to CH. The pseudo-code in Algorithm 3.1 illustrate the working of E^2 MHR-GA protocol.

ALGORITHM 3.1: E^2 MHR–GA

Route (Formation)

$C \leftarrow$ Set of all CHs

$C_c (=)$ Current CH

while($C_c \rightarrow CH_{(near_B S)}$)

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for each ( $C_{next} \in Adj(C_c)$ )
 $C_f = Energy(C_j) / (No(C_j) * Dist(C_i * C_j))$ 
end for
Select  $C_{next}$  from  $Adj(C_c)$  having maximum  $C_f$ 
 $C_c = C_{next}$ 
end while

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4. SIMULATION RESULTS

E^2 MHR-GA routing protocol is implemented in MATLAB 7. For simulation environment Following parameters in Table 1 are considered for simulation.

TABLE 1. Parameters of Simulation

Parameter	Value
Number of Nodes(n)	200
Topology size	100*100m ²
Transmission Range	50-90m
Initial Energy	0.1-0.5J
Probability (p)	0.1-0.5

Figure 2 shows comparison between the total remained energy of SNs in between E^2 MHR-GA protocol and LEACH protocol.

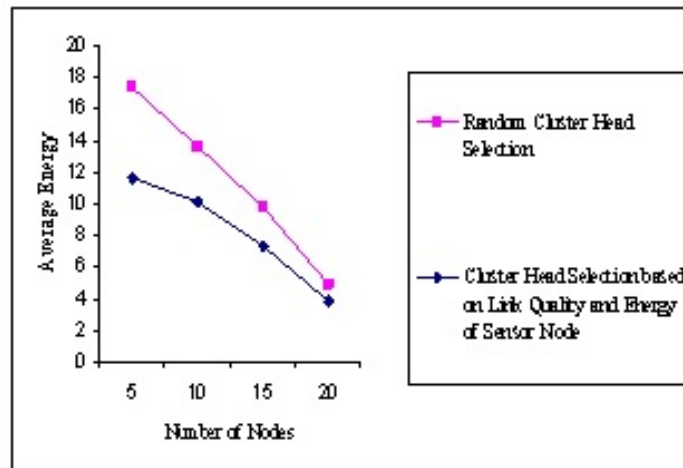


FIGURE 2. Remaining Average Energy Vs No. of Nodes

Figure 3 analyze that the as the probability of CH selection increases also improve the energy balance of network. This is because each CH has more choice of candidate CHs to get elected in routing path.

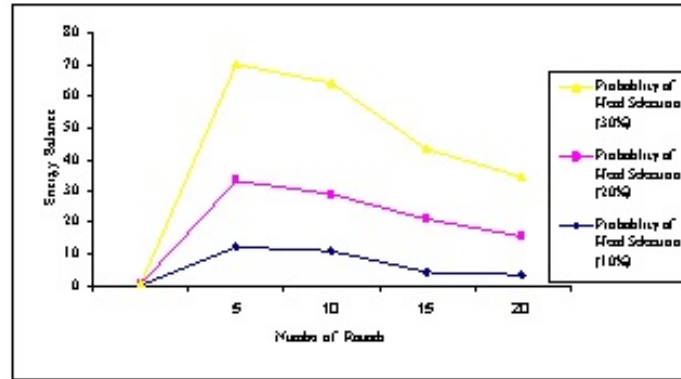


FIGURE 3. Energy Balance after 5-20 Rounds with Different Probabilities (p) on E_2 MHR-GA

Figure 4, It can be analyzed that the network lifetime enhances as the probability of CH selection and initial energy of node increases. The reason for this is that in proposed E2MHR-GA routing protocol, next node in route is selected having higher fitness function C_f .

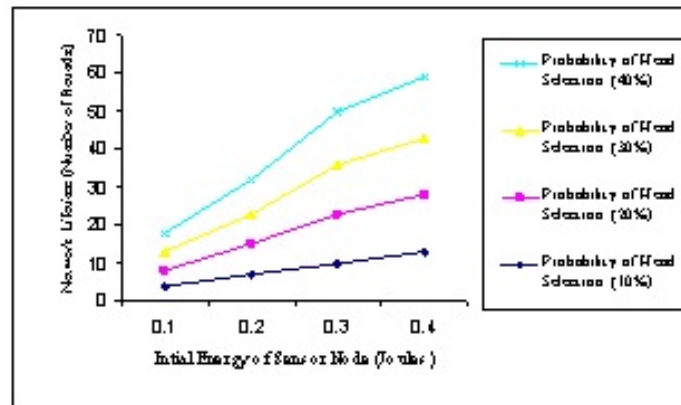


FIGURE 4. Text Pre-Processing of Text mining

5. CONCLUSION

WSN based upon cluster formations for routing is remarkable to enhance lifespan of the network. Out of the many protocols, LEACH is a predominant protocol used for clustering in WSN. But limitation of LEACH is that it connects CH and BS without any intermediary for communication. And this assumption is not affordable for larger network because more distance between BS and CH consume more energy. To overcome this limitation, we propose E2MHR-GA based routing protocols that establishes communication between CH and BS through multi-hop network links and results with an augmented lifespan of WSN. Future work includes the implementation of E2MHR-GA protocol for heterogeneous WSN.

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