Prof. Dr Preben Mogensen  
Aalborg University  
Department of Electronic Systems,

Aalborg, 18.10.2013

Review
of the doctoral thesis prepared for
the Council of the Faculty of Electronics and Telecommunications
of Poznan University of Technology

Title of the dissertation: Radio Resource Management for Multi-Carrier Relay-Enhanced Networks

Author of the dissertation: Jacek Góra

1. What scientific issue is considered in the dissertation (dissertation thesis)? Has it been formulated by the author sufficiently clearly? What is the character of the dissertation (theoretical, experimental, other)?

The topic of the thesis is in accordance with the title: Radio Resource Management for Multi-Carrier Relay-Enhanced Networks. LTE-Advanced (4G) is used as a case study for the dissertation. A large part of the research work has been created by the author while working in the EC, 7th Frame Program project: Advanced Radio Interface Technologies for 4G Systems (ARTIST4G), on behalf of Nokia Siemens Networks. The reviewer expect that the involvement in ARTIST 4G research project, for good or bad, may have set some direction and limits on the research topic of the dissertation.

2. Has the author properly performed literature analysis (including the state-of-the-art and industrial applications)? Have the conclusions drawn from this literature overview been formulated in a clear and convincing way?

Chapter 2 of the thesis presents “Baseline System and State of the art solutions”. Section 2.1 introduces the IMT-Advanced framework and also introduces the technical enhancements to LTE-Advanced and 802.16m in order to fulfill the IMT-Advanced requirements. These include: Advanced multi antenna techniques, Carrier Aggregation, HetNets, and improved interference mitigation techniques. The focus of the dissertation is to investigate two of the technical enhancements advanced for IMT-Advanced; Relay Node in systems utilizing multiple frequency carriers (including carrier aggregation techniques). The main base line for the dissertation is Release 10 of the LTE system.

Section 2.2.1 provides a tutorial on the classification of Relaying Concepts, and Section 2.2.2 goes into more details of Relay Node implementation in LTE-Advanced. Section 2.3 provides and Evolution of RRM concepts for interference coordination with main focus on soft or hard frequency reuse.

To my understanding, state of the art is not confined to Chapter 2, but is also propagating into Chapter 3 (and a bit into Chapter 4).
The Thesis includes 109 references. The reference list includes a good combination of 3GPP and WIMAX specifications, Internal ARTIST4G deliverables, conference and Journal publications.

I think the thesis could have improved on state-of-the art by:

- Shortening Section 2.2.1; Classification of Relay Concepts. It is a nice tutorial, but the choice for investigation is anyway not based on this tutorial, but according to LTE-Rel 10.
- Radio Resource management is much broader than Inter-Cell interference coordination
- Chapter 3 is a bit of a mixture of State of the art and the Authors own contributions – This makes it difficult for the reviewer to clearly understand what is state-of-the art background information and what is the Authors newly produced contributions.
- I would have expected the Author to also have included references to articles also more critical to the application of Relay Nodes, e.g.:

  Deployment of LTE In-Band Relay and Micro Base Stations in a Realistic Metropolitan Scenario. / Coletti, Claudio; Mogensen, Preben; Irmer, Ralf; IEEE VTS Vehicular Technology Conference. Proceedings, 10.09.2011

3. Has the author solved the stated problems and has he/she used the appropriate research method? If not, why? The author's contribution to state-of-the-art

As noted above the various contributions are solved somewhat independently. In mathematics, this is known as a non-common assumption. In 3GPP, there are two main assumptions to make the solution to make the solution valid. Simulation results are presented in Section A of the manuscript.

3.1.2.3. How the author has solved the problems

The author has solved the problems by using a different approach. The author has developed an algorithm for solving the problem. The algorithm is based on the solution presented in the manuscript.

3.2.1. The author's contribution to the state of the art

The author's contribution is the development of a new algorithm for solving the problem. The algorithm is based on the solution presented in the manuscript.

4. What is the individual and original contribution of the author towards the published thesis? How is a part of the thesis with respect to the state-of-the art or the techniques represented in the work literature?

The author's contribution to the thesis is the development of an algorithm for solving the problem. The algorithm is based on the solution presented in the manuscript. The algorithm is new and represents a significant improvement over existing techniques. The algorithm is presented in detail in Section A of the manuscript.

The main contribution of the Author has been towards QoS and various fairness criteria as part of the analysis.
It is the understanding of the reviewer that this topic has still only been sparsely researched and the research work of the dissertation provides substantial novelty to the topic.

5. Has the author shown his/her abilities of a correct and convincing presentation of the achieved results (concreteness, clarity, editorial correctness of the thesis)?

The Author is in general using a clear and easy to read language. The documentation is convincing and the result generation has been thoroughly. The thesis documents that the Author is able to handle a complex topic in a structured manner. The reviewer appreciate that the full set of simulation assumptions is summarized in Appendix A.

6. What are the weaknesses of the thesis and what are its main drawbacks?

The dissertation work documented in the thesis is a solid research contribution to the topic of RRM for relay nodes for single carrier and multi carrier networks. Hence the below mentioned issues shall not be interpreted as critical, but rather proposals for improvements:

The reviewer would have liked to see the Authors novel contributions clearly summarized at the end of Chapter 1: including contributions to simulator development, RRM for relay node concept creation, list of publications and filed patent applications.

Each of the contributing Chapters 2 to 5 includes a summary. Chapter 6 of the thesis is devoted to “Summarizing the Results and Conclusions”. To my taste, Chapter 6th is too much summarizing and too little concluding. The Chapter nicely summarizes what has been analyzed in the dissertation, but as an example there is not a single performance or gain number mentioned in Chapter 6th. The theses of the dissertation are nicely formulated in Chapter 1.2, but the respective conclusions on the theses are less clearly formulated in Chapter 6.

In Chapter 1 (page 2) the author state that his work assumes a holistic view on the evolution of cellular systems by consolidating various features proposed for the 4G systems. In this respect I am missing some initial examination and also final conclusions on whether Relay Nodes is at all an attractive method for cellular network evolution. How adequate it is compared to other network evolution options (and in what scenarios is it a less attractive solution).

The number of citations to the publications based on the dissertation work is rather low (with excluding self citations). This indicates that the research work of the dissertation may not have had high impact.

7. What is the usefulness of the thesis for development of technical sciences?

As already mentioned the thesis provides a solid research contribution to the topic of RRM relay nodes for single carrier and multi carrier networks under certain Qos and fairness requirements. The research work has been conducted thoroughly.

8. Please classify the thesis to one of the categories listed below:
   a) not fulfilling requirements for doctoral dissertations stated in the current law
   b) requiring corrections and the second review process
c) fulfilling requirements

d) fulfilling requirements with clear excess

e) remarkably good, deserving distinction

The reviewer evaluate the thesis to „fulfilling requirements”

The above stated questions have auxiliary character only. It is advised to formulate the content of the review in such a way that it can be read without reading these questions.

Signature

Preben Mogensen