Downlink Uplink Decoupling in Advance LTE HetNets

Tayyaba Khurshid[*], Nadia Mustaqim Ansari[**], Rizwan Iqbal[*], Muhammad Moin[***], Adnan Waqar[**], Sohail Rana[**], Talha Tariq[**], Muhammad Ismail[**], Syed Waqar Alam[**] and Maqsood ur Rehman Awan[**]

[*] Department of Telecommunication Engineering, Dawood University of Engineering & Technology, Karachi, Pakistan
[**] Department of Electronic Engineering, Dawood University of Engineering & Technology, Karachi, Pakistan
[***] Department of Electrical Engineering, Pakistan Institute of Engineering & Applied Sciences, Islamabad, Pakistan

Corresponding author: Nadia Mustaqim Ansari

Abstract- Cellular heterogeneous systems (HetNets) will be standout among those key empowering impacts for 5G. Downlink Uplink decoupling (DUDe) is an idea in which a user is associated with the macro cell for downlink connectivity and the small cell for uplink connectivity. It enhances uplink data rate, less power consumption, and balances load between the macro cell and small cells. Because of the incorporation of DUDe, a user needs to perform separate uplink and downlink connectivity dissimilar to traditional handovers in coupled networks. In this paper, we have calculated SIR, data rates, and CDF for small and macro cells for both coupled and decoupled networks. Simulation Outcomes demonstrate the impact of DUDe, expanded uplink, SIR, increased data rates, and Cumulative Distribution Function (CDF) plots show that decoupling dependably beats the coupled association.

Index Terms- Downlink Uplink decoupling, Signal to Interference Ratio, Cumulative Distribution Function.

I. Introduction

A recent study suggests that the future of the wireless network will be heterogeneous to achieve higher data rates, outages, and capacity [1]. Present-day cellular systems are developing from voice-situated to omnipresent portable broadband information networks. While the downlink of these systems regularly drives their bandwidth and speed prerequisites, upgrades in uplink performance are progressively important because of symmetric traffic applications like person-to-person communication, video calls, and media content sharing. Cellular networks have been designed for downlink connectivity because most traffic is symmetric. However, with time, the real-time application increased, and the uplink traffic increased.

Currently, the association is based on downlink receive power which is good for the homogeneous network where all Base stations transmit power is equal. But in heterogeneous, all BS does not have the same transmit power, and if the cell association is based on downlink receive power, it will be highly inefficient. Therefore, Downlink and Uplink Decoupling UDE are proposed [7]. Figure 1 shows a heterogeneous network where different small cells are deployed within the macro cell. The rise of Heterogeneous Networks where small cells is being deployed within Macro cells calls for revisiting the coupled association

approach. A device that is connected to a macro cell in the downlink may rather wish to be connected to a small cell in the uplink because of reduced path loss in the uplink. For UEs transmitting at the highest power, it is better to connect with the small cell in the uplink by reducing path loss. Additionally. Downlink Uplink Decoupling (DUDe) reduced uplink interference because of different correlative impacts [2].

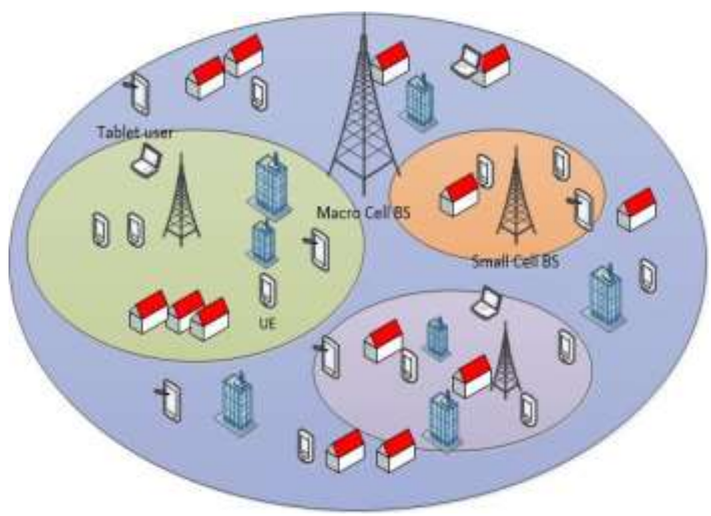

FIGURE 1. **Heterogeneous Network**

In traditional cellular networks, user association was normally based on the DL received signal power for both downlink (DL) and uplink (UL) transmissions. The association is generally known as Coupled UL-DL user association. Uplink and downlink connectivity depends on received signal strength, minimum path loss, distance, and SIR. It may be possible that a user connected to the macro cell may be good for downlink but not for uplink connectivity; this is termed as UL/DL imbalance. When a device gets connected to two different cells for uplink and downlink traffic, it is referred to as Downlink/uplink decoupling (DUDe) [3]. Figure 2 shows the concept of DUDe, where UE1 is connected to the macro cell for both uplink and downlink connectivity, UE3 is connected to the small cell for both uplink and downlink connectivity, while UE2 is in the decoupled region and connected to the macro cell for downlink connectivity and small cell for uplink connectivity. The transmission power of MC and SC are different; therefore, decoupling can be useful for load balancing [8]. Lower interference and stronger signal strength may also be achieved through DUDe [9].

In this paper, we have calculated SIR, spectral efficiency, and distance to the associated Base station in both coupled and decoupled networks. We have compared both system results and observed that decoupled is more efficient than the coupled system.

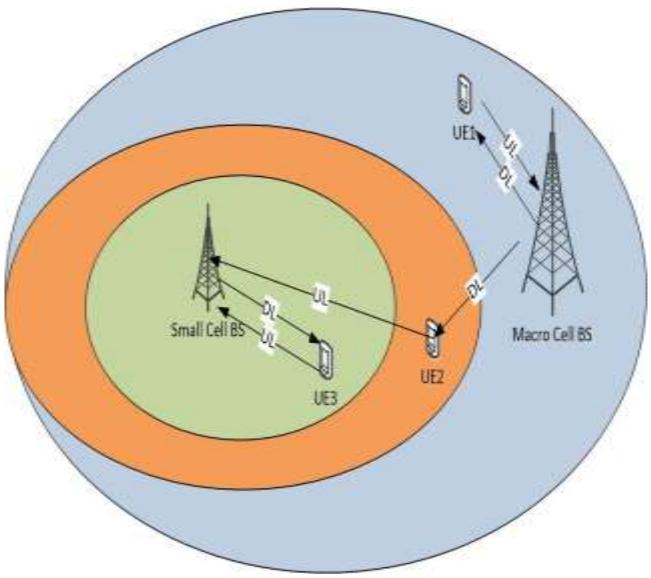

FIGURE 2. **Downlink Uplink Decoupling**

II. METHODOLOGY

In this paper, our focus is on the received SIR of test users from randomly chosen BS. In the coupled scenario, the Test user will connect to the base station from which it receives maximum downlink power. In the decoupled scenario, the Test user will connect to the base station from which it receives minimum path loss.

The system model represents a heterogeneous cellular network consisting of two tiers, the macro cell tier, and the small cell tier. A co-channel deployment is assumed, i.e., BSs of two tires re-use the same frequency band. The locations of BSs and the locations of devices are modeled by independent homogeneous Poisson Point Processes (PPPs).

Figure 3 shows the flow of the work to define iterations, generate cells, calculate path loss, signal to interference ratio, association with the base station, and calculation of cumulative distribution function.

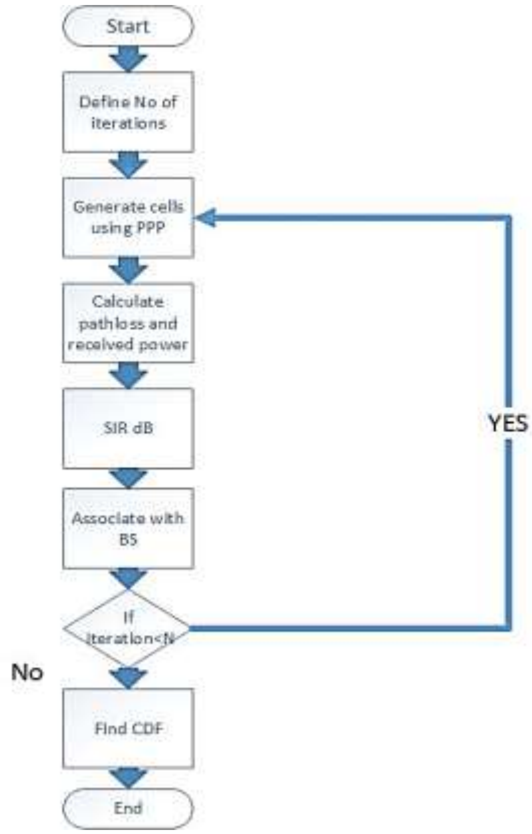

FIGURE 3. **Flow chart**

Figure 4 shows a simulation of macro cells, small cells, and users in an area of 1km by 1km according to the Poisson point process and considers the test user at the origin.

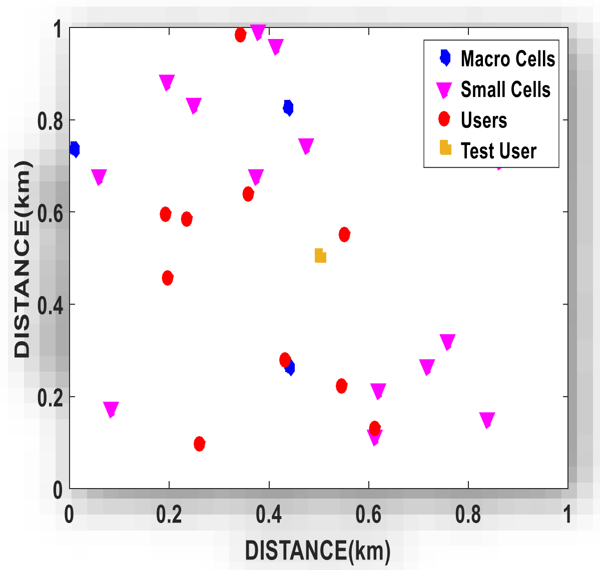

FIGURE 4. **Simulation of the macro cell, small cell, and UE**

This work mainly aims to calculate SIR and data rates of test user mobile users for both Coupled and decoupled networks. The notation is summarized in Table 1.

A. Signal-to-interference ratio

The signal-to-interference ratio is referred to as the ratio between signal powers to the noise power.

In this paper, we consider signal power and noise power. Using the notion of a typical device located at the origin, the Signal to Interference Ratio (SIR) is calculated in the UL at a BS located at yv ∈ e Φv, which is not at the origin. Using the definition for signal power in the UL SNR can be written as [5].

$$SIR^{UL} = \frac{Pdhyv\ Xv\|Yv\|^{\alpha}}{\sum_{yj \in \phi Id}^{n} Pdhyj\ Xv\|Yv\|^{\alpha}}$$

The interferer is another user for the uplink, but for the downlink, the interferer is all other base stations. The DL SIR can be written as

$$SIR^{DL} = \frac{Pv\ hv\ Xv\|Xv\|^{\alpha}}{\sum_{yj \in \phi Id}^{n} Pvhyj\ Xv\|yV\|^{\alpha}}$$

B. Spectral efficiency

Spectral efficiency is the rate of information that can be transferred on a specific bandwidth. The spectral efficiency, or the normalized throughput with DUDe, is defined as [4].

$$C_{DUDe} = \mathbb{E}\,[log_2\,(1+SIR^{UL})]$$

III. SIMULATION PARAMETERS

Following are the notations and parameters which are used in the simulation.

TABLE I
SIMULATION PARAMETERS

Notation	Parameter	Value (if applicable)
Φm, λm	Macro cells PPP and density	λm = 3 per km^2
Φs, λs	Small cells PPP and density	λs = 15 per km^2
Φu, λu	UEs PPP and density	λu = 10 per km^2
Pm	Macro cells transmit power	46 dBm,
Ps	Small cells transmit power	30 dBm
Pum,	UE transmits power to Macro cell	23 dBm
Pus	UE transmit power to small cell	23 dBm
h	Small scale fading	h ~ exp(1)

IV. SIMULATION RESULTS & ANALYSIS

This section presents the simulation results to analyze the performance of decoupled systems over coupled systems. Results are taken in the presence of multiple Macro cells and small cells. We have used MATLAB for our simulation experiments.

Figure 5 shows the data rate of uplink of small cell in both coupled and decoupled systems, and figure 4 shows the data rate of the uplink of macro cell in both coupled and decoupled networks. From both figures, data rates in the decoupled network are greater than data rates in coupled network.

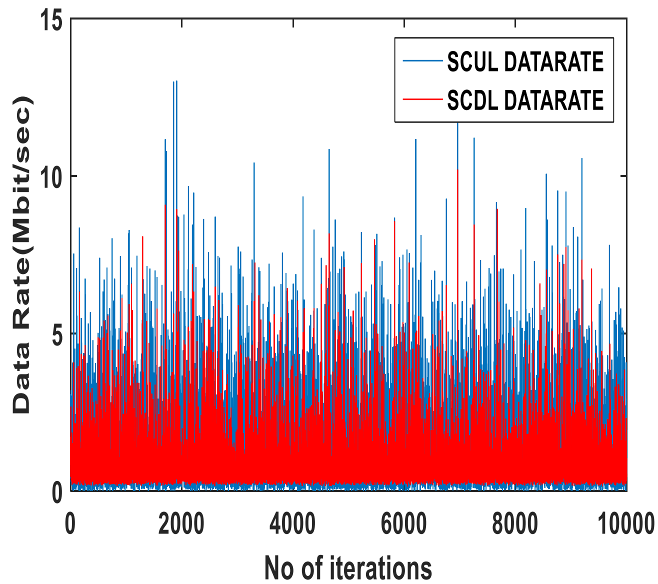

FIGURE 5. Spectral Efficiency of Coupled and Decoupled Small cell Uplink

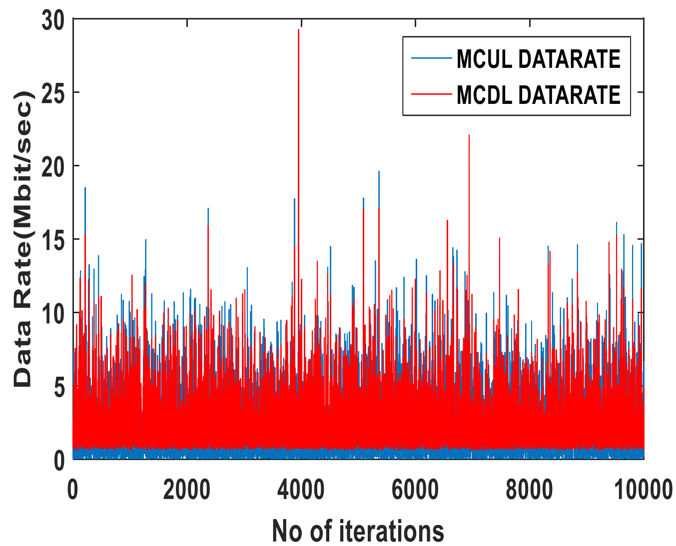

FIGURE 6. Spectral Efficiency of Coupled and Decoupled Macro cell Uplink

Figure 6 shows the CDF of uplink SIR received by different small cells for both coupled and decoupled networks. Figure 6 shows the CDF of uplink SIR received by different macro cells for both coupled and decoupled networks. Here, in a specific area of 1km by 1 km for a fixed location of the test user. In our simulation, SIR is calculated at 1000 iterations of the test user for both coupled and decoupled associations. The figure demonstrates that decoupling dependably beats the coupled association.

In figure 7, the CDF plot of SIR of coupled and decoupled Uplink Small cell is shown. From the figure, we can see that probability of getting lower SIR is high in the coupled system as compared to decoupled once. While in the decoupled probability of getting higher SIR is better.

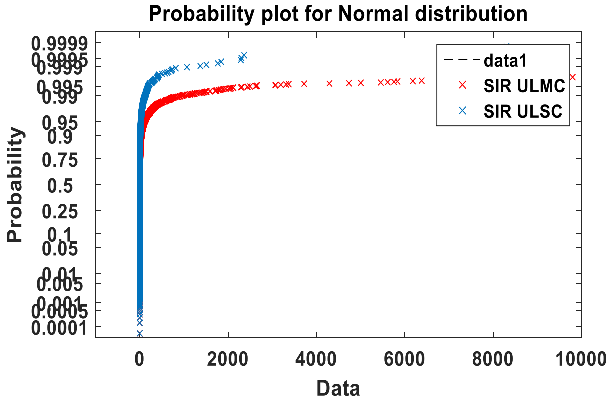

FIGURE 7. **CDF of SIR Small cell Uplink for coupled and decoupled Network**

In figure 8, the CDF of the probability of getting higher SIR of the macro cell for both coupled and decoupled systems is shown, and the figure shows the probability of getting a higher SIR value in a decoupled network is good as compared to coupled ones.

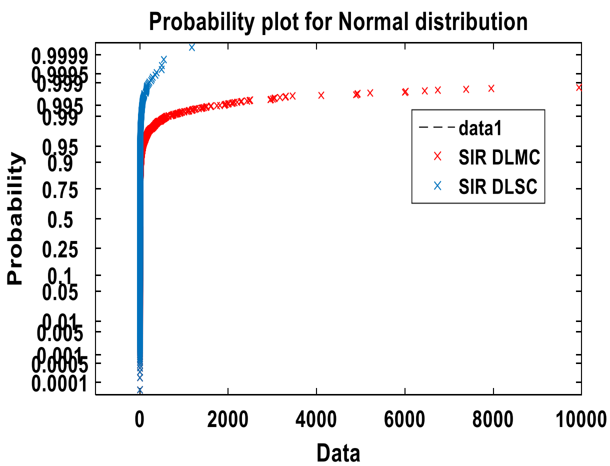

FIGURE 8. **CDF of SIR Macro cell Uplink for coupled and decoupled Network**

V. CONCLUSION

In this paper, we analyzed the data rates, SIR, and CDF of the coupled and decoupled systems and compared the results. Simulation results proved that decoupled networks' performance in terms of data rate and SIR is better than coupled networks. In the future, ways to improve spectral efficiency can be figured out. In this paper, two tiers are considered, i.e., macro, and small cells. In the future, multi-tier can be considered Uplink throughput, and coverage probability can also be considered in coupled and decoupled networks.

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