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Energy aware optimized dynamic routing mechanism in wireless sensor networks

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ABSTRACT

A trade-off between energy efficiency and optimized routing is massively recommended for transmission efficiency enhancement in wireless sensor networks (WSNs). Therefore, in this paper, graph-based energy optimized dynamic routing (GEODR) mechanism is introduced to set up a balance between energy consumption minimization and throughput enhancement using a dynamic and optimized routing mechanism in WSNs. A clustering scheme is employed based on graph theory, and cluster boundaries are formed using distance vectors. Cluster head (CH) selection is performed based on residual energy, the distance between CHs, and the mobility of the sink node. Each cluster is scattered with multiple tiny nodes, and event monitoring is performed. A model for graph-based dynamic routing to transmit data packets, cluster and cluster boundary formation, and optimization of routing problems is discussed. The performance efficiency of the proposed GEODR mechanism is determined by taking 100 sensor nodes, and 20 nodes are selected as CHs in a sensor network, and several other network parameters are also considered. A massive improvement in energy is observed by using sink node mobility. Experimental results are obtained using the proposed GEODR mechanism in terms of data packet transmission, alive nodes, dead nodes, and residual energy and compared against classical routing mechanisms such as low energy adaptive clustering hierarchy (LEACH) and stable election protocol (SEP).

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1. INTRODUCTION

The utilization of wireless sensor networks (WSNs) is rapidly enhanced in recent years. Wireless communication devices are massively utilized to measure data from sensor nodes and to transmit that information to a target location based on the advancements in sensor network techniques. Thus, these obtained senor values are gathered in form of electrical signals and transmitted to the desired destination with the help of different wireless techniques [1], [2]. Hundreds of sensor nodes are placed in a wireless network and form a network structure with wireless detection devices to sense and gather desired information. Sensor networks are utilized to collect environmental information and transmit it to the base station (BS). Therefore, the base station in WSNs is utilized for continuous monitoring and analysis purposes [3], [4]. WSNs are massively utilized in several applications such as the internet of things (IoT) [5], environmental air, noise, humidity and pressure, temperature detection, threat detection and in disastrous situations, intelligence reports, and attack detection. Therefore, the concept of WSNs provides a spatially distributed facility in which numerous devices link to each other to monitor environmental conditions, and information is gathered and transferred between them in a centralized manner [6], [7]. Several applications such as smart grids, intelligent homes, smart agriculture, and smart cities. constructed using sensors. Sensors are massively utilized for traffic observation [8], tracking of the target [9], war [10], and identification of forest fires [11]. WSNs are used in many applications and are very useful for social life.

Most of the sensor nodes utilize batteries as an energy source and battery charging in WSNs is not a feasible solution due to place in hard-to-reach areas and due to limited battery power in these sensor nodes, energy consumption is massive due to large data transmission between sensor nodes [12]. Therefore, a solution to the energy consumption problem is quite important and necessary so that data transmission can take place for a long time [13], [14]. Restricted resources such as storage memory, power resource, central processing unit, etc. are utilized in WSNs with sensor devices. Thus, there is a need to enhance the lifetime of the sensor network and reduce the energy consumption of WSNs. In addition, resource management minimization in WSNs is equally important.

Therefore, management of restricted resources and minimization of energy consumption is massively challenging. As a result, qualified data transmission becomes minimum or not up to the desired mark due to limited resource storage and restricted battery-enabled nodes. However, one of the most efficient and balancing techniques for WSNs is the clustering mechanism to reduce energy consumption [15]. This configuration consists of several sensor nodes and one of the sensor nodes is accurately selected as a cluster head node. All the other sensor nodes present in the clustering configuration, collect information and transmit it to the cluster head. Ultimately, cluster head (CH) transmits the processed information to the BS or sink node. However, cluster head selection and reception of transmitting information from sensor nodes reduce massive energy due to the high amount of workload on the cluster head. Moreover, every node consumes a fixed amount of energy due to information transmission and processing. Thus, after a certain time, all the energy of nodes vanishes and the active nodes becomes dead nodes [16]. Therefore, an efficient clustering mechanism needs to be formulated to reduce energy consumption and a proper routing mechanism needs to be selected so that sensor nodes can transmit information between each other efficiently.

Recently, several clustering mechanisms are employed to reduce energy consumption and enhance network lifetime. However, BS remains stationary in most of the clustering techniques, and the sensor nodes located near the BS are called relay nodes. Further, energy is consumed much faster in the case of the nodes which are located near the target area, and thus, energy holes get generated in a wireless sensor network. Thus, the utilization of mobile base stations is one feasible solution to handle this problem. The adoption of mobility of tiny nodes is mainly due to enhancing communication efficiency and handling sensing difficulties like energy consumption. The extension of the sensor network is achievable due to the use of mobility features in WSNs. Additionally, the lifetime of WSNs is massively improved using the mobility concept for sensor nodes, CHs, and Sink nodes, and data transmission efficiency becomes high. Furthermore, the mobility of sensor nodes can improve node connectivity and can extend the coverage area of transmission.

Mobility in WSNs can be classified using sensor node mobility and sink node mobility. For sensor node mobility, sensors remain in motion while the Sink node becomes static whereas in the second modality, sink node remains in motion and other sensor nodes remain static to gather sensed data. The main advantage of sensor node mobility is coverage enhancement especially helpful in those cases where sensor nodes get disconnected or energy is almost consumed. Further, several researchers and experts have provided massive efforts to indefinable arrangements of mobility cost reduction and energy reduction with higher transmission range and extended battery life. Thus, a present trend for energy harvesting technologies such as bluetooth low energy (BLE) and ZigBee utilizes industrial and scientific bands [17], [18]. However, power reduction and resource management still remain major challenges. Therefore, the performance of battery-powered devices needs to be enhanced and several publications are presented to reduce energy consumption, especially in the standby phase [19]. Thus, power consumption of sensor nodes, large overload of CH and improved routing efficiency to transmit data packets are still major problems in WSNs. Next sub-section provides details related to the literature review.

2. LITERATURE REVIEW

Energy minimization and proficient routing mechanisms are major challenges in WSNs due to restricted energy storage in sensor networks. Clustering-based algorithms are utilized to form a group of sensor nodes and a sensor node nearest to the cluster boundary is selected as CH and sink nod is referred to as the node which gathers information from other sensor nodes and is transmitted for further processing. Several clusters are formed in a sensor network and a cluster head is selected for each cluster. All the sensor nodes transmit information toward the cluster head. However, due to the massive workload on the cluster heads, energy consumption remains a major issue. Hence, a proper routing mechanism can improve resource utilization, transmission efficiency, and energy consumption of nodes. Nevertheless, numerous industry experts and researchers have provided great efforts to enhance transmission efficiency and reduce the power consumption of sensor nodes. Some of the associated works are discussed in the below paragraph.

Aydin *et al*. [20] shows an efficient clustering mechanism is adopted to minimize energy consumption and improve the routing process to transmit data packets, and enhance mobility in WSNs. This technique enhances the lifetime of sensor networks and the node with higher residual energy is selected as CH. Simulation results are obtained based on the genetic algorithm and the total number of routes utilized by a sink node is determined based on the genetic algorithm in a sensor network. Wang *et al*. [21] proposed destination-oriented routing technique is adopted to provide a proper balance between energy minimization of sensor nodes and data packet transmission efficiency enhancement. Power-efficient gathering in sensor information systems (PEGASIS) is utilized to reduce transmission power and enhance sink mobility. Zhu *et al.* [22] proposed an energy balancing technique is presented to minimize energy consumption through a clustering mechanism based on density peaks and fast search clustering. This technique enhances network flexibility and the formation of cluster boundaries based on membership probabilities. Energy consumption is minimized using a multi-cluster head design.

Jurado-Lasso *et al*. [23] proposed an energy-efficient routing technique is adopted using software-defined multi-hop transmission in WSNs. This technique is utilized to extend the lifetime of the network and optimize energy consumption. Network balancing is performed based on the data packet aggregation function. Rosa *et al*. [24] proposed an energy harvesting mechanism is presented to improve power consumption efficiency in WSNs and improve the performance of node lifetime. A wireless sensor platform is utilized to reduce resource utilization and improves network mobility cost. Singh *et al*. [25] proposed an energy efficient clustering (EEC) technique is adopted to improve node energy efficiency in WSNs and extend network lifetime and enhance mobility. A modified low energy adaptive clustering hierarchy (LEACH) mechanism is introduced to improve load balancing based on clustering size and simulation results show improvement from the traditional LEACH protocol.

Tekin *et al*. [26] proposed an error-controlling mechanism is adopted to prolong the lifetime of sensor nodes in WSNs and enhance the reliability of the network based on mixed-integer programming (MIP) formulations. A proper efficient routing mechanism is presented based on optimum parameters like automatic repeat request (ARQ), hybrid ARQ (HARQ), and forward error correction (FEC). Yang *et al*. [27] shows the Joint Routing Optimization is performed in this study to improve data storage reliability issues and reduce data redundancy. Here, the data delivery and the data storage ratio are improved using the data approximation algorithm. Markov approximation framework is utilized to deploy nodes efficiently and minimizes the NP-hardness problem. However, still, major issues like energy consumption and data packet transmission remain like before and practical implementation of these routing techniques is a little expensive and complex.

2.1. Research significance

A graph-based energy optimized dynamic routing (GEODR) mechanism is adopted in this paper to reduce the energy consumption of wireless sensor networks and network lifetime enhancement. The proposed GEODR mechanism enhances data transmission efficiency. The proposed GEODR mechanism forms cluster boundaries dynamically and data packets gathered from sensor nodes are transmitted to sink nodes inside a sensor network based on distance vectors while keeping fixed the dynamics and different parameters of the sensor network. Thus, the sink node has proper knowledge of network dynamics and is able to construct optimized cluster boundaries. This dynamic optimization of cluster boundaries is performed on the basis of energy consumption and senor node density. Mobility in the sink node is the main source of inspiration to improve energy consumption and data transmission efficiency. Further, the simulation results are obtained using the proposed GEODR mechanism in terms of residual energy, intra-cluster optimization, and alive nodes and dead nodes and compared against traditional LEACH and stable election protocol (SEP) routing protocols.

This paper is organized in the following style which is discussed below. Section 2, discusses related to the mathematical methodology based on the GEODR routing mechanism. Section 3 describes simulation results and compared them against traditional routing and energy reduction techniques and section 4 concludes the paper.

3. METHOD

This section discusses a detailed mathematical representation of proposed GEODR mechanism to improve energy efficiency and network lifetime. Cluster boundaries are constructed using the proposed GEODR mechanism and sensor nodes collects data packets and transmit it to the sink node with the help of distance vectors and varied fixed network parameters are utilized. The number of alive and dead nodes heavily depends on the total number of data samples transmitted.

As a result, energy is massively consumed in these battery-oriented sensor nodes. The proposed GEODR mechanism extends the size of the network and improves energy efficiency by exploiting the mobility of the sink node. Further, node density helps to form dynamic cluster boundaries and a route is selected with minimum mobility cost in a multi-hop communication from the cluster head to the sink node. Here, CH selection is performed based on residual energy, mobility, and the distance between the sensor node and node energy efficiency. The following paragraph shows comprehensive mathematical modeling of the proposed GEODR mechanism. The routing optimization in the proposed GEODR mechanism is performed using Graph-based theory in WSNs. The main role of Graph-based routing optimization is to reduce energy consumption in WSNs and a dynamic routing approach is required to minimize switching delay and collisions using the mobility of sink node. Low-level details are exploited to handle collisions between data packets and enhance network agility in dynamic routing optimization. Additionally, the GEODR mechanism is introduced to form a route towards the sink node from the sensor nodes and is utilized for mobility cost minimization of the constructed route from CHs to the sink node. High energy consumption is minimized using graph theory (GT) in the GEODR mechanism and security, reliability and trust (SNT) is utilized to partition a sensor network into smaller clusters for a given set of nodes. Each node is associated with its respective cluster referred to as a cluster cell. The proposed GEODR mechanism is utilized to keep a record of multi-hop connections and transmission with maximum transmission coverage. The routing between different clusters is performed using parallel computation in the proposed GEODR mechanism. Then, SNT is utilized to construct dynamic cluster boundaries and is controlled at the sink node. Further, senor network contains numerous senor nodes which are randomly dispersed. Node density is one network parameter based on which the sensor network is partitioned into small clusters and a CH is selected for each cluster. Then, consider some assumptions to model a sensor network and those assumptions are,

- Sensor network formation is based on the strong linkage of sensor nodes.
- Every node has its own unique node ID and data packets are transmitted and received through strongly connected neighboring links.
- Each node has knowledge of CH.
- All nodes know about the identification (IDs) of their neighboring nodes in graphs.
- Every node has the capability to broadcast and receive data packets.

3.1. Proposed GEODR mechanism

Here, the GEODR mechanism is proposed to form a hierarchical network and partitioned into different cluster regions. The proposed GEODR mechanism produces an event request between the sink node and sensor nodes. The data transmission take place between sensor nodes and sink node as well as reverse transmission can take place between sink node and sensor nodes. A graph is formed in which sensor nodes remain strongly linked with each other using Graph theory and the location of transmitted data is known through event request information. The proposed GEODR mechanism minimizes the mobility cost of transmitted data packets between one cluster head to another cluster head. Then, data packets are broadcasted to the sink node in a multi-cluster-based multi-hop transmission. Further, with the help of the mobility cost function, a cluster head is elected for every cluster present in the sensor network.

Thus, overall energy consumption is minimized by exploiting sink node mobility using the proposed GEODR mechanism. The flow diagram of data packet transmission using the proposed GEODR mechanism is presented in Figure 1. First of all, a message is transmitted to all the sensor nodes by the sink node in a wireless sensor network and the sink node receives data packets from all the nodes. Then, a distance between the sensor nodes and sink node is estimated using strength indicators which are utilized to measure the quality of received data packets. Further, the nodes which possess similar strength indicator values are placed in a cluster of tiny sensor nodes using the sink node. Then, the formation of cluster boundaries and radius extension is evaluated based on graph theory (GT). Initially, CH is elected randomly for every cluster. Then, the cluster head is re-elected after a certain period of time using sink node. Then, CH is re-elected based on the remaining energy in sensor nodes. A threshold is set up to a fixed number and the node having energy less than the fixed threshold number, is re-elected as the CH.

After the CH re-election, the sink node transmits a message to the newly re-elected CH. Then, the cluster radius is extended and energy parameters are kept constant and accordingly, generated graphs are updated. Till the evaluated number remains less than the threshold value, the CH remains similar. The best possible path from CHs to the sink node is elected on the basis of the proposed GEODR mechanism so that energy is minimized while maximum data transmissions. The sensor network model is performed in two hierarchical levels in which the first hierarchy discusses the route distance from CH to the sink node and the second hierarchy discusses the node distribution in clusters and cluster-based formation.

3.1.1. Route distance from CH to the sink node

The cluster-based sensor network is formed in a centralized manner. The CH election and formation of clusters as well as cluster boundaries are created using the sink node. The data transmission between CHs and the sink node is placed based on the sink node. Then, the sink node elects a node as CH based on energies present in the sensor nodes, and the node with the highest energy is elected as CH then, higher energy nodes are elected based on (1).

$$R(d) = \frac{q}{1-q\left(s\ mod\left(\frac{1}{q}\right)\right)} . M_n(M_b)^{-1} \tag{1}$$

Where the number of nodes present inside a cluster is denoted as q^{-1} and the number of times, the re-selection of CHs takes place is given by s. The residual energy of the sensor node is denoted by M_n. For each node, this function is utilized to estimate the energy of the sensor node. The node with the highest energy $R(d)$ is elected as the cluster head. A message is transmitted by the sink node to provide information about CH to all the nodes, once the re-selection of CH takes place. The nearest distance and maximized distance between the nodes are denoted by k_l and k_g, respectively, for a given sensor network. The radius of the cluster is determined using the distance between the sink node and sensor nodes. Then, the distance between sensor node and sink node is determined using (2).

$$S_a = 1 - \rho\left(\frac{k_g - k(d_j,SN)}{k_g - k_l}\right) \tag{2}$$

Where the radius of the cluster a^{th} is given by S_a and the total number of clusters present in the sensor network is denoted by A and a provide cluster information and belongs to $a \in 1,2,3, \dots \dots \dots, A$ and the energy available for each cluster is given by ρ. Thus, the range of energy parameter ρ lies between 0 to 1. Then, the energy parameter ρ is defined by (3).

$$\rho \to \left(\sum_{j=1}^{d} M_j\right)\left(S_j\right)^{-1} \tag{3}$$

The proposed GEODR mechanism is adopted to eliminate optimization problems and follows a probabilistic rule based on which the mobility cost of the transmission route is minimized. The proposed GEODR mechanism determines an optimum route using a set of points. Then, the shortest route from the cluster head to the sink node is determined using the random probabilistic rule among all the clusters. The probability of selecting a cluster j and traveling to another cluster z is given by (4).

$$Q_{jz} = \delta\beta_{jz}^{\rho}\aleph_{jz}^{\Omega} \tag{4}$$

Where the range of parameter δ lies between 0 and 1 and is referred to as the normalization constant and the heuristic value is denoted by $\aleph$ and the probability coefficient is denoted by β. The relative effect of heuristic data and the probability coefficient is indicated by the following parameters Ω and ρ. According to this hypothesis, when the probability coefficient becomes zero shows that the two nearest clusters are elected whereas when the value of the heuristic data is zero then the heuristic method is not applied and only theprobability coefficients-based method is applied. Then, the value of heuristic data for two neighboring CHs j and z is given by (5):

$$\aleph_{jz} = \Delta\left(1+\left(\frac{k(z,c)}{k(j,c)}\right)^{\varphi}\right) \tag{5}$$

where, energy consumption from j to z is given by Δ and defined using (6):

$$\Delta = \frac{M}{k(j,z)} \tag{6}$$

where, normalization functions are managed using a controller factor φ and substitute CH selection to link j and z are denoted by c and then, the probability coefficients are updated in (7).

$$\beta_{jz}(r+1) = (1-q)\beta_{jz}(r) + \Psi q\, \beta_{jz}(r+1,r) \tag{7}$$

Where the probability determination rate is denoted by $q = \frac{1}{D_n}$ and the rate of probability determination is utilized to permit negative reinforcements. Then, D_n represents the number of nodes used for the shortest route towards the sink. Ψ is defined using (8).

$$\Psi = \frac{M_j + M_z}{k^2(j,z)} \tag{8}$$

3.1.2. Node distribution in clusters and cluster formation

Each cluster is scattered with multiple tiny nodes and event identification is carried out based on cluster level so that event monitoring is performed. These sensor nodes change their position regularly and transmit data to the desired location. A trade-off is set up between network complexity and latency based on the defined margin using the proposed clustering mechanism. Further, nodes present inside the clusters are utilized to construct a graph to generate an extensive coverage area of transmission. For a certain time period, the selected cluster is denoted as E to formulate a graph and handle mobility cost functions. Then, based on the link strength indicator, a balance between mobility cost function and energy efficiency is derived. A cluster contains multiple numbers of nodes D and a CH is elected among those nodes. Then, the remaining nodes are linked with the CH to minimize collision and traffic load of data packets. Thus, Graph based routing optimization is performed for dynamic routing. Link strength indicator Y_{pj}, the radius of coverage area and energy efficiency are the main parameters for the evaluation of mobility cost function. The quality of the Link strength indicator Y_{pj} get affected by parameters of wireless channel scenarios and event signals present in the sensor network. Then, the quality of Y_{pj} can be improved based on the identified event signals and residual energy. Then, the scalability of sensor network is enhanced using controller factors and accurate identification of event signals using (9).

$$A_{l,q\sigma} = \sigma K_a + (1-q)\left[\sigma Y_{pj} + (1-\sigma)M_n\right] \tag{9}$$

Where the number of links related to each tiny sensor node $D_a$is indicated by $q = 1/D_a$ and strength indicator values evaluated from each tiny sensor node $D_a$are summed up and indicated by K_a. Then, the balance between remaining node energy M_n and Link strength indicator Y_{pj} is set up using σ and the trade-off also depends on the transmitter coefficients. Therefore, user-defined controller coefficients are utilized for mobility cost evaluation based on the event probability and remaining node energy M_n. Multiple links are constructed between the mobile sink node and CH in a cluster. Further, a node with the highest energy and lowest mobility cost is selected as a CH. Further, all the nodes remain strongly linked with each other inside a graph to enhance the data transmission rate. For a particular time period, single link is selected. Thus, the transmission overhead is minimized in wireless communication using an optimal dynamic path. This dynamic path is generated using the proposed GEODR mechanism. This dynamic route is created by linking all the sensor nodes present in a cluster and data packets are broadcasted using this dynamic route towards CH. Further, maximum likelihood is obtained using data values and combined state energy is indicated by $\{\xi, x\}$ and defined using (10).

$$M\ (\xi, x; \phi) = \sum_{j=1}^{K} \frac{\left(\xi_j - t_j\right)^2}{2\varpi_j^2} - \sum_{j=1}^{K} \sum_{z=1}^{B} F_{jz} x_z \frac{\xi_j}{\varpi_j} - \sum_{z=1}^{B} x_z h_z \tag{10}$$

Where, real strength indicator values are given by $\xi \in S^K$ and transformation matrix is indicated by the parameter $x \in \{0,1\}^B$ which represents binary hidden coefficients, and modeling coefficients are given by$\phi = \{F, \varpi^2, h, t\}$. Here, symmetric function is given by F_{jz} to evaluate symmetry between visible and hidden parameters ξ_j andx_z, respectively. Further, bias functions are denoted by t_z and h_z. Thus, combined distribution is defined using visible and hidden parameters ξ_j andx_z using (11):

$$Q\ (\xi, x; \phi) = \left(V(\phi)\right)^{-1} \exp\left(-M\ (\xi, x; \phi)\right) \tag{11}$$

where the normalization constant parameter is indicated by $V(\phi)$ and distribution over visible parameters ξ is given by the proposed GEODR mechanism using (12).

$$Q\ (\xi; \phi) = \sum_x \frac{\exp\left(-M(\xi, x; \phi)\right)}{\int_{\xi'} \sum_x \exp\left(-M(\xi, x; \phi)\right) k\xi'} \tag{12}$$

Then, the conditional distribution for (10) is given by (13) and (14).

$$q\left(\xi_j = (u|h)\right) = (2\pi\varpi^2)^{1/2} \exp\left(\frac{-\left(u-t_j-\varpi_j \sum_z x_z F_{jz}\right)^2}{2\varpi_j^2}\right) \tag{13}$$

$$q\left(x_z = (1|\xi)\right) = e(x_z) + \sum_j F_{jz} \frac{\xi_j}{\varpi_j} \tag{14}$$

where, mean of Gaussian distribution is transformed into weighted arrangements for hidden layer activation considering visible parameters. Then, logistic functions are given by (15).

$$e(u) = (1 + \exp(-u))^{-1} \tag{15}$$

Then, log-likelihood of model parameters are given by (16):

$$\frac{\varrho \log Q(\xi;\phi)}{\varrho F_{jz}} = M_{Q_{info}}\left[\frac{\xi_j x_z}{\varpi_j}\right] - M_{Q_\eta}\left[\frac{\xi_j x_z}{\varpi_j}\right] \tag{16}$$

where $M_{Q_{info}}[\cdot]$ indicates estimation of data distribution and M_{Q_η} indicates estimation of modelling distribution. Then, gradient estimation of objective functions is given by (17):

$$\Delta F = \rho\left(M_{Q_{info[\xi x^R]}} - M_{QR}[\xi x^R]\right) \tag{17}$$

where, rate of learning coefficients is given by ρ and hidden state variables and visible state variables are defined by distribution parameter Q_R. The ultimate feature-based sensor output is given by (18):

$$Q\left(v_z \middle| v_j, f_j\right) \propto d_{v_{jz}}^{f_z} + \psi d_{v_{zj}}^{k_z} + \delta \tag{18}$$

where feature weights are given by f_j and samples based on conditional distributions is indicated by z. Further, δ and ψ are tuning variables and features f_z are allocated to v_z, the total number of times $d_{v_{jz}}^{f_z}$.

3.1.3. Mobility exploitation of sensor network

Energy consumption is massively decreased using the mobility concept in WSNs by estimation of a proper route for data transmission between mobile sink nodes and CHs. Estimation of the optimum path for mobile sink nodes with respect to CHs is an optimization problem for efficient data packet transmission. Thus, an efficient solution for this optimization problem is presented by exploiting the mobility concept in sink nodes. The main focus of mobility exploitation is finding the exact position of sensor nodes to minimize path loss between mobile sink nodes and CHs. The optimal position of mobile sink node $i(\mathbb{X}_i, \mathbb{Y}_i)$inside a cluster is evaluated as shown in (19) and (20):

$$\mathbb{X}_i = \frac{\sum_{\mathbb{k}=1}^{D_{n_i}}(\mathbb{X}_{\mathbb{k}})}{D_{n_i}-1} \tag{19}$$

$$\mathbb{Y}_i = \frac{\sum_{\mathbb{k}=1}^{D_{n_i}}(\mathbb{Y}_{\mathbb{k}})}{D_{n_i}-1} \tag{20}$$

where, $\mathbb{X}_{\mathbb{k}}$ and $\mathbb{Y}_{\mathbb{k}}$ are the x and y coordinates of mobile sink node present inside cluster i and the total number of mobile sink node present inside the cluster i are expressed by D_n. In some cases, when sensor nodes change their position to the optimum location, then some sensor node goes out of reach considering the coverage area range of CHs. However, in those situations, both CH and mobile sink nodes regain the node connectivity by adjusting their transmission energy. The process of changing positions or locations of sensor nodes is a continuous process in a full life-cycle of WSNs.

Algorithm 1 shows the proposed GEODR mechanism, and flowchart representation has shown in Figure 1; where it explains from the step 1 cluster formation considering all nodes using GEODR. It performs graph-based optimized dynamic routing to select best suitable route for CH and connect CH with other sensor nodes, at last it update probability coefficients and feature weights based on senor output.

Algorithm 1. Proposed GEODR mechanism

```
Step 1: Cluster Formation considering all nodes using GEODR
Step 2: Nodes with same strength indicator values placed in one cluster
Step 3: For every CH
Step 4: If Sink Node (SN) then
 Perform re-election of CH
 End if
Step 5: Transmit link to all adjacent sensor nodes using graph theory
Step 6: Perform Graph-based Optimized Dynamic Routing
Step 7: Hop Exploration
Step 8: Handle obtained routes
Step 9: determine mobility cost function and select the route of minimum mobility cost
Step 10: Selected best suitable route for CH and connect CH with other sensor nodes
Step 11: if defined margin then
 Do sensor network monitoring
 End if
Step 12: Update Probability coefficients and feature weights based on senor output
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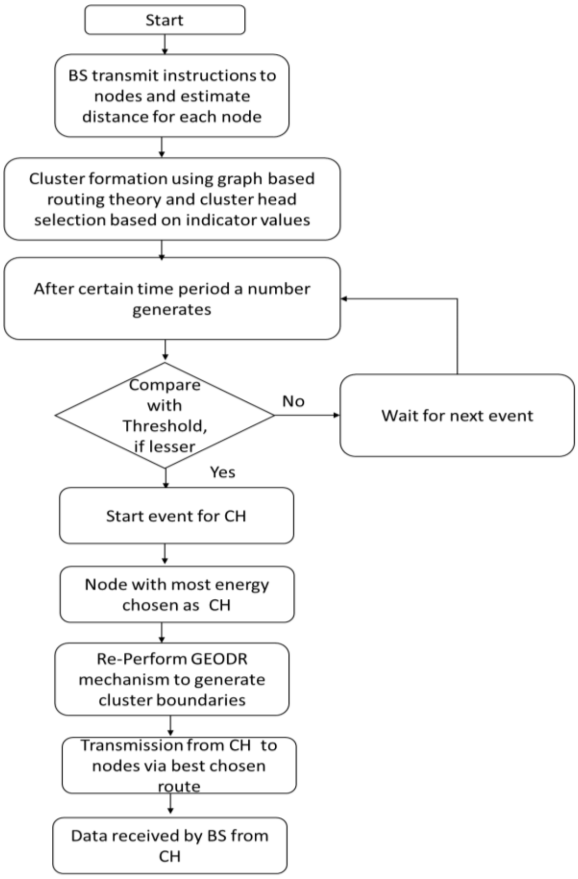

Figure 1. Flow diagram of proposed GEODR mechanism

4. RESULT AND DISCUSSION

In this section, performance efficiency is evaluated using proposed GEODR mechanism and a detailed comparative analysis is presented against varied routing optimization techniques in terms of alive nodes, dead nodes, throughput and node connectivity etc. The strong connectivity between sensor nodes is generated using proposed GEODR mechanism to improve network capacity and throughput of network. A comprehensive analysis is carried out on network performance. The focus area of this research work is formation of cluster with multiple nodes and generate a strong node connectivity so that data transmission accuracy is enhanced between sensor nodes and CH. A dynamic optimized route is selected using graph theory to transmit data packets from CHs to BS. Then, the pre-defined threshold value is compared against generated random numbers periodically and based on their output, the formation of cluster boundaries and CH selection is carried out so that data transmission can take place efficiently in a sensor network. Efficient training is conducted considering rounds and data packets received by CHs. The number of rounds is referred to as the time lapse between the event created by the sink node and data packets received from all the cluster heads. Rounds are normalized to get performance analysis for the proposed GEODR mechanism and existing LEACH mechanism. Performance results and sensor network optimization is performed using MATLAB. However, the proposed GEODR mechanism handles throughput and transmission accuracy efficiently. Several parameters like network area, network width, node energy, and received data packets are the main parameters to perform connectivity in the sensor network.

Furthermore, the performance efficiency of the proposed GEODR mechanism is evaluated by taking 100 sensor nodes in a sensor network and 20 nodes are selected as CHs among those given 100 nodes. Here, Figure 2 shows node connectivity and node density results obtained using Graph Theory to improve the coverage area for data packet transmission. It is evident from Figure 2 results that the coverage area enhances with an increase in node density. Once clusters are formed, graph-based dynamic optimized routing is performed to transmit data packets between nodes and cluster heads. In Figure 2, CHs are represented by green dots and the yellow dot represents a sink node. Vertical and horizontal axis in the graph represents the distance in meter. Dynamic and optimal routing is performed between cluster heads using the proposed GEODR mechanism for 200 rounds. Further, at the sink node, the energy of mobility cost function is determined over 200 rounds.

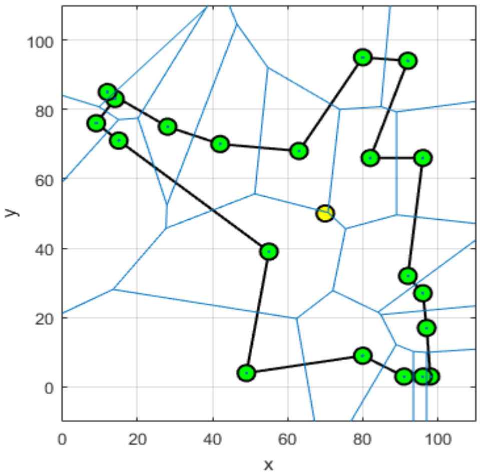

Figure 2. Node connectivity using the proposed GEODR mechanism

Considering the sensor network, the performance of the proposed GEODR mechanism is calculated in terms of a data packet transmitted towards the sink node, mobility cost function minimization, energy consumption reduction, and dead nodes against the number of rounds. Figure 3 demonstrates the energy of mobility cost function minimization against the number of rounds. The number of rounds taken to evaluate mobility cost function energy is 200. Random allocation of CHs is determined based on the obtained mobility cost function energy. The mobility cost function is evaluated to minimize optimum resource utilization in a sensor network. Moreover, the optimum route for data packet transmission is selected with minimum mobility cost.

Figure 4 demonstrates a graphical representation of the number of alive nodes against the number of rounds. The number of rounds taken to determine the number of alive nodes is 9,000. Figure 4 shows a performance comparison of the proposed graph-based dynamic optimized routing mechanism against classical routing optimization techniques like LEACH and SEP. Figure 4 shows that the proposed GEODR mechanism has the number of alive nodes almost five times higher than the traditional SEP routing algorithm and almost four times higher than the classical LEACH routing algorithm. Thus, the overall number of alive nodes is more and remains alive for the number of rounds.

Similarly, Figure 5 demonstrates a graphical representation of the number of dead nodes and data packet transmitted towards BS against the number of rounds. The number of rounds taken to determine the number of alive nodes is 9,000. It is evident from Figure 5 that the first node becomes dead after nearly 1,500 rounds using the proposed GEODR mechanism whereas, in classical routing algorithms like LEACH and SEP, the first dead node appears after the number of 1,000 and 1,050 rounds, respectively. A quantitative analysis of total the network behavioris presented in Figure 6 considering data packet transmission. The rate of data packet transmission is massively enhanced in the proposed GEODR mechanism and compared against traditional routing mechanisms like LEACH and SEP. Figure 7 and Figure 8 demonstrates a graphical representation of residual energy and normalized average energy against number of rounds. The number of rounds are taken to determine number of alive nodes are 9,000.

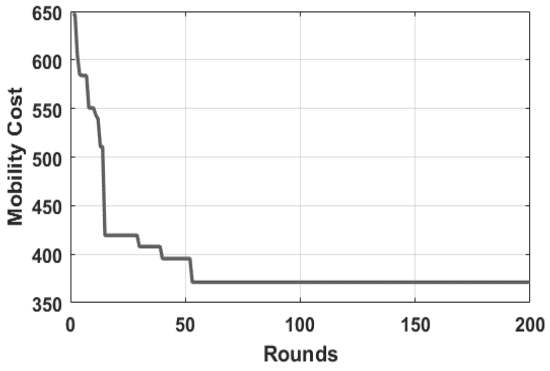

Figure 3. Mobility cost function minimization energy against number of rounds

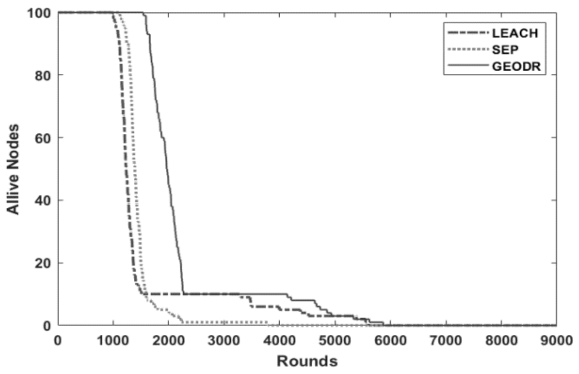

Figure 4. Number of alive nodes against number of rounds

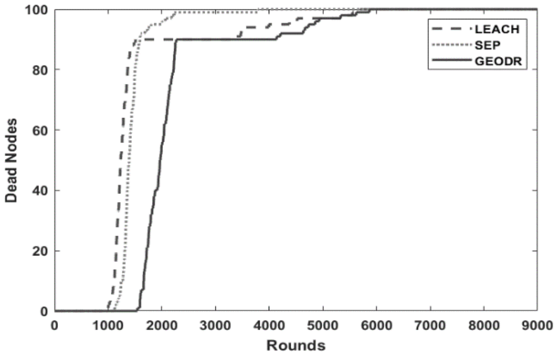

Figure 5. Number of dead nodes against number of rounds

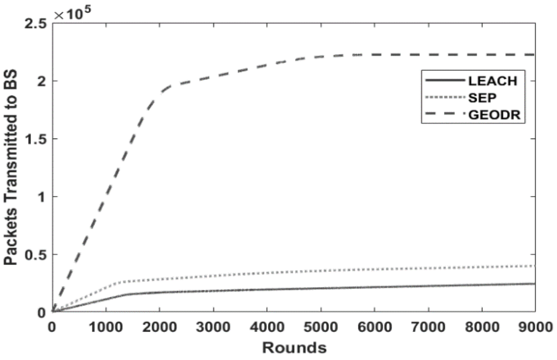

Figure 6. Number of packets transmitted against number of rounds

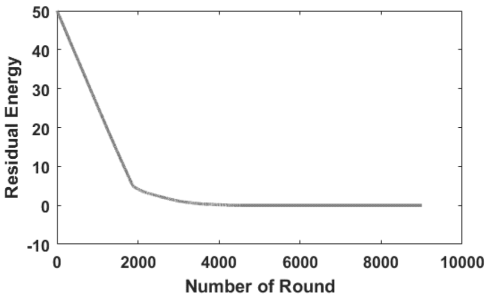

Figure 7. Residual energy against number of rounds

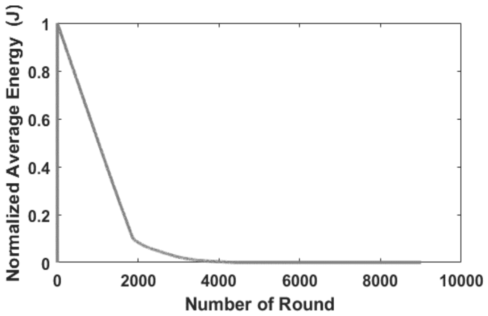

Figure 8. Normalized average energy against number of rounds

It is evident from Figure 7 that residual energy start decaying from number of rounds zero to 2,000 and then becomes constant till 9,000 rounds for proposed GEODR mechanism. This result shows high efficiency of proposed GEODR mechanism in terms of residual energy. Whereas in Figure 8, overall average energy of sensor network is presented. It is evident from Figure 8 that energy drainage rate is quite low and becomes minimum after 4,000 rounds. Thus, proposed GEODR mechanism outperforms the classical routing algorithms like LEACH and SEP in terms of alive nodes, dead nodes and data packet transmission rate.

5. CONCLUSION

The significance of proper and efficient routing mechanism is quite massive in WSNs. Therefore, in this study, a GEODR mechanism is presented to minimize energy consumption and life-time enhancement of sensor nodes in WSNs so that efficient and extended data packet transmission can take place. A detailed mathematical representation of proposed GEODR mechanism is presented to improve network throughput and establish a best suitable route to transfer data packets towards BS. Energy consumption is massively improved using sink node mobility. Based on graph theory, energy utilization can be minimized and cluster radius can be extended. Proposed GEODR mechanism utilizes 100 sensor nodes and 20 sensor nodes are elected as CHs in a sensor network among those 100 nodes. Network connectivity between sensor nodes, CHs and different clusters is obtained using Graph theory. Random allocation of CHs and minimization of optimum resource utilization are determined based on the obtained mobility cost function energy. Simulated results are carried out in terms of alive nodes, dead nodes, residual energy, average energy, and data packet transmission rate against classical routing algorithms like LEACH and SEP. The proposed GEODR mechanism outperforms both the traditional routing techniques in terms of all performance metrics.

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