OPTIMIZATION OF CLUSTER HEAD SELECTION APPROACH USING STATE TRANSITION AND GENETIC ALGORITHM

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Abstract— Clustering is one of the prominent methods that are opted for routing in wireless networks. Clustering is such a vast field itself that lots of research works is in conduct in order to solve the various clustering issues. One of the issues is that, the trust model was used for electing the cluster heads to represent the particular cluster in the network. By using trust model, the node with the highest trust value was elected as cluster head.

In this study a proposal is presented which comprises of trust model for evaluating trust values of the nodes and GA and State Transition for optimizing the cluster heads. The proficiency of the proposed work is evaluated by comparing the proposed work on the basis of variations in number of total nodes in the network.

Keywords—Wireless Sensor Network, routing, Clustering. Trust Model, GA, State Transition, Optimization.

I. INTRODUCTION

Wireless Sensor Networks are the networks which consist of multiple small sensors which initialize and complete the communication from source to destination node by creating a dedicated route to transmit the message. Routing is a term that is used to describe the process of route creation by inter-connecting the nodes in a wireless network. But for completing the transmission of data the nodes consumes the energy. If the energy consumed by the nodes is at high level then in this way the allotted energy to the nodes will be exhausted earlier which affects the reliability and proficiency of the network. Therefore it is mandatory that the network should be energy efficient so that it consumes only feasible amount of energy or each and every processing in the network. For this purpose various concepts had been developed such as clustering, energy efficient protocols etc.

Clustering is the well-organized method [5] to exploit the energy in a competent manner. Grouping of sensors that performing alike tasks are recognized as clusters. In hierarchical cluster, it encloses Cluster Head, sensor nodes and Base Station. Successive to the cluster head is chosen, it gathers the data from all of its related nodes and growing it in order to eliminate the redundancy. Thus, it limits the quantity of data transmitted to the Base Station, therefore the residual energy level is augmented and network lifetime is exploited.

There are various key attributes [6] which must be cautiously deliberate, while creating the clusters in WSN:

- **Issues to be considered in Clustering**

To generate a structure surrounded through sensor nodes in WSN, it has the capability to deploy them in an ad hoc manner, because it is not possible to systematize these nodes into groups pre-deployment. Intended for this reason, there has been a huge amount of research in conduct of generating these organizational structures or clusters. The clustering occurrence, plays significant role in not just association of the network, but can noticeably influence network performance. There are various key confines in WSNs, that clustering methods must be considered.

1) **Limited Energy** Dissimilar energetic designs, wireless sensor nodes are off-grid, connotation that they have inadequate vigor storage and the well-organized use of this energy will be imperative in identifying the range of appropriate applications for these networks. The derisory energy in sensor nodes must be considered for proper clustering can decrease the all over energy custom in a network.
2) **Network Lifetime:** The vigor restraint on nodes results in an insufficient network lifetime for nodes in a network. Appropriate clustering should attempt to decrease the power usage, and hereby augments network lifetime.
3) **Limited Abilities:** The diminutive physical measurement and minute quantity of stored energy in a sensor node limit various capabilities of nodes in the terms of the indulgence and communication capabilities. A perfect clustering algorithm should make use of communal resources contained through an organizational structure, as taking into account the restraint on individual node capabilities.
4) **Application Dependency:** Recurrently a given application will really rely on cluster organization. When manipulative a clustering algorithm, application forcefulness must be measured because a high-quality clustering algorithm should be able to acclimatize to a diversity of application requirements.

The parameters that are used in proposed work for cluster head selection are as below;

1. Trust Model
2. Reputation Value

1. TRUST MODEL

In a wireless sensor network, trust identifies the dependability or trustworthiness of sensor nodes. Trust [3] might be secret in dissimilar methods based upon, however they are used. A trust may be slanted or object based upon the task. Depending on possessions, trust might be communal trust or QOS trust. Communal trust considers intimacy, sincerity, solitude, centrality, connectivity. QOS trust considers vigor, selflessness, ability, cooperativeness, dependability, task achievement capability, etc. Generally, a trust may be secret as behavioral or computational trust based upon where it is used. Behavioral trust describes trust relations that are surrounded through people and organizations. Computational trust defines the trust relation through devices, computers, and networks.
The given table (Table 1) shows the advantages and disadvantages of trust models. But it is concluded that the advantages outnumbers the disadvantages which makes it more useful and preferable to use for clustering.

Table I Pros and Cons of Trust Model

S.No	Structure	Pros	Cons
1.	Centralized	Least computational overhead, less memory usage	Most Communication overhead, least reliable, lack of scalability
2.	Distributed	Most reliable and scalable	Most computational overhead
3.	Hybrid	Less communicatio n overhead than centralized and less memory	Large computational overhead than centralized, large memory requirement than centralized , less reliable and scalable compared to distributed

The evaluation of trust values can be defined in two types i.e. evaluation of direct trust value and evaluation of indirect trust value. These calculations are defined as below.

Calculation of direct trust value

Choose any two adjoining nodes Ni and Nj (i, j=1, 2.....n, where n is the numeral of nodes in the network), S i->j (where i is the ID of surveillance nodes, and j is the ID of objective nodes) is the number of winning interactions among Ni and Nj. Ci->j(where i is the ID of observation nodes, j is the ID of goal nodes) is the total number of victorious interactions among Ni and Nj. The computation formula of the direct trust value T_direct (i->j) nodes Ni and Nj is as below:

$$T_{direct(i\rightarrow j)} = W_{olddirec} * T_{olddirect} + W_{newdirect} * T_{newdirect}$$
$$T_{newdirect(i->j)} = S_{i->j} / C_{i->j}$$
$$W_{olddirect} + W_{newdirect} = 1 \quad (1)$$

$W_{olddirect}$ and $W_{newdirect}$ are the heaviness value of the older direction, trust value ($T_{olddirecr}$) and the load value of the novel direct trust value ($T_{newdirect}$) correspondingly. The values of $W_{olddirect}$ and $W_{newdirect}$ are resolute based upon the exact deployment situation.
The subsequent is the analysis of the consequence of $W_{olddirect}$ and $W_{newdirect}$ on direct trust value computation: $=W_{olddirect}/W_{newdirect}$

Calculation of indirect trust value

In the algorithm, the indirect trust value can be attained from the ordinary neighbors of the e spectator and the experiential, the indirect trust value ($T_{recommnd}$ (i->j)) of node i in node j can be computed based upon the billowing method:

$$T_{recommend(i->j)} = 1/n * \sum_{k=1}^{m} T_{direct(i->k)} * T_{direct(k->j)}$$

Wherever, m is the numeral of ordinary adjoining nodes of nodes i and j.

2. REPUTATION VALUE

It is one of the parameter that is used to evaluate for cluster head selection. It is a parameter which is used to measure the reputation value of each and every node on the basis of routing information of the node. It is evaluated by using the following equation:

$$Rep_v = \frac{routed\ packets - dropped\ packets}{Total\ number\ of\ delivered\ packets} \dots\dots\dots\dots (8)$$

For more justification let's consider an example, suppose total number of delivered packets are 100 and out which 80 are routed successfully and 20 are dropped then as per equation (8) the reputation value is

$$Rep_v = \frac{80-20}{100} = \frac{60}{100} = 0.6 \dots\dots (9)$$

The node with routed packet will give a positive acknowledgement and the node with dropped packet will give a negative acknowledgement

II. PROBLEM FORMULATION

As in earlier Wireless Sensor Network protocols are used to improve the energy efficiency and to enhance the lifetime of the network. In this process first of all the whole network is divided into small clusters. The number of these clusters can vary from network to network. And then from these clusters, cluster heads are selected then cluster heads collect the sensed data form clusters and then forward this collected data to the base station and sink node. The only problem in traditional work was the criteria opted for selection of cluster heads. Earlier only trust value was considered for selecting the cluster heads. The node having maximum trust value was selected as a cluster head. Additionally none of the algorithm had been applied to the network for the purpose of optimization. This increases the efficiency of the network but only up to certain limited point. This process leads to the reduction in security of the network as a single node can become cluster head again and again. Therefore the main problem was less number of parameters was considered for cluster head selection. Hence there is a need to develop such a method which can remove the backlogs of the traditional work.

III. PROPOSED WORK

In the proposed technique the security of the system is enhanced by changing the criterion for CH selection. In the earlier techniques only the trust value of nodes was considered for CH selection but in this proposed technique reputation value is also considered along with the trust value of nodes. In proposed work, an optimization is also applied to the network after selecting the CH. For optimization purpose State Transition algorithm is applied. Hence this approach increases the effectiveness and recital of the network. In proposed work first of all network parameters are initialized. Then trust value of nodes on the basis of defined parameters is calculated. After trust value a reputation value is generated. Then on the basis of trust value and reputation value the process of CH selection has been initialized. After this the State Transition algorithm is applied for CH optimization. And at last the generated results of performance parameters prove the efficiency of the proposed work.

IV. METHODOLOGY

The methodology and block diagram of proposed work is as follows:

1. First step is to initialization and creation of the network parameters.
2. After network initialization process of nodes deployment in the given area of the network.
3. Then trust value of the deployed nodes will be calculated.
4. After evaluation of trust value, a reputation value corresponding to the nodes will be generated.
5. Then the criterion for CH selection is considered by combining the trust value and reputation value of the nodes.
6. Then the GA and ST algorithms are applied for optimization of Cluster Heads. The GA performs crossover and mutation is replaced with state transition algorithm.
7. Then data transmission is done between clusters and Base station through Cluster heads.
8. At last performance parameters are calculated and compared.

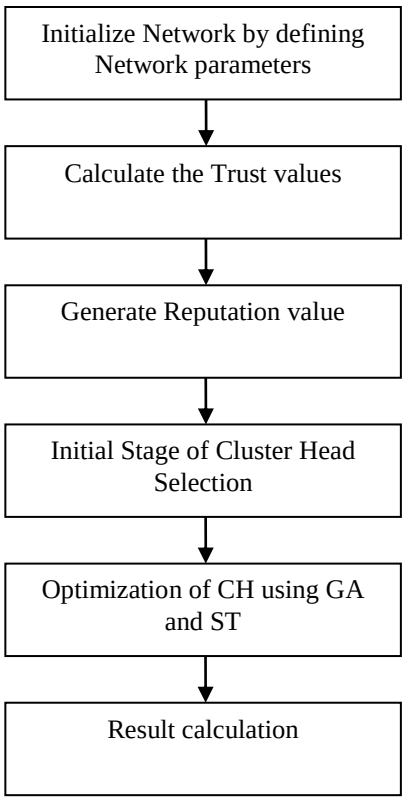

Figure 1: Block Diagram of Proposed Work

V. RESULTS

This section represents the results that are obtained after implementing the proposed work. The implementation is done in the MATLAB. There are some graphs in this section which proves the efficiency of proposed technique with respect to various aspects such as number of dead nodes, number of alive nodes and energy etc. These parameters are examined using following equations such as:

1. No. of Dead Nodes

Nodes whose energy is less than or equal to 0 is considered as the dead nodes in the network. The evaluation of the dead nodes is done as:

$$No.of\ dead\ nodes = E \leq 0 \text{.....(2)}$$

In the above equation E is referred as the energy parameter and compares it with the value 0. If the node's energy is less than or equal to 0 then the corresponding node is declared as the dead node.

2. No. of Alive Nodes

Those Nodes whose energy is greater than 0 are considered as the alive nodes in the network. These nodes can be used for the transmission from source to the sink.

$$No.of\ Alive\ Nodes = Nodes_{Total} - Nodes_{Dead} \text{.....(3)}$$

In the equation 2, $Nodes_{Total}$ is considered as the total number of nodes in the network and for the simulation it is 100. And $Nodes_{Dead}$ is the total number of dead nodes among the total nodes. Therefore, the total number of alive nodes will be the subtraction of dead nodes from the total number of nodes used for the simulation.

3. Energy

The amount of energy depletion has done through the following used equations such as:

1. **Dissipated energy to run the transmitter**

$$E_{elec} = 50\frac{nJ}{bit} \text{.....(4)}$$

2. **Energy Dissipation of the transmission amplifier**

$$E_{amp} = 100\frac{pJ}{bit}/m2 \text{.....(5)}$$

3. **Transmission Costs**

$$E_{Tx}(k,d) = E_{elec}\,K + E_{amp}Kd^{\lambda} \text{.....(6)}$$

4. **Receiving Costs**

$$E_{Rx}(k) = E_{elec}K \text{.....(7)}$$

In the above equations, K represents the message length in bits, d referred as the distance between the nodes and $\boldsymbol{\lambda}$ is the path loss exponent i.e. $\lambda \geq 2$. On the basis of these parameters the performance of the traditional as well as proposed technique can be judged and conclude.

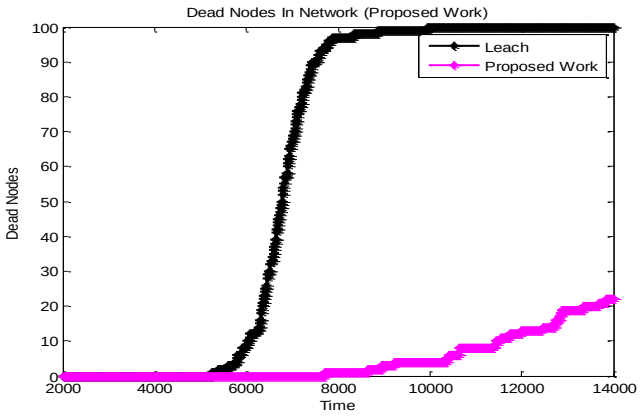

Figure 2 Comparison of LEACH and proposed technique with respect to dead nodes in the network

The graph (fig 2) shows the efficiency of the proposed work in the terms of dead nodes with respect to traditional technique such as LEACH and proposed. All the nodes are dead in case of traditional but in the proposed technique some of the nodes are still alive for the transmission. For the simulation, dead nodes are examined with respect to time which is varying from 2000 to 14000.

The figure 3 defines the comparison graph of traditional technique i.e. LEACH and proposed work on the basis of number of alive nodes in the network. The graph shows that the proposed system has large number of alive nodes in the network as compare to other works. The Number of alive nodes till number of rounds is more stable in case of proposed technique as compared to LEACH i.e. traditional work.

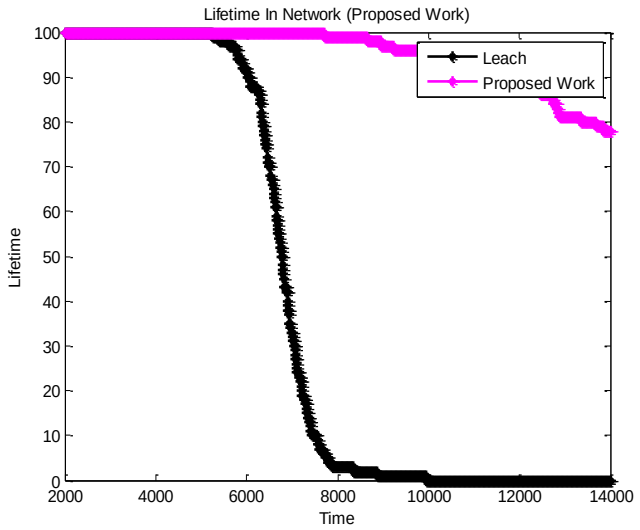

Figure 3 Comparison of LEACH and proposed technique in terms of Alive nodes in the network versus rounds

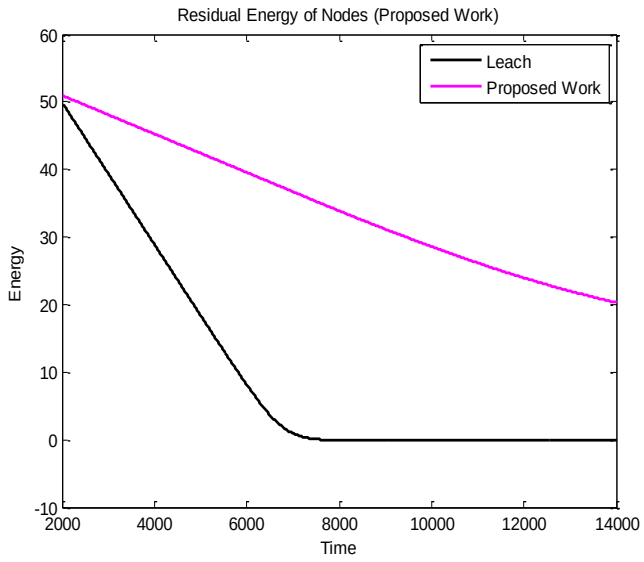

Figure 4 Residual energy of different techniques in the network

The figure4 shows a comparison graph on the basis of average residual energy in the network. The graph shows that the average residual energy of LEACH is exhausted after 7000 hr, whereas in case of proposed work the residual energy remains till the completion of rounds. Moreover, initially energy was at peak point and suddenly falls down whereas in proposed work it is more stable.

The following table 2 shows the results value acquired after applying traditional and proposed technique. Table 2 represents the performance parameters when the number of nodes in considered being 100 in the network.

Table 3 depicts the values corresponding to performance parameters when network consist of 150 sensor nodes.

Similarly in Table 4 represents the resultant values corresponding to the network which is made up of 200 nodes.

The parameters used for the evaluation are total number of nodes, number of dead nodes, number of alive nodes, Initial energy of the network and residual energy.

From the statistical analysis it has shown that the proposed technique surpasses the traditional technique in terms of each parameter while having same number of nodes and initial energy.

Table 2 Results acquired from Traditional and Proposed technique (Nodes 100)

TECHNIQUES / PARAMETERS	PROPOSED TECHNIQUE	TRADITIONAL TECHNIQUE
Total number of nodes	100	100
Initial Energy	0.5	0.5
Number of Dead Nodes	23	100
Number of Alive Nodes	77	0
Residual Energy	0.1591	0

Table 6.2 Results acquired from Traditional and Proposed technique (Nodes 150)

TECHNIQUES / PARAMETERS	PROPOSED TECHNIQUE	TRADITIONAL TECHNIQUE
Total number of nodes	150	150
Initial Energy	0.5	0.5
Number of Dead Nodes	71	150
Number of Alive Nodes	79	0
Residual Energy	0.14841	0

Table 6.3 Results acquired from Traditional and Proposed technique (Nodes 150)

TECHNIQUES / PARAMETERS	PROPOSED TECHNIQUE	TRADITIONAL TECHNIQUE
Total number of nodes	200	200
Initial Energy	0.5	0.5
Number of Dead Nodes	82	200
Number of Alive Nodes	118	0

Residual Energy	0.13529	0

VI. CONCLUSION AND FUTURE SCOPE

After reading the related work section it is concluded that the performance an lifetime of the wireless sensor network relies on the amount of energy consumed by its nodes for data transmission, amount of energy consumed by the nodes. There are various techniques have been developed which are helpful for route selection. But all of these techniques have some lacking point. This work proposes a new technique for enhancing the lifetime of the network and for efficient routing on the basis of State Transition and Genetic Algorithm. The proposed technique selects the route for data delivery on the basis of various parameters such as Trust value of the nodes, reputation of the nodes. The efficiency of the proposed work is measured in various terms such as number of alive nodes, number of dead nodes, energy consumed by the nodes and number of alive nodes in the network. Hence proves that the proposed work is able to enhance the lifetime and security of the network as it works on several parameters rather than a single trust parameter.

In future more updations can be performed in the proposed techqniue such as:

- The Proposed model can be updated with recent trending optimization techniques such as PSO etc.
- The scenario of the proposed technique can also be analyzed in the Mobile Ad Hoc Networks.

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