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Energy Efficiency in Wireless Sensor Network: Survey and Discussions

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ABSTRACT
Cognitive radio (CR) technology provides a paradigm shift in the way scarce spectrum bands are being utilized. It is a relatively new area of research in wireless communication that provides efficient utilization of communication channels within the spectrum band. Wireless sensor network (WSN), which operates in the license-free industrial scientific and medical (ISM) band is faced with the problem of spectrum scarcity within this band due to over-crowding of different communication systems within this band. To solve this problem, CR is being proposed for WSN. In this paper we present the survey on wireless sensor network to solve the problem of traditional sensor networks, here we also survey the tools and techniques used in the wireless network such as cognitive radio sensor network.

Keywords: Cognitive radio, Wireless Sensor Network, Cognitive Radio Network, Wireless local Area Network, Spectrum Sensing, Cellular Networks.

INTRODUCTION
WSN is a popular and have capability to high penetrate with several applications areas. It consists of small nodes having limited sensing, computation, and wireless communications capabilities. A typical WSN usually consists of a large number of sensors, which are distributed over a given area and generate local observations, together with a fusion center (FC), where messages from sensors are decoded to reach a global decision. When the sensors and the FC are connected by wireless links, energy efficiency is one of the key issues for designing high performance WSNs. Wireless Sensor Networks are grossly employed in applications like environmental monitoring (for pollution and species monitoring), physiological monitoring, medical diagnosis (for computer aided detection of brain tumor, cardiovascular disorders & breast cancer renewable energy generation etc. . To optimize the usage of WSNs for various applicative trends, energy consumption forms the major cause of concern due to the energy consumed during transmission of data. This is so, because WSNs are mostly used in such areas where human approach is nearly impossible; and non-rechargeable batteries of sensor nodes cannot be recharged which leading to network failure.

The usual topology of wireless sensor networks involves having many network nodes dispersed throughout a specific physical area. There is usually no specific architecture or hierarchy in place and therefore, the wireless sensor networks are considered to be ad hoc networks. An ad hoc wireless sensor network may operate in a standalone fashion, or it may be connected to other networks, such as the larger Internet through a base station. Base stations are usually more complex than mere network nodes and usually have an unlimited power supply. Regarding the limited power supply of wireless sensor nodes, spatial reuse of wireless bandwidth, and the nature of radio communication cost which is a function of the distance transmitted squared, it is ideal to send information in several smaller hops rather than one transmission over a long communication distance. Wireless Sensor Networks (WSN) is one of emerged technology that is being rapidly adopted due to their flexibility and use in a various environments. Networks protocols in WSN have to achieve fault tolerance whenever individual node is failed and energy consumption [5] as to be reduced. Moreover the routing protocols in WSN should have capability to perform local collaboration to reduce the bandwidth requirements, since the channel bandwidth is shared among all the sensor nodes in the network.

WSN’s are one of best technology for monitoring critical situations and remote fields which far away from the human perspective. Network lifetime can be defined as the time elapsed until the first node (or the last node) in the network depletes its energy (dies). For example, in a military field where sensors are monitoring chemical activity, the lifetime of a sensor is critical for maximum field coverage. Energy consumption in a sensor node can be attributed to either “useful” or “wasteful” sources. Useful energy consumption can be due to (i) transmitting/receiving data, (ii) processing query requests, and (iii) forwarding queries/data to neighboring nodes. Wasteful energy consumption can be due to (i) idle listening to the media, (ii) retransmitting due to packet collisions, (iii) overhearing, and (iv) generating/handling control packets.

Cognitive radio is widely expected to be the next Big Bang in wireless communications, Spectrum regulatory Committees in many countries have been taking steps to open the door to dynamic spectrum access using this technology and also laying down the rules for its implementation. International organizations have also been striving for standardizing and harmonization this technology for various applications.

Cognitive radios are widely viewed as the disruptive technology that can radically improve both spectrum efficiency and utilization. Cognitive radios are fully programmable wireless devices that can sense their environment and dynamically adapt their transmission waveform, channel access method, spectrum use, and networking protocols as needed for good network and application performance. One of the applications of cognitive radio is more efficient, flexible, and aggressive dynamic spectrum access.

The rest of this paper is organized as follows in the first section we describe an introduction of about the wireless sensor and cognitive radio network. In section II we discuss about the component of wireless sensor network. In section III we discuss about the CRS application. In section IV we discuss about the rich literature for the cognitive radio and wireless sensor networks, finally in section V we conclude the about our paper which is based on the literature survey and specify the future scope.

II NODE HARDWARE COMPONENTS

A basic sensor node consists of five main hardware components namely: the processor; memory; sensor; communication device and power supply. Below Figure shows the schematic diagram of the sensor node components.

- **Processor**

The processor is the core of the wireless sensor node. It collects data from the sensor, processes the data, decides when and where to send it, receives data from other sensor nodes, and decides on the actuator’s behavior. It has to execute various programs, ranging from time critical signal processing to communications protocols to application programs. Essentially, it is the heart of the node.

- **Memory**

The memory component consists of Random Access Memory (RAM) to store intermediate sensor readings, packets from other nodes; and an Electrical Erasable Programmable Read-Only Memory (EEPROM) to store program code as RAM that loses its contents once the power supply is interrupted. Flash memory is EEPROM-like but enables data to be erased and written in blocks instead of bytes. It can also be used as intermediate storage if the RAM is insufficient but the long read/write access delays of flash memory and the high energy required must be accounted for when doing so.

➢ **Communication device**

The communications device is used to exchange data between individual nodes. The transmission medium of choice for sensor networks is Radio Frequency (RF) based communications. Although RF communications require modulation, filtering, and multiplexing circuitry, which make them more complex and expensive, it is preferred because it does not require visual line of sight between sender and receiver. Packets conveyed in the sensor network are small, data rates are low and frequency reuse is high due to the short communications distances. Typically, communications frequencies range between 433 MHz and 2.4 GHz.

➢ **Sensors**

Sensors used in WSN can be categorized into three categories. The first is passive, Omni-directional sensors that measure the quality at the point of the sensor nodes without actually manipulating the environment by active probing such as light sensors, microphones, thermometers, and vibration sensors. The second is passive, narrow beam sensors that have a well defined direction of measurement as in the case of cameras. The third is active sensors that actively probe the environment such as laser or sonar systems.

➢ **Power supply**

Once deployed, sensor nodes are usually inaccessible. As such, the lifetime of a sensor network is dependent on the power resources of the nodes. Hence, the nodes power supply is a crucial system component. The typical form of energy source are the traditional batteries which have a fixed lifespan. One way to extend the life of a node is by recharging the battery from the environment, i.e., energy scavenging [9]. Solar cells are an example of techniques used for energy scavenging.

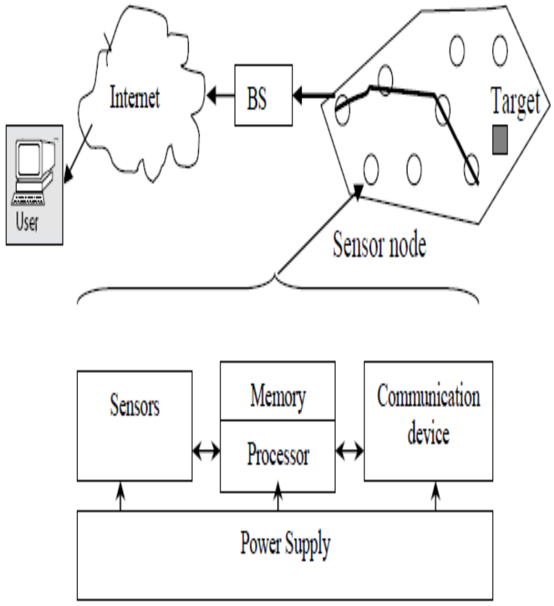

Figure 1: Components of a Sensor Node.

III CRS APPLICATIONS

More flexible and efficient use of spectrum in the future open up exciting opportunities for cognitive radio to enable and support a variety of emerging applications, ranging from smart grid, public safety and broadband cellular, to medical applications. This section presents a brief view on how cognitive radio would support such applications, the benefits that cognitive radio would bring, and also some challenges that are yet to be resolved.

- **PUBLIC SAFETY NETWORKS**

Wireless communications are extensively used by emergency responders (e.g., police, fire, and emergency medical services) to prevent or respond to incidents, and by citizens to quickly access emergency services. Public safety workers are increasingly being equipped with wireless laptops, handheld computers, and mobile video cameras to improve their efficiency, visibility, and ability to instantly collaborate with central command, coworkers, and other agencies. The desired wireless services for public safety extend from voice to messaging, email, web browsing, database access, picture transfer, video streaming, and other wideband services.

Video surveillance cameras and sensors are becoming important tools to extend the eyes and ears of public safety agencies. Correspondingly, data rates, reliability, and delay requirements vary from service to service. On the other hand, the radio frequencies allocated for public safety use have become highly congested in many, especially urban, areas. Moreover, first responders from different jurisdictions and agencies often cannot communicate during emergencies. Interoperability is hampered by the use of multiple frequency bands, incompatible radio equipment, and a lack of standardization.

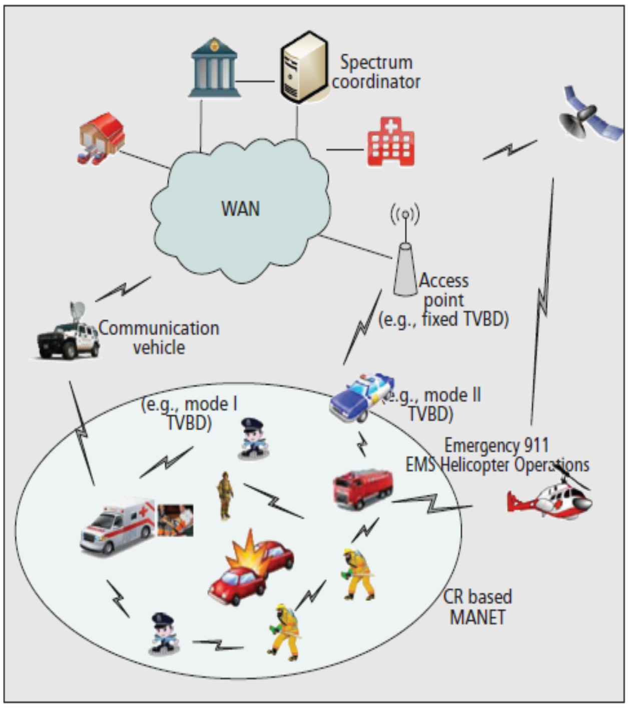

Figure 2: Public safety networks.

- **CELLULAR NETWORKS**

The use of cellular networks is undergoing dramatic changes in recent years, with consumers' expectations of being always connected, anywhere and anytime. The introduction of smart phones, the popularity of social networks, growing media sites such as Youtube, Hulu, and flickr, introduction of new devices such as ereaders, have all added to the already high and growing use of cellular networks for conventional data services such as email and web-browsing. This trend is also identified in the FCC's visionary National Broadband Plan. This presents both an opportunity and a challenge for cellular operators. The opportunity is due to the increased average revenue per user due to added data services. At the same time, the challenge is that in certain geographical areas, cellular networks are overloaded, due partly to limited spectrum resources owned by the cellular operator.

Recent analysis suggests that the broadband spectrum deficit is likely to approach 300 MHz by 2014, and that making available additional spectrum for mobile broadband would create value in excess of $100 billion in the next five years through avoidance of unnecessary costs. With the FCC's TVWS ruling, new spectrum becomes available to cellular operators. In the long term, television band spectrum that is currently not described as white spaces may also become available to cellular operators, as discussed in the National Broadband Plan. Specifically, the plan discusses the possibility for current license holders of television spectrum to voluntarily auction their licenses, in return for part of the proceeds from the auction.

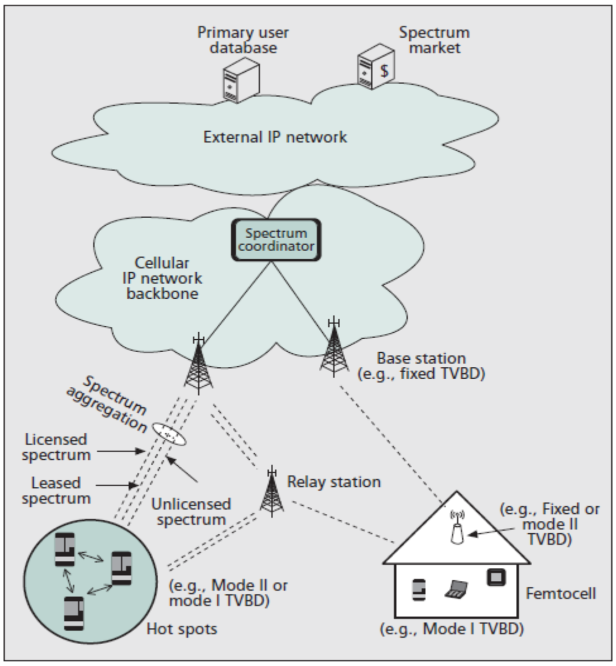

Figure 3: Cellular networks.

III RELATED WORK

In this section we discuss about the rich literature survey for the cognitive radio and wireless sensor networks**.**

[1] In this paper, they have studied the dynamic channel accessing problem to improve the energy efficiency in clustered CRSNs. By considering the energy consumption in channel sensing and switching, they have determined the conditions of sensing and accessing licensed channels for potential energy consumption reduction. It can provide some insights for making channel switching decisions in CRSNs, from the perspective of energy efficiency.

[2] In this paper, author present a survey on the novel design of CR based MAC, identify the main advantages and challenges of using CR technology, and compare the different method of improving energy efficiency. They believe that CR-WSN is the next-generation WSN. In this paper, they also discussed the open issues to motivate new research interest in this field. There are several medium access control protocols are designed for WSN as well as for CRN. Comparison and surveys of them are also published. But that protocols are not directly applicable to CR-WSN due to the limitation of wireless sensor node which is resource limited device. Recently, several studies on CR-WSN's protocols have been proposed and some of the papers also published which have already done a review on CRSN.

[3] In this work, they propose a resource allocation solution for the HCRSN to achieve the sustainability of spectrum sensors and conserve energy of data sensors. The proposed solution is achieved by two algorithms that operate in tandem, a spectrum sensor scheduling algorithm and a data sensor resource allocation algorithm. The spectrum sensor scheduling algorithm allocates channels to spectrum sensors such that the average detected available time for the channels is maximized, while the EH dynamics are considered and PU transmissions are protected. The data sensor resource allocation algorithm allocates the transmission time, power and channels such that the energy consumption of the data sensors is minimized.

[4] This paper examines the energy-throughput trade-off for cooperative spectrum sensing and formulates an optimization problem for the trade-off between energy and throughput for secondary users based on spectrum sensing efficiency. The objective is to minimize the energy consumed in spectrum sensing, reporting cooperative decisions to a central entity and data transmission while satisfying reliability constraints and providing a given throughput to secondary users. A heuristic solution is developed that determines the optimal sensing, reporting and transmission duration. Analysis and simulation results reveal the optimal value for sensing, reporting and transmission duration in order to achieve the best trade-off between energy consumption and throughput for secondary users.

[5] They present an optimization formulation to obtain the channel access policy for the secondary user to maximize its throughput. Both the case that the secondary user knows the current state of the channels and the case that the secondary knows the idle channel probabilities of channels in advance are considered. However, the optimization requires model parameters (e.g., the probability of successful packet transmission, the probability of successful RF energy harvesting, and the probability of channel to be idle) to obtain the policy. To obviate such a requirement, they apply an online learning algorithm that can observe the environment and adapt the channel access action accordingly without any a prior knowledge about the model parameters.

[7] In this paper, they discuss the potential benefits and current limitations of using cognitive radio techniques in industrial wireless sensor networks. Cognitive radio approaches can be added to the lower layers of existing industrial network stacks to improve resistance to interference, simplify coexistence with other industrial and consumer networks, and offer additional communication

spectrum to allow wideband communication or additional narrow-band channels.

[9] In this article, they provide an overview of the RF-powered CRNs and discuss the challenges that arise for dynamic spectrum access in these networks. Focusing on the tradeoff among spectrum sensing, data transmission, and RF energy harvesting, then we discuss the dynamic channel selection problem in a multi-channel RF-powered CRN.

[10] This paper focuses on the investigation of the receiver-based routing protocol for enhancing QoS in cognitive radio-enabled AMI networks, due to their potentials of enhancing reliability and routing efficiency. In accordance with practical requirements of smart grid applications, a new routing protocol with two purposes is proposed: one is to address the real time requirement while another protocol focuses on how to meet energy efficiency requirements.

[11] In this paper, a cognitive adaptive MAC (CAMAC) protocol, which supports opportunistic transmission while addressing the issue of power limitation in CRSNs, is proposed. Energy conservation in CAMAC is achieved in three fronts: on-demand spectrum sensing, limiting the number of spectrum sensing nodes, and applying a duty cycle. Spectrum sensing is initiated on-demand when the nodes have data to transmit, and it also exploits a subset of spectrum sensing nodes to gather spectrum availability information for all the nodes.

[12] This paper first focuses on providing a survey of CB schemes for traditional wireless networks such as cellular networks, wireless local area networks and wireless sensor networks, and then provides a detailed discussion on the CB schemes proposed for cognitive radio networks.

[13] This paper provides an overview of cognitive radio (CR) networks, with focus on the recent advances in resource allocation techniques and the CR networks architectural design. The contribution of this work is threefold. First, a systematic way to study the resource allocation problem is presented; various design approaches are introduced, such as signal-to interference and-noise ratio (SINR) or transmission power-based, and centralized or distributed methods.

[14] This paper formulates the two fundamental performance metrics in CRSN; bandwidth and delay. The performance is analyzed for a CSMA-based medium access control protocol that uses a common control channel for secondary users (SUs) to negotiate the wideband data traffic channel. The two performance metrics are derived based on the fact that SUs can exploit the cognitive radio to simultaneously access distinct traffic channels in the common interference region. This feature has not been exploited in previous studies in estimating the achievable throughput and delay in cognitive radio networks. Performance analysis reveals that dedicating a common control channel for SUs enhances their aggregated bandwidth approximately five times through the possibility of concurrent transmissions on different traffic channels and reduces the packet delay significantly.

[15] In this paper, a cognitive networking with opportunistic routing protocol for WSNs is introduced. The objective of the proposed protocol is to improve the network performance after increasing network scalability. The performance of the proposed protocol is evaluated through simulations. An accurate channel model is built to evaluate the signal strength in different areas of a complex indoor environment. Then, a discrete event simulator is applied to examine the performance of the proposed protocol in comparison with two other routing protocols. Simulation results show that when comparing with other common routing protocols, the proposed protocol performs better with respect to throughput, packet delay, and total energy consumption.

[17] In this paper, they study resource management and allocation for Energy Harvesting Cognitive Radio Sensor Networks (EHCRSNs). In these networks, energy harvesting supplies the

network with a continual source of energy to facilitate self-sustainability of the power-limited sensors. Furthermore, cognitive radio enables access to the underutilized licensed spectrum to mitigate the spectrum-scarcity problem in the unlicensed band. They develop an aggregate network utility optimization framework for the design of an online energy management, spectrum management and resource allocation algorithm based on Lyapunov optimization. The framework captures three stochastic processes: energy harvesting dynamics, inaccuracy of channel occupancy information, and channel fading.

[18] In this article author propose a secure and energy-efficient collaborative spectrum sensing scheme to resist SSDF attacks and enhance the energy efficiency in CRSNs. Specifically, they theoretically analyze the impacts of two types of attacks, i.e., independent and collaborative SSDF attacks, on the accuracy of collaborative spectrum sensing in a probabilistic way. To maximize the energy efficiency of spectrum sensing, we calculate the minimum number of sensor nodes needed for spectrum sensing to guarantee the desired accuracy of sensing results. Moreover, a trust evaluation scheme, named FastDtec, is developed to evaluate the spectrum sensing behaviors and fast identify compromised nodes. Finally, a secure and energy-efficient collaborative spectrum sensing scheme is proposed to further improve the energy efficiency of collaborative spectrum sensing, by adaptively isolating the identified compromised nodes from spectrum sensing.

V CONCLUSIONS AND FUTURE WORK

CR-WSN is a network of WS nodes with an extra feature of cognitive capabilities. They are not only using the white space/idle channel but also protect the rights of primary users (PUs), provide opportunistic channel access to WS nodes, dynamic spectrum access, improve the energy efficiency and reduce the overall delay. In this paper we presents the rich literature survey for the cognitive radio based wireless sensor network, in future we plan to implement the best solution for the problem discussed in the related work.

REFERENCES:-

[1] Ju Ren, Yaoxue Zhang, Ning Zhang, Deyu Zhang, and Xuemin Shen, “Dynamic Channel Access to Improve Energy Efficiency in Cognitive Radio Sensor Networks”, IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 15, 2016. pp 3143-3156.

[2] Jemish Maisuria, Saurabh Mehta, “An Overview of Medium Access Control Protocols for Cognitive Radio Sensor Networks”, 4th International Electronic Conference on Sensors and Applications, 2017. pp 1-7.

[3] Deyu Zhang, Zhigang Chen, Ju Ren, Ning Zhang, Mohamad Khattar Awad, Haibo Zhou, Xuemin (Sherman) Shen, “Energy Harvesting-Aided Spectrum Sensing and Data Transmission in Heterogeneous Cognitive Radio Sensor Network”, IEEE 2016. pp 1-20.

[4] Waleed Ejaz, Ghalib A. Shah, Najam ul Hasan, Hyung Seok Kim, “Energy and throughput efficient cooperative spectrum sensing in cognitive radio sensor networks”, TRANSACTIONS ON EMERGING TELECOMMUNICATIONS TECHNOLOGIES, 2014. pp 1-12.

[5] Dinh Thai Hoang, Dusit Niyato, Ping Wang, Dong In Kim, “Opportunistic Channel Access and RF Energy Harvesting in Cognitive Radio Networks”, IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, VOL. 32, 2014. pp 2040-2054.

[6] Ayaz Ahmad, Sadiq Ahmad, Mubashir Husain Rehmani, and Naveed Ul Hassan, “A Survey on Radio Resource Allocation in Cognitive Radio Sensor Networks”, IEEE COMMUNICATION SURVEYS & TUTORIALS, VOL. 17, 2015. pp 888-917.

[7] Tapiwa M. Chiwewe, Colman F. Mbuya, Gerhard P. Hancke, “Using Cognitive Radio for Interference Resistant Industrial Wireless Sensor Networks: An Overview”, IEEE 2015. pp 1-16.

[8] Ghalib A. Shah, Member, IEEE, Fatih Alagoz, Member, IEEE, Etimad A. Fadel, and Ozgur B. Akan, "A Spectrum-Aware Clustering for Efficient Multimedia Routing in Cognitive Radio Sensor Networks", IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 63, 2014. pp 3369-3380.

[9] Lu Xiao, Ping Wang, Dusit Niyato, Ekram Hossain, "Dynamic Spectrum Access in Cognitive Radio Networks with RF Energy Harvesting", 2014. pp 1-16.

[10] Zhutian Yang, Shuyu Ping, Hongjian Sun, A. Hamid Aghvami, "CRB-RPL: A Receiver-based Routing Protocol for Communications in Cognitive Radio Enabled Smart Grid", Durham Research Online, 2016. pp 5985-5994.

[11] Ghalib A. Shah, Ozgur B. Akan, "Cognitive Adaptive Medium Access Control in Cognitive Radio Sensor Networks", IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 64,2015. pp 757-857.

[12] Syed Hashim Raza Bukhari, Mubashir Husain Rehmani, and Sajid Siraj, "A Survey of Channel Bonding for Wireless Networks and Guidelines of Channel Bonding for Futuristic Cognitive Radio Sensor Networks", IEEE Communications Surveys and Tutorials, 2016. pp 924-948.

[13] Georgios I. Tsiropoulos, Octavia A. Dobre, Mohamed Hossam Ahmed, and Kareem E. Baddour, "Radio Resource Allocation Techniques for Efficient Spectrum Access in Cognitive Radio Networks", IEEE COMMUNICATION SURVEYS & TUTORIALS, VOL. 18, 2016. pp 825-849.

[14] J. Ren, Y. Zhang, K. Zhang, and X. Shen, "Exploiting mobile crowdsourcing for pervasive cloud services: Challenges and solutions," IEEE Commun. Mag., vol. 53, no. 3, pp. 98–105, Mar. 2015.

[15] N. Zhang, H. Liang, N. Cheng, Y. Tang, J. W. Mark, and X. Shen, "Dynamic spectrum access in multi-channel cognitive radio networks," IEEE J. Sel. Areas Commun., vol. 32, no. 11, pp. 2053–2064, Nov. 2014.

[16] O. B. Akan, O. Karli, and O. Ergul, "Cognitive radio sensor networks," IEEE Netw., vol. 23, no. 4, pp. 34–40, Jul./Aug. 2009.

[17] M. Timmers, S. Pollin, A. Dejonghe, L. Van der Perre, and F. Catthoor, "A distributed multichannel mac protocol for multihop cognitive radio networks," IEEE Trans. Veh. Technol., vol. 59, no. 1, pp. 446–459, Jan. 2010.

[18] S. Bayhan and F. Alagoz, "Scheduling in centralized cognitive radio networks for energy efficiency," IEEE Trans. Veh. Technol., vol. 62, no. 2, pp. 582–595, Feb. 2013.

[19] Z. Liang, S. Feng, D. Zhao, and X. Shen, "Delay performance analysis for supporting real-time traffic in a cognitive radio sensor network," IEEE Trans. Wireless Commun., vol. 10, no. 1, pp. 325–335, Jan. 2011.

[20] A. O. Bicen, V. C. Gungor, and O. B. Akan, "Delay-sensitive and multimedia communication in cognitive radio sensor networks," Ad Hoc Netw., vol. 10, no. 5, pp. 816–830, 2012.

[21] S.-C. Lin and K.-C. Chen, "Improving spectrum efficiency via in-network computations in cognitive radio sensor networks," IEEE Trans. Wireless Commun., vol. 13, no. 3, pp. 1222–1234, Mar. 2014.

[22] P. T. A. Quang and D.-S. Kim, "Throughput-aware routing for industrial sensor networks: Application to ISA100. 11a," IEEE Trans. Ind. Informat., vol. 10, no. 1, pp. 351–363, Feb. 2014.

[23] N. Zhang, N. Lu, N. Cheng, J.W. Mark, and X. Shen, "Cooperative spectrum access towards secure information transfer for CRNS," IEEE J. Sel. Areas Commun., vol. 31, no. 11, pp. 2453–2464, Nov. 2013.

[24] Y.-C. Liang, Y. Zeng, E. Peh, and A. T. Hoang, "Sensing-throughput tradeoff for cognitive

radio networks," IEEE Trans. Wireless Commun., vol. 7, no. 4, pp. 1326–1337, Apr. 2008.

[25] O. Simeone, I. Stanojev, S. Savazzi, Y. Bar-Ness, U. Spagnolini, and R. Pickholtz, "Spectrum leasing to cooperating secondary ad hoc networks," IEEE J. Sel. Areas Commun., vol. 26, no. 1, pp. 203–213, Jan. 2008.

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