Energy Efficiency in Cognitive Wireless Networks

Project manager:
Assoc. Prof. Ligia Cremene, Ph.D

http://users.utcluj.ro/~cligia
Adaptive Systems Interdisciplinary Research Lab
http://asl.utcluj.ro/asl
Coordinator: Ligia Cremene, Ph.D
Members: Mihai Suciu, Ph.D, Noemi Gasko, Ph.D

In collaboration with the Centre for the Study of Complexity, UBB, http://csc.centre.ubbcluj.ro
Romanian Academy Award 2012

Ericsson Award for Excellence in Telecommunications 2006

Over 50 scientific works among which **42 indexed scientific papers** (7 ISI journal papers, 13 ISI proceedings papers, 6 book chapters (Springer), 16 IDB (9 journal papers + 7 conf. proc.), 2 books, one manual, an edited book.

Over 20 scientific and technical reports presented at national and international scientific events.

**7 national competition grants, 5 international projects**

1 patent (OSIM), 2 patents pending (OSIM).
Summary

A new power coordination model for mitigating interference and energy consumption in cognitive wireless networks was proposed.

The model was adopted as a pivotal solution for the ISM-Advanced concept (COST-TERRA IC0905 Action) that proposes novel spectrum access rules for unlicensed frequency bands.

Furthermore, the possibility of eliminating the EIRP limit has been demonstrated (100mW in the 2.4 GHz band and 250mW in the 5 GHz band).
General context / problem

Inefficient use of radio resources
Deregulation of the frequency spectrum
Crowding of the unlicensed bands
Need for dynamic radio access
Interference mitigation

Solutions

Cognitive Radio (CR)
Game Theory (GT)
It was posited that,

With appropriately designed rules, the CR-enabled devices should be perfectly capable of choosing most appropriate transmit power while seeking the optimum compromise between link range/quality, ambient interference level, and its own energy consumption.

Conceptual and computational framework to solve this → Game Theory
CR interactions are **strategic interactions**: each player’s payoff depends on the other players’ actions. (basis of GT)

RESOURCES ACCESS
CRs are independent, autonomous decision makers
Main objective:
Introducing new distributed power allocation algorithms for energy efficiency in cognitive wireless networks.

Activities:
• Investigate optimality of Nash equilibrium in interference-aware power coordination games
• Choose and adjust the appropriate GT model
• Design and test GT-based algorithms
• Demonstrate convergence to stable states (e.g. NE)

Additional objectives & activities: experimental validation of the proposed algorithms on real-world testbeds
To establish **realistic simulation scenarios**

To design **game scenarios** that lead to stable states and to ensure that those equilibria are optimal

To devise simple, **distributed algorithms** to be **embedded** in the reconfigurable radio devices

To **transfer theoretical concepts and models into practice**.
First set of experiments conducted on real infrastructure by mixed team UTCN – JSI/ Ljubljana

LOG-a-TEC testbed (VESNA platforms)

Convergence to NE has been demonstrated (lots of challenges on the hardware part)
Results

A new Interference-aware Power Coordination Game for ISM Bands

A set of energy-efficient interference coordination algorithms (that minimize power and maximize throughput)

First CR GT experiment on a real-world testbed (transferring a theoretical model into practice) - in collaboration with JSI Slovenia (lead to FP7 CREW Open Call)

Other experiments on real-world testbeds – in collaboration with VGTU Lithuania (COST Action IC0905 TERRA)

Publications 2014:
4 top conference papers
1 Springer book chapter
4 journal papers under review
Published papers


L. Cremene, D. Dumitrescu, ”A Relevant Equilibrium in Open Spectrum Sharing: Lorenz Equilibrium in Discrete Games, the 14th Int. Conf. on Next Generation Wired/Wireless Advanced Networking - NEW2AN 2014.
L. Cremene, D. Dumitrescu, A. Vlaicu, ”Emergence of Techno-Social Norms in Cognitive Radio Environments”, under review at Telecommunications Policy.


Next steps

Expand the experimentation scenarios on the JSI testbed

Continue transferring theoretical models for efficient use of radio resources into practice

Integrating the validated GT-based model into new protocols

Investigating new capacity dynamics models.
How will the radio spectrum look like in 10 or 20 years from now on?
chaos

bottleneck

Central authority

Self-organization attempt

Emerging structure

Efficient use, full capacity

whitespaces