



# Mitigating Hot Spot Problem in Wireless Sensor Networks using Political Optimizer Based Unequal Clustering Technique

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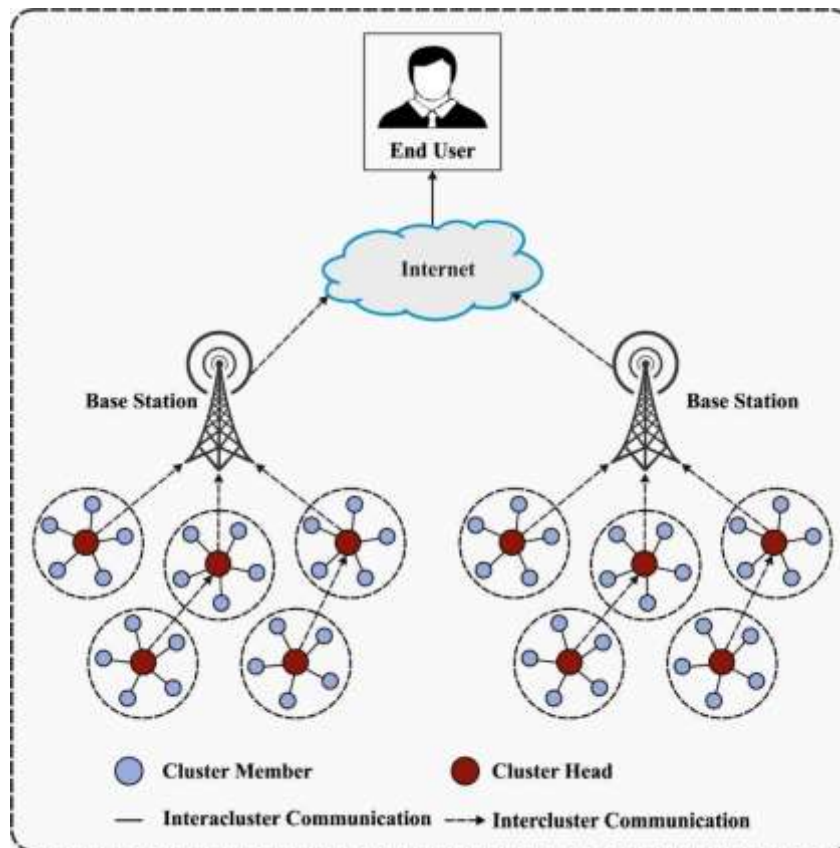
## Abstract

Wireless Sensor Network (WSN) encompasses a set of wirelessly connected sensor nodes in the network for tracking and data gathering applications. The sensors in WSN are constrained in energy, memory, and processing capabilities. Despite the benefits of WSN, the sensors closer to the base station (BS) expels their energy faster. It suffers from hot spot issues and can be resolved by the use of unequal clustering techniques. In this aspect, this paper presents a political optimizer-based unequal clustering scheme (POUCS) for mitigating hot spot problems in WSN. The goal of the POUCS technique is to choose cluster heads (CHs) and determine unequal cluster sizes. The POUCS technique derives a fitness function involving different input parameters to minimize energy consumption and maximize lifetime of the network. To showcase the enhanced performance of the POUCS technique, a comprehensive experimental analysis takes place, and the detailed comparison study reported the better performance of the POUCS technique over the recent techniques.

**Keywords:** Unequal clustering, WSN, Energy efficiency, Cluster head, Hot spot problem, Political optimizer.

## 1. Introduction

WSN is made out of massive SNs portrayed by compactness, minimal expense, and energy utilization. In this way, WSN is broadly utilized in military observation, environment, and climate checking, catastrophic event cautioning and therapy, shrewd clinical innovation, and different fields [1, 2]. WSN are separated into static WSN and mobile WSN as per the SNs [3, 4]. At the stationary WSN, the area of SNs is fixed whenever it's sent. Since SNs with restricted energy close to the static BS might be frequently allocated as cluster head (CH), prompting high energy utilization of those SNs may cause unexpected passing of those SNs. In mobile WSN, the SNs can move as per explicit mission, in this manner, portable sink might be acquainted with ease energy utilization of SNs close by BS [5-7]. To manage the WSN challenges, numerous energy-efficient methodologies have been proposed, incorporating energy-effective MAC layer protocol, routing, aggregation, clustering, and so on [8-11]. In a cluster-based model (as shown in Figure 1), the SNs are assembled into many clusters with a fixed cluster count [12].



**Figure 1. Overview of clustering in WSN**

During scheduling, a set of SNs are actuated for a couple of rounds to check the objective district. While the leftover SNs will be in a rest mode, this technique will safeguard the energy of the SNs, which will delay the organization's lifetime [13]. As referenced previously, the SNs have restricted range in their detecting and sending process, and the SNs can convey just in case they are inside a similar transmission range. In clustering process, SNs are coordinated into clusters that comprise cluster heads (CHs) and cluster individuals (CMs). CMs gather and send the information to their particular CH. CHs assume information accumulation/combination responsibility to decrease information repetition and forward handled information to the BS through single jump or multi-bounce. Clustering strategies in WSN enjoy many benefits like high energy effectiveness, low duplication, crash aversion, etc. In any case, there are a few issues in cluster-based models [14]. In a large-scale WSN, the multi-hop data transmission takes place to save energy. In this situation, the CHs nearer to the BS will take on additional sending errands, which brings about the substantial overhead of CHs, and these CHs will run out of force sooner than different SNs. It causes the breakdown of the cluster and the correspondence lost between CHs, named as hot spot issue. Moreover, because CHs are liable for amassing/melding information from part SNs and sending information to BS, the CHs burn through more energy than CMs, which additionally prompts energy unbalance of generally speaking organization. The unequal clustering strategy is perhaps the most productive approach to managing hot spot issues since it may be very well for load adjusting among the CHs [15].

This paper presents a political optimizer-based unequal clustering scheme (POUCS) for mitigating hot spot problems in WSN. The goal of the POUCS technique is to choose cluster heads (CHs) and determine unequal cluster sizes. The POUCS technique derives a fitness function involving different input parameters to minimize energy consumption and maximize lifetime of the network. To showcase

the enhanced performance of the POUCS technique, a comprehensive experimental analysis takes place and the detailed comparison study reported the better performance of the POUCS technique over the recent techniques.

## 2. Related works

An enhanced BA method is proposed for improving the uneven clustering technique by making group beforehand electing CHs [16]. Based on power storing, know the position of the sink node in WSN plays an important role. According to the Metaheuristic method, BA, PSO, and WOA is currently an effective clustering method. Calculate the network lifespan; this study proposed a developed BA. Moussa et al. [17] proposed an ECRP-UCA and enhanced ACO technique. This method splits the network into uneven clusters according to remaining energy, distance to sink, amount of neighboring node, and a novel parameter called the amount of backward relay node in prior rounds for appropriately balancing the loads amongst CHs. They proposed a batch-based clustering technique that allows the networks to function with no requirement controls for their configurations. Furthermore, devised an enhanced ACO-dependent routing method for reliable and efficient intercluster routings from CH to sink.

In [18], fuzzy dependent uneven clustering and CAR process using GSO is proposed in RWP dependent active WSN. According to FL, uneven clustering is made, and an optimum CH is chosen to convey the data from CM to BS to increase the systems lifetime and decrease the power utilization. Furthermore, the routing processes are executed with the CAR process using GSO procedure to enhance network efficacy. Finally, research on FF detection is provided as an explanation of the proposed model. In [19], a CSO-dependent algorithm was presented, as CSO-UCRA. Firstly, the CH election method was proposed that depends upon the CSO method, then allocates the non-CH sensor to CH according to the derivative CH ability functions. Lastly, a CSO-depending routing method was proposed. An effective particle encoding scheme and new FF was proposed.

In [20], an EAUCA is presented for diminishing the power hole and improve the network lifespan. The presented EAUCA creates an uneven cluster in the BS that the neighborhood is small compared to the furthest. The competition radius for dividing the networks into uneven clusters is determined as nodes remaining energy and distance. The CH is picked up concerning energy and a nodes amount in a competition radius. In [21], a new secured uneven clustering method using the IDS method is proposed for achieving QoS parameters such as security, energy, and lifetime. Firstly, the presented method utilizes an adoptive neuro-fuzzy dependent clustering method to select the TCH with three input parameters: remaining energy, distance to BS, and neighbor. Next, the TCH competes for the last CH and the optimum CH is elected by the DHO. The DHO dependent clustering method derives an FF with link quality, energy, distance to BS, node degree, and node centrality.

## 3. The Proposed Model

PO is stimulated from the concept of politics that encompasses two major processes. An initial consideration is that the citizens aim to optimize the friendliness for succeeding in the voting process. The next concern is that every party attempts to get many seats in the parliament. The PO comprises five distinct stages: party formation & constituency allot, vote campaign, party switch, inter-party election, and parliamentary affair [22]. The procedure involved in the PO is detailed in the following. The whole population under split into  $n$  political parties, as given in the following.

$$P = \{P_1, P_2, P_3, \dots, P_n\} \quad (1)$$

The parties comprise  $n$  party members, as given below.

$$P_i = \{p_i^1, p_i^2, p_i^3, \dots, p_i^n\} \quad (2)$$

The party members include  $d$  dimensions, as represented below.

$$p_i^j = [p_{i,1}^j, p_{i,2}^j, p_{i,3}^j, \dots, p_{i,d}^j]^T \quad (3)$$

The solutions represent an election candidate. Let  $n$  electoral districts exist as defined below.

$$C = \{C_1, C_2, C_3, \dots, C_n\} \quad (4)$$

It is considered that there are  $n$  members in every individual constituency, as provided in the following:

$$c_j = \{p_1^j, p_2^j, p_3^j, \dots, p_n^j\} \quad (5)$$

The party leader can be represented as the member with the optimal fitness in the party, as defined in the following:

$$q = \operatorname{argmin}_{1 \leq j \leq n} f(p_1^j), \forall i \in \{1, \dots, n\} \quad (6)$$

$$p_i^* = p_i^q \quad (7)$$

Every party leader can be demonstrated as follows.

$$P^* = \{p_1^*, p_2^*, p_3^*, \dots, p_n^*\} \quad (8)$$

The victors of the diverse electorates are named parliament members, which can be denoted as follows.

$$C = \{c_1^*, c_2^*, c_3^*, \dots, c_n^*\} \quad (9)$$

At the time of the voting campaign phase, the following equations are used to update the meaningful solutions' location.

$$p_{i,k}^j(u+1) = \begin{cases} \text{if } p_{i,k}^j(u-1) \leq p_{i,k}^j(u) \leq m^* \text{ or } p_{i,k}^j(u-1) \geq p_{i,k}^j(u) \geq m^*, \\ \quad m^* + r(m^* - p_{i,k}^j(u)); \\ \text{if } p_{i,k}^j(u-1) \leq m^* \leq p_{i,k}^j(u) \text{ or } p_{i,k}^j(u-1) \geq m^* \geq p_{i,k}^j(u), \\ \quad m^* + (2r-1)|m^* - p_{i,k}^j(u)|; \\ \text{if } m^* \leq p_{i,k}^j(u-1) \leq p_{i,k}^j(u) \text{ or } m^* \geq p_{i,k}^j(u-1) \geq p_{i,k}^j(u), \\ \quad m^* + (2r-1)|m^* - p_{i,k}^j(u-1)|; \end{cases} \quad (10)$$

$$p_{i,k}^j(u+1) = \begin{cases} \text{if } p_{i,k}^j(u-1) \leq p_{i,k}^j(u) \leq m^* \text{ or } p_{i,k}^j(u-1) \geq p_{i,k}^j(u) \geq m^*, \\ \quad m^* + (2r-1)|m^* - p_{i,k}^j(t)|; \\ \text{if } p_{i,k}^j(u-1) \leq m^* \leq p_{i,k}^j(u) \text{ or } p_{i,k}^j(u-1) \geq m^* \geq p_{i,k}^j(t), \\ \quad p_{i,k}^j(u-1) + r(p_{i,k}^j(u) - p_{i,k}^j(u-1)); \\ \text{if } m^* \leq p_{i,k}^j(u-1) \leq p_{i,k}^j(u) \text{ or } m^* \geq p_{i,k}^j(u-1) \geq p_{i,k}^j(u), \\ \quad m^* + (2r-1)|m^* - p_{i,k}^j(u-1)|; \end{cases} \quad (11)$$

For balancing the tradeoff between exploration and exploitation, party switch process take place. An adaptive parameter  $\lambda$  is utilized that linearly reducing from 0 to 1 at the time of iteration procedure. Every candidate is chosen based on the probability  $\lambda$  and swapped with the poor member of an arbitrarily elected party, as defined below.

$$q = \operatorname{argmax}_{i \leq j \leq n} f(p_i^j) \quad (12)$$

At the time of election phase, the conqueror in a constituency can be accomplished using Eq. (13):

$$q = \operatorname{argmin}_{i \leq j \leq n} f(p_i^j) \quad (13)$$

$$c_j^* = p_q^j$$

An objective function has been modeled with minimized the optimization of entire transmission distance in the cluster member for CHs and CHs to BS apart from with balance energy utilization

amongst the CH and group member. Mentioning that Eq. (14), the CHs have been elected dependent upon energy remaining.

$$f_1(x_i) = \frac{\sum_{i=1}^N E_i}{\sum_{k=1}^k E_{CH_k}} \quad (14)$$

Eq. (6) utilizes only the optimized module, which is independent of parameters compared with microcontroller and supply voltage distance. Therefore,  $E_{frame}$  refers to one of the issues of energy loss depends on the distance of cluster in WSN. Thus, the utilizing energy of the network has been depended on the distance from the cluster. The sensor nodes were clustered by utilizing total distances such as  $E_{distance}$ , where  $k$  is the provided cluster.

$$E_{distance} = \sum_{j=1}^k \sum_{i=1}^{n_i} \left( d_{ij}^2 + \frac{D_j^2}{n_j} \right) \quad (15)$$

Another issue which results of the fitness function has been computed as:

$$f_2(x_i) = \min \left( \sum_{j=1}^k \sum_{i=1}^{n_j} \left( d_{ij}^2 + \frac{D_j^2}{n_j} \right) \right) \quad (16)$$

Where  $\sum_{j=1}^k n_j + k = N$  implies the number of nodes from the networks,  $d$  and  $D$  are the intra and inter-cluster distances correspondingly [23]. An objective function to the equivalent cluster from the WSN is determined as:

$$\text{Minimize } F = \theta \times f_1(x_i) + (1 - \theta) \times f_2(x_i) \quad (17)$$

Where  $\theta$  represents the weight of an objective function, these unequal clustering scenarios are considered to manage the hot spot issue in WSN. The separated cluster in the network of uneven clusters is distinct sizes. The sets nearly the BS are lesser to individual's cluster distant in the BS [23]. To avoid this hot spot issue, it can be defined that adaptable parameters are not only compared with objective function but also with the optimized technique. To the objective function of creating an unequal cluster all CH requires for adjusting their equivalent cluster distance:

$$D_j = D_j \times R_c \quad (18)$$

where  $D_j$  refers the distance in node  $CH_j$  to BS, and  $R_c$  represents the ratio modifying parameter. The computation to  $R_c$  has been determined as:

$$R_c = \left[ 1 - \alpha \frac{d_{\max} - D_j}{d_{\max} - d_{\min}} - \beta \left( 1 - \frac{E_r}{E_{\max}} \right) \right] \times R_{\max} \quad (19)$$

Where  $d_{\max}$  and  $d_{\min}$  are the maximal and minimal distance of CH from the network to BS,  $R_{\max}$  signifies the maximal value of competition radius,  $\alpha$  stands for the weighted factor whose value from 0 and 1, and  $E_r$  indicates the remaining energy of  $CH_j$ . The optimized clustering formation has been complete by carrying out an optimum objective function in Eq. (17) with the assistance of distinct distances Eqs. (18) and (19).

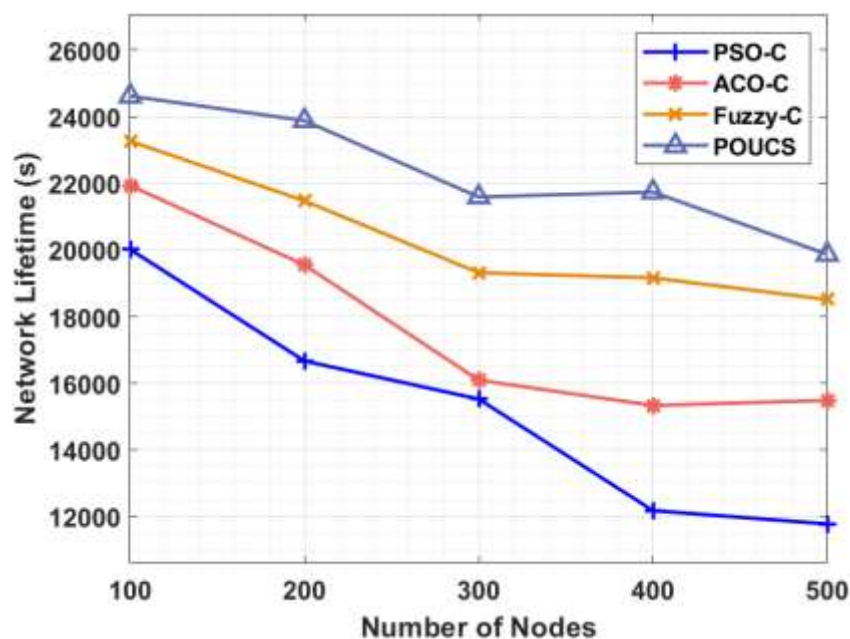
#### 4. Experimental Analysis

The proposed POUCS technique is simulated using MATLAB tool. The results are assessed interms of network lifetime (NLT), total energy utilization (TEC), and throughput in Table 1. Figure 2 investigates the NLT analysis of the POUCS technique with existing techniques under different node counts. The results demonstrated the supreme performance of the POUCS technique with the maximum NLT. For instance, with 100 nodes, the POUCS technique has accomplished an increased NLT of 24627 rounds, whereas the PSO-C, ACO-C, and fuzzy-C techniques have obtained a reduced NLT of 20020, 21939, and 23273 rounds, respectively. Moreover, with 300 nodes, the POUCS technique has

accomplished an increased NLT of 21596 rounds, whereas the PSO-C, ACO-C, and fuzzy-C techniques have obtained a reduced NLT of 15529, 16096, and 19321 rounds, respectively.

**Table 1 Results analysis of POUCS technique under varying node count**

Network Lifetime (s)				
Number of Nodes	PSO-C	ACO-C	Fuzzy-C	POUCS
100	20020	21939	23273	24627
200	16671	19555	21480	23889
300	15529	16096	19321	21596
400	12178	15335	19167	21745
500	11777	15488	18518	19873
Total Energy Consumption (J)				
Number of Nodes	PSO-C	ACO-C	Fuzzy-C	POUCS
100	7.59	5.46	3.94	2.38
200	11.52	10.54	7.38	5.52
300	13.29	12.83	10.73	7.88
400	15.61	12.23	10.64	9.72
500	18.07	15.25	12.67	10.08
Throughput (Kbps)				
Simulation Time (s)	PSO-C	ACO-C	Fuzzy-C	POUCS
200	37.39	32.46	48.01	55.61
400	45.04	43.22	50.79	62.96
600	50.71	47.02	58.81	63.64
800	57.50	51.74	62.86	70.55
1000	58.72	57.79	64.99	71.80



**Figure 2. NLT analysis of POUCS Technique under diverse nodes**

Furthermore, with 500 nodes, the POUCS technique has accomplished an increased NLT of 19873 rounds whereas the PSO-C, ACO-C, and fuzzy-C techniques have obtained a reduced NLT of 11777, 15488, and 18518 rounds, respectively.

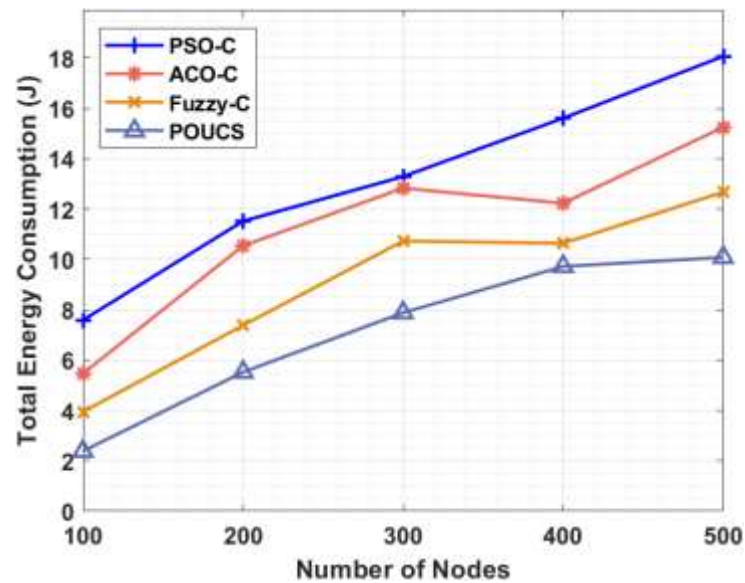
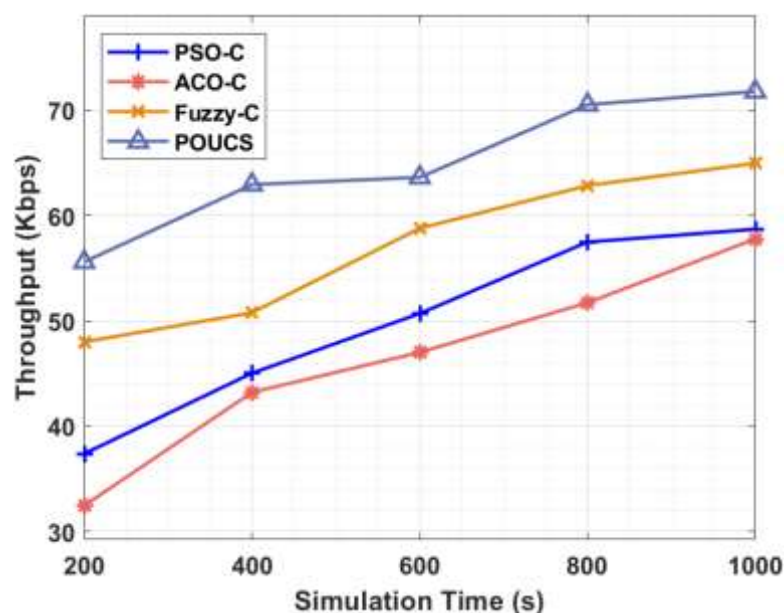


Figure 3. TEC analysis of POUCS Technique under diverse nodes

Figure 3 investigates the TEC analysis of the POUCS technique with existing techniques under different node counts. The results confirmed the ultimate performance of the POUCS technique with the lower TEC. For instance, with 100 nodes, the POUCS technique has offered a reduced TEC of 2.38J, whereas the PSO-C, ACO-C, and fuzzy-C techniques have resulted in an increased TEC of 7.59J, 5.46J, and 3.94J rounds, respectively. At the same time, with 300 nodes, the POUCS technique has offered a minimal TEC of 7.88J rounds, whereas the PSO-C, ACO-C, and fuzzy-C techniques have achieved a maximum TEC of 13.29J, 12.83J, and 10.73J rounds, respectively. Additionally, with 500 nodes, the POUCS technique has accomplished a decreased TEC of 10.08J. In contrast, the PSO-C, ACO-C, and fuzzy-C techniques have obtained an increased TEC of 18.07J, 15.25J, and 12.67J rounds, respectively.



#### Figure 4. Throughput analysis of POUCS Technique under diverse simulation time

Figure 4 examines the throughput analysis of the POUCS technique with existing techniques under different simulation periods. The results demonstrated the supreme performance of the POUCS technique with the maximum throughput. For instance, with 200s simulation time, the POUCS technique has accomplished an increased throughput of 55.61Kbps. In contrast, the PSO-C, ACO-C, and fuzzy-C techniques have obtained a reduced throughput 37.39Kbps, 32.4Kbps, and 48.01Kbps respectively. With 600s simulation time, the POUCS technique has accomplished an increased throughput of 63.64Kbps, whereas the PSO-C, ACO-C, and fuzzy-C techniques have obtained a reduced throughput 50.71Kbps, 47.02Kbps, and 58.81Kbps rounds, respectively. With 500 nodes, the POUCS technique has accomplished an increased throughput of 71.80Kbps, whereas the PSO-C, ACO-C, and fuzzy-C techniques have obtained a reduced throughput 58.72Kbps, 57.79Kbps, and 64.99Kbps, respectively. Therefore, the POUCS technique has appeared as an effective tool to mitigate hot spot problems in WSN.

#### 5. Conclusion

In this study, a new POUCS technique is derived from resolving the hot spot problem in WSN. The POUCS technique intends to elect CHs and compute unequal cluster sizes. The POUCS technique derives a fitness function involving different input parameters to minimize energy consumption and maximize the network's lifetime. To showcase the enhanced performance of the POUCS technique, a comprehensive experimental analysis takes place, and the detailed comparison study reported the better performance of the POUCS technique over the recent techniques. Therefore, the POUCS technique can be employed as a proper tool to alleviate hot spot issues in WSN. In the future, intelligent time synchronization techniques can be included to enhance the efficiency of the WSN.

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