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# Q-E2RPC: ENERGY AND QOS-ORIENTED ROUTING PROTOCOL FOR CO-OPERATIVE MIMO BASED MOBILE WSNS

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***Abstract:*** *Recently, multimedia data transmission over WSN has gained a lot of attention as a dominant research and application region. This trend began relatively recently. On the other hand, major industries, the defense sector, and civil societies have all expressed a desire for increased mobility in sensor networks. On the other hand, it is a well-known fact that in a scenario involving mobility or a running competition, WSN presents a number of difficulties. However, WSN performance is ultimately determined by criteria such as the appropriate number of clusters, optimal CH selection, and transmission. Using a single mobile sink allows for better throughput, lower energy consumption, and delay assurance than typical multi-hop transmission-based WSNs.*

**Keywords:** Data, Sensor, Network. Cluster, Optimal

## I. INTRODUCTION

In most current routing techniques, focus is put on increasing QoS, latency and energy usage. However, recovering a strong routing solution to suit all afore-mentioned network criteria has long been an open research subject. Among key options, co-operative communication has been shown potential to promote effective routing. Sharing of real time network information among the connected nodes (CNs) assists in improved routing choices. To help energy and resource efficient communication, Multiple-Input Multiple-Output (MIMO) approach is proven to have prospective. It seeks to satisfy the requirement of dependable and time efficient communication via wireless link, especially under extreme network circumstances that makes MIMO a dominant choice for WSNs as well as and cellular communication. It plays crucial function in easing the fundamental challenges of poor transmission rates and low dependability. Since, the sensor nodes lifespan mostly depends on its battery capacity; WSNs necessitate dealing with energy depletion difficulties. Additionally, in a real-world setting, the nodes of a WSN need to have secure communication channels to deliver as promised. In order to fulfil these needs, MIMO may take use of diversity to promote benefits like increased spectrum efficiency and lower bit error ratio (BER). Most WSNs function because nodes only have so much storage space and power. It may be challenging to build WSN nodes with numerous antennas due to size and complexity restrictions. To combat this, WSNs may use MIMO cooperatively, ensuring not just secure communication but also efficient transmission across a specified area of the network.

To make typical MIMO communication possible across clusters, CMIMO requires numerous nodes to coordinate their data exchange and transmissions. To provide stable communication in densely distributed networks, CMIMO takes use of the cooperation between nodes. The goal is to increase throughput at the receiver while decreasing energy consumption and latency, so that QoS requirements may be met. Increased communication efficiency is one of the main benefits of adopting CMIMO, which allows several sensor nodes to work together. When using this method, a collection of sensor nodes is networked together to create a "cluster," wherein individual nodes in the cluster share resources and use less energy for communication inside the cluster than they do with other nodes in the cluster. To reduce the problem of redundancy and power fatigue, MIMO systems need conducting early (i.e., delay sensitive) data collecting.

## II. LITERATURE REVIEW

**Fuseini Jibreel, et al (2022) -** Wireless sensor networks, also known as WSNs, continue to offer vital services for a wide variety of applications, including monitoring, the collection of data, and the transfer of data from potentially dangerous situations to locations that are less risky. This has been made possible thanks to energy-efficient routing protocols, which were primarily developed for these kinds of applications. The Gateway-based Energy-Aware Multi-hop Routing protocol, also known as MGEAR, is one of the homogeneous routing systems that was recently developed in order to more effectively limit the amount of energy consumption by remote nodes. However, it has been shown that the protocol has a high energy consumption rate, a lower stability period, and inferior data transmission to the Base station (BS) when it was deployed for a longer duration of time. These findings were made when the protocol was used for a longer amount of time. An improved version of the heterogeneous gateway-based energy-aware multi-hop routing protocol, known as HMGEAR, is suggested in this article. The proposed routing scheme is based on the introduction of heterogeneous nodes into the existing routing scheme, the selection of the head based on the residual energy, the introduction of multi-hop communication strategy in all regions of the network, and the implementation of an energy hole elimination technique. The overall goal of these solutions is to cut energy usage while simultaneously extending the lifespan of the network. According to the findings, the routing system that was developed is superior to two others that are already in use in terms of stability period, throughputs, residual energy, and the lifetime of the network.

**Santosh Anand and B. P. Adithi (2022) -** When it comes to the transmission of data from source to sink node, Wireless Sensor Network (WSN) runs into a lot of problems. The data or information must be sent in a safe and secure manner. If the information is not transferred in a secure manner, then it is necessary to secure that particular node. In a WSN, communication takes place between two nodes, each of which must have access to a source of energy in order to do so. Because it has less energy and bandwidth than the other nodes, the node that is in communication with the other node eventually becomes defective. As a result, it is essential to take precautions to protect the node in order to prevent disruptions in the flow of communication. Honeypot nodes will be utilized in the planned study activity in order to identify the problematic node. When a faulty node has been identified, appropriate security measures are implemented to protect it from outside intrusion. Utilizing the Honeypot nodes in between the other nodes in order to get the best result in identifying the defective node is how the comparison of the previously conducted study with the new work will be carried out.

**Sheetal Kumar Dixit and Mahainder Kumar Rao (2022) -** A routing protocol for a WSN may be based on the network topology or on the protocol operations itself. Within a wireless sensor network, the routing process may be broken down into three distinct categories: flat, hierarchical, and location-aware. Hierarchical Routing may be further subdivided into two distinct categories: dynamic and static hierarchical routing, as well as clustering-based routing. Protocols that are said to be based on dynamic clustering are ones in which the clusters are produced and decreased in a dynamic manner. Static Clustering-based Routing Protocols are those in which clusters, once created, remain the same throughout the entirety of the network's existence. In this article, we cover all of the different Dynamic and Static Clustering based Routing Protocols, as well as their benefits and drawbacks. An infrastructure that is made up of sensing (measuring), computation, and communication components is known as a wireless sensor network. This infrastructure allows an administrator the capacity to instrument, watch, and react to events and phenomena that occur in a particular environment. In most cases, a civic, governmental, commercial, or industrial organization serves in the capacity of administrator. The environment might be a biological system, the physical world, or even a foundation for information technology (IT). Due to the high number of sensor nodes in a wireless sensor network, routing can be an extremely challenging process.

**T. G. Ganga and R. A. Roseline (2021) -** In wireless sensor networks, often known as WSNs, the amount of energy that sensor devices may store is restricted. One of the fundamental architectural challenges posed by WSNs is that sensors might fail owing to the loss of battery capacity. It is for this reason that it is stated that preserving energy is the most important need for any protocol that is developed for WSNs. For the purpose of gathering information in Wireless Sensor Networks, thousands of sensors that are both lightweight and affordable may be randomly dispersed in open and hazardous locations (WSNs). The short battery life of battery-operated sensors, in addition to harsh environmental conditions, necessitates the creation of sensor network protocols that are energy-efficient, secure, and dependable. Routing, out of the wide variety of network protocols, is the most important in terms of energy consumption. This is due to the fact that data transmission consumes around 70% of the total energy in WSNs. As a consequence of this, energy-efficient routing solutions need to be developed in order to reduce overall energy consumption and lengthen the lifespan of the network. However, routing can be difficult due to resource-constrained sensors, the absence of a universal solution method, and the application-specific nature of wireless sensor networks (WSNs). In addition, the lack of security is still another significant issue with WSNs. This is due to the fact that sensors are generally located in unsecured places, making them vulnerable to security breaches. A significant number of today's routing protocols already incorporate a wide variety of security precautions into their design in order to fulfil their respective security objectives. We provide a concise overview on a variety of safe and energy-efficient routing protocols in wireless sensor networks, elaborating on their fundamental principles and the activities they carry out.

**Nitul Dutta, et al (2021) -** ICN places a significant emphasis on routing research as one of its primary fields of inquiry. It is possible that the performance of ICN may be greatly improved by an efficient routing method, which would therefore boost its acceptance. The robustness of networks and applications are two significant features of efficient routing, and they are among the many benefits that efficient routing provides. To this point, there have been several routing suggestions proposed for ICN that take into consideration the NDN architecture as a means of putting such schemes into action. A good number of them need to centre their attention on extending conventional routing methods to ICN, and they can do this either by treating content transmission as an overlay or as a distinct notion. The importance of integrating in-network caching and routing has been underlined by many. In several recent ideas, the utilization of the Software-Defined Network (SDN) to implement ICN routing has also been discussed. In this chapter, we will provide a concise introduction of a few different routing protocols for ICN. At the end of the chapter, a table that compares all of these protocols is provided so that the reader may comprehend the improvements that have been made to these protocols. Research obstacles and potential future directions are also discussed.

## III. CMIMO BASED DATA TRANSMISSION

In addition, the speed of the mobile nodes is much lower than the speed of the electrical connection; therefore, improving the movement patterns of the mobile sink is still an open task. In order to address this issue, heuristic techniques such as the Traveling Salesman Problem (TSP) can be utilized to help the sink get in contact with CHs as soon as possible for the purpose of data collection. It has been suggested that the MIMO approach be used to gather data from CHs because, as a consequence, it might assist in producing error-free data while maintaining a high pace of transmission. During the Q-E2RPC protocol, the CHs send data to the mobile sink by utilizing MIMO. The mobile sink then sends a Data Transmission Request (DTR) to the CHs so that they can continue broadcasting the data to the CNs. After the mobile sink has received the DTR answer from CH, it will resend the DTR, and then it will begin relaying data from CH to the mobile sink. The availability of direct connection between CNs and mobile sink is yet another innovation that has been implemented as part of Q-E2RPC. In a normal scenario, CNs will send data to the linked CH, and the CH will then send the data on to the mobile sink. However, the in-depth research suggests that there is room for future improvement, particularly with regard to the transmission of data in a delay-efficient manner. In Q-E2RPC, the planned transmission is carried out in such a way that, if the mobile sink node is closer to CH than CH itself, a CN is able to send sensed data to the mobile sink directly, therefore avoiding the transmission delay that would have been created by sending the data through CH.

CNs send data based on the responsiveness factor in order to reduce the amount of energy consumed during the transmission process. According to what was covered, responsiveness is assessed using parameters, and. As a result, these parameters may be attached to the DTR message before it is sent back to the mobile sink. After the deployment of cluster nodes in the network, the information on each node's position is shared with the other nodes that belong to the same cluster. Due to the fact that this information exchange takes place just once after the deployment of the nodes, it is possible to limit the amount of unnecessary signaling overhead. When a node is part of more than one cluster, it can use the responsiveness factor to determine which of those clusters' CHs the most appropriate to forward data is to. For instance, in the event where a node possesses the responsiveness, of $\varphi_{n1}$= 0.8 and $\varphi_{n2}$ = 0.2 after having received DTR from CH of cluster 1, the nth node is responsible for transmitting 80% of the data. In the event that it gets DTR from cluster 2, it will send the remaining 20% of the data to the mobile sink using the CH that is associated with the second cluster. To satisfy quality of service requirements, it guarantees that the data will arrive at the sink in a reliable and timely manner.

## IV. RESULTS AND DISCUSSION

This section focuses mostly on the experimental design and the findings that were collected.

### Simulation Setup

Throughout the entirety of this study, the primary focus was placed on the creation of a novel QoS-oriented and energy-efficient WSN routing protocol known as Q-E2RPC. This was accomplished through the utilization of an enhanced clustering approach, CH selection, co-operative communication, and a single mobile sink based data collection method. Taking into account the vast scope of the network, network partitioning was initially carried out so that the total network could be organized into two distinct groups. This allowed for the discovery of the relevance of finding the optimal number of clusters inside the network. The first step in the clustering approach that was proposed was to use FCM to achieve initial cluster formation, and then the next step was to use EM-based clustering. In Q-E2RPC, EM-based clustering made use of initial cluster information to perform clustering. This was then followed by the use of multiple network parameters to perform final clustering. These parameters included inter-node distance, residual energy of node, signal-to-noise ratio, and responsiveness of the node within a cluster. The Responsiveness factor, which is a derived network parameter, played an essential part in allowing effective clustering, which directly influences the total number of CHs across the network.

Taking into account a number of different choice criteria, FLC was utilized to make an estimation of the ideal node to serve as CH for each cluster. In contrast to traditional ways of data transfer, the Q-E2RPC protocol incorporates cooperative communication between connected nodes (CNs) and their related children nodes (CHs) and children nodes to the mobile sink. A mobile sink was deployed to gather data from each CH for the purpose of quality of service delivery and energy-efficient communication in order to address the problem of excessive energy consumption that was caused by multi-hop MIMO transmission. It is important to note that in Q-E2RPC, the movement of the mobile sink was regulated depending on the data requests from CHs. The routing model was designed in such a manner that it not only prioritizes the conservation of energy but also guarantees the delivery of quality of service by minimizing end-to-end latency, maximizing bandwidth usage, and ensuring a better level of dependability. Communication between CNs and their respective CHs and CHs and the mobile sink was successfully carried out by Q-E2RPC thanks to the utilization of CMIMO. CH selection, which improved the effectiveness of clustering, reinforced timely data transmission, boosted energy efficiency, and decreased signaling overheads. All of these benefits were due to the reduction of signaling overheads. The Q-E2RPC protocol was designed on top of the IEEE 802.15.4 MAC.

The entire amount of time spent simulating is 800 seconds, and the transmission speed that was used for testing was 2kb/sec. In order to evaluate the effectiveness of the Q-E2RPC protocol, the Network Simulator tool, more often referred to as NS2, was analyzed. In addition, the programmer MATLAB 2015a was utilized in order to plot the graphs.

Table 1 provides an overview of the simulation environment that was taken into account for this work.

**Table 1 Simulation Environment**

| **Parameter** | **Value** |
|---|---|
| MAC | IEEE 802.15.4 |
| The efficiency of an RF power amplifier | 0.47 |
| Link margin | 40 dB |
| Gain factor | 30 dB |
| The Power density of AWGN channel | -134 dBm /Hz |
| Noise Figure (Receiver) | 10 dB |
| Path loss | 3-5 |
| Carrier frequency | 2.5 GHz |
| Bandwidth | 20 KHz |
| BER performance | 10-3 |
| Transmitter circuit power consumption | 98.2 mw |
| Receiver circuit power consumption | 112.6 mw |
| Antenna gain of Transceiver | 5 dB |
| Routing table update (exchange) period for each round | 5 |
| Routing table size | 100 |
| Transmission rate | 2p/sec |

| | |
|---|---|
| Packet size | 2 kb |
| Transmission probability of each node | 0.8 |

Throughout the course of this simulation, a number of sensor nodes were dispersed in a haphazard fashion around the network space (Figure 1).

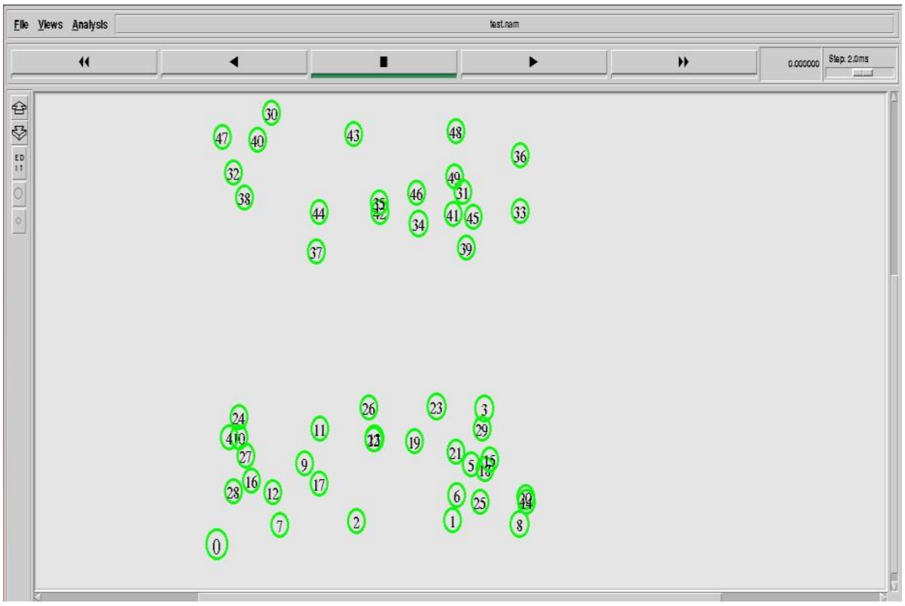


**Figure 1 Random node distributions across the WSN network**

Network partitioning was carried out in the Q-E2RPC protocol (which used FCM and EM-based clustering) in order to enable quick and effective communication across WSN. Within the framework of Q-E2RPC, the entire network region was sectioned off or divided into two groups, in addition to a solitary mobile sink (green colour in Figure 2). It is important to note that the linked sensor nodes of one group can only interact with the nodes that are connected to that group. To put it another way, the sensor nodes that are attached to one group are unable to interact with the sensor nodes that are connected to other groups. (Figure 2).

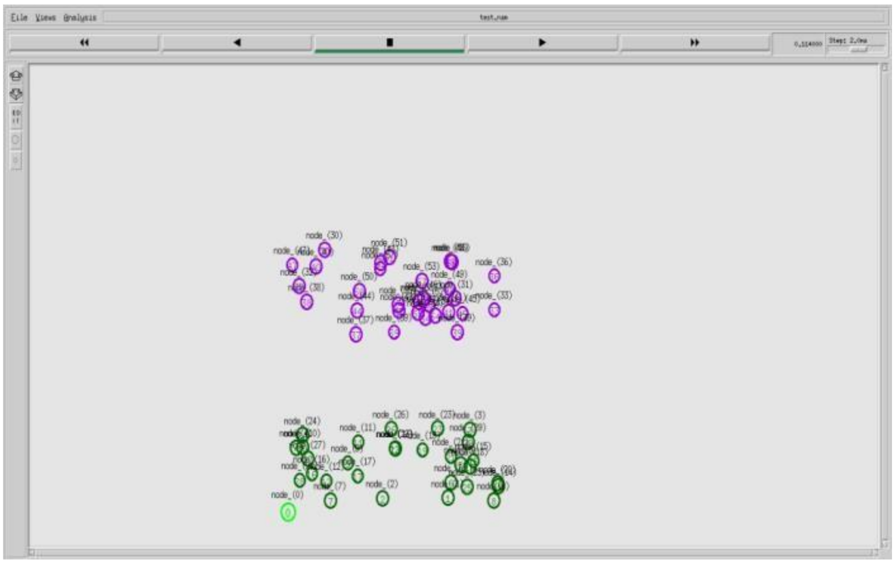
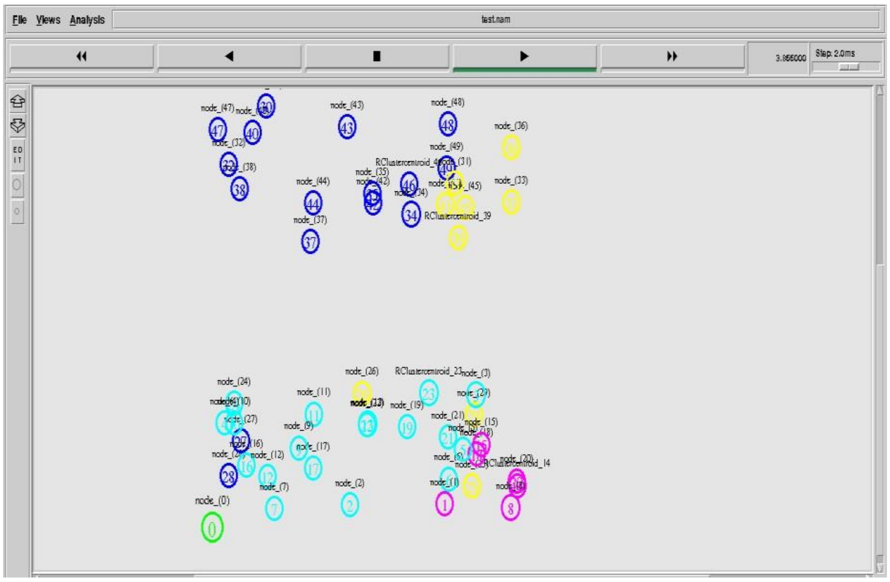


Figure 2 Network partitioning into two groups

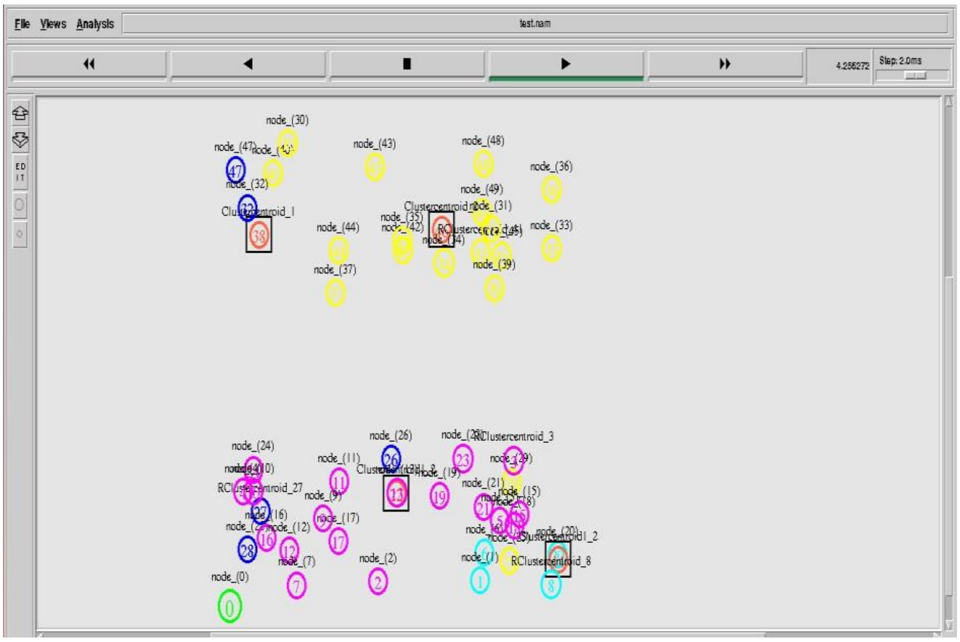
After the nodes were divided into two groups, the clustering process was started. At first, FCM clustering was used, which utilised the inter-node distance in order to produce initial clusters. Nevertheless, after becoming aware of the requirement to improve clustering through the incorporation of node responsiveness, EM-based clustering was developed. Therefore, on the basis of the dual-phase clustering that was just explained, the ideal number of clusters was calculated, and it is displayed in Figure 3.

Several distinct clusters, each represented by a unique hue, are displayed in Figure 3. Following the completion of the clustering process, the CH selection was carried out utilising the node information, which included the node position, signal-to-noise ratio, residual energy of each node, and responsiveness of a node to the cluster to which it belonged.

Initial Clustering was helped out by FCM.



(a) FCM assisted initial clustering



b) FCM+EM based clustering for Q-E2RPC routing protocol

Figure 3 Dual phase clustering results

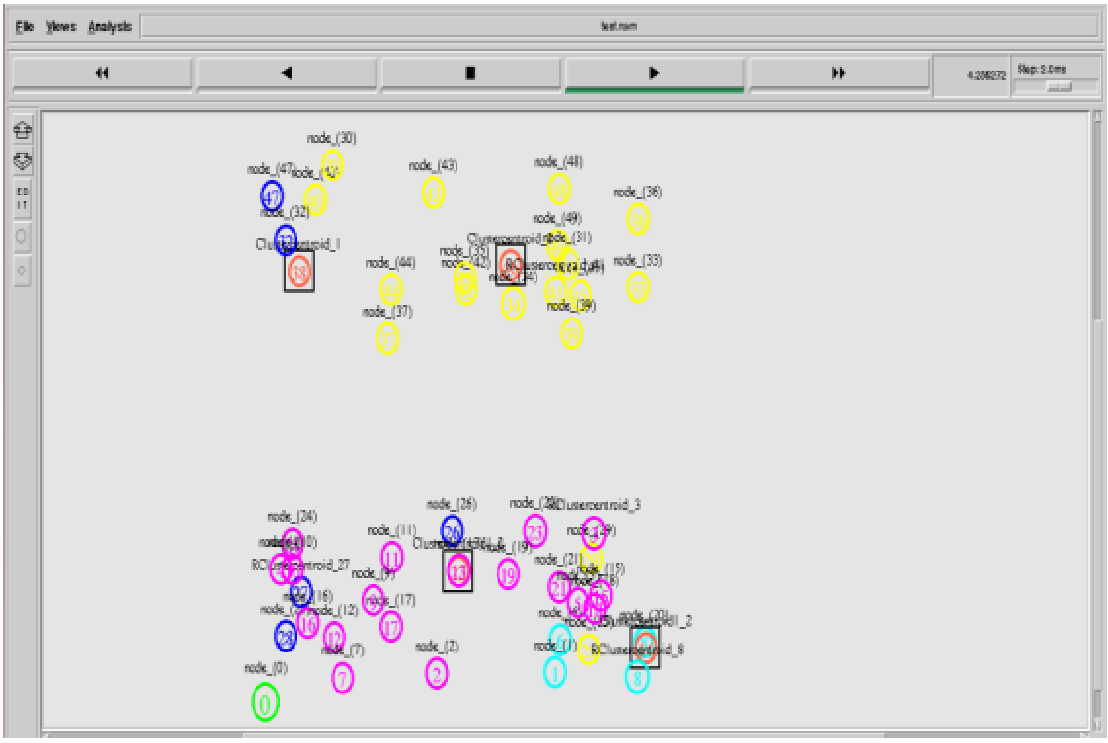


Figure 4 FLC based CH Selection

Following the completion of the CH selection procedure, CMIMO transmission was used to carry out communication between the CN and the linked CH. This information was then sent to the mobile sink for the subsequent decision-making process. Figure 4 provides a visual representation of the CH that was calculated for each cluster (black square box). A fragment of cooperative communication between CHs and mobile sink is presented here depicted in Figure 5.

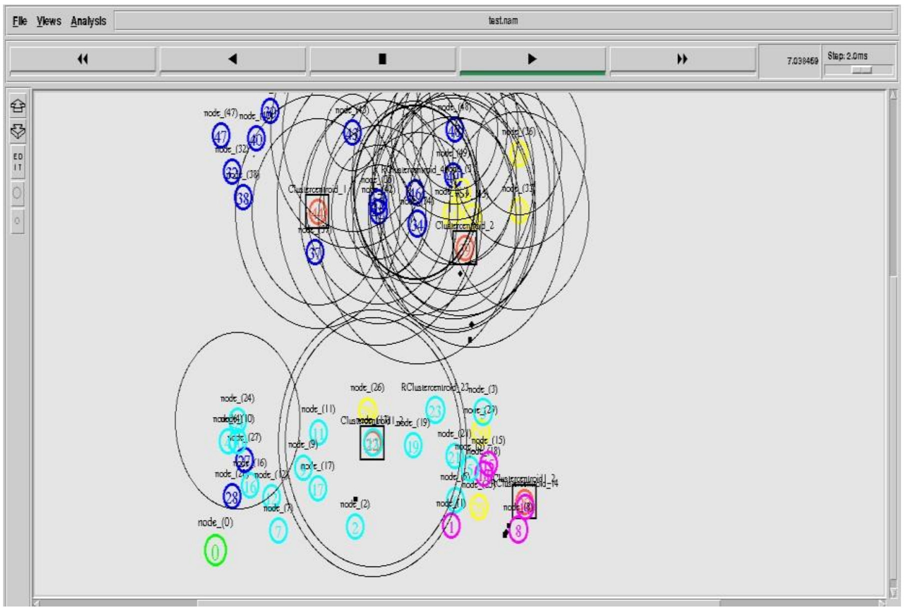


Figure 5 Co-operative MIMO based data transmission (Mobile sink Location-1)

The starting point of the mobile sink, displayed in green in Figure 5, can be seen clearly. After making specific movements to another area, the mobile sink was able to gather data from CHs, as shown in Figure 6. (Figure 6). Notably, nodes in Q-E2RPC interact with one another using the cooperative MIMO technique.

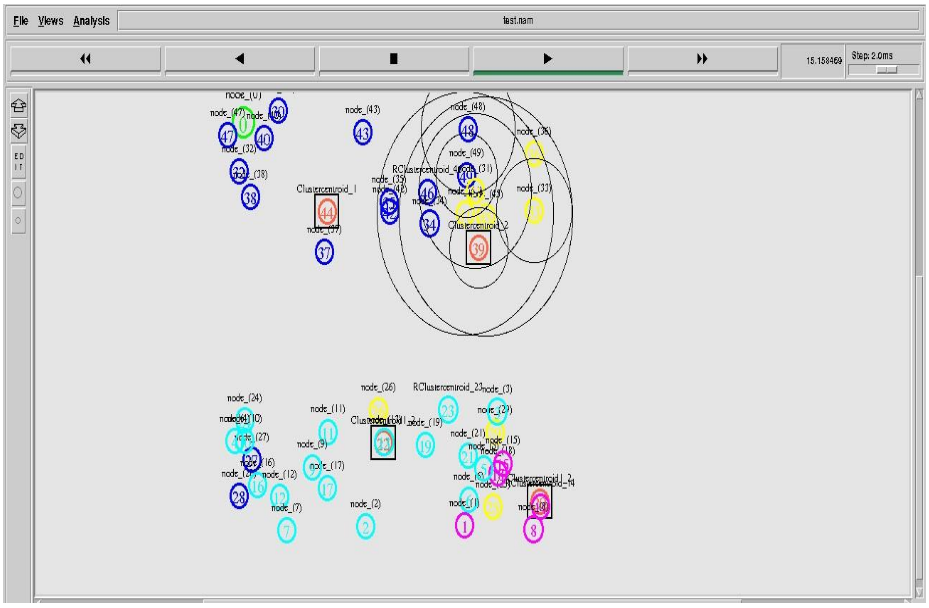


**Figure 6 Cooperative MIMO based data transmission (Mobile sink Location-2)**

## V. CONCLUSION

In this research phase, the data collection based on a single mobile sink not only reduced the cost of retransmission or the amount of energy consumption, but it also ensured reliable and delay-resistant transmission. A new network metric denoted the connectedness and dependence of a node on a cluster. This new parameter was given the term "Responsiveness," and it was developed as an innovative value addition. In this case, an FCM was utilized to learn over the present network states, which included the locations of the linked sensor nodes as well as the remaining energy and responsiveness of the nodes, which ultimately enabled CH selection. Within the framework of the Q-E2RPC routing architecture, CH was responsible for collecting data from the linked sensor nodes and then transmitting that data to the mobile sink using the CMIMO transmission mechanism. The total outcomes that were achieved with regard to Q-E2RPC surpasses standard techniques in terms of packet delivery ratio, energy consumption, latency, and efficiency. These metrics show that CMIMO and parameter-based CH selection are less effective than Q-E2RPC.

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