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Sparrow Search Algorithm based Cluster Head Selection in WSN

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Abstract - **Wireless Sensor Networks (WSN) are resource constrained, therefore saving energy is critical. So, the clustering is a better choice to save the energy in WSN. In recent years, the researchers are introduced several clustering protocols to increase the network lifespan. However, clustering techniques have certain drawbacks, including increased latency and a longer time to converge when picking the Cluster Head (CH). To address this problem, this paper presents a Sparrow Search Algorithm (SSA) for determining the CH in a network. Thus, SSA increases the network lifespan. The efficacy of proposed SSA algorithm is compared with popular existing algorithms BOA-C and QOBOA-C. The SSA outperforms by means of lifespan as well as data delivery ratio.**

Keywords- Clustering protocol, Cluster Head, Optimization Algorithm, Wireless Sensor Networks.

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I. INTRODUCTION

WSN is one of the emerging research areas in Information and Communication Technologies (ICT) to remotely monitor the physical environment [1-3]. In WSN, one of the major challenges is the devices are battery powered. So, energy conservation is one of the crucial roles in WSN. The applications of WSN are environmental monitoring, patient monitoring, home monitoring, farm management, etc [4, 5]. In WSN, the nodes are placed either fixed place or random places in the network. Later, we can follow any one of the routing strategy to exchange the data from one place to another [6,7]. Fig.1 illustrates the architecture of WSN. It consists of sensing area and sink node. In the sensing area, the nodes generate the data and exchange the data through intermediate nodes. The Sink node collects the data from sensing area and it is connected to the Internet. Finally, the user can monitor or control the environmental condition remotely [8, 9].

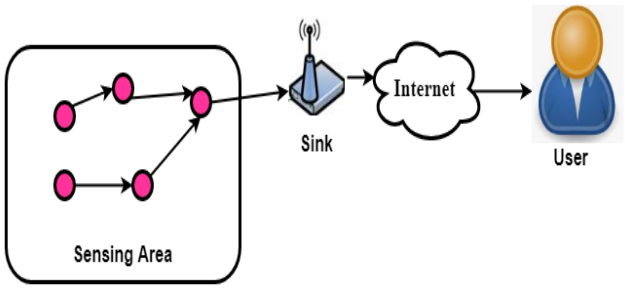

FIG.1 WSN ARCHITECTURE

In WSN, routing is one of the prominent things, which can be used to exchange the data from one node to another. In routing, the researchers have proposed various protocols. However, we have some limitations such as network traffic and load unbalance, more latency. To overcome these limitations, clustering is one of the better choices to exchange the data. Fig.2 illustrates the clustering protocol in WSN.

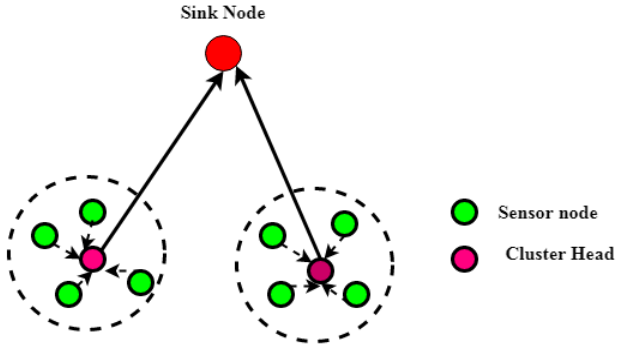

FIG.2 GENERAL ARCHITECTURE FOR CLUSTERING PROTOCOL IN WSN

In clustering protocol, the major role is Cluster Head (CH) in each round. The researchers have followed certain

strategy to pick the CH node in the cluster. The majority of studies have chosen the CH in the cluster using an optimization approach. However, some optimization algorithms require more time to choose the optimum CH in the cluster. So, this paper proposes a Sparrow Search Algorithm (SSA) based CH selection in WSM. The simulation has been conducted using MATLAB. The proposed SSA is compared to BOA-C and QOBOA-C in terms of effectiveness [10-12].

The following sections comprise the paper: The related work is discussed in Section 2. A discussion of the proposed CH selection process that has been developed is presented in Section 3. Section 4 presents the findings as well as the related discussions. Section 5 contains the conclusion as well as recommendations for further study.

II. RELATED WORK

Different cluster-based routing protocols are examined in further detail in Section 2.

Malisetti and Pamula [13] proposed QOBOA algorithm for picking CH in WSN. Saving the energy is a difficult task in WSN, because the devices are limited capacity devices. In clustering, the hierarchical cluster is a better choice to save more energy in the network. The nodes are distributed across the network in a random fashion. The CH is selected using QOBOA. When comparing QOBOA to BOA, the efficiency of QOBOA is higher. The result confirms that the proposed QOBOA provides superior performance by means of network lifespan. During the CH selection process, however, it requires longer convergence time.

Altakhayneh et al. [14] proposed genetic algorithm based CH selection in WSN. In WSN routing, the major changes are lifespan of the network and number packet transfer rate. To address these issues, this article proposed that a Genetic Algorithm be used in LEACH to increase the network's overall lifespan by a factor of ten. In this, The CH node is picked by genetic algorithm. The efficiency of G-LEACH is compared to LEACH. The proposed G-LEACH is improved the lifespan of the network by 61.7%. It is more efficient in all the cases when compared LEACH protocol. However, sometimes take more time to compute best CH in the network.

Swarm Intelligence based Fuzzy clustering (SIF) technique was suggested by Zahedi et al. [15] for use in WSN. The SIF consists of two phases namely, cluster formation and CH selection. Clustering is accomplished using the fuzzy c-means technique. According to fuzzy rules, the CH is chosen from the cluster.. The fitness function is decided by the application requirements. The efficiency of SIF is compared to ASLPR and LEACH-FL. The proposed SIF extended the network's life. However, the objective function for CH selection is varied from application to application.

Singh et al. [16] proposed hybrid optimization algorithm combination of PSO and GSA algorithm called PSOGSA to control the congestion in the network. The PSOGSA is taken into account the multi-objectives. The fitness is computed on the basis of energy. Also, it is considered one of the parameter as arrival data rate, which calculated on the basis of priority. PSOGSA's efficiency is contrasted to that of Adaptive Cuckoo Search (ACS) and CS. Network lifetime and data transfer are improved with the proposed PSOGSA algorithm.

Bhatia et al. [17] proposed genetic algorithm based CH selection WSN. In WSN, the major challenges are energy conservation in the network. In standard LEACH protocol, the CH selection is performed by the probability basis. An evolutionary strategy for selecting the CH in a network is proposed in this study in order to reduce network node energy depletion and depletion. When compared to LEACH, the performance of GADA-LEACH is significantly better. The proposed GADA-LEACH is outperforms by means of lifespan and end to end delay. However, GADA-LEACH protocol is extended the lifespan to certain extent.

III. THE PROPOSED CH SELECTION USING SPARROW SEARCH ALGORITHM

The nodes are considered as sparrow 'S' and it is placed randomly in the network. The positions of sparrows are represented and it is given in Eq. (1).

$$S = \begin{bmatrix} S_{1,1} & \dots & S_{1,d} \\ \vdots & \vdots & \vdots \\ S_{n,1} & \dots . & S_{n,d} \end{bmatrix} \quad (1)$$

where d indicates the dimension, n denotes the number of sparrows.

The fitness function decides the optimal solution in the problem search space. The fitness function is calculated using the network parameter Residual Energy (RER).The value of RER in each node is calculated and it is given in Eq. (2).

$$RER(S_i) = \frac{Available\ Energy}{Total\ Energy} \quad (2)$$

The fitness value of each sparrows can be computed and it is given in Eq. (3).

$$S_{Fitness} = \begin{bmatrix} f(S_{1,1,}\ S_{1,2,\dots\dots\dots S_{1,d}}) \\ f(S_{2,1,}\ S_{2,2,\dots\dots\dots S_{2,d}}) \\ \vdots \\ f(S_{n,1,}\ S_{n,2,\dots\dots\dots S_{n,d}}) \end{bmatrix} \quad (3)$$

The producers (parent sparrow) are the entire caregiver and providing the guidance to other sparrows for finding the

food location. In each iteration, the sparrow movement is calculated and it is given in Eq. (4).

$$S_{i,j}^{t+1} = \begin{cases} S_{i,j}^{t} + \exp\left(\frac{-i}{\alpha \times maximum\ iteration}\right) & if\ rand < AV \\ S_{i,j}^{t} + Q \times L & if\ rand \geq AV \end{cases} \quad (4)$$

Where t represents the present iteration, j represents the dimension, 'i' indicates row, α and rand are random values between 0 and 1, Q follows the normal distribution and it is generated as random number, AV is alarm value between 0 and 1, L is a 1×d matrix in the whole population.

If the producers find the food, the entire sparrow searches the position and eats all the food. The position of the sparrow in each iteration is given in Eq. (5)

$$S_{i,j}^{t+1} = \begin{cases} Q \times \exp\left(\frac{S_{worst}^{t} - S_{i,j}^{t}}{i^2}\right) & if\ i > n/2 \\ S_{p}^{t+1} + \left|S_{i,j}^{t} - S_{p}^{t+1}\right| \times A^{t} \times L & Otherwise \end{cases} \quad (5)$$

Finally, the location of the best food node act as CH. The CH node collects data and sends it to the Sink in an aggregated form.

IV. RESULT AND DISCUSSIONS

The efficacy of SSA protocol is assessed with existing popular protocols BOA-C and QOBOA-C. The simulation has been conducted in MATLAB. The overall network area is 400m ×400m. The nodes are places randomly and these are fixed statically. The sink node is fixed the location at (200, 200). In this simulation, we conducted several times and its maximum iterations are 1000. The simulation setting parameter and its values are given inTable-1.

TABLE I
SIMULATION PARAMETER

Simulation parameter	Values
Simulator	MATLAB
Network area	400m ×400m
Node type	Static
Total number nodes	100
Sink position	(200,200)
Maximum number of rounds	1000

A. *Average Network Lifetime*

Fig.3 shows the number of alive node concerning number of rounds. The efficacy of SSA is compared with BOA-C and QOBOA-C.It is observed that the number of alive nodes in BOA-C, QOBOA-C and SSA are 40, 55, and 65 respectively for the network round of 1000. The proposed SSA protocol increases the network nodes by 25% and 10% compared to BOA-C and QOBOA-C. It is owing to the consideration of SSA during the CH selection.

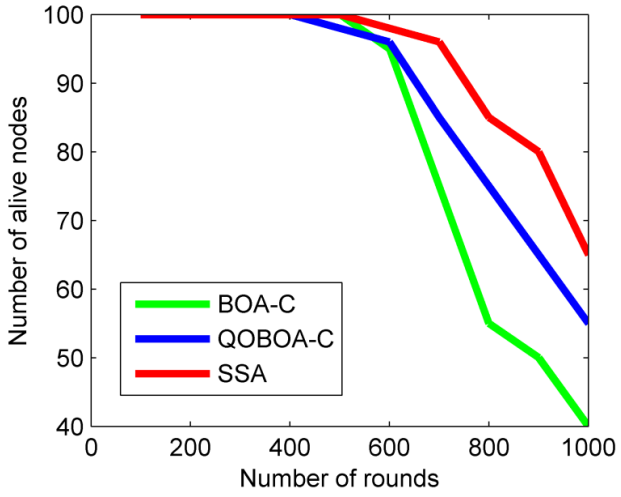

FIG.3 NUMBER OF ALIVE NODES VS. NUMBER OF ROUNDS

B. *Energy Consumption for Sink at (200,200)*

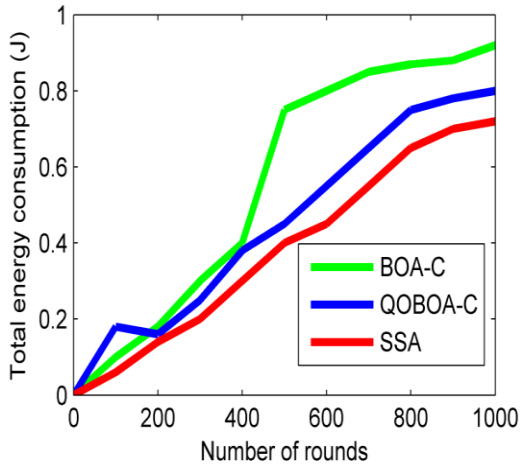

FIG.4 AVERAGE ENERGY CONSUMPTION VS. NUMBER OF ROUNDS

Fig.4 illustrates the average energy utilization each round. The efficacy of SSA is compared with BOA-C and QOBOA-C. It has been observed that the energy consumption in BOA-C, QOBOA-C, and SSA is 0.92J, 0.80J, and 0.72J, respectively, for the network round of 1000 in each of the three algorithms. The proposed SSA protocol decreases the energy consumption by 20% and 8% compared to BOA-C and QOBOA-C. It is owing to the consideration of SSA during the CH selection.

C. *Total number of packets Received by Sink*

The total number of data packets that the sink has received is shown in Fig. 5. The efficacy of SSA is compared with BOA-C and QOBOA-C. Based on where the sink was positioned, it displayed the total number of packets

that had been received. The number of packets in BOA-C, QOBOA-C and SSA are 8000, 8500 and 9000 at the Sink location (200,200). The number of packets in BOA-C, QOBOA-C and SSA are 4000, 5000, 6000 at the Sink location (200,400).The number of packets in BOA-C, QOBOA-C and SSA are 3800, 4500 and 5500 at the Sink location (200,420). The maximum number of packets that may be received by a sink at a given location should be kept in mind (200,200).

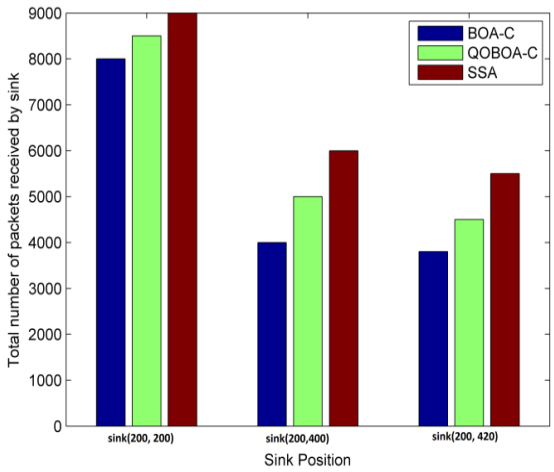

FIG.5 TOTAL NUMBER OF PACKETS RECEIVED BY SINK

V. CONCLUSION

In a WSN, conservation of energy is critical because the devices are limited in capabilities. The CH node in the network was chosen using an SSA approach presented in this paper. Because of this, SSA extends the life of the network and speeds up data transmission. The efficacy of proposed SSA algorithm is compared with popular existing algorithms BOA-C and QOBOA-C. The SSA extends the life expectancy by 10-15% and boosts the data delivery ratio by 5–10%.

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