

Agenda item: 6.3.8
Source: Samsung
Title: Per Cluster Based Opportunistic Power Control
Document for: Discussion/Decision

1 Introduction

In Macro-Femto cochannel deployment, the introduction of new low power nodes benefits the system average throughput due to the cell-split gain, while the macro UE may suffer from the interference caused by another cell layer. The main reason of the uplink edge coverage degradation in Het-Net is the intensive interference aggression from another layer's UEs, which makes the received SINR not sufficient [1]. Thus, this may lead to poor edge coverage performance, especially for a MUE near the area where Femto-cells are densely deployed (e.g., complex shopping center, apartment building area), as shown in Figure 1. To mitigate the aggregate interference, the existing power control (PC) algorithm in [2] has considered path loss (PL) but did not reflect shadow fading. Hence, we here propose the PC algorithm considering the uncertainty caused by shadow fading.

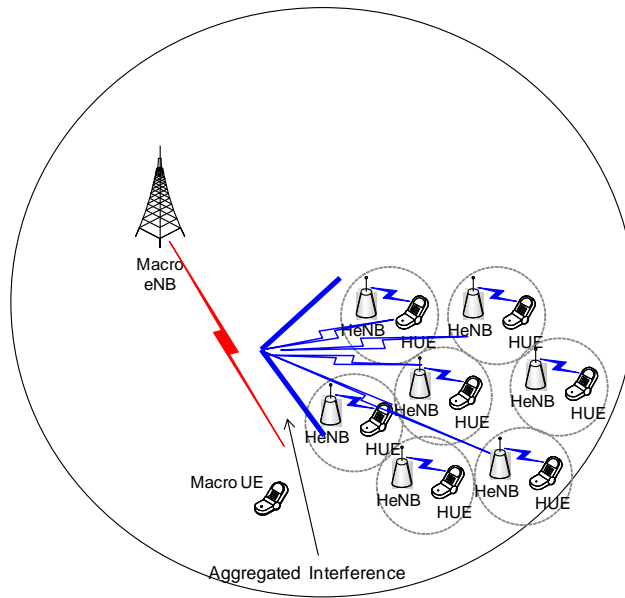


Figure 1: Uplink interference scenario of Macro and Femto cochannel deployment.

2 Power Control with Interference Allowance

The interference to PUCCH in Het-Net can be mitigated by power control. The main motivation of this PC algorithm is to increase total cell throughput of the Het-Net system with little degradation to other layers by uplink interference allowance per Femto-cell (P_f). The interference allowance per Femto-cell guarantees uplink transmission quality from MUE to MeNB by limiting the interference per Femto-cell. When the interference allowance is predicted, large-scale channel information is exploited. To ensure the proper functionality of a network, the shadowing variation is controlled by an outage probability constraint. The maximum outage probability δ is allowed with required SINR threshold (Γ). The outage probability constraint for large-scale shadow fading is defined as (derivation omitted due to limited space)

$$1 - Q\left(\left[\left(\ln N + \ln P_f - \ln(Tx_power_{MUE} \cdot PL_{MUE-MeNB}) - \alpha(N)\right) + \ln \Gamma\right] / k \sqrt{\sigma_c^2 + \sigma_f^2}\right) < \delta \quad (1)$$

Here, $k = \ln 10 / 10$, the parameters σ_c^2 and σ_f^2 are shadowing variances of Macro and Femto, respectively, and $\alpha(N)$ denotes the remaining shadowing terms as a function of N for simplicity. Thus, the interference allowance can be predicted when the number of active Femto-cells (N) is *a priori* known. The HUE transmit power (Tx_power_{HUE}) is then allocated according to the interference allowance (P_r) since P_r is defined as

$$P_r = Tx_power_{HUE} \cdot PL_{HUE-MeNB} \quad (2)$$

3 Per Cluster Based Opportunistic Power Control

The Macrocell receives the interference from only those active HUEs transmitting to their own HeNBs. The PC algorithm should reflect the number of active HUEs, not the number of entire HUEs. The *opportunistic* power control based on the *effective* interference level can increase cell throughput because more power can be allocated to active HUEs when more HUEs are in idle mode. Figure 2 shows two sensing algorithms to enable opportunistic power control.

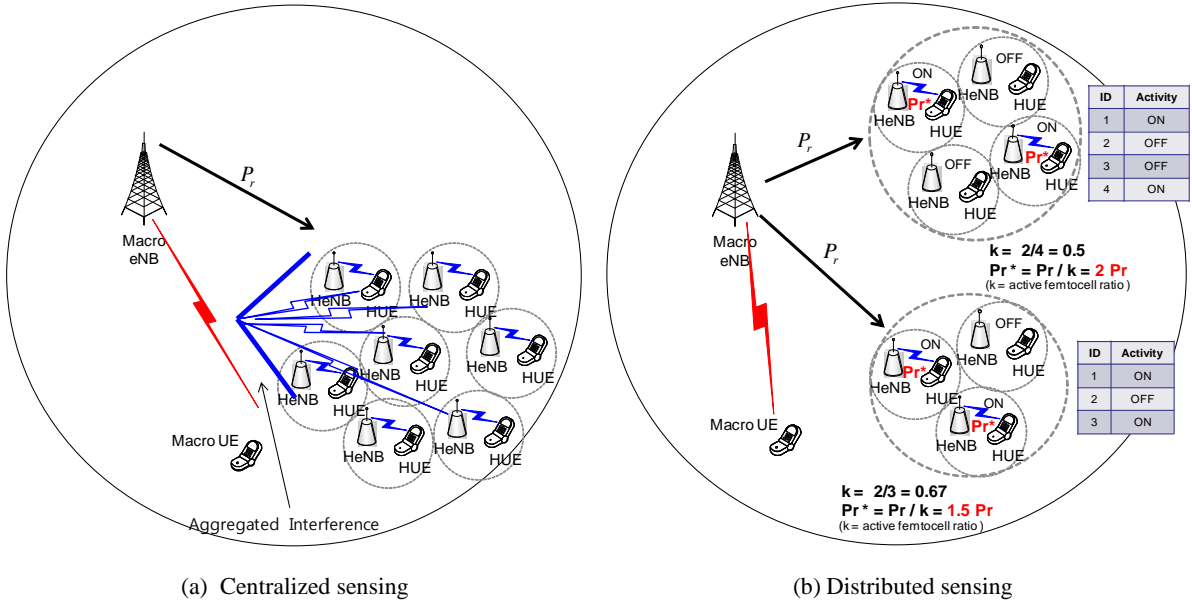


Figure 2: Opportunistic power control with two sensing algorithms.

Proposal: Self-Configuration Algorithm.

By *centralized sensing*, MeNB can estimate the number of active Femto-cells per cluster (i.e., sectoring). Since the *aggregate* interference from all active Femto-cells in each cluster has a lognormal random characteristic, the number of active Femto-cells (N) can be estimated using the first two moments of the aggregate interference. Once N is estimated, HUE uplink power is allocated in (2) using the interference allowance predicted by (1) with the estimate of N , *entirely*.

Proposal: Self-Optimization Algorithm.

In order to reduce the message overhead of X2 interface, the sensing algorithm can be conducted locally. In *distributed sensing* algorithm, some of Femto-cells constitute a new cluster in less than cut-off distance and each Femto-cell senses whether the others are active in the same cluster. Each one then makes a table about the cell ID and activity (ON/OFF) from directly connected one (1 hop) to the farthest one in order. By using this information, an active Femto-cell ratio can be computed, which allows to determine the *effective* interference allowance by normalizing with the ratio. Hence, Femto-cells can opportunistically increase their uplink power by sensing the channel activity in the same cluster, *locally*.

4 Conclusions

In this contribution, we have proposed per cluster based opportunistic power control via activity sensing, along with PUCCH power control for a cochannel deployment with Macro and Femtos. The following conclusions can be drawn:

- a) **The PC scheme exploits large-scale channel information and shadowing variation to predict the interference allowance per Femto-cell. The PC scheme guarantees the MUE uplink channel quality.**

- b) The two sensing algorithms estimate the number of active Femto-cells to perform opportunistic power control, either entirely or locally. Thus, total cell throughput can be increased.**

References:

- [1] R1-103499, "Uplink Data Channel Interference Mitigation via Power Control", CATT
[2] 3GPP TR 36.814, "Further Advancements for E-UTRA Physical Layer Aspects", v9.0.0, March 2010