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# Energy-Recognition Clustering Technique Based on Reinforcement Learning In WSN

Journal of Electrical Systems

***Abstract:*** WSN (Wireless Sensor Network) technology has recently gained a lot of attention. This began with the deployment of small WSNs and moved to the deployment of big and IoT WSNs, all with an emphasis on energy conservation. Wireless sensor networks can benefit from network clustering to increase their energy efficiency. The practise of dividing nodes into clusters before picking multiple cluster heads is known as network clustering (CHs). Clustering in wireless sensor networks is known to save energy and extend the network's lifetime (WSNs). Energy efficiency is a hot topic in existing wireless sensor networks, although it's not generally discussed. In this research, we offer a reinforcement learning (RL) based energy-aware clustering approach, whereby peripheral cluster nodes monitor environmental factors like energy use and choose an optimal cluster leader (CH). Connect the CH (BS) to the base station. In the simulation (PDR), performance factors such as network lifetime, energy tax, network stability period, and packet delivery rate are all taken into account. The simulation results show that the proposed QL-ReLeC performs around 11% better than the reference protocol in terms of PDR and 11% better in terms of energy tax.

***Keywords:*** Wireless Sensor Network (WSN), Internet of Things (IoT), Cluster Heads (CHs), Reinforcement Learning (RL), Base Station (BS).

## I.INTRODUCTION

WSN (Wireless Sensor Network) research has attracted a lot of attention in recent years. These burgeoning interests necessitate in-depth studies that offer scholars with a thorough comprehension of the subject matter. A wireless sensor network (WSN) is an ad hoc network of sensor devices that collaborate to accomplish certain tasks, such as detecting the physical environment, making decisions, and delivering observed data to the relevant edge. WSN has a significant impact on the Internet of Things (IoT), which connects a huge number of devices and provides a platform for sharing information among these devices to increase users' control over the environment.

A Wireless Sensor Network (WSN) is a group of nodes with a certain composition that gathers information like temperature and humidity. An ADC (Analog to Digital Converter) converts the collected data into a digital signal, which is then sent to a central server known as a base station (BS). BS looked at the information and made conclusions based on it. Source and sink nodes are used in WSN [3]. A WSN is depicted in the figure as an image. The clustering structure based on WSN reinforcement learning is depicted in this diagram. Health monitoring, military control, digital housing, vehicle tracking and detection, factory control, and other applications are among the WSNs available today. The data is passed to the appropriate node after the node identifies that it is in the same region.

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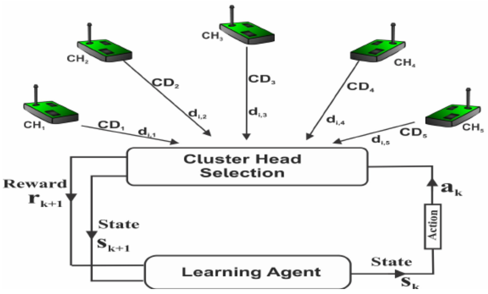


**Figure 1: Reinforcement learning based clustering in WSN**

The limited power and processing capabilities of sensor nodes, on the other hand, limit WSN applications and reduce their lifetime [24-26]. If the WSN is positioned in the environment, the sensors are normally power constrained and cannot be altered. As a result, energy is WSN's most valuable resource, and energy-saving techniques can help it last longer [30-31]. [32] Identify strategies to increase network longevity, particularly energy-efficient routing algorithms, in order to efficiently employ limited resources and perform load balancing across nodes. This is significant in WSN [33-35] since it is possible to do. There's an issue here. WSN [36-38] should be consumed to extend its survival time. As a result, energy consumption due to forwarding can be avoided by the cluster's member nodes. [43] Establishes a secondary node to segregate data transfer from data transfer in order to prevent some nodes from being terminated prematurely owing to frequent data transfer. These techniques, however, have a few drawbacks. For starters, they rely on complex mathematical models that take too long to develop and waste too much energy. Second, the practicality of these solutions is hampered by the fact that WSNs are prone to congestion due to their inability to adapt to various network topologies and scales. As a result, new approaches to resolving these issues are required [44].

In terms of optimization methods, this research also looks at the WSN clustering protocol. The methodologies and properties of the algorithms discussed in recent research on optimising clustering solutions have been thoroughly examined and reviewed. To compare clustering protocols, standard parameters for clustering and optimization process parameters for compatibility with varied network characteristics are used to evaluate these strategies. We will use optimization parameters to evaluate the technique and obtain a general understanding of the clustering protocol in this review. It suggests parameters for meta-heuristics, fuzzy algorithms, and hybrid algorithms, among other optimization techniques.

## II. LITERATURE SURVEY

To review the available research on WSN clustering protocols, this article applies several optimization strategies. This method has benefits over epic style, according to. You can find gaps in existing research, access literature from diverse viewpoints, and assist new ideas by identifying areas covered in existing research, highlighting gaps, and facilitating new insights. This study using optimization strategies and clustering procedures searches online databases and other resources for all papers that meet particular criteria, enters data about each study into a personal database, and summarises the table's present state. The extensive literature review process is depicted in Figure 2.

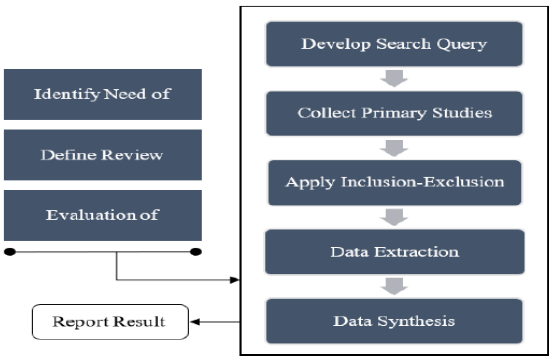


**Fig 2: Literature Review Process**

Among the WSN's energy-consuming aspects, communication between sensors is the most problematic. The routing strategy determines the forwarding path between the sender and the recipient. Wireless sensor networks' lifespans may be increased with the use of efficient routing techniques, which also dramatically lower communication costs. Routing methods are categorised based to network setup, topology, and other factors in most extant WSN green routing protocol studies. Few categorization methods, on the other hand, can help WSNs become more energy efficient. We propose a novel classification approach in this study that categorises existing energy-saving routing algorithms into three categories: specific node settings based on energy-saving methodologies, energy-saving scheduling, and data flow optimization. The hierarchical node and special function node settings are part of the special node routing algorithm settings. Two routing techniques that conserve energy are static node scheduling and mobile node scheduling. The single-channel and multi-channel routing techniques are two data flow routing algorithms that have been optimised. One of the best methods for reducing energy consumption and increasing the lifespan of wireless networks is clustering. There are two types of communication phases in most existing clustering methods: (i) CH selection, (ii) numerous data communication steps and intra- and inter-communication processes. Figure 3 depicts a general data transfer scenario involving clustering techniques.

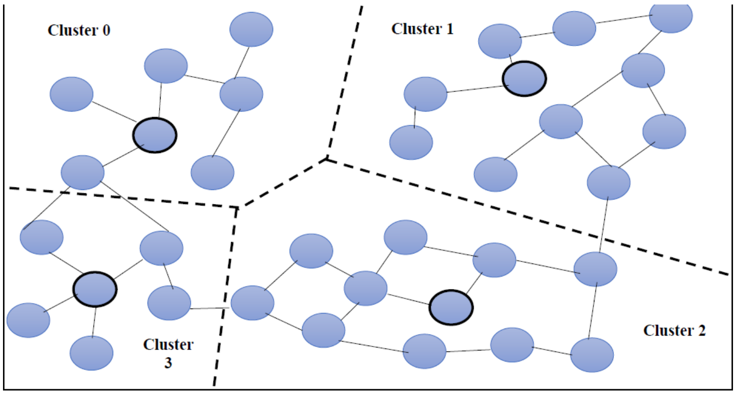


**Fig 3: Cluster Approach**

All scientific articles are cited in this article and can be found on the internet. Digital databases like IEEE Navigation, Science Direct, Springer Link, and the ACM Digital Library were used to find scholarly papers for this investigation. During the search, keywords such as optimization of the WSN clustering protocol, WSN clustering, WSN clustering protocol, principles, requirements, and obstacles were utilised to narrow down the results. Article titles from April 2021 were used to do searches. Twenty-three papers were chosen and reviewed from a variety of data sources for their relevance to the research question.

## III.PROBLEM STATEMENT

The authors spent a lot of time thinking about routing algorithms for energy conservation and hole avoidance in order to overcome the challenges mentioned above. Algorithms can extend network lifetime and balance energy usage, therefore FN selection must be immutable to assure failsafe [10]. Q-Learning (QL) is utilised in this case to minimise network overhead and energy consumption dramatically. To reduce control overhead, QL employs a hybrid technique of post-policy and pre-policy. The former technique uses control packets to discover neighbouring nodes and associated routes by broadcasting them throughout the network. Tables are kept up to current with node and path information. This method, however, can deplete the node's battery if used frequently. When the network topology changes, the latter strategy sends control messages out. As a result, there is less network overhead and memory storage [2]. QL balances active and post-response tactics in an uncertain environment by learning from rewards. Furthermore, QL aids in the optimization of agent behaviour and the avoidance of excessive energy consumption. The routing protocol's requirements, however, influence proxy behaviour optimization. In addition, optimizations of compensatory parameters are compared to network longevity. This indicates that a high level of optimization will extend the network's lifespan [11].

Only the next hop of the planned job is the recipient of control packets. Only the information about their neighbours is kept by nodes. They have no interest in learning about routes. In order to overcome these issues and capitalise on the benefits of both approaches, the proposed Q-learning based EEBDG (QL-EEBDG) and QL-EEBDG adjacency node (QL-EEBDG-ADN) routing protocols have been developed. Furthermore, the proposed routing protocol can identify forwarding nodes as alternative paths automatically to avoid node fatigue. This node swapping extends the network's life and maintains balanced energy consumption. This is a continuation of [12], with the following significant additions.

*Contributions:*

The work makes a six fold contribution.

- QLEEBG and QL-EEBDG-ADN are two proposed whole detection mechanisms.
- The suggested routing system automatically switches a route from an energy-draining node to another.
- Using the agent's compensation mechanism, use QL to precompute routes.
- We suggest a transmission failure recovery strategy for extending network lifetime in this paper.
- For the best outcome, this task calculates the viable region.
- The most cutting-edge routing technology is used in comparative analysis. As a result, the proposed mechanism raises the PDR by 11% while also increasing the energy tax by 25%.

The following is how the rest of the paper is organised. The second section of the paper is devoted to a thorough examination of the literature. In Section 3, the proposed routing protocol's use of QL is detailed. The protocol's performance is assessed and compared to that of other protocols in Chapter 4. The conclusion is provided in Chapter 5. In Tables 1 and 2, you'll find a list of acronyms and symbols used in the formulas.

## IV.PROPOSED METHOD

### *A. Reinforcement Learning based clustering Protocol*

With the help of neighbours, the proposed ReLeC protocol enables devices to make more precise routing decisions, which can enhance next-hop selection and use less energy. Although the transmitting side adds local data to the packet header, the routing table of the peripheral device adjusts in accordance with the information in the packet header of the communication device. The ID, amount of energy left, locations, and NH are among the local data provided. Like other effective cluster-based routing systems, ReLeC has three phases: network start up, CH selection and cluster building, and communication phases.

### *B. Network Initialization*

With this option, network nodes are permitted to calculate the first Q-value using local data. The position coordinates are then transmitted in a transmission by the base station. Once the packet has been accepted, each node keeps its location relative to the base station and uses the residual, Emin, Emax, NH, and probability parameter p to calculate the first Q value according to the provided equation. This assignment introduces a modification influenced by Shannon entropy to discover the initial Q-value, offering a suitable extension to [16].Additionally, we consider that each node has a varied energy level. We establish a (distance) threshold as a criteria between the cluster head and the base station or receiver in order to decrease network overhead, making it simpler for sensors located distant from the base station to locate the CH. In order to avoid connections becoming convergent and branching out from the base station, CHs are not situated at the network's edge. Longer communication distances and energy loss may arise from this. Algorithm 1 is a representation of the CH selection process. As seen below, the first Q value is determined.

Algorithm 1: Cluster-head selection and network configuration.

for each node i, do
set $D_{euclidean} = Euclidean(node\ i, sink)$
set $N_H = (D_{euclidean}/Transmission\ Range)$
set $Q = \left(P \times (E_{residual}/E_{max} - E_{min})\right) + \left((1-P) \times \left(N_H \times log\left(\frac{1}{N_H}\right)\right)\right)$
end

while$len(CH_{list}) \leq CH_{total}$, do
for each node i, do
if$MIN_{threshold} \leq D_{euclidean} < MAX_{threshold}$, then
if $CH_{list}$ is empty, then
add node i to $CH_{list}$
pop node i from stack
else
for head⟵1 to$len(CH_{list})$, do
dist = Euclidean (node i, CH head)
if $dist \geq MIN_{threshold}$, then
set flag=1
else
set flag=0
break
end
if flag==1, then
add node i to $CH_{list}$
pop node i from stack
end

$$Q = \begin{cases} \left(N_N \times \log(\frac{1}{N_n})\right) E_{max} = E_{min} \\ \left(\left(P \times \left(\frac{E_{residual}}{E_{max} - E_{min}}\right)\right) + \left((1-P) \times \left(N_H \times log\left(\frac{1}{N_H}\right)\right)\right)\right) E_{max} \neq E_{min} \end{cases}$$

According to Wang et al., the number of hops (NH) is roughly equal to the ratio of the Euclidean distance to the transmission range, or NH≈Deuclidean/transmission range.

*C. Cluster-Head Election and Cluster Formation*

Figure 1 depicts the network configuration and cluster head selection flowchart.

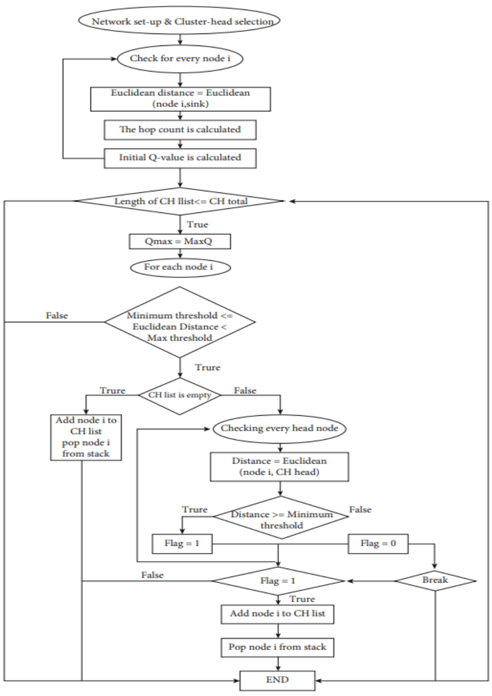


**Figure 1: Flowchart for network configuration and choosing cluster leaders.**

Each CH notifies all devices within its transmission range that it has been chosen by sending an invitation message after the selection phase. The initial Q-value, ID, and coordinates are also included in the invitation. Except for the CH, every node chooses which cluster to join and sends a request to that specific CH with distance-based information. Additionally, if a node is at the confluence of many clusters and receives more than one invitation, it can select the node with the nearest CH [18]. Check to see if cluster membership is established when all devices make queries.

It is not necessary for nodes to join the cluster if they are inside the base stations broadcast range. Immediately interacts with the washbasin to conserve energy. ReLeC may also be utilised for intra- and inter-cluster communication in a variety of contexts. Multi-hop communication between CHs is connected to inter-cluster communication. A CH far from the receiver, for instance, may route packets through a CH nearer the recipient [19].

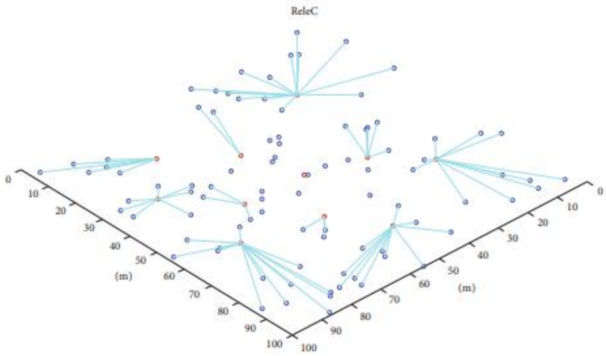


**Figure 2: Cluster formation and CH selection**

If devices within the cluster may send data to the CH directly or over several hops, intra-cluster communication is comparable. Even if they are far distant, nodes can link to other cluster nodes. Nodes have various energy levels and transmission ranges, as was previously indicated. Figures 2 and 3 illustrate how clusters develop.

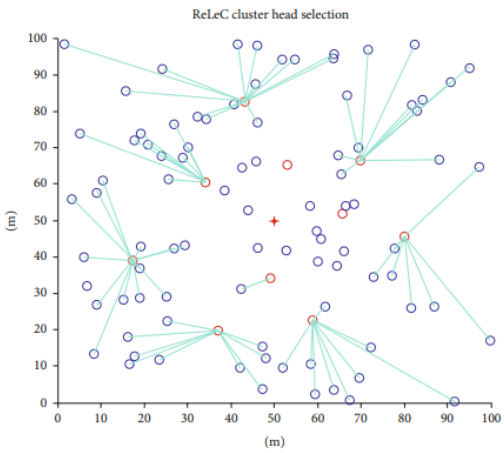


**Figure 3: Cluster formation and CH selection**

*D. Energy Consumption Model:*

Using the radio model offered by Shah and Rabaey [10], the continuous residual energy of each node is determined after the current round. The transmitter and receiver are powered by Eelec = 50 nJ/bit, and amplification = 100 pJ/bit/m2 is the constant relating the power consumption of message amplification to the distance d. The wasted energy is computed as follows for gearbox:

$$E_{transmission}(k,d) = E_{elec} \times k + \varepsilon_{amplification} \times k \times d^{w}$$

Where w = 2 or 4.

Similarly, it costs $E_{reception}(k)$ to receive a k-bit message at a distance d. The formula below may be used to compute this:

$$E_{reception}(k) = E_{elec} \times k$$

In Figure 4, the primary radio model is displayed.

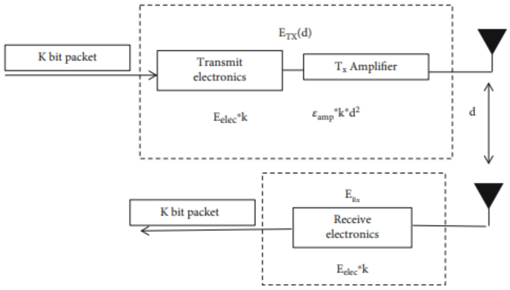


**Figure 4: First-order radio model.**

V.RESULT

Comparisons of the suggested method's performance with that of methods with and without RL as well as Kiani et al. Simulations are not performed using the MATLAB 2019a simulator [37]. We use 100, 200, and 300 nodes to test the performance of the suggested approach. The placement of nodes throughout the network is random. The simulation network has a surface size of 100 by 100 metres. Throughput, network longevity, and overall energy consumption are used to assess the proposal's overall efficiency, which is then compared against leading-edge work using the same simulations. The simulation settings and values are displayed in Table 1.

**Table 1: Simulation parameters settings**

| **Parameters** | **Values** |
|---|---|
| Simulator | Matlab 2021a |
| Simulation area | 1200m * 1200m |
| Number of sensor nodes | 50,100,150,200,250,300 |
| Number of data packets | 30,60,90,120,150 |
| Mobility model | Random Waypoint model |
| Nodes speed | 0-25 m/s |
| Simulation time | 400 sec |
| Routing Protocol | DSR |
| Number of runs | 10 |

The network lifespan in this procedure measures how long the network will last. As the initial sensor stops working, coverage decreases, the network collapses, and the model no longer works in the equations (53), the signal-to-noise ratio decreases,

**Table 1: Network Lifetime**

| **Number of nodes** | **Without RL** | **With RL** | **Kiani et al.** | **Proposed** |
|---|---|---|---|---|
| 50 | 6 | 15 | 7 | 10 |
| 100 | 9 | 18 | 13 | 17 |
| 150 | 12 | 21 | 15 | 21 |
| 200 | 15 | 24 | 20 | 25 |
| 250 | 18 | 27 | 25 | 28 |
| 300 | 25 | 32 | 30 | 34 |

Packet loss lowers the performance of the network. Multipath fading, corrupted node infiltration, and node energy efficiency are the causes of this. In order to prevent packet loss, the aforementioned elements must be under control. According to the aforementioned statistical data, the suggested technique works rather effectively even at greater packet loss rates. The packet loss rate is decreased to 20% and 33%, respectively, in comparison to [19, 20].

**Table 2: PDR**

| Number of nodes | Without RL | With RL | Kiani et al. | Proposed |
|---|---|---|---|---|
| 50 | 76 | 88 | 78 | 81 |
| 100 | 77 | 89 | 80 | 83 |
| 150 | 78 | 90 | 85 | 86 |
| 200 | 79 | 90 | 88 | 90 |
| 250 | 80 | 91 | 89 | 94 |
| 300 | 80 | 92 | 90 | 98 |

*A. Packet Delivery Ratio:*

It is calculated as the ratio of the total number of packets delivered by the source node to the number of packets successfully received by the base station. The following is the mathematical formula for calculating packet transmission rate:

$$Ratio_{PD} = \frac{[dp_{received}]}{[dp_{sent}]}$$

Regarding packet transfer rates, Table 3 compares the projected and actual performance with and without RL as well as the performance of RL and Kiani et al. technology. The amount of packets sent by the sink node is used to estimate network performance. As a result, a network is considered to have strong performance if its PDR is high. This programme uses a bat optimisation approach to determine the most reliable channel for data transmission based on fitness function and selection probability. The nearest, most reliable, and having a high residual energy path is this one. High link stability is present.When under assault, dependable nodes are employed to deliver sensitive communications continually. The number of communicated packets varies from 50 to 300 packets, according to an analysis of the performance of the proposed method and the other two conventional approaches, and as a consequence, the suggested system's packet transmission rate is lower than [19, 20].

**Table 3: PDR**

| Number of nodes | Without RL | With RL | Kiani et al. | Proposed |
|---|---|---|---|---|
| 50 | 318 | 288 | 321.54 | 312 |
| 100 | 324 | 300 | 325.05 | 326 |
| 150 | 330 | 312 | 333.52 | 331 |
| 200 | 336 | 325 | 319.05 | 342 |
| 250 | 342 | 328 | 354.76 | 367 |
| 300 | 347 | 333 | 345.85 | 387 |

Packet loss rate can generate a lot of congestion when data aggregation is done at the sink node. It is measured by,

$$PLR = \frac{DP_l}{DP_s} \times 100$$

**Table 2: Packet Loss rate analysis**

| No. Of Nodes | Without RL | With RL | Kiani et al. | Proposed |
|---|---|---|---|---|
| 50 | 16.66 | 13.33 | 11.65 | 8.6 |
| 100 | 17.15 | 13.85 | 12.15 | 9.1 |
| 150 | 17.35 | 14 | 12.85 | 9.9 |
| 200 | 18 | 14.25 | 13.1 | 10.2 |
| 250 | 19.35 | 14.55 | 11.75 | 10.8 |
| 300 | 20.4 | 16.15 | 12.45 | 11.4 |

## CONCLUSION

WSN, like other current networks, was built for specific uses such as military, rescue, and agriculture. Each one necessitates its own set of capabilities. Depending on the network context, each requires a distinct communication protocol. In order to obtain the necessary performance, network design elements must also be addressed. Clustering technique optimization is widely recognised as a viable strategy for achieving the highest energy efficiency in WSNs. A detailed analysis of novel hierarchical optimisation techniques for communication, aggregation, and the selection of cluster heads.To determine the ideal number of clusters in the network, the network's energy usage for inter-cluster and intra-cluster communication is first examined. It also explains how to use a reward points-based RL technique to choose an appropriate CH. In terms of network longevity, packet transmission rate, and energy usage, simulation results suggest that the method performs better. The maximum PDR increase is 15%, with a 2.79 percent increase in energy savings.

ABBREVIATION;

| WSN | Wireless Sensor Network |
|---|---|
| IoT | Internet of Things |
| CHs | Cluster Heads |
| RL | Reinforcement Learning |
| BS | Base Station |
| QL | Q-Learning |
| NH | number of hops |

## ACKNOWLEDGMENT

All Authors in the Manuscript has Acknowleged .

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