**A Novel Wireless Sensor Network Framework for Reliable Transportation Theory**

***Abstract***

*In a wireless sensor network (WSN), reduced energy resources between nodes present a complicated challenge in terms of data collection, routing, and aggregation, as all of these procedures consume energy. The network's stability period, lifetime, and potential are all metrics that must be optimized within the limits. Firstly, this research describes the WSN architecture, its main components, characteristics, and applications in various fields. The Cluster Head (CH) selection problem in heterogeneous wireless sensor networks has received little attention and needs to be improved further to fully use WSN's potential. In this research, a novel WSN framework is designed by using transportation theory Clustering is performed using the fuzzy set theory. Furthermore, based on the clustering, the CH is defined by computing the CRV value. The entire process works towards designing a reliable WSN system and keeping the point of energy consumption into consideration for the entire design and its working. Finally, the results revealed that the proposed WSN framework is 99.9% efficient which is higher than any other conventional method.*

***Keywords:*** *WSN, Cluster Head, Fuzzy Theory, CRV, Clustering.*

1. **Introduction**

The Intelligent Dust project introduced the concept of wireless sensor nodes in 1998 WSN [1]. A sensor node is the most essential component of a WSN. A sensor, a Central Processing Unit (CPU), as well as a wireless communication unit, are the three parts that make up a sensor node. The WSN is composed of a great number of minuscule sensor nodes that are limited in power and energy. Sensor nodes are powered by tiny battery-operated gadgets that cannot be replenished at the time they are being placed. The WSN has been utilized as a regulated and observational platform in a wide range of contexts, including surveillance systems, home environment monitoring, and volcano monitoring, to name just a few instances of these applications. The WSNs have been used in a variety of applications, including target tracking, environmental control, and the protection of homes [2].

* 1. **Wireless Sensors Network Architecture**

A WSN is constructed using access points that are often rather tiny and lightweight. The sensor networks serve as the fundamental building blocks of the network. Sensors, external memory, and power are the three components that make up a typical node. Figure 1 presents the primary architecture of the network nodes that could detect, interpret, and transmit relevant sensory and temporal characteristics of data. This form of monitoring node is put in place at key locations to keep an eye on a certain system or the surrounding environment [3].

Diagram

Description automatically generated

Figure 1: Basic architecture of a sensor node [3]

A WSN node could both detect and regulate various physical conditions such as temperature, volume, or pressure. In addition, for the nodes to carry out the work of autonomous sensing, they need to connect by employing wireless communication; however, some user-driven data gathering is also conceivable [4]. Actuation, wireless processing, sensing, and communication are all capabilities that these nodes possess. The Internet of Things (IoT) is becoming an increasingly important part of various infrastructures, including water networks, electric grids, intelligent buildings, medical services, smart farming, as well as intelligent vehicle approaches [5].

The WSN only required a little amount of power because the mobile nodes are frequently not powered. Although WSNs have a variety of applications, research may be difficult because of their limited resource availability and application-centric architecture. As demand for wireless sensor networks develops, resource limits placed on WSNs limit the technology's potential utility. Wi-Fi sensor nodes have a big challenge as their hardware is confined in terms of controlling power and memory capacity, and power and transmitting bandwidth [6]. Its notoriety has skyrocketed in tandem with the expansion of the market for embedded devices. As the number of nodes increases the complexity of the network increases, for example, the challenge to provide the required continuing Quality of Service (QoS) despite the growth in the number of nodes [7].

A gateway node in a WSN is responsible for collecting data from sensor nodes that are dispersed across the sensing zone. The expected demand on a node in such a network is higher than the maximum of that node, congestion occurs in the network. Congestion must also occur when the bandwidth of a channel drops because of fading in the channel. The power from the battery runs out, which leads to the failure of the node [8]. A decrease in the amount of battery (or power) that is used is thus essential for the node's lifespan. Therefore, to prevent both traffic congestion and the loss of packets, nodes need to make the most of both their buffer plus their battery capacity [9].

* 1. **Transportation Theory**

The transportation system must be able to withstand disruptions, that are well to be complicated and must be caused by several different types of uncertainty. The transportation must be considering all the possible causes of uncertainty, system optimization must make the system's functioning resilient against many kinds of disruptions. In addition, degraded modes need to be studied and optimized either as part of the transportation model or independently. The authors examine and contrast two approaches to air traffic monitoring and management: centralized traffic control and rolling horizon congestion control. Both approaches are used in a busy terminal restricted zone. The solution to the control issue in disturbed take-off and land operations minimizes the propagation of delays, the amount of time an aircraft travels, energy consumption, and other factors. Several fictitious disturbance situations are modeled and simulated, which is a sign of a real-world airport, and the various suggested timing and routing options are evaluated and contrasted [10].

1. **Literature Of Review**

The list of authors' works in the field of sensor networks that follows may be seen below.

**Razan Jamous et al., (2022) [11]** studied that the emerging networks known as WSNs were already being employed in a wide number of applications, including remote sensing imaging, defense, health, and traffic monitoring. These mission-critical applications have varying degrees of security requirements, but owing to the constraints of the sensor networks, achieving adequate security might be difficult since typical approaches are not applicable. The WSN is believed to be the heart of both the Internet of Things (IoT) and smart cities. However, security has emerged as one of the most serious issues concerning the applications of the IoT and smart cities. They provide effective and safe routing in WSNs are considers the constraints imposed by sensor nodes and information from layers. It suggests a Tow-ACKs Trust (TAT) networking protocol for use in WSNs to provide safe routing. Even when there are many malicious nodes, the findings of the simulation show that TAT is scalable and offers superior performance to both bio-inspired trust and reputation model and Peer trust models.

**S. Rajasoundaran et el., (2022) [12]** examined that the security concepts of the Fifth Generation (5G) are generally anticipated to include efficient cryptography models, information security models, and Machine Learning (ML)-based Intrusion Detection System (IDS) for IoT-based WSN. The existing security models are not adequate to protect against the dynamic nature of WSNs. The suggested system creates a Deep Convolutional Neural Network (DCNN) and a Distributed Particle Filtering Evaluating Scheme (DPFES) to build a safe and cooperative multi-watchdog system. An eye on the data being sent from each sensor node, the Deep Learning (DL)-a based dynamic multi-watchdog system that is presented can keep them all safe. The work being suggested incorporates secure assessment methods that are essential for increasing the secured medium of 5G-based IoT-WSN networks. The author implements the developed approach, and the outcomes are analyzed with other relevant research. The performance of the cooperative multi-watchdog system that has been developed produces results that are between 10 and 15 percent better than those obtained using other methods.

**Perumal et al., (2021) [13]** determined that wireless networks do not prioritize aspects such as Ultra-high Reliability and Low Latency (URLL) as their most important characteristics. In mobile networks, there are content and services that can tolerate being delayed and that are not vital and are built on human-centered communication. The purpose of wireless networks is to improve data transfer rates while simultaneously expanding their coverage areas via the use of the most effective networking strategy. The primary purpose of the wireless communication device is to ascertain the state of the entity by providing improved help with wireless connections and, as a result, elevating the status of the commodity. The spectral band's systematic super-duper accuracy and low latency communication, technologies such as numerous schemes, synchronization, etc., and channel code design are implemented at the physical layer. The methods that have been created specifically for the goal of monitoring and manipulating the development of plants are referred to as precision agriculture techniques. Integrating IOT with cloud computing helps mitigate some of the shortcomings of monitoring and managing systems. The main motive of the author is to build a communication system that is suitable for use in precision farming using WSNs.

**Rachit Manchanda and Kanika Sharma (2021) [14]** suggested that an energy-limited sensor node is a problem in the WSN, which is also known as the WSNs. The node uses excessive energy dependent on how much data is being provided or received by other nodes in the system. The network's lifespan would be extended because of the conservation of energy. Its scalability is investigated via the use of a range of performance metrics, and the data is analyzed. As contrasted to the energy-adjusted high-level data total tree protocol. It improves the stability period and network lifespan by 52% and 46%, respectively, for one of the two scenarios. It achieves superlative performance in the other case and compares the two distinct kinds of network architectures.

**Abdulkarem et.al., (2020) [15]** focused that the combined knowledge of researchers using WSNs for basic health monitoring is provided. The WSN architecture, connectivity, and common operating systems, along with wired or wireless sensor system technologies. First, some background information was presented on wired networks Structure Health Monitor (SHM) technology and WSN-based SHM systems. The next thing that would be looked at is whether SHM might benefit from wireless platform technologies in the academic and business worlds. A significant amount of emphasis has been focused on the most significant difficulties associated with WSNs for SHM in addition to a comprehensive and effective classification of the potential solutions.

**Gogolák et.al., (2020) [16]** studied that Industry 4.0 takes substantial information management to achieve perfection in the assembly process. Information management is especially important regarding the physical attributes and location of components that are being created, or the construction parts and components. The newly constructed WSN technologies for assembly process monitoring and an adapted overall supervisory paradigm for assembly systems, which is built on a customized four-layer control system order, are presented by the author. A comprehensive solution to the issue of system regulation can be applied to systems of any size or form and places a significant emphasis on the problem of addressing the issue of localization. The results of the investigation were used to come up with the essential parts for improving the effectiveness of the localization.

**Salman et. al., (2019) [17]** determined that the primary attention is now being placed on the development of WSN-based smart homes. A home automation detection system that is based on WSN ensures a risk-free environment in which to live. The development of a smart house is connected to the construction of an accurate WSN, and the monitoring and management of private vitality are accomplished for the management of home automation. It provides an essential and flexible online arrangement for smart things of temperatures, gas, movement, humidity, and light by using reliable sensor hubs that were controlled and observed. They automate temperature, gas, movement, and moisture in the house. As a direct consequence of the achievement, there is now the potential for an increase in the total number of devices that must be used inside the house for personal computing.

**Khalaf et.al., (2019) [18]** suggested that the Distribution Least Mean P-Norm Method was attempted in three different approaches: incremental, consensus, and scattering. The methods were used to test the dispersed frequency of the signal. An approximation of the frequency of common sinusoidal signals that have a common frequency may be achieved in a WSN via the use of a distributed method that is based on the construction of acceptable cost functions. The use of Matrix Laboratory (MATLAB) simulations that the suggested technique performed better than its rivals, such as single-sensor or distributed systems. Estimates of the domain and phase that converge adequately and quickly may be obtained locally using the method that has been developed while concurrently obtaining estimates of the distributed frequency. The planned approach is simpler, and its convergence rate is both adequate and superior to the distributed filter method.

**Guillermo et. al., (2018) [19]** focused that the architecture is an agrotechnological device for family cocoa farmers that collects, stores, regulates and visualizes agricultural data. The gathering of the information is essential to securing the crop's long-term survival. It will ensure that resources are allocated appropriately and that frequent quality checks of the product can be carried out. It is possible, with the help of the data produced by Mobile Computers and Communication Architecture systems, to improve the production, quality, and long-term profitability of an agricultural business.

**Deng et. al., (2018) [20]** examined that a self-powered WSN node's hardware platform is built, produced, and detailed in the document for deployment in real-world applications. The primary objective of its design is to develop a method known as hybrid energy gathering, to lengthen the amount of time that WSN nodes remain operational in the field. The amount of power that a device needs might think about using other sources of energy rather than constantly charging or replacing batteries. The platform consists of a supercapacitor, a Radiofrequency (RF) transmitter, and the CPU. A WSN node system with suitable integration can meet the long-term power supply requirements of a WSN node in the passive mode without the utilization of batteries. It was found that the WSN node had an average daily output capacity of 7805.09 J, which is much higher than the WSN node's energy use.

**Pei et. al., (2017) [21]** analyzed that an excessive number of sensors in wireless networks may lead to a vulnerability in delays. The traditional methods of traffic congestion reduction rely on rate adjustment. The Delay-Aware Congestion Control (DACC) protocol offers a one-of-a-kind congestion control model that considers both the current real-time storage occupancy and the typical amount of time it takes for a packet to be transmitted. The correctness of the traditional approach is helped along by this, which is helpful. The DACC can communicate congestion information because it makes use of bits in the Decentralized Coordinating Function (DCF) frame header that was unused in the past. According to the findings of simulations, DACC is superior to DCF, Primary concern is Congestion Control Protocols (PCCP), and Disentangling Congestion Control as well as Fairness in packet delivery ratio and buffer load.

**Hayes et. al., (2017) [22]** evaluated that the Medium Access Control (MAC) protocol is significant in Mobile Wireless Sensor Networks (MWSNs) in terms of dependability, latency, or energy utilization. The finding suggests that there is a dearth of MACs for minimalist design MWSNs, which is the topic of the remaining study. They implement three new MAC protocols, each of which would be tailored to meet the specific needs of flat MWSN networks. It makes use of Coherent Sensing Multiple Access (CSMA), Network Divisional Multiple Access (NDMA), and Network. In the application on both the link layer and the network layer, a wide range of hypothetical situations with different levels of traffic are modeled and simulated. The unusual nature of the recommended processes, in addition to the provision of four well-known MACs, a performance baseline has been established for the findings.

**Hayes et. al., (2016) [23]** suggested that the unique technology known as Place Sensor Routing has been developed specifically for MWSNs. New applications need both high dependability and low latency. The protocol made use of position information; a gradient field could be maintained even in settings with a high degree of mobility. The packets were sent using a mechanism known as blind forwarding and were propagated toward the sink. Route variety and resilience must be achieved by concurrently using several different pathways. The varied applications of laser are beneficial to the automation of vehicles on land, at sea, and even in the air. The experiments including modeling and simulation have shown the flexibility and robustness of the developed routing protocol. A comparison is made between more modern adaptive cross-layer routing protocols for high mobility networks, as well as for ad hoc on-demand distance vector and optimal link-state routing. The effectiveness of protocols is measured according to a variety of parameters, including throughput, energy consumption, end-tone delay, and packet delivery ratio. The findings demonstrate that laser is superior to the best practices that are already in use, to having exceptional performance in a variety of demanding environments.

**Nikhade et. al., (2015) [24]** focused that WSN technology has become a feasible answer to an extensive range of innovative applications. Raspberry Pi, ZigBee, and several other accessible hardware platforms are used in the construction of a WSN. Environmental monitoring applications benefit from the low cost of the system, the system's low power consumption, and the system's great scalability. The system is suitable for a wide range of applications. Sensor nodes, the XBee communication technology, a Raspberry base station, and several open-source software packages are the components that go into the construction of a WSN. The reduced, lending computer Raspberry Pi, which provides the gateway of a WSN as well as a DBMS server software server, could be quickly programmed to work without the need for a keypad, monitor, or mouse. The made possible by the overall system's compactness, which allows for more room for other components. The use of sort of technology is of significant advantage to a wide variety of environmental monitoring and data-collecting applications. Table 1 shows the summary of the presented literature review.

Table 1: Summary of the Literature Review

|  |  |  |
| --- | --- | --- |
| **Author(s)** | **Techniques** | **Outcomes** |
| Razan Jamous et al., (2022) [11] | WSNs | Simulation findings show that TAT is scalable and outperforms BTRM or Peer trust models, even with many malicious nodes. |
| S. Rajasoundaran et el., (2022) [12] | IoT | Implementation of the system is completed, and the findings are then compared to those of similar previous studies. The suggested cooperative multi-watchdog system outperforms previous approaches by 10% and 15%, respectively. |
| Perumal et al., (2021) [13] | Full-duplex transmission | Developing a WSN-based precision agricultural communication system known as UHLL. |
| Manchanda and Sharma (2021) [14] | WSN | The stabilization period overall network lifespan is improved by 52% and 46%, respectively, as compared to the power high-level data forest canopy protocol. |
| Abdulkarem et.al., (2020) [15] | SHM | WSNs must be used in SHM systems to make cities safer, according to the information presented here. |
| Gogolák et.al., (2020) [16] | WSN | The results of the investigation were used to come up with the essential parts for improving the effectiveness of the localization. |
| Salman et.al., (2019) [17] | WSN | As a direct consequence of the achievement, there is now the potential for an increase in the total number of devices that may be used inside the house for personal computing. |
| Khalaf et.al., (2019) [18] | DLMP | Estimates of the domain and phase that converge adequately and quickly may be obtained locally using the method that has been proposed while concurrently obtaining estimates of the distributed frequency. |
| Guillermo et.al., (2018) [19] | MOCCA | It is not impossible to improve an agricultural company's output, its quality, and its capacity to remain profitable over the long run. |
| Deng et.al., (2018) [20] | WSN Node | It was revealed that the WSN node had an average daily output capacity of 7805.09 J, which would be a significant amount greater than the energy consumption of the WSN node. |
| Pei et.al., (2017) [21] | DACC | To improve the current approach's accuracy, DACC offers a new congestion control model that takes into account both real-time storage capacity and average packet transmission time. |
| Hayes et.al., (2017) [22] | MAC | MAC studies demonstrate that collision-free protocols are the most reliable, whereas GTDMA gives the best throughput. MAC and routing must be considered while constructing a network. |
| Hayes et.al., (2016) [23] | Laser | The findings demonstrate Laser's superiority above currently accepted best practices, as well as its outstanding performance in a variety of challenging situations. |
| Nikhade et.al., (2015) [24] | Raspberry Pi | A wide range of environmental monitoring and data-collecting applications may greatly benefit from the usage of this sort of technology. |

1. **Background Study**

The energy requirements of data routing, collecting, and aggregation, a WSN's nodes' limited energy resources provide a complex problem. Optimizations must be made while considering the network's lifetime, stability interval, and WSN capacity. WSN's capabilities in cluster head selection in non-homogenous networks have not been completely examined. The WSN is a network of tiny, battery-operated sensor nodes established in each region. A sink, which is an information processing center, receives data from these sensor nodes and processes it. It is quite difficult to add data to these networks due to the limited number of energy resources, inaccessibility, and limitations on onboard processing and calculation that come with WSNs that are scattered in nature. Sensor nodes have been spread out in a variety of ways. Structured and unstructured WSNs are categorized according to their deployment. In an unstructured WSN, many sensor nodes could be transported around. In an unstructured network, network maintenance is challenging since it is a difficult task to do [25].

1. **Problem Formulation**

In an application system with a quasi-distribution of minimum WSN, data transmission could create several challenges, including data loss, increased latency, and higher energy usage, among other things. The most important aspects to concentrate on are power usage and network dependability, which are at odds with one another. The Data transmission systems that are resistant to selective forwarding and wormhole-type assaults are described in this research. Inspector Nodes (IN), Sensor Nodes (SN), and CH are labeled on the sensor node list. Per the instructions given to it upon installation, the IN node is designed to help with the detection, prevention, and subsequent tracking of the whole transmission process. Every step of the design and implementation process is focused on creating a dependable WSN system while keeping energy consumption in mind. A diversity-driven multi-parent evolutionary algorithm is utilized in this work to choose the best CH in a heterogeneous WSN with a Composite Reputation Value (CRV). While selecting CH for the cluster design, the CRV identifies the energy and transmission.

1. **Research Methodology**

In this research methodology, some techniques are used Clustering, CRV, Fuzzy Theory, Genetic Algorithm, and Node Residual Energy.

## **WSN Network**

Security is a major concern when it comes to wireless networking. WSNs are susceptible to assault because of their low energy and mobility. Attacks are classified as passive and active attacks. Data cannot be altered by passive assaults. In addition to active assaults, attacks might occur at the Link, Application, Transport, Network, and Physical levels of wireless sensor networks. The OSI layers as well as the Open System linked model communicate with one other in this way. An aggressive assault might cause the gadget to be damaged by shifting the data. Data transitions include modifications, dynamic network observation, or information disturbance. These attacks are much more difficult to prevent than to recognize and avoid. A comparable Denial-of-Service (DOS) attack must be found in the Layer of the Open Systems Interconnection Model (OSI) layer 3. Passive attacks alter data without affecting the network's nodes. Detecting a passive assault is a challenging task.

## **Clustering**

The reduce energy consumption and lengthen the lifetime of a Sink Node (SN) in a network, clustering is an essential guideline to follow. Every SN in the field tries to create a cluster after being randomly deployed in the target area. The transmission spectrum can only talk to a small number of SNs at a time. Clustering is not always apparent from the beginning. Each node utilizes a variety of messages, including join, status, and broadcast. Figure 2 depicts the clustered networks.

Diagram

Description automatically generated

Figure 2: Clustered Networks [26]

The network has the capability of broadcasting a message to everyone in the surrounding area. The node would decide whether it is a Root Node (RN) based on the delay, the number of new messages, and the amount of energy left. The shortest delay would be caused by the node with the highest remaining energy. As a CH, the node may transmit a status message to its neighbors upon receiving a join request from the other nodes [21].

The source node, the CH would send data to the destination node the sink. The method of energy-efficient heterogeneous clustering is the one that is recommended for use while dealing with heterogeneous SNs. The grouping of nodes that have varied sensing distances, energy levels, transmission ranges, and other characteristics is referred to as heterogeneity. A cluster wireless sensor network may be produced using the Editing via Homogenous Clusters (EHC) method. It employs a decentralized strategy for the establishment of clusters and the identification of cluster heads. A route identification approach that employs an algorithm for finding the shortest path while avoiding obstructions, the quickest way to the sink node for communication could be determined. The CHs can form connected networks after a normal route has been established. It is possible to dynamically change the CH identification from time to time to prolong the lifetime of the network. The lifetime of the network would extend because of this dynamic cluster development, which would also reduce overall energy usage. Figure 3 shows the architecture of the clustering system.

Graphical user interface, diagram

Description automatically generated with medium confidence

Figure 3: Clustering System Architecture [26].

## **Composite Reputation Value (CRV)**

The decoding function of each node's CRV is composed of the forwarding rate of the node and the surplus energy shown below, with the one that has the highest value being chosen as CH and the one that has the lowest value being chosen as IN:

(1)

where 0 < a < 1, 0 < b < 1, a + b = 1 and a, b are parameters. The starting node’s energy is E0, and the surplus energy is E else; is CRV of the node; is the node's forwarding rate [27].

## **Fuzzy Theory**

The crisp data is handled during the processing stage of fuzzy logic control, and new crisp data is produced during the processing stage. Therefore, sound producing is used at the beginning of the system to turn clear input into fuzzy data, and just a de-sound producing is used after the system to reverse this process. The components are located at the front end of the system. The single brought into play is the most popular kind of fuzzifier [26], perhaps it is both simple and requires little in the way of computing resources. Even though the specific kind of fuzzifier could not always be enough, especially when there is noise present in the training data or when the data is eventually executed by the system after some time has passed. The IF-THEN rule is used rather often by the fuzzy inference system to identify the degrees to which the incoming information fulfills the criterion specified by the rule. Figure 4 depicts a technique for estimating the degree to which a fuzzy criterion LOW (temperature) differs from a fuzzy input T. The approach could be used to compare two fuzzy values [28].



Figure 4: Fuzzy input with a fuzzy condition [28]

## **Genetic Algorithm (GA)**

The principles of Darwinian evolution, including mutation, selection, and crossover, are used during a GA's search for the optimal strategy. The method presents each potential solution in the form of a binary structure that is referred to as a chromosome. A collection of chromosomes is referred to as a population. Applying the method before the requirements that have been stated have been satisfied therefore leads to an increase in the best fitness value of the solutions. A fitness function was developed to better describe the purpose of the challenge; this function is then used to quantify the fitness value. Figure 5 illustrates the overall search process of the GA [29].

Diagram

Description automatically generated

Figure 5: Genetic Algorithm Process [30]

According to the natural system's idea of evolutionary survival, the selection is the process of picking 2 options that are more desired than others to decide the composition of the next generation's children. The selection of chromosomes is accomplished either by assigning a probability to each chromosome that is proportional to its level of fitness or by arranging the fitness levels from highest to lowest. The option that provides the most benefit to the user should be chosen. The selection procedure was to be repeated, it is hypothesized that lesser answers would be eliminated, while great ones would be preserved and passed down the ages [31].

The crossover operation is the GA's representative function. The process of creating new children via the combination of genes inherited from both parents is known as crossover. The most cases a group of specific spots is divided between two parental chromosomes, and the pieces that are separated are passed down between the children. A uniform crossover involves randomly exchanging genes from one set of parents with genes from the other set of parents in various spots. The beneficial genetic material of chromosomes from earlier generations must be preserved via the use of numerous crossover approaches, and at the same time, improved chromosomes that are superior to those discovered before could be simultaneously screened [32].

## **Evaluation of Node Residual energy**

After each node has sent or received k bytes of data, the power estimate for that node is then updated. The process is done as many times as necessary until all the nodes are deemed to be dead. The amount of energy that is left in a node is either negative or zero, that node is referred to as a dead node. The amount of energy that a node still has after the most recent round serves as the basis for deciding on which cluster to join. It is only responsible for transmitting, collecting, collecting, and sending information, the cluster head nevertheless consumes much more energy than the other sensor nodes. After each cycle of communication, the energy consumption of the cluster head lowers more rapidly than other nodes [33].

(2)

Whereas is the node’s residual energy after rounds and is the power used in the round. It should come as no surprise that the behavior of heterogeneous nodes differs significantly depending on the kind of node being considered, have a higher impact. for advanced, intermediate, and normal nodes would be , and for the first round ().

## **Distance between node and sink**

Every communication that takes place between a node and the cluster head, or between a node and a sink, uses up a certain amount of power that is proportional to the function of the node. The connecting, greater the distance between the nodes, the greater the amount of power that is required, and the opposite is also true. The following equation is used in the process of determining the distances that separate sensor nodes and sinks [32]:

(3)

The situation with many goals, the one pertains to fitness and is the second aim. Calculating the distance between sensor nodes or cluster heads requires applying the appropriate formula:

(4)

Where are the number of cluster heads that need to be given, the length of a single node (Di), and the distance between multiple objectives (Dij), the sensor and sink nodes respectively are denoted by X and Y.

## **Transportation theory**

The goal of the transportation problem, a subset of Linear Programming (LPP), is to find the optimal route for the delivery of a product from a set of origin points to a set of final destinations while keeping the total cost of distribution to a minimum. In this research, transportation theory is used to minimize the total time of communication between the nodes [34].

* **Assumptions in the transportation model**

1. The sum of the supply (quantity) from all possible locations meets the sum of the demand (quantity) at all possible destinations.
2. From any origin to any destination, items can be transferred quickly and easily.
3. Including all origins and ending points, the total cost per unit of the item's transportation is known with absolute certainty.
4. The final price of every particular root is related to the quantity sent along each given route.
5. The goal is to reduce transportation costs across the board, not only at each supply or destination point.

## **Proposed Methodology**

The clustering of sensor nodes is handled by the residual energy with the help of fuzzy sets and a genetic algorithm. The nodes that make up the wireless sensor system are produced at random with a constant overall population of NP and the generation parameter set to 0. The fuzzy theory is used to achieve the clustering of all the sensor nodes. The selection of the Cluster head or inspector node is specified based on the ideal method. The Cluster head is responsible for transmitting the data, and the inspector node keeps track of the data transmission via CH while IN checks the data transfer fully. If there is no abnormality found, then the transfer is finished. If any data is found to be abnormal, then IN tends to take the charge but also replaces the CH node or other vulnerable node to finish the transmission of the data. If there is no abnormality found, then the transmission is finished. After the transmission IN is finished, notify the modifications and update. After the clustering performance, the calculation of the CRV value for each of the sensor nodes, using the equation to optimize the cluster head node or inspector nodes was completed in equation (1). Equations (2) and (3) are used to determine the distance between the node and the sink as part of the selection criterion for the cluster head in equation (3). It does not meet the selection requirements; it would be put through a genetic algorithm (gen = gen + 1) to determine its place in the cluster head and its inspector node classification. It does meet the criteria; it would be given direct access to those classifications. They execute a choice of these node's positions, which are then updated based on the algorithm in the phases of cross-over and mutation, and then create the mutation for the offspring. The addition to using operation-based learning derived from machine learning to get the offspring of the sensor nodes, a group or pool of offspring that has been produced via crossover and mutation is formed. The network has been established, the nodes with the highest CRV values are chosen to serve as CH, and the other nodes are given the role of Inspector Nodes (IN). The available nodes each have a unique role to perform, and the iN’s job is to identify the cluster node activity based on this information. The IN is taught to do this based on a set of predetermined guidelines, as illustrated in Figure 6 below:

A picture containing graphical user interface

Description automatically generated

Figure 6: Intended Methodology

**Step 1:** The nodes that make up the wireless sensor network are produced at random with a population size of NP that is constant, and generation is set to 0.

**Step 2:** The fuzzy theory is used to execute clustering on all of the sensor nodes to find the optimal solution for decreasing the distance between both the cluster head as well as the base station based on the residual energy of each node, which is calculated using an equation (2). The selection of a cluster head and also the inspector node is carried out based on the procedure that is outlined in figure 7 below.

The selection of the Cluster head and the inspector node, which is responsible for transmitting the data, monitoring its progress as it travels through the CH, and ensuring that it has been sent accurately, is determined based on an optimum algorithm. If there is no indication of anything out of the ordinary, the broadcast will be finished. If any suspicious data is discovered, it would step up to the plate and replace the CH node, as well as any other compromised nodes, to ensure that the data is successfully sent.

A screenshot of a computer

Description automatically generated with medium confidence

Figure 7: Selection of Cluster Head and Inspector Node.

**Step 3:** After the cluster performances, the calculation of the CRV values for each of the sensor networks, using the equation to optimize the cluster node and the inspector nodes was completed in equation (1).

**Step 4:** Equations (2) and (3) are used to detect the length between the node as well as the sink as part of the selection criterion for the cluster head in equation (3).

**Step 5:** If it does not meet the requirements for selection, a genetic algorithm (gen = gen + 1) is used to assist it to undergo mutation. If it does meet the criteria for selection, it is given direct access to the cluster and inspector node categorization.

**Step 6:** In this step, execute a choice of these node's positions, which are then updated based on the algorithm in the phases of cross-over and mutation, and then create the mutation for the offspring.

**Step 7:** In this step, it is getting the progeny of the sensor nodes, a group or pool of offspring resulting from mutation and crossover is produced, and operation-based learning derived from computer vision is also used.

**Step 8:** After the network has been established, the nodes with the highest CRV values are chosen to serve as Cluster Heads, and the other nodes are given the role of Inspector Nodes (IN).

**Step 9:** The available nodes each have a unique role to play, and the IN's job is to identify the cluster head node's activity from that data. The IN is taught to do this based on a set of specific criteria, which are outlined below:

1. **Reception and delay rule:** To prevent the attack from happening, the sink is required to receive the whole of the data packets sent by MNs as well as the CH within the allotted amount of time.
2. **Cluster Head member rule of sub-list:** When the Cluster head does not have a whole list of MNs from the initial packet that was sent, it is reasonable to assume an assault.
3. **Information loss rule:** At the beginning of the communication, the CH sends a data packet to the sink. This packet contains accurate guidance about the investigator node and the member node. It is important to ensure that the pertinent data about the network element is both exchanged and accessible; otherwise, malicious behavior may result.
4. **Time to react/Response time rule:** Following the successful detection of the assault, an inspector node is required to report the response rates of the cluster head as well as the MN, and if any asymmetry is found, the appropriate actions are done.
5. **Results and discussion**

The result part of the research is presented in this section. The implementation of the methodology is performed in MATLAB software. The accumulated round-by-round temporal information between two nodes is shown in Table 2. Timekeeping data between the sender and the receiver, as indicated by the Sender ID and Receiver ID columns, is communicated via the round column. Time acquired during two-way communication between nodes 1 and 2 for the exchange of timing information without transportation theory optimization is shown in Figure 5. For 20 iterations, both nodes communicate with one another via a time message.

Table 2 Information of two nodes at different rounds [25]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Round** | **Sender ID** | **Receiver ID** | **sender Timestamp** | **Receiver timestamp** |
| 1…20 | 1…n | 1…n - 1 | In msec | In msec |

Figure 5 Timing information collected between receiver and sink node.

* **After optimizing the timing between node 2-way communication using transportation theory**

Figure 6 shows the optimized time collected during two-way communication between sender node 1 and sink node 2. The time is optimized using transportation theory. Both the nodes exchange their timing message for 20 rounds.

Figure 6 collected between nodes.

The clock offset is calculated between sender 1 and sink node 2 for 20 no. of rounds further it is calculated for all the nodes and the obtained values are shown in the table. Figure 7 shows the clock offset concerning no. of rounds graphically. The clock offset () is calculated using the given formulae:

(5)

Where, at time , represents the clock offset between nodes S1 and S2. The packet arrives at node S2 at time . Once the data packet is sent from node S2 to node S1 at time , the reply is received by node S1 at time .

Table 3 Clock offset for 20 no. of rounds between sender node 1 and sink node 2.

|  |  |
| --- | --- |
| **Clock offset** | **No. of rounds** |
| -2514 | 1 |
| -2512.24 | 2 |
| -2513.89 | 3 |
| -2511.89 | 4 |
| -2514.34 | 5 |
| ….. | …. |
| -2520.21 | 16 |
| -2517.56 | 17 |
| -2521.56 | 18 |
| -2518.49 | 19 |
| -2520.22 | 20 |

Figure 7 Clock offset between sender 1 and receiver 1.

The mean clock offset is calculated for all nodes using the formulae given in equation (6). Figure 8 shows the mean clock offset concerning a combination set of clock offsets.

(6)

Where M is the mean clock offset, N is the no. of data points, and xi represents the value of the offset.

Figure 8 The value of MEAN associated with the major subset algorithm for node 1 and node 2.

Figure 9 shows the standard deviation and coefficient of variance graphically. The standard deviation and coefficient of variance are calculated by using the given formulas:

For standard deviation (SD),

(7)

where is the average value and is the total squared difference between each data point and the mean.

For the Coefficient of variance (CV),

(8)

|  |  |
| --- | --- |
|  |  |
| (a) | (b) |
| Figure 9 (a) shows the standard deviation and 9 (b) shows the CV | |

* **Comparative analysis**

In this section, the proposed model is compared with other existing methods based on mean standard deviation coefficient variance and efficiency. Table 4 shows the comparison of the proposed model with the previously developed model based on mean, standard deviation, and coefficient of variance. Figure 10 (a), (b), and (c) shows the same graphically.

Table 4 Comparison based on the selection of the most probable clock offset for sender node 1 and sink node 2.

|  |  |  |  |
| --- | --- | --- | --- |
| **Model** | **Mean** | **SD** | **CV** |
| **MPT** | -2528.59 | 0.44230 | -0.000174 |
| **Proposed model** | -2530.45 | 0.5011 | -0.000182 |

|  |  |
| --- | --- |
|  |  |
| (a) | (b) |
|  | |
| (c) | |
| Figure 10 Comparison graph based on Mean, SD, and CV | |

Table 5 shows the comparison of the proposed model with the existing technique and David L. Mills algorithm based on efficiency. It was found that the proposed algorithm gives better results in terms of efficiency. The efficiency of the proposed model is 99.9%. Graphically, figure 11 shows the comparison of the proposed model with the existing technique based on efficiency.

Table 5 Comparison based on efficiency.

|  |  |  |  |
| --- | --- | --- | --- |
| Factor | Proposed | MPT | David’s |
| Efficiency | 99.9 | 99.8 | 98.2 |

Figure 11 Comparative analysis based on efficiency.

1. **Conclusion and future scope**

The performance of the WSN is analyzed for comparison regarding the typical amount of energy used and the amount of bandwidth used. There are more nodes in a WSN region, has built helps to reduce the amount of energy that is wasted while maintaining a high level of efficiency. The suggested architecture based on transportation theory is utilized effectively to address the issue of network routing while simultaneously reducing the amount of energy that is used, hence increasing the lifespan of a WSN. Finally, the results concluded that the proposed model has an overall efficiency of 99.9% which is higher as compared to other conventional techniques. In the future, work on developing a more secure architecture that can identify a variety of attacks that can arise at distinct layers of the WSN.

**References**

Prasad, Poonam. "Recent trend in wireless sensor network and its applications: a survey." *Sensor Review* (2015).

Alrajeh, Nabil Ali, Maryam Bashir, and Bilal Shams. "Localization techniques in wireless sensor networks." International journal of distributed sensor networks 9, no. 6 (2013): 304628.Can, Z., & Demirbas, M. (2013). A survey on in-network querying and tracking services for wireless sensor networks. Ad Hoc Networks, 11, 596–610.

Wu, F.; Rüdiger, C.; Yuce, M.R. Real-Time Performance of a Self-Powered Environmental IoT Sensor Network System. Sensors 2017, 17, 282.

Abu-Mahfouz, A.M.; Hamam, Y.; Page, P.R.; Djouani, K.; Kurien, A. Real-time dynamic hydraulic model for potable water loss reduction. Procedia Eng. 2016, 154, 99–106.

Gante, A.D.; Aslan, M.; Matrawy, A. Smart wireless sensor network management based on software-defined networking. In Proceedings of the 2014 27th Biennial Symposium on Communications (QBSC), Kingston, ON, Canada, 1–4 June 2014; pp. 71–75.

Cheng, B.; Cui, L.; Jia, W.; Zhao, W.; Hancke, G.P. Multiple Region of Interest Coverage in Camera Sensor Networks for Tele-Intensive Care Units. IEEE Trans. Ind. Inform. 2016, 12, 2331–2341.

Rajan, Annie Uthra, Kasmir Raja SV, Antony Jeyasekar, and Anthony J. Lattanze. "Energy-efficient predictive congestion control for wireless sensor networks." *IET wireless sensor systems* 5, no. 3 (2015): 115-123.

Ling, Zhen, Kaizheng Liu, Yiling Xu, Yier Jin, and Xinwen Fu. "An end-to-end view of iot security and privacy." In *GLOBECOM 2017-2017 IEEE Global Communications Conference*, pp. 1-7. IEEE, 2017.

Alrahhal, Hosam, Razan Jamous, Rabie Ramadan, Abdulaziz M. Alayba, and Kusum Yadav. "Utilising Acknowledge for the Trust in Wireless Sensor Networks." *Applied Sciences* 12, no. 4 (2022): 2045.

Bhouri, Neila, and Nadir Farhi. "Towards efficient and reliable transportation systems." *Transportation research. Part C, Emerging technologies* 47, no. 1 (2014): pp 1.

Alrahhal, Hosam, Razan Jamous, Rabie Ramadan, Abdulaziz M. Alayba, and Kusum Yadav. "Utilising Acknowledge for the Trust in Wireless Sensor Networks." *Applied Sciences* 12, no. 4 (2022): 2045.

Rajasoundaran, S., A. V. Prabu, Sidheswar Routray, Prince Priya Malla, G. Sateesh Kumar, Amrit Mukherjee, and Yinan Qi. "Secure routing with multi-watchdog construction using deep particle convolutional model for IoT based 5G wireless sensor networks." *Computer Communications* 187 (2022): 71-82.

Perumal, Mahendran Sivananaintha, Braveen Manimozhi, Hareesha Dandamudi, Vijendra Babu Durairaj, and Arunnehru Jawaharlalnehru. "Ultra-reliable low latency communication technique for agriculture wireless sensor networks." *Arabian Journal of Geosciences* 14, no. 13 (2021): 1-9.

Manchanda, Rachit, and Kanika Sharma. "A novel framework for energy‐efficient compressive data gathering in a heterogeneous wireless sensor network." *International Journal of Communication Systems* 34, no. 3 (2021): e4677.

Abdulkarem, Mohammed, Khairulmizam Samsudin, Fakhrul Zaman Rokhani, and Mohd Fadlee A Rasid. "Wireless sensor network for structural health monitoring: a contemporary review of technologies, challenges, and future direction." *Structural Health Monitoring* 19, no. 3 (2020): 693-735.

Gogolák, László, and Igor Fürstner. "Wireless sensor network aided assembly line monitoring according to expectations of industry 4.0." *Applied Sciences* 11, no. 1 (2020): 25.

Salman, Ayman Dawood, Osamah Ibrahim Khalaf, and Ghaida Muttashar Abdulsahib. "An adaptive intelligent alarm system for wireless sensor network." *Indonesian Journal of Electrical Engineering and Computer Science* 15, no. 1 (2019): 142-147.

Khalaf, Osamah Ibrahim, and Ghaida Muttashar Abdulsahib. "Frequency estimation by the method of minimum mean squared error and P-value distributed in the wireless sensor network." *J. Inf. Sci. Eng.* 35, no. 5 (2019): 1099-1112.

Guillermo, Juan Carlos, Andrea García-Cedeño, David Rivas-Lalaleo, Mónica Huerta, and Roger Clotet. "Iot architecture based on wireless sensor network applied to agricultural monitoring: A case of study of cacao crops in ecuador." In *International Conference of ICT for Adapting Agriculture to Climate Change*, pp. 42-57. Springer, Cham, 2018.

Deng, Fang, Xianghu Yue, Xinyu Fan, Shengpan Guan, Yue Xu, and Jie Chen. "Multisource energy harvesting system for a wireless sensor network node in the field environment." *IEEE Internet of Things Journal* 6, no. 1 (2018): 918-927.

Pei, Tingrui, Fangqing Lei, Zhetao Li, Gengming Zhu, Xin Peng, Youngjune Choi, and Hiroo Sekiya. "A delay-aware congestion control protocol for wireless sensor networks." *Chinese Journal of Electronics* 26, no. 3 (2017): 591-599.

Hayes, Tom, and Falah H. Ali. "Medium access control schemes for flat mobile wireless sensor networks." *IET Wireless Sensor Systems* 7, no. 4 (2017): 105-112.

Hayes, Tom, and Falah H. Ali. "Location-aware sensor routing protocol for mobile wireless sensor networks." *IET Wireless Sensor Systems* 6, no. 2 (2016): 49-57.

Nikhade, Sudhir G. "Wireless sensor network system using Raspberry Pi and zigbee for environmental monitoring applications." In *2015 International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM)*, pp. 376-381. IEEE, 2015.

Upadhyay, Divya, Ashwani Kumar Dubey, and P. Santhi Thilagam. "Time synchronization problem of the wireless sensor network using maximum probability theory." International Journal of System Assurance Engineering and Management 9, no. 2 (2018): 517-524

1. Elma, K. Johny, and S. Meenakshi. "Energy-efficient clustering for lifetime maximization and routing in WSN." International Journal of Applied Engineering Research 13, no. 1 (2018): 337-343.
2. Zhou, Hai, Yuanming Wu, Li Feng, and Daolei Liu. "A security mechanism for cluster-based WSN against selective forwarding." Sensors 16, no. 9 (2016): 1537.
3. Kacprzyk, Janusz. "Studies in Fuzziness and Soft Computing 295." (2013).
4. Damaso, Antonio, Nelson Rosa, and Paulo Maciel. "Reliability of wireless sensor networks." Sensors 14, no. 9 (2014): 15760-15785.
5. Mirjalili, Seyedali. "Genetic algorithm." In *Evolutionary algorithms and neural networks*, pp. 43-55. Springer, Cham, 2019.
6. Kim, Youngmin, Wonbin Ahn, Kyong Joo Oh, and David Enke. "An intelligent hybrid trading system for discovering trading rules for the futures market using rough sets and genetic algorithms." Applied Soft Computing 55 (2017): 127-140
7. Yong, Zhu, and Qing Pei. "An energy-efficient clustering routing algorithm based on distance and residual energy for wireless sensor networks." Procedia Engineering 29 (2012): 1882-1888.
8. Wang, Jin, Jiayi Cao, R. Simon Sherratt, and Jong Hyuk Park. "An improved ant colony optimization-based approach with mobile sink for wireless sensor networks." The Journal of Supercomputing 74, no. 12 (2018): 6633-6645.
9. Ambrosio, Luigi, Alberto Bressan, Dirk Helbing, Axel Klar, Enrique Zuazua, Luigi Ambrosio, and Nicola Gigli. "A user’s guide to optimal transport." Modeling and Optimisation of Flows on Networks: Cetraro, Italy 2009, Editors: Benedetto Piccoli, Michel Rascle (2013): 1-155.