Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 3, March : 2023

A NOVEL APPROACH FOR COGNITIVE RADIO NETWORKS WITH NON ORHOGONAL MULTIPLE ACCESS SCHEME.

Author: Subhendu kumar Behera (DRIEMS)
Author: Sukanta kumar Biswal (TITE)
Author: Surya Narayan Sahoo (TITE)
Author: Jibanananda Mishra (KEC)
Author: Subhendu Pani (KEC)

Abstract: -

Non-orthogonal multiple access (NOMA) has been identified as a promising multiple access technique, which can handle the high traffic volume and optimize spectral efficiency (SE) . In the NOMA technique, multiple users can be served by shared frequency/code/time resources, but with various power allocation (PA) factors. In particular, NOMA gives additional power to users with weak channel quality while using successive interference to help users with stronger channel conditions recognise their own signals.. Another technique that can improve the SE is an underlay cognitive radio (CR) network, where secondary users (SUs) are allowed to transmit only if they do not cause harmful interference to primary users (PUs). The joint study of the NOMA and CR techniques can provide further improvement in the efficient spectrum utilization. Considering this fact, the underlay CR-NOMA network was investigated, where the secondary transmitter sends a superimposed signal to the secondary NOMA destination users. This paper surveys such studies, dealing with different architecture which include both cognitive radio with NOMA.

Introduction: - Explosive growth of mobile data traffic and the proliferation of Internet of Things (IoT) devices have led to ever-increasing demand for wireless communication services that support high spectral efficiency (SE), high data rate and massive user access. According to the 3rd generation partnership project (3GPP), fifth generation (5G) wireless networks are envisioned to support three major categories of applications, which include enhanced mobile broadband (eMBB), massive machine type communications (mMTC) and ultra-reliable, low-latency communications (URLLC) [1-2], which demand massive connectivity, improved SE, high system throughput, and ultra-low latency. In order to meet these challenging requirements, several key enabling technologies have been developed for 5G wireless networks, which include cognitive radio (CR), device-to-device (D2D) communication, in-band full-duplex (IBFD) communication, non-orthogonal multiple access (NOMA) and so on [3].

Recently, NOMA has emerged as a key multiple access technology for 5G wireless networks, due to its potential capability to improve the SE by efficient utilization of the scarce spectrum resources [4-6]. In conventional orthogonal multiple access (OMA) schemes, users are allocated orthogonal resources (e.g., frequency channels or time slots) to avoid multi-user interference. However, this poses a limit on the number of users that can simultaneously access the network resources, which leads to SE degradation. On the other hand, NOMA schemes improve the SE by allowing multiple users to simultaneously utilize the same time-frequency resource block, while separating them in either power domain (i.e., power domain NOMA) or code domain (CD-NOMA).

I.Non-orthogonal Multiple Access in Large-Scale Underlay Cognitive Radio Networks

It considers a large-scale underlay spectrum sharing scenario consisting of the PN and the secondary network (SN). In the SN, we consider that a secondary BS is located at the origin of a disc, denoted by D with radius RD as its coverage. The M randomly deployed secondary users are uniformly distributed within the disc which is the user zone for NOMA. The secondary BS communicates with all Sus within the disc by applying the NOMA transmission protocol.

It is worthy pointing out that the power of the secondary transmitter is constrained in order to limit the interference at the PRs. In the PN, we consider a random number of PTs and PRs distributed in an infinite two-dimensional plane. The spatial topology of all the PTs and PRs are modelled using homogeneous poisson point processes (PPPs), denoted by Φb and $\Phi \ell$ with density λb and $\lambda \ell$, respectively. All channels are assumed to be quasi-static Rayleigh fading where the channel coefficients are constant for each transmission block but vary independently between different blocks.

According to underlay CR, the transmit power Pt at the secondary BS is constrained as follows:

$$P_t = \min \left\{ \frac{I_p}{\max\limits_{\ell \in \Phi_\ell} |g_\ell|^2}, P_s \right\},$$

where Ip is the maximum permissible interference power at the PRs, Ps is maximum transmission power at the secondary.α is the path loss exponent. A bounded path loss model is used to ensure the path loss is always larger than one even for small distances.

II.Underlay cognitive radio networks with cooperative non-orthogonal multiple access

In this work, a cooperative scheme is used to enhance the outage performance at a cell edge user for user fairness and NOMA aims to improve its decreased spectral efficiency. In this context, we propose a cooperative NOMA for a CR network to enhance both spectral
efficiency and user fairness. In this analysis, a number of secondary users employ cooperative NOMA, in which a user with strong channel gains is properly selected (to act as a relay) by a multiantenna BS for assisting another user with poor channel gains in the presence of a primary network. Closed-form expressions for the outage probabilities are derived, which allow us to provide several insights into the behaviour of the outage performance in different
cases. For instance, our results show that the outage probabilities at both users decrease significantly by increasing the number of antennas at the BS. Interestingly, an outage floor which relies on the maximum tolerable interference is observed in the outage probability. Furthermore, the impact of multiple antennas on the outage floor is discussed as well as the impact of the number of multiple cooperative secondary users in multi-user scenarios. As
will be shown, the mathematical treatment adopted in this work is different from other related works due to the involvement of the moment generating function (MGF).

It considers a cooperative NOMA scheme for an underlay CR network in which a secondary BS intends to communicate with two groups of secondary users in the presence of one primary
transmitter PUTx and one primary receiver PURx as shown in Fig. Assume that the BS is equipped with M antennas and adopts a transmit beamforming technique, while all other nodes are equipped with a single antenna. Suppose that user U1 is located far away from the BS while user U2k is near to the BS. Our preliminary analysis is performed considering only two secondary users U1 and U2, and afterwards.

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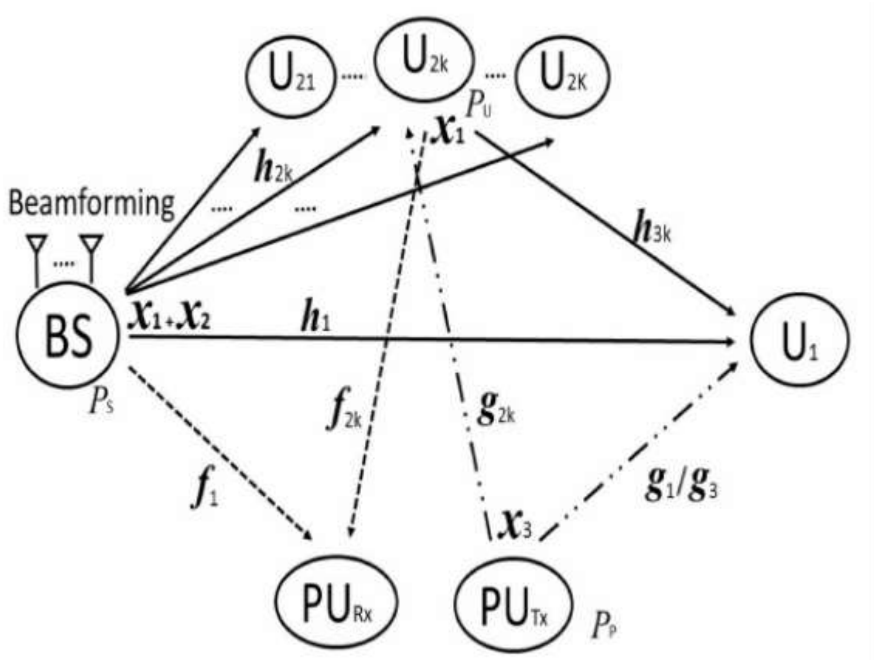
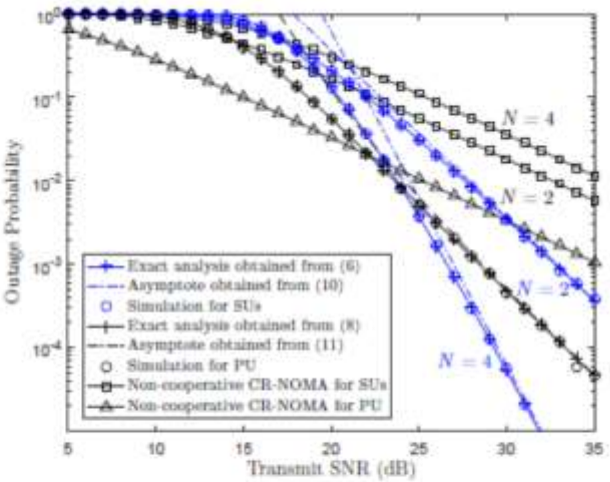


III.Cooperative Non-Orthogonal Multiple Access in Cognitive Radio

Consider a downlink CR-NOMA system, a BS provides unicast/ multicast services to a PU and a group of multicast SUs, denoted by $N = \{1, 2, \cdots, N\}$. By employing the NOMA signalling, both messages of high priority for the PU and low priority for the SUs are transmitted simultaneously from the BS. It assume all nodes are equipped with a single antenna

and operate in a half-duplex mode. All channels experience independent but not necessarily identically distributed (i.n.i.d.) Rayleigh block fading. The total transmit power at each node is

limited by P, and the additive white Gaussian noise (AWGN) is represented by a zero-mean, complex Gaussian variable with variance $N0$.



Outage probability for the primary and secondary systems versus transmit SNR

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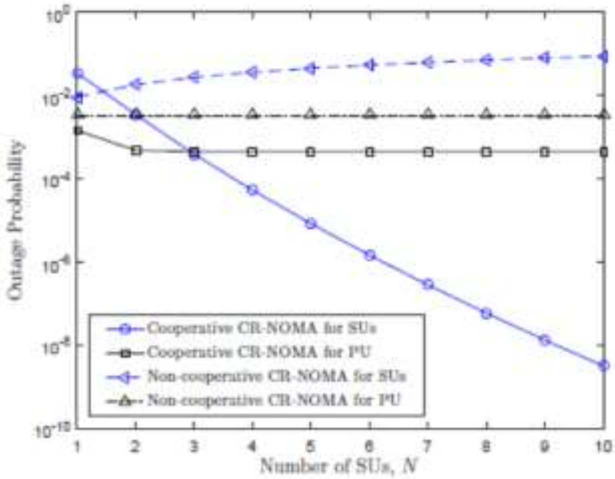


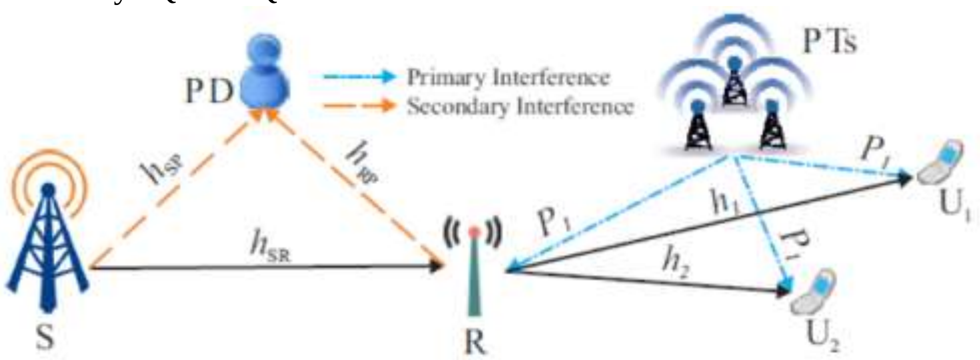
Outage probability for the secondary systems versus number of Sus

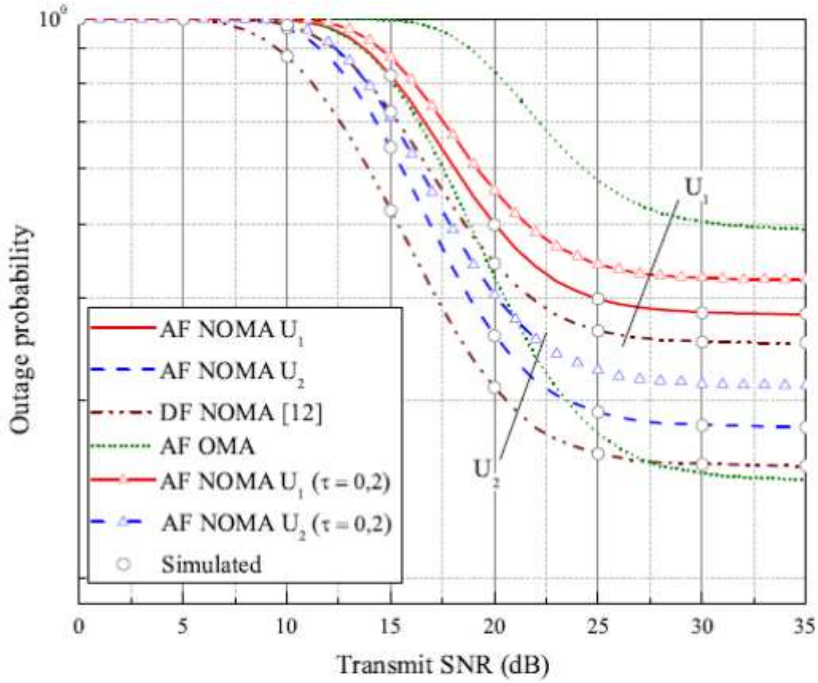
IV.Application of Non-Orthogonal Multiple Access in Cooperative Spectrum-Sharing Networks over Nakagami-*m* Fading Channels

Consider a cooperative spectrum-sharing network consisting of the primary and secondary nodes, denoted by PT, PR, ST, and SRi, $i \in K = \{1, 2, \cdots, K\}$, respectively. Each node is equipped with a single antenna and operates in a half-duplex mode. All channels are assumed to experience independent and identically distributed (i.i.d.) Nakagami-*m* fading. In particular, the channel gains from PT and ST to SRi are denoted by hp,i and hs,i.

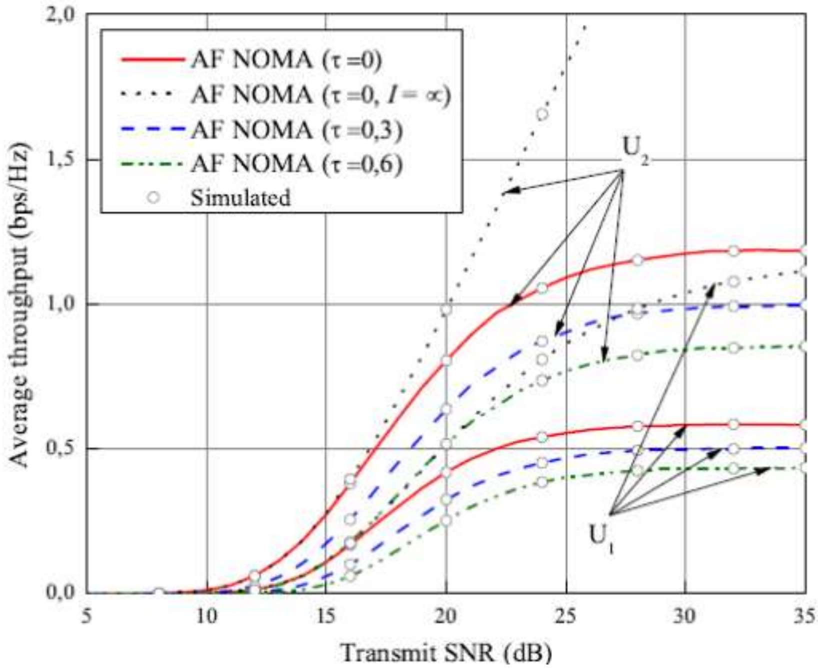
V.Performance Analysis of Underlay Cognitive Radio Non-Orthogonal Multiple Access Networks

Consider an underlay CR-NOMA network, which operates under the presence of a primary network1 (PN), as illustrated in Fig. . In the secondary network (SN), a secondary source (S) broadcasts a superimposed message to secondary NOMA destination users (U1 and U2) via a half-duplex AF-based relay (R), where both S and R can cause interference to a primary destination (PD). Similarly, primary transmit nodes cause interference to U1 and U2. We consider flat Rayleigh fading. Channel gains and distances between nodes are respectively
denoted by hQ and dQ.





The OP of U_1 and U_2 versus the transmit SNR



The average throughput versus the transmit SNR

Conclusion: -We conducted a survey on the cognitive radio network with NOMA. Our survey considers emerging application of NOMA access technology to different architecture of cognitive radio network .We consider five different architectural network and we showed the outage probability curve with variation with input SNR.

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