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Efficient Heterogeneous Wireless Sensor Network Using Improved Energy Optimization Approach

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***Abstract*- Wireless Sensor Network is collection of Sensors. Sensor nodes gather the sensory information and communicating with other nodes in networks. Key Challenges in Wireless Sensor Network is saving energy and extend the network life time. Many routing protocol are used to manage the data transference in Wireless Sensor Network. Routing protocols are used in two types of network: Homogenous and Heterogeneous. Heterogeneous Wireless Sensor Network (WSN) comprises of sensor nodes with distinctive capability, for example, diverse computing power and sensing range. Contrasted with homogeneous WSN, arrangement and topology control are more perplexing in heterogeneous WSN. Although, many protocols evolve to optimize enery but is not appropriate for heterogeneous WSNs. In this paper, we test Stable Election Protocol (SEP) and Firefly algorithm based cluster-head election under a few distinctive situations holding high level heterogeneity to low level heterogeneity.**

***Index Terms:* Heterogeneous Wireless Sensor Network, Clustering Protocol, Fireflies Algorithm, Stable Election Protocol.**

I. INTRODUCTION

The key concern in setting up the legitimate operation of WSN is expanding the lifetime of the system by minimizing the consumption of energy. Wireless sensor network is a set of tiny, resource constrained sensors interconnected with each other to gather data about physical or environmental objects [1]. The sensing gadgets measure surrounding condition identified with nature's domain encompassing the sensor and changes them into an electric indicator. Handling such an indicator uncovers a few properties about items found and/or events happening in the region of the sensor.

A sensor system comprises of a few sensing gadgets conveyed in a given topographical territory for collaboratively assembling/sensing particular data in the environment relating to later on assessment in a center base station. The sensor nodes self-organize right after deployment to ascertain radio communication paths towards the sink. The sensing gadgets are low power gadgets comprising of a microcontroller for data transforming, a microchip and receiving wire for radio correspondence and a sensor for sensing ecological components like heat range, dampness, and light quality and so on. Some of the applications of sensor networks are disaster relief operations, biodiversity mapping, precision agriculture, habitat monitoring applications, Security purposes, Military services programs [2].

1.1 Clustering in Heterogeneous WSN Model

1.1.1 Types of Heterogeneous Resources

There are three common forms of resource heterogeneity in sensor nodes computational heterogeneity, Link heterogeneity Energy heterogeneity [3]. Computational heterogeneity implies that the heterogeneous node has a more capable chip and more memory than the typical node. Link heterogeneity implies that the heterogeneous node has high-data transmission and long-separation system transceiver than the typical node. Energy heterogeneity suggests that the heterogeneous node is line powered or its battery is useable [4, 7].

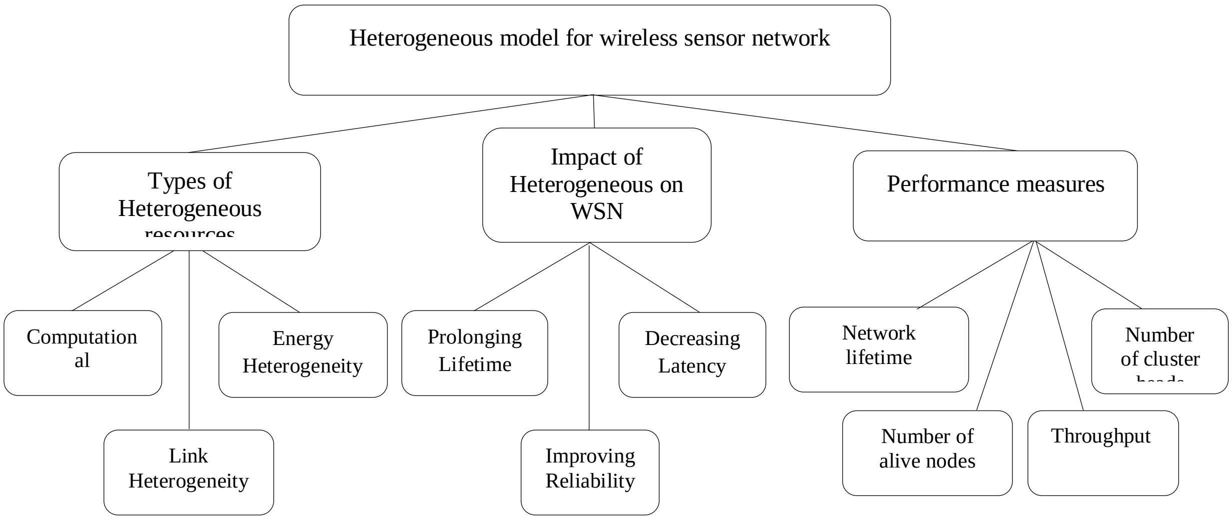

Figure 1.1: Heterogeneous model for wireless sensor network

1.2 Impact of Heterogeneity on Wireless Sensor Networks

It Decreases latency of information transportation such as Computational heterogeneity can diminish the processing latency in quick nodes and link heterogeneity can diminish the waiting time in the transmitting line. Prolonging network lifetime and improving dependability of information transmission.

1.3 Performance Measures

Some execution measures that are used to ascertain the execution of clustering conventions are recorded underneath. network lifetime, number of cluster heads for every round, number of dynamic nodes for every round, throughput.

1.4 Clustering

Figure 4.3.1 shows the cluster based data communication model. The process of communication is logically divided in cluster based wireless sensor network. Here, the sensor nodes are divided into small groups, which are called clusters. Each cluster will be having a cluster head(CH), which will monitor the remaining nodes(SN). Nodes in a cluster do not communicate with the base station (BS) directly. SN senses the data and send that to the CH. The CH will aggregate sensed data, remove the redundant data and transmit it to the BS. So the energy consumption and number of messages transmitted to the BS will be reduced and number of active nodes in communication is also reduced. In this way the network lifetime is increased [5, 6].

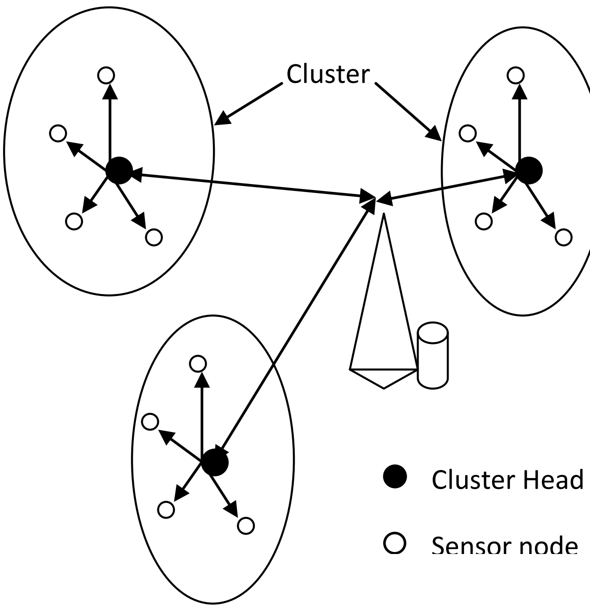

Figure 1.2: Data communication in a clustering network

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II. PROPOSED SOLUTION

2.1 Cluster-Heads Election Using Firefly Algorithm

Selection of cluster-heads plays an important role while simulation and analysis of network model. The proposed work shows the optimal selection of cluster-heads based on weight values and considering various parameters like residual energy, average energy and shortest path. As the optimal probability is function of spatial density when nodes are distributed uniformly over the field, optimality will be achieved when energy consumption of nodes will be uniform over the area and overall energy consumption is minimum resulting in enhance network lifetime.

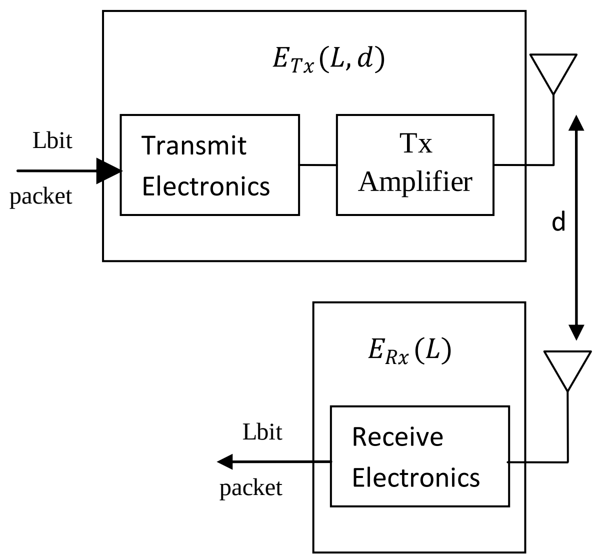

Figure 2.1: Radio Energy Dissipation Model

Consider the radio energy dissipation model as shown in Fig. 1, the energy spend by the radio to achieve satisfactory Signal-to-Noise Ratio while transmitting L-data bits over a distance d is given by:

$$E_{T_x}(l,d) = \begin{cases} L.E_{elect} + L.\epsilon_{fs}.d^2 & if\ d < d_0 \\ L.E_{elect} + L.\epsilon_{mp}.d^4 & if\ d \geq d_0 \end{cases} \quad \text{........(1)}$$

Hence the energy expended by the receiver to receive L-bit message is given by:

$$E_{R_x} = L.E_{elect} \quad \text{.........(2)}$$

Assuming the field area to be 100×100 square meters and 100 nodes are uniformly distributed over the field. Therefore the energy dissipation of clusterhead node during a round in is given by:

$$E_{CH} = L.E_{elect}\left(\frac{100*}{k} - 1\right) + L.E_{DA}\frac{100*}{k} + L.E_{elect} + L.\epsilon_{fs}.d^2_{toBS} \quad \text{....... (3)}$$

Here k is number of clusters, E_{DA} is data aggregation cost.

Energy dissipation of a normal node (non-CH) is given by:

$$E_{nonCH} = L.E_{elect} + L.\epsilon_{fs}.d^2_{toCH} \quad \text{..... (4)}$$

Where d_{toCH} is distance between normal node and its clusterhead.

The energy dissipation of a cluster can be given as:

$$E_{cluster} \approx E_{CH} + \frac{100*}{k}E_{nonCH} \quad \text{........ (5)}$$

And total Energy dissipation of network is given by:

$$E_{T_d} = L.\left(2nE_{elect} + nE_{DA} + \epsilon_{fs}\left(k.d^2_{toBS} + n\frac{M^2}{2.\pi.k}\right)\right) \quad \text{.........(6)}$$

The optimal number of cluster can be found by differentiating equation (6) with respect to k and equating it to 0 and it is given by:

$$k_{opt} = \sqrt{\frac{n}{2\pi}}\frac{M}{d_{toBS}}$$

And also the optimal probability of a node to be elected as clusterhead is given by:

$$p_{opt} = \frac{k_{opt}}{n}$$

This probability p_{opt} is further optimized by Firefly Algorithm. . Flow diagram is shown below for cluster-heads election.

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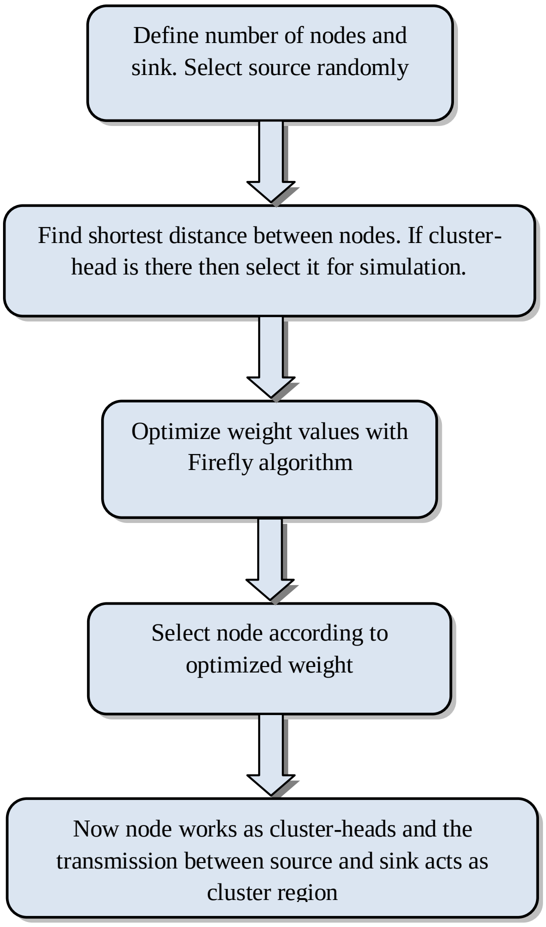

Figure 2.2: Flow diagram of cluster-heads election using firefly algorithm.

2.2 Firefly Algorithm

Firefly is an insect that mostly produces short and rhythmic flashes that produced by a process of bioluminescence. The function of the flashing light is to attract partners (communication) or attract potential prey and as a protective warning toward the predator. Thus, this intensity of light is the factor of the other fireflies to move toward the other firefly.

Firefly algorithm was followed three idealize rules:

1. Fireflies are attracted toward each other regardless of gender.
2. The attractiveness of the fireflies is correlative with the brightness of the fireflies, thus the less attractive firefly will move forward to the more attractive firefly.
3. The brightness of fireflies depends on the objective function [9].

2.3 Structure of Firefly Algorithm

Objective function $f(x)$, $x = (x_1, \ldots, x_d)^T$

Generate initial population of fireflies $x_i (i = 1, 2, \ldots, n)$

Light intensity I_i *at* x_i *is determined by* $f(x_i)$

Define light absorption coefficient γ

while $(t < MaxGeneration)$

for $i = 1{:}n$ *all* n *fireflies*

for $j = 1{:}i$ *all* n *fireflies*

if *(Ij > Ii), Move firefly i towards j in d-dimension;* **end if**

Attractiveness varies with distance r *via* $\exp[-\gamma r]$

Evaluate new solutions and update light intensity

end for j

end for i

Rank the fireflies and find the current best

end while

Postprocess results and visualization

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III. Result Analysis

3.1 Simulation Parameters

Table 3 Parameters table

Field area	100×100 meter squares
Number of nodes in the field	100
Optimal Election Probability	0.1
Initial Energy of nodes	0.5 J
Energy consumption of transmit and receive amplifiers	500 Nano Joules Per Round
Maximum number of rounds	6000

3.2 Evaluation Parameters

3.2.1 Throughput

It is the ratio of the total number of successful packets in bits received at destination in a specified amount of time.

$$TH = \sum \text{Transmission of Routing Packets}$$

3.2.2 Network Lifetime

The lifetime in a WSN is the time period throughout which the system ceaselessly fulfils the provision necessity.

3.2.3 Cluster Head Selection

Number of cluster heads selected in each round.

3.3 Simulation Results

Simulation is carried out using MATLAB 2010a

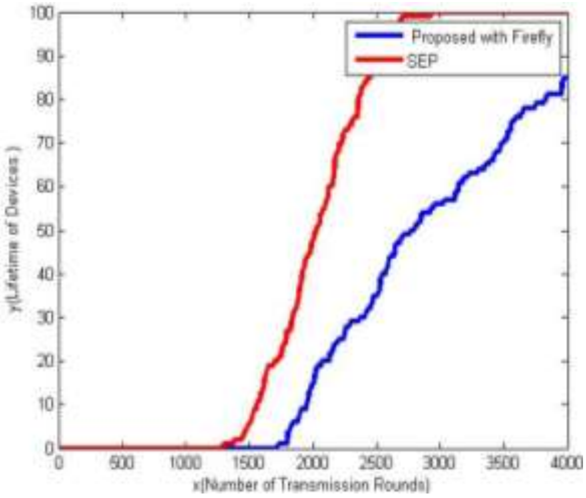

Figure 3.1: Network lifetime comparison for SEP and proposed approach

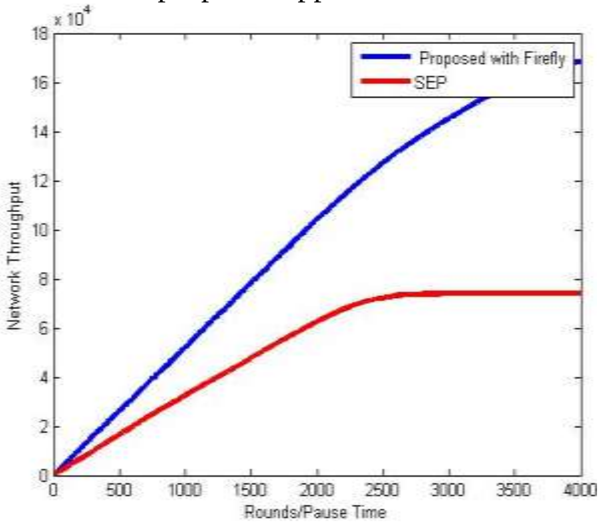

Figure 3.2: Network throughput comparison for SEP and proposed approach

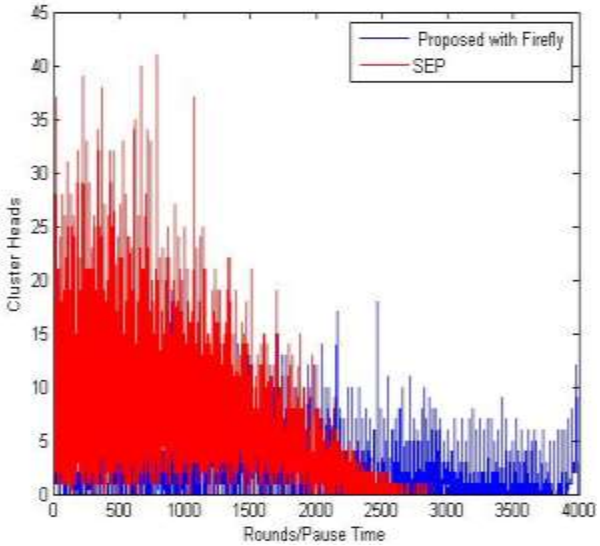

Figure 3.3: Cluster head selection for SEP and proposed approach

VI. CONCLUSION

In this paper, we have inspected the existing state of proposed clustering algorithm, particularly concerning their power and reliability quality necessities. In wireless sensor networks, the energy limits of nodes assume an essential part in planning any protocol for execution. We have examined Stable Election Protocol (SEP) [10] and Firefly algorithm based cluster-head election for heterogeneous WSNs containing different level of heterogeneity. Simulations prove that Firefly algorithm based cluster-head election performs well in all scenarios. It has best performance in terms of Network Throughput and Lifetime.

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