International Journal of Engineering Trends and Technology
ISSN: 2231 – 5381 /doi:10.14445/22315381/IJETT-V69I4P226

Volume 69 Issue 4, 183-187, April 2021

Optimized Path Selection using GWO routing to enhance the lifetime of Sensor Node in WSN

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Abstract

Wireless sensor networks are used in various fields to monitoring, sensing, and transmitting the information. Nowadays, it acts as a major role in the field of surveillance and health care medical applications. Even in this digital world, in risky places Replacing and recharging the batteries of sensor nodes are not possible. Many researchers focus on improving the lifetime of the sensor network. Various protocols are introduced for energy efficiency and consumption. Optimized path selection helps to transmit the data as soon as possible and avoid data congestion, and it consumes less energy. The proposed grid-based clustering FTM-GRP introduces GWO based routing algorithm to find the best-optimized path between the CH to sink and to the Base station for forwarding the data. MATLAB simulation results show the best performance in network stability and load balancing with less energy for the entire network.

Keywords: *Virtual Grid, Meta Heuristics, Energy Consumption, Delay, Energy Efficiency*

I. INTRODUCTION

In Wireless Sensor Network is made by countless sensor hubs which are conveyed to detect, interact, and speak with others. Every sensor hub has fundamental energy. WSN permits irregular and uniform conveyance of SN. A portion of the applications uses WSN to following the data, checking, reconnaissance, building automation, military application, and others. It is made out of a limited arrangement of sensor gadgets topographically circulated in a given indoor or outside climate. Many researchers develop protocols and techniques to clarify the issues and low power-based sensor and circuit designs [18]. Each sensor network node typically has several parts, a radio transceiver with an internal antenna, a microcontroller, electronic circuit for interfacing with the sensors. WSN faces a very challenging task for energy consumption and energy efficiency. Various routing protocols are used to overcome the problems. Recharging the batteries in sensor nodes is not possible.

In wsn, grid-based clustering is normally preferred. The entire network is divided into a grid-based on network population. But, it suffered by its size and grid count. The network performance also degraded due to its non-uniform deployment. Furthermore, grid-based clustering do not elect a fair cluster head with respect to all nodes in the network.[4] Clustering is used to solve the issues of WSN. In this clustering, concept nodes are separated into a number of clusters. Each cluster has a CH to receive the information from the SN. CH reduces the extra effort of the base station. It avoids the collision between the SN and reduces the overall energy depletion.

Finding the optimal path to transfer the data is also helps to transfer the information quickly. For that, virtual grid algorithms are introduced to separate the network location into the number of grid cells. Each cell contains the CH to receive the data. In network topology, discovering the best set of CH with a Non-deterministic Polynomial hard optimization problem supports consuming less energy to transmit the data.

The remaining section of this paper deals with optimal path selection for data transmission. Sections are organized by the following titles such as Section II Related Works, which describes the previous work that supports grid partition and data transmission, Section III suggests that FTM-HGRP and LOA approach for finding the optimal path, Section IV demonstrate Results and its Discussion. Section V concludes the topics and future enhancements.

II. Related Works

Various routing and clustering algorithms have been proposed for sensor networks. Selvalakshmi, 2020 et al. proposed an algorithm Enhanced cluster head selection approach for improving energy efficiency, Base station act as a selection station to elect a CH based on distance and energy. CH reaches the threshold value, then automatically, the next node in the array act as a CH. Sensor nodes are assigned as cluster members for the CH within the range. In this algorithm, isolated nodes not able to communicate with the base station. [13]

Gou, P 2019 et al. have proposed “A Mean Shift-based node localization algorithm Based on 3D Grid partition and Mean shift Iteration for WSNs” for the virtual grid-based network. This algorithm supports embedding the data objects into 3D space into the number of grid cells. The proposed algorithm uses a density threshold to find the dense units and identify the density-based clusters in the grid cells. It reduces the positioning errors in the localization. It takes multiple iterations to find the optimal solution of probability density.[7]

Kareem et al. 2018 have introduced a routing protocol called a Virtual Grid-Based routing protocol (VGRP) in order to retain load balancing and improve the stability period of WSN. It takes more energy for the sensor node to process the data and balancing the load between the sensor nodes. It uses an energy-efficient routing algorithm. MATLAB results illustrate that the VGRP method beats the conventional algorithm in both network load balancing and network stability periods.[10]

Bhatti et al. 2017 have proposed an improved version of the Virtual Grid-Based routing protocol. The proposed method firstly divides the entire network into k-cells, and the cluster head is selected among cluster members. It achieves energy efficiency by reducing route construction complexity from node to sink. If the number of nodes increased, then it is not possible to calculate the optimal path between the nodes. Takes more route construction cost for different node density.[4]

Amsalu et al. 2016 et al. have proposed a grid-based routing protocol called Grid Clustering Hierarchy (GCH). When compared to other grid protocols, it divides the entire network based on the average energy of the network. To select a cluster head, round-robin scheduling has been used. The network energy uniformity is distributed by using round-robin scheduling. The simulation results show that the proposed approach better than LEACH in terms of total packets received, network lifetime, and the amount of energy spending per successful data report.[3]

III. Proposed algorithm

When compared with other clustering protocols, Grid clustering and routing have less complexities. Grid-based topology helps to divide the location into the number of the grid. Fine Tune Meta heuristic- Hexagonal grid routing protocol (FTM-HGRP) is supposed to divide the network location into the number of the hexagonal virtual grid. Each grid is separated into the same size. The Meta heuristic helps to identify the CH depends upon the residual energy and average distance between the member nodes.

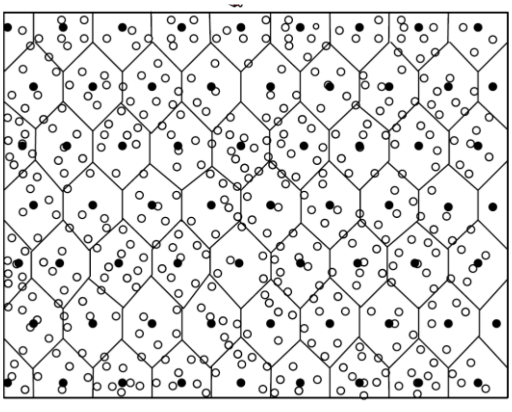


Figure 1 Hexagonal grid division

In Figure1. The hexagonal grid covers a large amount of area than square-shaped clusters. It uses the basic steps of exploration, exploitation, and randomization. FTM-HGPA performs grid partition and CH selection.

SELECTING THE OPTIMIZED PATH

Selecting the optimization comforts to allow the cluster member to transfer the data packets from a cluster member to cluster head. It allows forwarding the data packets. Another important method in this section we proposed the Grey wolf optimization-based optimized path selection algorithm.

$$\text{Minimize } f = \text{Energy} + \text{delay} \qquad (1)$$

In Equ 1, the objective function identifies the best routing node with minimized energy and delay cost.

In Meta, heuristic optimization techniques are used for the following benefits: It eliminates the local minima, complex less implementation. Different types of the algorithm have been introduced to solve the optimization problem, Grey wolf optimization (GWO) identified and inspired with great hunting leadership strategy. Strategy is divided into four categories 1. Alpha, 2. Beta, 3. Delta, and 4. Omega. A number of nodes are grouped in a single cluster. High energy node act as a CH. That CH node is denoted as a leader node.

The leader wolves responsible for hunting, decision making and sleeping places, etc. Next to leader wolves, Beta wolves guide alpha wolves for decision-making. Similar to Beta wolves, delta wolves obey the commands of alpha and beta wolves and instruct other remaining wolves called Omega wolves or sub-ordinate wolves. In hunting, omega wolves have the lowest ranging and hardly help other wolves in critical situations.

The whole chasing cycle of wolves is coordinated into three fundamental developments of wolves: GWO deals with this chasing procedure, and that has made it fascinating. The chasing of Gray wolves depends on three significant moves: (1) following and finding the prey, (2) pursuing and disturbing the prey until prey quits moving, and (3) assaulting the prey. In light of these significant moves, GWO adds to both investigation and misuse stages. To locate the ideal arrangement, surrounding and assaulting related moves are viewed as generally significant. In the enclosing prey stage, the position vector of prey is resolved. The encompassing of prey is communicated as:

$$\vec{M} = |\overrightarrow{K1} \cdot \overrightarrow{L_p}(t) - \vec{L}(t)|$$

$$\overrightarrow{L}(t+1) = \overrightarrow{L_p}(t) - \overrightarrow{K2} \cdot \vec{M} \qquad (2)$$

Where t denotes the current iteration, $K1$ and $\overrightarrow{K2}$ are the coefficient vectors, position vector of the prey is denoted as $\vec{L}p$, L is the position vector.

The vector $\overrightarrow{K1}$ and $\overrightarrow{K2}$ are calculated as follows:

$$\overrightarrow{k1} = 2\vec{u}\,.\vec{d} - \vec{u}\ldots \quad (3)$$

$$\overrightarrow{k2} = 2\,.\vec{d}$$

Where $\vec{u}$ is straightly diminished from 2 to 0 in every cycle and $\vec{d}$ is an irregular vector in [0,1]. The current situation of x and y refreshed to the situation of x* and y* by changing the estimations of coefficients K1 and K2. Because of the bigger space best arrangement not got without any problem. The chasing system to discover the best arrangement with the thought of omega wolves communicated as the situation of the hunt specialist [x,y] is changed depending on the situation of the prey acquired up until now [X*, Y*]. The coefficient vectors A $^{\rightarrow}$ and C $^{\rightarrow}$ are acclimated to accomplish the best specialist in better places. In the Hunting stage, dim wolves are coordinated by αs(alpha), at that point β and δ.

$$\overrightarrow{V_\alpha} = |\,\overrightarrow{a_1} * \overrightarrow{L_\alpha} - L\,|$$

$$\overrightarrow{V_\beta} = \left|\,\overrightarrow{a_2} * \overrightarrow{L_\beta} - \vec{L}\,\right|$$

$$\overrightarrow{V_\delta} = |\,\overrightarrow{a_3} * \overrightarrow{L_\delta} - \vec{L}\,| \quad (4)$$

Where $V\alpha$,$\vec{V}\beta$ and $\vec{V}\delta$ is the updated distance vectors corresponds to other wolves and $a1$, $a2$, and $\vec{a}3$ are the three coefficient vectors used to correct the distance vector. The newly updated vector expressed as :

$$L(\mathrm{k}+1) = \frac{\sum_{i=0}^{n} \vec{l_1}}{n} \quad (5)$$

Where $\vec{L}1$ (t+1) is the concluded new position vector calculated by the position of all updated wolves.

The following algorithm describes the pseudo-code of the entire GWO algorithm.

Initialize the GreyWolf population Pi (i = 1, 2, . . . ,)

Calculate the fitness of each agent
Initialize solutions of Lα, Lβ and Lδ
While (t< solution achieved)
For i = 1: n
Update the current solution using (14)
End for
Calculate the fitness
Update the coefficient K1 and K2
End while

The following algorithm describes the pseudo-code of the entire GWO based routing algorithm

1.Find best-effort route
2: all grid(i,j)
3: **repeat**
4: Apply each node yi(1<i <n) to the grid
5: **for** j = 1 --> k **do**
6: **repeat**
7: Initialize population Lm(1 <m < S)
8: **for** m = 1 → S **do**
9: **for** i = 1 → n **do**
10: Apply node to the minimum distance
11: **end for**
12: find cost function
13: Update the best solution using equation 14
Update coefficient values
16: **end for**
17: **until** reach destination
18: **end for**
19: **end for**
20: **until** the network is dead

Results and Discussion

The proposed algorithm has been implemented using MATLAB, deployment area 500*500m for a simulation time of the 60s. This is because of the proposed convention pick group heads, which balance energy utilization similarly and pick bunches dependent on the most noteworthy leftover energy. Simultaneously, diminishes correspondence overhead by thinking about the distance between hubs. Consequently, keep away from hub bites the dust early, and lifetime gets expanded.

GWO routing

Consider a communication model. In this model, Ërx and Ëtx denote the energy consumption of transmitting a bit of data to distance d and receiving data, correspondingly. The expression for computing energy consumption is as follows:

$$\varphi_{rx} = \varphi_{rx-elec}(a) = a\varphi_{elec}$$
$$\varphi_{tx}(a,d) = \varphi_{tx-elec}(a) = \varphi_{eltx-amp}(a,d)$$

$$\{a\varphi_{elec} + a\varepsilon_{fs}d^2 \quad ,d < d_0$$
$$\{a\varphi_{elec} + a\varepsilon_{fs}d^4 \quad ,d \geq d_0 \quad (6)$$

In the formula, Ëelec is the energy consumption of the device for transmitting and receiving unit data (bit), α_{fs} and αmp are denoted the attenuation coefficients, and d0 =(α_{fs}/α_{mp})1/2 is the distance threshold.

By using the MATLAB simulation platform of the proposed algorithm compared with DHGRP ,QDVGDD, and Hui zhang algorithm using the performance parameters of total energy consumption, the total number of remaining nodes, and packet delivery ratio The detailed simulation parameter is shown in Table 1.

Parameter	Value
Number of nodes	100
Distributed area	500*500
Initial energy of sensor node (Ei)	2J
Ëelec	50nJ/bit
Ëamp	10Pj/bit/m^2
Packet length(l)	4000 bit
Max transmission range(r)	150m
W1(factors in objective function)	0.5
W2(factors in objective function)	0.5

Table 1

Figure 2: Delay analysis

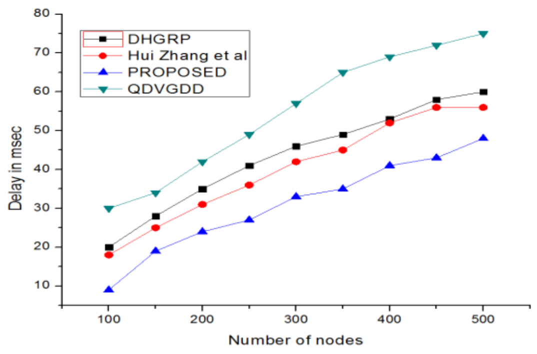


Figure 3: Data Delivery analysis

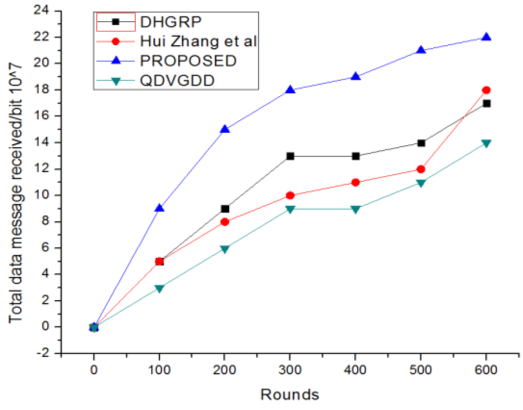
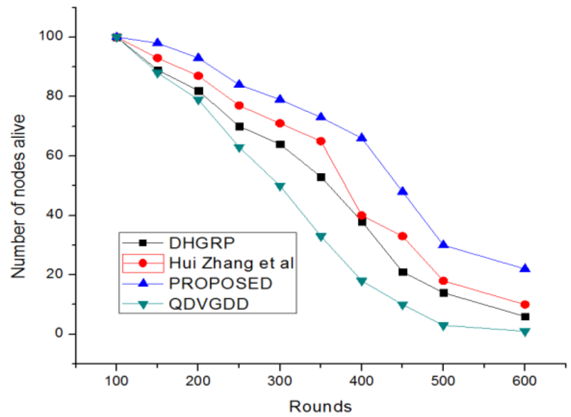


Figure 4: Lifetime analysis



For a sensor organization, lifetime is one the main execution boundary to examine a proposed framework, Figure 2 saw that the proposed GWO best course discovering convention accomplishes the greatest lifetime by diminishing dead hubs. The GWO work used to decrease complete transitional hub consider well as by and large energy utilization from source to the objective.

From the information conveyance diagram, Figure 4, the lifetime chart shows that the absolute message got to the sink hub is higher than other directing conventions. The fundamental explanation is GWO improves the course determination measure by concentrating both the number of steering hubs and energy, which guarantee the conveyance of more parcels to the base station.

Conclusion

For directing, GWO improved steering convention is proposed to lessen the force utilization of remote sensor organizations. The proposed convention selects the best exertion directing way by addressing wellness conditions regarding energy and distance. It disperses the complete energy dissemination of the hubs similarly all through the organization. MATLAB execution results show that the proposed bunching and steering convention with enhanced work improves network lifetime, energy utilization, and bundle conveyance proportion impressively when contrasted with any remaining standard directing conventions. Presently the bunching and correspondence way depends on ideal and least distance. The outcomes have demonstrated critical advancement over the current plan regarding all organization execution boundaries. In the future, we planned to implement the IOT to transfer the data from the location to BS directly using improved GWO.

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