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A Review on Cognitive Radio Sensor Networks for Internet of Things

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Abstract

Cognitive radio sensor networks (CRSNs) can effectively manage communication through clustering. This paper examines Internet of Things Cognitive Radio Sensor Networks. An important step towards a world of smart technology is the Internet of Things (IoT) system based on Cognitive Radio (CR). Many frameworks for creating CR-based IoT systems have been put forth. IoT frameworks based on CR are the main topic of the survey. One possible approach to improving the effectiveness of wireless communication in the Internet of Things (IoT) is the use of Cognitive Radio Sensor Networks (CRSNs). The increasing number of IoT devices cannot be supported by traditional wireless sensor networks due to issues like interference and spectrum constraint. By using cognitive radio technology, CRSNs solve these problems by enabling sensors to dynamically sense, adjust, and use available frequency bands. Although CRSNs have many advantages, there are various difficulties associated with their implementation. Managing the spectrum is still a vital concern, necessitating efficient policies and algorithms to control access to the spectrum and prevent clashes with primary users. Moreover, energy limitations present a challenge because IoT devices need to function effectively within restricted power supplies. Concerns about security, including breaches of data and unauthorized access, necessitate effective countermeasures to safeguard the integrity of the network. This analysis examines the design, essential elements, and operational concepts of CRSNs, emphasizing how they enhance network performance and spectrum efficiency. It talks about the benefits of CRSNs, such as improved energy efficiency, communication dependability, and flexibility under changing conditions. We also examine the difficulties in implementing CRSNs, including spectrum management issues, energy limitations, and security concerns.

Keywords: Internet of Things, cognitive radio, wireless sensor networks, clustering protocol, WI MAX

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INTRODUCTION

Cognitive sensor technology that allows cognitive sensors (CSs) to access randomly licensed channels is suggested considering the severe increase in demand for wireless services and the limited availability of spectrum resources. Many people consider radio sensor networks (CRSNs) to be a viable option for reliable and effective wireless Internet networks (IoT).

An effective technique for controlling connections to CRSNs is clustering. To guarantee the proper organization of spectrum-aware connections, Integrated CRSN assigns local coordinators to oversee the network. However, because spectrum dynamics cause the typical topology variation of CRSNs, existing methods suffer from high frequency interactions. The number of devices connected to the Internet has increased because of technological advancements. By 2020, there will be 200 billion connected devices, up from 2 billion in 2006, according to Intel. By 2020, 75% of automobiles will have an Internet of Things (IoT) connection, predicts Business Insider.

Therefore, a lot of new problems arise every day because of the Internet of Things' (IoT) unprecedented growth in the number of devices connected to the Internet. Today, IoT applications are everywhere. In recent years, several new IoT-related objectives have surfaced, such as smart industries, smart transportation, smart agriculture, smart cities, smart homes, and smart living. Therefore, putting IoT systems into place will save a lot of money and generate income in many areas, especially in keeping an eye on things and providing maintenance services. As a result, these growths have compelled businesses to implement a variety of strategies to address dynamic growth and associated challenges, such as allocating adequate spectrum belts to IoT systems. These include poor transmission performance, insufficient spectrum, spectrum sharing, device interference, and so on. In recent years, the implementation of Cognitive Radio Networks (CRNs) on the Internet of Things has shown comparable or superior performance to that of currently used networks like Bluetooth, Wi-Fi, and WI MAX. To create concerning spectrum resources, one of the main challenges is figuring out how to regulate and manage the Radio Frequency (RF) spectrum. As wireless communication systems expand at an unprecedented rate, users and applications are consuming more spectrum, which makes it crucial for connected devices to communicate with one another. Consequently, there is a growing need for intelligent gadgets that can control and modify transmission limits by detecting spectrum in spatiotemporal sizes. Cognitive Radio (CR), a versatile radio and network technology that automatically recognizes wireless spectrum channels and modifies transmission parameters to allow for more communication while enhancing radio behavior, is the best candidate technology. The four stages of CR's awareness cycle are hearing, sharing, mobility, and decision-making. The SS phase, which begins the perception cycle, uses a variety of SS techniques to acquire available spectrum resources over the selected spectrum band. Either the band should be shared or the transfer to that band should be stopped, depending on the acquisition results. To guarantee PU protection, power allocation should be considered and the proper Medium Access Control (MAC) protocol used if CR chooses to use the band. Finally, the movement phase is used to switch between bands. The main design characteristics of CR-based IoT systems are covered in this work first. Additionally, the study examines the latest research on spectrum sharing and SS, separates them, talks about how they are used on the Internet of Things, and presents the best MAC protocol and SS technique for the IoT system based on -CR. Additionally, the MAC protocols utilized in this field are analysed and contrasted by this function.

LITERATURE REVIEW

Meng Zheng, et al. [1] encouraged CRSNs to use the network stability-aware clustering (NSAC) protocol. For the first time, spectrum dynamics and energy consumption are incorporated into the design of the NSAC protocol. Extensive mimicking shows that the suggested NSAC protocol performs noticeably better than current methods in terms of power consumption and network stability.

FAROQ A et al. [2] outlined hearing and sharing techniques and talks about their suitability and constraints. The design characteristics of CR-based IoT are also covered in this survey, along with advice on selecting the most effective SS and access techniques. The survey also examines the integration of CR-based IoT systems with new and developing technologies. The survey ends with open-ended questions and suggestions for additional research after discussing some of the new issues.

Heejung et al. [3] highlighted the difficulties facing the upcoming generation of IoT networks, which need to increase output without compromising reliability while continuously lowering overall network latency. Utilizing various frequencies for networking is an additional choice. But supplying data bandwidth and guaranteeing spectrum availability are difficult tasks. Therefore, the best technology to handle all the issues of IoT, WSN, 5G, and beyond is understanding radio networks (CRN).

W.S Ahmed et al. [4] The objective is to perform a comprehensive analysis of the latest 5G-enabling technology and spectrum-sharing technology (SS) in development. In addition to reviewing surveys and studies on SS strategies for 5G networks, SS strategies are categorized. The three primary SS methods were determined by the network structure, spectrum distribution behavior, and spectrum access method of the surveys and studies. Additionally, there is a comprehensive study being conducted on radio technology (CR) in SS in relation to the deployment of 5G.

According to Abdelmohsen et al. [5], key methods are classified according to radio parameters. We then examine the current spectrum sensor functions utilized in different categories, including collaboration sensors, narrowband sensing, narrowband spectrum monitoring, wideband sensing, and practical application considerations for different techniques. Finally, we examine the latest levels based on the interweave network model. Furthermore, we outline the most recent advancements in asset spectrum sensing methodology. We end this survey paper by outlining some unrestricted research questions and recommendations for CR networks in applications for the next generation of the Internet of Things.

Antoni et al. [6] provided a detailed analysis of the spectrum sensitivity mechanisms that are discernible from received signal samples by a factor that extracts them to give the main user (PU) accurate signal processing. The main characteristics of each type are outlined, along with their advantages and disadvantages, including computer complexity, model/sound prediction, probability, intensity, and dimension. A wireless approach-based method is presented to elucidate the function of spectrum-based CR in future networks, based on existing 6G network and application concepts.

Erick et al. [7] provided an overview of the needs of smart cities established by Cooperative Sensor Networks. Based on the challenges due to emerging needs and rapid technological advancement, the front radio frequency (RF) transmitter must restructure its normal configuration to achieve service integration. An RF-frontend architecture solution for a system based on the Internet sensor network is proposed. It has been suggested that modern technology should be developed in terms of spectrum allocation, operational bandwidth and energy consumption.

Simon Haykin and Peyman Setoodeh [8] explored different approaches to managing spectrum access in wireless networks, focusing on two distinct models: open-access and market-driven spectrum allocation. Each model offers unique advantages and is better suited to specific scenarios, highlighting their complementary roles in spectrum management. The authors present analytical models that help in understanding both the steady-state (equilibrium) and dynamic (transient) behaviours of these networks. Their research provides valuable insights into optimizing spectrum utilization, ensuring efficient communication in various network environments.

Ayaz Ahmad et al. [9] presented a comprehensive review of recent advancements in radio resource allocation for Cognitive Radio Sensor Networks (CRSNs). Resource allocation strategies are categorized into three primary types: centralized, cluster-based, and distributed approaches. Each category undergoes further examination based on crucial performance optimization factors, including energy efficiency, throughput enhancement, quality of service (QoS) assurance, interference mitigation, fairness, priority handling, and handoff reduction. Their research provides valuable insights into the various methodologies employed to optimize radio resource allocation, aiding in the efficient functioning of CRSNs.

Design Factors of CR-Based IoT Systems

The primary goal of an Internet of Things (IoT) system is to create seamless connectivity between various devices and platforms while ensuring efficient resource usage. Factors, such as cost, power consumption, and hardware complexity must be minimized without compromising performance. Maintaining uninterrupted connectivity is essential for IoT networks to function effectively, which highlights the importance of efficient spectrum utilization and signal sensing (SS) mechanisms in CR-based IoT systems.

For a CR-enabled IoT device, selecting an optimal SS strategy is crucial to ensure smooth communication while adhering to spectrum-sharing protocols. Additionally, designers must allocate spectrum bands carefully, making use of available frequency gaps while ensuring minimal disruption to primary users (PUs). To achieve these objectives, the following aspects must be considered:

- *IoT Applications:* The specific use cases and requirements of IoT solutions must be analyzed to determine the most suitable network and communication strategies.
- *Enabling Technologies:* The integration of CR with IoT requires leveraging advanced technologies, such as artificial intelligence, machine learning, and cloud computing for effective spectrum management.
- *Regulatory Compliance:* IoT systems must adhere to spectrum allocation and usage policies defined by governing authorities to prevent interference and ensure efficient coexistence with existing communication networks.

APPLICATIONS OF IOT IN SMART SYSTEMS

IoT technology is revolutionizing various sectors by enabling automation, smart decision-making, and real-time data exchange. Some key applications include:

- *Smart Access Control Systems:* Automated security systems for doors that use sensors and wireless authentication to control entry.
- *Intelligent Lighting Solutions:* Energy-efficient lighting systems for homes and offices that adjust brightness based on occupancy and ambient conditions.
- *Automated Garage and Gate Control:* Remote-controlled and sensor-driven gate and garage door automation for improved security and convenience.
- *Climate Control Systems:* Smart humidity controllers and thermostats that optimize indoor climate settings based on environmental conditions.
- *Traffic Management Systems:* IoT-enabled traffic monitoring and control solutions that help optimize vehicle movement and reduce congestion.
- *Smart Street Lighting:* Adaptive lighting systems that adjust brightness based on traffic flow and pedestrian activity to conserve energy.
- *Environmental Monitoring:* Sensors that track air pollution levels and report real-time data for better urban air quality management.
- *Smart Parking Solutions:* IoT-based parking systems that help drivers locate available parking spots and optimize space usage.

These applications demonstrate how IoT, combined with cognitive radio technology, can significantly enhance automation, efficiency, and sustainability in various domains.

CONCLUSIONS

To the best of our knowledge, this paper looks at all the methods that deal with the spectrum allocation/CRIOT editing problem. It should be noted that while most IoT configurations do not use this number, most of the research in this field does. One new way to increase the number of IoTs is to add edge nodes that can control the number of IoTs to control channel planning and CRN allocation.

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