



Campaign 2010 Description of the PHD

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Location: Issy les Moulineaux (Paris area)

PHD title: Advanced inter-cell interference mitigation for 4G networks

Global context and state of the art

Coordinated Multipoint (CoMP) is one of the techniques identified as key to alleviate inter-cell interference in 4G mobile networks. In March 2010, 3GPP decided to postpone the inclusion of CoMP in LTE-Advanced beyond Release 10, because the technology was judged not to be mature enough yet. The main problem is the sensitivity of the current algorithms to the practical channel impairments (e.g. channel estimation errors, feedback delay). Therefore, one objective of the thesis is to propose realistic CoMP schemes that achieve gains in the real network.

On the other hand, it is likely that even efficient CoMP schemes will not be able to suppress all the inter-cell interference. An alternative promising approach to interference reduction has been recently identified: the mixed approach combines interference reduction via transmitter processing (typically CoMP) with interference processing at the receiver. However, enabling efficient inter-cell interference processing at the receiver implies constraining the scheduler. Several problematics are associated with this approach, which are not well understood at the moment. For instance, is it better to take advantage of the frequency-scheduling gains provided by unconstrained scheduling, or to reduce the scheduling gains but reduce the interference? A second objective of the thesis is to evaluate the feasibility and associated gains of the mixed approach.

At last a breakthrough technique called interference alignment has appeared recently in the literature. This technique implies processing the signal at several transmitters so that the interference it creates at one receiver lies in a single signal dimension (e.g. the Q branch) and can thus be easily suppressed at the receiver. Although the feasibility of this approach has been demonstrated in theory, no practical scheme has been identified so far. A third objective of the thesis is to investigate the interference alignment concept and propose practical schemes relying on it.

PHD objectives / Expected results / Scientific challenges / Key Issues

As explained above, the objectives of the thesis are to investigate interference reduction techniques, according to the following research axes:

- Design realistic CoMP schemes that deliver effective gains in the real network, taking into account practical impairments.
- Investigate the feasibility and gains of the mixed approach.
- Explore the interference alignment concept and propose practical schemes relying on it.

All these problematics constitute open and challenging research topics at the moment. The thesis will focus exclusively on the downlink (transmission from the base station to the mobile terminal).

Methodological approach proposed by the supervisor

The candidate shall be highly motivated by research in an industrial context, and have a solid background on digital communications, signal processing and information theory. In addition, due to the foreseen participation in a European collaborative project, the candidate will need to have an excellent level in written and spoken English. The additional necessary knowledge include Matlab and C/C++.

The thesis environment will be 4G systems, in particular the 3GPP LTE-Advanced. The following knowledge components will thus need to be acquired: MIMO, OFDMA, scheduling, receiver processing, system-level simulations. Then, the candidate will need to get familiar with the state of the art in CoMP, both from the academic literature as well as contributions submitted to 3GPP. This will be able to be performed first via a bibliographic study as well as initial simulations via a simplified Matlab system-level simulator already available. Then practical CoMP schemes will be studied, in particular with respect to robustness to channel estimation errors and limited feedback.

In a second phase of the thesis, a state of the art about advanced receiver techniques for MIMO OFDM will be performed, together with a review of the ongoing investigations on the mixed approach within the ARTIST 4G project. Practical strategies for combinations of advanced receiver techniques with CoMP will be identified and evaluated, including scheduling constraints.

The last phase of the thesis will be devoted to the study of the concept of interference alignment in the context of the mixed approach. It will start with a familiarization with the theoretical concepts of interference alignment. Then practical schemes relying on interference alignment will be investigated. This last phase may actually be combined with the second one.

Global schedule

1. [T0, T0+ 6 months]: familiarization with the context of the thesis: LTE-Advanced, MIMO, OFDMA, scheduling, receiver processing, system-level simulations, state of the art in CoMP.
2. [T0+ 6 , T0 + 12]: investigation of practical CoMP schemes
3. [T0+12, T0+24]: investigation on the mixed approach
4. [T0+24, T0+30]: exploration of the interference alignment concept
5. [T0+30, T0+36]: writing of the report, defense.

Additional contributions

Participation in the European Commission collaborative project FP7 ARTIST 4G.