# GAUSSIAN-BASED IMPROVED POWER-AWARE ROUTING WITH BALANCED GROUPING IN SENSOR MESH NETWORKS

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**Abstract**

Prolonging the network lifetime has been crucial since wireless sensor networks have limited resources interest. One effective method of routing is clustering-based hierarchical routing, finding the ideal quantity of cluster heads has posed a challenge. This paper employs two hierarchical fuzzy logics to assess the suitability of sensors to function as cluster heads. Relevance, proximity to the base station, and separation of cluster heads are among these criteria. The simulation yields five metrics reveal that the suggested strategy uses less energy and approximately 54% longer network life compared to different algorithms. Energy parameters are used to define each network node. Energy is used throughout each network communication to some extent. The goal of the ECHGRP(Energy Clustering Head Gaussian Routing Protocol)proposed work is to extend the life of the network by maximizing connection while utilizing the notion of prioritizing and mobile base stations via circular paths in a clustered network. Each communication node will be prioritized, and this is done based on parametric considerations including connectivity, residual energy, and distance. Remaining energy will serve as the basis for the initial prioritizing. High energy is taken into consideration when choosing a cluster head. The fuzzy logic technique will be used to make all prioritized decisions. The nodes in the base station's sensing range will turn on and engage in direct communication with it whenever it updates its location since the base station has a set communication range.

**Index Terms :** Selection of Cluster Heads, Energy Prediction, Fuzzy Inference, Sensor Networks, Fuzzy Systems, WSN, Leader of Cluster Head, Mobile Station.

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## I. INTRODUCTION

Sensor Networks are spatially dispersed autonomous sensor networks that work in concert to relay data to a central location about physical or environmental factors like temperature, sound, pressure, etc. Today's networks are bidirectional, which means you can control sensor activity as well. The impetus to develop them was the military's use of wireless sensor networks, e.g. battlefield surveillance. These networks today are used to monitor machine health, process controls and industrial processes in a range of commercial and consumer applications.

‘These sensor nodes' systematic data aggregation (to reduce the quantity of data transmissions by removing redundant information) and subsequent transmission of the obtained data to a base station (BS)is two of its most crucial responsibilities. The key to extending the life span of wireless sensor networks is to optimize energy consumption.

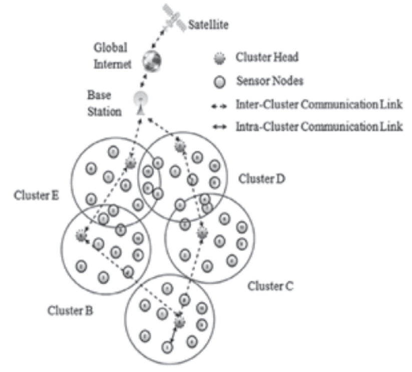


**Fig 1: General System Model of Clustered WSN**

A sensor network's performance has also been evaluated in terms of bandwidth, memory, signal intensity, time,battery life, etc. Capturing and analyzing the modelling process of Environmental, agriculture,habitat,detecting the fire,wildlife protection, and military devices that are used to detect objects in area applications are just some of the applications of wireless sensor networks.

Due to the clustered network designs used in this paper, all nodes send data first to the cluster head, who then sends it to the base after being aggregated. Here, it is dependent upon prioritizing and all prioritization decisions will be based on a fuzzy logic method to choose nodes for cluster head.

Hierarchical or cluster-based routing is one of the most crucial routing techniques. It is possible to use higher and lower energy nodes in the hierarchical architecture for data analysis and transmission, while low energy nodes are capable of sensing closer to the target. [1,2].

Hierarchical routing protocols include LEACH [3,4], PEGASIS [5], TEEN [2] and APTEEN [2].

In the past, numerous studies have been conducted to increase the energy efficiency of sensor networks. Low Energy Adaptive Clustering Hierarchy (LEACH) is one of them [3, 4]. The protocol is hierarchical. In addition, this is a system that uses one hop route for every sensor node to send data into the cluster's head. Consequently, it is not recommended for large areanetworks.The sentence seems a bit fragmented. Here's a revised version that flows more smoothly. Subsequently, utilizing a multihop routing schema, supplementary protocols are proposed to enhance the energy efficiency of the LEACH protocol, including BCDCP [6,7], PEGASIS [8], CELRP [9,10], and GPSR [9]. A centralized routing system known as Base-Station Control, Dynamic Clustering system (BCDCP) [7] connects to CH using Minimal Spanning Tree (MST) [2], which selects a leader at random to deliver data to sink.

In Fuzzy Logic-Based Clustering Algorithm [2], supercluster head (SCH) was selected byMamdani's rule which requires the adaptation of appropriate fuzzy descriptors in order to transmit the data to the mobile Base Station (BS).

In order to improve thedata transmission rate and to improve networklifetime further, data collected by SCH should betransmitted to the BS within particular time periodbecause BS is not static.

A wide range of application software can be made available and used regularly in the Application Layer, according to a number of sensing tasks.

The following definitions outline the main contributions of this study to fault identification the energy-conscious WSN:

- It creates an energy-aware WSN model and design a fault detection module.
- It Process inter- and intra-segmentation phases, to determine and enhance the coverage area.
- To establish intermediary nodes for configuring the environment's detector nodes.

Paper is structured in accordance with the following sequence: Current algorithms for fault detection with different challenges are analyzed in Section 2, suggested process for coverage analysis, fault identification is presented in Section 3. Section 4 culminates by presenting the simulation results of the proposed model.

## II. RELATED WORK

According to a review of research on routing based on mesh initiated by the recipient, flooding is used within a group's mesh to move the packet to the intended location. [3]. As a result of using greater overhead, the network becomes more robust. Separate and multiple casting are effective strategies in sensing networks to deal with floods.

The ERASCA protocol [4] makes advantage of the IP multicast service paradigm to enable data transmission to a receiver group without any prior knowledge of or communication with that group. This protocol does not require the sender to join the group in order to transmit data. A status declaration (SD) message is used by the central node to form, uphold, and revise the recipient group.

A hierarchical protocol called Low Energy Adaptive Clustering Hierarchy (LEACH), which transmits to cluster heads of the majority nodes, is presented in [9]. There are two stages to LEACH's operation:

• Set-up Phase:During the Set-up phase, clusters are organized and cluster leaders are chosen.Every node makes a decision about whether to become the cluster head in each round using a stochastic algorithm. After a node becomes a cluster head once for P rounds (where P is the desired percentage of cluster heads), it cannot become a cluster head again.

• Steady Phase:During the steady state phase, the data are sent to the base station. In terms of time, the setup phase is shorter than the steady state phase.

Power-Efficient Gathering in Sensor Information Systems (PEGASIS) [2] is an energy-efficient technique that performs better than LEACH. Each node in PEGASIS only connects with its close neighbors to exchange data. The amount of energy needed for each round will decrease, when data is transmitted in turn to the base station.Each node is arranged to form a chain, which can be computed by BS and sending information to every sensor node simultaneously or created on its own using greedy algorithms starting with one specific node.

The cluster head of LEACH is established on this node through a stochastic mechanism. It leads to imbalanced energy reserves in the nodes, which increases the overall energy loss in the interconnected system. The location of the base station and the nodes' remaining energy are not taken into consideration when choosing cluster heads in PEGASIS.PEGASIS outperforms LEACH [3], but repeated data transmissions occur due to the nodes' chained connectivity.

In order to deal with sudden changes in the environment detected, a hierarchical technique called Threshold Sensitive Energy Efficient TEEN has been developed [4]. As the network's responsiveness is so crucial for timecritical applications, it needs to work in a reactive manner.

In case of abrupt changes in sensed qualities, TEEN's main advantage is that it works effectively. However, because of long-distance communications, TEEN tends to consume an excessive number of resources in broad networks and when there are a several levels in the that hierarchy.

The energy-efficient Shortest Hop Routing Tree protocol, or SHORT, enables the effective acquisition of essential information from a remote connected sensor to a base station [5]. The leading node shall be selected in accordance with this Protocol, having the highest amount of remaining energy.The routing system known as Extending Lifetime of Cluster Head (ELCH) [6] offers self-configuration together with hierarchical routing.It will select cluster heads, in accordance with the approval ratings of network routers.

## III. THE GAUSSIAN ENERGY-EFFICIENT ROUTING PROTOCOL PROPOSAL

This section introduces ECHGRP(Energy Clustering Head Gaussian Routing Protocol), a unique energy-efficient routing protocol. ECHGRP, like the majority of the previously suggested protocols, selects the network's cluster leaders using a model.

In primary distinction between this protocol and others is that it chooses a cluster head node using a process that is more effective. To optimize network longevity, this done by taking into account the nodes' predicted future residual energy as well as their current residual energy and the duration for which they can serve as cluster heads. ECHGRP uses Gaussian elimination approach to pick the cluster heads of the network following a logical model of the network and the resources consumed by the nodes.An overview of the topic is given in Article 3.1 of the energy model utilized in ECHGRP, whereas Subsection 3.2 provides specifics on the routing model.

### 3.1 An Overview of the Applied Energy Model

Low-energy radios are currently the subject of extensive investigation.Depending on assumptions regarding radio properties, particularly the loss of energy in transmission and receiving modes, a variety of protocols do not work as well.

This work employs the following energy model: the radio powers the transmitter and receiver circuits using 100 pJ/bit/m2 and 50 nJ/bit (Eelec) of energy.

For the transmit amplifier, use (Eamp) [1]. The force at which an individual node vanishes during a k-bit broadcast communication over a d-bit separation.

As a result of the radio communication of a k-bit communication over a d-bit separation, a node expends energy EKx(k, d), operating the amplifier transmitter EKX-amp(k, d) and the circuitry for communicators EKx-elec(k), and is expresses itself as follows:

$$Ekx(k,d)=Ekxelec(k)+Ekx\text{-}amp(k,d)=Eelec.k+Eamp.k.d2$$

when Eelec remains a transmitter's circuitry the dissolution each gently whose value is equal with the related recipient electronic components Efficiency every gently and Eamp is the transmit amplifier dissipation per bit per square meter. Furthermore, EKx(k, d) is reduced when using multi-hop routing as opposed to single-hop routing.

Similarly, the energy needed to run the transmitter circuit, for instance, ERx-elec(k), as shown by the following the model, determines a node's energy consumption upon receiving an ERx(k) message with k bits.:

$$ERx(k)=ERxelec(k)=Eelec.k$$

**3.2. Overview of the Suggested Routing Model**

In the case of ECHGRP, central hub is considered as limitless power reserves and interaction capacity. In addition, the BS is presumed to be positioned somewhere inside or on the periphery of the sensor field.The amount of energy needed by each node to transmit data to the central hub increases with the proximity of the sensing area position to the base station. System devices are dynamically organized into clusters and are expected to be situated within the detection area. From among the nodes in that cluster, each cluster's cluster head is selected. As a result, there are exactly the same numbers of clusters as cluster heads. Clusters shall be considered as the first level of cluster heads, where they are located within sufficient range of a network base station.

The head selection procedure is ECHGRP's defining feature. In this protocol, the process for choosing the pathway details, the entire group, and the resource usage in the connection is shown as a single line., and Gaussian elimination procedure used to determine its solution. hence, group the nodes with the cluster's lowest overall energy consumption are chosen to be heads.

The majority of the protocols that have been presented so far designate a cluster's node with the most residual energy as chosen to lead the cluster. As you can see from the following example, there are ways this decision could lead to inefficiencies. Suppose node x has more left over power than the rest of the nodes within a group, as is shown by Figure 2. The new cluster head is then selected for this node. However, it is necessary, takes more energy to send data in the opposite direction, from the remaining nodes to the base station.

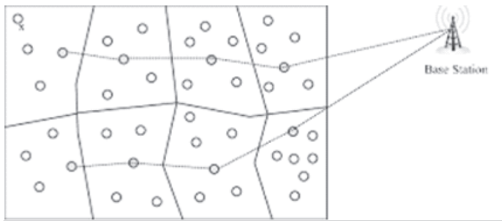


**Figure 2: The Network Model Adopted**

Select cluster leaders once the groups have been established through a Gaussian algorithm, the following procedures shall be observed:

1. A Time Division Multiple Access (TDMA) schedule is established by the BS, similar to other protocols, and asks the nodes to advertise it.

2. Every node communicates its location and energy status to the nodes nearby by sending messages.

Each node creates a neighbor information table based on the information that has been exchanged, records the positions and energy levels of its neighbors, and sends this table and the information that goes with it nearby nodes. The procedure is repeated prior the central hub has received data from every node in the network, giving the BS a comprehensive understanding of the network.

3. To extend the network's lifetime, the central hub calculates the maximum number of phases each node can handle using a reduction technique based on Gaussian distribution. In first phase of cluster head selection process, a BS shall select nodes closest to himself as high level clusters

heads. Additionally, certain nodes are regarded as lowlevel cluster heads if the BS hasn't received any direct marketing messages from them. The cumulative count of nodes chosen by head represents 5 % of all network nodes to achieve top-notch performance in a dependable connection with different variable configurations [1]. Additionally, various ratios can be applied.

4. The distinctive IDs of the recently chosen group heads will be broadcast by the central hub, which will be used by the nodes and their cluster members to create and join the cluster. Each node may represent a cluster head, so all nodes are capable of knowing how many times it can't. In order to determine the appropriate number of rounds for each node which will be used as Cluster Heads the BS uses a Gaussian reduction process. It then notifies the appropriate nodes of this information.

5. The central hub isn't directly broadcast to by the next-stage heads of clusters. It utilizes the higher-level cluster members as links to relay signals and repeat their data to the BS.

6. Each cluster head creates the TDMA plan, which is then distributed among the cluster nodes so that each device is aware of its assigned transmission scheduled time segment.

7. Nodes communicate with their cluster head by sending data about observed events based on the allotted transmission time. Each node's transmission power is adapted bare minimum required connect to adjacent node on the subsequent hop. As a result, there is less energy loss as well as interference with other transmissions.

8.The reduced information must be gathered by each subordinate group head and sent to the upper lever clusters until it reaches the central station. Following the conclusion of a data transmission round, this procedure shall be resumed at step 4.

9. Once more employing the Gaussian elimination method, the Base Station (BS) will select the appropriate cluster head in scenarios where the network topology alters, either due to node repositioning or the overall depletion of residual energy.

10. The protocol ceases to run as soon as every router in the connection flows out of power.

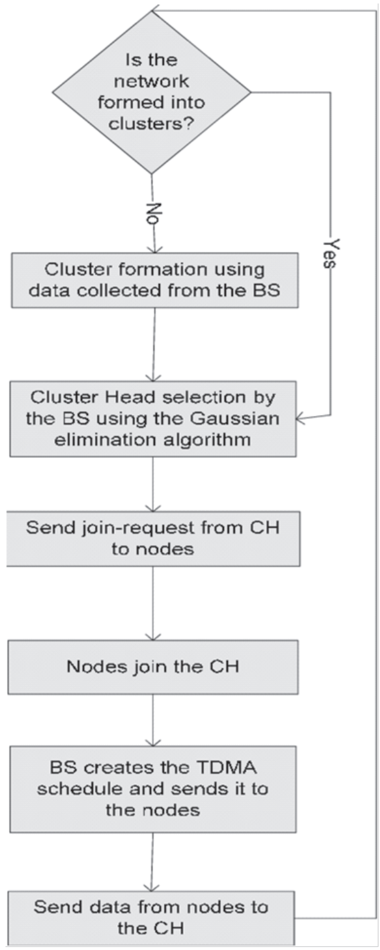


**Figure 3: Gaussian algorithm is used in ECHGRP for both cluster formation and data transmission.**

**Table 1- shows the pseudo-code for the ECHGRP algorithm for Gaussian elimination.**

```
for (s=1;s<k+1;s++)
i_maximum:=valuemax(i=s…m,abs(x[I,s]));
if(x[i_max,s]=0)
error"Matrix form !";
swap rows(s,i_max);
for(i=s+1; i<l+1;i++)
for(j=s+1;j<v+1;j++)
x[I,j]:=x[I,j]-x[k,j]*(x[I,k]/x[k,k]);
x[I,k]:=0;
```

Clustering is done only once, at the beginning of the protocol. As a result, the protocol can spare users the time and resources required for re-clustering. The network node energy consumption model is linear, and the central hub uses a Gaussian elimination method to calculate its power use if it's one of the cluster leaders in the next round while having regard to all possible combinations. As a result, a combination that reduces overall energy use while extending the network is chosen.

The Gaussian elimination procedure is completed in two stages. The forward elimination technique is used in the first phase to reduce the method's position, indicating the power used. Through, this is made possible.

In the second stage, the spine replacement method is used to determine the solution for the system.

The energy utilization of the cluster leader shall be determined by the transmission of messages from clusters to higher level nodes or base stations, as well as for data reception between them and Cluster Nodes. Data transfer of messages to the cluster head determines how much energy is used by cluster node.

**IV . Performance Evaluation of ECHGRP**

More than 50 different network topologies of 100 m to 100 m were used in order to evaluate the performance of ECHGRP simulations. The following network architecture has been taken into account:

- The force vitality allocations of sensor nodes are identical and are limited; the initial position is stationary and located at a distance from the detection field.

- Each node senses its surroundings at predetermined speed, continuously transmitting data to the Base Station when an event occurs.

- The sensor nodes are presumed to be immobile. However, mobility of nodes can also be supported by the protocol.

- The network is homogeneous and each node has the same computing and communications capacity, which means that all nodes are equivalent.

- Location unawareness occurs when nodes' actual locations are unknown in advance.

- The transmitter's amplifier strength can be modified in response of transmission distance.

In a realworld application, in which sensors are grouped into clusters and communicate Information about the cluster of the next structure, the proposed protocol can be used for fire monitoring systems.

The simulation was carried out by creating a specialized Java basedsoftwareenvironment, programming dialect. In each of the simulated cases that were looked at, 500 homogenous nodes with a 2 J of starting energy were dispersed at random over a 100 m2 area, sensor array. The 500-byte packets were sent from the central hub located within the (0, 150), which maintained a minimum distance of 100 meters from the closest device. The first method is used to calculate the energy required for communication.
Table 1 compares ECHGRP to LEACH, PEGASIS, and BCDCP in relation to the separation between the detection area's center and the central hub as the starting device power is reduced to 2 J.

Compared Protocol illustrates results regarding the base station that is situated 150 and 300 meters depicted at a distance from the center of the detector area.When the network's node ratio Nr of higher level nodes to lower level nodes is 1.1, the proposed protocol performs better.

The technique of Outcome as The First Node Depletion Time and the proximity among the Base Station and the focal point of the sensor grid section (m) are determined using the central hub location, energy consumption, and an analysis of the ECHGRP protocol.

Cluster heads send not only their own data to the base station, but also the data of lower level cluster heads that are headed there as well. As a result, they dissipate more energy on average than nodes at lower levels. The distribution of nodes in the network topology was correlated with the ECHGRP performance.

## V. CONCLUSION

The current research introduced ECHGRP process an energy-efficient procedure for WSNs. To extend the interconnected system lifespan as much as possible, ECHGRP will take account of currently available and projected residual energy at nodes as well as the number of rounds which might be cluster leaders. The protocol is used to calculate the energy.

As a result, ECHGRP is significantly more energy efficient than any of the previously proposed protocols, in particular LEACH, PEGASIS and BCDCP, as demonstrated by simulation tests.

The proposed protocol is unique in that it makes use of the Enhanced Greedy Forwarding and Clustering structure. It allows us to improve network flexibility, longevity, end-to-end delay, and load balancing by selecting different cluster heads in each round.

The Gaussian elimination approach was used to reduce total network energy usage.Every single round, consumption is required. Thus, rather than the node with more energy remaining, as many others do, it selects a node to reduce total cluster energy consumption. protocols. A multihop routing protocol is also used by ECHGRP method for transmitting combined data to the initial position.
Consequently, as demonstrated by simulation studies, ECHGRP achieves significant energy efficiency, outperforming various previously proposed protocols, particularly LEACH, PEGASIS, and BCDCP. ECHGRP can be improved in the future by incorporating metrics relating to QoS and time limitations.

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