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EFFICIENT POWER-AWARE PROTOCOLS FOR GREEN COGNITIVE RADIO NETWORKS IN INDUSTRIAL COMMUNICATIONS

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Abstract. In industrial environments characterised by harsh communication conditions and spectrum scarcity, cognitive radio networks (CRNs) offer promising solutions to enhance communication reliability and efficiency. However, leveraging CRNs in such environments requires addressing challenges related to spectrum detection, allocation, and energy-efficient transmission. To tackle these challenges, we propose an integrated system that combines intelligent spectrum detection, spectrum allocation using reinforcement learning, Dynamic spectrum access (DSA) with Proximal policy optimisation (PPO), and energy-aware transmission optimisation. Our proposed system aims to enhance the performance and sustainability of CRNs in industrial settings by accurately identifying available spectrum bands, optimising spectrum allocation, and dynamically adjusting transmission parameters based on real-time channel conditions and energy constraints. We employ spectral density estimation and detection thresholds for intelligent spectrum detection, reinforcement learning-based spectrum allocation for efficient spectrum utilisation, and DSA with PPO for adaptive transmission parameter adjustment. Additionally, energy-aware transmission optimisation ensures minimal energy consumption while maintaining reliable communication links. Experimental results demonstrate the effectiveness of our proposed system in optimising energy consumption, improving data transmission efficiency, and enhancing network reliability in industrial CRNs. Overall, our system presents a comprehensive approach to address the challenges of spectrum scarcity and energy efficiency, making it suitable for various industrial communication applications.

Keywords: industrial application, cognitive radio network, energy efficient protocol.

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AIMS AND BACKGROUND

In harsh communication environments mountainous regions and natural disasters, where traditional communication methods face severe time delays[1]. Leveraging cognitive radio network (CRN) technology with an energy harvesting approach, these protocols identify and utilise unused spectrum bands opportunistically to mitigate spectrum scarcity issues[2]. CRNs enable secondary users (SUs) to continuously sense primary users' (PUs) spectrum, ensuring the security of PU data transmission while accessing vacant spectrum for their own transmission needs[2]. Additionally, CR networks play a vital role in advancing fifth-generation (5G) wireless communication systems, offering solutions to key issues like high-speed data transmission, seamless connectivity, and increased mobile data demands[3]. The emergence of 5G green communication systems signifies a revolutionary leap in technology, promising faster, more reliable, and secure internet connectivity[4]. Furthermore, wireless sensor networks (WSNs) play a crucial role in this context, facilitating the monitoring and transmission of environmental data via multihop routing[5]. The various studies present advancements in CRNs, Firstly, a channel reservation scheme managed by a centralised cognitive manager (CCM) optimises dynamic spectrum access (DSA), ensuring uninterrupted service for SUs while meeting PUs quality of service (QoS) requirements[6]. Secondly, a hybrid prediction model, KHWO-ACNN-HMM, enhances spectrum sensing accuracy in CR networks. It combines krill-herd whale optimisation, actor critic neural network (ACNN), and hidden Markov model (HMM) techniques, providing more precise spectrum allocation[7]. In line with these advancements, our proposed system contributes to the field of cognitive radio networks by introducing the Energy-Aware Transmission Optimisation Protocol, which enhances load balancing among cluster heads (CHs) and reduces overall network energy consumption. By strategically positioning CHs near energy centroid locations and selecting gateway nodes for multi-hop communication to transmit data to the base station (BS), our protocol maximises CH coverage and minimises transmission power. Through the integration of energy consumption modelling, energy centroid calculation, gateway node selection, and CH joining weight computation, our protocol optimises network performance and energy efficiency. Additionally, the protocol's three-phase process, including CH selection, gateway selection, and data transmission, ensures reliable and energy-efficient data transfer, making it suitable for applications requiring robust and sustainable communication solutions within cognitive radio networks.