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The emerging Spectrum Efficiency (SE) and Energy Efficiency (EE) topics in Fifth Generation (5G) are focused in this dissertation. To increase the SE performance, the Non-Orthogonal Multiple Access massive Multi-Input-Multi-Output millimeter Wave (NOMA -massive-MIMO-mmWave) system is proposed as well as the analysis of its capacity performance. Compared to prior Long Term Evolution (LTE) system, the SE performance is greatly enhanced by this proposal. Additionally, on the study of EE topic, to improve the system's EE performance, a comprehensive system architecture is proposed afterwards. Based on this architecture, the EE analysis is addressed with proposed the Cellular Partition Zooming (CPZ) mechanism and optimization method while taking more elements into consideration. The system EE performance is increased via those methods compared with prior studies. Detail content of each chapter is given as follows:

In chapter 1, titled "Introduction", the rapid cellular communication evolution and growing massive devices that connected to the internet is reviewed. Recently, as known, the 5G wireless communication is brought up to tumble down the even speedy increasing massive connected devices with the requirements of much larger throughput per cell, and much faster transmission rate per device. Meanwhile, due to the even faster rate, energy consumption becomes another vital issue. In this case, to accomplish the even higher transmission rate and even lower system energy consumption requirements of 5G, the SE and EE are summarized as two critical issues, which is the study focus of this dissertation.

In chapter 2, titled "Capacity Analysis of NOMA-massive-MIMO-mmWave Systems", the SE issue is focused. As noticed, prior technologies to achieve higher SE performance mainly consist of the massive MIMO and NOMA. Recently,

mmWave technology attracts a lot of attentions in literature. The purpose of mmWave is to allocate more and higher frequency resources to alleviate the bottleneck of spectrum resources' shortcoming. Yet it is noticed that less studies have been done on combining the NOMA, mmWave and massive MIMO together for the comprehensive capacity and sum rate analysis. In this dissertation, the combined system is proposed and analyzed of its capacity performance with a proposed mmWave channel model. Due to the complex analysis procedure, the analysis procedure is divided into the low Signal to Noise Ratio (SNR) and high SNR regimes. It is found from the simulation results that the capacity is greatly enhanced with this combined system. Given the even wider bandwidth provided by mmWave, the sum rate can be further increased.

In chapter 3, titled "Integrated Energy Efficiency Architecture and Analysis of 5G", it is found that in the prior studies of EE performance, most of the work is trying to reduce the system energy consumption, or to integrating optimize the system consumption with more components taking into consideration. Other than those, we first propose a method to re-deign the system of wireless networks for better deployment of select/sleep mechanism with the purpose of better EE performance. Besides, a CPZ mechanism is proposed based the Cloud Radio Access Network (C-RAN) architecture. Compared with prior zooming scheme, this mechanism is capable of saving more energy and of better EE performance. This is especially useful in remote area, late night scenes with fewer users accessing the internet.

In chapter 4, titled "Integrated Energy Efficiency Analysis of Massive MIMO Based C-RAN", based on the comprehensive system architecture proposed in chapter 3, additionally, a method to further enhance the system EE performance based the convex optimization tool is brought up. In which, more components are taken into consideration. Simulation results demonstrate that this method can satisfy the transmission requirement of each user while further reduce the consumed energy, which in turns, yields better system EE performance.

In chapter 5, titled "Conclusion", the main discoveries of this dissertation are finally summarized up with regard to both SE and EE topics. The potential mobility environment, Ultra-Reliable Low Latency Communication (URLLC) topics are listed as well for future studies.

To sum up the dissertation, the SE and EE topics in 5G are investigated. It is demonstrated that with the proposed NOMA-mmWave-massive-MIMO system, cellular SE performance is greatly increased compared to prior MIMO systems. In addition, with the proposed comprehensive system model, CPZ mechanism, and optimization method while taking more elements into optimization. The system EE performance is enhanced compared to prior studies in this method. Finally, the potential future research topic is given as well to conclude the dissertation.

Study on Spectrum Efficiency and Energy Efficiency in Cellular Systems

セルラーシステムにおける周波数利用効率とエネルギー利用効率改善に関する研究

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Global Information and Telecommunication Studies

Wireless Communication System II

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