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PREDICTIVE ENERGY- EFFICIENT AND SECURE AD-HOC COGNITIVE NETWORK ROUTING STRATEGY FOR SENSORS

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Abstract
The Cognitive Radio (CR) network is capable of autonomously detecting unoccupied channels within the wireless spectrum. The spectrum provides various frequency ranges that can be utilized for communication purposes. Furthermore, it should be noted that a specific amount of energy is expended during the process of communication among all nodes. Energy consumption is a prominent issue in sensor networks, thereby necessitating the implementation of efficient routing strategies to optimize energy utilization and improve overall network performance.These networks possess the ability to rapidly deploy in accordance with specific application needs, while also exhibiting self-sufficiency, self-organization, and self-configuration. The Low Energy Adaptive Clustering Hierarchy (LEACH) is a methodology that employs a cluster-based approach to optimize energy utilization. This study aims to conduct a comparative analysis of the energy-efficiency between the proposed LEACH CR, which is designed to be more energy-efficient, and the established LEACH protocol. Performance matrices are employed for the purpose of assessing the efficacy of the proposed LEACH protocol. The results of our experiments indicate that nodes, particularly in environments characterized by high levels of traffic, possess, at most, inaccurate state information. In the proposed methodology, the Low-Energy Adaptive Clustering Hierarchy (LEACH) algorithm is utilized to establish clusters and provide energy reports for each cluster's zone. In the context of enhancing communication reliability, LEACH employs a selection mechanism where nodes with higher energy levels are chosen for data transmission. This study also investigates the outcomes in relation to network metrics, such as throughput, packet delivery ratio, and additional metrics.

Keywords: LEACH, Cognitive Radio (CR), Ad hoc CR, Sensor Network, Energy Efficiency.

I.INTRODUCTION

Wireless communications systems: Wireless communication systems have emerged as a crucial component of contemporary society. Wireless communications technology finds widespread application in various commonplace devices, including but not limited to garage door openers, TV remote controllers, cellular phones, personal digital assistants (PDAs), and satellite TV receivers. The aggregate number of individuals subscribed to cellular wireless services has surpassed the cumulative number of individuals subscribed to conventional telephone services. In addition to cellular wireless technology, cordless phones, wireless local area networks (WLANs), and satellites are extensively employed for voice and data communications purposes, as well as for the provision of entertainment services.

The increasing demand for wireless communications in consumer electronics applications and personal high-data-rate networks presents a substantial potential for business growth. The proliferation of wireless devices utilizing diverse concepts and technologies is experiencing rapid growth. However, the scarcity of radio spectrum will inevitably give rise to novel challenges. Nevertheless, it is imperative to address the aforementioned concerns in order to facilitate the continued growth of these prospective enterprises and establish a robust framework for our forthcoming information society.

1.1.2 Cognitive Radio Networks: Cognitive radio is a novel paradigm for developing wireless communications systems that attempts to maximize the use of the radio frequency (RF) spectrum.

1.1.3 Sensor Networks Based on Cognitive Radio: The incorporation of cognitive radio capabilities has the potential to enhance the adaptability of current wireless systems to the existing spectrum allocation in deployment areas, thereby leading to an overall improvement in spectrum usage [1]. The utilization of these characteristics, alongside others, can effectively tackle numerous distinct demands and obstacles encountered in wireless sensor networks (WSN). These networks are conventionally presumed to employ fixed spectrum allocation and are distinguished by limitations in resources, specifically pertaining to the communication and processing capabilities of low-end sensor nodes. In actuality, a Wireless Sensor Network (WSN) comprised of sensor nodes that are equipped with cognitive radio technology can potentially derive advantages from the dynamic spectrum access capabilities, including:

II . SURVEY OF LITERATURE

Earlier research in the field of cognitive radio networks is discussed in this section.

Indushree Banerjee et al., 2014 In the event of a failure in physical communication network infrastructures, infrastructure-less communication networks, such as mobile ad hoc networks (MANET), can serve as a viable alternative for communication. Nevertheless, this requires the adaptability of Mobile Ad hoc Networks (MANETs) to accommodate dynamic environments characterized by varying device density, mobility patterns, and the presence of diverse energy sources. [2].

Ayaz Ahmad et al. (2015) The present study involved the implementation of a survey pertaining to the allocation of radio resources within cognitive radio sensor networks. This study provides a summary of the latest advancements in radio resource allocation within Cognitive Radio Sensor Networks (CRSNs). In the field of Cognitive Radio Sensor Networks (CRSNs), three primary types of radio resource allocation strategies are commonly employed: centralised, cluster-based, and distributed techniques. [3].

Muhammad Usman et al., 2016 introduced the distributed multichannel (DMMAC) protocol for multichannel cognitive radio ad hoc networks (CRAHNs). They also compared DMMAC to previous medium access control (MAC) protocols and discovered that it provides higher evaluation performance[4].

K. Bava Rinku and colleagues, 2017 The performance of two medium access control protocol scenarios, namely the single radio-multiple channels cognitive medium access control protocol

(NS-1) and the two radios-multiple channels cognitive medium access control protocol (NS-2), was assessed using Network Simulator 2. The researchers examine the impact of increased packet sizes on performance metrics, specifically network throughput. Based on simulation results, it has been observed that increasing the packet size leads to superior performance in all performance metrics for the single radio-multichannel cognitive medium access control protocol compared to the two radios-multichannel cognitive medium access control protocol. [5].

Meng-Xin Wu et al. (2018) The distributed multichannel (DMMAC) protocol was introduced as a solution for managing multichannel cognitive radio ad hoc networks (CRAHNs). In addition, a comparative analysis was conducted between DMMAC and prior media access control (MAC) protocols, revealing that DMMAC exhibits superior assessment performance. [6].

Shimaa Abdzaher and colleagues, 2019 The performance of two medium access control protocol scenarios, namely the single radio-multiple channels cognitive medium access control protocol (NS-1) and the two radios-multiple channels cognitive medium access control protocol (NS-2), was assessed using Network Simulator 2. The researchers examine the impact of increased packet sizes on performance metrics, specifically network throughput. Based on the simulation results, it can be observed that increasing the packet size leads to superior performance in all performance metrics for the single radio-multichannel cognitive medium access control protocol compared to the two radios-multichannel cognitive medium access control protocol. [7].

Ramahlapane Lerato Moila et al., 2020 The study focused on examining the Quality of Service (QoS) routing parameters in Cognitive Radio Ad Hoc Networks (CRAHNs). A comprehensive review of pertinent literature was conducted to identify the most relevant research in this area. Subsequently, two routing protocols that exhibited superior performance were selected for further analysis. The objective was to assess the extent to which these protocols enhanced the quality of routing in CRAHNs. The simulation experiments were conducted on the Linux operating system utilizing network simulation version 2. The robustness and quality of the simulation results. The Aware Cognitive Ad-hoc Routing Protocol (Q-RACARP) protocol demonstrated superior performance in terms of robustness. The protocols underwent testing within a limited network setting; however, the obtained results suggest that their effectiveness warrants further evaluation within expansive networks characterized by significant mobility. [8].

Qianao Ding et al., 2021 The present study involved the development of energy-efficient routing algorithms in wireless sensor networks, utilizing machine learning techniques. Machine learning (ML) technology has demonstrated superior efficacy compared to traditional methods in various domains such as image and audio recognition, recommendation engines, and natural language processing. In recent times, there has been a surge in attention towards the application of machine learning (ML) techniques within the domain of wireless sensor networks (WSNs). In this paper, we examine and promote a theoretical hypothetical model formulation of machine learning (ML) as a viable approach for constructing a power-efficient green routing model that surpasses the constraints of conventional green routing techniques. The report provides a comprehensive overview of past, present, and anticipated advancements in green routing methodologies within Wireless Sensor Networks (WSNs). [9].

Thirumala Akash K and colleagues, 2022 LEACH (Low-Energy Adaptive Clustering Hierarchy) This study proposes the integration of a straightforward routing strategy with time division multiple access (TDMA) for the purpose of clustering in wireless sensor networks (WSNs). The Wireless Sensor Network (WSN) comprises a substantial quantity of nodes or devices that are powered by batteries. These nodes or devices exhibit a deficiency in the initial energy necessary for the uninterrupted transmission of data, thereby contributing significantly to their overall energy expenditure. The primary criterion entails the selection of the cluster head (CH) based on two factors: the battery level and the distance from the base station. The cluster head assumes the responsibility of facilitating data transmission among clusters and coordinating the operations of the individual nodes within the cluster. The application of clustering techniques in network systems has been found to enhance the overall longevity of the network and contribute to energy conservation among individual nodes. [10].

Reeya et al., In 2023, a study was conducted to examine ad hoc networks and their diverse topologies, encompassing mobile ad hoc networks, wireless sensor networks, and wireless mesh networks. In an ad hoc network, wireless devices are capable of establishing communication with each other in the absence of a central Wireless Access Point (WAP). A base station or wireless access point (WAP) device commonly oversees and facilitates the transmission of data among wireless devices. An ad hoc network is established when multiple devices establish connections with each other. [11].

III . PROBLEM STATEMENT

Wireless sensor networks represent a novel communication technology that leverages radio frequency and cognitive radio networks for the purpose of facilitating affordable communication among sensor devices. A Wireless Sensor Network (WSN) is a collection of small, low-power sensor nodes that are coordinated and controlled by a central base station. Every individual sensor node is characterized by a finite storage capacity, constrained energy resources, and limited processing capabilities. The objective of our study is to develop an energy-efficient path selection mechanism for sensor ad-hoc cognitive radio networks. This mechanism aims to address the energy issue by selecting routes and forming clusters based on the least power requirement. Additionally, we aim to enhance network performance by comparing various network parameters**.**

IV. WORK PROPOSED

In a sensor ad hoc cognitive radio network, secondary users opportunistically utilize temporarily unoccupied channels that are not being used by primary users. The establishment of a communication link between two secondary users relies on the transmitting and receiving activities of neighboring primary users. The primary users within a sensor ad hoc cognitive radio network are individuals or entities that possess the ability to route and establish connectivity between two secondary users. The primary paper partitions the clusters into sub-clusters and utilizes two operational states, namely active and sleep. In active modes, the nodes that engage in route or data transmission are considered active, while the remaining members enter sleep mode. This results in the formation of two sub-clusters, which aim to minimize network energy consumption. A comparison is made between this approach and the low energy adaptive cluster head (LEACH) routing protocol. The findings indicate that the proposed protocol outperforms the LEACH protocol. The objective of this study is to enhance the reliability and efficiency of energy utilization in sensor ad-hoc cognitive radio networks, thereby enhancing the performance of existing systems. The proposed technique involves the formation of a cluster by multiple sensor nodes, which is determined by the radio zone and the distance from the base stations. The clusters are divided into two distinct categories, namely cluster heads and cluster members. The cognitive radio network utilizes a radio channel to facilitate communication, wherein a solitary base station assumes the responsibility of coordinating and transmitting information across multiple cluster zones. The proposed method involves the timely initiation of the election message for the selection of the cluster head, which is dependent on the energy of nodes or their movement. Each sensor node within a specific zone receives the message and elects the cluster head based on criteria such as the maximum number of nodes covered, the energy level of the specific node, and the rate of energy consumption. After the cluster head has been selected, the members are linked together using multicast routing to facilitate communication between different cluster zones or within the same cluster. The subsequent stage is the phase of route selection, which entails determining the trajectory from the origin to the destination node, whether it be within or between cluster zones. The primary responsibility of the cluster head is to establish an energy-efficient routing path between the source and the receiver, thereby enhancing the overall longevity of the network. Cluster heads are responsible for partitioning a given cluster into two distinct sub-cluster zones, namely the sleep mode and the active mode. In the active mode, all nodes actively engage in communication, while in the sleep mode, the remaining nodes are inactive. This division effectively minimizes the overall energy consumption of the network and consequently enhances the longevity of the network. The chosen communication pathway computes the energy consumption of each node. If the energy level falls below a predetermined threshold, the cluster head employs the local route repair method to establish an alternative route. The local route repair method is a streamlined and effective approach to route discovery, which resolves the issue of disconnected routes by removing the disabled node and establishing a connection with a new node possessing the necessary network capabilities. The proposed mechanism incorporates dynamic changes to the cluster head, taking into account factors such as remaining energy, neighbor connectivity, and cluster head movement. Specifically, if the cluster head's energy falls below a certain threshold, neighbor connectivity decreases to less than five, and the cluster head relocates to an area with weak signal strength, the election message is re-initiated and the cluster head selection procedure is repeated. The proposed solution successfully fulfills the objectives outlined in the objectives section, while also enabling efficient energy-based communication between the source and receiver nodes in a sensor ad-hoc cognitive radio environment.

A. Proposal for an Algorithm Design

Sensor ad-hoc cognitive radio networks have the potential to provide assistance in emergency situations and address the issue of areas with limited coverage. The method proposed in this study presents a comprehensive framework for simulating the energy-based path selection technique within the context of a cognitive radio network. The system is divided into distinct submodules that are responsible for generating the necessary outcomes, including cluster head election, route selection, and data transmission. The algorithm consists of three main components: the declaration of input parameters or variables, the determination of predicted outputs, and the execution of the process or algorithm.

Algorithm: Efficient Energy based path selection in Sensor Ad-hoc Cognitive Radio Network

Input: M: nodes
S: sender nodes
R: receiver nodes
I: intermediate nodes
E: (E_n… $E_{i.}$ E_m) set of energy
N_i: (N_n… $N_{i.}$ N_m) number of neighbour nodes
P_x: ($P_{xn\dots}$ $P_{xi.}$ P_{xm}) require transmission power
T_x: ($T_{xn\dots}$ $T_{xi.}$ T_{xm}) require transmission time
C: (C_n… $C_{i.}$ C_m) set of cluster
G: (g_n… $g_{i.}$ g_m) consume energy

$$C_i \begin{cases} S_i & \text{if m nodes in sleep (Subset1)} \\ A_i & \text{n nodes in active (Subset2)} \end{cases}$$

Where $C_i = \{ S_i \text{ U } A_i \}$

Th: energy threshold 10 joule
LEACH: energy protocol

Output: Cluster Head, members in cluster, node live, PDR, Overhead, Throughput

Routine:
M← execute (election message)
M_brodcast (id, E_i, $N_{i.}$)
While (M-1 =in range) **do**
M_n ← receives (election msg)
M_n-Compare-M (E, N_i)
$g_n = P_{xn} * T_{xn}$
If M_n ($E_n > E_i$ && $N_n > N_i$ && $g_n < g_i$) **Then**
M_n form cluster C_n
M_n select as cluster head
Broadcast winning message
M_n: responsible (join, leave, $E_{i,}$ store (g_i))
Else
Search m –n nodes
End if
End do
S← send-data(S,R, M_n)
While M_n identified S send data to R **do**
M_n← generate (routing-table (higher E_j, min C_j)
M_n← forward-routing-table to S
M_n divides two sub clusters
$C_i = \{ S_i \text{ U } A_i \}$

S established path via A_i
While (R not in range M_n) **do**
M_n provides inter cluster communication
R receives data from I node ϵ A_i
End do
Calculate energy of M nodes in path A_i via LEACH
If energy of I node < Th **Then**
Call Routine module
New Route Established
End if
End do

V. THE PARAMETERS FOR THE SIMULATION ARE AS FOLLOWS:

Network Simulator-2 (NS-2) is a widely recognized and reputable software tool developed collaboratively by various academic institutions, including the University of California, Berkeley. Due to its robust capabilities, NS-2 is highly regarded for its effectiveness in analyzing the behavior of mobile ad-hoc networks. The presented table exhibits the simulation parameters employed for the analysis of network operations, encompassing factors such as node count, routing protocol, transport protocol, traffic nature, and other relevant variables..

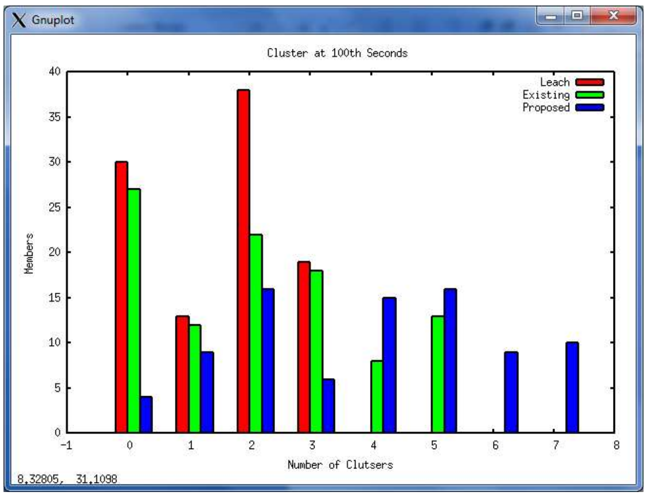
Area of Simulation	800m x 600m
Antenna Type	Omni-Directional
Mobile Nodes	100
Radio Range (meters)	550
Transferring Mode	Multi-hop
Maximum Speed (ms)	Random
Routing Protocol	AODV,LEACH
Transport Layer	TCP , UDP
Traffic	CBR
Application Layer	FTP
Simulation Time (sec)	500
Packet Size	512 bytes

VI. OUTCOME

This study encompasses the simulation of three protocols: the conventional Low Energy Adaptive Clustering Hierarchy (LEACH), the LEACH protocol in Cognitive Radio (CR) networks, and the proposed LEACH in Cognitive Radio Networks (CRNs). The proposed leach method demonstrates enhanced routing performance.

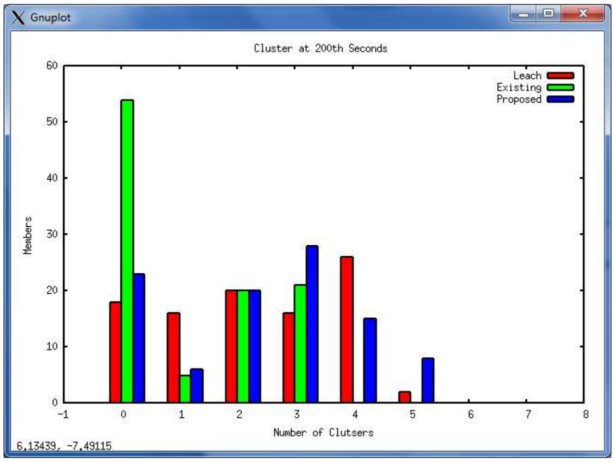
1. Member Analysis and Cluster Formation at the 100th Second of Simulation

Based on the findings of Time, it has been observed that there is a decline in node energy within the network, consequently leading to a deterioration in node communication performance. The selection of specific nodes in routing introduces a heightened risk of link breakage. However, the proposed approach mitigates this issue by selecting nodes based on their higher energy level. The graph illustrates the formation of clusters among mobile nodes in the LEACH protocol and two other cluster-based routing protocols after 100 seconds. In the present scenario, there is an increased quantity of cluster formations in the proposed LEAH protocol, as well as a larger membership size within this protocol. The original LEACH protocol exhibits the highest number of cluster members, with a total of 38. In comparison, the existing protocol demonstrates a smaller number of cluster members than LEACH. Conversely, the suggested CRN protocol showcases a greater number of cluster members, while maintaining efficient energy consumption.



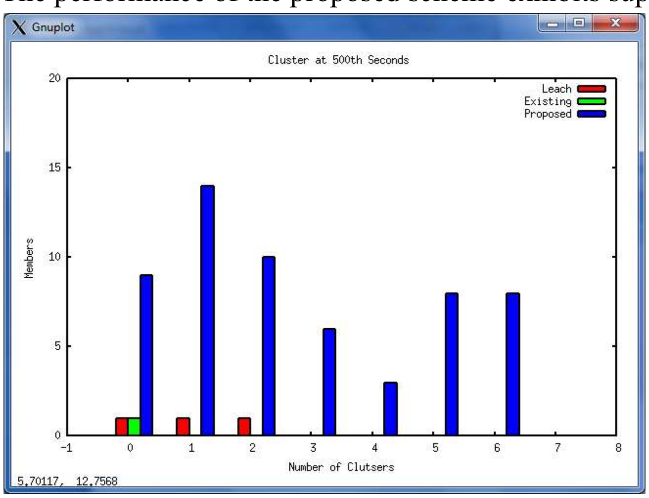
2. Member Analysis and Cluster Formation at the 200th Second of Simulation

The efficacy of communication within a dynamic network is contingent upon the formation of clusters and the composition of cluster members. There exists an inverse relationship between the quantity of cluster formations and the likelihood of achieving energy efficient routing. However, this relationship is accompanied by an increase in the number of members engaged in communication within a single cluster Head. The graph illustrates the progression of mobile node clusters in the context of the proposed Cognitive Radio Network (CRN) LEACH protocol, an existing protocol, and Normal LEACH-routing after 200 seconds. In this particular scenario, the performance of the current scheme is approximately equivalent to having a total of 52 cluster members within a single cluster. The experimental results indicate that, at a time interval of 200 seconds, the proposed CRN leach technique exhibits superior performance compared to the conventional LEACH protocol.



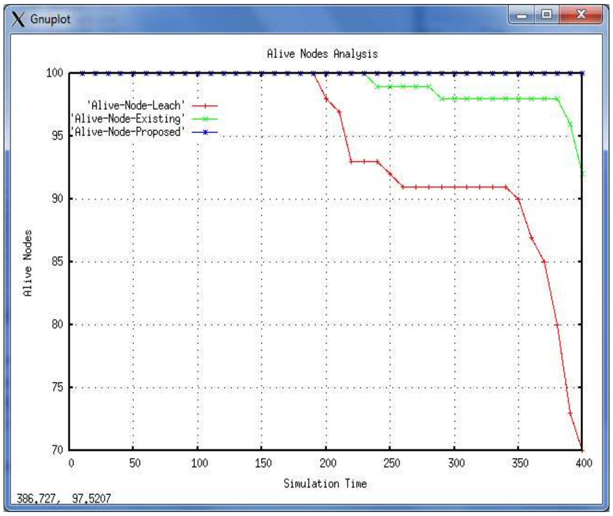
3. *Member Analysis and Cluster Formation at the 300th Second of Simulation*

Enhanced data reception is crucial for optimizing network performance and serves as an indicator of the establishment of a robust and reliable connection. The graph presented at the 500-second mark illustrates the process of cluster formation among mobile nodes in the context of the LEACH protocol, as compared to the traditional cluster-based routing approach. In the present scenario, the quantity of cluster formations within the proposed LEAH protocol persists within the network, while the membership count in this protocol is higher. The maximum number of members is 16, yet the performance of the remaining protocols does not surpass 3. The performance of the proposed scheme exhibits superior energy utilization.



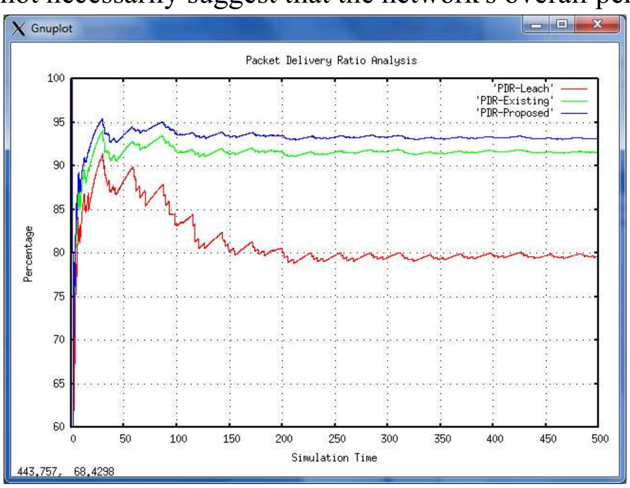
4. *The determination of the number of active nodes.*

Efficient routing in a network necessitates the transmission of a large volume of data packets with a minimal number of routing packets, as the act of routing packets consumes energy. The graph presented illustrates the examination of active nodes in the proposed cluster-based scheme, the current scheme, and a standard cluster-based routing approach after a simulation period of 400 seconds. The graph clearly illustrates the progressive decline of energy from initial energy to the energy remaining in nodes at the conclusion of the simulation period. This implies that the proposed scheme-based routing selection technique effectively preserves the reliability of the network. In contrast to the existing methodologies, the proposed solution exhibits a substantial quantity of nodes.



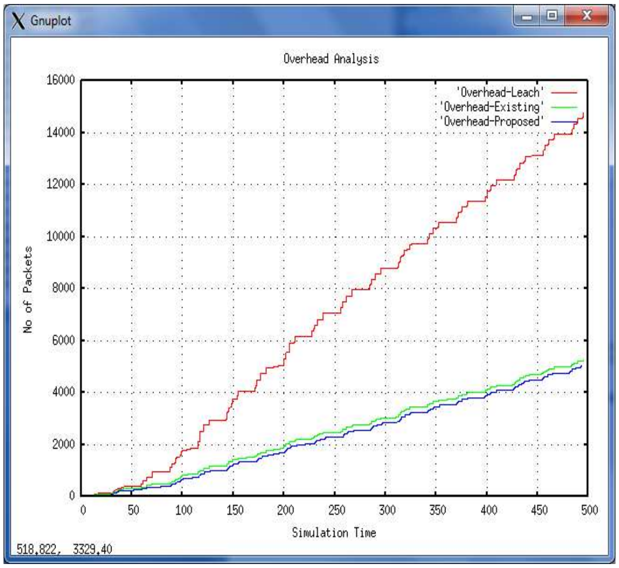
5. Performance Analysis of the Packet Delivery Ratio (PDR)

The analysis of Packet Delivery Fraction (PDF) quantifies the proportion of data that is received without error at its intended destination. The graph illustrates the percentage of packets in the energy-based routing approach compared to the conventional energy shortest path selection routing method. The proposed LEACH cluster-based routing exhibits a higher PDF of approximately 93%, compared to the existing protocol which achieves a PDF of approximately 91%. However, it is important to note that the routing load during typical cluster formation reaches approximately 80% by the end of the simulation. When the routing load within a network is elevated, there is a corresponding increase in energy consumption, resulting in premature node failure. This indicates that the PDF value is satisfactory, however, it does not necessarily suggest that the network's overall performance is superior.



6. An analysis of the number of routing packets in the context of flooding.

Efficient routing in a network necessitates minimizing the number of routing packets required to transmit a significant volume of data packets, as the process of routing packets consumes energy. The graph illustrates that the routing load is greater in the scenario of conventional cluster-based routing with energy factor. This suggests a higher occurrence of connection failures. Additionally, the proposed LEACH cluster-based routing with multipath exhibits increased energy requirements for routing packet transmission. However, this approach effectively reduces energy consumption and minimizes routing overhead. The current protocol exhibits a marginally higher routing overhead compared to the proposed CRN LEACH. However, the standard LEACH protocol demonstrates an exceedingly high overhead, thereby emphasizing the necessity for routing adjustments..



Parameters	Leach	Existing	Proposed
Data Send	8366	9074	10708
Data Receive	6664	8314	9979
ROUTINGPKTS	14751	5272	5042
PDF	79.78	91.53	93.31
Normal Routing Load	2.22	0.62	0.52
No. of dropped data	1700	760	727
Average Energy Consume (Joule)	42.2	22.92	19.2

7. *Evaluation of Overall Performance*

Table 6.2 presents a comprehensive overview of the complete analysis conducted on three different schemes: normal LEACH, the pre-existing scheme, and the proposed LEACH cluster-based scheme. It is evident that the proposed approach results in a higher volume of packets being transmitted within the network compared to conventional routing methods. The significance of PDF lies in its ability to deliver exceptional performance. The decrease in routing load and latency undoubtedly contributes to energy conservation.

VII. FINAL REMARKS

The Cognitive Radio Network (CRN) is employed for the purpose of detecting radio frequency spectrum (RFC) channels. The Sensor Ad hoc Cognitive Radio Network (CRN) refers to a network composed of nodes or battery-powered devices that form a transient infrastructure for distributed communication. Sensor devices are capable of establishing a dynamic connection in order to facilitate the distribution of data. The utilization of multipath routing technique reduces the probability of link failure caused by node departure from the designated link and in scenarios of high network traffic. The energy or power available in sensor nodes is constrained, necessitating efficient utilization to extend the longevity of the network. In this study, we proposed a revised iteration of the LEACH protocol for implementation in Sensor Ad hoc CRN. The proposed methodology involves the selection of reliable nodes with higher energy levels, which leads to the establishment of a resilient link that mitigates the risk of data loss caused by insufficient energy resources. The analysis of Cluster Heads (CH) and Cluster Members (CM) is conducted over a simulation time of 500 units. The results indicate that the number of CHs varies across different time intervals, while the number of CMs remains relatively low. However, the proposed measurement is deemed suitable, as it demonstrates the potential for energy-efficient routing. The remaining performance indicators, including throughput and routing overhead, demonstrate that the proposed LEACH algorithm exhibits superior routing performance compared to the conventional LEACH algorithm. The proposed LEACH protocol demonstrates a higher rate of node survivability within the network, thereby indicating the preparedness of nodes for future communication in the context of Sensor Ad hoc CRN. The previously established protocol in Sensor Ad hoc Cognitive Radio Networks (CRN) exhibits superior performance compared to the conventional Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol.

FUNDING

Nil

CONFLICT OF INTEREST

None

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INTRODUCTION

Wireless communications technology has become an integral part of contemporary society. Several commonplace items, such as satellite TV receivers, cell phones, TV remote controls, and garage door openers, use wireless communications technology. Cellular wireless services are now used by more people than all wired telephone services put together, exceeding the number of people using traditional telephone services. The goal of cognitive radio is to maximise the usage of the radio frequency (RF) spectrum. Cognitive radio is a revolutionary paradigm for developing wireless communications systems. Thanks to cognitive radio's capabilities, several of the current wireless systems might be able to adjust to the deployment field's current spectrum allocation, which would improve overall spectrum usage. Wireless sensor networks (WSNs), which are frequently assumed to use fixed spectrum allocation and are characterised by resource limitations in terms of the communication and processing power of low-end sensor nodes, can use these features, among many other things, to address many of the specific needs and challenges they face[1]. In practise, a WSN composed of cognitive radio-capable sensor nodes may gain from the potential advantages of important dynamic spectrum access features, such as:

a. *Taking advantage of available channels for bursty traffic*: A WSN sensor node sends out bursts of packet traffic when it discovers an event. In densely deployed sensor networks, several nodes competing for the same channel within the event zone. This increases the risk of collisions and lowers the overall communication dependability since packet losses cause significant power consumption and packet delays. Sensor nodes having cognitive radio capabilities may opportunistically access a variety of channels to get around these potential problems.
b. *Dynamic spectrum access:* In general, the WSN deployments already in place presume fixed spectrum allotment. WSN must, however, either get a spectrum lease for a licenced band or operate in unlicensed bands. The cost of a spectrum lease would normally be high, increasing the overall cost of deployment. Moreover, this violates the fundamental principles of WSN design [2]. On the other hand, unlicensed bands are also used by other devices including PDAs, Bluetooth gadgets, and IEEE802.11 WLAN hotspots. Sensor networks must contend with crowded spectrum as a result [3]. So, in order to maximise network functionality and be able to successfully collaborate with other types of users, opportunistic spectrum access strategies must also be implemented in WSN.
c. *Reducing power consumption through adaptability:* The time-varying nature of the wireless channel results in packet losses and retransmissions, which use energy. Cognitive radio-capable sensor nodes might be able to adjust their operating parameters to match channel conditions. By increasing transmission efficiency, this functionality can aid in lowering the amount of power used for transmission and reception.
d. *Overlapping the deployment of multiple concurrent WSNs*: With the increased use of sensor networks, one area may host multiple sensor networks that have been set up to work towards fulfilling specific criteria of diverse applications. In this case, dynamic spectrum management may greatly help in the efficient and resource-efficient coexistence of spatially overlapping sensor networks.

e. *Access to multiple channels to conform to different spectrum regulations:* Every country has rules governing spectrum regulation, therefore access to many channels is necessary to comply with various restrictions. An encouraging band that is available in one country might not be in another. It may not be possible to employ typical WSN with a constant working frequency when manufactured nodes are to be distributed in multiple locations. But, nodes might alter the frequency of their transmissions to get around the spectrum availability issue if they have cognitive radio capability available. Wireless sensor networks can so benefit from cognitive radio and dynamic spectrum management features.

Wireless Sensor Networks: Each sensor node in a network is able to collect local information and send it to the sink. The sink is used in a multi-hop infrastructure-free design to transfer data back to the sink. Only a few of the many factors that influence sensor network design include the acceptance of failures, scalability, production costs, sensor network architecture, operational environment, hardware constraints, transmission media, and power consumption.

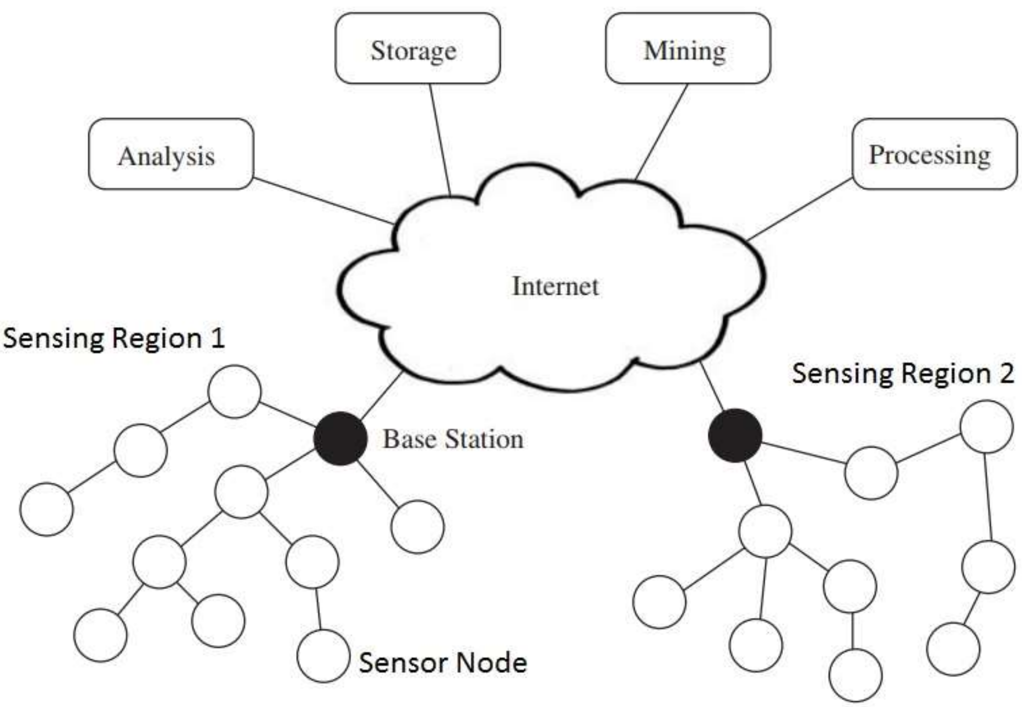

Fig . 1 Wireless Sensor Network

Objective

For the purpose of channel detection from the radio frequency spectrum, cognitive radio networks are helpful. A static or dynamic nature is a sort of wireless sensor communication. Designing an effective energy base path selection and cluster head selection that extends the life of the sensor network will help us reduce the network's routing overhead. to prolong the network's lifespan. For that reason, we'll suggest an energy module that operates with the least amount of power possible while transmitting, receiving, resting, sensing, and in the best case scenario. Our protocol will guarantee that there will be a limited amount of packet dropping in the network, ensuring successful data transfer with the least amount of overhead necessary.

Related Work

The section discusses earlier research in the area of cognitive radio networks.

Banerjee Indushree *et al.,* 2014 If physical communication network infrastructures collapse, infrastructure-less communication networks, including mobile ad-hoc networks (MANET), can be utilised as a backup. Yet, this calls for MANETs to be able to adapt to changing contexts marked by fluctuating device density and mobility, as well as the availability of energy sources[4].

Ayaz Ahmad *et al.,* **2015** conducted a survey on the allocation of radio resources in cognitive radio sensor networks. They provided a summary of recent developments in radio resource allocation in CRSNs in this article. The three main types of radio resource allocation techniques used in CRSNs are centralised, cluster-based, and distributed[5].

Muhammad Usman *et al.,* **2016** For multichannel cognitive radio ad hoc networks (CRAHNs), they presented the distributed multichannel (DMMAC) protocol. They also compared DMMAC to various medium access control (MAC) protocols from the past and found that it offers better evaluation performance[6].

K. Bava Rinku *et al.*, 2017 Using Network Simulator 2, we assessed the performance of two different medium Access control protocol scenarios: single radio-multiple channels cognitive medium Access control protocol and two radios-multiple channels cognitive medium Access control protocol (NS-2). They look into how larger packet sizes affect performance indicators like network throughput. According to simulation results, when the packet size is increased, the single radio-multichannel cognitive medium access control protocol beats the two radios-multichannel cognitive medium access control protocol in all performance parameters[7].

Meng-Xin Wu *et* *al.,* **2018** for multichannel cognitive radio ad hoc networks (CRAHNs), they presented the distributed multichannel (DMMAC) protocol. They also compared DMMAC to various medium access control (MAC) protocols from the past and found that it offers better evaluation performance[8].

Shimaa Abdzaher *et al.,* **2019** Using Network Simulator 2, we assessed the performance of two different medium Access control protocol scenarios: single radio-multiple channels cognitive medium Access control protocol and two radios-multiple channels cognitive medium Access control protocol (NS-2). They look into how larger packet sizes affect performance indicators like network throughput. According to simulation results, when the packet size is increased, the single radio-multichannel cognitive medium access control protocol beats the two radios-multichannel cognitive medium access control protocol in all performance parameters[9].

Ramahlapane Lerato Moila *et al.,* 2020 researched parameters influencing QoS routing in CRAHNs, examined relevant studies, selected the two best performing routing protocols, and assessed how well they improved routing quality. The network simulation version 2 was used for the simulation experiments, which were run on the Linux operating system. The Quality-Robustness of the simulation results Robustness was exceeded by the Aware Cognitive Ad-hoc Routing Protocol (Q-RACARP) protocol. The protocols were tested in a small network setting, but based on the results, it is clear that their usefulness should be assessed in big networks with plenty of mobility [10].

Qianao Ding *et al.,* 2021 Developed Energy-Efficient Routing Algorithms Based on Machine Learning in Wireless Sensor Networks. Machine learning (ML) technology has proven to be more effective than traditional methods in a number of fields, including picture and audio identification, recommendation engines, and natural language processing. Recently, there has been a lot of interest in using machine learning (ML) in wireless sensor networks (WSNs). In this paper, we investigate and recommend a theoretical hypothetic model formulation of ML as a successful method for creating a power-efficient green routing model that gets beyond the limitations of traditional green routing techniques. The paper also provides a summary of past, present, and future developments in green routing methods in WSNs[11].

Thirumala Akash K *et al., 2022* In WSNs, the LEACH (Low-Energy Adaptive Clustering Hierarchy) protocol uses a straightforward routing scheme with time division multiple access (TDMA) for clustering. A sizable number of battery-operated nodes or devices make up the Wireless Sensor Network (WSN). These nodes or devices lack the initial energy needed to convey data continuously, which is a large component of their overall energy cost. The primary requirement is to select the cluster head (CH) based on battery level and distance from base station. The cluster head organises the work of the cluster's component nodes and directs data between clusters. Clustering prolongs the life of the network and saves node energy[12].

Reeya *et al.,* 2023 addressed the study of ad hoc networks and its several configurations, including mobile ad hoc networks, wireless sensor networks, and wireless mesh networks. In an ad hoc network, wireless devices can connect with one another without using a central Wireless Access Point (WAP). Usually, data transfer between wireless devices is managed and guided by a base station or WAP device. An ad hoc network is immediately established whenever two or more devices communicate with one another[13].

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