

ERCIM “Alain Bensoussan” Fellowship Scientific Report

Fellow: **Ioannis Chatzigeorgiou**
Visited Location: **Norwegian University of Science and Technology (NTNU)**
Duration of Visit: **9 months (January 7, 2010 – September 30, 2010)**

I - Scientific activity

In the first weeks of my visit, I was invited to deliver two talks, as part of the seminars that are held at the Department of Electronics and Telecommunications at NTNU. The first presentation familiarized the audience with my involvement in past research projects, whilst the second talk was more technical and focused on my recent research interests.

The ERCIM fellowship allowed me to concentrate on the completion of work that I had initiated in previous years and submit it to international journals. Previously, I had obtained mathematical expressions that accurately described the outage probability of collaborative decode-and-forward networks. Nevertheless, the complexity of the exact expressions did not shed much light into the impact of each network parameter on the overall network performance. I considered specific realistic scenarios and obtained tractable asymptotic approximations that clearly illustrate the dependence of the outage probability to the network size, the adopted transmission scheme and the channel conditions. I compiled the research outcomes in a paper that I submitted to the IEEE Transactions on Communications in early 2010. The manuscript has been accepted for publication and it will appear in a forthcoming issue of the journal.

In addition to the previously described work, I had also initiated a joint project with Dr. Alberto Tarable from Politecnico di Torino, with whom we had presented the early outcomes of our collaborative research in the 2009 Information Theory Workshop. During the past months, we developed a complete system model for relay networks that store and forward source packets to one or more destination nodes in a random fashion. Based on a Markov chain approach, we established a framework for the computation of the erasure probability of packets, that is the probability that the destination will not manage to recover the transmitted source packets. Moreover, we demonstrated that the erasure probability can be minimized by adjusting the frequency with which relays change their operational state independently of each other; note that a relay can either receive packets from a source or forward them to a destination. More importantly, we obtained closed-form expressions for the case of relays that are equipped with large memories and we showed that our proposed scheme performs better than conventional first-in first-out forwarding. We are in the process of preparing a journal paper, which we plan to submit to the IEEE Transactions of Information Theory in the next few weeks.

I also had the opportunity to interact with members of the Signal Processing Group and the Radio Group at NTNU and identify thematic areas of common interest. More specifically, Dr. Kimmo Kansanen, Dr. Ghassan Kraidy and I have formulated a problem of practical interest for delay-critical wireless networks. According to the system model, receiving nodes should be

able to obtain an increasingly good estimate of the source information as additional data are successfully recovered. We have already laid the foundations for joint collaborative research that will investigate the trade-off between delay and distortion, explore the benefits of feedback channels and develop coding schemes for practical scenarios.

During the past 9 months, apart from working on projects of personal interest, I also reviewed journal papers for the IEEE Transactions on Wireless Communications and the IEEE Signal Processing Letters, as well as conference papers for the 2010 International Conference on Telecommunications, the 2010 International Conference on Cognitive Radio Oriented Wireless Networks (CrownCom) and the 2010 IEEE GLOBECOM workshop on Mobile Computing and Emerging Communication Networks.

II- Publication(s) during your fellowship

I. Chatzigeorgiou, W. Guo, I. J. Wassell and R. Carrasco, “Exact and asymptotic outage probability analysis for decode-and-forward networks”, accepted for publication in the *IEEE Transactions on Communications*.

Abstract: We consider decode-and-forward cooperative networks and we derive analytical expressions as well as tractable asymptotic approximations for the outage probability of a network node. Our analysis sheds more light on the interplay between the channel conditions, the network size and the adopted transmission scheme, and provides a useful tool for the design of cooperative networks.

A. Tarable and **I. Chatzigeorgiou**, “Random selection and forwarding: Analysis of a probabilistic packet-erasure relay channel”, to be submitted to the *IEEE Transactions on Information Theory*.

Abstract: In this paper, we introduce an accurate semi-analytical method, based on Markov chains, to compute the average erasure probability of packets in relay networks under block fading. We consider a network in which relays decide independently of each other to either receive a packet from the source and store it in their finite memory or randomly select a packet from their memory and forward it to the destination. We present a detailed analysis of the proposed method, we derive an accurate closed-form approximation and we compare theoretical predictions to simulation results. We demonstrate that the average erasure probability can be minimized by optimizing the various network parameters and we conclude that our proposed protocol, which we call random selection and forwarding, yields a lower erasure probability than conventional first-in first-out forwarding.

III -Attended Seminars, Workshops, and Conferences

During the course of my visit, I attended various **Seminar Talks** that were delivered by members of the Signal Processing Group and the Radio Group. I also had the opportunity to be present at two **PhD thesis defences**, one at NTNU, Norway and one at IST, Portugal. Even though I did not attend any conferences in 2010, I was a member of the **Technical Programme Committee** of the 7th International Symposium on Communication Systems, Networks and Digital Signal Processing that was held at Newcastle, UK, in July 2010.

IV – Research Exchange Programme (12 month scheme)

First ERCIM institute: Instituto Superior Técnico (IST), Lisbon, Portugal

Scientific contact: Assistant Professor João Xavier <jxavier@isr.ist.utl.pt>

Dates of visit: May 18 to May 26, 2010

Description: The work at the Signal Processing Group within the Institute for Systems and Robotics (ISR) is concerned with the development of fundamental theory for signal processing and its application to wireless communications, image analysis and video processing. My scientific advisor, Dr. Xavier, has previously worked on blind equalization and iterative techniques but his current focus is on optimization theory. During my visit, I presented my recent work to the Signal Processing Group and I triggered the interest of its members, who gave me constructive feedback and suggestions for future work. We also met regularly with Dr. Xavier, who expressed his interest in receiving a preprint of our latest paper for IEEE Transactions on Information Theory (please see above) to study it and use his expertise in optimization techniques to contribute to future research directions.

Second ERCIM Institute: INRIA Paris-Rocquencourt, France

Scientific contact: Professor Anne Canteaut <Anne.Canteaut@inria.fr>

Dates of visit: *My visit was cancelled*

Description: I was planning to visit the SECRET team at INRIA during the fall of 2010 but I had to cancel my plans and terminate my contract with ERCIM prematurely, because I was offered a lectureship at Lancaster University, UK, with effect from October 1, 2010.

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