Determination of Optimal Routing Path In Wireless Sensor Network Using Energy Aware Routing Protocol

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Abstract- *Wireless sensor networks (WSNs) provide tremendous benefit for many industries. Having the flexibility to add distant sensing stations is a huge plus. It emphasizes the necessity of low-cost running wires, which provide several benefits such as energy and material savings. One of the most important responsibilities in WSNs is routing. However, selecting a dependable path in routing has gotten more difficult. A novel routing strategy is given in this research so that WSNs can guarantee great reliability throughout transmission. The suggested method is divided into two stages. In the first, sensor nodes are clustered and an appropriate cluster head is chosen using the k-means clustering algorithm. Clustering is done depending on the energy of the sensor nodes. The cluster head's energy cost and the sensor nodes' trust level are then calculated. In the second stage, an ideal path for routing will be chosen. The Genetic Algorithm (GA) is used to choose the best path based on the energy cost at the cluster head, the confidence level at the sensor nodes, and the path length. The best path offered great reliability, faster speeds, and longer lifespan. The proposed routing system is tested using MATLAB software, and the results are evaluated.*

Keywords- Genetic Algorithm, K-means Algorithm, LEACH protocol, Trust-Distrust protocol, WSNs.

I. INTRODUCTION

A Wireless Sensor Network is made up of a large number of low-cost sensor nodes, such as hundreds of thousands of sensors. Transmitting capacity, energy, limited processing and storage are the restraints in a sensor node. These wireless sensor nodes observes both environmental as well as physical conditions, for instances humidity, pressure, motion, fire, temperature and so on. Nowadays WSN takes an essential place in various fields and have lot of applications such as, preventive maintenance, event detection, intelligent building, facility management, tracking, biodiversity mapping, healthcare, disaster relief, surveillance, monitoring and etc. An unattended as well as hostile environment areas are selected for positioned the sensor nodes for gathering more information regarding these areas like, nuclear reactors, wild forest, battlefield, chemical plants. Therefore, when recharge or replace the battery is considered as a strenuous task.

The sensor nodes are in charge of gathering various environmental data and relaying that data to the sink node, which is the base station. Generally the base station is made on resource-rich device, which contain high storage capability, unlimited power and communication. It may be considered in many scenarios as well as applications as a mobile node or base station. Furthermore, the sensor nodes are interconnected with one another to communicate with one another, allowing the sensor nodes to collect data and share it with the user via the internet or current communication systems. In order to extend the system's lifespan and avoid energy constraints, an energy efficient routing protocol is typically utilized in WSN contexts.

II. LITRATURE REVIEW

Routing strategies have recently played an important role in wireless sensor networks. In a large number of sensor nodes structure, allocate the global ids is very challenging. Therefore, WSN cannot function in conventional routing protocols such as, cellular network, MANET and etc. Various inherent features are in WSN and it contains limited storage, energy and processing capability and have extremely high dynamic network. Developing a routing protocol is difficult because of these characteristics.

Youniset al. (2004) had developed Hybrid Energy-Efficient Distributed clustering (HEED) routing protocol. It's a wireless sensor network multi-hop clustering approach that focuses on efficient clustering via optimal cluster head selection. The cluster head is selected based on a variety of parameters, including residual energy and intra-cluster transmission costs.

Muruganthan et al. (2005) had presented a centralised energy-efficient routing approach of LEACH-C. LEACH-C is a centralised clustering control version of LEACH. The base station collects the position information and residual energy of each node in the network during the setup phase, then selects the cluster heads and configures the other nodes into clusters using this information.

Mohammad Reza Mazaheri, Behzad Homayounfar, (2011) QEMH. QoS based and Energy aware Multi-path Hierarchical Routing Algorithm Each CH collects data from the cluster members within its cluster, aggregates the data and then transmits the data to the sink

III. METHOLODOGY

LEACH is the initial network protocol for wireless sensor networks that uses hierarchical routing to extend the network's life. Local clusters are formed by all of the nodes in a network, with one node serving as the cluster's leader. The operation of LEACH is divided into rounds. The clusters are established first, followed by a steady-state phase in which multiple frames of data are passed from the nodes to the cluster-head and onto the base station.

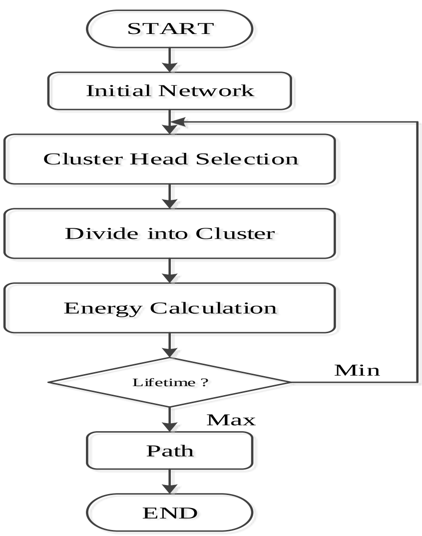


Fig 1:LEACH

Set-Up Phase

Cluster-head nodes should be dispersed throughout the network to reduce the distance over which non-cluster-head nodes must deliver data. A sensor node chooses r, which has a random value between 0 and 1. Then, consider threshold value be $T(n)$:

$$T(n) = \frac{P}{1 - P \times (r \bmod P^{-1})}$$

$T(n)$ the node becomes a cluster-head for the current round if this random number is smaller than a threshold value. The threshold value is determined using the equation, which takes into account the desired percentage to become a cluster-head.

Steady-State Phase

The cluster-head must keep its receiver turned on in order to receive all data from the cluster's nodes. After the cluster-head has received all of the data, it can process it, and the resulting data is delivered from the cluster-head to the base station.

Trust-Distrust Protocol

Because proving a constant link between nodes in a WSN is a difficult undertaking, the proposed system creates a virtual topology and then performs further routing procedures based on this topology. The topology is maintained using the k-means algorithm, and the topology is constructed using the distance. The fitness value of each node is then assessed by sending and receiving sample packets. Following that, the fitness value is used to define the trust-distrust value for the nodes, and the routing path is chosen based on this value.

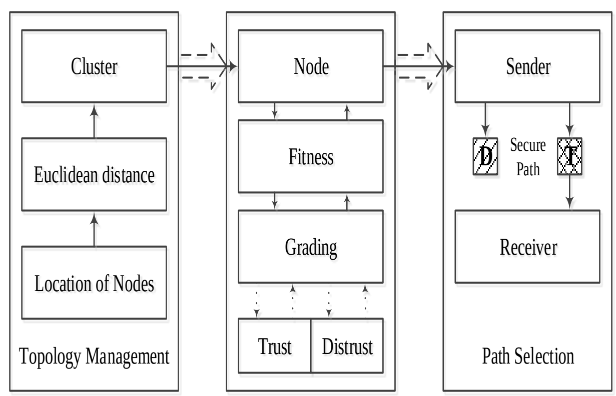


Fig 2: Architecture of TDP

Topology Management

The technique is proposed instead of being made up of objects, the cluster is built up of WSN nodes. Distance and energy are the attributes that are used to group the nodes in this case. As a result, the nodes in this study are clustered according to their distance from one another, with the shortest distance and closest energy remaining in the same cluster. The selection of clusters is one of the most difficult processes in any clustering operation. The cluster leader has complete control over the cluster's effectiveness. For cluster head selection and clustering, the suggested method uses the k-means algorithm.

The cluster is built using the Euclidian distances between the objects in the K-means algorithm, and the center nodes are considered the cluster. As a result, the central node (centroid point) in this technique collects information about all nodes' node ids and positions and stores it in a list.The clustering method is used once all of the data has been collected from all nodes (k-mean). The steps in the modified k-means method for clustering the nodes in WSN are as follows. The clustering technique is the same as before because this strategy uses the classic k-means algorithm.

IV. PROPOSED SYSTEM

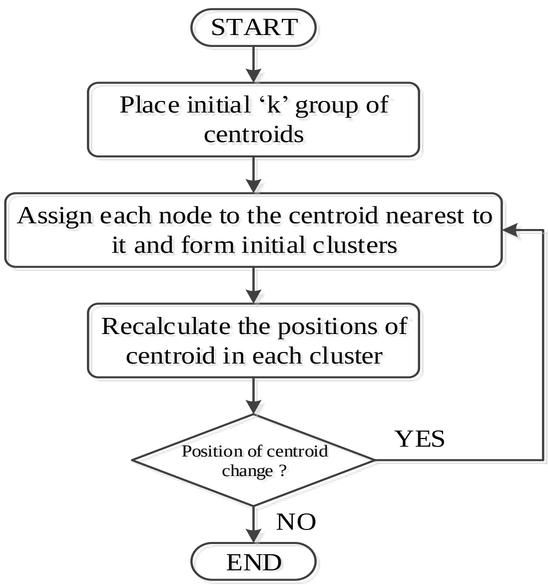


Fig 3:Cluster formation

Step 1: Start by installing 'k' centroids at random points throughout the network if you want to cluster the sensing nodes into 'k' clusters in a WSN.

Step 2: Calculate the Euclidian distance between each node and all centroids, then assign it to the centroid with the shortest distance. By this 'K' initial clusters are created. Initial clusters are created as a result of this 'k'. Assume there are n nodes in the graph, each of which belongs to R_d. The problem of finding the minimum variance clustering of these nodes into k clusters is that of finding the k centroids $\{m_j\}^k \; |j=1$ in R_d such that,

$$\left(\frac{1}{n}\right)\times\sum\left(\min_j d^2(X_i, m_j)\right), \quad \text{for} \quad i=1 \text{ to } n$$

Where, $d(X_i, m_j)$ denotes the Euclidean distance between X_i and m_j. The points $\{m_j\}^k \; |j=1$ are known as cluster centroids or as cluster means.

Step 3: Recalculate the centroids' positions in each cluster and compare to the previous one.

Step 4: If any centroids position changes, proceed to Step 2, otherwise the clusters are complete and the clustering procedure is complete.

The processes above can be used to cluster nodes into 'k' clusters, and the cluster heads in each cluster must be chosen

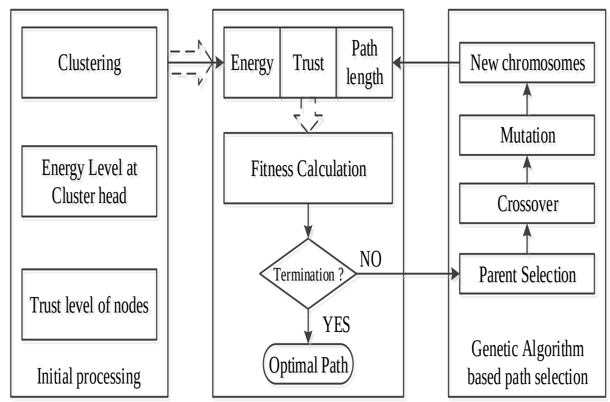


Fig 4:Optimal path

K-means algorithm for clustering and cluster head selection

Clustering is the challenge of grouping a set of items so that objects in the same group (referred to as a cluster) are more similar to each other (in some sense) than objects in other groups (clusters).

Determination of the Energy Level of a Cluster Head

The cluster is established in the prior phase, and each cluster head is assigned a fitness value (energy level) in this stage. The maximization of system lifetime will be driven by effective energy.

$$EC = (e_{mn})\tilde{E}_m^{-1} + (e_{nm})\tilde{E}_n^{-1}$$

Where,

'$\tilde{E}_m$' - residual energy of node 'm'

'$\tilde{E}_n$' - residual energy of node 'n'

'EC' - energy cost for transmitting a packet

'e_{nm}' - transmission energy essential for n to m

'e_{mn}' - transmission energy essential for m to n

$$EL_j = \tilde{E}_j - EC_j$$

Where, at head j, 'EL_j' denotes the Energy Level, '$\tilde{E}_j$' denotes the cluster head j's leftover energy and 'EC_j', signifies the cluster head's energy cost j.

Trust level

The trust level will be determined depending such as, cluster head, energy, path length and node once the fitness value has been calculated. The level of confidence will be determined by three criteria such as, cluster head, path length, and energy cost. The equation 3.7 can be used to determine a node's trust level. The level of trust also serves as a fitness function.

$$T_i = \frac{FP_i}{RP_i} \times 100$$

Where,

'RP_i' - No of packets received by i^{th} node

'FP_i' - No of packets forwarded by i^{th} node

'T_i' - Percentage of Trust at i^{th} node

Path selection based on GA modeling

The Genetic Method (GA) is one of the meta-heuristic search optimization algorithm depends on natural selection and genetics as evolutionary notions. GAs are not random, even though they are randomized; rather, they use historical data to direct the search to a better performing position within the search space. The GA was created to mimic operations that occur in nature and are essential to evolution.

Fitness Calculation

The suggested method's fitness function aims to find the most reliable transmission path in WSNs. As a result, the path length of the node, the energy of the cluster head, and the level of trust make up this fitness function.

$$F = \frac{T \times EL}{PL \times 100}$$

Selection

During this phase, a region of the parent chromosome will be chosen for genetic operations like as mutation and crossover. The proposed technique aims to increase dependability by selecting the best-fitting chromosome and creating a new set of chromosomes around it.

Crossover

Crossover is one of the most useful methods in GA optimization. In this step, two new offspring (chromosome sets) are formed by fusing two selected chromosomes from the preceding phase. The crossover is achieved using the traditional GA strategy in this proposed method.

Mutation

The GA's final stage is mutation, which generates a completely new set of solutions. From the previous phase, a partially rearranged solution was acquired, which was adjusted and a whole new solution was created. The usual mutation is used in the proposed method.

Termination criteria

If the next generation chromosome produces satisfactory fitness and meets the termination conditions, the process is terminated; otherwise, the procedure resumes from the selection phase.

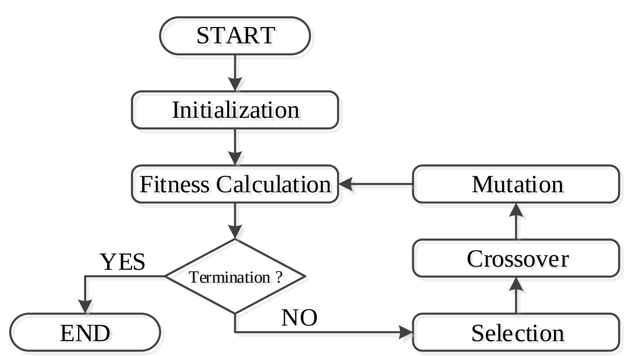


Fig 5:GA for path selection

V. RESULT

The sensor nodes are clustered using the k-means algorithm, and each sensor node's trust level is determined by sending and receiving packets to their group nodes. Ten packets are sent to each node in the group using the described mechanism. The nodes receive the packets, which they then transmit to the cluster head. The packets delivered and received will determine the trust level of each node.

Table 1: Initialization of parameters

Parameter	Value
No of cluster	6
Total no of sensor nodes	100

Table 2: Nodes Trust Level

Cluster head	Energy Level (in joule)
1	62
2	63
3	68
4	58
5	57
6	50

The energy that persists after a single transmission. The figure depicts the varied ranges of energy present at various nodes in a wireless sensor network.

Table 3:

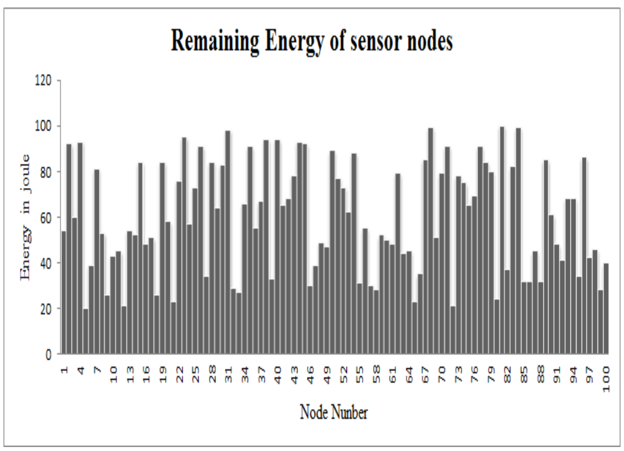
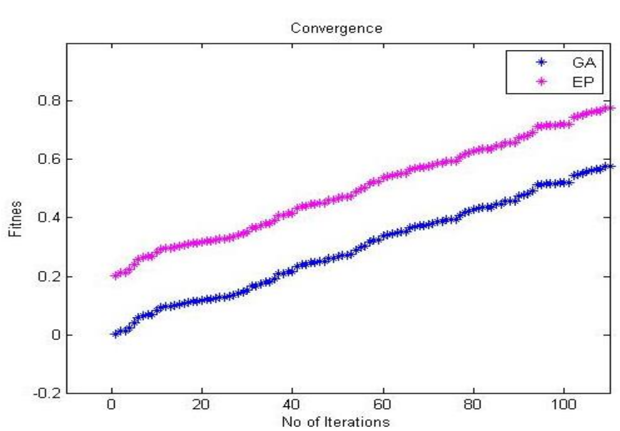


Table 4:



VI. CONCLUSIONS

The unique approach will give a high reliability path with increased performance, and it is recommended as an optimal routing algorithm for information transmission in WSNs. We introduce a novel optimal context-based routing algorithm for the WSN in this paper. Energy-based Clustering is constructed for the sensor nodes in the first stage. After that, the cluster head is calculated based on the cost of energy. The k-means technique is used for clustering and cluster head selection. The optimum way is then chosen based on the cost of energy at the cluster head depends on the path length and sensor nodes. The proposed approach use GA-based optimization to find the most reliable path in WSN. The execution outcome and performance examination reveal, the proposed system improves system lifetime and transmission rate in a short path, resulting in high reliability. As a result, the suggested strategy is appropriately suitable for high-reliability routing in WSNs. Another optimization approach will be employed in the future to improve the system's performance even further.

VII. SCOPE FOR FUTURE WORK

In the implementation analysis, the proposed approach for increasing security while routing in WSNs functioned well. However, you can improve its performance by adding extra information or objectives, such as data transmission quality, while routing. Additionally, attempt to apply an optimization strategy during the path selection stage, as this might lead to a more stable and secure path throughout the transmission.

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