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Approach to Adopt Uneven-Clustering Mechanism for Spectrum Sensing and Prevents Premature Creation of Energy Holes in WSN

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Abstract-The cognitive engine includes an integrated body that is regulated by a supervision algorithm, which indicates that the suggested cognitive engine uses a trial and error strategy to get closer to optimum performance. Many functions are managed by the suggested algorithm. It ensures that the modules are activated and coordinated.It chooses to experiment with the configuration adequacy predictor (CAP) module's local exploration probability. Designing the clustering and multi-hop routing method to extend the network lifetime using this inquiry. It will accept the rotation of and chose CH with larger leftover energy and use the Uneven-clustering process with this methodology. This strategy ensures your safety
Keywords- CRSN, DSA, CH, LEAUCH, LEACH.

I. INTRODUCTION

One of the essential success criteria in medical informatics is the quality of the organized network architecture. Communication networks, which are a pillar of evidence sharing, are facing significant issues due to the variety of communicating objectsand the diversity of services. Whether for health or not, services and apps are consuming an increasing amountof resources while remaining limited.The remaining performance or broadband concerns that are crucial to particular medical content categories, such as multimedia, are these restrictions. To suit application needs, these various difficulties have boosted the demand for more flexible or smarter communication systems. As a new technology, Cognitive Radio is suitable for this purpose..

The usual wireless sensor network (WSN) operates inside an open, uncontrolled band that has gradually aggregated as a result of large-scale remote communication developments. The growing unaffected disturbance caused by the coexistence of a small, diversified agenda within the limited resources spectrum without a license band has become a critical problem that considerably hinders the encouragement of Communication Networks improvement. [2]. The CRSN's were imposed to solve the above WSN concerns, where dynamic spectrum access is frequently used—presenting the

CR innovation into WSN, which will impact sensor hubs to have range detecting capability. WSN would be ready to beat the inactive authorized range band, which may diminish the impact likelihood of channels as increment range usage and growth of the work range band. The throughput of the network will increasefurther, so communication delay is reduced. Hence could arbitrarily convey countless hubs with constrained vitality in cruel conditions and work by shaping a system in an unscripted way. Such a situation requires a vitality productive steering convention that represents adaptability. Clustering is applied to realize the constraints and usually enhance the network's lifetime.

In any case, CRSN gets another technical test term of its directing calculation. From one viewpoint, the present directing methodologies in CR organize (CRN) mostly focus on conquering the range shortage and expanding the range usage by giving the range and course the blend plan. In any case, they neglect to think about the vitality shortage issue and equipment confinement issue acquired from the customary WSN. But the present grouping steering calculations in non- CR WSN primarily focus on limiting vitality utilization in hubs. However, the spectrum sensing and spectrum management issue are not considered; thus, they can't 6exploit the advantage of spectrum resources brought by CR function in diminishing energy utilization. Hence, can't effectively work in CRSN.

Lately, CRSN has pulled in much consideration of explores from the planet, and a couple of literary works, including directing calculations, are likewise distributed. To mishandle the uneven gathering technique snared into the channel resources. More specifically, the amount of idle channels for every node is taken as its weight, and therefore the nodes with more idle channels are selected as cluster head (CH) nodes. There arefewer individuals within the groups on the sink's brink in light of the lopsided bunching strategy's likelihood. The vitality of CHs on the verge of the sink is often spared. The energy is often utilized for sending information, which may adjust vitality utilization among CHs under various bounces transmission implies in CRSN. Moreover, while choosing the subsequent bounce hub, the CHs believe its relative separation to the sink also maintains the applicant hubs' vitality.

II. Cognitive Radio

Expanding the use of remote interchanges set off the improvement of the dynamic range get to plans. The key empowering innovation giving dynamic, spectrum access is the cognitive Radio. Subjective Radio can detect the content and decide the open groups. By dynamically changing its operating parameters, expressing the standard fixed spectrum assignment approach in terms of overall spectrum utilization in cognitive Radio can opportunistically use those available bands [4]. With all these features, cognitive radios can operate in unlicensed bandsand licensed bands as well. Subscribers with a specific license (the primary user), prioritize communicating over the allocated band or channel. Similarly, CR users(secondary users), can access the track as long as they do not interfere with the PU.

A. *Principle of Cognitive Radio*

Basically, there are two categories of frequency bands: licensed bandswhich means, individual companies pay a licensing expense for the exclusive right in a given geographic zone to transmit on allotted channels within that band. The second one is the Licensing round, which guaranteeing that wireless operators don't interfere with each other's transmissions. Unlicensed wireless technologies don't require any authorization, as long as things and clients comply with the rules related to that unlicensed band (for example, most significant transmission power). But unlicensed wireless technologies are, by nature, powerless to interference.In common, the free frequencies effectively reach the immersion state whereas a few private frequency ranges are vacant. Based on this classification, the Cognitive Radio rule identifies two categories of users, primary and secondary.

• Primary Users (PU): They form the set of the users made redundant or prioritize and have a right to exploit the given frequency.

• Secondary Users (SU): They group all the users who do not enjoy any freedom of exploitation on the frequency bands but can opportunistically explore the rounds, taking the appropriate measures to minimize the risks of inconvenience. They are then referred to as cognitive radio users.

The principle of Cognitive Radio is based on a reasoning capacity, knowledge base structuring decision-making rules. Thus, the approach and operation of Cognitive Radio equipment integrate the classic schema of the cognition cycle, as presented in section A.

B. *The Cognition Cycle*

In this context, the cognition cycle defines the interactions between cognitive radio equipment and its environment. Analysis of observation, action planning, and decision-making form the foundation for these activities, as presented in Fig. 1.1.

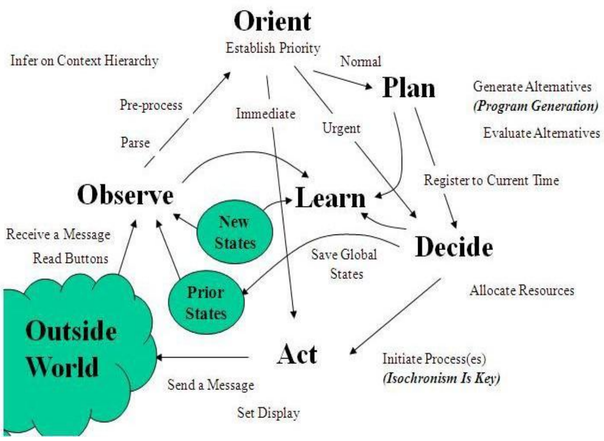

Fig. 1.1: Cognition Cycle

In short, cognitive radio equipment emits while considering the context and constraints of the underlying applications; it refers to an essential factor that can benefit health with its flow at different levels of urgency. This mechanism is made possible by the actions or functions introduced by the cycle of cognition. Indeed, the observation (Observe) of its environment precedes the decision making (Decide) best suited. It is a process that passes through a series of steps, including Orientation, Classification for Priority Setting, Planning for Activities, and Learning by Experience. Cognitive Radio is composed of two essential entities that we present through its architecture [1].

III. LITERATURE SURVEY

In "Cognitive radio-based wireless sensor networks," proposed by D Cavalcanti, S Das, J F Wang, K

Challapali [1]. Recently, there's an immense development within the application of Wireless Sensor Networks in unlicensed spectrum bands. It's conceivable to utilize the Dynamic Spectrum Access (DSA) demonstrated in WSN to encourage access for reducing the crowded spectrum and it improves the propagation characteristics. It represents the conceptual design of CR based WSN, challenges using CR technology, identification of main advantages,2and to suggest possible remedies to overcome the challenges. Develop a conceptual design of cognitive radio system, determine the advantages and challenges of cognitive radio method, and discussed about the solutions to overcome the challenges.

In "Cross-layer support for energy-efficient routing in wireless sensor networks," proposed by N Chilamkurti, S Zeadally, A Vasilakos, V Sharma [6]. The CR technology is used for opportunistic spectrum access. It can progress rapidly even though the research in this domain is still in its infancy. This work's primary focuson differentiate the existing literature of the emerging application area of Cognitive Radio Wireless Sensor Network, which highlights the critical research that has already undertaken and specify open problems. The author narrates the difference between ad hoc CR network, WSN, and CRWSN. It also explains the advantages of CRWSN. CRWSN scenarios with suitable sensing schemes are discussed, which incorporates an accentuation on participation and spectrum access strategies within the availability of the required Quality of Service (QoS).

In "Distributed spectrum aware clustering in cognitive radio sensor networks," proposed by H Zhang, Z Zhang, H Dai, R Yin, X M Chen [8]. The distributed spectrum aware clustering (DSAC) scheme is introduced in the context of CRSN. By restricting the interference to the PU system, the main aim of DSAC is to developing an energy- efficient cluster in a self- organized fashion. The spectrum aware cluster structures is available due to the communication, consisting of intracluster aggregation and inter relaying. A limited number of clusters is obtained. The idea of group-wise constrained clustering is proposed to limit the intracluster distance under spectrum aware constraint. To protect the communication power under dynamic DSAC, it practically demonstrates preferable stability sociality because of its low complexity and quick convergence.

In "An energy-efficient unequal clustering mechanism for wireless sensor networks," CF Li, M Ye, G H Chen, J Wu [9] proposed. The proposed Unequal Cluster- based Routine (UCR) protocol mitigates the hotspot problem in multi hops sensor networks. The cluster heads closer to the base station will be burdened with heavy relay traffic that leads to dying much faster, resulting in leaving network areas uncovered and causing network partitions. The UCR combine the nodes into unequal sizeclusters. Thusit helps for inter-cluster information sending, which save energy as well. Cluster heads closer to the base station have littler clusters sizes than those farther from the base station. Also, for inter- cluster communication, a greedy geographic and energy- aware routing protocol is designed. It can overcome the hotspot problem and improves network lifetime.

Cognitive Radio (CR) is an effective way to reduce spectrum scarcity. Provide Dynamic Spectrum Access (DSA) to overcome the contradictions between the growing demand for different product types and the use of older models [13]. The primary purpose of DSA is to provide accurate feedback that allows radio transmission between radio systems and ensures the best service in all areas. The first part of this paper provides a brief concept of the CR concept to enable DSA. The next part of this work shows the complexity of running a cognitive management system and advanced spectrum management schemes in different formats. The presented data may explain environmental factors and long-term forecasts based on vector representations. It suggests that identifying a reliable radio environment that combines information about its environment with statistical analysis and traffic generation can ensure that the resource's current performance is performing well. ,Conceptually, the development and evaluation of cognitive management discussion include case study and implementation of the current session.

Advances in digital IoT technology are a challenge for wireless technologies. Cognitive Radio can be adapted to different sizes and dimensions to minimize famine problems and meet the high demand for highly remarkable IoT integration. This author explains the spectrum allocation to an IoT cognitive radio network [14]. On the other hand, every connection in the transmission line tries to enhance a given spectrum channel's performance to improve end-to-end throughput. Similarly, these links use the same type of spectrum channel and act simultaneously for better control. This paper developed a state-of-the-art network distribution system that shows that interference and competition have come to an end during synchronization equipment to overcome this problem. This model develops plans for different connections, such as chromosomes (solutions) and genetic algorithms. Next, a multi- objective processing system called the Non-dominated Sorting Genetic Algorithm-II was introduced. It shows that critical features can determine the best design and, in most cases, meet the type of sample required [14].

In [15], the authors conduct extensive research on CR technology and focus on current research trends and developments. Also, support technology, which may be close to 5G research shortly, will be reflected in the full spectrum sharing process, various visual archiving systems, and applications based on visualization type and accessibility.Depending on the job description in the modules, other issues that provide good results in CR development and implementation research, such as supervised communication, non-orthogonal multiple accesses, energy harvesting, and aeronautical communication are analyzed. With this analysis the author expected to help researchers develop cognitive radio technology in the 5G region.

IV. METHODOLOGY

A. LEAUCH protocol Discussion

The basis of selecting a cluster head hub Low-Energy.AdaptiveUneven Clustering Hierarchy (LEAUCH) protocol haphazardly chooses cluster head at each round. Due to being chosen as the cluster head numerous times, a few hubs may deplete energy as well rapidly

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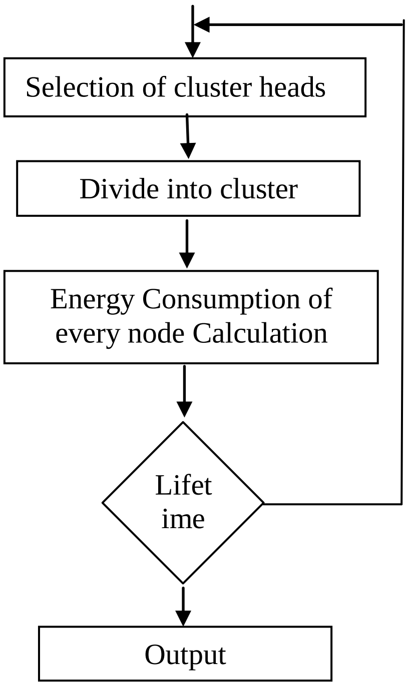

Fig 4.1: Flow chart of LEAUCH protocol

Fig 4.1 shows the entire process of the LEAUCH protocol. Every hub that turns into the group head (CH) will make a TDMA plan for the bunch's sensor hubs. That permits each non-CH intersection's radio segments to be killed on all occasions except amid their transmit time.LEAUCHprotocolcommunicates with sink among a cluster heads hence support Multi-hop communication. The Energy utilization between, group head and sink are more prominent than vitality utilization among bunch heads so that the group head will deplete vitality soon. Multi-jump correspondence can maintain a strategic 1distance from the entire system from kicking the bucket rapidly and adjusting the vitality utilization among the procedure for improved drag out the system lifetime.

Low- Energy Adaptive Uneven Clustering Hierarchy (LEAUCH) is one of the most popular hierarchical routing protocols. The operation of LEAUCH is divided into rounds.Cluster heads change arbitrarily over time to adjust the dissipation of energyin hubs. The hub chooses an irregular number between 0 and 1. The hub becomes a cluster head for the current round if the number is less than the threshold. The decision is based on choosing an arbitrary number between 0 and 1. If the number is less than a point, the hub becomes a cluster head for the current round.

The cluster head hub transmits the data packets to all the hubs in its cluster by setting TDMA schedule, and completing the setup phase, which is at that point taken after by a steady-state operation.

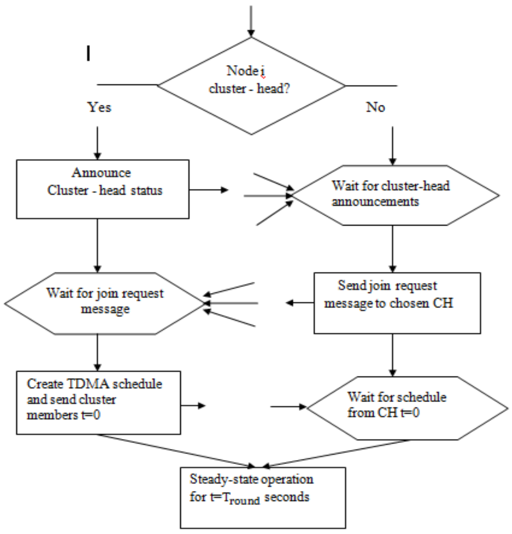

Fig 4.2: Cluster formation of LEAUCH protocol

Steady- state phase: This operation is broken into number of frames, where hubs transmits their information to the cluster head at most once per frame during their alloted slot represented in Fig. 4.2. It expects hubs to continuously send the data; The data is sent during their specified transmission time to the cluster head. This transmission employs sum of vitality (chosen based on the gotten quality of the cluster-head notice). Each non- cluster- head hub can be turned off until the node's designated transmission time, in this way minimizing vitality dissemination in these hubs. The cluster- head hub must keep its collector on to get all the data from the cluster's hubs. When all the informationobtained, the cluster head hub performs flag preparing capacities to compress the data into a single flag.

B. Cluster formation of LEAUCH protocol

LEAUCH is the most well known progressive steering conventions. The activity of LEAUCH is partitioned into adjusts. The hub picks an arbitrary number somewhere in the range of 0 and 1. If the number is not precisely the edge, the hub turns into a group head for the current round. This choice depends on picking an arbitrary number somewhere in the range of 0 and 1; if the number is not precisely an edge, the hub becomes a bunch head for the current round. The group head hub sets up TDMA stratergies and then transmits the schedule to all the hubs in its bunch, finishing the arrangement stage. Constant state-stage[8] The consistent state activity is broken into outlines, where hubs send their information to the bunch head at the premier once per outline during their apportioned opening appeared in Fig. 4.3.

The hub sends information during the dispensed transmission time to the bunch head. This transmission uses an unimportant proportion of essentialness (picked subject to the gathering head notice). The $E\{\#CHs\} = k,$ vitality dissemination in the hubs is least because each of the non-group head hubs are regularly killed until its designated TRM.The gathering head hub must keep its recipient getting all the data from the pack's hubs. The bunch head hub performs signal preparation when all the information has been obtained to pack the data into a solitary sign.

C. Proposed system

In the proposed algorithm, considering the situation where there are N haphazardly sent CRSN nodes gathering information intermittently and P essential clients (PU). Let s_i is the i^{th} node, and the corresponding set of nodes is represented as

$C = \{1, 2, ..., m\}$ $S = \{s1, s2, ..., sN\}$. Let, represents the channels available in the network, and Ci is the idle channels available to hub s_i.The sink node is located outside the square perception territory. Once sent, the CRSN node and the sink node will never again be moved. All hubs are homogeneous and have the capacity of data combinations. Every hub has an $E\{\#CHs\} = k,$ exceptional recognizable proof (ID). Every node has the capability of range detecting and can accurately recognize the accessible diverts in the environment.

All nodes can alter its transmition power to spare energy based on its distance from the recipient.The CR technology is presented into sensor hubs in CRSN, so the conventional LEAUCH algorithm must be improved to adjust to the modern scenario. For making the amount of CMs near the sink moderately little, the CRSN is part of numerous uneven clusters supported the determined CHs, as shown in Fig. 4.2. The circles of diverse sizes speak to the diverse competitive ranges of the CHs, and the lines with a bolt speak to different hop information transmission among CHs.

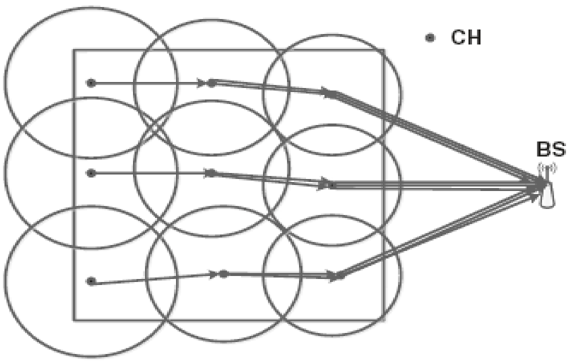

Fig4.3: Uneven clustering routing algorithm.

D. Candidate CHs Determination

In the regular LEAUCH, *Pi(t)* is chosen such that where,

$$P_{i(t)} = \begin{cases} \frac{k}{N - k\left(r \bmod \frac{N}{k}\right)} & : ci = 1 \\ 0 & : ci = 0 \end{cases} \quad (1)$$

Here, N denotes the full range of nodes, and k denotes the specified range of (average) CHs per spherical, r denotes this spherical range, Relate $C_i(t)$ is an indicator work crucial whether or not the hub, i, has been a CH for the first recent r mod (N/K) rounds. This equation of Pi(t) keeps up that each node is selected as a CH once per cycle of operation and so equalizes the load among hubs and extends the primary hub passing the time. The number of idle channels recognized in every hub is considered crucial considering selecting CHs. If the node i detects more idle channels than node j, it's more opportunity

toseek out a standard channel with nearby nodes, which can end in more opportunity to set up a cluster with a common channel.
A sort of Pi(t) should be represented such that:

(2)

The nodes with lot of idle channels is a lot of probably to become a CH. In keeping withthe literature [10], the likelihood of a

$$Pi(t)=min\left(k\frac{ci}{\sum_j^N cj},1\right) \qquad (3)$$

Where c_i is a variety of available channels, nodes with the probability of are selected as $Pi(t) > 0.4$ candidate CHs.

Determination of CHs

The $Pi(t) > 0.4$ nodeswith are selected as the candidate CHs and begin to compete for CHs; other nodes go into sleep mode until the competition is over. Let $s_i$denotes the candidate CH, and its competition radius Rc can be calculated based on the distance from the sink.[5]When the competition starts, if s_i wins, then all other candidate nodes within its competition radius Rc quit the competition for CHs. The topology structure of candidate CHs are shown in Fig. 4.4.The circles with different sizes represent the competition radius of candidate CHs shown in Fig. 4.3. Under the rule of crucial CHs, s_1 and s_2 becomes the final CHs simultaneously, but s3 and s4 cannot be the final.

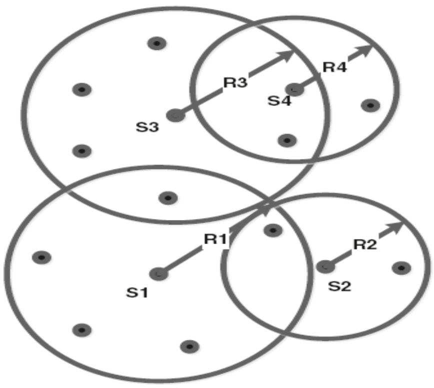

Fig 4.4: The candidate CHsCompetition radiuses.

In CHs rivalry calculation of LEAUCH, the arrangement of contiguous CHs of the up-and-comer 3CH s_i is indicated by S_{si} and S_{sj}
= {sj sj is competitor CH,d(si,sj)<max(Rsi,Rsj)}

From the above calculation, every competitor hub communicates its opposition message in an equal force, including hub ID, rivalry sweep Rc, and current vitality. To spare vitality,the communication range is set to R_{0c}. After getting the communicate message, every applicant CH structures its nearby up-and-comer CH set and afterward chooses whether it turns into the CH or not. The accompanying advance can conclude 8CHs.

The hub s_i with the most noteworthy leftover vitality in Ssi become CH, at that point communicate it; if the hub si gets the s_j, ($s_j \in S_{si}$), triumphant message from s_i stops the opposition and displays the quit message; On the off chance that hub si gets the quit message from then si will ($s_j \in S_{si}$), expel sj from the neighboring ch

In this calculation, the bunches close to the sink have a short rivalry range and fewer CMs. Their CHs can utilize more vitality to convey among groups and further equalize the vitality utilization among CHs. Let Rc be the most extreme estimation of rivalry range of competitor CHs; at that point, the opposition sweep of the up-and-comer CHs can be dictated by $(1-c)\,R_{0c}$, where c is the utilized parameter for controlling its worth and c∈[0, 1]. Consequently, the opposition sweep Rc of a competitor hub Si can be controlled by:

$$Rc=(1-c\,(dmax-d(si,BS))/(dmax-dmin))\,R0c$$

Where, dmax and dmin mean the most extreme and least good ways from the hubs to the sink individually. $d\,(si,\ BS)$ signifies the separation between the hub si and sink. The opposition sweep diminishes straightly with the right ways from the hubs to the sink. For instance, c = 1/4, the scope of the opposition span is

$$3/4R0c \sim R0c.$$

V. EXPERIMENTAL RESULT

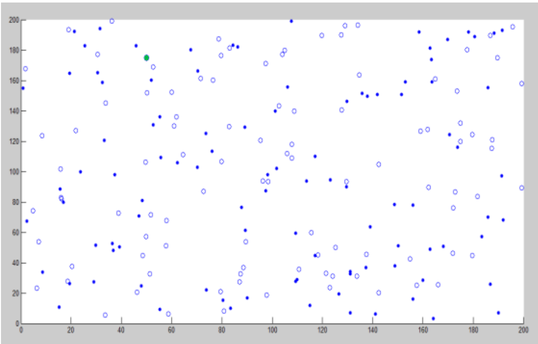

Fig 5.1: Cluster model

In Fig. 5.1, the cluster model of LEAUCH is captued. Rectangular consists of length and width(200 and 200). This yard can be selected in any shape such as circle, square, rectangle, or shapes. There are 100 nodes present in the yard (for experimental analysis). This model consists of nodes, cluster heads, and a common ground station for all the nodes within the given area. The green color dot is a base station, and the blue colors are the cluster heads, and the remainings are the nodes, as shown in Fig. 5.1.

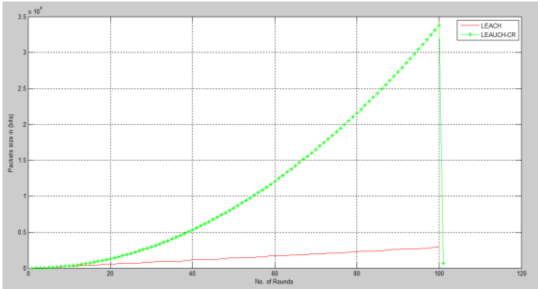

Fig 5.2: Comparison of LEACH & LEAUCH with packets size

In Fig. 5.2, comparison of packets size (bits) in both LEACH and LEAUCH are shown. The green color line represents LEAUCH-CR, and the red color line represents LEACH. The packets size in the LEAUCH-CR algorithm is rapidly increasing with an increasing number of rounds compare to the LEACH algorithm

In Fig. 5.3, the plotting of energy stored in CHs (Joule) vs. several rounds is shown. Where the LEAUCH-CR protocol stores the energy more in CHs compared to the LEACH protocol. At the end of 100 rounds, LEAUCH-CR has more energy in it because LEAUCH-CR utilizes less energy for the transmission of packets than LEACH. The storage of energy in the cluster head will be longer to permit the transmission with the other nodes for each round by utilizing less energy from the CHs

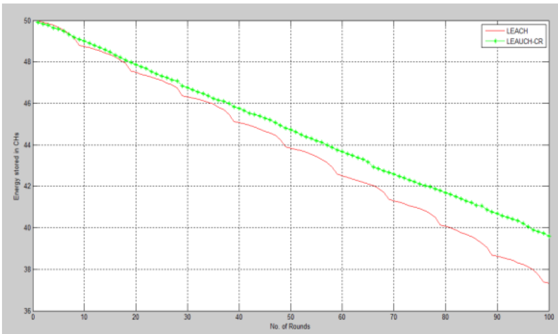

Fig. 5.3: Energy stored in LEAUCH-CR

The above Fig 5.4 shows the plot for several alive nodes Vs. several rounds. Here a comparison between LEACH and LEAUCH protocols is shown. By default, the number of nodes present in the yard is 100. This graph is plotted to check how many numbers of alive nodes will be present in the given yard of LEAUCH-CR compared to the LEACH protocol. As shown in Fig. 5.4, the maximum number of nodes active in the given area of LEAUCH-CR than the LEACH. It means the dead nodes are less.

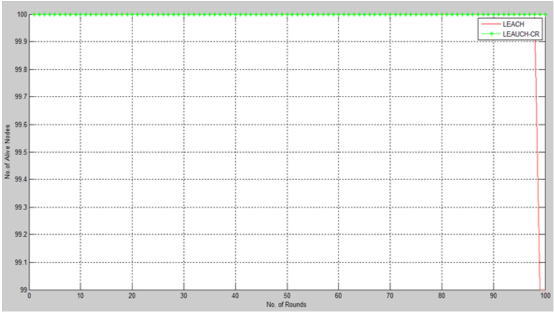

Fig5.4: Number of Alive nodes

Fig 5.5 shows the packets sent to BS, dead nodes, and sum of energy vs rounds. Here it has been shown that the packets are sent to the BS from the selected cluster head for every rounds in the first plot. The default size of the packet is 6400 per transmission. In the second plot, it has plotted for dead nodes vs number of nodes, to analyze any dead nodes are present in the yard. In the third plot, the sum of energy of nodes vs the rounds is shown to check the energy consumption in every node on each round.

Fig 5.6 shows the base station which has received the packets, and the sum of energy of nodes are represented. Along with this, the number of dead nodes is shown in the second plot. As the number of rounds increases, the packet sent to BS will also increase.

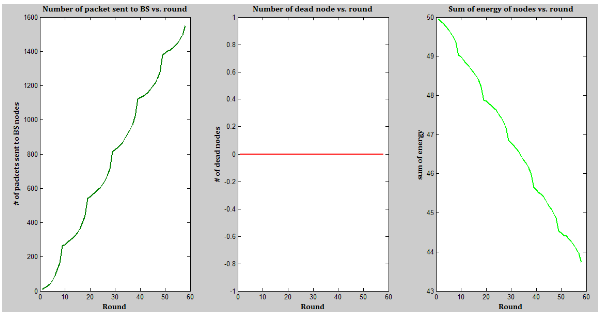

Fig5.5:packet sent to BS, dead nodes and sum of energy vs round

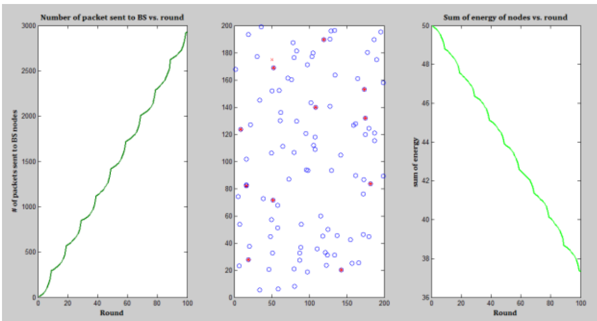

Fig 5.6: Cluster model with dead nodes.

VI. ADVANTAGES

- It gives versatility in the system by constraining a large portion of the correspondence inside the diverse bunches of the system.
- A vast, versatile system without traffic over-burden can be sent, and by this likewise better vitality, productive system topology can be accomplished.
- Distributiveness property interior the bunch, where it passes on the work of CH to another group of individuals interior the group. It increments the lifetime of the network in three stages. Initial, it disseminates the work of CH to interchange hubs within the gather. Second, it aggregates the detected data by the CHs. At last, by the method of TDMA puts most of the sensor nodes within the rest mode.
- It does not require the information of the sensor hubs' region within the system to create the groups. In this manner, it could be a beneficial steering convention, and it is significantly essential too.
- It gives the dynamic clustering approach. It is well-suited for applications where consistent monitoring of the natural data is required, and the information collection handle occasionally happens to a centralized area of the network.

CONCLUSION

The 1proposed 2work is the 3LEAUCH algorithm for1CRSN, in this 1method1LEAUCH consider the weight of each nodes in the idle6channel and the 3nodes will be selected based on the 7more 8idle channels as 5applicants 0CHs. The 9limitations and 9advantages of 0CSRN are deliberated and discovered the current networking applicability resolutions of CSRN in the wireless sensor networks. Further, the algorithm proposed intends the method of clustering irregularly and the consumption of energy can be balanced between the CHs beneath the several hops means. The above experimental outcomes show that the algorithm projected will be able to achieve the best performance with respect to active nodes, reduced CHs consumption of energy and packet dimensions and correspondingly it demonstrates the network model, packets to be directed and dead nodes.

FUTURE WORK

The proposed algorithm tends to increase the energy efficiency of the sensor nodes and indeed the lifetime of WSN also increases. Periodically the sensors are activated to monitor the physicals status like pressure, to identify the location of objects and temperature. The low-slung bandwidth applications are required and these are typically delay tolerant. In forthcoming works, the reduced delay application situations and the throughput will be added more as it is also taken into the consideration and hence the additional complex network topology will be evaluated further to check the performance.

REFERENCES

[1] D Cavalcanti, S Das, JF Wang, K Challapali, in *Proceedings of 17th International Conference on Computer Communications and Networks*. Cognitive Radio based wireless sensor networks, (2008), pp. 1–6.

[2] Mitola, Joseph, and Gerald Q. Maguire. "Cognitive radio: making software radios more personal." *IEEE personal communications* 6, no. 4 (1999): 13-18.

[3] Akyildiz, Ian F., Won-Yeol Lee, Mehmet C. Vuran, and ShantidevMohanty. "NeXt generation/dynamic spectrum access/cognitive radio wireless networks: A survey." *Computer networks*, 50, no. 13 (2006): 2127-2159.

[4] ZY H Z Zhang, Zhang, Yuen Chau, Energy-efficient spectrum-aware clustering for cognitive radio sensor networks. Chinese Sci. Bull. **57**(28-29), 3731–3739 (2012)

[5] Khayami, Hossein, Mohsen Ghassemi, KamyarArdekani, BehrouzMaham, and WalidSaad. "Cognitive radio ad hoc networks for smart grid communications: A disaster management approach." 2013 IEEE/CIC International Conference on Communications in China (ICCC).

[6] N Chilamkurti, S Zeadally, A Vasilakos, V Sharma, Cross-layer support for energy-efficient routing in wireless sensor networks. J. Sensors. **2009** (2009).

[7] Lu, Yingqi, Pai Zhu, Donglin Wang, and Michel Fattouche. "Machine learning techniques with probability vector for cooperative spectrum sensing in cognitive radio networks." In *Wireless Communications and Networking Conference (WCNC), 2016 IEEE*, pp. 1-6. IEEE, 2016.

[8] H Zhang, Z Zhang, H Dai, R Yin, XM Chen, in *IEEE Global Telecommunications Conference*. Distributed spectrum-aware clustering in cognitive radio sensor networks, (2011), pp. 1–6.

[9] CF Li, M Ye, GH Chen, J Wu, in *IEEE International Conference on Mobile Ad hoc and Sensor Systems*. An energy-efficient unequal clustering mechanism for wireless sensor networks, (2005), pp. 604–612.

[10] Gorcin, Ali, and HuseyinArslan. "Public safety and emergency case communications: Opportunities from the aspect of cognitive radio." In *New Frontiers in Dynamic Spectrum Access Networks, 2008. DySPAN 2008. 3rd IEEE Symposium on*, pp. 1-10. IEEE, 2008.

[11] Onem, Evren, SalimEryigit, Tuna Tugcu, and Ali Akurgal. "QoS-enabled spectrum-aware routing for disaster relief and tactical operations over cognitive radio ad hoc networks." In *Military Communications Conference, MILCOM 2013-2013 IEEE*, pp. 1109-1115. IEEE, 2013.

[12] Defense Advanced Research Projects Agency (DARPA), neXt Generation Communications Program. http://www.darpa.mil/default.aspx, program funded by the *Department of Defense's (DoD) project started in the 2000s; Web page visited on the 29 May 2018*.

[13] Raschellà, A., Militano, L., Araniti, G., Orsino, A., and Iera, A., 2017. Cognitive management strategies for dynamic spectrum access. In *Handbook of Cognitive Radio* (pp. 1-35). Springer.

[14] Manjunatha R C, Dr. Rekha K R, Dr. Nataraj K R " Implementation and comparative analysis Of Fuzzy Based Simulation Frame Work for Clone Detection with conventional algorithms in Wireless Sensor Networks" *International Journal of Electrical and Computer Engineering (IJECE) 2017, Volume 6, number 4, ISSN: 2088-8708*.

[15] Hu, F., Chen, B., and Zhu, K., 2018. Full-spectrum sharing in cognitive radio networks toward 5G: A survey. *IEEE Access*, *6*, pp.15754-15776.

[16] Dr. Naveen Nandal, Dr. AarushiKataria, Dr. Meenakshi Dhingra. (2020). Measuring Innovation: Challenges and Best Practices. International Journal of Advanced Science and Technology, 29(5s), 1275 - 1285.