THINK INDIA JOURNAL

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

Cognitive Radio – Adaptive, Intelligent and Network technology A review

Kamal Kumar Sharma*, Yogita Thareja**

*Professor, SEEE, Lovely Professional University, Phagwara
**Research Scholar, SEEE, Lovely Professional University, Phagwara
kamal.23342@lpu.co.in

Abstract

Cognitive radio CR is a software Defined Radio (SDR) that consequently distinguishes the encompassing RF, impetuses and cleverly obliges its working parameters to the framework of system and changes it conduct as needs be. In this article we proposed a new integration approach to sensor nodes with cognitive radio (CR) nodes to route sensor data to sink using licensed channels opportunistically. In many investigations the researches found inefficient utilizations of spectrum. To solve it cognitive radio network is introduced in order to access the dynamic spectrum. The spectrum sensing issue is one of the most challenging problem in CR systems to get in information of the available frequency bands. In this paper we will study various researches which have been carried out for efficient spectrum management such as spectrum sensing, dynamic spectrum access, channel access and allocation. Moreover, energy harvesting, resource management and energy aware routing schemes are also presented.

Keywords*: Cognitive Radio, spectrum sensing;, Clustering techniques, Wireless sensor network routing*

Introduction

Recently, the wireless sensor network (WSNs) are widely adopted and studied in the field of real-time applications, industries, and academia. The applications of WSNs include several compelling operations such as disaster management, environment monitoring, battlefield surveillance, health care systems, underwater surveillance and many more. Generally, the WSNs follow event-driven mechanism to communicate with other nodes. there may exist a few heterogeneous sensor systems which may attempt to get to the activated occasion which can cause delay and inappropriate data collection. In addition, these systems are typically sent in the blocked off area; in this manner, self-organizing capability and network lifetime are pivotal parts of WSN . According to the WSN architecture, it may consist of hundreds of sensor nodes which are deployed randomly in the monitoring sensor field. Source node and base station are the two components of WSNs for data collection. The source noes transmit the data to the base station with the help of single or multi-hop data transmission scheme. Then, the sink node transmits the data to the desired location with the help of the communication channel to accomplish the monitoring application task. Figure 1 shows a general architecture of WSN.

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

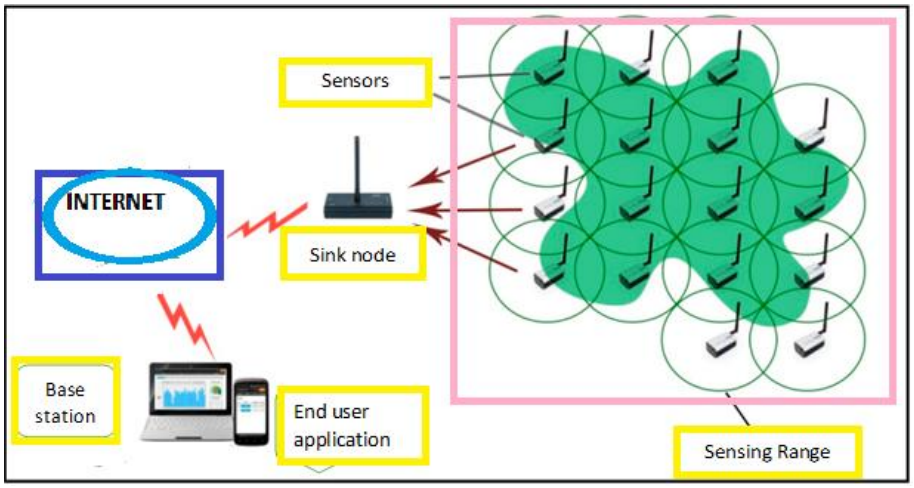


Figure 1 WSN Architecture

Generally, the WSNs maneuver in industrial scientific and medical (ISM) frequency band whose frequency is assigned as 2.4GHz by Federal Communications (FCC) regulations. However, the ISM bands are unlicensed bands which are also accessible by IEEE 802.11 systems, IEEE 802.15.4 WPAN, wireless microphones, and Bluetooth applications. Immense growth and proliferation of wireless communication have led towards the smooth and reliable communication among multiple devices. Hence, the demand for wireless devices is increasing rapidly with a rate of 30-40% every year [1]. The expanded number of wireless devices operating in the ISM band produces interference in all among unrelated applications in wireless communication. which are using this band. Moreover, the increased number of wireless devices promotes the spectrum scarcity issues because of the availability of limited resources. Additionally, system throughput depends on the use of the channel [3]. Thus, interference, channel utilization, and spectrum management remain challenging issues in wireless communication.

Cognitive radio: a breakthrough in WSN

Recently, the cognitive radio (CR) scheme has emerged as a promising solution to mitigate the issues of spectrum resource scarcity by improving the utilization of available resources. Cognitive radio network (CRN) architecture comprises of primary and secondary users. Whenever, the PU spectrum is underutilized, the secondary users can access it. This process helps to improve spectrum utilization and mitigate the issue of overcrowding of unlicensed band [4]. In CRNs, SUs are not allowed to create any interference to PUs. Once PU initializes any communication on the same channel where SUs is communicating, SUs must evacuate the channel to maintain the no-interference paradigm. The cognitive radio communication

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

techniques are adopted in various types of existing technologies such as machine to machine networks, WBANs, WSN, etc. The cognitive radio networks enables PHY and MAC layers to dynamically detect the available spectrum and change their parameters to achieve the concurrent wireless communication in the given spectrum band. In this work, we consider cognitive radio sensor network (CRSN) as specific technique due to its huge applications in IoT paradigms.

Unlike the conventional WSNs, the CRSNs operate on licensed band and opportunistically sense the spectrum to achieve the channel state information. Similar to CRN, PUs have direct access to the spectrum whereas SUs are allowed to access the spectrum opportunistically. On the other hand, CRSN adopts the general limitations of conventional WSNs such as energy consumption, and network lifetime. Moreover, the spectrum sensing is also considered as a crucial aspect in implementation of CRSNs. The SS has impact on energy consumption because more number of SUs for sensing will require more energy. Hence, current research progresses are focused on efficient approach for spectrum sensing. Similarly, routing and resource allocation is a challenging task in CRSNs. By taking the advantage of spectrum utilization rule of FCC and advancements of networking technology, the combined wireless sensor network and CR can mitigate the challenging issues such as spectrum utilization, resource allocation, and routing to improve the network efficiency.

Contribution of work

This section presents a brief discussion about recent trends and techniques in the field of WSN, CR, and CRSNs. Spectrum sensing is a most important task of CR which has a significant impact on network lifetime when combined with WSN. Various researches have been carried out for efficient spectrum management such as spectrum sensing, dynamic spectrum access, channel access and allocation. Moreover, energy harvesting, resource management and energy aware routing schemes are also presented.

Zhang et al. [5] presented a joint energy harvesting and spectrum sensing approach for heterogeneous CRSNs. In this work, authors take the advantage of EH-enabled sensor nodes for sensing the spectrum availability. The main contribution of this work is to improve the sustainability of spectrum sensors and conserving energy of data sensors. In order to achieve this, spectrum sensor scheduling approach is presented which is helpful for maximizing the channel available time; similarly, data sensor resource allocation is presented which is used for allocating the channel, power and transmission time such that the energy consumption can be minimized. These objectives are achieved by solving a nonlinear integer programming problem. However, this work lacks in the routing, time varying EH rates and detection threshold of sensors.

As discussed in previous section, the more number of sensing node require more energy which can lead towards the degraded network lifetime. Moreover, CSRNs are vulnerable to spectrum sensing data falsification (SSDF) attacks which can degrade the sensing accuracy. In order to overcome these issues, Ren et al. [6] developed decision rule for collaborative spectrum sensing.

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

Later, FastDtec scheme is presented to determine the suitable threshold. Further, the compromised nodes are discarded to maintain the security and energy efficiency of the network.

Game theory based schemes are also adopted for spectrum allocation and management. Zeng et al. [7] used Bertrand game theory model for spectrum sharing in CRSNs. According to this process, the secondary BS obtains the communication condition of secondary network and charges for the required spectrum from primary base stations using Bertrand model. Later, spectrum allocation problem is formulated as non-linear programming puzzle which can be solved using Nash bargaining. Similar to this, Abdalzaher et al. [12] used Stackelberg game approach to improve the security in CRSNs.

Byun et al. [8] introduced dynamic spectrum allocation using game theory approach. The main aim of this work is to address the following issues such as maximizing the spectrum utilization, spectrum allocation,. Due to the cooperative nature of cognitive radio enabled WSN, Wu et al. [9] adopted multi-agent reinforcement learning scheme to maximize the network performance. The reinforcement learning analyzes past choices of sensor nodes and creates a learning model for power and spectrum selection. This approach follows reward mechanism to maximize the throughput by providing reward for each successful transmission. Similarly, the energy cost reward assignment is incorporated to penalize the high energy consumption.

Zhang et al. [10] focused on resource allocation and management in Energy Harvesting Cognitive Radio Sensor Networks (EHCRSNs). The energy harvesting helps to improve the sustainability of power-limited sensors and cognitive radio mitigates the spectrum scarcity issues in unlicensed bands. In this work, Lyapunov optimization problem scheme is applied to achieve power management, sensing and resource allocation.

Zhao et al. [11] presented cooperative spectrum sensing, channel access and resource allocation in overlay CRNs. In this work, imperfect reporting channels are considered and a multi-channel allocation framework is presented by introducing an access factor. The access factor presents a common matrix model to describe the multi-user multi-channel allocation in CRNs. In order to facilitate the spectrum to SUs, a non-convex optimization problem is for throughput maximization under the transmit power, interference and detection probability limitations for both single and multiple SUs. Later, alternating optimization problem are developed based on the hidden convexity of the considered optimization problem and optimal solutions are obtained.

Zhang et al. [13] presented resource allocation approach, transmission power and spectrum sensing approach for a CRSN where channel state and energy harvesting states are not known or imperfectly known. According to this work, resource allocation problem is formulated as an infinite-horizon discrete-time Markov decision process (MDP0 to maximizing the throughput. At this stage, transmit power and sensing time are considered to adapt the battery states.

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

Similar to these conceptions, routing in CRSNs is also discussed and adopted widely. Fadel et al. [14] introduced bio-inspired routing in cognitive radio sensor networks for smart grid applications. According to this work, honey-bee mating optimization strategy is developed for efficient routing and cooperative channel assignment. Liu et al. [15] developed a novel routing for delay sensitive applications. In this approach, the duty cycle of each node is measure and the higher duty cycle nodes are placed far from the sink node and lower duty cycle nodes are placed near to the sink node to achieve the energy balance.

Clustering is also known as an important part of routing in these networks. Zheng et al. [16] developed a novel routing approach named as NSAC (network stability-aware clustering) where spectrum dynamics and energy consumption are combined together to improve the system performance. Similar to this work, Wang et al. [17] focused on spectrum scarcity and introduced weighted clustering approach. In this scheme, cluster heads are selected based on temporal-spatial correlation, residual energy, and confidence level. Idoudi et al. [18] used clustering mechanism for scheduling purpose to improve the throughput and reduce the energy consumption. The first step is to assign channels to each node which helps to reduce the inter-cluster collision. Later cluster head and cluster member scheduling is performed.

The above discussion concludes that in cognitive radio sensor network and novel approach to improve the overall communication performance is mandatory A heterogeneous cognitive radio sensor network (HCRSN). A cognitive radio enabled sensor network is deployed where they defined various standard parameters such as node capacity, channel, bandwidth available, and bandwidth consumption by each node, power requirements, number of licensed and unlicensed users etc.

Clustering is an effective method to manage communications in cognitive radio sensor networks (CRSNs). In this phase, we perform cluster head and cluster member selection based on their bandwidth availability and channel information [23].

Table 2 Graphical Representation

Sr. No.	**Graphical Represenation**

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

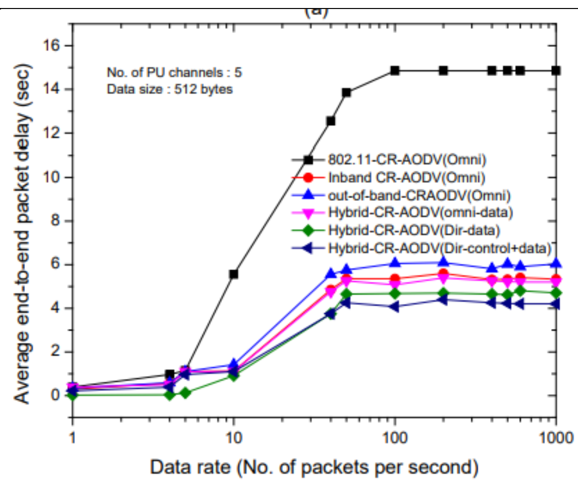
<table>
<tr><td>1</td><td>


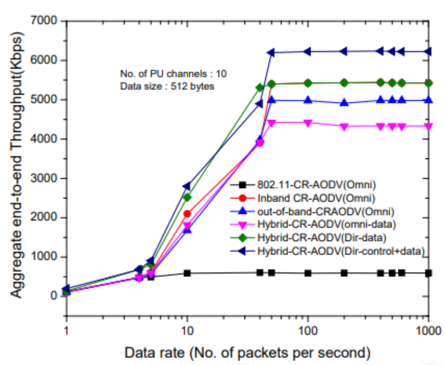
Figure 2 Packet Delay [20]
</td></tr>
<tr><td>2</td><td>


Figure 2 Average throughput [20]
</td></tr>
<tr><td>3.</td><td></td></tr>
</table>

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

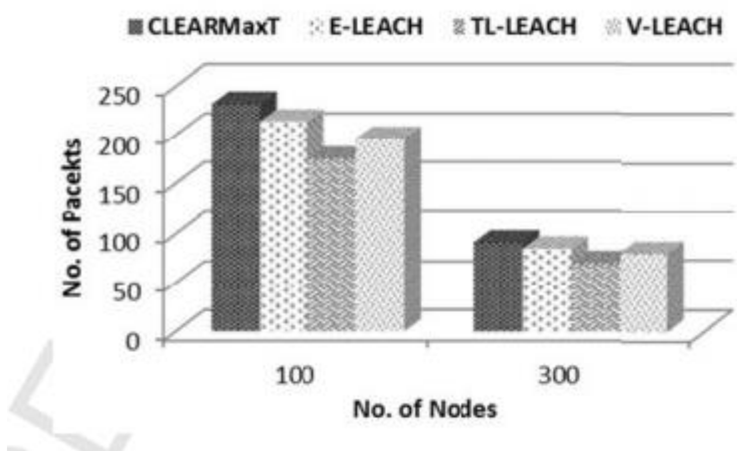


Figure 3 Packets versus Nodes [22]

Conclusion and Future work

The above table (table 2) includes the throughput , postpone time , packet drop to enhance the general overall performance of cognitive radio . If the convention time is included at every step with proper acknowledgement then the quality may be improved further. It is required to focus on the cognitive radio sensor network and introduce a novel approach to improve the overall communication performance. A novel useful resource allocation and spectrum sensing version with interference cancellation and cooperative routing scheme to enhance the throughput must be evolved.

Fault Tolerance is the maximum tough problem in CR-WSN. The protocols designed for cognitive radio do not have the capability to tolerate fault. This influences the overall performance of the wi-fi sensor community. CRN is excessive failure susceptible because of the node mobility and primary consumer (PU) interference. Therefore, a robust routing protocol to address failure at some point of data transmission in CRN is required with some hybrid technology.

References

1. Ali, A. Abbas, L. Shafiq & Kwak, "Hybrid fuzzy logic scheme for efficient channel utilization in cognitive radio networks," IEEE Access, vol, 7, PP24463-24476. 2019.
2. A. Ali et al., ''Raptor Q-based efficient multimedia transmission over cooperative cellular cognitive radio networks,'' IEEE Trans. Veh. Technol., vol. 67, no. 8, pp. 7275–7289, Aug. 2018

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

3. So, J., & Srikant, R. (2015). "Improving channel utilization via cooperative spectrum sensing with opportunistic feedback in cognitive radio networks". IEEE Communications Letters, vol 19(6), PP 1065-1068.
4. A. M. Wyglinski, M. Nekovee, and Y. T. Hou, "Cognitive Radio Communications and Networks: Principles and Practice," Academic Press, Vol 6, PP 344-348, 2009.
5. D Zhang, Z Chen, Ren, J Zhang, "Energy-harvesting-aided spectrum sensing and data transmission in heterogeneous cognitive radio sensor network". IEEE Transactions on Vehicular Technology 66(1), PP 831-843, 2016
6. Ren, J.Zhang, "Exploiting secure and energy-efficient collaborative spectrum sensing for cognitive radio sensor networks". IEEE Transactions on Wireless Communications, Vol 15(10), PP 6813-6827, 2016.
7. Zeng, C. Zhang & S Wang, S. " Spectrum sharing based on a Bertrand game in cognitive radio sensor networks. Sensors" vol 17(1), pp 97-101, 2017.
8. Byun & J.M Gil, "Fair Dynamic spectrum allocation using modified game theory for resource-constrained cognitive wireless sensor networks. Symmetry", vol 9(5), pp 67- 73, 2017.
9. C Wu, Y. Wang, & Z. Yin, "Energy-efficiency opportunistic spectrum allocation in cognitive wireless sensor network", EURASIP Journal on Wireless Communications and Networking, vol (1),PP 8- 13. 2018
10. D. Zhang, Chen, Z. Awad, M. K., Zhang, Zhou, & Shen, X. S. " Utility-optimal resource management and allocation algorithm for energy harvesting cognitive radio sensor networks", IEEE Journal on Selected Areas in Communications, vol. 34(12), pp 3552-3565 2017
11. N. Zhao, N, "Joint optimization of cooperative spectrum sensing and resource allocation in multi-channel cognitive radio sensor networks. Circuits, Systems, and Signal Processing," vol 35(7), pp 2563-2583. 2016
12. Abdalzaher, Seddik, K., & Muta, "Using Stackelberg game to enhance cognitive radio sensor networks security. Iet Communications," vol 11(9), pp 1503-1511, 2017
13. F Zhang,, Jing, Huo, & K. Jiang, "Joint Optimization of Spectrum Sensing and Transmit Power in Energy Harvesting Cognitive Radio Sensor Networks", The Computer Journal, 62(2), pp 215-230. 2018
14. Fadel, Faheem, Gungor, " Spectrum-aware bio-inspired routing in cognitive radio sensor networks for smart grid applications. Computer Communications," vol 101, pp 106-120, 2017
15. A Liu, W Chen , & Liu "Delay optimal opportunistic pipeline routing scheme for cognitive radio sensor networks", International Journal of Distributed Sensor Networks, 14(4), pp 1550 2018
16. Zheng, M., Chen, S., Liang, W., & Song, M. "NSAC: A Novel Clustering Protocol in Cognitive Radio Sensor Networks for Internet of Things", IEEE Internet of Things Journal. 2019

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

17. T Wang, “A Spectrum-Aware Clustering Algorithm Based on Weighted Clustering Metric in Cognitive Radio Sensor Networks”, IEEE Access. Vol 6{7}, pp 103-107, 2017
18. Idoudi, H., Mabrouk, O., Minet, P., & Saidane, L. A. “Cluster-based scheduling for cognitive radio sensor networks”, Journal of Ambient Intelligence and Humanized Computing, 10(2), 477-489. 2019
19. Carie A, Li M, Marapelli B, Reddy P, Dino H, Gohar M. “Cognitive radio assisted WSN with interference aware AODV routing protocol. Journal of Ambient Intelligence and Humanised computing.” Vol 6, pp-12-19, 2019.