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Improving IoT based WSN Lifetime using Cuckoo Search Optimization

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Abstract: A Wireless Sensor Network (WSN) is a collection of energy- and processing-constrained devices that collect information on a variety of occurrences. Clustering organization, which groups sensors hierarchically and designates one of them as a CH, is an efficient way to extend the lifetime of a wireless sensor nodes. A such CH is in charge of individual behaviors including such collecting data from other cluster sensors and relaying it to the base station over the internet. The process of collecting data is enhanced and, as a result, the lifetime of the network is extended when using a cluster-head organization. The existing I-Sep approach, considered for comparison in this research, distinguish cluster heads based on energy and has the disadvantage of consuming more energy if the higher energy node is far away from the BS. Cuckoo search algorithm was deployed to solve the energy-efficient CH selection, which presented several criteria such as fitness function, computational cost, and so on, and quickly chose a better CH that used less energy. The simulation findings reveal that, when compared to the existing method I-SEP, the dynamic cluster head selection method using CSA provides more energy efficiency in terms of the number of alive nodes, dead nodes, remaining energy and throughput of the network.

Keywords: WSN, Heterogeneous Network, CH selection, Network lifetime, Cuckoo Search approach.

1. INTRODUCTION

Wireless Sensor Networks (WSNs) are used for a variety of applied to a wide scale of situations, including emergency aid, smart cities, precision agriculture, health care. A WSN is comprised of a large number of energy- and processing-constrained devices that collect data on a set of events [1]. As a result, it is preferable that the system remain operational for as long as possible. Sensors are often placed at randomly in a pre-determined region and broadcast the collected data via the internet to a BS in another location. The organization of sensors in groups, which organizes the sensors hierarchical manner in groups & appoints one of them as a CH according to particular requirements, is an efficient way to extend the lifetime of a wireless sensor system. A cluster head is in charge of specific activities, such as collecting information from other sensors in the cluster & transmitting it to a BS through the system. The green color square in Figure 1 represents a SN, while the orange color square represents a base station, both of which act as the data processing step for the system.

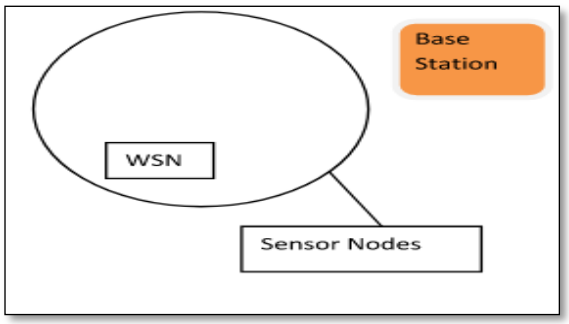

Figure 1: Generic wireless sensor network[2]

Components of WSN

The BS and SN are the two primary elements of a WSN network, so they are explained below:

Sensor node: It has the ability to collect information & communicate via a network[3].

Base station: It is usually believed of as simply a component that collects information from numerous nodes. To share knowledge, a WSN Application & BS are connected to the Web. Information processing, evaluation, storage, and extraction can all be done with WSN. Sensors are used in WSN to gather data as well as to collect climatic conditions. Since action should be taken on the information at the BS, every sensor in the system sends data to the BS. The BS send commands to the sensor nodes, or the SN collaborates to complete the allocation, after evaluating the information. The SN transmits the relevant information to the Bs after collecting it.

The rest of this article is structured as obeys. Section II describes the Clustering the suggested approach. Section III presents the Cuckoo search. Section IV represents the literature survey. Section V shows the proposed Work. Section VI shows results. Section VII gives the conclusion of the proposed work.

II. Clustering

Clustering is a technique for increasing the lifetime of a sensor system by reducing the amount of resource it consumes. A high level of connectivity is required for data transfer. Clustering may also aid in increasing system scalability.

As a result of the use of cluster heads, the data gathering process is enhanced, as well as the life time is increased as a result. However, because of the additional tasks that each CH must complete, their own energy is depleted quicker than that of the neighboring sensors. When a cluster head's batteries run out, a replacement CH must be selected among the rest of the cluster's sensors in order to continue with the head's functions. The cluster heads might well be chosen at random or according to predetermined parameters such as residual energy, node distance, signal intensity, or connection. As a result, such criteria are dependent on the optimization goals, such as maximizing network lifetime or reduce electricity use. Furthermore, because every sensor in the network could be a CH, selecting one is a combinatorial challenge. The WSN clustering as well as cluster-head selection issue is acknowledged to be NP-hard. The CH selection model can be formulated as a generic multi-objective optimization problem in general, such as a resource allocation problem with input data, necessary outputs, objective function optimization, as well as constraint satisfaction [3].

As a result, certain goals are simple to find, like maximizing network lifetime, maximizing coverage, reducing cost, decreasing energy usage, or maximizing spectrum utilization. Nonetheless, based on the sensor device's specific purpose, there could be a broad array of goals that should be optimized. As a result, it's critical to figure out which objectives are important to the issue and which can be improved by achieving other goals, because it's generally recognized that not all of them are required [4].

III. Cuckoo Search Approach

The Cuckoo Optimization Concept is derived by the life of a 'cuckoo' bird[5]. This innovative efficiency approach is based on the bird's specific breeding and egg laying behaviour. This modeling was done with adult cuckoos & eggs. Adult cuckoos lay their eggs in the nests of other birds. If the eggs are not discovered and destroyed by the host birds, they will grow into a full cuckoo. Cuckoo migration and external conditions should hopefully drive them to meet and find the best location for reproduction and breeding. This is the optimum location for the optimization problem. Yang & Deb created Cuckoo Optimization in 2009, which was influenced by nature. Rajabioun created the Cuckoo Optimization Technique in 2011. The Cuckoo Optimization Technique (COA) is a brand-new continuously all-aware search method inspired by the life of a cuckoo bird. COA, like other meta heuristics, starts with a core community of cuckoos. Other host birds' habitats are used by these cuckoos to lay their eggs. The habitat in COA is represented by a random assortment of appropriate solutions.

Cuckoo Search Implementation steps

A cuckoo egg signifies a fresh happened solutions, so each egg in a nest represents an alternative. The goal is to use new and perhaps superior alternatives (cuckoos) in the nests to substitute less-than-ideal alternatives. Each nest has one egg in its most basic form. The approach could be expanded to more sophisticated scenarios, such as when each nest contains many eggs, each representing a set of solutions [5]. Three idealized principles underpin the CS approach:

- Each cuckoo lays one egg at a time and deposits it in a nest.
- The best nests with the highest quality eggs (solutions) would be passed down to future generations.
- The list of available host nests is constant, as well as a host has a probability of pa [0,1] of discovering an alien egg. In this instance, the host bird has the option of either discarding the egg or abandoning the nest & starting over in a new site.

IV.LITERATURE REVIEW

Ali et al.,(2020) demonstrated an IEECP to extend the life of WSN-based IoT. The proposed IEECP is broken down into three sections that must be completed in the proper sequence. To begin, an ideal number of clusters is committed for the overlapping equitable clusters. The consistent clusters are then created utilising an adjusted fuzzy C-means algorithm and a structure to reduce or maintain the SN's energy consumption. Ultimately, multiple cluster members rotate the CH characteristic to employ a new CH selection-rotation method that integrates a back-off timing method for CH selection with a rotation technique for CH orientation to pick CHs in ideal capacities. The proposed framework reduces and optimizes node power consumption through strengthening structural components, with IEECP being ideal for devices with a longer life. As per outcomes, The IEECP beats earlier methods [6].

Kumar et al.,(2018) discussed how to leverage opportunistic transmissions in compartmental design-based cluster features. When compared to the sequential & log models, the compartmental layout has a significant improvement in average power utilization of 6% & 8%, respectively. Both WiFi and acoustic messages are shown to be 13 percent less efficient than visible light signals. Moreover, analyzing simply the second order component of the Taylor series has advantages. Additional work on recommendation systems, malicious sensor detection & localization, the SGD method in a large WSN, and the Cramér-Rao constraint for variable estimation will be built on the modern conception.

Daneshvar et al.,(2019) introduce a new clustering method that uses the GWO to choose CHs. GWO is a

cutting-edge multi-agent strategy based on grey wolf behaviour, with unique features and competitive results. The options are evaluated based on the expected energy consumption and the present residual energy of each node in critical CHs. To improve energy economy, the proposed method utilizes the same clustering in multiple successive matches. This reduces the amount of energy required to change the clustering. Authors also present a new dual-hop routing mechanism for CHs that are far away from the BS, demonstrating that the suggested technique ensures the lowest and most balanced power usage while the remaining nodes communicate via single-hop interaction. The method is evaluated in a variety of scenarios, & it is shown that the routing architecture extends the device's life when contrasted to a number of recent similar approaches[8].

Neamatollahi et al.,(2018) recommended an HCSP that induces node-driven clustering instead of time-driven clustering like GRBP. According to HCSP, each cluster is only modified once during each local super cycle. As a consequence, cluster reconfigure frequency varies depending on demand and may change from one cluster to the next during the channel's lifespan. Nonetheless, at the conclusion of each global hyper round, global clustering is performed to recharge the system communication structure. As a consequence, in clustering-task scheduling, HCSP aspires to be more adaptive, energy-efficient, & extensible than GRBP. Clustering inefficiency is the most major downside of clustering algorithms, and this approach decreases it. The usefulness of HCSP in conserving energy and extending lifetime of the system is demonstrated by simulations of power utilization and also thorough computations[9].

Lata et al.,(2020) The LEACH-FC approach was recommended for the high-rise era, and a FL-based CH selection & produce complex was carried out. For cluster head selection and cluster creation, authors employed a centralised technique rather than a distributed one. Also employed FL, a centralised algorithm, to select the vice CH. The new framework was shown to be useful for computing the power requirements at each node, improving WSN reliability. It outperforms other proposed methods in terms of extending the program's life and reducing power consumption[10].

Behera et al.,(2019) focused on a precise Ch election method that switches the CH placement among several nodes with faster speeds than others. The method evaluates remaining energy, power consumption, and an average value of CH to select the next group of CH for the platform that is suited for IoT apps like environmental watching, smart cities, devices. According to simulation data, the modified version beats the LEACH technique by boosting throughput by 60%, lifespan by 66%, and RE by 64% [11].

Liu et al.,(2019) provided an EAKDE, a new uneven scheduling method that aims to balance energy dissipation among the CHs. EAKDE uses fuzzy logic to assess the focus of nodes competing for CH. The adaptive kernel density prediction approach is used to assign the appropriate uneven cluster diameter to SN, allowing it to adapt to changing node situations dynamically. In many cases, the simulation results show that EAKDE outperforms previous techniques in terms of system throughput, transmission range, and energy consumption[12].

Zhao et al.,(2019) suggested a better CH characteristic for picking the CH of each cluster in each loop, as well as the best CH feature is built utilizing the RE and node roles. Finally, based on the network architecture, a few parameters of the ideal CH feature are determined in order to maximize the CH economic plan. The modeling results show that the suggested routing strategy outperforms four other methods in terms of reliability,

which is critical for the app. in the observation of the atmosphere in three dimensions[13].

Trupti Mayee Behera et al [2020] Wireless Sensor Networks (WSN) is a virtual layer in the paradigm of the Internet of Things (IoT). It inter-relates information associated with the physical domain to the IoT drove computational systems. WSN provides ubiquitous access to location, the status of different entities of the environment, and data acquisition for long-term IoT monitoring. Since energy is a major constraint in the design process of a WSN, recent advances have led to project various energy-efficient protocols. Routing of data involves energy expenditure in considerable amount. In recent times, various heuristic clustering protocols have been discussed to solve the purpose. This article is an improvement of the existing Stable Election Protocol (SEP) that implements a threshold-based cluster head selection for a heterogeneous network. The threshold maintains uniform energy distribution between member and cluster head nodes. The sensor nodes are also categorized into three different types called normal, intermediate and advanced depending on the initial energy supply to distribute the network load evenly. The simulation result shows that the proposed scheme outperforms SEP and DEEC protocols with an improvement of 300% in network lifetime and 56% in throughput. [14].

V.PROPOSED WORK

Research gaps pointed out are that existing I-SEP selects cluster head based on kind of nodes: more priority is given to the nodes having higher energy. It ignores other parameters like distance of nodes, number of neighbor which can be considered while selecting them as cluster heads. The data transmission is done using single hop interaction among cluster head & the BS. This method builds use of larger distances between CH and BS which attracts higher power usage.

In order to overcome the research gaps mentioned above, we compare the existing I-SEP with the

proposed bio inspired approach for IOT in WSN based on the set of alive nodes and dead nodes.

Research Methodology

In order to achieve the above objectives, the first step is to select optimal cluster head in the network. In the existing scheme, the preference has been given to the node having higher residual energy in the network; however, in the proposed scheme we will use cuckoo search optimization to select the cluster head. In this optimization, every solution/node needs to have a fitness function over which it can be evaluated. The fitness function of the node will be computed based on: Remaining energy of the node, Distance from the base station and Number of cluster members.

Once the cluster heads get elected in the network, they form clusters will the nearby neighbouring nodes. In this cluster formed, each cluster member forwards the data at the cluster head which then relays the data to the base station. In the existing scheme, this relaying of the data is performed using single hop communication which is quite energy consuming approach. Therefore, in the proposed work we will use multi hop communication to forward data from cluster head to base station. This will be done by making use of AODV routing protocol. This will build multiple paths from source cluster head to base station. From these paths, the cluster head will choose shortest path to forward the data to the base station.

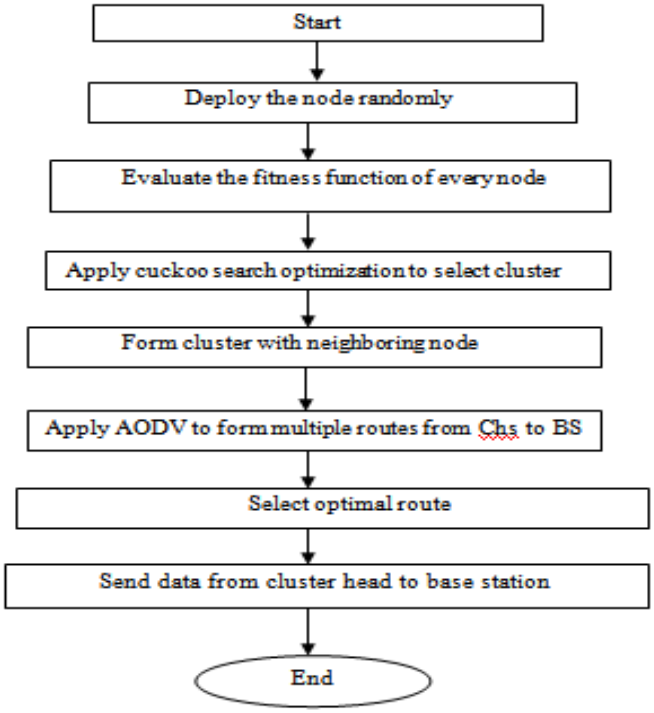

Figure 2: Flowchart of Cuckoo Search

VI.RESULTS

This section presents the findings of the suggested Cuckoo search method. To verify the suggested technique, the energy conversion efficiency as well as clusters transferred to BS are chosen as output parameters. All sensor nodes in the aforementioned sensor area are evenly distributed, and BS is expected to be within the sensor zone. The suggested approach is

designed in the PYTHON environment. The energy conservation variable is defined by the collection of alive and dead nodes. For simulation, 100 randomly dispersed nodes in the network were used to create four situations. The number of alive nodes and the number of dead nodes were used to measure the network's efficiency.

- **Number of Alive Nodes:** The set of alive nodes was determined for every round to determine the device's energy usage. For the suggested work the set of rounds contains is [1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000].

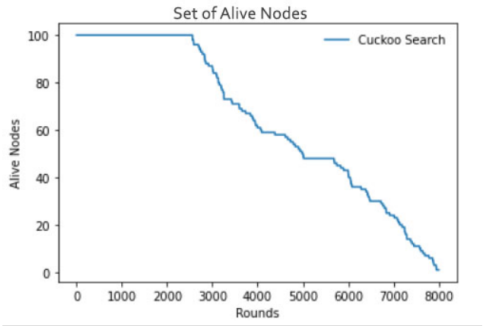

Figure 3: Alive Nodes

Figure 3 shows that for suggested technique, the first node dies on the 8000th round. As a consequence, it is clear that the provided method improves system stability because

CH are chosen correctly using the suggested approach CSA.

- **Number of Dead Nodes:** Each cycle, the number of dead nodes was calculated to find the system's energy consumption. The number of dead rounds for the suggested task is [1000,2000,3000,4000,5000,6000.7000.8000].

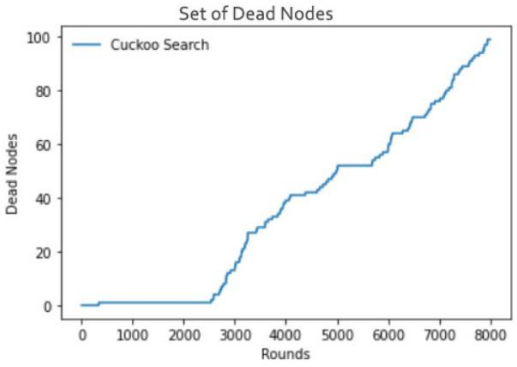

Figure 4: Dead Nodes

Figure 4 shows dead nodes in proposed methodology after eight thousand rounds. As the network's area grows, the no. of dead nodes also increases. Consequently, the protocol's efficiency suffers. The proposed methodology continues to outperform the competition by contrasting the results of each protocol.

Additionally, because a single route is not employed, the strain on the CH building the route is raised. In comparison to previous ways, [14]the CH would send data to the BS via an adjacent CH or directly to the BS (if the BS could be extended immediately). As a result, the values for two measures, including no. of alive nodes, no. of dead nodes are improved by the suggested technique.

VII. CONCLUSION

Because of its effective coverage in practical systems, the rapid advancement of WSN approaches is attracting a great attention from the scientific community. It has become a vital approach with a wide variety of features since it provides useful knowledge to target customers about a targeted area under real-time observation. Furthermore, dealing with the challenges of appropriate cluster head selection, energy instability, & network lifetime enhancement is still seen as a mammoth undertaking. This author presents an energy-efficient Cuckoo search algorithm (CSA) for WSN. In addition, the suggested method is implemented PYTHON. The CHs are determined using the CSA approach from the network's accessible sensor nodes. Finally, using a link to another SN within its service area, every CH created a cluster. The suggested CSA strategy's performance was evaluated in terms of the amount of alive & dead nodes. The computer outcomes showed that the proposed method consumed fewer energy & performed better than older studies.

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