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**Abstract:**

The invention provides advanced signal processing methods designed to significantly improve the performance and efficiency of Cognitive Radio Networks (CRNs). It incorporates adaptive spectrum sensing using machine learning algorithms to enhance the accuracy of spectrum availability detection and interference identification. The invention also features advanced interference mitigation techniques, such as adaptive filtering and signal separation, to reduce interference from adjacent channels and improve signal quality. Intelligent resource allocation is achieved through AI-driven algorithms that dynamically optimize spectrum and power usage based on real-time network conditions. Additionally, the invention enables real-time adaptation of modulation and coding schemes to match varying channel conditions, enhancing data throughput and reliability. Cross-layer optimization integrates these improvements across different network layers to achieve a cohesive and efficient network performance. By addressing current limitations in the invention transforms wireless communication systems, enabling more flexible, adaptable, and efficient use of the radio spectrum.

**Complete Specification**

**Description:**The embodiments of the present invention generally relates to the field of wireless communications, with a specific focus on Cognitive Radio Networks (CRNs). More particularly, the invention addresses advancements in signal processing methodologies that enhance the performance, efficiency, and adaptability of CRNs. This includes improving spectrum management, optimizing signal detection and interference mitigation, and implementing dynamic resource allocation techniques. The invention is applicable to various domains within wireless communications, including but not limited to cellular networks, satellite communications, and ad hoc networks, where cognitive radio principles and advanced signal processing techniques can be utilized to address the challenges associated with spectrum scarcity and dynamic network conditions.

**BACKGROUND OF THE INVENTION**

The following description of related art is intended to provide background information pertaining to the field of the disclosure. This section may include certain aspects of the art that may be related to various features of the present disclosure. However, it should be appreciated that this section be used only to enhance the understanding of the reader with respect to the present disclosure, and not as admissions of prior art.

In the rapidly evolving field of wireless communications, the efficient use of the radio frequency spectrum has become a critical challenge. Traditional wireless communication systems are often constrained by static spectrum allocation, leading to suboptimal utilization of available frequencies and increased interference. This is exacerbated as the demand for wireless services continues to grow, pushing the limits of spectrum availability and network performance.

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