Power-Domain Non-Orthogonal Multiple Access (NOMA) in 5G Systems: Potentials and Challenges

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***Abstract*—Non-orthogonal multiple access (NOMA) is one of the promising radio access techniques for performance enhancement in next-generation cellular communications. Compared to orthogonal frequency division multiple access, which is a well-known high-capacity orthogonal multiple access technique, NOMA offers a set of desirable benefits, including greater spectrum efficiency. There are different types of NOMA techniques, including power-domain and code-domain. This paper primarily focuses on power-domain NOMA that utilizes superposition coding at the transmitter and successive interference cancellation at the receiver. Various researchers have demonstrated that NOMA can be used effectively to meet both network-level and user-experienced data rate requirements of fifth-generation (5G) technologies. From that perspective, this paper comprehensively surveys the recent progress of NOMA in 5G systems, reviewing the state-of-the-art capacity analysis, power allocation strategies, user fairness, and user-pairing schemes in NOMA. In addition, this paper discusses how NOMA performs when it is integrated with various proven wireless communications techniques, such as cooperative communications, multiple-input multiple-output, beamforming, space–time coding, and network coding among others. Furthermore, this paper discusses several important issues on NOMA implementation and provides some avenues for future research.**

***Index Terms*—Non-orthogonal multiple access (NOMA), orthogonal multiple access (OMA), 5G, NOMA solutions, NOMA performance, research challenges, implementation issues.**

I. Introduction

FROM analog phone calls through to all Internet Protocol services, including voice and messaging, each transition has been encouraged by the need to meet the requirements of the new generation of mobile technology. Subsequently, mobile communications technology is presently facing a new challenge, giving birth to a hyper-connected society through the emergence of fifth-generation (5G) services. With enormous potential for both consumers and industry, 5G is expected to roll out by 2020. From the next-generation radio access technology viewpoint, a step change in data speed and a significant reduction in end-to-end latency is a major concern for 5G, since the rapid development of the mobile Internet and the Internet of Things (IoT) exponentially accelerates the demand for high data–rate applications. In particular, many of the industry initiatives that have progressed with work on 5G declare that the network-level data rate in 5G should be 10-20 Gbps (that is, 10-20 times the peak data rate in 4G), and the user-experienced data rate should be 1 Gbps (100 times the user-experienced data rate in 4G). They also set the latency (end-to-end round-trip delay) at 1 millisecond (one-fifth of the latency in 4G).

The underlying physical connection in a cellular network is called radio access technology, which is implemented by a radio access network (RAN). A RAN basically utilizes a channel access technique to provide the mobile terminals with a connection to the core network. The design of a suitable multiple access technique is one of the most important aspects in improving the system capacity. Multiple access techniques can broadly be categorized into two different approaches [1], namely, orthogonal multiple access (OMA) and non-orthogonal multiple access (NOMA). An orthogonal scheme allows a perfect receiver to entirely separate unwanted signals from the desired signal using different basis functions. In other words, signals from different users are orthogonal to each other in orthogonal schemes. Time division multiple access (TDMA) and orthogonal frequency-division multiple access (OFDMA) are a couple of examples of OMA schemes. In TDMA, several users share the same frequency channel on a time-sharing basis. The users communicate in rapid succession, one after the other, each using their assigned time slots. OFDMA allows multi-user communications through an orthogonal frequency-division multiplexing (OFDM) technique in which subcarrier frequencies are chosen so that the subcarriers are orthogonal to each other. In contrast to OMA, NOMA allows allocating one frequency channel to multiple users at the same time within the same cell and offers a number of advantages, including improved spectral efficiency (SE), higher cell-edge throughput, relaxed channel feedback (only