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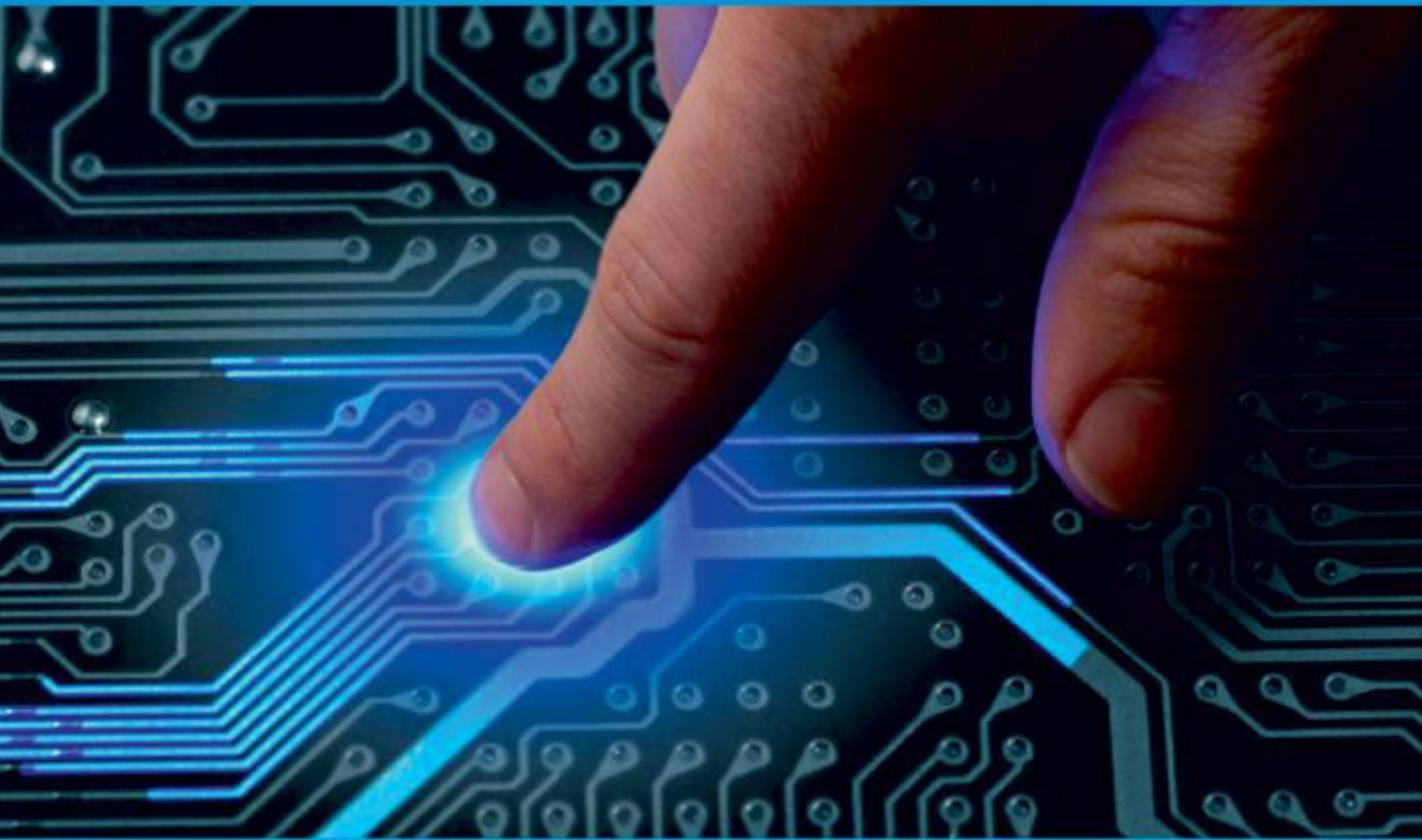

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Review of Resource Allocation in Heterogeneous Cognitive Radio Network

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ABSTRACT: Non-orthogonal multiple accesses (NOMA) is a promising candidate technology for 5G cellular systems. Presently MIMO-OFDM wireless technologies are using in 4G LTE advance wireless communication. This paper discuss about the role of MIMO-OFDM and NOMA as foremost contributing performance factors in beyond 4G LTE Wireless Transmission Technology from a technical perspective. Long Term Evolution (LTE) uses Orthogonal Frequency Division Multiplexing (OFDM) along with MIMO (Multiple Input Multiple Output) antenna technology standard to achieve high radio spectral efficiency and multicarrier approach for multiple accesses.

KEYWORDS: Beyond, 4G, LTE, OFDM, MIMO, FDM

I. INTRODUCTION

Long Term Evolution (LTE) is a Fourth Generation 4G wireless broadband technology developed by the 3rd Generation Partnership Project (3GPP), an industry trade group. 3GPP was established in 1998 thereby started working on the radio, core network, and service architecture of a globally applicable Third Generation (3G) technology specification. 3G is specified by European Telecommunications Standards Institute (ETSI) and 3GPP within the framework defined by the International Telecommunication Union (ITU) standard known as International Mobile Telecommunication 2000 (ITU-200). Even though 3G data rates were already real in theory, initial systems like Universal Mobile Telecommunications System (UMTS) did not immediately meet the IMT-2000 requirements in their practical deployments. Hence the standards needed to be improved to meet or even exceed them.

The combination of High Speed Downlink Packet Access (HSDPA) and the subsequent addition of an enhanced dedicated channel, also known as High Speed Uplink Packet Access (HSUPA), led to the development of the technology referred to as High Speed Packet Access (HSPA+) or, more informally, 3.5G. LTE got its name because it represents the next step (4G) in a progression from GSM, a second-generation (2G) wireless network standard, to UMTS, the third-generation 3G technologies based upon GSM (Global System for Mobile Communication) standard. 4G LTE provides significantly higher peak data rates than the earlier 3GPP technologies, The highest theoretical data rate is 50 Mbps in uplink and with Multiple input multiple output (MIMO) the rate can be as high as 100 Mbps in the downlink with reduced latency, scalable bandwidth capacity, short round trip delay and backwards compatibility with existing GSM and UMTS technology. Unlike its predecessor technologies, however, LTE's upper layers use TCP/IP, enabling all traffic such as data, voice, and video and messaging to be carried over all-IP networks.

A. OFDM-MIMO IN WIRELESS COMMUNICATION

MIMO technology has recently emerged as a new paradigm to achieve very high bandwidth efficiencies and large data rates in modern wireless communications. Conventional MIMO is a cellular wireless technology which enables the use of multiple transmitting and receiving antennas to transfer more data in less time.

A MIMO channel is implemented in a wireless link between M transmits and N receive antennas. It consists of M x N elements that represent the MIMO channel coefficients. NOMA is to use the power domain for multiple access, whereas the previous generations of mobile networks have been relying on the time/frequency/code domain. Take the conventional orthogonal frequency-division multiple access (OFDMA) used by 3GPP-LTE as an example.

A main issue with this orthogonal multiple access (OMA) technique is that its spectral efficiency is low when some bandwidth resources, such as subcarrier channels, are allocated to users with poor channel state information (CSI).

On the other hand, the use of NOMA enables each user to have access to all the subcarrier channels, and hence the bandwidth resources allocated to the users with poor CSI can still be accessed by the users with strong CSI, which

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significantly improves the spectral efficiency. non-orthogonal multiple access (NOMA) has been recently proposed for 3GPP Long Term Evolution (LTE) and envisioned to be an essential component of 5th generation (5G) mobile networks. The key feature of NOMA is to serve multiple users at the same time/frequency/code, but with different power levels, which yields a significant spectral efficiency gain over conventional orthogonal MA. This article provides a systematic treatment of this newly emerging technology, from its combination with multiple-input multiple-output (MIMO) technologies, to cooperative NOMA, as well as the interplay between NOMA and cognitive radio.
All of the current cellular networks implement orthogonal multiple access (OMA) techniques such as time division multiple access (TDMA), frequency division multiple access (FDMA) or code division multiple access (CDMA) together. However, none of these techniques can meet the high demands of future radio access systems.

B. NOMA in Beyond 4G LTE Communication

The characteristics of the OMA schemes can be summarized as follows. In TDMA, the information for each user is sent in non-overlapping time slots, so that TDMA-based networks require accurate timing synchronization, which can be challenging, particularly in the uplink. In FDMA implementations, such as orthogonal frequency division multiple access (OFDMA), information for each user is assigned to a subset of subcarriers. CDMA utilizes codes in order to separate the users over the same channel. NOMA is fundamentally different than these multiple access schemes which provide orthogonal access to the users either in time, frequency, code or space. In NOMA, each user operates in the same band and at the same time where they are distinguished by their power levels. NOMA uses superposition coding at the transmitter such that the successive interference cancellation (SIC) receiver can separate the users both in the uplink and in the downlink channels.
NOMA was proposed as a candidate radio access technology for 5G cellular systems. Practical implementation of NOMA in cellular networks requires high computational power to implement real-time power allocation and successive interference cancellation algorithms. By 2020, the time that 5G networks are targeted to be deployed, the computational capacity of both handsets and access points is expected to high enough to run NOMA algorithms.

II. RELATED WORK

W. Xu et al., [1] we study resource allocation problems for a two-tier cognitive heterogeneous network in interweave spectrum sharing mode. Secondary users (SUs) in small cells (SCs) opportunistically access the licensed spectrum resources. Non-orthogonal multiple access (NOMA) is used to boost the number of accessible SUs sharing the limited and dynamic licensed spectrum holes. Practically, there exists a tradeoff: an SC can increase its instantaneous sum throughput by accessing more idle bandwidth, which creates higher liability due to the dynamics of licensed spectrum and contention among the multiple SCs. Aiming to maximize the sum throughput of second-tier SCs network, we formulate a mixed integer non-linear programming problem with the constraints of the available idle bandwidth, the successive interference cancellation complexity, the transmission power budget, and the minimum data requirements.

Z. Ruoyu, et al., [2] To reduce the overwhelming pilot overhead, a hybrid orthogonal and non-orthogonal pilot distribution at the base station (BS), which is a generalization of the existing pilot distribution scheme, is proposed by exploiting the common sparsity of channel due to the compact antenna arrangement. Then the block sparsity for antennas with hybrid pilot distribution is derived respectively and can be used to obtain channel impulse response. By employing the theoretical analysis of block sparse recovery, the total coherence criterion is proposed to optimize the sensing matrix composed by orthogonal pilots. Due to the huge complexity of optimal pilot acquisition, a genetic algorithm based pilot allocation (GAPA) algorithm is proposed to acquire optimal pilot distribution locations with fast convergence. Furthermore, the Cramer Rao lower bound is derived for non-orthogonal pilot-based channel estimation and can be asymptotically approached by the prior support set, especially when the optimized pilot is employed.

Y. Zhang et al., [3] In the 5G wireless networks, non-orthogonal multiple access (NOMA) is a promising paradigm to improve its high spectrum efficiency. This study considers applying simultaneous wireless information and power transfer (SWIPT) technique to cooperative NOMA wireless networks, where energy-constrained relay nodes harvest the ambient radio-frequency signal and use the harvested energy to forward the packets from sources to destinations. To this end, the authors first formulate the energy-efficient cooperative transmission problem for SWIPT in NOMA with imperfect channel state information.

L. You et al., [4] It is investigate non-orthogonal unicast and multicast (NOUM) transmission for massive multiple-input multiple-output systems, where only statistical channel state information of all user terminals is available at the base station. We adopt a weighted sum of the achievable ergodic unicast rate and multicast rate as the design objective.

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We first show the closed-form eigenvectors of the optimal unicast and multicast transmit covariance matrices, respectively, which reveals the optimality of beam domain transmission and simplifies the large-dimensional matrix-valued NOUM transmission design into a beam domain power allocation problem. Via invoking the concave-convex procedure, we, then, propose an efficient iterative beam domain power allocation algorithm with guaranteed convergence to a stationary point.

Y. Feng et al., [5] With non-orthogonal multiple access (NOMA) in a passive eavesdropping scenario, we tackle the maximization of the secrecy rate for the strong user subject to a maximum allowable secrecy outage probability while guaranteeing a constraint on the transmission rate to the weak user. For the first time, the dependence between the eavesdropper's ability to conduct successive interference cancellation and her channel quality is considered.

X. Wang et al., [7] In this paper, we study the potential of non-orthogonal multiple access (NOMA) for the purpose of interference mitigation in downlink small cell networks (SCNs). Different from prior works, we focus on opportunistically multiplexing different users on the same subchannel to avoid the severe inter-cell interference brought in by ultradense networking. Aiming to maximize the network throughput, we formulate a distributed subchannel assignment problem with local information exchange. This problem is analyzed through a locally cooperative game model, and the existence of Nash equilibrium (NE) is confirmed by proving that the formulated game is an exact potential game.

H. Zheng et al.,[8] To achieve more efficient spectrum utilization in the intelligent transportation system, non-orthogonal multiple access-enabled (NOMA-enabled) V2X communications have been emerging as a promising technology. In this paper, the resource allocation problem for NOMA-enabled V2X communications is investigated. For V2I links, in view of the user fairness and the different requirements of cellular users (CUEs), weighted max-min rate fairness for CUEs is applied, where both identical weights and different weights are considered. As for V2V users (VUEs), the minimum signal-to-interference-plus-noise ratio (SINR) requirements are imposed on the problem formulation.

D. Wang et al., [9] In order to improve the spectrum efficiency and secrecy energy efficiency, in this paper, we propose a non-orthogonal multiple access (NOMA)-based secure scheme for cognitive radio networks. In the proposed scheme, the secondary users harvest energy from the radio-frequency signals to securely transmit the secondary privacy information with the NOMA technique. Unlike the conventional ideal linear energy harvesting, we employ the practical nonlinear energy harvesting model for energy harvesting. To implement the proposed scheme, the energy transmitter first broadcasts radio-frequency signals to power the secondary users. Then, the secondary users employ the NOMA technique to transmit the uplink privacy information, which is threatened by the eavesdropper. Considering two scenarios: two secondary users and more than two secondary users, we first provide comprehensive analysis of the secondary secrecy performances and derive the closed-form expressions of the secrecy outage probability for both scenarios.

S. Zhang et al.,[10] This paper investigates the physical-layer security of uplink non-orthogonal multiple access (NOMA) in the cellular Internet of Things (IoT) with invoking stochastic geometry. Poisson cluster process-based model is applied to characterize the NOMA uplink transmission scenario, where IoT terminals are located around the serving base station. Considering the severe interference brought by a large number of IoT terminals, inter-cell interference is also taken into account. To enhance the physical-layer security of uplink NOMA transmission with limited overhead increment at IoT terminals, the base stations not only receive the signals from IoT terminals but also keep emitting jamming signals all the time to degrade the performance of any potential eavesdroppers.

III. OFDM Vs NOMA

In OFDMA technique BS (Base Station) shares its resources by transmitting to UEs at different time instants and frequencies. OFDMA allocates subchannels and time slots to the users based on desired bandwidth or data rate. Each of the subchannels are mapped with few number of subcarriers after permutations and hence OFDMA is robust against fading. The technologies such as Mobile WiMAX, LTE, LTE-advanced and 5G uses OFDMA technique for resource sharing.

OFDM Makes efficient use of the spectrum by allowing overlap. By dividing the channel into narrowband flat fading subchannels, OFDM is more resistant to frequency selective fading than single carrier systems are. Eliminates ISI and IFI through use of a cyclic prefix. Using adequate channel coding and interleaving one can recover symbols lost due to

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the frequency selectivity of the channel. Channel equalization becomes simpler than by using adaptive equalization techniques with single carrier systems. It is possible to use maximum likelihood decoding with reasonable complexity. OFDM is computationally efficient by using FFT techniques to implement the modulation and demodulation functions. Is less sensitive to sample timing offsets than single carrier systems are. Provides good protection against cochannel interference and impulsive parasitic noise. Limitation of OFDM is signal has a noise like amplitude with a very large dynamic range, therefore it requires RF power amplifiers with a high peak to average power ratio. It is more sensitive to carrier frequency offset and drift than single carrier systems are due to leakage of the DFT. The NOMA is a multiple access technique employed in 5G cellular wireless network. The main function of NOMA is to serve multiple UEs (User Equipments) using single 5G-NB (Node B or Base Station). It serves multiple users on same time/frequency resources. There are two main techniques employed in NOMA for multiple access.

Power domain: Here NOMA achieves multiplexing based on different power levels.
Code domain: Here NOMA achieves multiplexing based on different codes.

Transmit side: NOMA uses superposition coding at the transmitter end. The different power levels have been assigned to users. As shown in the figure-1, Base Station transmits superposed signals to User#1 and User#2. Here User#2 uses high gain and User#1 uses low gain as shown.

Receive side: NOMA uses SIC (Successive interference cancellation) technique to retrieve data of both the users. At receiver, User#2 (Strong User) substracts signal of user#1 through SIC and later decodes its own signal. User#1 (Weak User) treats signal of User#2 as noise and decodes its own signal directly.

Table 1: NOMA vs OFDMA

Specifications	NOMA	OFDMA
Full form	Non-Orthogonal Multiple Access	Orthogonal Frequency Division Multiple Access
Spectrum Efficiency	Higher	Lower
Capacity (Number of users/cell)	Less	More

IV. CONCLUSION

In this paper, the contribution of MIMO-OFDM in 4G LTE wireless technologies discussed. The use of multiple antennas at both ends of a wireless link (multiple input multiple output (MIMO) technology) has recently been demonstrated to have the potential of achieving extraordinary data rates in 4G-LTE. Orthogonal frequency division multiplexing (OFDM) significantly reduces receiver complexity in wireless broadband systems. The use of NOMA technology for beyond 4G LTE wireless technologies therefore seems to be an attractive solution for future broadband wireless systems.

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