CONACYT program 2015

PhD project proposal form

Discipline
Engineering Sciences

Doctoral School
422 - Sciences and Technologies for Information, Telecommunications and Systems

Thesis subject title
Fluid modeling for K-tier cellular networks

Laboratory name Laboratory of Signal and Systems (L2S)
Laboratory web site https://www.l2s.supelec.fr/

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- **Thesis proposal (max 1500 words)**

Small cell and more generally femtocell technologies are used to face the rapid growth of cellular network traffic in terms of density and diversity. A small cell or a femtocell is a low-cost low power base station, used in a plug and play manner by customers. Originally, femtocells were envisioned as a way to provide better coverage for voice data in case of indoor utilization. Nowadays, they are used to offload macro-cellular networks and to improve both capacity and coverage in both indoor and outdoor utilization.

Deployment of femtocells within a macro cellular network forms an heterogeneous network also called 2-tier network. More generally, an heterogeneous network (k-tier network) is an economical and efficient solution to increase capacity and coverage in radio transmission. However, communications suffer from interference due the spectrum sharing and the random location of femtocell base stations. Several solutions have been proposed for spectrum management and resource sharing including power control, multiple antennas, adaptive FAP (Femtocell Access Point), cognitive radio. The topic addressed in this thesis deals with the problem of energy saving and cell association in an heterogeneous network. The work aims at developing a tractable and an accurate model to represent the behavior of heterogeneous network using an appropriate modeling approach called spatial fluid modeling.

Thesis expectation

Stochastic geometry modeling tools are extensively used to develop more tractable analytical models to study the performance of k-tier networks in terms of the probability of coverage/outage and throughput. For example, Poisson Point Process is used to describe the position of the femtocell base stations and the mobile users and to derive the communication performance like the coverage/outage probability and the throughput. However, stochastic models are difficult to compute, and in most cases simulation is used to evaluate their accuracy.

To reduce the computation complexity, a fluid modeling is used without over-simplifying the model. The spatial fluid modeling was used in macro cellular network to give an explicit expression of the interference factor and to take into account the distance a mobile to its serving base station. The model of the interference factor obtained like so, was used to evaluate the quality of service over macro cellular network, the capacity of OFDMA network, the outage probability and for network dimensioning.

The objective of this thesis research is to use spatial fluid modeling to evaluate the performance of a k-tiers network using beamforming antennas. This work will consist in two parts. The first part will focus on the extension of the fluid model of the interference factor to consider the constraints of a k-tier network on both the uplink and the downlink. It allows then to evaluate the capacity, the coverage and the outage probability using this model.
In the second part, using the obtained model, the work will be focused on the network connectivity in case of outdoor deployment of femtocells. Moreover, it will serve to study the impact of the association and biasing policies, to define some energy saving policies and to evaluate the gain on the network with respect to coverage and capacity.

Brief description of scientific and technical steps — this thesis aims to study and propose innovative models for the multicellular networks. The PhD involves the steps sketched below.

- Bibliography on k-tier cellular networks
- Bibliography on PPprocess and fluid models
- Study of alternative models
- Study of energy saving policies and modeling

Pre-requisites — The applicant, beyond the Master degree (acquired in telecommunication engineering or computer science, for example), should have good skills in networks protocols, 3G and 4G cellular mobile networks, simulation, probability and performance evaluation, stochastic modeling and C/C++ programming.

Skills fostered/gained during PhD — The PhD is at the crossroad of two scientific areas: modeling and cellular networking.

- **Publications**

[1] J. G. Andrews, H. Claussen, M. Dohler, S. Rangan, and M. C. Reed, “Femtocells: Past, present, and future,” IEEE Journal on Selected Areas in Communications, vol. 30, no. 3, pp. 497–508, 2012.
[2] W. C. Cheung, T. Quek, and M. Kountouris, “Throughput optimization, spectrum allocation, and access control in two-tier femtocell networks,” IEEE Journal on Selected Areas in Communications, vol. 30, no. 3, pp. 561–574, 2012.

[3] J.M. Kelif**,** M. Coupechoux **and** P. Godlewski, **"**A Fluid Model for Performance Analysis in Cellular Networks", EURASIP Journal on Wireless Communications and Networking - Special issue on interference management in wireless communication systems: theory and applications Volume 2010, January 2010
[4] H. Wang, X. Zhou, and M. C. Reed, "Analytical evaluation of coverage oriented femtocell network deployment," CoRR, vol. abs/1305.3356, 2013.