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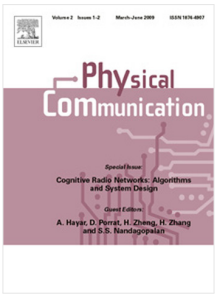

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A Network Steganographic Approach to Overlay Cognitive Radio Systems Utilizing Systematic Coding

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***Abstract*—Network steganography is an information hiding technique that utilizes network protocols to facilitate hidden communication. The aim is to embed secret information bits into regular network traffic (as a carrier) so that confidential data can be transmitted covertly between two communicating parties. In this paper, the concept of network steganography is extended for overlay cognitive radio networks utilizing cooperative relaying protocols with systematic channel codes. In the considered model, the cognitive node relays the primary data according to a time-slotted decode-and-forward cooperative protocol with maximum-ratio combining (MRC) at the primary destination. We propose a steganographic approach in which the cognitive node embeds confidential cognitive data at the wavelet transform domain into primary data code words. In this approach, the embedding operation is designed to preserve the statistical properties of the cover data in terms of decoded BER after MRC decoding of code words at the destination node which includes both the effect of wireless channel errors and errors due to embedding distortion. From this point of view, the proposed scheme may be seen as a lossless steganography scheme that embeds secret data into coded data strings. We provided implementation examples using both systematic BCH and turbo channel coding. The results show that the proposed scheme can provide diversity gain using stego-based MRC at the primary receiver and covert confidential cognitive data communications simultaneously.**

***Index Terms*—Overlay cognitive radio network; systematic coding; covert communication; network steganography.**

I. Introduction

Cognitive radio technology has emerged as a new wireless data transmission paradigm which can improve spectrum utilization through opportunistic spectrum access [1]. A precise look at the Federal Communications Commission (FCC) frequency allocation chart reveals that most of wireless spectrum has been already assigned and currently there is no considerable additional bandwidth for new emerging wireless systems which makes the design of such systems a challenging task [2]. In this regard, according to a cognitive radio paradigm, a smart wireless device can opportunistically access to parts of previously assigned spectrum that are underutilized by the owner of the spectrum bandwidth. In the literature, three main cognitive radio paradigms are classified as underlay, overlay (the focus of this paper), and interweave [1]. In wireless networks the cooperative relaying technology may be utilized to achieve the spatial diversity and the throughput gain. As illustrated in [3-4], cooperative relaying may be realized by transmission between primary and secondary (cognitive) users in a way that the secondary user acts as a relay for the primary user transmission. In particular, in [4] the overlay cognitive paradigm using cooperative relaying has been described as a system in which the primary licensed user leases some of the owned spectral resources to the secondary user in exchange for the cooperation. In this scheme, a minimum quality-of-service constraint is set by the cognitive user as a requirement for cooperation on the leased spectrum, and the overall result of cooperation leads to an improved performance of the primary system. In such system, the secondary user forwards packets of the primary user that have not been correctly received by the primary destination. Clearly adding relaying capability to the cognitive transmitter would be helpful if the two-hop propagation channel from the primary transmitter to the primary receiver (through the secondary transmitter) has a better signal-to-noise (SNR) state with respect to the direct primary transmitter-receiver channel.

Most of the reported research works in the area of cognitive radio networks has been focused on the development of efficient algorithms related to topics such as spectrum sensing, allocation and sharing, and transmission strategy design [1][3-5]. It should be noted that in the design of such algorithms system security and covertness aspects are not considered. However, in practice there is several security issues related to the applicability of cognitive radio paradigm in wireless networks [6]. For example, in the context of smart grid networks information related to consumers is private and needs to remain confidential when transmitted through cognitive radio techniques over the network. Hence, to achieve this goal, network elements (e.g., smart meters) within the smart grid have to implement security and covertness functions to guarantee data privacy [7-8]. In this paper, we specially focus on the design of a covert secure transmission protocol for overlay cognitive radio systems in which the privacy aspect of cognitive data transmission is directly considered as a design goal in a network steganographic framework.

Steganography is the technique of concealing confidential information bits into cover media (data) so as to be undetectable by eavesdroppers. This method is especially

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