Interference management in femtocell-aided cellular networks

Supervisors: Guillem Femenias Nadal and Felip Riera Palou
{guillem.femenias,felip.riera}@uib.es
Office 109, 1st floor, Anselm Turmeda building
Mobile communications Group
Telf: 971-173196

Background

In recent times the concept of femtocell has become a hot topic that it is currently being discussed within the different standardisation communities working towards the definition of 4G systems [1, 2]. A femtocell refers to a (cheap) user-deployable base station with very limited coverage area (typically a household or an office) and connected to the backhaul via a broadband connection (e.g. ADSL, fiber). The driving force behind the femtocell approach is the fact that recent studies have shown that the vast majority of data traffic originates indoors, where often, conventional cellular coverage (e.g. via macrocells) is poor. If these indoor traffic can be routed into the cellular network using a nearby femto base station, the corresponding users will experiment an increase in capacity (i.e. throughput) while macro BS resources might be spared, which in turns implies a reduction in network maintenance and deployment costs for the operator. Note that unlike WiFi systems, femtocells are expected to operate in a licensed frequency band typically subject to tight regulations. Femtocells can be broadly categorized as closed- or open-group depending on whether the femto BS only provides service to registered users (closed) or, on the contrary, spontaneous users located nearby the femto can exploit the femtocell resources (open).

Despite its promising advantages, femtocells are not free from drawbacks. In particular, handling the interference between the macro and femto layouts is an open problem currently subject of intensive research [3]. Focusing on closed femtocells, strong uplink interference can arise when a macrouser located on the (macro)cell edge radiates at high power while being close to a femto BS, thus potentially disrupting the operation of the femtocell users. Similarly, in the downlink, the macrocell user will have to handle the large amount of interfering signals generated by close-by femtocell users while trying to recover a weak signal transmitted from a distant macro BS. Moreover, inter-femto interference becomes an issue whenever femtocells coverage area overlap. Several approaches have been proposed to tackle the femtocell interference problem. Among them, fractional frequency reuse (FFR) has been proposed in the context of OFDMA-based networks. In FFR, macro and femto users are assigned different subcarriers depending primarily on their geographical position. A more promising approach is a technique known as dynamic resource partitioning (DRP) [4] where subcarriers are dynamically assigned to femto/macro users in a time varying fashion depending on the particular interference pattern created between the two tiers of the network [5].

Keywords: Femtocell, Macrocell, Interference, fractional frequency reuse, OFDMA.

Objectives

The main aim of this project is to evaluate the performance of DRP and FFR in a femtocell-assisted OFDMA-based network defined in accordance with the 4G requirements (e.g. LTE Advanced). Building mainly on the work of [5], the idea is to compute the interference powers experienced by the different user types (macro *vs* femto, uplink *vs* downlink, inter-femto) and subsequently derive expressions for the signal-to-noise ratio (SNR) and capacity that can provide a good indication of the achievable throughputs. These physical layer measures (capacity, SNR, throughput) can then form the stepping stone onto which to build efficient radio resource management (RRM) schemes aiming at the optimization of different performance metrics (throughput, fairness,...). Over the course of this project we aim to answer the following questions:

1. What are the effects of interference on the different user types?
2. What are the benefits of femtocells at a user and network levels?
3. What are the advantages of DPR over FFR?

To fulfill this goal, student are expected to:

- Acquire a reasonable amount of knowledge on some state-of-the-art wireless topics such as multicarrier and femtocells and also on state-of-the-art standards such as 3GPP-LTE Advanced.
- Understand in detail the different femtocell architectures that are being considered in 4G networks.
- Derive capacity expressions for the different types of users and scenarios in a femto-assisted network defined in accordance with 3GPP-LTE specifications and using FFR.
- Become competent in the use of Matlab.
- Develop a Matlab simulation environment for evaluating the interference issues in femto-assisted networks.
- Write a technical report describing the work done.
- Prepare an oral presentation highlighting the main points of the project.

Tools: Search engines for literature review (*scholar.google.com, www.ieeexplore.org*), Matlab for programming, LaTEX for report writing.

Pre-requisites: general knowledge of communication theory and mobile communication networks.

Bibliography

[1] V. Chandrasekhar, J. Andrews, and A. Gatherer, "Femtocell networks: a survey," *Communications Magazine, IEEE*, vol. 46, no. 9, pp. 59 –67, september 2008.

[2] H. Claussen, L. Ho, and L. Samuel, "An overview of the femtocell concept," *Bell Labs Technical Journal*, vol. 13, no. 1, pp. 221–245, 2008.

[3] D. Lopez-Perez, A. Valcarce, G. de la Roche, and J. Zhang, "OFDMA femtocells: A roadmap on interference avoidance," *Communications Magazine, IEEE*, vol. 47, no. 9, pp. 41 –48, september 2009.

[4] T. Lee, H. Kim, J. Park, and J. Shin, "An efficient resource allocation in OFDMA femtocells networks," in *Vehicular Technology Conference Fall (VTC 2010-Fall), 2010 IEEE 72nd*, sept. 2010.

[5] Z. Bharucha, A. Saul, G. Auer, and H. Haas, "Dynamic resource partitioning for downlink femto-to-macro-cell interference avoidance," *EURASIP Journal on Wireless Communications and Networking*, vol. 2010, no. ID 143413, 2010.