Spider Web Based Layered Hexagonal (SWLH-LR) Architecture For Optimal CH Selection (CHS) With Linear Routing For Extending Lifetime Of WSN

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Abstract. This research paper focuses on designing an efficient bio-inspired architecture called as spider web based layered hexagonal architecture for effective CH selection within a cluster and that helps for extending the lifetime of WSN. This made the researcher of WSN to focuses on WSN based application and the extension of survival time of sensor node(S). There are various parameters which involve in increasing the survival time of sensor node of the WSN, one of the important areas to be concentrated is selection of CH. Out of various sensor node filtering out the best CH is a challenging process, to perform this the clustering technique is used for grouping of few sensor nodes and form it as a cluster. Among this sensor node one of the nodes will be selected as CH. The simulation process for the proposed algorithm was done in MATLAB, which shows efficient results relating with the extension of survival time, DDR and decrease in delay, while comparing with the standard set of algorithm such as GSO, FFOA, ABC, and PSO.

Keywords: CH selection, Bio-inspired architecture, Base station, clustering, Hexagonal linear routing..

1 Introduction

Nowadays WSN are growing tremendously with a recent advent and growth of tiny sensors, microelectronic circuit's devices and wireless form of transmission based communication systems. The WSN comprising of scattered arranged micro sensors with minimum energy and memory capacity and low functioning nature that helps in transferring of data sensed by the sensor node(S) to the sink and further moved on to the system end for analysis process [1]. For the forthcoming 5G based communication environment, the WSN were implemented in different domain based applications such as monitoring of the environment smart home implementation, health environment monitoring, Farming and agriculture, strategic defense applications, oil and nature gas environment and finally rich machinery monitoring in manufacturing industries [2].The major thing is very limited battery capacity for sensors that acts as a hectic bottleneck problem for the operations of the WSN [3]. As the implementation of WSN poses to different hard environment, managing the battery life is challenging task and

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there is limited option for replacement, so in order to manage the battery life and to increase its lifetime, effective use of power based resources and to design an efficient packet transmission process is necessary[4].There are lots of research works to extend the survival time of network using CH (cluster head) selective methodology for balancing load of the network and increase the network performance, the selection and updating of CH from a cluster is a challenging process [5]. The rest of the content of this paper is constructed with the following topics, topic 2 covers the review of the survey of the various papers , topic 3 depicts the proposed algorithm named as SWLH-LR, topic 4 describes the various discussions & results obtained for the SWLH-LR algorithm and finally topic 5 deals with the conclusion of the paper.

2 Review of the Literature

In the year 2018, Zhu & Ma et al [6] proposed that sensor nodes are evenly distributed and packed as a cluster(Cr) and every clusters are controlled by a leader named as cluster head(CH), clustering helps to break down a vast geographical space into smaller areas and distribute the load between all the nodes evenly.In 2015, Zhang et al [7] proposed that selection of CH is an important aspect in sensor networks for providing best pattern of information transmission and the CH selection is random to provide the better performance in terms of data transmission. The major work of CH is to coordinate with all the sensors in a cluster to transmit data effectively. In 2015, Xie et al [8] proposed that optimal CH selection is an essential one to route the collected information from the cluster(Cr) to the sink location present within the sensor(S) network and the process of optimal CH selection is the major factor in managing the sensor network.In 2012, Chen et al [9] proposed Low latency data aggregation schedules algorithm to place the sensor nodes in the branches of spanning trees and transmission of data among them helps to extension of lifetime of each sensor.

In 2016, Zhang et al [10] proposed a clustering routing energy wireless framework for optimal selection of CH using clustering mechanism and network gradients to split the entire network into various small areas equal number of clusters. The results were based on energy used by each sensor node & CH and balance energy that each sensor node possesses after each round.In 2018, Wang et al[11], proposed a PSO based coverage mechanism for sensor network, The entire sensor network is segregated into smaller number of grids and sensor are randomly distributed among the grids and the ability of all the sensor in sensing the data are simulated to provide the best coverage of area. In 2020, Ren et al [12] proposed EECHSs and EH-WSNs, the sensor nodes present within a cluster are categorized into three forms as cluster members, scheduling nodes and cluster head. The CH's are associated with the scheduling nodes shows the better performance in terms of PDR, lifetime.In 2020, Umbreen et al [13] proposed that energy efficient mobility based CH selection. The performance of SNs are evaluated based on the remaining energy, the length range between the cluster head(CH) to the sink(B) aggregation pattern of each clusters and for routing such as single hop and multiple hop were used for data transmission in between the clusters.

3 Proposed [SWLH-LR] CH selection algorithm with linear routing

Here in these algorithm two important things to be focused, one is the data transmission transferred in terms of wave like structure from the centroid position of the architecture. Hexagonal based architecture gives the priority for CH- selection shown in Figure 1.

This hexagonal architecture design has several advantages, the sensor node placement can be fixed and only in the edges of the pattern. So that tightly packed sensor node is possible and manage the coverage problem or black hole problem. The hot spot problem can be solved using this nested hexagonal based architecture design for sensor node placement and the CH selection within a particular cluster.

3.1 Algorithm - Spider web based layered hexagonal based (SWLH-LR) routing

Step 1: Initialization of n parameters and for each cluster initialize centroid S as CH.
Step 2: Initialize first layer S as Alternative set of CH.
Step 3: Calculate the distance between S to B based on n parameter.
Step 4: Find the Highest threshold value, set S as CH and repeat the above step for n rounds.
Step 5: Drafting a Multi-layered nested hexagon shaped architecture.
Step 6: Every layer will act as a cluster with 3 edges or maximum 4 edges, each edges is positioned with a sensor node and angle of coverage of cluster head is 360 degree, so that it will cover all the clusters around it.
Step 7: Placement of Cluster head (CH) in the centroid position of three multi-layered clusters and data is transferred between the sensor(S) and S to the sink location(B) using the multi-hop mechanism and any sensor node would have the ability to transfer the data to the cluster head(CH) with just 1 hop to 4 hops. Dt(S) ← Dt(CH) [1 – 4 hop]
Step 8: One CH would able to cover 3 multi-layered clusters with n sensors.
Step 9: Cluster A will hold a total of 36 sensors and Cluster B will hold a total of 33 sensors and Cluster C will hold a total of 33 sensors and Pr (CH) is the primary CH for all clusters.
Step 10: If the Pr (CH) prone to death, the next level centroid CH of each cluster will come into action as the next CH. Now, the Dt(S)← Dt(CH) [1- 5 hop]
Step 11: Transmission of data from sensor node(S) to cluster head(CH), cluster head(CH) to another CH and cluster head(CH) to Sink(B) follows the linear directional routing strategy.

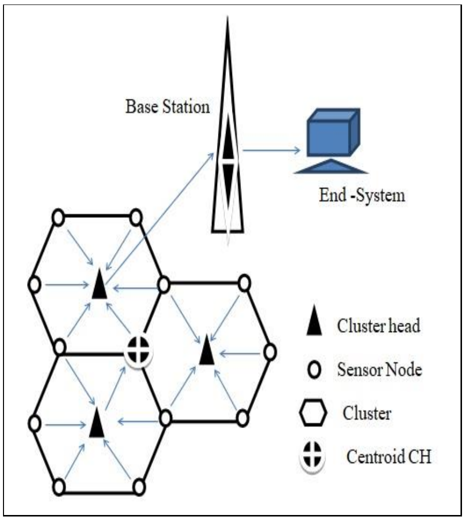

Table 1		
Parameter	**Variable**	**Value**
Deployment area	-	200 m X 200 m
Number of nodes	S	~500
Base Station	B	(x,y)
Data packet size	Dp	2000 bits
Control packet size	Cp	200 bits
Initial energy	Ei	~2 J
Tx & Rx energy	Et & Er	~50 nJ/bit
Clusters	Cr	~25
Residual Energy	R	J
MAC	-	802.11
Model	Multihop	-

Fig. 1. Architectural Diagram Hexagon CH

3.2 Proposed algorithm – PCH – Priority CH selection

Input : Sensing source node S, cluster Cr, Base station or sink B
Output :HTV with best CH
Method :Priority Oriented Efficient CH selection
Let S as Sensing source Node, *Cr as Cluster,* R as Residual Energy of sensor node
Then $S \leftarrow S1, S2, S3 \ldots Sn$, $Cr \leftarrow Cr1, Cr2, Cr3 \ldots Crn$, $R \leftarrow R(S1, S2, S3 \ldots \ldots Sn)$ (1)
To obtain the maximum value of residual energy present within the sensor node(S) using max() function.

$$Max (R (S)) \leftarrow Max (R (S1, S2, \ldots \ldots Sn)) \quad (2)$$

Let the length range between the Sensing Sensor node(S) of the cluster(Cr) as Dt(S)

$$\sqrt{\ } Dt (S) \leftarrow \sqrt{\ } Dt ((S1.. Sn))] \text{ then } Min(\sqrt{\ } Dt (S) \quad (3)$$

Let the length range between the Sensing Sensor node of the cluster(Cr) to the Base station(B) as Dt (Cr(n)(Sn-B))

Then $$\sqrt{\ } Dt (Cr(n) (Sn-B)) \leftarrow [\sqrt{\ } Dt (Sn) - \sqrt{\ } Dt ((B))] \quad (4)$$

To find the minimum distance between the sensing node to the Base station, the below function min() is used $Min (\sqrt{\ } Dt (Cr(n)(Sn-B)))$ (5)

Let the centroid point of the Sensor node as Cd (Cr (S))
Then $$Cd (Cr (S)) \leftarrow ((S1 + S2 + S3 \ldots .. Sn) / n) \quad (6)$$
Let the delay in time during data transmission is calculated using

$$Tt \leftarrow [l / size (dp) / Bw] * (S1, S2, \ldots \ldots \ldots Sn) \quad (7)$$

Then to find the minimum of Tt, the function used is Min (Tt)
To find the cumulative value of all the parameter as Pr

$$Pr \leftarrow \sum [(Tt * (Max (R (S)) + 1) *([Min (\sqrt{\ } Dt (S)) + 2]) *$$

$([Min (\sqrt{} \text{Dt} (\text{S-B})) + 3]) * ((\text{Cd} (\text{Cr} (S)) + 4)))] / n$ (8)

if $(Pr == 6 \lor 7 \lor 8)$ choose as Primary CH and set P-I (9)

else if $(Pr == 3 \lor 4 \lor 5)$ choose as secondary CH and set P-II (10)

else select as Tertiary CH and set P-III.

2 Results and Discussions

The simulation environment for CH selection was worked in MATLAB 2018. This section shows all the results obtained from the algorithm SWLH-LR by comparing with the standard set of existing algorithm such as GSA - Glow worm optimization algorithm, FFOA - fruit fly optimization algorithm, ABC - Artificial Bee colony algorithm, PSO - Particle swarm optimization algorithm, this simulation was done using the MATLAB environment. The simulation parameter and its values used are shown in the Table1.

4.1 Parameter used in the evaluation procedure

The Listed parameters are considered to measure the working condition of the proposed algorithm.

i. Network lifetime: *Network lifetime* = ∑ *rounds* / ∑ *Alive sensor node* (11)

ii. *DDR* = ∑ *Overall data packets reception by all the receiving node* / ∑ *Overall data packet transmitted by all the sending node* (12)

iii. Data rate: *Data rate* = *Total Data transfer (kbps) / Total time taken (ms)* (13)

iv. *D (ms) = average time taken to deliver all the data packets in the network / Average time required to deliver the entire data packet in the network.* (14)

Figure 5 depicts the network lifetime of the proposed algorithm, while comparing with the existing standard set of algorithm this SWLH-LR algorithm gives better results in terms of survival time of the network. The proposed algorithm shows 90.8% increase in lifetime by comparing with the GSO, FFOA, ABC and PSO with 50%, 66.6%, 75%, 83.3%.

Figure 6 depicts the data delivery ratio of the proposed algorithm, while comparing with the standard set of existing algorithm, the proposed algorithm obtains the highest percentage of data delivery ratio. For egs. in 250 sensor node(S), this SWLH-LR algorithm resulted with 74% of DDR, comparing with the GSO, FFOA, ABC, and PSO with lowest DDR of 51%, 59.5 %, 66%, and 68% respectively.

Figure 7 depicts the data rate of propose algorithm, due to linear direction routing the proposed algorithm tends to shown an enhanced data rate of 87 kbps in 250 nodes, whereas the existing algorithm such as GSO, FFOA, ABC, and PSO are with lowest data rate of 58, 63, 74 and 79 kbps.

Figure 8 shows that delay in transmission(D) of the proposed SWLH-LR algorithm by comparing with the existing standard algorithms. For egs., in 250 sensor nodes(S), this SWLH-LR algorithm reached the lowest transmission delay with the value of 27ms by comparing with the GSO, FFOA, ABC and PSO with some higher delay with 44, 43.5, 36 and 34.5 ms.

5 Conclusion and Future work

Extending the lifetime of the WSN is a challenging area focused by all the researcher, As there are numerous parameters involved in simulating the survival time of the sensors(S) packed within the WSN, the architecture paradigm is less focused.

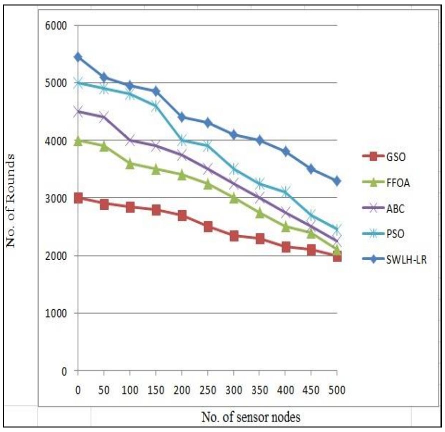

Fig. 2. Network Lifetime vs. total no. of rounds

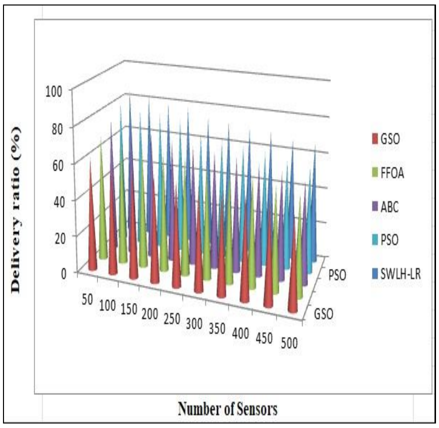

Fig. 3. Data delivery ratio vs. Number of Sensor node(S)

The spider web is a nature based bio-inspired pattern could be used for effective architecture design, that impose best solution for positioning sensor nodes(S) within a cluster(Cr) and that solving the coverage issues in the WSN environment along with optimal CH solution and routing data between the sensors, sensors to cluster head(CH), and cluster head(CH) to sink(B). The SWLH-LR architecture gives primary CH and centroid CH that proves the best in class performance. Thus the proposed algorithm results with 90.8% of extension in network lifetime, 74% of DDR, 87 kbps of data rate and 27ms of delay while comparing with the existing algorithm such as GSO, FFOA, ABC, and PSO. In future the lifetime can be further extended by optimizing the proposed algorithm with artificial intelligence based solution.

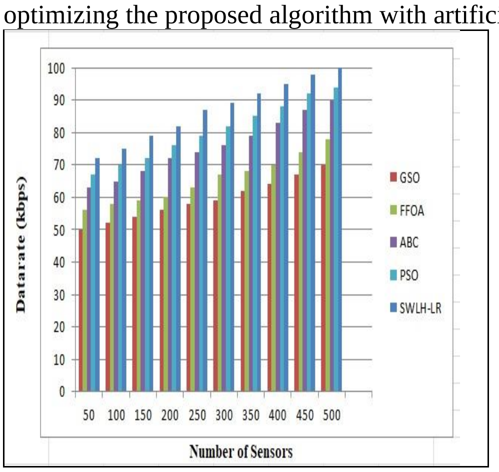

Fig. 4. Data rate vs. Number of Sensor node(S)

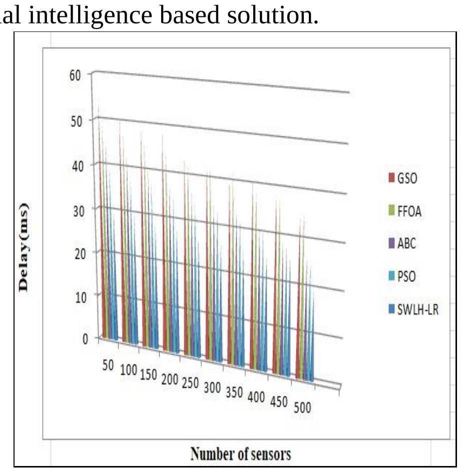

Fig. 5. Delay vs. Number of Sensors node(S)

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