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Simplified LEACH Protocol with Superior Energy Efficiency for the Internet of Things

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Abstract*:*The Internet of Things (IoT) has evolved as a paradigm shifter that allows various intelligent devices to connect and communicate seamlessly. The overall performance and lifespan of the network are, however, seriously hampered by the energy limitations of IoT devices. In order to solve the issue of energy efficiency in IoT networks, this research suggests an asimplifiedLow Energy Adaptive Clustering Hierarchy (LEACH) protocol based on Alternative Convergent Sunflower Optimization (ACSO). The suggested algorithm's diversifying and intensifying mechanisms can find equilibrium with this method's invocation, preventing it from getting trapped in local minimums. By comparing those concepts' approaches to the traditional SO method, CEC2015 evaluations validate the optimization effectiveness. In regards to energy efficiency, network lifespan, and data transmission accuracy, the findings show considerable gains. The findings of this study open the path for future developments in IoT network energy-efficiency approaches, making it possible to realize an IoT ecosystem that is more energy-efficient and durable.

Keywords:*Internet of Things (IoT), energy efficiency, LEACH protocol, Alternative Convergent Sunflower Optimization (ACSO)*

1. Introduction

A system in the cyber-physical-social sphere known as the Internet of Things connects various material things, sensors, and homes to the Internet to generate, gather, and share massive amounts of data. To address the needs of this sensor-based big data, big data platforms, infrastructure, services, devices, and analytics applications must be created [1]. The term "Internet of Things" (IoT) refers to a collection of a wide range of internet-connected objects and people. The wireless sensor network (WSN) will take center stage in Internet of Things (IoT) scenarios due to advancements in wireless technology and the smart city. In order to sense, quantify, and report on any modifications in the environment, sensors are linked to the web and interact with one another wirelessly. Because WSN deployment is so simple, IoT has many uses, including smart cities, buildings, industry, weather, security, and military applications. It also has applications for environmental monitoring and tracking.

IoT has been increasingly important in the healthcare industry in recent years as a means of improving the precision, dependability, and efficiency of electronic equipment and its potential to fend off pandemic diseases [2]. With the introduction of connectivity between heterogeneous systems and seamless mobility in the fifth generation (5G) of cellular networks, the sector of communications has expanded from the 1st generation (1G) to the 4th generation (4G) of IP. For the 5G network to deliver continuous connection and the appropriate quality of service (quality of service) for heterogeneous devices, a multi-level framework design is necessary. The primary goal of the 5G mobile network was to link diverse devices and users with diverse quality of service requirements, as opposed to the cellular network of the preceding generation, which was primarily focused on supplying bandwidth to its end user. Thus, to achieve the quality of service requirement, given the high end-user traffic density, different technologies must be combined [3]. A network of wireless sensors allows for the simultaneous monitoring and recording of conditions across a large region. Keeping track of factors like moisture, pressure in the atmosphere, the temperature of the air, the speed and direction of the wind, lighting intensity and color temperature, as well as factors like power-line voltage, chemical concentrations, and pollution levels, is not very frequent [4]. According to a standard definition of the Internet, it is a system of interconnected computer networks that uses TCP/IP to transmit and receive data via a variety of media. The web, in its current state, was developed using a variety of technologies. This has made it possible for an increasing number of gadgets to connect, giving them a chance to speak with one another

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across various types of networking and within local networks, ultimately leading to a world that is much more linked. A new networking idea known as the (IoT) has emerged due to the increasing prevalence of these gadgets and intelligent things in our daily lives [5].

An intelligent environment for a dynamic world is provided by the connections between smart devices on the Internet of Things (IoT). IoT stands for the interconnection of networks between diverse wireless sensors and commonplace physical objects dispersed in a monitoring area in order to sense, gather, share, and transfer data within the system and give people a more intelligent life. IoT devices are now capable of detecting, analyzing, interacting, communicating, and corporation, thanks to recent advancements in technology and protocols [6]. In the upcoming few years, an IoT platform is anticipated to be one of the revolutionary technologies. Various IoTapplications will fundamentally improve human comfort in daily life in the new IoT age. Agriculture, environmental monitoring, household and industrial automation, and transportation systems will all use the IoT, which is evolving into a large-scale, pervasive network [7]. Although the terrestrial Internet of Things cannot gain worldwide coverage, its introduction has had a significant effect on people's lives and ways of working. Due to its extensive coverage, satellite communication can provide seamless worldwide coverage, significantly enhancing the commercial potential of the grounded Internet of Things. As a potent addition to the ground network and a crucial component of the 5G worldwide communication system, satellite communications are available [8].

This research presents a simpler LEACH protocol based on ACSO to address the issue of energy utilization in IoT networks.The remainder of the paper is divided into subsequent parts. Part 3 contains the proposed method explained. Part 4 includes the results and analysis. While Part 5 discusses the conclusions.

2. Related Works

Clustering is a standard algorithm used to enhance the performance of vehicle ad hoc networks. The expected outcomes of many of these methods include clustering during each round of single-hop data transfer to the roadside unit, which supports numerous transmissions of data to the street unit. However, clustering during each round raises the number of control messages, which raises the chance of collision and lowers network energy[9]. Applications for the Internet of Things (IoT), particularly in smart cities, are quickly evolving. For addressing IoT problems, including energy efficiency, scalability, resilience, mobility, load balancing, and other related ones, clustering is a promising option. The IoT-compatible clustering method organizes sensor nodes into groups, with a single node serving as the cluster head. As an example of smart cities, this research aims to ascertain how clustering is used in the Internet of Things[10]. The Internet of Things (IoT) as a technology that combines sensors, networks, radio frequency identification, cloud computing, and large-scale monitoring. Studies have emphasised on ways to lower the energy usage of wireless sensor networks (WSN), which are the perfect basis for the Internet of Things. Cluster head nodes in hierarchical networks must do additional energy-consuming tasks. As a result, a sensible cluster head selection strategy and a regular node joining cluster method become crucial. In order to conserve energy and extend network life, this research suggests a new clustering technique[11]. Wireless sensor networks (WSNs) are based on significant breakthroughs that have been made in the Internet of Things (IoT). Coordinated phenomena, such as higher resource utilization and efficient service delivery, are critically needed to ensure seamless connectivity. Most of the time, IoT devices are used in remote areas and have limited battery life. Because of this, networks can only be used in certain situations when the battery life is short [12]. The primary goal of Industry 4.0 is the modernization of manufacturing processes across a variety of industries through the use of cutting-edge production methods that record real-time data, employ machine learning techniques, enable the system to make decisions on its own, and connect the system as a whole. Due to its significant impact on the industrial manufacturing process, it aims to usher in a new industrial revolution with the aid of Internet of Things technology[13]. In their domain, where nodes play a vital part in the IoT, WSN distribute less expensive sensor nodes (SNs). IoT nodes that use WSNs typically have resource limits in various areas, including resources for energy, storage, processing, and so forth.

Effective routing protocols (RP) are necessary for greater energy efficiency and extended longevity[14]. The capabilities of machine-to-machine (M2M) and Internet of Things (IoT) communication systems have been increased by wireless sensor networks (WSNs), a dispersed and infrastructure-free network. The search for more effective routing solutions has been sparked by the rise in energy efficiency requirements. Although LEACH is the most efficient, it has a limited advantage since it pays less attention to topology dynamics and QOS requirements. In order to satisfy the quality of service and energy utilization criteria of the IoT/M2M communication system, this study offers a network adaptive multi-mode LEACH protocol (M2M-LEACH). In order to accommodate three alternative transmission modes—(CN-BS), (CNG), cluster head (CH), and base station (BS), it executes a network adaptable grid partitionisng. For the CH selection, it takes into account remaining power and inter-node distance[15].

3. Proposed Method

3.1. LEACH protocol

Low energy adaptive clustering hierarchy (LEACH) protocol is used in WSNs. To uniformly divide the energy load overall sensor nodes in the network, the cluster-head nodes are chosen at random for each cycle. Because of the cluster head's switching method used in the LEACH protocol, it is believed that all sensors will survive for roughly the same amount of time. Cluster setup and data transmission stability are the first two steps of each cycle's cluster rebuilding process. Each sensor receives an arbitrary value between 0 and 1 during the cluster creation procedure. The node will be referred to as the node and will be able to communicate with the non-cluster head nodes if its size is smaller than the threshold T(k). These non-cluster head nodes will get in touch with one another within the cluster after receiving the message, notifying the node. In LEACH, take into note that the total number of nodes is represented by set S, and those nodes that weren't chosen to be nodes in the prior [1/p] (the integer part of 1/p) round make up that set of nodes known as G. where p is the percentage of nodes that the cluster-head nodes make up.

$$b = 1 - \frac{|S|}{|G|}$$

The probability of those nodes being selected in the graph G is (k is a random node in G).

$$D(r) = \begin{cases} \frac{b}{1-b.\left(k \bmod \left[\frac{1}{b}\right]\right)} r \in S \\ 0 \quad otherwise \end{cases} \quad 1$$

The chosen probability is fixed to 0 for all nodes included in S G. If only one node is present in G, Equation (2)'s probabilities of selection T (k) is always equal to 1. Since each node has the potential to be the node in the upcoming round, every node is listed in G when the present phase is finished. Following the selection of the cluster-head node, the remaining network nodes will choose the cluster based on the intensity of the signal received. The scheduling table for each cluster is chosen once all nodes have been assigned. Energy is the key concern for the LEACH protocol; energy consumption significantly impacts the lifespan of wireless sensor networks. The following presumptions serve as the foundation for the LEACH network model.

- The network's nodes are all stationary and dispersed throughout the identified area;
- The communication, computation, and storage capacities, as well as the energy cap, are the same for all nodes (apart from the root station);
- radio transmission uses the same amount of energy in every way;
- The gathering node has just one permanent location.

In the LEACH protocol, the cost of energy is mainly made up of the consumption of data aggregation and information communication (data transfer and data receipt). The two models that take into account the distance among the sending and receiving nodes are the multiple fading paths model (4 d consumption) and the space model (2 d consumption), which are employed for data transmission. Distance d between the sending and receiving nodes determines how well the two models work. The free space concept is applied when transmission range d is below the threshold 0 d; otherwise, the multiple paths attenuation model is applied. As an example, consider the energy needed to convey l bits of data:

$$A_{DY}(f,t) = \begin{cases} f.A_{elec} + f.\varepsilon_{LG} t^2 t < t_0 \\ f.A_{elec} + f.\varepsilon_{DK} t^4 t < t_0 \end{cases} \quad 2$$

Where d is the distance between both sensor nodes, A_{elec} is the energy required to send or receive one bit of data, and A_{KY} and A_{EY} are the amplifications of the free-space model and the model of multipath fading, respectively.

$$A_{KY}(f) = f.A_{elec}$$

$$A_{EY}(f) = f.A_{da}$$

Where A_da represents the energy required to aggregate 1-bit data.

3.2. Sunflower Optimization (SFO) Algorithm

The program imitates how the closest two sunflowers pollinate one another as they travel toward the sun. The SFO algorithm's characteristics and critical operations are highlighted in the following sections. The closest 2 sunflowers, Y_{i+1} and Y_i, can pollinate each other as the sunflowers move nearer the sun each morning. The sun's rays are absorbed by each sunflower. Each sunflower's total radiation output is influenced by how close it is to the sun. The amount of radiation (heat) that the sunflowers receive from the sun decreases with increasing distance between them and the sun. Equation 3 illustrates the quantity of heat received from the sun by each sunflower.

$$\mathcal{O}_j = \frac{U}{4\pi v^2} \quad 3$$

Where $\mathcal{O}_j$ is the heat emitted, the solar power is W., and c is the range among the optimal answer (the sun) and the sunflower Y_j.

Each sunflower's orientation vector is determined under Equation 4.

$$\vec{g}_j = \frac{Y^* - Y_j}{\|Y^* - Y_j\|}\ j = 1,2,\ldots,M. \qquad 4$$

Where N is the population size, $Y_j$is the solution i, and Y^* is the overall best solution.

Equation 5 determines each sunflower's $Y_j$step size as it moves toward the sun.

$$t_j = \alpha \times B_j(\|Y_j + Y_{j-1}\| \times \|Y_j + Y_{j-1}\| \qquad 5$$

The likelihood that the nearest two sunflowers will pollinate one another, Y_i and Y_{i+1}, is given by$B_j(\|Y_j + Y_{j-1}\|$, where denotes the inertial displacement of the sunflower. Sunflowers that are closest to the sun perfect their positions with fewer steps (the exploitation process), whereas sunflowers that are farther away wander erratically. To prevent passing from the border for each solution, The maximum step size t_{max}applies to all sunflowers' step sizes. Equation 6 illustrates the calculation for each sunflower's maximum step size.

$$t_{max} = \frac{\|Y_{max} - Y_{min}\|}{2 \times M} \qquad 6$$

In order to produce new plants, the top sunflowers will fertilize their vicinity. Equation 7 can be used to depict the fertilization procedure for each sunflower.

$$Y_{j+1} = Y_j + t_j \times \vec{g}_j \qquad 7$$

3.3. Alternative Convergent Sunflower Optimization (ACSO)

Like other SI algorithms, the typical SFO technique has a sluggish convergence rate and is susceptible to local minimum trapping. To improve the SFO diversity search, to create a new iteration of the SFO method known as an Alternative Convergent Sunflower Optimization (ACSO), we use the LFO on it. A random walk method called the lèvy flight operator can assist the SFO in avoiding early convergence and escaping from being trapped in the local minima. The proposed ACSO algorithm follows the same basic steps as the conventional SFO algorithm, except that we use the lèvy flight operators as the Equation7 step size as indicated.

Where lèvy distribution is represented by Levy (v).

Algorithm 1 presents the suggested ACSO algorithm's structure.

Algorithm 1.The ACSO algorithm

Step 1*: The values of the parameters for the maximum number of repetitions max_i, size of population N, mortality rate m, and pollination rate P should be created.*

Step 2*: Set the iteration counter at an initial value of 0.*

Step 3*: With i = 1... N, a random number generator, creates the starting population$X_i^{(t)}$.*

Step 4*: In the number of individuals f ($X_i^{(t)}$), determine the function of fitness for each solution (sunflower).*

Step 5: *The best overall answer is given the letter X^*.*

Step 6: *Repeat*

Step 7*: According to Equation 13, each solution changes how it faces the sun (optimal solution) X^**

Step 8: *Thenew people are inserted into the population to replace the worst m% solutions.*

Step 9*: Equation 17's lèvy flight operator is used by the solutions to update their positions.*

Step 10: *the population f ($X_i^{(t)}$)'s new solutions (sunflowers) and determine the function of fitness for them.*

Step 11*: When compared to the existing solutions, new solutions are allowed if they are fit.*

Step 12: *Set t = t + 1.*

Step 13: *until (t >max_{itr}).*

Step 14: *The optimal resolution is offered.*

4. Result and Discussion

On a computer with an Intel Core i5 CPU running at 2.30 GHz, 8 GB of RAM, and Windows 10 Pro (64-bit) installed, they developed the proposed ACSO algorithm using MATLAB R2019b. Four factors—Energy Consumption, Communication Overhead, Scalability, and Network Lifetime—have been taken into account to assess the efficacy of the suggested method.

Table 1. Experimental setup parameters

Parameters	Values
Initial energy	0.5J
Most iterations	5000
Data pack	4000bits
The probability of becoming cluster head	0.05
No of nodes	300

Network lifetime is the time frame or lifespan of a network before it stops functioning properly or becomes unusable owing to a variety of reasons, including power depletion, component failure, or changes in network needs. It is a crucial measure in network design and administration, especially in contexts with limited resources like wireless sensor networks, IoT deployments, and other environments.Compared to other approaches, the suggested method has better performance in terms of network lifetime (figure 1).

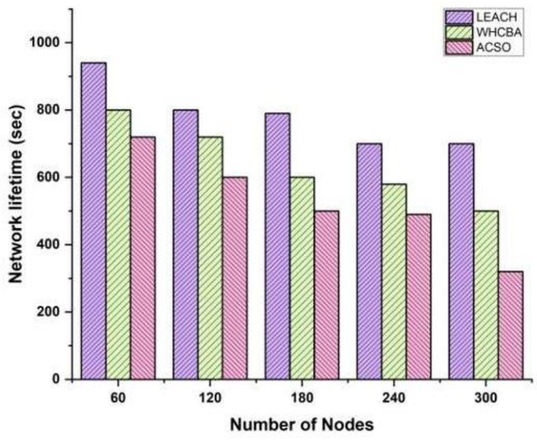

Fig.1. Network Lifetime

The entire amount of energy utilized or consumed by multiple processes, systems, or activities over a specific time frame is called energy consumption. It gauges how quickly energy is converted from one form to another and used to fulfill needs or carry out tasks. British thermal units (BTUs), kilowatt-hours (kWh), and joules (J) are standard measures used to measure energy consumption.Compared to other approaches, the suggested method has better performance in terms of energy consumption (figure 2).

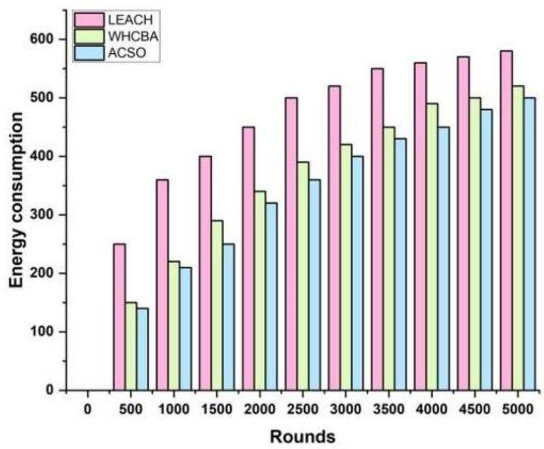

Fig.2. Energy consumption

The extra resources, time, or processing needed to establish and sustain communication across various components or systems inside a computer network or distributed system is called communication overhead. It alludes to the expenses of relaying information and messages across numerous processes, threads, or nodes.Compared to other approaches, the suggested method has better performance in terms of communication overhead (figure 3).

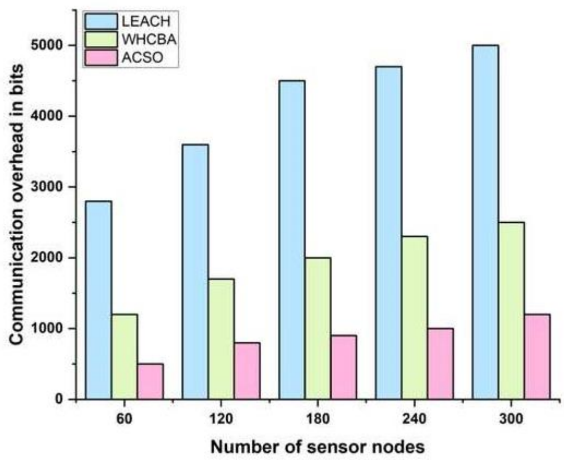

Fig.3.communication overhead

Scalability is the capacity of a system, process, or organization to effectively manage an increase in the volume of work, resources, or people. It is a quality that allows a system to keep up with or enhance its performance, capacity, and dependability as the demand or workload increases.Compared to other approaches, the suggested method has better performance in terms of scalablity (figure 4).

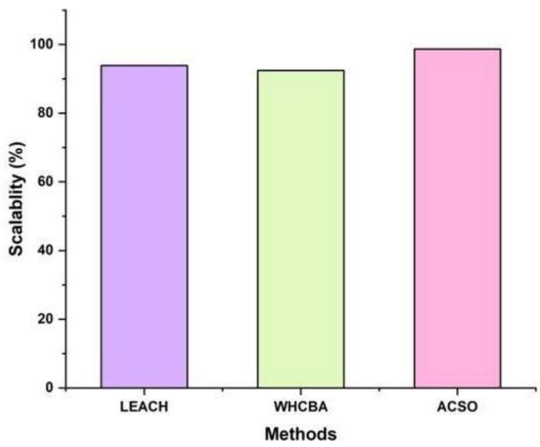

Fig.4. Scalability

5. Conclusion

The widely used LEACH protocol, which provides a foundation for the Simplified LEACH protocol, was first developed. It offers increased energy efficiency and scalability by simplifying and strengthening specific protocol features, making it an appropriate option for IoT deployments. This study proposes an Alternative Convergent Sunflower Optimization (ACSO)-based Low Energy Adaptive Clustering Hierarchy (LEACH) technique. A more advanced version of the SFO algorithm—the SFO algorithm is created and used to resolve this issue. To evaluate the effectiveness of the recommended alternatives, four factors—Energy Consumption, Communication Overhead, Scalability, and Network Lifetime—have been considered. The energy efficiency of LEACH is increased; however, scaling problems arise as the network size grows. The methods for cluster creation and data aggregation become more complicated as the number of nodes rises, which can result in more overhead and worsening performance. The research in this paper can improve the functionality of the Internet of Things' extensive data sensing systems. Future research topics include using LEACH and other powerful algorithms and their applicability to real-world issues.

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