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A Pegasis-Driven Approach for Enhanced Performance for Optimizing Energy Efficiency in Wireless Sensor Networks

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Abstract: In order to improve the performance of wireless sensor networks (WSN), it is necessary to use energy-saving measures, cluster-based hierarchical systems, and efficient routing protocols. Protocols like IEE-LEACH and variants of the PEGASIS protocol are studied in detail because of the important roles they play in reducing energy consumption and extending the lifetime of networks. In addition, it delves into the performance analysis of algorithms like AO, showing how nodes can be more resilient and efficient in their energy consumption in different scenarios. Also included are new methods like IMA-NCS-3D that aim to make networks last longer by balancing traffic and optimizing node scheduling. The complete abstract provides insight into the dynamic.

Keywords: *Energy efficiency, Wireless sensor networks, Optimization, Enhanced performance. Pegasus.*

1. Introduction

A fascinating new frontier for the development of novel applications has opened up with the advent of wireless sensor networks (WSNs). In a WSN, , a vast network of tiny sensing nodes keeps tabs on its surroundings, processes data as needed (with the help of microprocessors), and then relays that processed data to and from other nodes in the network. In centralized networks, these dispersed sensing nodes communicate with a central sink node; in decentralised networks, they communicate with one another [2]. The "sink" in centralized networks is responsible for collecting data from sensors so that users can access it. The sink can often broadcast information about network policies and controls, which activates sensing nodes There are three typical design issues that have a significant impact on the overall network's productivity and connectivity, as there are with other networks: Using network protocols to reduce the number of control and data packets, choosing an optimal topology based on the placement of nodes, and implementing a routing algorithm to efficiently transmit data from the source node to the destination node or nodes are the three main components of a network. There are two types of node distributions in the environment: structural and non-structural. The former is employed in situations when nodes are not subject to any kind of control following distribution;

Their sole purpose is to gather data, observe their surroundings, and construct the network by establishing connections with other nodes. In the second case, though, you can see see exactly where every node— sensing and sinking nodes alike—will be in the future. With the nodes under control, programmable inter-node communication, and simplified management and maintenance, not to mention a significantly reduced environmental cost due to the reduced number of nodes needed. The widespread sensing and processing capabilities made possible by wireless communication in today's smart device technologies have accelerated the expansion of the Internet of Things (IoT), allowing for the connection of massive physical objects to the Internet. The Internet of Things (IoT) currently represents the future of the internet, and there is a fantastic opportunity for academic and business sectors to provide customer service in many areas of contemporary life. Logistics, manufacturing, services, finance, and all other types of industrial activity can benefit from the Internet of Things (IoT) [3]. This technology has been extensively studied by several academics, leading to exciting new opportunities in both academia and industry. You can check the object's status and, if possible, change it using its networking skills. In a broad sense, the Internet of Things (IoT) describes a future where every object and accessory is networked in order to do complex activities requiring a high level of intelligence. Internet of Things (IoT) devices combine several technologies into a single, intelligent system by means of embedded sensors, actuators, CPUs, and transceivers.

2. Literature Review

2.1. Liu et al. (2019)

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[11] To diminish the power utilization of WSNs, bunch based various leveled steering strategies are critical. To resolve this issue, one application-explicit convention plan for WSNs is the low-energy versatile bunching progressive system, or Drain. In any case, the Drain convention will raise the organization's energy utilization without taking the circulation of bunch heads (CHs) into account in the pivot premise. To make the WSN more energy effective, we propose another altered steering convention in this article. The as of late recommended IEE-Drain convention takes both the normal organization energy and the remaining hub energy into account. To decrease sensor energy utilization to a palatable level, the proposed IEE-Filter thinks about the quantity of ideal CHs and prohibits hubs that are geologically near the base station (BS) from framing bunches. As well as using single-bounce, multi-jump, and crossover interchanges to additional upgrade network energy effectiveness, the proposed IEE-Drain embraces another limit for choosing CHs among the sensor hubs. The aftereffects of the reproduction show that the recommended convention altogether brings down the energy utilization of WSNs when contrasted with some current steering conventions.

2.2. Abdelaal et al. (2016)

[1] One common way to reduce power consumption is by "squeezing" other QoS metrics that are application-specific, such throughput and delay. Consequently, those quality of service aspects need to be considered by energy-saving strategies. This study provides a comprehensive overview of current research on energy efficiency in WSNs and examines how various strategies have affected the quality of service that is offered. In addition, to address the trade-off between energy usage and other quality-of-service characteristics, we suggest a new divide-and-conquer approach. The goal is to reduce the amount of energy that is pulled by addressing a specific source of energy consumption. Then, other service qualities are taken into account when this energy-saving technology is enhanced. Three energy-saving strategies that account for QoS difficulties are provided as examples to back up our claim. To reduce wireless traffic while maintaining high precision, the first approach uses a so-called Fuzzy transform for lossy data compression. The second approach makes use of trustworthy virtual sensors to zero in on the sensing module. While we sleep, these energy-hungry sensors aren't available, so these ones step in to fill the void. Third, by making use of design-time knowledge and purposefully lowering the lifetime below the maximum time, a self-adaptive mechanism is employed to enhance the QoS parameters.

2.3 Balasubramanian and Govindasamy (2019)

[2] With its elastic foundation that allows any user to easily build sensor-based applications, the wireless sensor network is one of the most rapidly expanding and extremely demanding networks. Existing infrastructure can support most WSN applications, and no specified infrastructure is necessary for the rest. However, the challenges with it are made much more complicated by its vast variety of global uses. For the simple reason that energy consumption is a big issue with WSNs, which are networks with limited resources. Deterministic methods, which were covered in earlier studies, helped with some of the issues. One deterministic approach that deals with an efficient routing algorithm is dynamic programming, which is useful in cases when messages need to be routed efficiently over a network. However, deterministic techniques can be a bit tedious for a lot of WSN. Conversely, evolutionary algorithms have been a rapidly expanding field in recent decades, and they have successfully tackled numerous issues related to WSNs.

2.4. Karakus et al. (2013)

[7]Energy efficiency in computation and communication at the sensor node level is closely correlated to the longevity of wireless sensor networks (WSNs). Assuming a sparse underlying signal, the theory of compressive sensing (CS) proposes a novel approach to signal sensing that uses a significantly smaller number of linear measurements than the traditional situation. The ramifications of this finding for WSN energy efficiency and network lifetime extension are substantial. This research examines the impact of CS-based measurement acquisition, processing, and communication on WSN lifetime compared to more traditional methods. In order to build a mixed integer programming framework that reflects the energy costs for computation and communication for both CS and conventional methodologies, energy dissipation models for both methods are constructed and utilized. A numerical analysis is carried out by methodically sampling the parameter space, which includes the number of nodes, the network radius, and the sparsity levels.

2.5. Khan et al. (2020)

[9]The coming of remote sensor organizations, or "The Web of Things," has introduced a computerized age that is fundamentally not the same as the one portrayed by customary processing. Remote sensor organizations (WSNs) are comprised of little, economical sensors that can detect, impart, and do calculation. The restricted assets of these organizations are a steady wellspring of dispute, with energy effectiveness being the most disagreeable and significant issue in WSNs. For a few undertakings, including broadcasting, bunching, on-board estimations, limitation, support, and steering, sensors use energy. However, there are three key regions where energy is spent at the hub level: detecting through sensor-module, handling through microchip, and correspondence through radio association. In addition to the fact that broad detecting lessens network life-time, yet over-costs handling and regular correspondence likewise influence the accessibility of these assets for different undertakings. Another framework named "A Substance based Versatile and Dynamic Booking (Lowlifes) utilizing two different ways correspondence model in WSNs" has been introduced to increment life-time and make an energy-productive WSN. As information is collected, Creeps changes another state for every hub relying upon the items in the parcels of detected information. By sending control messages in a contrary manner, the analyzer module at the base station can direct a hub's capabilities and test the items in noticed information bundles. CADS reduces energy usage by avoiding redundant message-forwarding and wasteful network traffic. Findings from simulations demonstrate a 9.65% improvement in energy efficiency with respect to network lifetime in a 100 node network, an 11.36% improvement in a 150 node network, and a 0.94% improvement in a 300 node network.

3. Structure of Wireless Sensor Network

3.1. Sensor Nodes

An electronic device that detects and transmits data is known as a sensor. Each mote in an ad hoc network has its own memory, battery, processor, and A/D converter; these components can communicate with one another, as well as with sensors and radio transceivers. A sensor node is formed by a mote and a sensor.

3.2. Base Station

The sensor network is connected to another network through a base station, which includes a processor, radio board, antenna, and USB interface board. It can communicate with other wireless sensor nodes because it comes pre-installed with software for low-power mesh networking [4].

3.3.Router

A router is a device that connects multiple networks by means of data lines controlled by microprocessors. These networks can be located in the same physical location or in various parts of the world. Furthermore, it is able to transmit data packets from one network to another. Connecting many networks is the job of routers, which take in incoming packets, determine their final destination, and then send them on their way using the most efficient route possible. Upon receipt of a data packet on one of the lines, the router ascertains its destination by examining the address information contained within. The packet is forwarded to the next network based on the data in the routing table.

4. Pegasis Protocol

The core idea behind the PEGASIS protocol is for nodes to receive data from and send it to nearby nodes, with each node taking turns being the leader in sending data to the base station. This method ensures that the sensor nodes are all subject to the same amount of energy consumption. The nodes self-organize into a chain after being distributed at random across the field. This chain can also be computed by BS and then broadcast to all the nodes [5].

4.1. Types of Pegasis protocols

4.1.1. Energy Efficient Pegasis Based (EEPB)

WSN uses an improved PEGASIS algorithm. The data chain in PEGASIS is formed using a distance algorithm, which can cause sensors to have an excessively lengthy connection distance. Because of the high energy consumption during data transmission, the sensors have a short lifespan. Nodes in a chaining process take the average chain distance (or "threshold distance") into account [6]. A node is considered to be "far" if it is more than thresh distance from both the upstream and closest nodes. A "long chain" is formed when the nearest node joins the network. By utilizing a distance threshold, EB-PEGASIS skirts this issue. Not only does it save power at the threshold, but it also keeps all the sensor nodes' power consumption in check [8].

4.1.2. The Pegasis-Ant5

Instead of the greedy method, the protocol uses the ANT colony algorithm to build the data chain. Attaining global optimization is aided by this. In doing so, it shortens the transmission distance and creates a more evenly distributed path. Additionally, it ensures that the nodes are using an equal amount of energy. Every time a transmission cycle begins, the nodes' energy levels determine which one will act as the leader and have direct communication with the base station. The lifetime of the network is extended by this algorithm. The PEGASIS protocol has been expanded upon in H-PEGASIS 5. The original intent of its introduction was to reduce transmission packet latency to the BS. By taking energy X delay measurements into account, it suggests a way to fix data gathering issues. Data messages are sent simultaneously to decrease latency.

4.1.3. PEGASIS with double Cluster Head (PDCH)

extends the life of the network by distributing the load evenly among all nodes. In most cases, the PEGASIS protocol will only allow a single CH to communicate with the BS. To avoid extended chaining, this method uses a hierarchical structure and uses two CHs in a single chain instead of one. Instead of using dynamic cluster formation, PDCH reduces the distance between nodes, uses just one transfer to BS per round, and reduces the amount of messages transmitted to and from other nodes, making it more efficient than PEGASIS. The longevity and quality of a network are both improved by distributing the energy burden among its nodes.

4.1.4. Improved Energy Efficient PEGASIS Based (IEEPB)

protocol, solves the problems that EEPB has. Because the threshold used is complex and unclear, EEPB creates what is known as a "long chain" when it builds a chain. It prioritizes leader selection over other factors, such as node energy and distance from BS to node. This allows IEEPB to determine the shortest path between any two nodes by comparing their distances twice. In order to prevent the establishment of a "long chain," the chain construction is made simpler. Additionally, IEEPB takes into account the node's energy and the distance between the BS and the node when choosing the leader. It then normalizes and applies distinct weight coefficients to these two aspects. In the end, the node with the lowest weight takes charge. Due to its greater energy efficiency, IEEPB allows networks to last longer [9].

5. The Proposed Framework

The investigation of force execution in reasonable wave environments is led related to the techno-financial assessment of wave power ranches. We present a mathematical model that considers the control and tuning of wave energy converter power take-off frameworks to upgrade the changed over energy while limiting the levelized cost of energy (LCOE). We consider the hardware requirements of force take-off force, and mathematical discoveries show that power execution and LCOE of wave power ranches contrast over wave environments.

5.1. Network Model

Assembling nodes into clusters and defining and representing a CH in a WSN are also possible. In order for a cluster to be considered complete, all of its nodes must have been physically close to CH. A node can transmit data while also acting as a sensor and a CH [12]. Most WSN plans incorporate suitable information detecting, geography highlights, radio correspondence, sensor portion, and energy utilization. The all-out sensor hubs will gather information from the normal spot and communicate it to CH as the method advances. From that point forward, the BS gets the interpreted information from the assigned CH. Different heterogeneous energy implies are related with every hub. The energy model will characterize these energy misfortunes as they happen during information transport across hubs.

5.2. Energy Model

Sensing, receiving, aggregating, and transmitting are only a few of the network's many energy-intensive operations. At any point during data transmission or reception, the sensor node can be swapped out. Any time a sensor node sends or receives data, it uses energy. Nodes in a network start with an energy value of P0 and cannot have their energy restored [KK16]. The energy loss PTk during the transmission of K bits/packet, with respect to the distance d from the regular node ath to the CH bth, is defined by [YM22] according to Equation (1). If the transmission model's connection distance d is modest (free space model), then the distance is d2. Otherwise, it's multi-path d4, and both the sender and receiver distances are taken into account. To receive k bits/packet at a distance d, the received energy, PRk, is defined according to Equation (2). Several modules, including spreading, are represented by Pel, the amount of electronic energy consumed per bit. Pfs gives the free space energy model, while Pmp stands for the multi-paths model. Equation (3) shows the threshold distance, denoted as d0.

$$P_{TK}(K.d) = \begin{cases} K\left(P_{el} + P_{fs} * d^2\right) & if\ d < d_0 \\ K\left(P_{el} + P_{mp} * d^4\right) & if\ d \geq d_0 \end{cases} \quad (1)$$

$$P_{TK}(K.d) = K * P_{el} \quad (2)$$

$$d_0 = \sqrt{P_{fs}/P_{mp}} \quad (3)$$

The proposed protocol aims to improve load balancing, stability, energy efficiency, and network lifetime. The energy model provided above is used to compute the energy dissipation during transmission. Information gathering and reception: The two stages of operation for the suggested methodology are the setup and stationary phases. We build clusters, choose CHs, and send data from CHs to BSs. Use of this WSN basically results in a heterogeneous network. Both basic and advanced nodes make it up. Advanced nodes with greater starting energies enhance network performance because of the non-uniformity in the network. Superior to ordinary nodes in terms of energy efficiency, advanced nodes are scarce compared to ordinary ones. Optimization tactics that mimic nature to address optimization problems are known as meta-heuristics, and they draw inspiration from natural processes. Impressive outcomes boost the feasibility and promise of algorithms inspired by nature and their development in other domains. Here we provide WSNs with stable and energy-efficient clustering algorithms like LEACH, as well as more conventional protocols like GA, COY, AO, and HHO. In order to get the best answer, we compared the algorithms.

6. Evaluation of The Proposed Algorithm

6.1. The Number of Alive Nodes

In the primary case, with the base station at (0,0), Figure 1 shows that after 500 and 800 rounds, separately, the hereditary and Filter (customary) calculations lose almost 70% of the hubs. Interestingly, the Bashful calculation loses similar sum at 1100 rounds and the (AO, and HHO) calculations misfortune similar sum at 1250 rounds. At 1250 rounds, the proposed AO technique accomplishes the best misfortune rate.

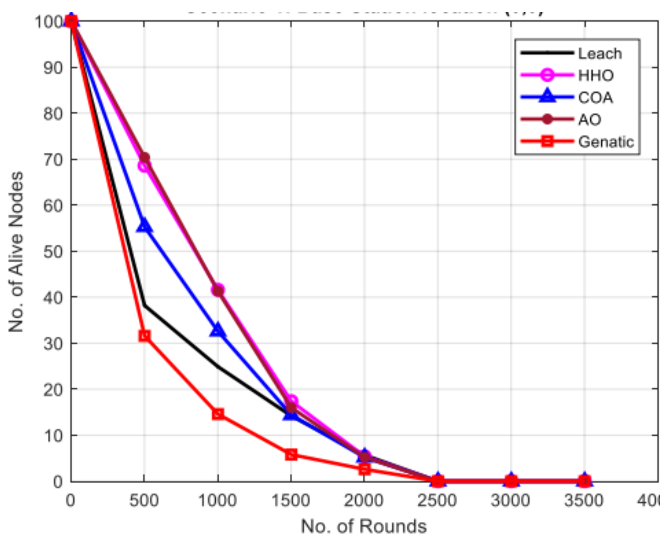

Figure 1: Number of alive nodes in case of scenario 1: BS at (0,0).

Figure 2 shows that after 500 and 1700 rounds, separately, the hereditary qualities and Drain (customary) calculations lose 70% of the hubs in the second situation with the BS position at (50,50). Conversely, the Hesitant system loses similar sum at 1800 rounds and the (AO and HHO) calculations lose similar sum at 2000 rounds. At 2000 rounds, the AO calculation accomplishes the best misfortune rate in this present circumstance. The ideal number of rounds for the AO calculation to accomplish a misfortune here is 2000. In view of the information displayed in Figure, it tends to be seen that hereditary and Drain (traditional) calculations experience a 70% hub misfortune after around 500 rounds, calculations around 1200 rounds, and the HHO calculation at around 1250 rounds. Conversely, the third situation has the BS situated at (100,100) [13]. The recommended AO calculation has a common misfortune rate after 1200 rounds in this situation.

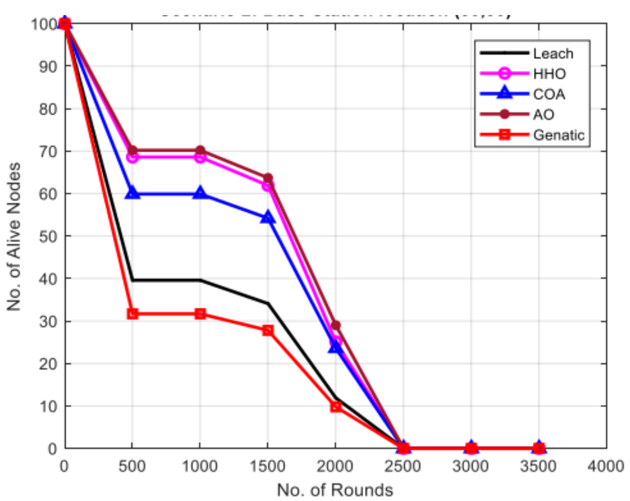

Figure 2: Number of alive nodes in case of scenario 2: BS at (50,50).

The recommended AO strategy beats existing calculations regarding energy and most noteworthy number of alive hubs in three different BS areas situations: (0,0), (50,50), and (100,100). The recommended AO strategy beats the Drain, calculations, with mean alive hub acknowledge of 1250, 1800, and 1200 rounds, separately, in three situations. The ideal misfortune rate at 1800 rounds with BS area (50,50) is accomplished by the given AO technique in this climate. Besides, the proposed AO calculation outflanks the Filter, Shy, HHO, and GA calculations concerning the typical standardized energy in three unique situations: 450, 800, and 400 rounds, separately. At 800 cycles with a BS area of (50,50), the given AO calculation accomplishes the best energy misfortune rate, driving us to reason that AO further develops framework soundness.

7. Node Energy-Efficient Scheduling Method IMA–NCS-3D

There will likely be two stages to our plan to lower the network's energy usage and increase its lifespan. Reducing the number of active nodes by bringing them out of sleep during the node scheduling phase, which occurs after the nodes have been deployed, helps to lower the energy usage of the network. In contrast, after the network is operational, the data transmission phase occurs during the routing phase. Efficient routing mechanism algorithms are its bread and butter, and they're responsible for making data transfer more efficient. Consequently, energy conservation is a two-part process that begins with node scheduling and ends with data transmission. Increasing the network's lifetime is the final aim [14].

Essentially, MA is just a more refined version of the genetic algorithm with a greater emphasis on local search operations. This addresses the problem with the genetic algorithm's limited ability to search locally. A small number of parameters, high search efficiency, and quick convergence have made the memetic algorithm a popular tool for engineers. Global search and local search are the two components that make up the approach. Also, it can handle large, complex optimization problems and can do parallel processing. For the purpose of abstracting HWSNs nodes as genes, a simple 0/1 identification of node activity is enough. So, a good node scheduling system may be set up with the help of improved MA.

One part of IMA-NCS-3D finds usage in providing the best network scheduling strategy and reducing the number of active nodes. To further distribute the network's traffic, there is also the node cooperation strategy. We illustrate node scheduling with a basic example diagram using five nodes and four target points. The first subgraph on the left shows the original distribution of nodes' locations; by default, all of the nodes are inactive. The central subplot involves rousing certain nodes to construct a functional set, covering all the desired points, while putting other nodes into a state of hibernation to prolong the network's lifespan [15]. When the nodes' energy runs out, the reconstructed working set shows what happens when the dormant nodes are awakened to ensure the network's monitoring task is completed (rightmost subplot).

8. Conclusion

The development of Wireless Sensor Networks (WSNs) is propelling advances in data transmission, network stability, and energy efficiency, opening up a promising future for a wide range of applications. In order to improve WSN performance, the literature emphasizes the importance of effective routing protocols, energy-saving techniques, and cluster-based hierarchical approaches. Proposed protocols that show significant progress in lowering energy usage and extending network lifetime are IEE-LEACH and PEGASIS versions. Moreover, the analysis of algorithms like AO demonstrates enhancements in node survival and energy efficiency in diverse situations. Furthermore, novel techniques such as IMA–NCS-3D demonstrate the possibility of prolonging network lifetime by means of efficient node scheduling and traffic load balancing. All things considered, these developments highlight how WSNs are changing and are positioned to handle the complexity of contemporary applications while opening the door for more effective and long-lasting network infrastructures.

Author contributions

Ravi Datta1 Dubey1: Conceptualization, Methodology, Software, Field study **Santosh Kumar2 Yadav2:** Data curation, Writing-Original draft preparation, Software, Validation., Field study **Sanjeev3 Gangwar3:** Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest

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