

CHAPTER IV

NOVELTY AND CONTRIBUTIONS

The concept of heterogeneous networks has attracted a lot of interest recently as a way to improve the performance of the network. The heterogeneous networks approach consists of complementing the Macro layer with low power nodes such as Femto base stations. This approach has been considered a way to improve the capacity and data rate in the areas covered by these low power nodes; they are mostly distributed depending on the areas that generate higher traffic.

This thesis consists of two parts. The first topic of PhD study is mainly focused on interference mitigation in LTE heterogeneous network which will be described in section 4.1. We use two mitigation interference schemes; power control method and almost blank subframe (ABS). We also modify proportional fair scheduling algorithm to improve cell edge user throughput.

In the second part of the work, downlink performance of Non Orthogonal Multiple Access (NOMA) is evaluated and compared to Orthogonal Multiple Access (OMA) based on system level simulation with practical assumption. We propose new transmit power allocation scheme and compare it with existing transmit power allocation. We also propose NOMA in a base station cooperative scenario. We summarize our contribution in section 4.2. In section 4.3 provides system methodology of this PhD study.

4.1 MODIFIED PROPORTIONAL FAIR FOR LTE FEMTOCELL

There are two major limitations for wireless communications: Range and capacity. The service providers increase the coverage area by either deploying a macrocell while consuming high power, or using smaller base stations that cover a smaller area but provide high data rates at lower power levels. Femtocells appear to be an effective solution satisfying the coverage and data rate needs of the operators in conjunction with inducing little upfront cost to the service provider. From a financial point of view, femtocells offer low cost solutions to operators presenting an alternative to high cost high power macrocell base station installations to provide the same Quality of Service (QoS).

When a macrocell network operates on the same carrier as HNBs, HNB-macrocell interference can result in a certain amount of outage and performance degradation for MUE. One solution for mitigating the HNB-macro interference would be to make sure the carrier(s) used by HNBs are not used by the macrocell network. Although this method reduces HNB-macro interference noticeably, it is not efficient in terms of spectrum utilization, especially if HNB deployment density is not high. For most operators with limited carriers (e.g., two or three carriers), sharing the carriers between HNBs and macrocell network would be preferable. In this case, HNBs can be deployed on the least used macrocell carrier(s), and if mobile MUE still

experiences significant interference from an HNB, the macrocell network can perform inter-frequency handover of that MUE to another macrocell carrier frequency.

Transmission power control of CSG HeNBs is a viable way to improve performance of UEs that are affected by strong interference from HeNBs. An autonomous power control method is employed in our simulation based on a variant of the smart power control algorithm described in next chapter. This method relies upon measurements at HeNB side and does not require complicated backhaul negotiation among the HeNBs, and thus it could be considered a baseline Release 8/9 interference management technique. The goal is to minimize the interference to the macro network and yet ensure HeNB coverage according to a specific targeted path loss value

The first topic of PhD study is mainly concerned with interference mitigation in LTE heterogeneous network. We use two mitigation interference schemes; autonomous power control method and enhanced ICIC in time domain which is named as almost blank subframe (ABS). In simulation, we show the effect of interference cancellation on macro user throughput.

We modify proportional fair scheduling algorithm to improve cell edge user throughput. We use almost blank subframe with modified proportional fair. To alleviate Almost Blank Subframe (ABS), subframe resources are split among macrocell and femtocell to improve reliability, it means that macrocell can use all resources but femtocell can use only half of all subframe. Although this scheme affects indoor UEs which mitigate interference from HeNB when HeNB is silent, it also affects outdoor UEs close building.

4.2 DOWNLINK JOINT PROCESSING FOR NOMA

Cooperative communication is one of the emerging technologies that promise significantly higher reliability and spectral efficiency in wireless networks. Unlike conventional point-to-point communications, cooperative communication is a new form of diversity that allows users or nodes to share resources to create collaboration via distributed transmission and processing of messages. This cooperative diversity concept is similar to the multiple-input multiple-output (MIMO) system but is applied in a networked setting. As a result, it is often called a distributed MIMO or network MIMO. It represents a paradigm shift from a network of conventional point-to-point links to network cooperation.

Non-orthogonal access code-division multiple access (CDMA) based on direct sequence-code division multiple access (DS-CDMA) is widely used in the 3rd generation mobile communication system. In the 3.9 and 4th generation (4G) mobile communication systems such as LTE and LTE-Advanced adopt orthogonal multiple access based on orthogonal frequency multiple access (OFDMA) in the downlink and signal carrier (SC)-FDMA in the uplink. It is a reasonable choice for achieving good system-level throughput performance to orthogonal access in packet-domain services.

However, considering the future radio access in the 2020s, further enhancement to achieve significant system throughput and user fairness has become one of the key issues in handling this explosive data traffic increase in 5th generation (5G) mobile communication systems and need for

enhanced delay-sensitive high-volume services. Non-orthogonal multiple access (NOMA) with successive interference cancellation (SIC) is considered to be a promising technology that could improve the sum throughput. Because the communication resources (time and frequency) in a NOMA system are shared by all the users (as shown in figure 4.2), the sum throughput can be enhanced over what is possible, compared with orthogonal multiple access (OMA).

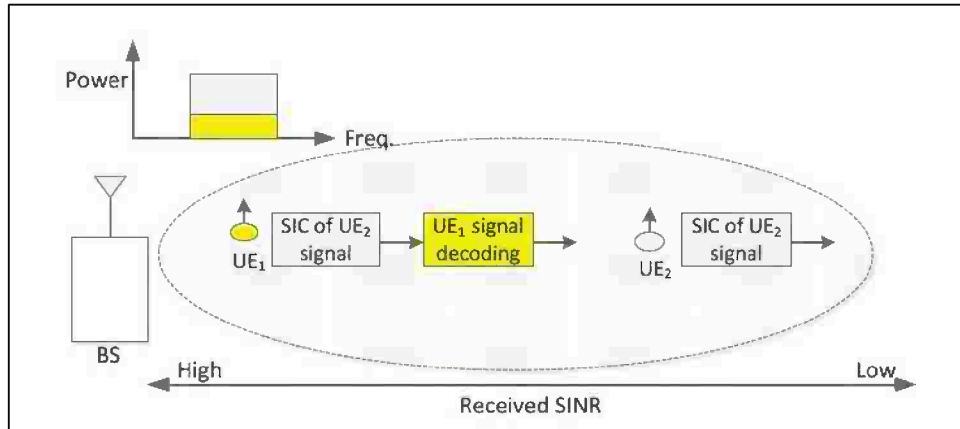


Figure 4.1 Basic NOMA scheme with SIC for receiver in downlink

In the second topic of PhD study, we compare between orthogonal multiple access (OMA) and non orthogonal multiple access (NOMA) to evaluate user throughput between two multiple access schemes. We compare between two multiple access scheme in macro-femto network (heterogeneous network).

Due to power domain multi user multiplexing, the transmit power allocation (TPA) is important consideration in NOMA downlink; it affects the achievable throughput of not only that user but throughput of system. We propose new transmit power allocation scheme and compare it with used in [43]. In our proposed scheme, users with large channel gain difference (e.g., large path-loss difference) are paired with high probability. We show that the proposed transmit power allocation scheme achieves better user throughput compared to scheme in [43].

In practice, the impact of SIC error propagation on NOMA performance remains as one concern. To emulate this effect in NOMA, we assume imperfect interference cancellation in our simulation and show how imperfect interference cancellation affects on user throughput.

For the proposed NOMA in a BS cooperative scenario, we employ NOMA with Joint transmission in this thesis. We show that the proposed NOMA scheme with BS cooperation achieves better system-level throughput compared to OMA. We also show that the effect of the proposed NOMA scheme is more significant when BS cooperation is assumed since the BS cooperation improves the channel conditions of the cell-edge users, which are appropriate for obtaining a higher non-orthogonal user multiplexing gain.

The primary contributions of this thesis are briefly summarized below:

- We use two mitigation interference schemes in heterogeneous network and evaluate macro user throughput.

- We modify proportional fair scheduling algorithm to offer performance gain in cell edge user throughput.
- In simulation model we apply NOMA as a non-orthogonal multiple access and compare NOMA with OMA.
- We propose new transmit power allocation scheme and compare it with existing transmit power allocation.
- The main contribution of this research is extending NOMA scheme to the BS cooperative MIMO cellular downlink for future radio access. We apply Joint transmission scheme in macro-femto network using non orthogonal multiple access. We show that the proposed NOMA scheme with BS cooperation achieves better system-level throughput compared to OMA. We also show that the effect of the proposed NOMA scheme is more significant when BS cooperation is assumed since the BS cooperation improves the channel conditions of the cell-edge users, which are appropriate for obtaining a higher non - orthogonal user multiplexing gain.

4.3 SIMULATION METHODOLOGY

The purpose of this section is to provide our simulation assumptions and methodology for heterogeneous LTE network, based on 3GPP analysis in [29].

We consider a heterogeneous LTE network deployed according to the models described in [29]. 19 macro eNBs are dropped following a hexagonal layout with an inter site distance (ISD) of 500m, which corresponds to 3GPP evaluation methodology. Each macro node includes three sectors. For each sector, 25 macro UEs are randomly dropped within the sector area. Moreover, one cluster of femtocell is dropped in the coverage area of each macro sector with random location as shown in figure 4.2. We assume two transmit antennas at the eNBs and two receive antennas at the UEs. UEs are assumed to be served using closed-loop spatial multiplexing, also known as transmission mode 4 (TM4) in the LTE terminology. All the simulation results refer to an LTE cellular system occupying a DL bandwidth of 10MHz, where all cells, both macro eNBs and HeNBs, transmit on the same DL channel (i.e., co-channel deployment). A TU-3 radio channel model is used to capture the frequency-selectivity of the channel. The simulation parameters are described in next chapter.

This methodology for evaluating interference scenarios between femtocells and users is applied to provide more results for interference scenarios and mitigation methods to increase user throughput. Our simulations can be compared with two scheduling algorithms, proportional fair scheduling and modified proportional fair scheduling (MPF). We show the improvement in user throughput when using MPF.

We use two interference mitigation methods in our simulation; Automatic Power control and almost blank subframe. Due to transmission power control of HeNBs is a viable way to improve

performance of UEs that are affected by strong interference from HeNBs. An autonomous power control method is employed in this thesis. In Almost Blank Subframe (ABS), the HeNB can mute all downlink transmissions to its UEs in certain subframes. In this scenario, a macro UE very close to an aggressor HeNB may report a low CQI on the unprotected subframes, where HeNBs is allowed to transmit, and thus will be scheduled on protected subframes only, where HeNBs is silent and the UE is not subject to strong interference.

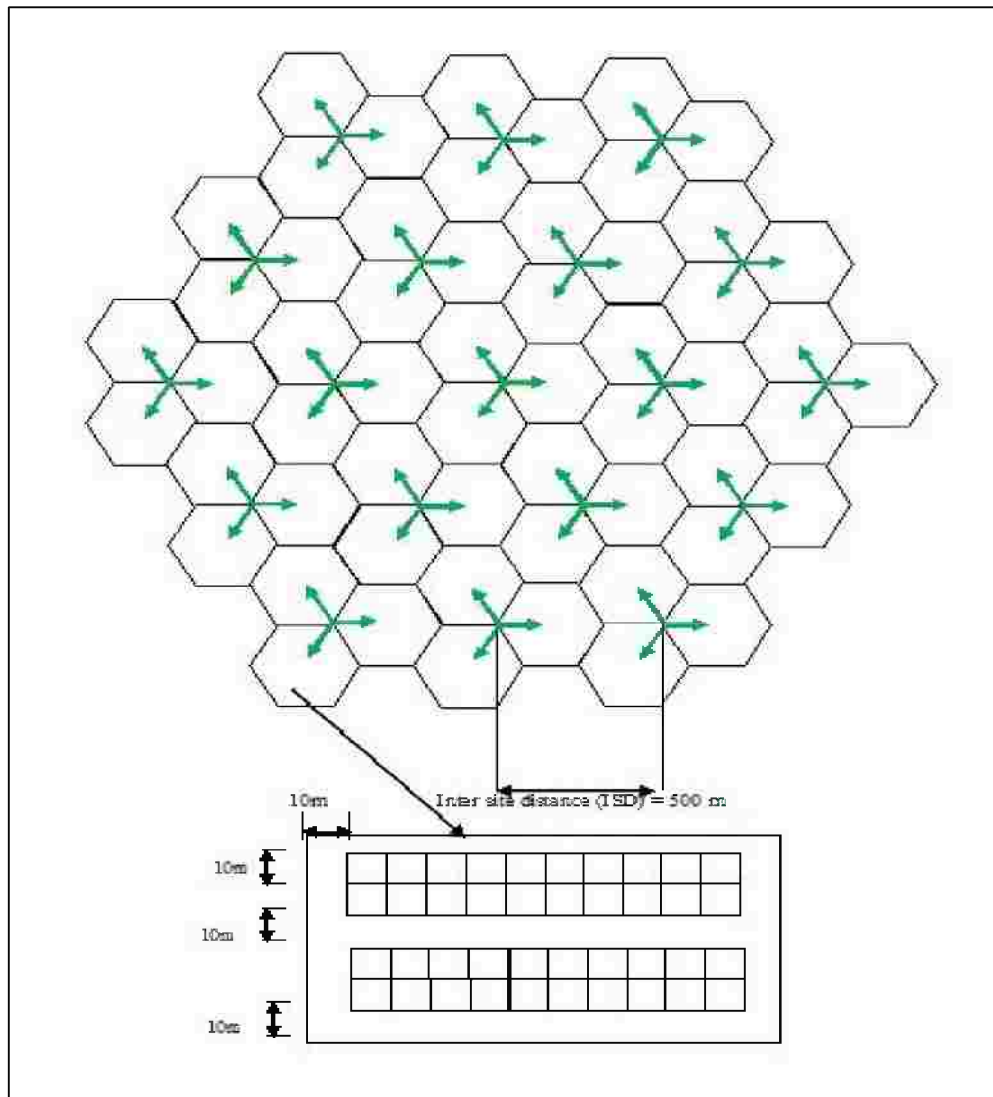


Figure 4.2 Macro Femto Network Layout

We apply non orthogonal multiple access (NOMA) and compare with orthogonal multiple access (OMA). So the same methodology can be applied for both NOMA and OMA. However, the detailed assumptions could differ such as power allocation for users. In NOMA, We modify proportional fair scheduling algorithm when selecting users depending on user selection power allocation method. For Imperfect interference cancellation, we assume two values to show the

effect imperfect interference cancellation on user throughput. Joint transmission is coordinated multiple access scheme which is applied in our simulation to improve user throughput. The traffic model employed for these simulations is based on packets of size 2 Mbytes and adaptive Poisson arrivals with average inter-arrival time of 1s.