applied system innovation

MDPI

Article

# Energy Efficient Routing Protocol in Novel Schemes for Performance Evaluation

**S. Pradeep [1,*], Yogesh Kumar Sharma [2], Chaman Verma [3,*], Surjeet Dalal [4] and Cvpr Prasad [1]**

[1] Department of Computer Science and Engineering, Malla Reddy Engineering College for Women (UGC—Autonomous Institution) Maisammaguda, Secunderabad 500014, India
[2] Department of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram 522302, India
[3] Department of Media & Educational Informatics, Faculty of Informatics, Eotvos Lornad University, 1053 Budapest, Hungary
[4] Department of Computer Science and Engineering, Amity University, Gurugram 122412, India
* Correspondence: pradeep.sunkari87@gmail.com (S.P.); chaman@inf.elte.hu (C.V.); Tel.: +91-991-220-4100 (S.P.)

**Abstract:** Wireless sensor networks (WSNs) are a comparatively new revolutionary technology that has the potential to revolutionize how we live together with the present system. To enhance data archiving, WSNs are frequently used in scientific studies. Many applications have proved the value of wired sensors; however, they are prone to wire cutting or damage. While preventing wire tangles and damage, wireless sensor networks provide autonomous monitoring. The WS network suffers from a number of fundamental restrictions, including insufficient processing power, storage space, available bandwidth, and information exchange. Consequently, energy-efficient strategies are necessary for maximizing the performance and lifespan of WSNs. As a result, the special cluster head relay node and energy balancing techniques will be applied to deal with WSN energy consumptions. This extends the life of the network. In wireless sensor networks, clustering is a smart approach to reduce energy consumption. Energy scarcity and consumption are serious issues that must be addressed with effective and dependable solutions. The proposed MGSA considers the distance between each node and its corresponding CHs, as well as the residual energy and delay, as important factors in the relay node selection. The proposed approach outperforms the current methods, such as low-energy adaptive clustering hierarchy, LEACH (in terms of data delivery rate), energy efficiency, and network longevity. The next level, which will boost the efficiency of wireless sensor networks, with two fitness functions, is proposed. The cluster head (CH) is in charge of collecting and transmitting data from all other cluster nodes. The flow of the consistency of the cluster head selection process will beat the improved data delivery rate, energy efficiency, recommended fuzzy clustering performance experiments, and assessments. As a result, energy-efficient operations are necessary to maximize the WSN performance and lifespan.

**Keywords:** WSN; energy efficiency; clustering head; mgsa-osr; base station

check for updates

**Citation:** Pradeep, S.; Sharma, Y.K.; Verma, C.; Dalal, S.; Prasad, C. Energy Efficient Routing Protocol in Novel Schemes for Performance Evaluation. *Appl. Syst. Innov.* **2022**, *5*, 101. https://doi.org/10.3390/asi5050101

Academic Editors: Christos Douligeris, Luca Foschini, Gang Li, Eirini Eleni Tsiropoulou, Theofanis P. Raptis and Dimitrios N. Kallergis

Received: 5 August 2022
Accepted: 3 October 2022
Published: 13 October 2022



## 1. Introduction

A WSN describes a collection of edge devices that are interested in observing and transmitting the physical conditions of the surrounding environment, without the requirement for any hardware. The base station is primarily where the layout and communications are handled and centrally controlled. Typically, a smart sensor network is made up of teeny detectors that are identified, interconnected via wireless networks, and placed either in concentrated or sparse populations to detect physical phenomena before being gathered in one place. Technologies of wireless transmission depend greatly on heterogeneous networks. WSNs are used for a variety of purposes, including in the civilian, medical, and defense areas. To measure the moisture, elevation, and stress, the nodes in networked wireless sensors are used. Nodes are capable of gathering and sending data to the B.S., regarding a specific physical location [1].

Since most of the WS stations were powered by lithium-ion batteries, and most functions are extended periods with off-servicing, it is challenging to access them and replace or replenish the batteries. Consequently, utilizing the energy of the sensor nodes effectively and quickly is one of the key hard goals. Large-scale networks with 100,000 sensor nodes are settled down with one pattern, in which the WSNs can be deployed. The significance of WSNs in communication technology is crucial [2].

The function of the cluster heads is crucial. A wireless internal network links the sensors together. Figure 1 shows the WSN node architecture and components (motes). The node has a location finding system, Mobilizer, and power generator, in addition to the sensing, processing, transceiver, and power components.

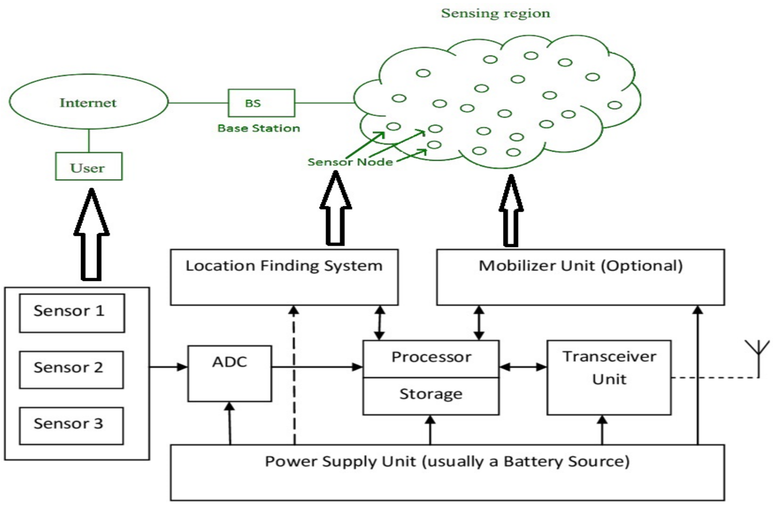


**Figure 1.** Wireless sensor network and node architecture.

The B.S. collects, analyses, and makes decisions based on the data that the WSN sensor nodes transmit to it, in order to connect the monitoring system to some other networking [3]. We look forward over the protocols based on parameters which are related to weak connectivity and coordination. Strong actors will help weaker sensors in many aspects such as routing and data forwarding and deploying few actors in sparsely. Actors can take, move and charge sensors and detect partitions of inter actor network [4–6]. The processing of this workflow will pertaining to wireless sensor networks, such as a summary of sensing techniques, node design, energy absorption constraints, and design problems, as well as the routing classification as priority. Next, the flow will cover the literature review of wireless sensor energy routing techniques, mechanisms, and cluster head criteria, which are analyzed. WSN routing techniques address the issue of insufficient battery capacity and support adaptation and resource-awareness to extend network longevity [7–11].

According to a network's structure, the routing protocols of WSN can be divided into two classes: hierarchical and flat routing protocols. Similar functions in the routing process are carried out by sensor nodes in the flat routing architecture that direct the transmission of sensed data to BS. Contrary to flat routing, the architecture of a hierarchical routing groups sensor nodes into clusters. Nodes within a cluster are distinguished based on the tasks they have completed. Low-level nodes, also known as cluster members (CM) in two-layer architecture hierarchy structure of routing these are transferred to the base level stations [12].

The source node will immediately transfer data to the sink in the event of an emergency or any fire incident. The amount of energy expended in the fire detection directly relates to the events that were held in that region [13]. It is noted that the data in this case contain both geographical and temporal correlations for the need of energy supply is the minimum for sensor node and consideration of energy efficiency for WSN [14]. These correlations are used to create clusters based on certain factors. Due to the farthest location, all sensor nodes send data to the cluster head rather than the SINK. Based on the processing of the data, energy will be consumed. Instead of delivering data packets to sink node on a regular basis, data might be sent based on demand to save energy.

Geographically close nodes are used to organize groups, and clustering algorithms refer to each group as a cluster [15]. Nodes in all clusters that are only allowed to play certain roles, such as member, SINK, or CH nodes. Data forwarding, data aggregation, cluster maintenance, and intra-cluster transmission arrangements are just a few of the several tasks that a CH might carry out as an organizer for the cluster [16].

CH selection processes vary depending on the application and algorithms since effective CH selection can lower energy usage [17]. Most of the techniques on offer use a two-step process. In the first stage, CHs are chosen based on a primary parameter, namely residual energy, and in the second step, a rotation among cluster members is carried out to balance energy utilization [18]. These selection methods and the other crucial criteria not impacting the CH selection are taken into account by a single node parameter. The CHs near the sink or over key links may result in an earlier mortality as a result of the significant inter-cluster communication delay [19,20].

Traditional WSN's dependency on insufficient battery capacity is one of their main drawbacks. As a result, to increase performance and longevity, energy-efficient techniques are needed. Numerous factors influence the rate at which energy is utilized [21–24]. Quite a bit of energy will be used for routing and data transmission. By using intermediary nodes to get to the final destination, routing is a method of transferring data packets from one location to another [25–27].

### 1.1. Related Work

The ever-growing energy consumption has facilitated the development of novel, efficient routing algorithms for improving the performance of the wireless sensor system. Now, we present the related works that are the closest to our research. For simplicity purposes, we have categorized the related work into three categories. The first category is the work carried out for selection of the CH and relay node with the fitness functions. The second category is the works that are related to the selection of CH with multi-objective parameters for optimal routing. The third category is the related works, regarding energy balancing for effective energy consumption. Table 1 shows about the Conventional methods by different authors commencing at Cluster head and relay node selection based on Fuzzy based, LEACH for consideration of network life and optimal routing and Table 2 shows the energy routing scheme for efficient energy directions of different boundaries with battery life, less no of nodes usage and multi objective cluster selection head.

**Table 1.** Conventional methods for CH and relay node selection.

| Authors and Reference | Category | Brief Description | Limitations |
|---|---|---|---|
| S Kole .S [28] | Article survey | The performance of the LEACH protocol was improved, and the network lifetime was increased, according to a study on the distance-based construction of cluster approach. | The cluster head and relay node selection with fitness function for optimal routing was not covered in this paper because it only focused on the distance-based CH selection. |
| Sai Krishna Mothku [29] | Article survey | An investigation was made on the methods used by fuzzy-based energy-aware and delay-intelligent routing to select effective routes. | Higher percentage of inactive nodes. There are fewer communications in the WSN as a result of these inactive nodes. |
| Abu Salem [30] | Article survey | To solve the shortcomings of the LEACH (low energy adaptive clustering hierarchy) protocol, a survey was carried out. Cluster heads should be selected using EN-LEACH approach, taking into account their proximity to the BS and degree of expertise. | This idea did not encompass multi-hop routing and not reacted to the relay of nodes. |

**Table 2.** Energy routing scheme with multi-objective CH selection.

| Authors and Reference | Brief Description | Cluster Head Selection | Limitations |
|---|---|---|---|
| Sateesh [31] | Proposed an efficient directing by choosing legitimate courses, based on the probability values appointed. | Residual energy. | Different boundaries, such as deferral and battery limit, were not considered for bunch head determination; subsequently, it results in wasteful steering. |
| Han and Zhang [32] | An energy-effective bunching system was executed by choosing suitable courses, in light of the distance among BS and CH. | R.E. and node degree. | This article was specific only to the distance-based CH selection and did not cover cluster head and relay node selection with fitness function for optimal routing. |
| Arivubrak an and Sundari [33] | With the procedures of clear to send and request to send, a new multicast directing convention was presented that chooses the data transfer capacity and multi-bounce distance from CH to group individuals (RTS). With the decreased postponement, this convention builds data transmission and parcel conveyance proportion. | — | Less number of nodes used. |
| Elsmany Eyman F. Ahmed, Omar [34] | The energy-efficient scalable routing algorithm, which is described in this study, is an energy-efficient clustering and hierarchical routing technique (EESRA). The suggested technique seeks to maximise network longevity despite growing network size. To reduce the stress on the cluster heads and randomise the selection of cluster heads, the method utilises a three-layer structure. | The LEACH protocol's stochastic rotation technique was used. | There is extension for additional likelihood to diminish energy utilization of the organization. |
| V. Nivedhit ha [35] | The dynamic multi-bounce energy-productive directing convention (DMEERP) picks a course founded on the channel limit model, which is carried out on both the transmitter and beneficiary sides. | Residual energy, delay, and bandwidth. | The creators did not consider mixing secure steering with information total methodology. |

### *1.2. Review of Related Work of Energy Balancing*

The minimum total energy (MTE) routing approach decreases the total energy consumed to reach the sink. If all traffic is sent via the lowest-energy path, however, the sensor nodes on that route will quickly run out of energy, causing the network to divide, while other nodes have enough [36]. As a result, since MTE ignores the nodes' remaining energy, it is unable to effectively extend the network's lifetime.

The remaining battery capacity is the parameter for Singh's min–max battery cost routing. Nodes with a large battery capacity can take on more routing duties than nodes with a small battery capacity. The MMBCR [37] increases the node's life span, without ensuring that the overall amount of energy consumed is kept to a minimum along the chosen path.

The conditional min–max battery cost routing–CMMBCR method takes together routes' minimal final energy usage of nodes' for balanced energy. When there is a lot of traffic, this technique does not guarantee that nodes with a lot of residual energy will survive [38].

Kim proposed the minimum drain rate method, which introduced the drain rate as a new metric. Based on recent traffic situation, these data are paired with a node's residual energy to estimate its lifetime [39]. Routing strategies that are only based inputs rules associated with balanced criteria of energy could not be recycled to determine the path of best work. A huge volume of traffic will flow through a node if it accepts all route requests, due to its higher remaining energy, thus causing its battery energy to quickly deplete. This could cause the node to run out of energy and die as a result. As a result, a metric depending on traffic load condition is essential for optimal cost function.

For increasing network lifetime, Chang and Tassiulas developed the flow augmentation (FA) technique, a straight routing strategy, based on connection costs, that represents both the required residual energy and communication energy levels [40]. This algorithm ignores the traffic load of the node, while choosing a route. Furthermore, the efficacy of this strategy is greatly reliant on the empirical values of the parameters provided.

DEBR is an abbreviation for distributed energy balanced routing [41]. This method, similar to FA, finds an optimal route path that achieves energy balance by combining the needed communication energy with the available energy. Each sensor calculates whether it is cheaper to send the desired traffic to one of the node's neighbors or BS directly. Research examines a specific circumstance, in which all sensors have direct access to the sink in a network.

Liuetal, two cost function-based routing strategies that are energy conscious have been suggested [42]. A modest change in nodal energy is translated into a big change in cost value using the Exponential and Sine Cost Function-based Route (ESCFR). On the other hand, the Double Cost Function based Route (DCFR) considers both the rate of energy utilization and the remaining energy of nodes. This new cost function accounts for the high rates of energy consumption experienced by hotspot nodes, resulting in improved energy efficiency while attempting to balance performance for the protocol

### 1.3. Problem Definition

WSNs are a relatively new technology that has the ability to transform the way we live. The WSN is often utilized in scientific studies to improve data archiving. Wired sensors have been shown to be useful for various applications, but they are susceptible to wire breakage or cutting. WSNs provide autonomous observation, while avoiding wire tangles and damage. Other uses for wireless sensor architecture include the inside auto status. Through the observation ship hull underwater acoustics and biological diagnosis, customers can obtain the best of both worlds by integrating both, using wireless connectivity for to the surge in the creation of mobile methods and structure of WSN information [43].

However, these battery-power sensor devices consume most of their energy, while performing various tasks, such as data processing collection, combing, forwarding, and processing power conservation for the deployment of significant limitations of typical WSNs that rely on battery power as a result. In order to optimize the WSN's performance and lifespan energy-efficiency required, unique strategies for cluster head relay node will be used to address WSN usage that prolongs the network's life.

### 1.4. Research Contribution

1. The serious issues that have been addressed with energy and consumption will affect the dependable solutions.
2. Wireless sensor network have to go with Clustering to save energy. As the Contribution will go with adaptive clustering, low energy and leach for data efficiency, energy, delivery rate and longer stay of network.
3. We went with two-function notations to improve the development of WSNs, i.e., CH using a single fitness function for accountable of data information, sending the data to the base station (BS) in the forwarded node.
4. The collection of nodes of all data reach out to the CH and nodes of other members. The collection of CH nodes from the total numbers of nodes are transferred to the base station.
5. Battery unit power will rely on the WSN. Operations are deployed to optimize the WSN operations for performance and life-span.

### 1.5. Research Objective

1. Residual power and possibility cost values for the sink and function depend on optimal CH.

2. The idea of efficient routing and dependent nodes is to improve performance of the modified gravitational search algorithm (MGSA).
3. To increase stronger adaptive multi-objective fuzzy clustering set of rules (EAMOFC) is to optimize the strength intake for multi-objective strong CH choice and improvement in records aggregation.
4. Balancing the energy improvement function in developing the energy levels.

### *1.6. Research Methodlogy*

To complete this examination work, we continue through a few phases. Our first methodology begins with a starter investigation of WSNs, distinguishing its significant difficulties and main points of contention, regarding executing the steering methods on asset imperative networks. The second stage remembers the direct review for steering techniques in WSN and examines the existing arrangements and approaches proposed for the best in class. We proposed novel directing techniques. The direction's fundamental objective is to diminish energy utilization in the WS networks, as well as recognizing which steering approach will influence the execution of the WSN, as far as its lifetime is concerned. As indicated by our proposed directing approaches, the best answers for advancing energy utilization in the WS networks are based on the grounds that different methodologies (FEARM [29], ELEACH [30], EESRA [34], and DMEERP [35]) actually have a few constraints that are not pertinent for creative and brilliant applications in WSNs. Our third stage recognizes the energy utilization issue in directing, and a calculation was recommended that meant to diminish the energy exhausted by sensor hubs, which, in turn, increments the organization's life expectancy. The fourth stage starts with fostering a clever strategy for productive energy cost capability, which decides the energy adjustments.

The reenactment is achieved by looking at the presentation of the proposed system with two unique strategies. The NS2 test system is being utilized in this examination, since it is an occasion-driven, discrete, and object-arranged network test system that addresses organizing research. On every remote organization, steering, UDP, and multicast convention copying are upheld.

## 2. Materials and Methods

### *2.1. GSA—Gravitational Search Algorithm*

Its been a Natural tool for validating the approximate solutions of NP –hard Problems in of Gravitational search algorithm has been employed in Figure 2 for finding optimal binding of cluster members to CH considering the communication cost of the associated cluster nodes and lifetime of CHs [44–46].

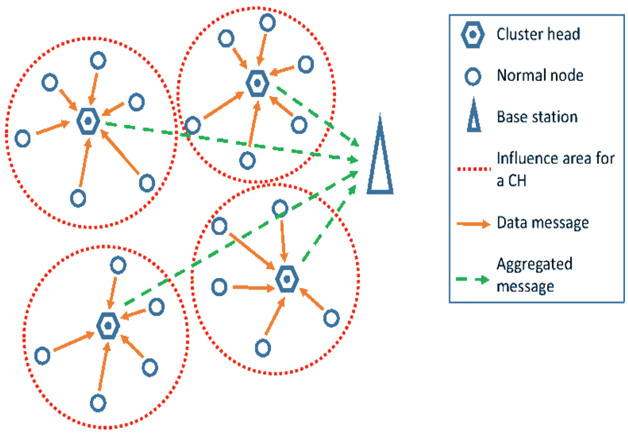


**Figure 2.** Gravitational search GSA in traditional networks, with parameters of CH, NN, BS, and AM.

Gravitational search algorithm is used to transfer information between the cluster head nodes and the sink node. As the gravitational search algorithm, the proposed method has improved energy consumption, efficiency, data delivery rate, and information packet transmission rate compared.

"Each molecule in the universe draws in each and every molecule with a power that is precisely relative to the result of their masses and conversely corresponding to the square of the distance between them,' as indicated by Newton's situation of gravity and movement". Specialists are seen as articles, and their separate masses are analyzed in GSA to decide their presentation. The gravitational power could bring these specialists (objects) together. Every specialist has four particular boundaries, including the item's mass, latent and dynamic gravitational masses, and position.

#### 2.1.1. Position

Involving every specialist in the GSA as a likely answer for the issue under each element of a specialist is haphazardly introduced during the interaction.

Next, is the depiction of *i*th specialist?

$$A_i = \left( A_j^1\ ,\ A_j^2, A_j^3, A_j^4 \ldots\ldots\ldots\ldots\ldots\ldots A_j^d \ldots\ldots\ldots\ldots A_j^n \right)$$

Here $j = 1, 2, \ldots\ \ldots\ N;$
Here, $A_j^d$ shows the $j_t$ agent $d_t$ dimension.

#### 2.1.2. Effective Gravitation

The gravitational field strength applied by a particular item is estimated for dynamic gravity mass. The little vigorous thing has a more vulnerable gravitational field than the bigger article. The gravitational mass is equivalent to the wellness esteem.

#### 2.1.3. In Effective Gravitation

The strength of an article, as related to the gravitational field, is evaluated for detached gravity mass. In the gravitational field, a thing with a more modest, uninvolved gravitational mass encounters less power than a bigger one. The wellness esteem is straightforwardly relative to the latent gravitational mass.

Here Equation (1) shows the force putting on mass '*k*' from mass '*l*' in the dth dimension at time t.

$$f_{k\ ,l}\ (t) = \frac{G(t) * M_{\ p,k}\ (t) *\ M_{a\ ,l}(t)}{R_{k,l}\ (t)}\ \left( A_l^d\ (t) - A_k^d\ (t) \right) \tag{1}$$

where

$M_{a,l}$ and $M_{p,k}$ denote effective and non-effective gravitational;
$R_{k,l}(t)$ denote about Euclidean length of two "$k$" and "$l$".

#### 2.1.4. Evaluation of Fitness Function

At each specialist area, the FF is assessed. The most reduced wellness esteem specialist is the best in a minimization issue, while the most noteworthy wellness esteem specialist is just plain horrible.

Here Equation (2) will gives lowest fitness value at best and high fitness value at worst

$$\frac{\textbf{Best}}{\textbf{Worst}} = \frac{\textbf{Min fit (t)}}{\textbf{Max fit (t)}} \tag{2}$$

### *2.2. Single Fitness Function of GSA Algorithm*

In WSNs, the energy proficiency is the most troublesome undertaking. Grouping has been demonstrated to be a powerful way for WSNs to save energy. Nonetheless, most of past cluster approaches flopped pitifully in the determination of CH, coming about in expanded energy utilization [47–50].

The ideal transfer hub determination really limits the sensor hubs' energy utilization. The proposed research brought about the presentation of most recent energy proficiency executive calculations, MGSA-ORS, with a novel technique for the determination of group head process and changed GSA for ideal forwarder hub determination. In this methodology, numerous boundaries, for example, the closeness to the sink, lingering energy of hubs, and likelihood esteem, are utilized to pick CHs.

The sink distance is thought to save extreme energy use because of the distance between the two hubs. Moreover, the proposed MGSA thinks about the separation from each hub to its individual CH, as well as the lingering energy of hubs and connection delay, as huge contemplations for the determination of forwarder hubs. Novel strategy plans expand CH proficiency when contrasted with real techniques.

- The lifetime of a sensor network is broadened, in view of further developed choice of transfer hub and utilization of refreshed GSA.
- Information moving among the sink and CH is improved, despite the fact that CHs are chosen as contingent upon sink closeness to save energy.
- Since hub postponement is an urgent measure for the ideal choice of forwarder hub in MGSA, start to finish, the information transmission time (delay) is reduced.

### *2.3. Modified Gravitational Search Algorithm—ORS*

MGSA-ORS is a cluster-based, energy-proficient convention that guarantees even-handed energy load dissemination across the entirety of the organization's sensor hubs.

(1) The selection of cluster heads relies upon the sink distance, likelihood, and leftover energy of hubs. It describes the proposed convention's presentation.
(2) The inter- and intra-cluster multi-hop station transmission favored the least energy escalated multi-bounce course.

The probability of individuals from the clusters imparts information straightforwardly to the clusters head. The capability of CH is not just the total information; it additionally sends information to the BS by means of multi-jump directing pathways. The hub distance from the sink is the most significant determination rule. Above the inside of the cluster's correspondence is limited to the cluster's head—those are nearer to base station forestall the group heads from high mortality. The hubs impart information for diminishing the energy/information parcel by picking a reasonable method with a minimal measure of correspondence energy, which shows the delay network organization initiate grouping process cluster development. CH selection start sensor hubs look for transfer hubs for CH intra-group-directing data transmission MGSA and hand-off determination. The appropriate transfer hub determination and data communication to the sink hub is a residual energy node distance from sink setup stage and the probability of the remaining energy node distance to the CH and steady state stage are the greatest probability. Because of the above new methodology, the WSN's life will be expanded.

The MGSA-ORS activity is isolated into adjustments, every one of which involves two stages: setup and consistent state. Clusters are coordinated during the arrangement stage, and multi-ways from each clusters portion of the CHs and BSs are chosen. The information is provided during the consistent state stage. As such, the arrangement stage span is more limited than the consistent state and progressively eases the span, concerning networks above minimization. Figure 3 portrays the proposed framework for the proficient choice of the group head and improvement of the forwarder hub determination. We design protocols for WSNs, optimization of energy consumption is the main issue and a popular solution for this issue is employing clustering techniques In the clustering scheme, the aim is to efficiently and effectively manage the WSN energy consumption by dividing the sensors into small groups called clusters. In addition, the aim is compressing data in clusters and transferring the compressed data to the base station using a limited number of sensors, namely cluster heads.

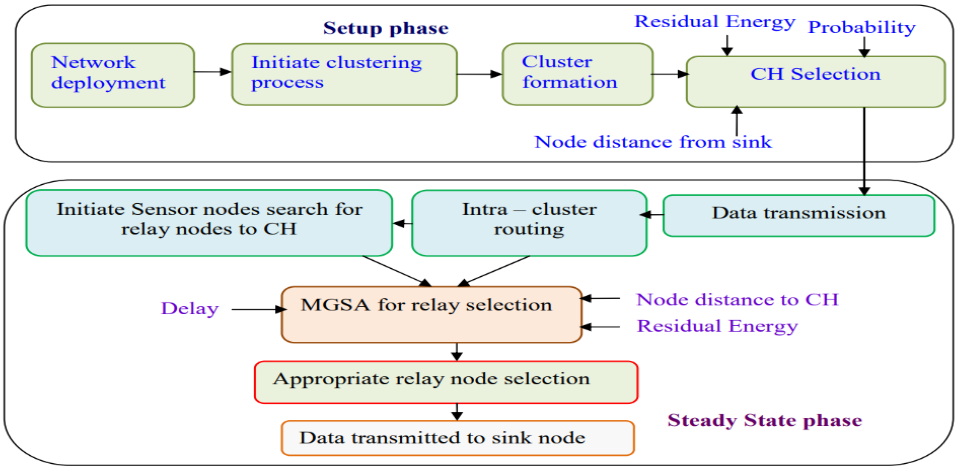


**Figure 3.** Block diagram representation with MGSA, node selection, and data transmission process for proposed method.

### 2.4. Cluster Head Selection

Every hub evaluates the sink distance toward the beginning of the arrangement stage; afterward, they share the leftover energy subtleties and distance data with their neighbors. Every hub's likelihood is determined utilizing an irregular number somewhere in the range of 0 and 1.

Here Equation (3) will determine the utilization of Euclidean distance equation for Sink distance.

$$d_{sink-node} = \sqrt[2]{(xpos_{sink} - xpos_{node}).^2 + (ypos_{sink} - ypos_{node}).^2}. \quad (3)$$

where $xpos_{sink}$ is the sink node's $x$-status, $xpos_{node}$ is the node's $x$-position, $ypos_{node}$ is the node's $y$-position, and $ypos_{node}$ is the node's $y$-position.

The node's remaining energy is resolved utilizing the Equation (4)

$$\mathbf{RE} = \mathbf{E_{initial}} - \mathbf{E_{consumed}} \quad (4)$$

Here, we denote $\mathbf{E_{initial}}$—sensor node; $\mathbf{E_{consumed}}$—energy utilized in 1 round.

As the nodes become CH, when the sensor node distance and sink are the nearest, and the remaining energy is higher than the left-over nodes in network.

Below is Algorithm 1 which states about the choosing of Distance of Sink and left over node energy in regards to cluster head list and no of sinks nodes.

Here

**Algorithm 1.** Selection of Cluster head

*$d_{i,\ sink}$ = Sink Distance*
*$E_{res,}$ = ith Node remaning energy*
*$Pro_i$ = ith Node of Probability*
*CH [i] = cluster heads list*
*As the total nodes of Sink(S) = {S1, S2, S3 . . . . . . . Sn}*
*Start:*
**For** $i = 1\ : i \leq n\ ; i++)$
*While (CH selection)*
*For cluster node Si*
*Determining the sink distance $d_{i,\ sink}$*
*Compute the sensor node probability Proi*
*Compute $E_{i,res}$ (remaining energy)*
*If (($d_{i,sink} < d_{i+1\ ,sink}$ ) && ( $E_{i,sink} > E_{i+1\ ,res}$ ) && ( $Pro_{i,} > Pro_{i+1}$ ))*
*CH [i] = Si;*
*Else*
$CH[I] = S_i + 1;$
*End*
*If n connects to CH [i]*
*End*

During the consistent state time frame, information is communicated. When multi-bounce pathways are utilized, the organization incorporates both intra- and between bunch correspondence. The ideal transfer hub is picked in view of factors such as the leftover energy of hubs, start to finish delay, and closeness among CH and part hubs. Transfer hubs are just sensor hubs that send information, starting with one sensor and then moving on to the next.

The ideal transfer hubs in this work are chosen from among the sensor hubs of a WSN utilizing a multi-boundary FF. The MGSA presents a wellness capability that boosts various qualities, including hub energy, closeness to CHs, and delay. Every hub could fulfill the wellness capability by offering the most noteworthy conceivable benefit to pick the sensor hub as a forwarder hub. Multi-metric Fitness function is shown in the Equation (5) as per the following:

$$\mathrm{Fitness(n)} = \{\mathrm{Dist_{n-CH}} + \mathrm{E_{res}}\ (\mathrm{n}) + \mathrm{D(n)}\} \tag{5}$$

where

$\mathrm{Dist_{n-CH}}$ tells approximation of 'nth 'node and respective CH,

$\mathrm{E_{res}}$ (n) represents 'nth' node balanced power, and

D (n) shows 'nth' node delay.

**3. Distance between Nodes to CHs**

The vicinity among CHs and sensor hubs is the wellness capability, which is one of the boundaries. To achieve compelling correspondence, it ought to be kept to a base.

For computing the distance between nodes to Cluster head(CH) we apply the following Equation (6)

$$Dist\ Dist_{n-CH} = \sqrt[2]{(\mathrm{xpos_{CH}} - \mathrm{XPOS_{node}})^2 + (\mathrm{ypos_{CH}} - \mathrm{ypos_{node}}).^2} \tag{6}$$

where:

$\mathrm{xpos_{CH}}$ denotes the cluster head's X-position;

X-position→$\mathrm{XPOS_{node}}$ is node's X-position;

Y-position denotes→$\mathrm{ypos_{CH}}$ denotes the CH node's;

Y-position denotes→$\mathrm{ypos_{node}}$.

In WSNs, the residual energy of nodes is computed to choose the Cluster Head and the residual energy node is calculated using Equation (4).

**4. Delay (D(n))**

The absolute amount of deferrals at every hub is characterized as the WSN's postponement. To select a hub as an ideal transfer hub, the defer worth ought to be less. Delay is determined in view of the accompanying hub qualities:

- Expected transmission count;
- Propagation delay;
- Network's communication delay.

Here delay between the two nodes in WSN computed using below Equation (7)

$$\mathrm{D(n)} : \sum_{i=1}^{n} \mathrm{ETC_n}\ (\mathrm{TD} + \mathrm{PDn}) \tag{7}$$

where:

$\mathrm{ETC_n}$→denotes the nth node expected transmission count;

TD→denotes complete transmissions of the entire network;

PDn→represents the nth node propagation delay.

The inputs of below Algorithm 2 which states modified gravitational search algorithm about best fitness of the node and enhancing the search efficiency with relay node or optimal node and also calculation of distance.

**Algorithm 2.** MGSA for choosing relay node

$P_i$ = total particles in WSN
$f_{I=}$ particle's fitness;
$B_{fit=}$best fitness of the node
$E_{res}$ = residual energy
$Dist_{i,CH}$ = the proximity, together with sensor nodes and cluster head
OFN = relay node or optimal forwarder
For ∀ nodes 'n'
Evaluate f–i of total particles P
Calculate $E_{res}$
Estimate $dist_{I,CH}$
Determine $D_n$
$F_i = \{dist_{i-CH} + E_{res} + D_n\}$
End
$B_{fit} = \{\max[f_i]\}$
For ∀ nodes 'n'
if $(B_{fit} P_i > B_{fit} P_{i+1})$
OFN = $P_i$
Else
OFN = $P_i + 1$
End for

### 4.1. Derivation of a Cluster Head Selection Fitness Function

(a) Energy: All part hubs impart information to important CH. Bunch head consolidates the approaching information and converts it into a solitary transmission parcel. Later, the bundles are directed to the BS. Therefore, CH utilizes more energy than other sensor hubs. Thus, a sensor hub with most elevated leftover energy should be picked as CH, proposing that energy utilization is lower for low-energy hubs, rather than higher for high-energy hubs. In this way, our underlying object is to limit F1, as we go with the following Equation (8)

$$F1 = \sum_{i=1}^{m} \frac{1}{E_{CHi}} \quad (8)$$

where Residual Energy = $E_{CHi}$ = $E_{intinal} - E_{consumed}$,
$E_{intial} \rightarrow$ energy of sensor nodes
$E_{consumed} \rightarrow$ consumed energy of sensor nodes

(b) Distance: utilized to decide the typical distance between the BS and sensor hub. It will be brought down when the energy utilization of the CH hubs is at its most minimal. Thus, CH has a more drawn-out life expectancy. The second parameter, F2, can be diminished to Equation (9).

$$F_2 = \sum_{j=1}^{m} \left( \sum_{i=1}^{i\,j} \text{dis}\ (\text{Si},\ \text{BS}) \right) \quad (9)$$

where:

$$\text{dis}(S_i\ ,\ B_s\ ) = \text{Sink Distance} = \sqrt[2]{(xpos_{sin\,k} - xpos_{node})^2 + (ypos_{sin\,k} - ypos_{node}\ )^2}$$

where:

$xpos_{sink}$ and $xpos_{node}$—here, the sink and node are denoted;
$ypos_{sink}$ and $ypos_{node}$ tells y position of sink and node.

(c) Probability Value: during CH determination, the sensor hubs make an irregular number. In a few strange occasions, the 'F1' and 'F2' upsides of at least two sensor hubs might be indistinguishable. In those conditions, the CH's not set in stone by the likelihood esteem. As an outcome, the third boundary, 'F3', can be limited utilizing Equation (10).

$$F_3 = \sum_{i=1}^{m} \Pr(S_i) \quad (10)$$

By utilizing numerous boundaries, the weighted aggregate strategy is applied to the single measurement inclined by Equation (11). Here $\beta_1$, $\beta_2$, and $\beta_3$ are weighted numbers apportioned to each boundary.

$$\text{Fitness} = \beta_1 * f_1 + \beta_2 * f_2 + \beta_3 * f_3 \tag{11}$$

Here

$$\sum_{i=1}^{3} \beta_i = 1 \ \textit{and} \ \beta \in (0,1).$$

As the Below Algorithm 3 which states about Gravitational search algorithm for selection of cluster head with no of sensor nodes and max/min fitness of applied excitation with worst/best solution.

**Algorithm 3.** Selection of Cluster head

Applied excitation:
Total sensor nodes set S = ($s_1, s_2, s_3 \ldots, s_n$)
Number of agents: $N_p$; dimension K;
Response: CHs set
Set up the agents $A_j$, where $1 \leq j \leq N_p$
While (j! = $N_p$) do
Determine fitness ($A_j$)
End
While (j! = $N_p$) do
best = max of (fitness($A_j$))
worst = min of (fitness($A_j$))
End
While (j! = $N_p$) do
Evaluate mass($A_j$)
End
While (j! = $N_p$) do
Find force ($A_j$), with the help of Equation (3)
Evaluate acceleration ($A_j$), with the help of Equation (4)
Updating coordinates $CH_j$ with the help of Equations (5) and (6)
End
Assign sensor to CHs
End

### *4.2. Derivation of Optimal Relay Selection Fitness Function*

During the consistent state time frame, information is communicated. When multi-bounce pathways are utilized, the organization incorporates both intra- and between bunch correspondence. The ideal hand-off hub is picked in view of factors such as the leftover energy of hubs, start to finish delay, and closeness among CH and part hubs.

(a) Distance between cluster member and CH:

The distance between the cluster member and Ch is the average length between the sensor node, as well as the CHs with which it is related. The maximum length shows maximum hops, which may raise the energy consumption of the network. Equation (12) can be used to minimize the first parameter, '$r_1$'

$$\boldsymbol{r}_1 = \sum_{j=1}^{m} \left( \sum_{i=1}^{ij} \boldsymbol{dis}(\boldsymbol{s_i}, \boldsymbol{CH}) \right) \tag{12}$$

Here,

$di$ ($S_i$, $cluster\ head$) is distance between cluster member and respective CH

$$\text{Dis (Si , CH)} = \sqrt[2]{(xpos_{CH} - XPOS_{node})^2 + (ypos_{CH} - ypos_{node})}.^2$$

where:

$xpos_{CH}$ and $xpos_{node}$ are $x$ position of the cluster head and node;

$ypos_{CH}$ and $ypos_{node}$ are $y$ position of the cluster head and node.

Residual energy ($E_{SI}$): through relay nodes, total cluster members provide data to respective CHs. Due to insufficient energy or exhaustion; the minimal energy node can expire or stop operating during data transmission. Equation (13) can be used to calculate the minimizing of the second parameter, '$r_2$ '

$$r_2 = \sum_{j=1}^{m} \cdot \frac{1}{E_{sii}} \quad (13)$$

Residual energy = $E_{Si} = E_{initial} - E_{consumed}$;

$E_{initial}$ denotes initial energy of sensor nodes;

$E_{consumed}$ represents consumed energy of sensor nodes.

There is the time required to communicate between sensor nodes.

As delay period grows, the network's energy usage grows, as well. For efficient data transmission, the relay nodes should have the shortest possible time delay.

Network's communication delay, the node's ETC and Propagation delay influences the delay. This delay function '$r_3$' can all be minimized as Equation (14)

$$r_3 = \sum_{i=1}^{m} min(D_{si}) \quad (14)$$

The delay can be determined as Equation (15)

$$\text{Delay Dsi} = \sum_{i=1}^{m} ETC_I\ (TD + PD_i) \quad (15)$$

where

$ETC_I \rightarrow$ denotes the ith node expected transmission count;

TD $\rightarrow$ denotes complete transmissions of the entire network;

$PD_i \rightarrow$ represents the ith node propagation delay.

The $ETC_I$ of node is determined by the RPDR of sensor node to FPDR at time 't'., and Equation (16) is used to compute it.

$$\text{ETC}_I = \frac{1}{f_i\ (t) + R_i\ (t)} \quad (16)$$

where:

$R_i(t)$ denotes the ith node's RPDR (received packet delivery ratio);

$F_i(t)$ denotes to the ith node's FPDR (forward packet delivery ratio) at time 't'.

Therefore, FF is computed from Equation (17)

$$\text{fitness} = \beta_1 * f_1 + \beta_2 * f_2 + \beta_3 * f_3 \quad (17)$$

Here, $\beta_1$, $\beta_2$, and $\beta_3$ are weighted numbers allocated to every parameter.

$$\sum_{i=1}^{3} \beta_i = 1\ \ and\ \ \beta \in (0,1).$$

From the below Algorithm 4 which states about the optimal relay node of Cluster heads and cluster members along with no of nodes and no of sensors. We also look for response of optimal and relay nodes and fitness

**Algorithm 4.** Selection of optimal relay node

Applied excitation:
Total sensor nodes set S = ($s_1$, $s_2$, $s_3$ . . . , $s_n$)
Number of agents: $N_p$; dimension K;
Response: optimal forwarder or relay nodes set
Set up the agents $A_j$, *where* $1 \leq j \leq N_p$
While (j! = $N_p$) do
Evaluate fitness ($A_j$)
End
While (j! = $N_p$) do
best = max of (fitness($A_j$))
worst = min of (fitness($A_j$))
End
While (j! = $N_p$) do
Evaluate mass ($A_j$)
End
While (j! = $N_p$), do
Find force ($A_j$), with the help of Equation (3)
Evaluate acceleration ($A_j$), with the help of Equation (4)
Updating coordinates $CH_j$, with the help of Equations (5) and (6)
End
Maximum (fitness (A j)) is used to choose forwarder or relay nodes for every route
End

## 5. Experimental Setup

The proliferation is finished to evaluate the suggested method's execution by separating it to two particular strategies. NS2 (network test framework 2) was utilized in this survey. An association test framework is object-arranged and event-driven, with bright lights on the framework's organization assessment. On each and every distant association, coordinating, UDP, and multicast show that entertainment is maintained. In this survey, an association model can be used, in which unflinching sensor center points in an association are of a homogeneous sort, with comparable radio-transmitter contraptions, limits, and confined energy resources, as well as vague basic energy and consistency association.

In this current situation, BS's position is fixed and taken out from the sensor center. Diversion testing is finished using static center points and plane headings. Exactly when center points with confined energy are assessed, the transmission of data, as well as obtaining it, may be restricted because the center point's fundamental energy is expected to be consumed.

These reproduced settings should be surrendered in the test and are recorded in Table 3.

**Table 3.** Member nodes of cluster and their cluster no.

| Cluster No. | Cluster Member Nodes |
|---|---|
| 1 | 7 13 17 22 26 27 31 34 36 48 |
| 2 | 10 11 12 20 30 32 33 37 45 47 |
| 3 | 5 6 14 15 16 18 21 23 28 35 40 43 |
| 4 | 1 2 3 4 8 9 19 24 25 29 38 39 41 42 44 46 49 |

Partial hubs of the clusters and their group no. are portrayed in Table 3. Cluster development happens when ensuing control parcels have been sent between the hubs. Altogether, WSNs are coordinated depending on four groups. In their separate organization spaces, each group has an alternate number of cluster individuals.

As 100 joules of energy are allocated to each of the sensor nodes in Figure 4, which are randomly positioned across the network and cover an area of 1000 × 1000 $m^2$, the placement of each sensing node was random for easier access and placed in the middle of the network.

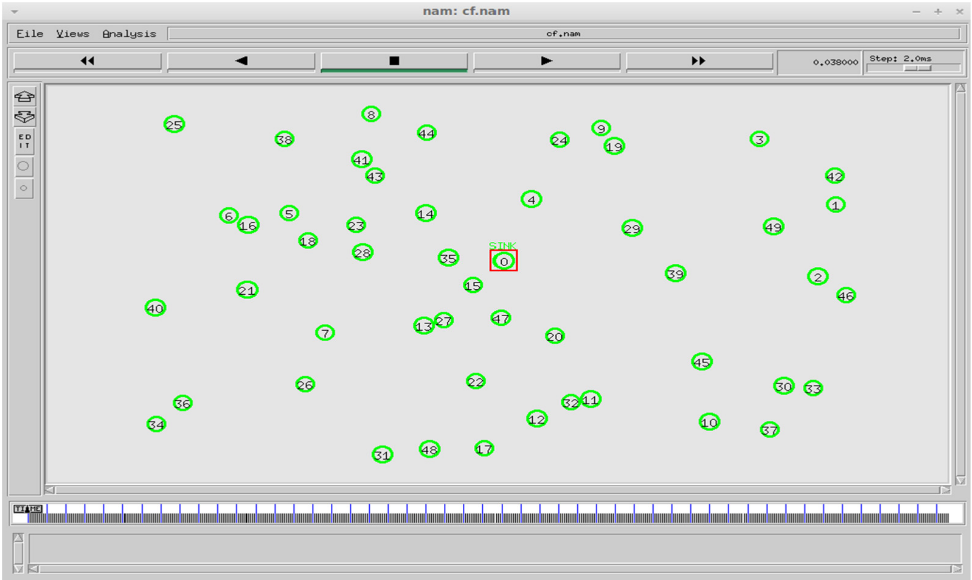


**Figure 4.** Center point for energy transmission in network deployment.

In the wireless sensor network, control packets are clustered and shared, as shown in Figure 5. Four clusters that are each connected to a different CH can be formed from this network. To distribute the CH selection values control packets in WS to neighboring nodes, control packet broadcasting is used.

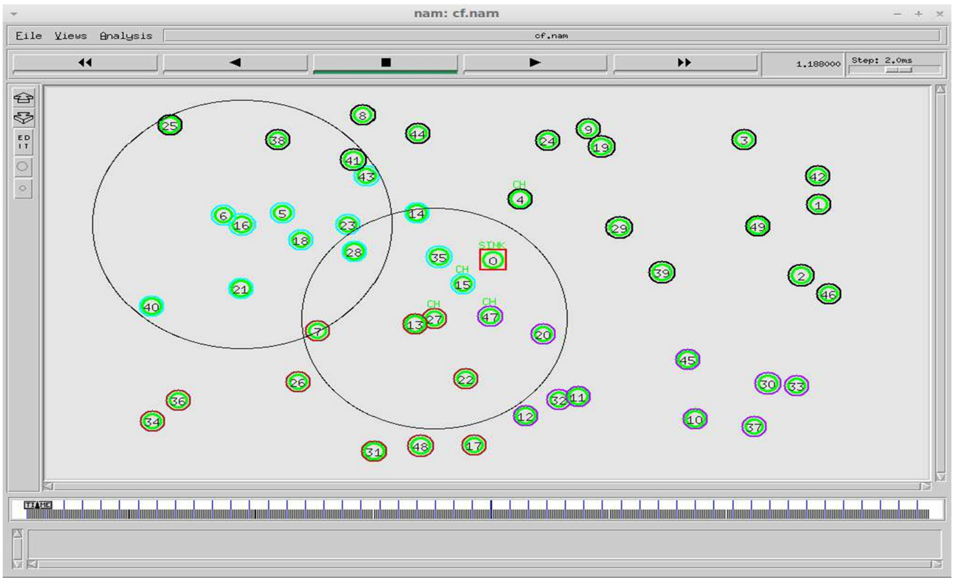


**Figure 5.** Clustering process, in the form of circles; blue circles in network deployment.

As Figure 6 illustrates the transmitting process at the cluster head (CH); from the sensor nodes to the proper CHs, the data packets are conveyed. The information packets must be transferred, utilizing the chosen vehicles, to their corresponding CHs. An improved gravity search algorithm has been used for the forwarder sensor nodes.

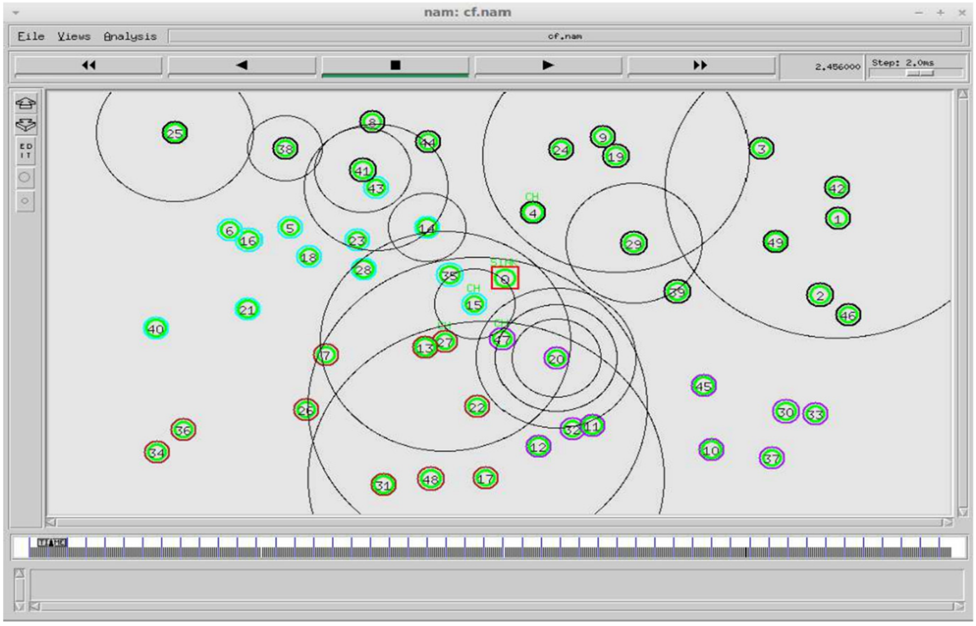


**Figure 6.** Broadcasting procedures of CHs.

Towards Figure 7 shows the data transmission between the CHs and sensor nodes, which involved 532 bytes. They exchange the data at predetermined intervals and collect the data using their member nodes.

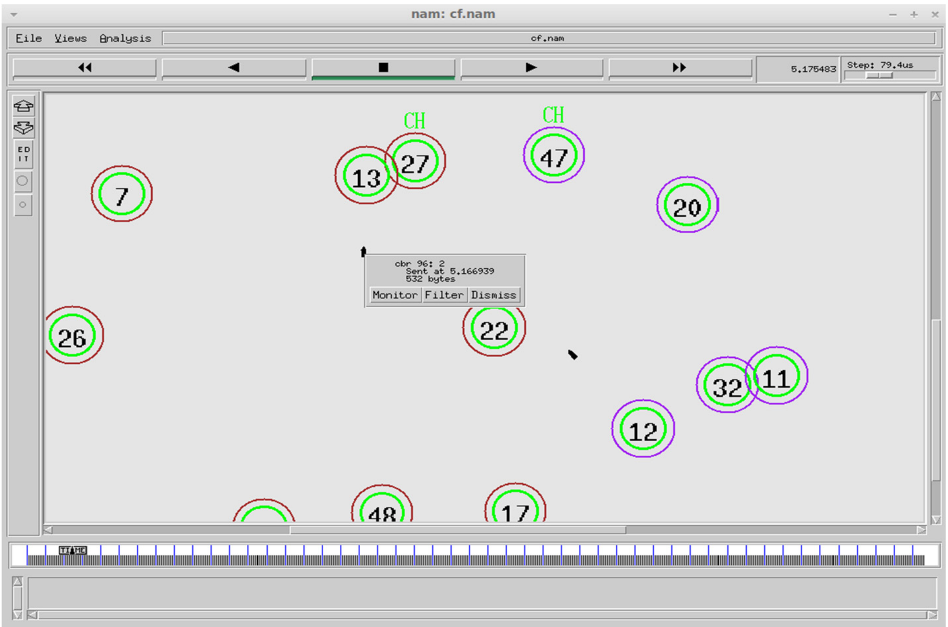


**Figure 7.** Cluster head points and sensor nodes data communication.

Figure 8 displays the data transfer process between the sink node and CHs. Rather than collecting data through sensor nodes; the CH nodes transfer the information to the sink. The MGSA chooses the better forwarder nodes and builds a route between them if the proximity of the ch node and sink prevents direct connectivity.

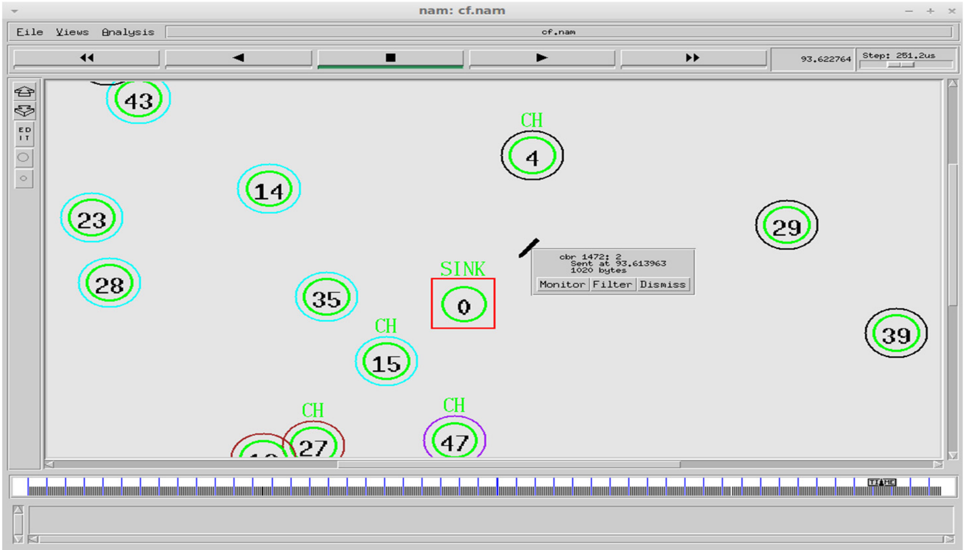


**Figure 8.** Data transfer between sink and CH's node.

### *5.1. MGSA—ORS*

The diverse boundaries sink hub, and sensor hub, as well as their positions, are discussed in Table 4. For CH determination, multi-objective qualities, for example, the sink distance, lingering energy, and likelihood of hub esteem, are considered. Since hub 27 is nearer to the sink, has more lingering energy, and has a higher likelihood esteem, it was picked as the CH.

**Table 4.** Multifaceted parameters.

| Sink Node | Node | Node (x_pos, y_pos) | Sink (x_pos,y_pos) | Sink Distance (m) | R.E(J) | Probability |
|---|---|---|---|---|---|---|
| 0 | 7 | (260,223) | (511,344) | 278.64314100 | 99.0325030 | 0.3680650 |
| 0 | 13 | (400,235) | (511,344) | 155.56992000 | 98.9487660 | 0.5082040 |
| 0 | 17 | (484,26) | (511,344) | 319.14416800 | 98.9577950 | 0.9023470 |
| 0 | 22 | (472,142) | (511,344) | 207.69448700 | 98.9097170 | 0.5728850 |
| 0 | 27 | (472,244) | (511,344) | 130.59862200 | 99.8801300 | 0.912580 |
| 0 | 31 | (341,16) | (511,344) | 369.43741000 | 99.0735020 | 0.5851150 |
| 0 | 34 | (25,68) | (511,344) | 558.90249600 | 99.3250840 | 0.2356530 |
| 0 | 36 | (61,103) | (511,344) | 510.47135100 | 99.2608170 | 0.1036330 |
| 0 | 48 | (408,25) | (511,344) | 335.21634800 | 99.0299930 | 0.8960380 |

The delay determines the effectiveness of the network. The higher latency causes a drop in overall network performance. Figure 9 shows the performance while being delayed. The computation of the distance between sensor nodes, which reduces end-to-end delay during data transmission, is one of the multi-metric criteria that the MGSA uses to select relay nodes. The results of the simulation reveal that the latency is considerably less than it was for earlier approaches.

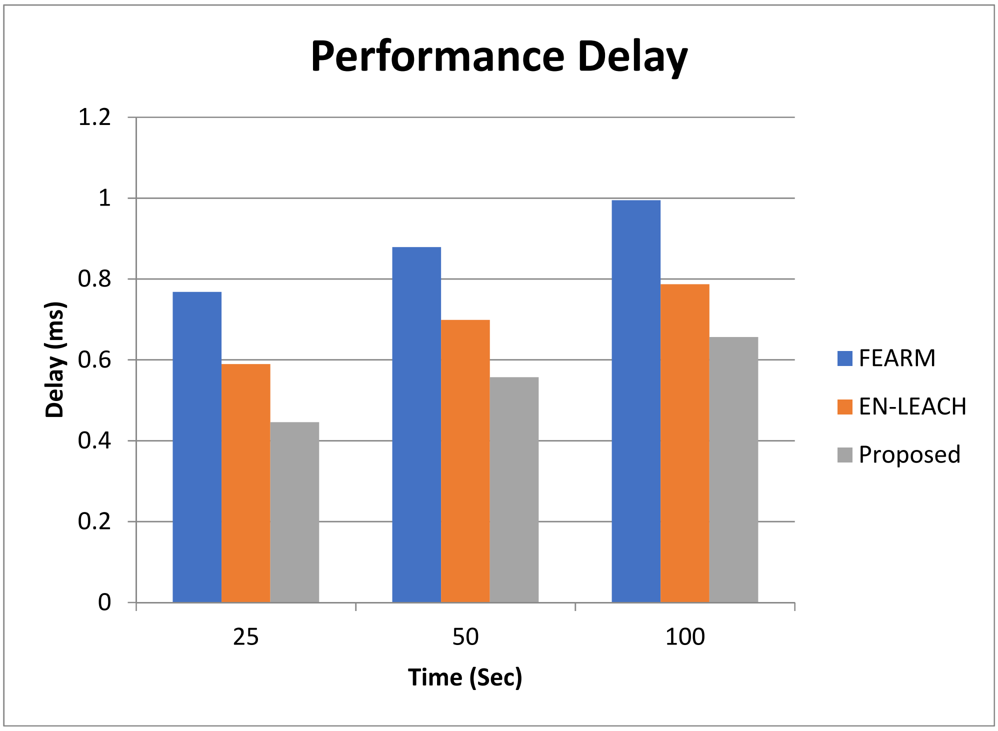


**Figure 9.** Performance Delay between sensor nodes.

The ability of the sensor nodes to get energy determines their participation in network operations. An organization's lifetime will be drawn out, in the event that its energy utilization is kept to a base. The transmission of information consumes a ton of energy. The MGSA forwarder hub choice diminishes energy protection by appropriately choosing the forwarder hubs. The aftereffects of energy utilization are displayed in Figure 10 and shows that the proposed calculation streamlines energy utilization over past conventions.

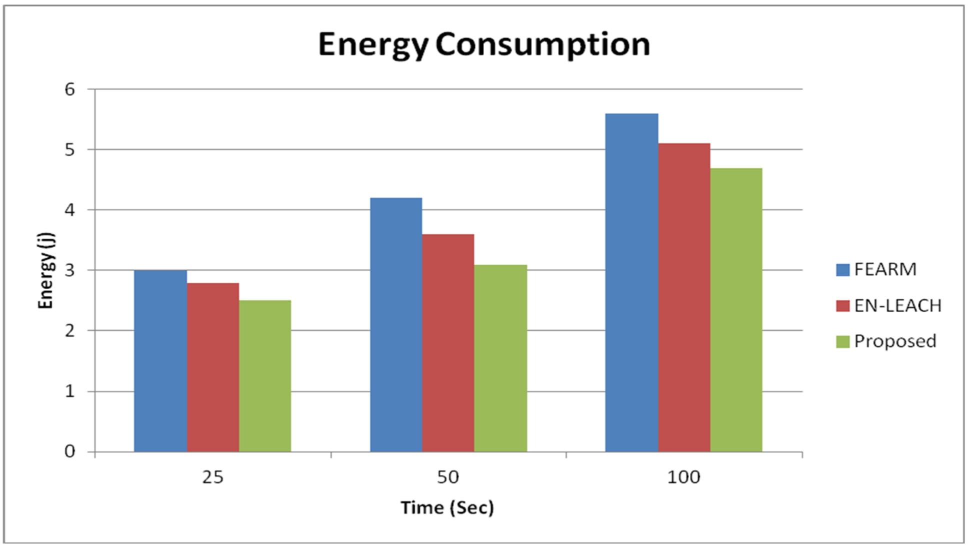


**Figure 10.** Energy consumption.

The effective information conveyance rate is characterized by throughput. Different factors regularly influence information transmission, which can be forestalled by utilizing a compelling hand-off hub political decision strategy. The recommended calculation picks hand-off hubs that rely upon a bunch of multi-layered that help transport information quicker. Charts of throughput, shown in Figure 11, exhibit that the proposed MGSA-ORS technique sends information more accurately.

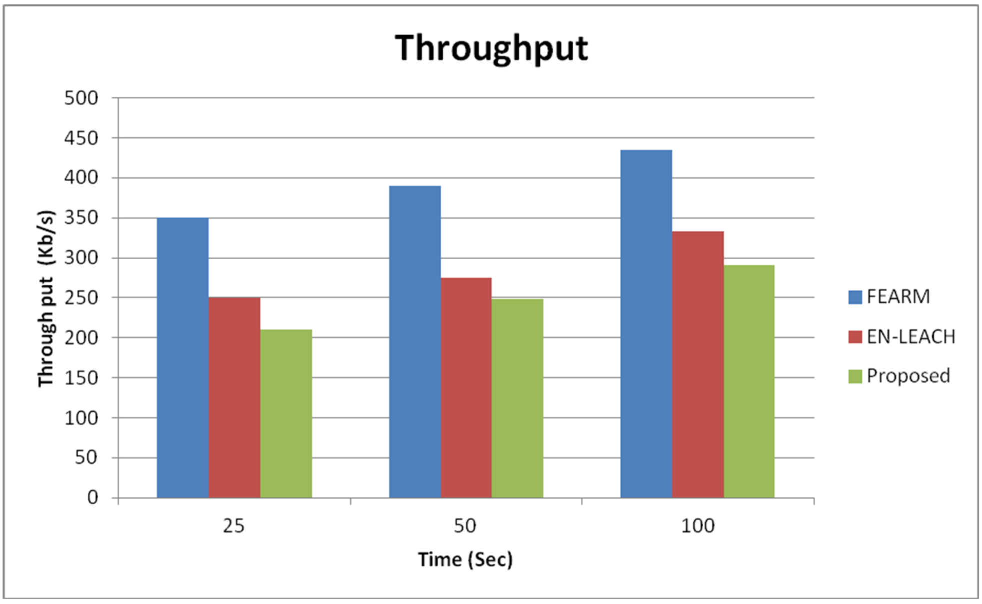


**Figure 11.** Throughput.

The level of intricacy that organizations should adapt to deal with these calculations is alluded to above. The organization favored a lower one (above). Directing intricacy is diminished by involving MGSA, as well as the information collection, and utilizing MGSA-chosen hand-off hubs. These measurement results are displayed in Figure 12, where determination of not entirely set in stone by sink distance boundaries, as well as the lessening correspondence (above) among the sink and CH.

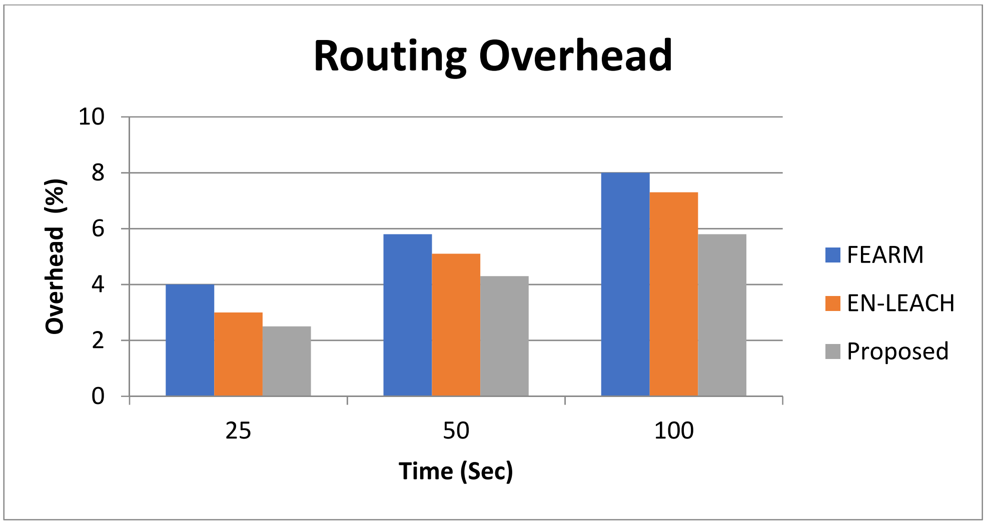


**Figure 12.** Routing overhead.

The PDR is communicated as the proportion of productive information conveyances over the long run. Because of bundle disappointments and deferrals, improper transfer hub political decisions, much of the time, influence PDR. The MGSA-ORS takes care of this issue by choosing hand-off hubs through adequate information sending capacity. The reenactment results are displayed in Figure 13; they are connected with the PDR, and the level of PDR is more noteworthy than the all-around suggested strategies.

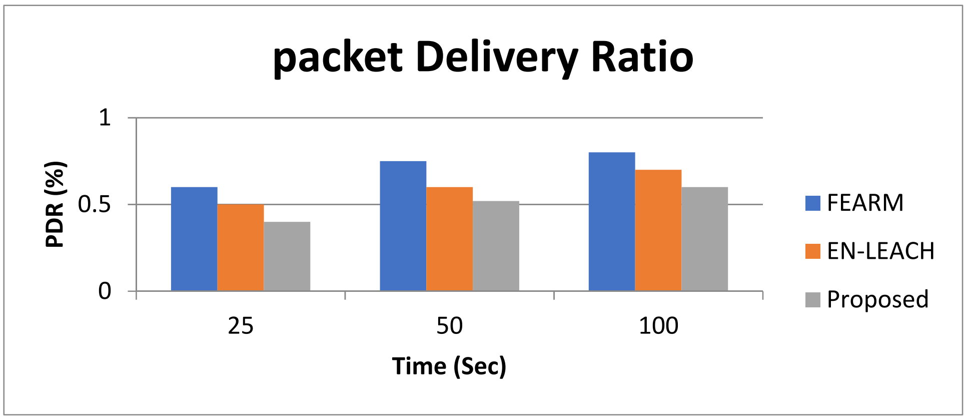


**Figure 13.** Packet delivery ratio.

### *5.2. Modified Gravitational Search Algorithm with Two Fitness Functions*

As the Table 5 shows Fitness functions of relay with multi factors of distance between nodes for reducing delay transmission results comparing with previous

**Table 5.** Information about performance proposed.

| TIME | FEARM | EN-LEACH | PROPOSED—ONE FF | PROPOSED—TWO FFs |
|---|---|---|---|---|
| 300 | 0.04800 | 0.03600 | 0.02900 | 0.02200 |
| 600 | 0.05100 | 0.03700 | 0.0300 | 0.02400 |
| 900 | 0.0500 | 0.03600 | 0.0300 | 0.02400 |
| 1200 | 0.05200 | 0.03900 | 0.03200 | 0.02600 |
| 1500 | 0.05200 | 0.04100 | 0.03500 | 0.02900 |

The network's efficiency is determined by the end-to-end delay. Total network performance decreases as a result of the increased latency. Figure 14 depicts the performance, regarding delay. The MGSA with two FF elects relay nodes, depending on multi-metric factors, with distance prediction between nodes being the most important parameter for reducing end-to-end delay during data transmission. The simulation results show that the delay is significantly reduced compared to that of previous approaches.

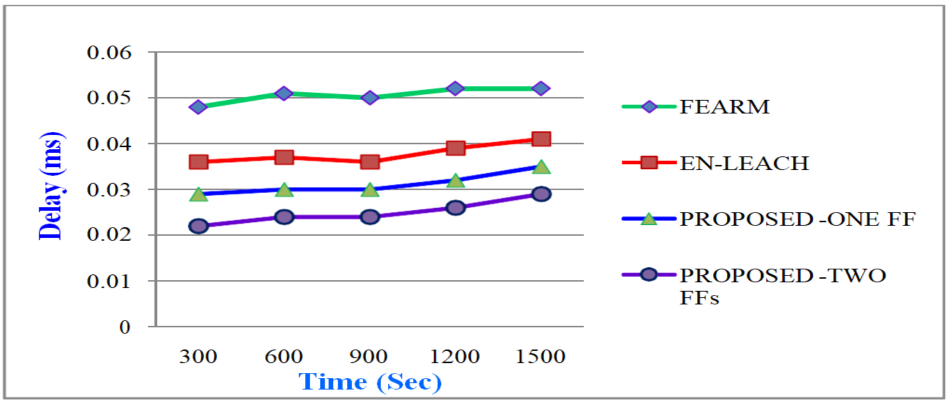


**Figure 14.** Performance on end-to-end delay.

As the Table 6 shows participation of the nodes for completing the network operations for energy consumption and also looks over the networks life span with minimum and optimized usage

**Table 6.** Information regarding energy consumption.

| TIME | FEARM | EN-LEACH | PROPOSED—ONE FF | PROPOSED—TWO FFs |
|---|---|---|---|---|
| 300 | 5.8900 | 4.1300 | 3.3600 | 2.600 |
| 600 | 5.9600 | 4.5600 | 3.8400 | 3.1200 |
| 900 | 6.1100 | 5.2600 | 4.2100 | 3.3600 |
| 1200 | 6.1500 | 5.800 | 4.9500 | 4.100 |
| 1500 | 6.1900 | 6.0100 | 5.1300 | 4.2500 |

For sensor nodes to participate in network operations, energy is essential. A network's lifetime will be prolonged if its energy consumption is kept to a minimum. The transfer of data consumes a lot of energy. The MGSA with two FF forwarder node selections reduces energy conservation by properly selecting forwarder nodes. The results of energy consumption are shown in Figure 15 demonstrating that the proposed technique optimizes energy usage over the other protocols.

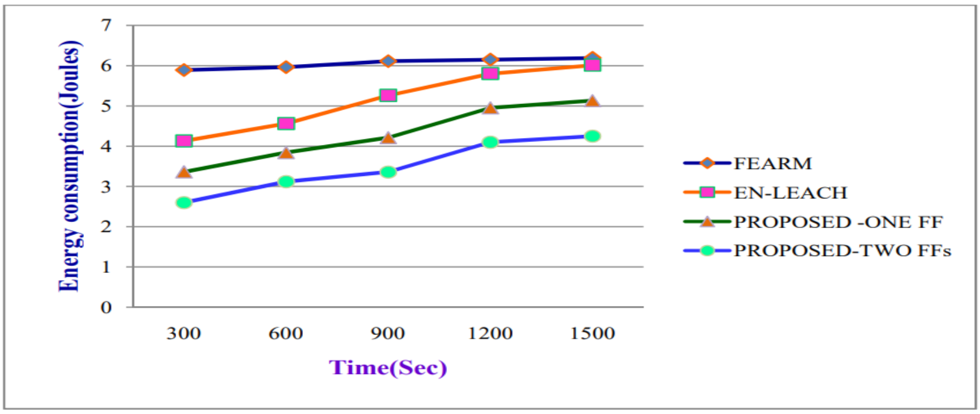


**Figure 15.** Energy Consumption.

As the Table 7 shows data delivery rate through different factors that are affecting data transmission. The process is been effected with parameters of relay node selection method of multi factors for faster data transport throughput displayed.

**Table 7.** Information regarding throughput proposal.

| TIME | FEARM | EN—LEACH | PROPOSED—ONE FF | PROPOSED—TWO FFs |
|---|---|---|---|---|
| 300 | 90.00 | 87.00 | 85.00 | 81.00 |
| 600 | 96.00 | 91.00 | 86.00 | 82.00 |
| 900 | 94.00 | 90.00 | 86.00 | 82.00 |
| 1200 | 95.00 | 89.00 | 83.00 | 82.00 |
| 1500 | 95.00 | 89.00 | 85.00 | 81.00 |

Here data delivery rate is referred to as throughput. Various factors frequently affect data transmission, which can be minimized by using an effective relay node method. MGSA-ORS with the FF method chooses forwarded nodes, depending on a set of multi-metric criteria that assist in transporting data faster. A graph of throughput displayed in Figure 16 demonstrates suggested MGSA-ORS, with two FF method transmitting data more effectively than prior methods.

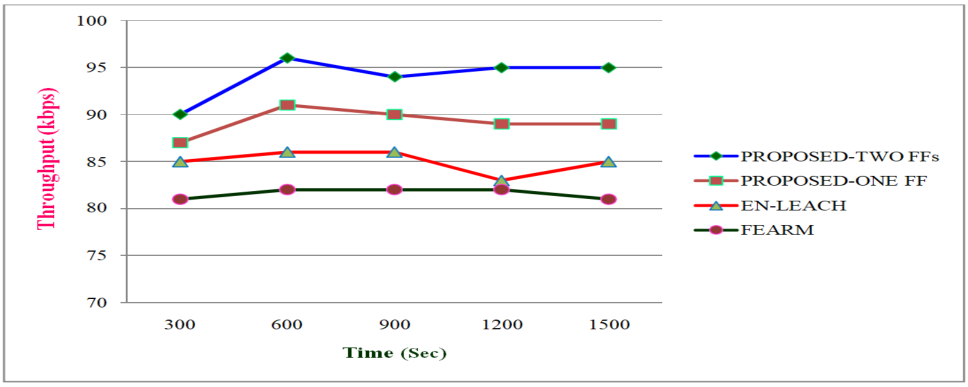


**Figure 16.** Flow of proposed factors by Throughput.

The Level of network with one lower overhead in order to reduce the routing complexity as well as data aggregation using MGSA-elected relay nodes. These metric results are shown in Table 8.

**Table 8.** Information regarding overhead proposal.

| TIME | FEARM | EN—LEACH | PROPOSED—ONE FF | PROPOSED—TWO FFs |
|---|---|---|---|---|
| 300 | 2.900 | 2.500 | 2.0300 | 1.5600 |
| 600 | 2.900 | 2.300 | 1.9300 | 1.5600 |
| 900 | 2.700 | 2.300 | 1.9100 | 1.5200 |
| 1200 | 2.600 | 2.200 | 1.8600 | 1.5300 |
| 1500 | 2.600 | 2.200 | 1.8600 | 1.5200 |

Level of complexity that network must cope with, in order to process these algorithms, is referred to as overhead. The network preferred the one with lower overhead. Routing complexity is reduced by using MGSA with two FF, as well as data aggregation using MGSA-with two elected relay nodes. These metric results are shown in Figure 17, where the selection of the CH is determined by sink distance parameters, and then reducing the communication overhead between the sink and CH.

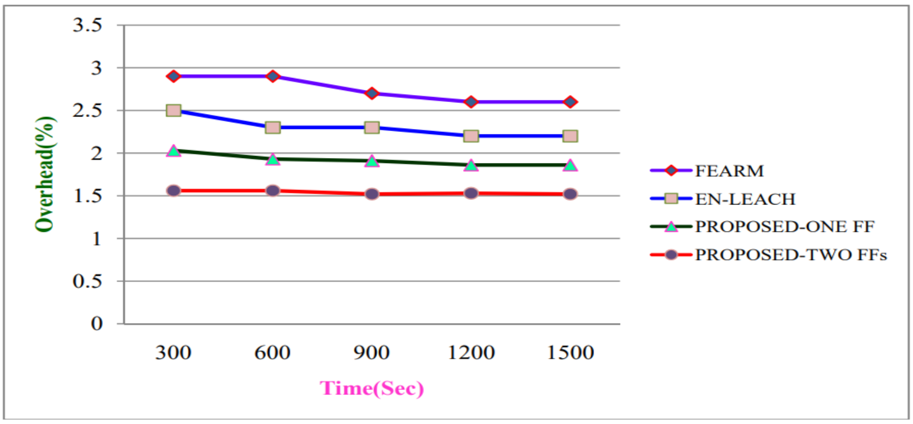


**Figure 17.** Overhead.

The inputs of data deliveries on over time due to packet failures and delays, inappropriate relay node election which are frequently affecting packet delivery ratio by electing the relay nodes through the inputs of transmit capability and simulation outcome is shown in Table 9

**Table 9.** Information regarding PDR proposal.

| TIME | FEARM | EN—LEACH | PROPOSED—ONE FF | PROPOSED—TWO FFs |
|---|---|---|---|---|
| 300 | 0.9400 | 0.9100 | 0.8900 | 0.8600 |
| 600 | 0.9800 | 0.9500 | 0.9200 | 0.8800 |
| 900 | 0.9500 | 0.9300 | 0.9100 | 0.8600 |
| 1200 | 0.9700 | 0.9400 | 0.9100 | 0.8700 |
| 1500 | 0.9700 | 0.9400 | 0.9200 | 0.8600 |

The PDR is expressed as the ratio of fruitful data deliveries over time. Due to packet failures and delays, inappropriate relay node election frequently affects PDR. The MGSA-ORS with the FF method solves this problem by selecting relay nodes with sufficient data transmit capability. Simulation outcomes are shown in Figure 18, and they are related to the PDR; the percentage of PDR is greater than the already recommended techniques.

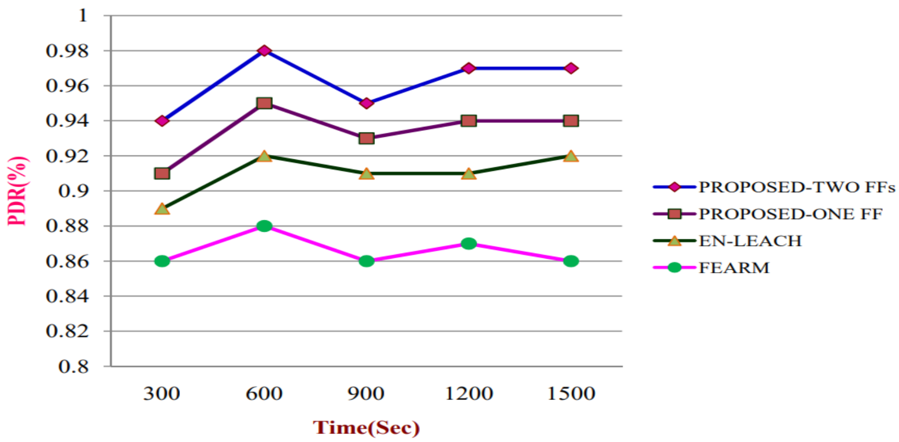


**Figure 18.** Packet delivery ratio.

## 6. Conclusions

This examination incorporates an energy-mindful determination of CH, as well as an ideal forwarder hub determination approach, contingent upon a multi-objective way to deal with the determination of CH and altered GSA strategies to track down the best courses. MGSA's utilization of multi-objective models for course disclosure is a key benefit, as the most productive course is found by using the hub's closeness to the CHs, remaining energy, and sensor hub's start-to-finish delay. To expand CH determination, multi-objective factors, for example, the sink distance, remaining energy, and likelihood esteem, are applied. The exploratory outcome shows that the created multi-objective MGSA-ORS strategy saves a ton of energy. The outcomes likewise uncover that, by picking CHs in light of hub distance and utilizing the sink approach, the information conveyance rate and throughput for between group information gatherings moved along. MGSA obtains superior execution with the expansion of multi-objective boundaries. As indicated by the discoveries of the recreations, the proposed MGSA-ORS beat all of the current energy-effective steering conventions in each respect.

We want to solve for delay-constrained WSN applications by developing another routing scheme that provides the optimal balance of the network's lifespan and delay in multi-hop communication systems. We set up an energy-efficient, clustering-inspired routing protocol in the WSN to improve the node stability and network lifetime; we also designed an artificial bee colony (ABC)-based meta-heuristic scheme, captivated by an efficient cluster-based, energy-efficient routing algorithm in the network to maintain maximum throughput with limited jitter and end-to-end delay.

**Author Contributions:** Authors contributed equally to the development of this work. Conceptualization, formal analysis, data curation, and validation, S.P.; methodology, supervision, Y.K.S.; writing—original draft, validation, C.P. and C.V.; software, writing—review and editing, S.D. and C.V. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Acknowledgments:** We would like to thank Y Madhavee Latha–Professor of ECE & Principal of Malla Reddy Engineering College for Women (UGC-Autonomous Institute), Hyderabad-500014, Telangana, India for supporting and enhancing my PhD work for further. We would like to thank you the reviewers for careful verification and approval of our manuscript. The work of Chaman Verma supported under ÚNKP, MIT (Ministry of Innovation and Technology) and the National Research, Development, and Innovation (NRDI) Fund, Hungarian Government. Also, his work supported by Faculty of informatics, Eötvös Loránd University, Budapest, Hungary.

**Conflicts of Interest:** The authors have declared no conflict of interest.

## Abbreviations

| | |
|---|---|
| CH | Cluster head |
| LEACH | Low-energy adaptive clustering hierarchy |
| DMEERP | Dynamic multi-hop energy-efficient routing protocol |
| MMBCR | Min–max battery cost routing |
| CMDR | Conditional minimum drain rate |
| DCFR | Double cost function-based route |
| EAMOFC | Adaptive multi-objective fuzzy clustering |
| RPDR | Received packet delivery ratio |
| Bs | Base station |
| EESRA | Energy efficient scalable routing algorithm |
| MTE | Minimum total energy |
| CMMBCR | Conditional min–max battery cost routing |
| ESCFR | Exponential and sine cost function-based route |
| MGSA | Modified gravitational search algorithm |
| ORS | Optimal relay selection |
| PDR | Packet delivery ratio |

## References

1. Akyildiz, I.F.; Melodia, T.; Chowdhury, K.R. A survey on wireless multimedia sensor networks. *Comput. Netw.* **2007**, *51*, 921–960. [CrossRef]
2. Akyildiz, I.F.; Kasimoglu, I.H. Wireless sensor and actor networks: Research challenges. *Ad Hoc Netw.* **2004**, *2*, 351–367. [CrossRef]
3. Akyildiz, I.F.; Su, W.; Subramaniam, Y.S.; Cayirci, E. Wireless sensor networks: A survey. *Comput. Netw.* **2002**, *38*, 393–422. [CrossRef]
4. Kashi, S.S.; Sharifi, M. Connectivity weakness impacts on coordination in wireless sensor and actor networks. *IEEE Commun. Surv. Tutor.* **2013**, *15*, 145–166. [CrossRef]
5. Melodia, T.; Pompili, D.; Akyldiz, I.F. Handling mobility in wireless sensor and actor networks. *IEEE Trans. Onmobile Comput.* **2010**, *9*, 160–173. [CrossRef]
6. Mothku, S.K.; Rout, R.R. Adaptive buffering using markov decision process in tree-based wireless sensor and actor networks. *Comput. Electr. Eng.* **2018**, *71*, 901–914. [CrossRef]
7. Zeng, Y.; Li, D.; Vasilakos, A.V. Real-time data report and task execution in wireless sensor and actuator networks using self-aware mobile actuators. *Comput. Commun.* **2013**, *36*, 988–997. [CrossRef]
8. Anwar, A.; Sridharan, D.; Anwar, A.; Sridharan, D. A survey on routing protocols for wireless sensor networks in various environments. *Int. J. Comput. Appl.* **2015**, *112*, 13–29.
9. Akkaya, K.; Younis, M. A Survey on Routing Protocols for Wireless Sensor Networks. *Ad Hoc Netw.* **2005**, *3*, 325–349. [CrossRef]
10. Al-Turjman, F. Hybrid approach for mobile couriers election in smart-cities. In Proceedings of the IEEE Local Computer Networks (LCN), Dubai, United Arab Emirates, 7–10 November 2016; pp. 507–510.

11. Toldan, P.; Kumar, A.A. Design Issues and various Routing Protocols for Wireless Sensor Networks. In Proceedings of the National Conference on New Horizons in IT, MET, Mumbai, India, 18–19 October 2013; pp. 65–67, ISBN 978-93-82338-79-6.
12. Abdulqader, M.; Walid, A.; Khaled, A.; Abdulrahman, A. A robust harmony search algorithm based Markov model for node deployment in hybrid wireless sensor network. *Int. J. GEOMATE* **2016**, *11*, 2747–2754.
13. Yick, J.; Mukherjee, B.; Ghosa, D. Wireless sensor network survey. *Comput. Netw.* **2008**, *52*, 2292–2330. [CrossRef]
14. Villalba, L.J.G.; Ana, L.S.O.; Cabrera, A.T.; Abbas, C.J.B. Routing Protocols in Wireless Sensor Networks. *Sensors* **2009**, *9*, 8399–8421. [CrossRef] [PubMed]
15. Heinelman, W.R.; Chandrakasan, A.; Balakrishnan, H. Energy efficient Communication Protocol for Wireless Sensor Networks. In Proceedings of the 33rd Annual Hawaii International Conference on System Sciences, Big Island, HI, USA, 7–10 January 2002; pp. 4–7.
16. Marjan, R.; Behnam, D.; Kamalrulnizam, A.B.; Lee, M. Multipath Routing in Wireless Sensor Networks: Survey and Research Challenges. *Sensors* **2012**, *1*, 650–685.
17. Tsai, J.; Moors, T. A Review of Multipath Routing Protocols: From Wireless Ad Hoc to Mesh Networks. In Proceedings of the ACoRN Early Career Researcher Workshop on Wireless Multihop Networking, Sydney, Australia, 17–18 July 2006.
18. Arjunan, S.; Sujatha, P. Lifetime maximization of wireless sensor network using fuzzy based unequal clustering and ACO based routing hybrid protocol. *Appl. Intell.* **2017**, *48*, 2229–2246. [CrossRef]
19. Pantazis, N.A.; Nikolidakis, S.A.; Vergados, D.D. Energy-efficient routing protocols in wireless sensor networks: A survey. *IEEE Commun. Surv. Tutor.* **2013**, *15*, 551–591. [CrossRef]
20. Jakllari, G.; Eidenbenz, S.; Hengartner, N.; Krishnamurthy, S.V.; Faloutsos, M. Link positions matter: A noncommutative routing metric for wireless mesh networks. *IEEE Trans. Mob. Comput.* **2012**, *11*, 61–72. [CrossRef]
21. Liu, X. A typical hierarchical routing Protocols for wireless sensor networks: A review. *IEEE Sens. J.* **2015**, *15*, 5372–5383. [CrossRef]
22. Gherbi, C.; Aliouat, Z.; Benmohammed, M. A survey on clustering routing Protocols in wireless sensor networks. *Sens. Rev.* **2017**, *37*, 12–25. [CrossRef]
23. Mundada, M.R.; Kiran, S.; Khobanna, S.; Varsha, R.N.; George, S.A. A study on energy efficient routing Protocols in wireless sensor networks. *Int. J. Distrib. Parallel Syst.* **2012**, *3*, 311–330. [CrossRef]
24. Ye, W.; Heidemann, J.; Estrin, D. An energy-efficient MAC protocol for wireless sensor networks. In Proceedings of the Twenty First Annual Joint Conference of the IEEE Computer and Communications Societies, New York, NY, USA, 23–27 June 2002; Volume 3.
25. Zhu, J.; Qiao, C.; Wang, X. On accurate energy consumption models for wireless ad hoc networks. *IEEE Trans. Wirel. Commun.* **2006**, *5*, 3077–3086. [CrossRef]
26. Liu, X. A survey on clustering routing Protocols in wireless sensor networks. *Sensors* **2012**, *12*, 11113–11153. [CrossRef] [PubMed]
27. Kole, S.; Vhatkar, K.; Bag, V. Distance-based cluster formation technique for LEACH protocol in wireless sensor network. *Int. J. Appl. Innov. Eng. Manag.* **2014**, *3*, 2319–4847.
28. Mothku, S.K.; Rout, R.R. Adaptive Fuzzy-Based Energy and Delay-Aware Routing Protocol for a Heterogeneous Sensor Network. *J. Comput. Netw. Commun.* **2019**, *2019*, 3237623. [CrossRef]
29. Sharma, Y.; Bagla, A. Security Challenges for Swam robotics. *Secur. Chall.* **2009**, *2*, 45–48.
30. Salem, A.O.A.; Shudifat, N. Enhanced LEACH protocol for increasing a lifetime of WSNs. *Pers. Ubiquitous Comput.* **2019**, *23*, 901–907. [CrossRef]
31. Sateesh, G.; Bhuvaneswari, M.V.; Sonam, P.; Prakash, M.C.; Alekya, M.G.P.; Mustafa, M. Energy efficient routing in wireless sensor networks using residual energy of nodes. *Int. J. Innov. Eng. Technol.* **2019**, *12*, 1–12.
32. Han, G.; Zhang, L. WPO-EECRP: Energy-efficient clustering routing protocol based on weighting and parameter optimization in WSN. *Wirel. Pers. Commun.* **2017**, *98*, 1171–1205. [CrossRef]
33. Arivubrakan, P.; Sundari, S. A protocol-based routing technique for enhancing the quality of service in multi hop wireless networks. *Int. J. Innovat. Technol. Explor. Eng.* **2019**, *8*, 1182–1186.
34. Elsmany, E.F.A.; Omar, M.A.; Wan, T.C.; Altahir, A.A. EESRA: Energy efficient scalable routing algorithm for wireless sensor networks. *IEEE Access* **2019**, *7*, 96974–96983. [CrossRef]
35. Nivedhitha, V.; Saminathan, A.G.; Thirumurugan, P. DMEERP: A dynamic multi-hop energy efficient routing protocol for WSN. *Microprocess. Microsyst.* **2020**, *79*, 103291. [CrossRef]
36. Rodoplu, V.; Meng, T.H. Minimum energy mobile wireless networks. *IEEE J. Sel. Areas Commun.* **1999**, *17*, 1333–1344. [CrossRef]
37. Singh, S.; Woo, M.; Raghavendra, C.S. Power-aware routing in mobile ad hoc networks. In Proceedings of the 4th annual ACM/IEEE International Conference on Mobile Computing and Networking, Dallas, TX, USA, 25–30 October 1998; pp. 181–190.
38. Toh, K. Maximum battery life routing to support ubiquitous mobile computing in wireless ad hoc networks. *IEEE Commun.Mag.* **2001**, *39*, 138–147. [CrossRef]
39. Kim, D.; Garcia-Luna-Aceves, J.; Obraczka, K.; Cano, J.-C.; Manzoni, P. Routing mechanisms for mobile ad hoc networks based on the energy drain rate. *IEEE Trans. Mob. Comput.* **2003**, *2*, 161–173.
40. Chang, J.-H.; Tassiulas, L. Maximum lifetime routing in wireless sensor networks. *IEEE/ACM Trans. Netw.* **2004**, *12*, 609–619. [CrossRef]

41. Ok, C.S.; Lee, S.; Mitra, P.; Kumara, S. Distributed energy balanced routing for wireless sensor networks. *Comput. Ind. Eng.* **2009**, *57*, 125–135. [CrossRef]
42. Liu, G.; Ma, M.; Liu, C.; Shu, Y. Adaptive fuzzy multiple attribute decision routing in vanets. *Int. J. Commun. Syst.* **2017**, *30*, e3014. [CrossRef]
43. Taheri, H.; Neamatollahi, P.; Younis, O.M.; Naghibzadeh, S.; Yaghmaee, M.H. An energy-aware distributed clustering protocol in wireless sensor networks using fuzzy logic. *Ad Hoc Netw.* **2012**, *10*, 1469–1481. [CrossRef]
44. Rashedi, E.; Nezamabadi-Pour, H.; Saryazdi, S. BGSA: Binary gravitational search algorithm. *Nat. Comput.* **2010**, *9*, 727–745. [CrossRef]
45. Soleimanpour-Moghadam, M.; Nezamabadi-Pour, H.; Farsangi, M.M. A quantum inspired gravitational search algorithm for numerical function optimization. *Inf. Sci.* **2014**, *267*, 83–100. [CrossRef]
46. Nezamabadi-Pour, H. A quantum-inspired gravitational search algorithm for binary encoded optimization problems. *Eng. Appl. Artif. Intell.* **2015**, *40*, 62–75. [CrossRef]
47. Handy, M.J.; Haase, M.; Timmermann, D. Low energy adaptive clustering hierarchy with deterministic cluster-head selection. In Proceedings of the IEEE 4th International Workshop on Mobile and Wireless Communications Network, Stockholm, Sweden, 9–11 September 2002; pp. 368–372.
48. Singh, S.K.; Kumar, P.; Singh, J.P. A Survey on Successors of LEACH Protocol. *IEEE Access* **2017**, *5*, 4298–4328. [CrossRef]
49. Jin, Y.; Vural, S.; Moessner, K.; Tafazolli, R. An EnergyEfficient Clustering Solution for Wireless Sensor Networks. *IEEE Trans. Wirel. Commun.* **2011**, *10*, 3973–3983.
50. Kang, S.H.; Nguyen, T. Distance Based Thresholds for Cluster Head Selection in Wireless Sensor Networks. *IEEE Commun. Lett.* **2012**, *16*, 1396–1399. [CrossRef]