On Handovers in Uplink/Downlink Decoupled LTE HetNets

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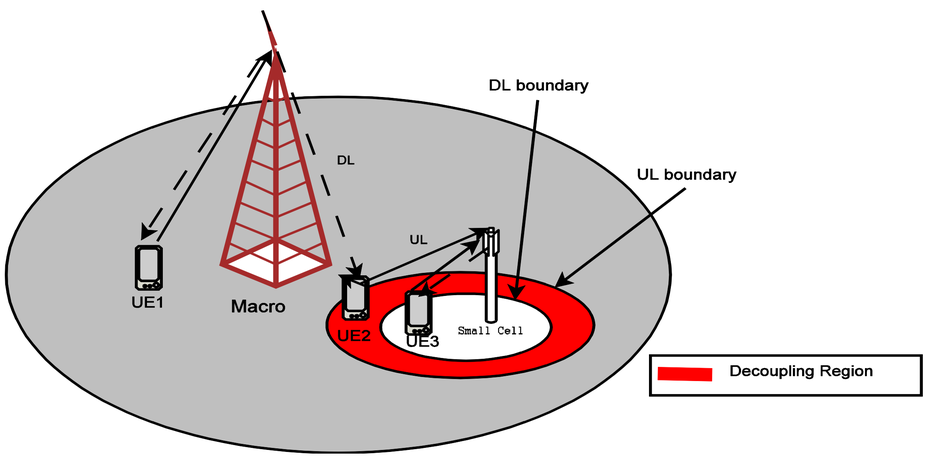
Introduction

- Presently, cellular network users are not only those which generate mostly downlink (DL) traffic (web browsing, downloading) but also combination of users generating symmetric (both uplink (UL) and downlink) traffic (social networking, gaming) and users generating uplink traffic (IoT devices)
- In such a heterogeneous environment, it is highly possible that a user equipment (UE) or a device will receive signals from different base stations (including Macro cell and small cells) and will have an option to connect with one of them.
- For a device, a base station which is good in terms of downlink connection, may not be good for uplink connection. This phenomena is termed as UL/DL imbalance.
- The concept that a device gets connected to two different cells in downlink and uplink respectively, is called as downlink/uplink decoupling (DUDe).

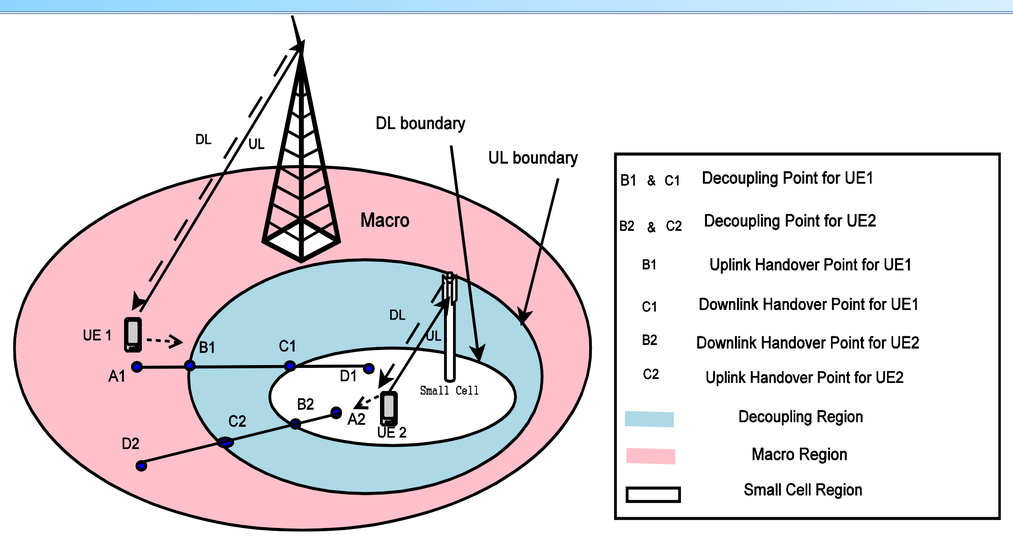
Advantages of Decoupling

- Due to smaller path loss, uplink SNR will increase and transmit power requirement for a device will be lesser for a fixed target SNR.
- Uplink interference condition will be improved due to reduced UL transmit power.
- Increased uplink SNR and decreased uplink interference will result in increased SINR and hence, uplink data rate will be increased.
- UL load on Macro cell can be pushed towards underutilized small cells.

An example of Downlink/Uplink Decoupling



Possible Handover Points in DUDe



Call Flow Diagrams for Handover

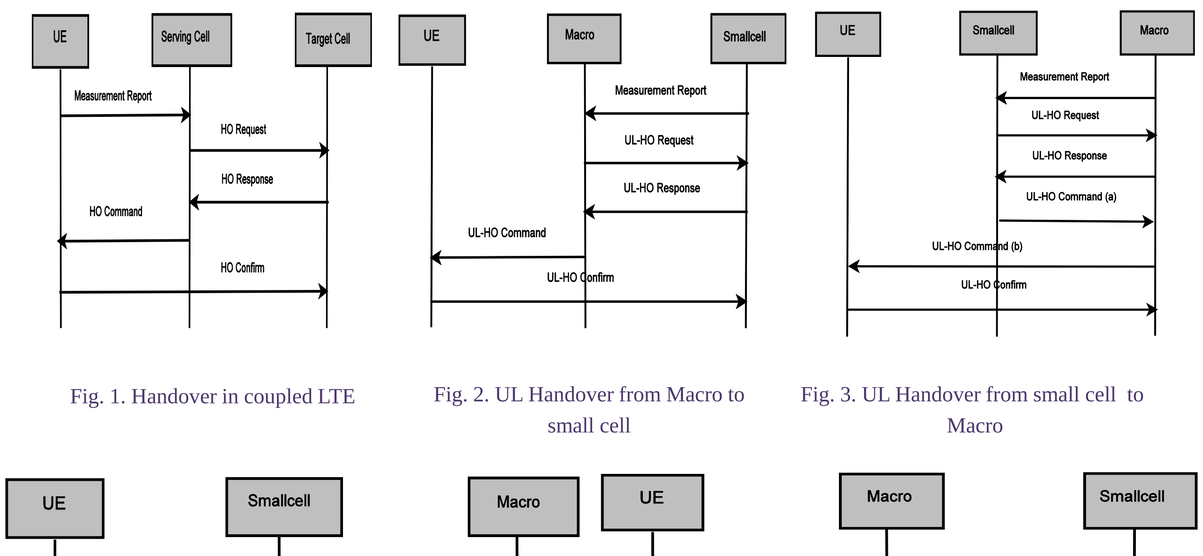


Fig. 1. Handover in coupled LTE

Fig. 2. UL Handover from Macro to small cell

Fig. 3. UL Handover from small cell to Macro

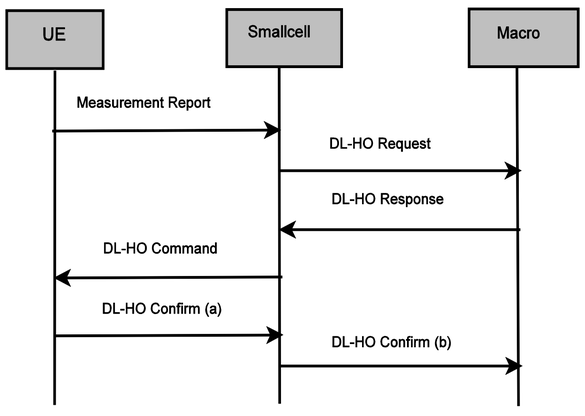


Fig. 4. DL Handover from small cell to Macro

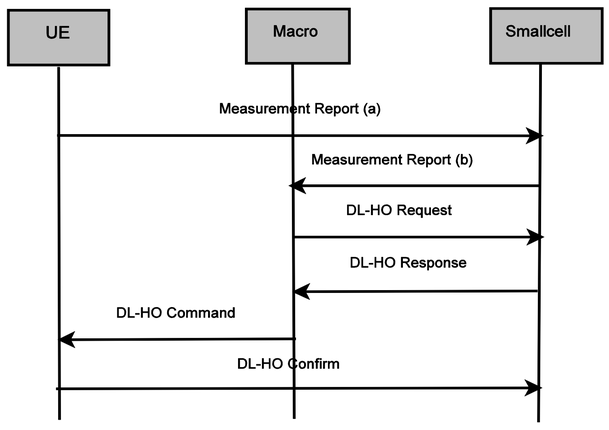


Fig. 5. DL Handover from Macro to small cell

SINR Analysis in Multiple Small Cell Scenario

$$SINR_M = \frac{10^{(\alpha-1)(35+30*\log(d_M))}}{L} \quad (1)$$

$$SINR_{S_1} = \frac{10(\alpha-1)(35+30*log(d_{S_1}))}{L} \quad (2)$$

From Equation (1) and (2), it can be written that

$$SINR_{S_1} = \left(\frac{d_M}{d_{S_1}}\right)^{30(1-\alpha)} * \mathrm{SINR_M}$$

Simulation Setup & Parameters

TABLE 1: SIMULATION PARAMETERS

Parameter	Value
Macro cell and small cell DL transmit power	40, 20 dBm
Maximum UE transmit power	23 dB
Number of resource blocks	10
Macro cell and small cell power control parameters α and β	0.7, 0.7
Macro cell coverage radius	1 KM
Small cell coverage radius	0.035 KM
Number of small cel1	8
Scheduling Algorithm	Round-Robin

Results & Analysis

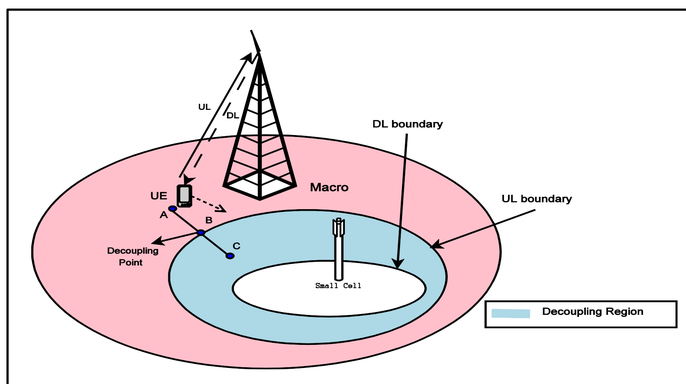


Fig. 6. Mobility in Decoupling Region

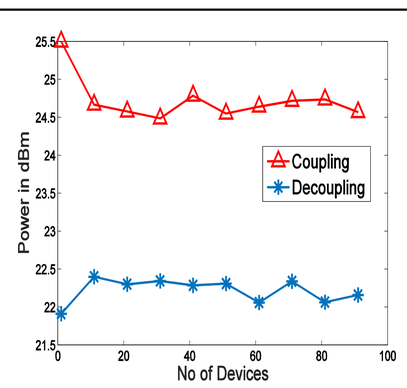


Fig. 7. Power Consumption in Round Trip Journey

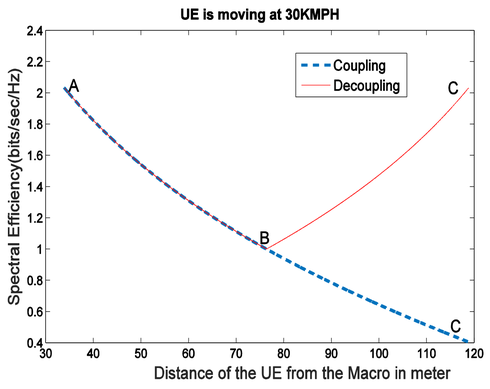


Fig. 8. Spectral Efficiency Comparison

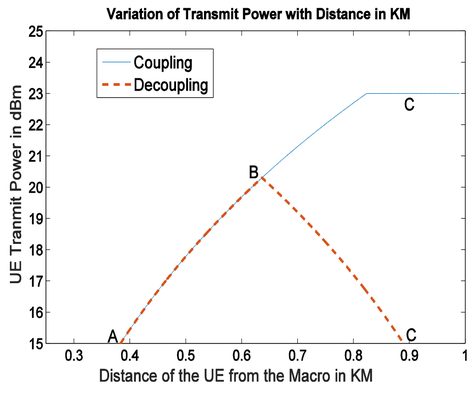


Fig. 9. Comparison of Transmit Power

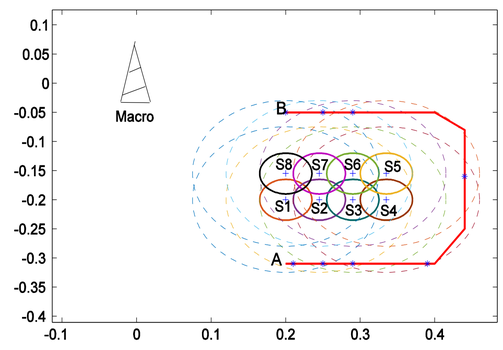


Fig. 10. Interference in Multiple Small Cell

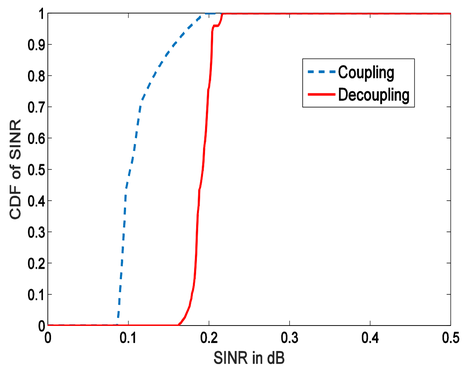


Fig. 11. CDF for Uplink SINR

- We can say that, in order to achieve same uplink SINR, required transmit power is more in coupled connection in comparison to decoupled connection

Conclusion

- In this work, new handover schemes are proposed and analyzed for DUDe systems which were not existing in legacy coupled systems.
- Results are confirming that DUDe is a better option to increase the efficiency of LTE HetNets.

Acknowledgement

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