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Encapsulation of Energy Efficient, Clustering Algorithm and Spectrum Sensing for Cognitive Radio Based Internet of Things Networks

Abstract: - Since the two decade the Internet of Things (IoT) plays an important role in the field of communication technology. Out of maximum of IoT devices are battery operated. So there should be energy efficient devices that can operate more functions with less power consumption. The main power constraints in the IoT devices are in the communication like spectrum selection, data transmission, etc. To perform communication between the two nodes the spectrum must be available. But as spectrums are limited and a lot of data is to be transmitted there may the issue of spectrum scarcity. The dynamic spectrum access is done using Cognitive Radio (CR) technology that can overcome spectrum scarcity issue. This paper gives the research work on energy efficient, clustering algorithm and spectrum sensing for CR based IoT networks in terms of the methods, merits, demerits and implementation. For efficiency in the spectrum sensing and energy consumption in 5G wireless communication network and data transfer between the IoT devices this study is essential. The biblometric analysis is shown by using VOSviewer to visualize the bibliometric information and the result as an analysis of ROC curve for Rayleigh and Rician channel is plotted using Matlab.

Keywords: Cognitive Radio, Clustering algorithm, Energy efficient, Internet of Things, Energy detection, Spectrum sensing, Spectrum scarcity.

I. INTRODUCTION

The father of Cognitive Radio (CR) Joseph Mitola who introduces the technology which was used for dynamic spectrum access. Before CR as the spectrum is limited and it is reserved for the primary user (PU) also known as license user. The spectrums were reserve for PU and even if spectrum is vacant (not used by PU to perform data transmission) secondary user (SU) could not send the data through the licensed spectrum it means there is the static spectrum access. In such cases few bands are heavily used some are moderately and few are lightly used. Because of which the spectrum scarcity issue occur that can overcome by CR technology [1]. CR technology has the vast area of research as data need to pass through the spectrum so the spectrum must be free so that along with PU, SU can also transmit the data without collision of the data. For that need to do the spectrum sensing. For spectrum sensing more power is required that must degrade the network performance and network life. So research have the area of power efficient spectrum sensing algorithms need to be event. The spectrum sensing is done by using various spectrum detection techniques. The spectrum sensing basically done for identifying the spectrum hole. For identifying the spectrum hole it is required to perform energy detection. When the SU perform data transmission and suddenly PU want to use the spectrum then SU has to perform spectrum handoff. For spectrum handoff also more power is required it should also be done in power efficient manner. To manage and regulate the spectrum utility Federal Communications Commission (FCC) put forward some policies [2]. IoT devices are almost all are battery operated and recently it is more demanded as they consume minimum power and low cost devices. These IoT devices are used in all the fields surrounding us like medical, transport, sports, studies, entertainments, smarts cities, smart homes, etc. [3]. To use IoT devices [4] in efficient manner CR plays a vital role. In IoT devices the data is transfer from node to node within inter cluster or intra cluster manner [6]. For the same the spectrum is used through which data is transmitted. The CR based IoT device for spectrum sharing and spectrum sensing approaches have some merits and disadvantages explained in [7] [16]. There are various kind of spectrum band that are reserve for communication [17]. CR allows SU to use the spectrum opportunistically without interfering the PU transmission can identify the spectrum hole and perform communication effectively and the uniform spectrum utilization is observed in wireless communication in the IoT network. The manuscript is organised as follows: Research Methodology in the review paper is in section 2 as Method, section 3 having the energy efficient for IoT with cognitive radio network, clustering algorithms for IoT with cognitive radio network is explained in section 4, section 5 focuses on spectrum sensing for IoT with cognitive radio network, result is explained in section 6, section 7 focused on discussion , section 8 covers conclusion and section 9 is for limitation and future scopes of the research.

II. METHOD

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In this research the numbers of the paper is collected from the major databases like Web of Science, Scopus, ScienceDirect, ProQuest, PubMed, Google Scholar, etc. from the field of IoT with Cognitive Radio Network with energy efficient, clustering algorithms and spectrum sensing. The total analysed paper from past ten years of 118 are considered. Fig.1 shows the number of papers identified as per the classes of Energy Efficient, Clustering Algorithm and Spectrum Sensing for IoT with Cognitive Radio Network. The analysed data representation is shown with the help of VOSviewer. In spectrum sensing the clustering mechanism plays an important role as per energy efficient CR network is concern. So the proposed method is used to form the cluster and perform the spectrum sensing in efficient manner.

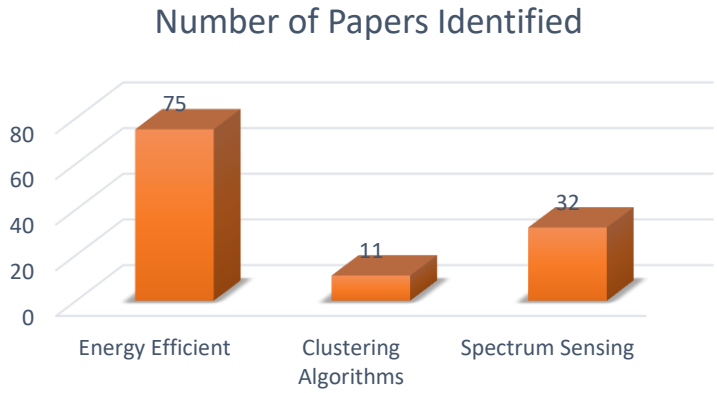

Fig.1 Number of papers identified

III. Energy efficient for IoT with Cognitive Radio Network

In CR network the energy of a signal plays an important role for performing communication in the network. As the license user only can transmit the data through the spectrum and by sensing the network energy the SU can transmit the data after identifying the white space [18]. So in spectrum sensing the energy is consume also to perform the spectrum handoff energy is required. Therefore there should be a system some method some algorithm so that the communication will be done in energy efficient manner and which can improve the network performance as well as network life. In the wireless powered CR Network based on the traffic specific the spectrum sensing with energy efficient method is proposed in [23]. The overview of various technologies like multiple radio access, cross layer optimization algorithm, dynamic power saving, cooperative communication, network coding, etc. are explained in [39]. For inter-cluster and intra-cluster communication k-hop clustering scheme is proposed in [8] also the nodes related parameters are deeply studied. The joint rate and power control impact CR adhoc network performance is investigated in [41]. Few papers are referred in this review research where the authors have applied different methods algorithms so that the network efficiency improved in a performance, accuracy and lifetime manner. The Co-authorship analysis of Energy efficient [64] for IoT with Cognitive Radio Network is shown in fig. 2.

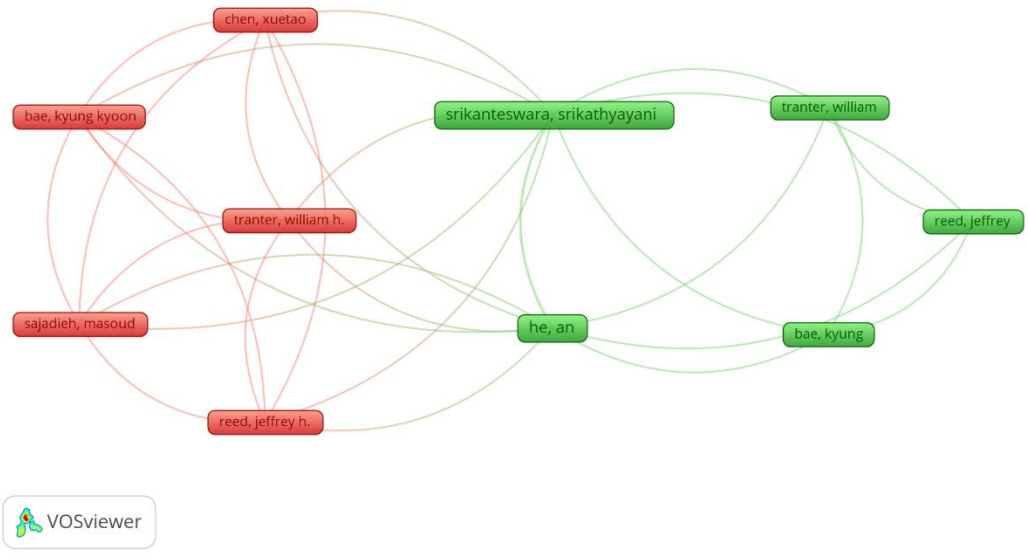

Fig.2 Co-authorship analysis of Energy efficient for IoT with Cognitive Radio Network

IV. Clustering algorithms for IoT with Cognitive Radio Network

In the IoT network the communication can be done by device to device connectivity. CR network with IoT is the intelligent communication [63] where the node are responsible to transmit and receive the information from the environment. The grouping of the sensor nodes forms the cluster that provide energy efficient network which is responsible for secure communication [52] [53] [54] between the inter cluster as well as intra cluster. The clustering mechanism consists of cluster node and cluster head [8]. The different clustering topologies that can improve the energy consumption in CR network is covered in [40]. Weighted clustering metric based a novel spectrum-aware clustering algorithm is introduced in [42]. In the cluster the node having highest energy is eligible to become cluster head while remaining cluster nodes can gather the relative data from the surroundings and forward it to the cluster head [43]. The cluster design is considered based on collaborative spectrum sensing in [44] and maximises the CR network's energy efficiency. From the LEACH algorithm after doing optimization the CogLEACH algorithm is introduced in [45] that have fast energy efficient clustering protocol for CR network. The network stability and minimum energy consumption can be obtained by clustering mechanism with network stability-aware clustering (NSAC) protocol [51] [55] for CR network is introduced in [46]. For reducing the power consumption a multi-hop clustering cooperative spectrum sensing algorithm is introduced in [47]. The responsibility of cluster head is to gather the information from cluster nodes and send it sink.

Clustering mechanism is energy efficient using this the network life is improve hence the various clustering algorithms are introduced so that the CR network become more efficient and hence it also improve the IoT technology. The fig.3 shows Co-authorship analysis of Clustering algorithms for IoT with Cognitive Radio [62] [65] Network.

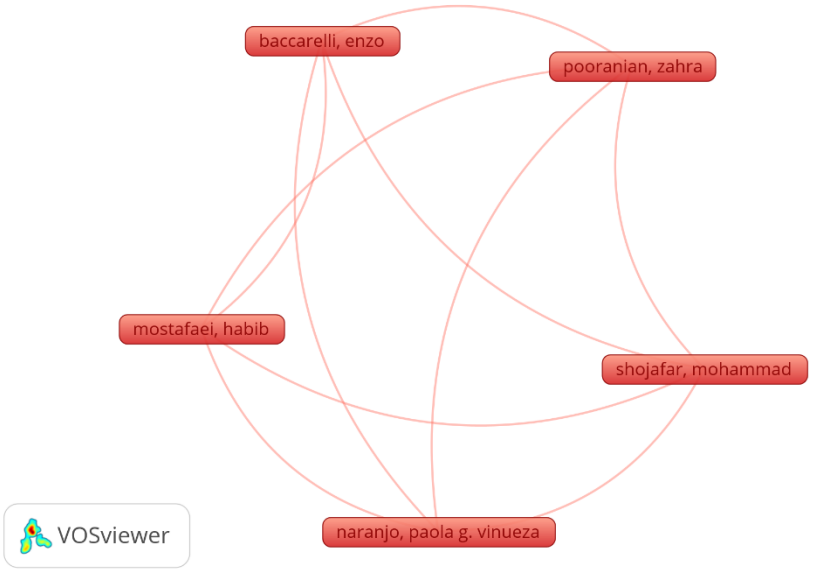

Fig.3 Co-authorship analysis of Clustering algorithms for IoT with Cognitive Radio Network

V. Spectrum Sensing for Cognitive Radio based IoT Network

Before the invention of CR the spectrum scarcity issues was there because of static spectrum allocation. As there is the limited band of frequency spectrum through which the information to be transfer and all the spectrums are reserved for the PU because of which few frequency spectrums are heavily utilised like mobile spectrum band and few are lightly utilised like Radio/TV spectrum band this is the spectrum scarcity issue [18] [19]. This problem is overcome by CR using this technology SU also able to use the license band opportunistically. The spectrum sensing overhead can be minimise by a narrowband CR IoT Network [20]. Whenever the PU not using the channel that means the channel is ideal SU can perform their data transmission to do that or to sense the white space it has to perform the spectrum sensing [21].

Spectrum sensing gives the status of the channel whether it is used or ideal. How the cooperative spectrum sensing can upgrade the working functionality of the CR network is explained in [22]. The cooperative spectrum sensing method, Eigenvalue and superposition based scheme is proposed in [24] which has better probability of detection with less sensing time. Using the techniques of Machine Learning the cooperative spectrum sensing in CR network is done in [38]. The basic of CR architecture the advantages and properties are explained in [25] [26]. To enhance the spectrum efficiency higher and throughput the spectrum sensing in multiple input multiple output system hybrid model can be used [30] [31]. The latest advancements in the spectrum sensing are covered in [32]. Once the channel is ideal SU identify the white space and utilize it for data transmission. Whenever PU again wants to

perform communication [59] SU do the spectrum handoff and again with the utility of spectrum sensing identify the white space and continue the data transmission in another free channel. There are multiple numbers of spectrum sensing methods and algorithms introduced by authors and tried to improve the spectrum efficiency, throughput and network life. Fig.4 shows Co-authorship analysis of Spectrum Sensing for IoT with Cognitive Radio [57] [60] Network.

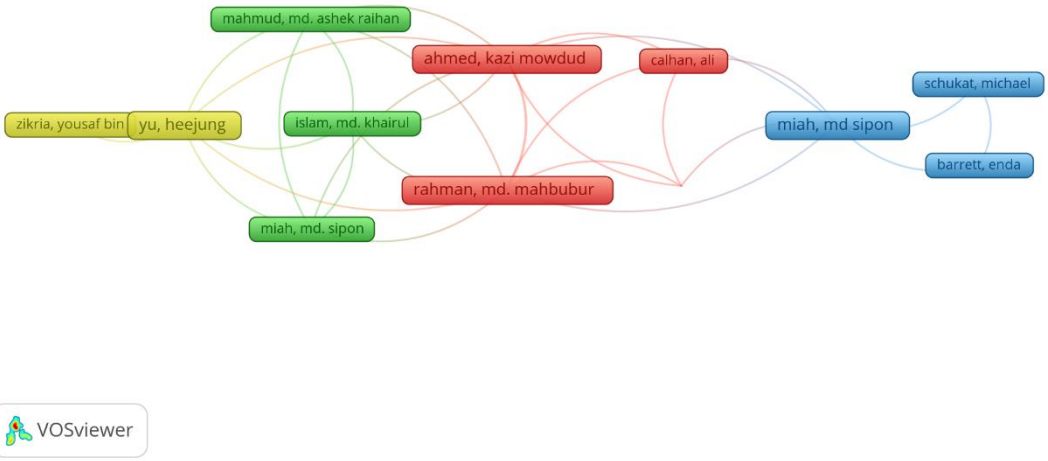

Fig.4 Co-authorship analysis of Spectrum Sensing for IoT with Cognitive Radio Network

Table 1. Traditional Spectrum Sensing Approaches

Reference	**Technique /Methods**	**Merit**	**Demerit**
Muhammad Shafiq *et al*. [5]	Handshake Sense Multiple Access with Collision Avoidance (HSMA/CA) protocol	This method avoided the sensing overhead that improved the spectrum sensing.	The processing time of this scheme was high
Saleem Aslam *et al*. [7]	Energy management scheme (EMS) and an innovative channel management scheme (CMS)	The proposed CMS provided higher stability channels.	It failed to compute the sensor node energy, thereby it affects the system performance.
Rajendra Prajapat *et al*. [8]	Neighbour discovery algorithm and greedy k-hop clustering schemes	The developed method increased the channel connectivity with minimum energy, which increased the lifetime of node.	The developed method failed to explore the applicability under different PU spectrum occupancy models
Nhu-Ngoc Dao *et al*. [9]	Probabilistic Decay Featured Sensing (PDFS) algorithm	The PDFS algorithm possesses low computational complexity, which is even applicable to lightweight IoTDs.	The decentralization transformation and/or control overhead of this scheme were high.
Muhammad Shafiq *et al*. [10]	Ranked Sense Multiple Access with Collision Avoidance (RSMA/CA) protocol	This method was a good candidate Media Access Control (MAC) Protocol for CR with multichannel networks since its working is insensitive to the number of available channels.	The throughput of this method was decreased with the increasing number of secondary user.

Md. Sipon Miah *et al*. [11]	Energy Detector (ED) method	The global error probability of this scheme was low.	It failed to processed under real time environment
Md. Sipon Miah *et al*. [12]	Kullback–Leibler divergence (KLD) scheme	The mentioned scheme provided an improved sum rate and required less sensing time while maintaining the sensing performance	The KLD technique dynamic threshold did not process under a noise uncertain condition.
Bekele M *et al*.[13]	Energy-efficient joint optimization of spectrum sensing and energy harvesting (E^2JOSSEH) method	It provided sufficient energy for sensing nodes that improved the lifetime of network	It failed to investigate additional Quality of Service (QoS) requirements for heterogeneous IoT nodes and exploiting interference for energy harvesting.
James Adu Ansere, *et al.* [14]	Cognitive Radio Internet of Things (CR-IoT)	It enhanced the energy efficiency of the data transmission.	The network lifetime of this method was low.
Ankush Mitra, *et al.* [15]	blockchain-based AI/ML	It provided security against various attacks in the data.	Some external attacks may drop the accuracy.

VI. Result

The Spectrum Sensing plays a vital role to design the energy efficient [56] CR network. Sensor nodes of the cluster collect the data form the surroundings and forward to the cluster head. Cluster head gather the data from all the sensor nodes in the cluster and divert the same to the sink or gateway. Gateway stored the data into the cloud and according the information is responsible for sensing the spectrum whether it is occupied or free. Hence the SU can identify the white space and perform its data transmission by opportunistically access the spectrum band. Fig. 5 and Fig. 6 shown the ROC curve for the introduced method for Rayleigh and Rician channel respectively. The graph of False Alarm against Probability of Detection is plotted using Matlab. The blue curve shown the proposed method as compare to existing methods it shows the proposed method if efficient as compared to existing once.

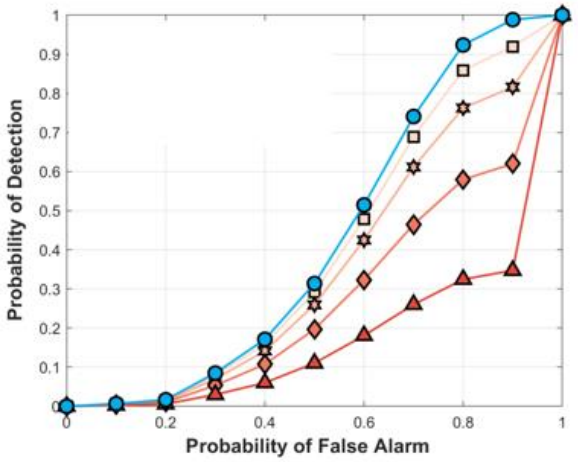

Fig. 5 Analysis of ROC curve for introduced method for Rayleigh channel

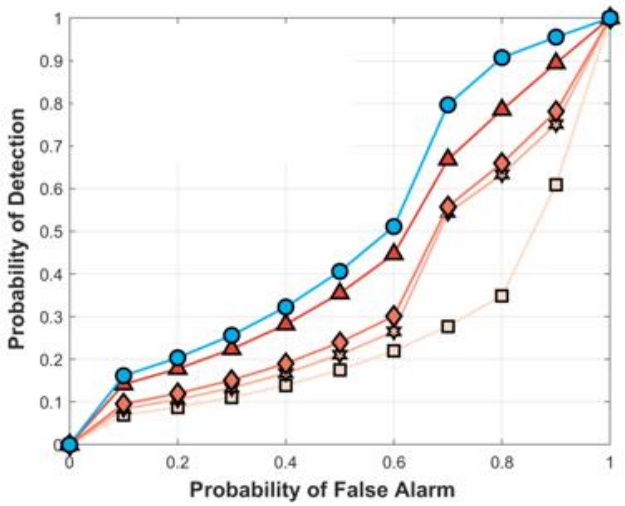

Fig. 6 Analysis of ROC curve for introduced method for Rician channel

VII. Discussion

CR technology invented by Joseph Mitola in 1999 for removing the spectrum scarcity problem. Along with license user (PU) SU can also opportunistically access the licensed spectrum and perform communication [50] without interfering PU. Dynamic Spectrum Access is possible only because of the CR technology. For providing better security in IoT network [27] by optimising Monarch-Earthworm Algorithm. Namib beetle optimization (NBO) algorithm is idea taken from the insect of the desert how he can collect the water and struggle to survive in the desert [28]. This algorithm is also application for sensing the spectrum. As the Taylor series is as similar as Auto Regression Model the linear statistical model is discussed in [29] to predict the accuracy and fast processing the Taylor series algorithm is applicable and it may use efficiently in spectrum sensing. To perform the accurate spectrum sensing even though no information of the spectrum a novel wavelet transform WATRAB is introduced in [33]. The cloud based intelligent data driven system is proposed in [34] where using IoT devices the data is extracted. The Salp Swarm Algorithm is introduced in [35] which is designed by the combination of Salp Swarm and Simulated Algorithm that is also known as the energy efficient routine algorithm. IoT based system [49] is suffering from different attacks those attacks are detected using deep learning based optimization in [36] [37].

VIII. Conclusion

The wireless network demand is increases day by day for IoT devices because of the feature of CR technology which encourages the dynamic spectrum access, remove spectrum scarcity issues, increases spectrum efficiency, increases throughput, increases network life, etc. The optimization techniques used for improving the energy efficient [61], clustering algorithms, spectrum sensing in CR based IoT network. By using the multiple access scheme in the CR network the mobile data traffic is diverted to the unoccupied channel that distribute the network [58] load uniformly. With the use of CR technology the huge volume of data across the IoT devices are easily handle. The spectrum sensing is uniformly utilised between licensed and unlicensed users in the CR based IoT devices to perform the communication in efficient and effective manner [48].

IX. Limitations and Future Scopes of Research

While performing this research most of the papers are gathers from databases like Web of Science, Scopus, ScienceDirect, ProQuest, PubMed, Google Scholar, etc. of the past ten years. Did the optimization in the CR network areas like Energy Efficient [66] [67], Clustering algorithms and Spectrum Sensing. Few upcoming areas are left like Artificial Neural Network, Deep Learning, Machine Learning, Bayesian Non-parametric Approach, Support Vector Machine. The different bibliometric analysis is visualised here for all the three optimization in CR network is done. The future scope of the research may be the area related to the artificial intelligence, machine learning, computer vision, cloud computing, information security, block chain in the field of CR technology.

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