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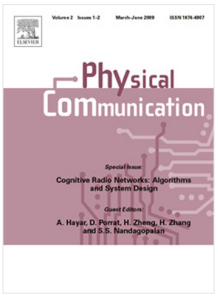

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Performance Evaluation of Cognitive Underlay Multi-hop Networks with Interference Constraint in Rayleigh Fading Channels Perturbed by Non-Gaussian Noise

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***Abstract*—In this paper, the performance of regenerative decode-and-forward (DaF) cognitive multi-hop underlay networks over independent but non-identically distributed (i.n.i.d.) Rayleigh fading channels with additive white generalized Gaussian noise (AWGGN) is analyzed. Precisely, we derive exact analytical expressions for the average bit error rate (BER) of M-ary quadrature amplitude modulation (M-QAM) and M-ary phase shift keying (M-PSK). Besides, an exact expression for the average symbol error rate (SER) of M-QAM is obtained. In addition, lower- and upper-bound expressions for the end-to-end ergodic capacity is provided. Some representative numerical examples are presented to study the impact of the noise shaping parameter and average power of the interfering and secondary links on the system performance. Our obtained analytical results are supported with Monte-Carlo simulations to validate the accuracy of the analytical derivations.**

***Index Terms*—Bit error rate, cognitive networks, generalized Gaussian noise, multi-hop communication, spectrum sharing.**

I. Introduction

COGNITIVE radio (CR) technology is proposed to improve spectrum utilization, and therefore may alleviate the spectrum scarcity in wireless communication systems [1, 2]. In the literature, there are two types of cognitive operational modes, namely, opportunistic spectrum access (OSA) and spectrum sharing (SS). In the OSA approach, secondary users (SUs) are allowed to opportunistically access the licensed spectrum only when it is not occupied by licensed primary users (PUs). However, SUs should immediately vacate that spectrum if PUs activity is detected. In the SS approach, the SUs (e.g., source and relays) are allowed to transmit as long as the generated interference does not exceed a predefined interference temperature limit at the primary receivers. However, in spite of the burden on PUs, the SS approach can improve spectral efficiency when compared to the OSA approach.

Relay communications has been a promising approach for improving the throughput and extend the coverage of wireless communications systems. In general, relays can be classified into two main categories: regenerative (decode-and-forward (DaF)) or non-regenerative (amplify-and-forward (AaF)). In regenerative networks, each relay node decodes the received signal and then forwards it to the next relay node. On the other hand, in non-regenerative networks, each relay node amplifies and forwards the received signal without any sort of decoding.

The performance of wireless networks is extensively analyzed over the past decades. In [3], the authors studied the end-to-end outage probability performance of cognitive DaF generalized order relay selection network where the PU receivers utilize orthogonal spectrums in Rayleigh fading channels and in the presence of interference. A new method for analyzing the bit error rate (BER) performance of two-hop AaF multiple relay networks is presented in [4]. The BER is derived assuming a flat-fading channel and a relay selection scheme based on the highest signal-to-noise ratio. A closed form expressions for the end-to-end BER of binary phase-shift keying (BPSK) modulation and end-to-end outage probability for two-hop DaF opportunistic relaying over Rayleigh fading channels were derived and evaluated in [5]. Deng and Wang analyzed the capacity performance of multi-hop Gaussian relay channel with linear relaying in [6]. The best relay selection scheme in a cooperative network with multiple fixed gain relays operating in non-identical Nakagami-m fading channels is analyzed in [7]. The authors in [8] derived closed-form expressions for the average BER of M-ary phase shift keying (M-PSK) and outage probability in a two-hop multi-antenna regenerative relaying system over Rayleigh fading channel. In [9], the authors analyzed the end-to-end BER of a traditional multi-hop regenerative relaying system over the α-μ fading channels with additive white generalized Gaussian noise (AWGGN). The outage probability of multi-hop relayed wireless networks is analyzed in the η-μ fading channels when both regenerative and non-regenerative relays are deployed [10]. In [11], the authors analyzed the outage probability and error performance of a regenerative DaF multi-hop cognitive relaying system over Nakagami-m fading channels subject to an AWGN. Muller and Speidel derived the exact symbol error probability (SEP) of M-PSK and M-QAM constellations in multi-hop communication systems with DaF relays are derived and evaluated in [12]. The authors in [13] studied the performance of multi-hop communications in wireless systems over generalized-K (K_G) fading channels. The performance was evaluated under different performance metrics such as SER, outage probability, average outage duration, and level crossing rate. The performance of an underlay cognitive radio network over α-μ fading channels in terms SER and effective capacity is analyzed in [14]. The analysis considered the peak interference power constraint in order to limit the interference to the primary user receiver. The authors in [15] investigated the performance of two-hop opportunistic relay in Rayleigh fading environment. To this end, an analytical expression for outage probability is derived and evaluated, and then its performance is compared with a single-hop single-input-multiple-output system in high path-loss conditions. Furthermore, the authors showed that the performance of the system can further be improved by proper power allocation and relay positioning.

In the literature, the performance of multi-hop underlay cognitive networks has been analyzed under different fading channels subject to AWGN. However, in practice, not all types of noise

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