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COGNITIVE RADIO SENSOR NETWORKS: A FUTURISTIC METHOD OF DYNAMIC SPECTRUM SENSING

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Abstract: Dynamic spectrum management has become a need of the hour as the licensed spectrum is getting overcrowded yet under-utilized. In wireless sensor networks the limitation of inefficiently use of the allotted bandwidth due to its burst traffic nature effect the overall throughput. Cognitive Radio based networks has emerged as a promising approach to cut down the spectral needs.In this paper, we focus on the usefulness of Cognitive Radio in burst data networks and the effect of combining Wireless Sensor Network with cognitive radio on the overall throughput of the networks.
Keywords: Dynamic Spectrum Management; Cognitive Radio; Wireless Sensor networks; Cognitive Radio Sensor Networks.

I. INTRODUCTION

Dynamic Spectrum Management (DSM) (or Dynamic Spectrum Access) is a technique which can help in significant growth in spectrum efficiency by utilizing the under-utilized as well as unutilized spectrum bands. Cognitive Radio Networks (CRNs) are the software defined radios (SDRs) which implement the concept of DSM so as to re-use the unused frequency bandwidths in the given spectral environment. On the other hand, Wireless Sensor Networks (WSNs) consists of number of wireless sensors spread on large physical area which may or may not be easily accessible. The sensors sense the information from the physical environment and collectively sends it to the base station through multi-hopping mechanisms. CRSNs are the combination of Wireless Sensor Network(WSNs) and Cognitive Radio(CRs). It may be defined as the wireless sensor network with the cognitive ability for efficient spectrum usage. CRSNs benefits us over both the CRNs as well as WSNs cause of these potential advantages [1]:

- Dynamic Spectrum Access
- Opportunistic use of channel with burst traffic
- Adaptability to reduced power consumption
- Overlaid deployment of multiple concurrent WSN
- Communication under different spectrum regulations.

Channel bonding is a scheme where contiguous non-overlapping wireless channels are combined to form a larger channel bandwidth. According to Shannon's capacity theorem the overall throughput of a channel is directly proportional to its bandwidth which means that with higher bandwidth better throughput can be obtained.

II. BACKGROUND: COGNITIVE RADIO SENSOR NETWORKS AND RELATED TERMS

A. Cognitive Radio

The term 'Cognitive Radio' was first coined by Dr. Joseph Mitola III in a conference at Stockholm. According to him "Cognitive Radio is a type of Software Defined Radio which continuously monitors its RF environment for Spectrum holes and provides this unused frequency band to another."The process by which CRs search for the unoccupied frequency bands in the RF environment is known as Spectrum sensing. [7] enlisted the methods through which CRs senses the spectrum. The RF spectrum environment consists of licensed and unlicensed frequency bands. With the advancements in telecommunication technologies and data networking the number of users of these licensed spectrum has increased exponentially to such an extent that allotted frequency bands are getting scantier.The concept of user Cognitive Radio came from the fact that these licensed spectrums remain unused for a greater interval of time as compared to the time of its usage [].CRs search for these unused bands and provide these to its users, thus helping in reducing the demands of bandwidth. The original users of the licensed spectra are called as primary users whereas the users who occupy the unused frequency bands through CRs are termed as secondary users.

The stage while CRNs perform spectrum sensing requires lot of transmitter's power:

- For continuously monitoring the spectral environment and search for spectrum holes.
- For calculations and estimations of availability of channels as per the CR user needs.
- For transmission and reception.
- Packet collisions and retransmissions of packets if it remains unacknowledged for specific time duration.

Optimal spectrum sensing can be obtained if a tradeoff between the time duration required for sensing the spectrum holes can be reduced []. Also in ref [] Liang et al. suggested that if we incorporate energy detection based spectrum sensing with cooperative sensing a 90% accuracy can be obtained when the signal to noise ratio of primary user radio is known. Despite of the advancements and studies in the field of CRNs the basic problem of interference of CR nodes into the already occupied PR nodes is yet to resolved completely with optimal throughput.

B. Wireless Sensor Networks

WSNs consists of a number of nodes distributed on a large physical space that are capable of sensing the environment, can compute accordingly and transfer the data wirelessly to a sink which is then connected to a server or data network using wired communication or wireless communication. The major requirements of wireless communication are:

- Robustness
- Latency
- Bandwidth
- Energy
- Density

Robustness gives WSNs the ability to convey the information without degradation even in the harshest environment whereas latency is delay associated with the end-to end communication between the sender and the receiver. Bandwidth is a major point of discussion as the data in WSNs are of usually of burst characteristics which requires high bandwidth for usually a small interval of time. Allotting specifically high bandwidth to each and every WSNs permanently is wastage of scarce resource i.e. bandwidth. Energy consumption place an important role in every phenomenon related with WSNs as the nodes are usually battery operated. Usually the number of nodes deployed in the field are much higher as compared to number of bands nodes can share thus the higher density results in congestion in the network. Providing cognitive ability to the wireless nodes in WSNs makes use of the available radio spectrum efficiently.

III. COGNITIVE RADIO SENSOR NETWORKS: BASICS, BENEFITS AND APPLICATIONS

The ability of cognitive radio to change its operating characteristics dynamically can be adapted by WSNs to increase its overall throughput. As the bandwidth provided to the WSNs is usually small as compared to the burst data that nodes need to transfer (for e.g. multimedia messages) data traffic tends to get slower due to congestion. Moreover, increasing number of packets of smaller size will result in increased number of overheads and also increase the energy consumed during computation. Cognition of the sensor nodes will provide the following benefits []:

- Ability to access the spectrum dynamically.
- Efficient way of energy consumption
- Opportunistic burst traffic transfer protocol.
- Coexistence of overlapping WSNs
- Communication under different spectrum regulations.

The major difference between classical sensor networks and CRSNs in terms of hardware is the replacement of traditional transceivers by transceivers with cognitive radio. When the intended sensor which needs to transmit sense the channel as empty it occupies the whole channel and sends the burst data in multi-hop manner from one node to another and ultimately to sink. When the channel is preoccupied the sensor has to wait until it is free again. Since the data content is usually not too long transmission time gets reduced due to large bandwidth and the nodes need not have to wait for too long for its turn. The channel can even be shared with other overlapping CRSNs when the all the nodes are ideal and there is nothing to transmit.

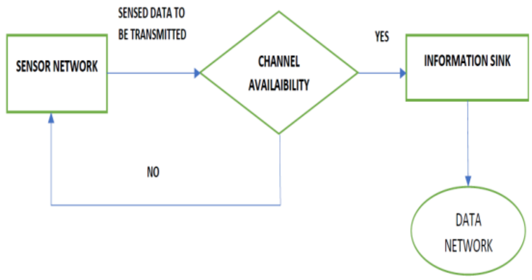

Fig. 1 Data flow in CRSNs

CRSNs may find its application in many fields due its ability to change its operating characteristics according to the radio spectrum environment. Some of the potential areas of application are:

- Defensive strategies and military based applications
- Indoor surveillance and home security.
- Traffic management.
- Smart grid applications
- Internet of things and making cities smarter.
- Bandwidth specific applications
- Health care applications and many more

CRSNs performance is limited by number of factors like false alarm, efficient sensing mechanisms, miss-detection, interference in PR nodes, security issues, power consumption and quality of services.

IV. CONCLUSION

CRSNs can make life easier and efficient for the WSNs by making them dynamic. There are much to be studied in this regard and the limitations has to be taken care of. CRSNs, if have contiguous bandwidth can be applied with different channel bonding schemes which will make the WSNs more efficient in terms of throughput and bandwidth efficiency.

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