

# **Game Theory for Wireless Communication Networks**

Instructor: Zaheer Khan

Centre for Wireless Communications (CWC), University of Oulu

Contact email: [Zaheer.khan@oulu.fi](mailto:Zaheer.khan@oulu.fi)

Course period 16th October 2017 – 16th January 2018

**Course Description:** The course will introduce the fundamental concepts of Game Theory and application of these concepts to model different wireless networks problems. Game theory is the formal study of conflict/competition and cooperation. In the context of wireless networks game theoretic concepts apply whenever the actions of several entities are interdependent. These entities may be individual devices, wireless infrastructures, networks, or any combination of these. In the course ideas such as Nash equilibrium, best response, will be discussed. Different game theoretic frameworks such as coalition games, repeated games with (different) monitoring models, congestion games, will be taught. The applications of different game theoretic frameworks to model wireless communications problems relating to directional antennas, dynamic spectrum access, infrastructure sharing, cloud-assisted radio access, cooperative content delivery, will be explained.

Time span: 16th October 2017 – 16th January 2018

**Place and time:** Weekly three-hour lectures will be given on every Monday at 13:00 in the lecture room (to be announced).

**Homework assignments:** Before attending a lecture, students must read from the selected chapters from books, notes/handouts, selected papers. Handouts and lecture slides will be posted before every lecture via email. Students will also be asked to solve homework assignments.

**Credits:** The course can be taken by both master and doctoral students. The number of credit points is seven (7).

**Exam:** The exam date(s) will be communicated later.

**Prerequisites:** A prerequisite for this course is knowledge in wireless communications and networks, random processes, probability theory. Also, students will be asked to read handouts/chapters.

# 1 Course Material

## For easy introduction to game theory:

i) Networks, Crowds, and Markets: Reasoning about a Highly Connected World

by David Easley (Chapter titled Game Theory)

Others:

ii) GAME THEORY by Thomas S. Ferguson: Part IV. Games in Coalitional Form (online available)

iii) Algorithmic Game theory by Noam Nisan, Eva Tardos Chapter 19) Network Formation Games and the Potential Function method

iv) Repeated games and reputations (Long-run relationships)

by George J. Mailath, Larry Samuelson (Chapters 1-3)

v) Information Economics by Dirk Bergemann, Department of Economics, Yale University

Part IV Moral Hazard

## Some examples relating to Wireless Communication

### Problems:

i) Game Theory in Wireless Networks: A Tutorial by M Felegyhazi (online available)

ii) Zaheer Khan, Savo Glisic, Luiz A. DaSilva, Janne Lehtomäki. Modeling the Dynamics of Coalition Formation Games for Cooperative Spectrum Sharing in an Interference Channel. IEEE Transactions on Computational Intelligence and AI in Games, vol. 3, no. 1, pp. 17-30, March 2011

iii) Zaheer Khan, Janne Lehtomäki, Marian Codreanu, Matti Latva-aho, Luiz A. DaSilva. Throughput-efficient Dynamic Coalition Formation in Distributed Cognitive Radio Networks. EURASIP Journal on Wireless Communications and Networking, vol. 2010, Article ID 653913, 13 pages, 2010.  
doi:10.1155/2010/653913

iv) Zaheer Khan, Janne J. Lehtomäki, Luiz A. DaSilva, Ekram Hossain, Matti Latva-aho. Opportunistic Channel Selection by Cognitive Radios Under

Imperfect Observations and Limited Memory: A Repeated Game Model.,  
accepted, IEEE Transactions on Mobile Computing, 2015

v) Database-Assisted Distributed and Cloud-Based Access Methods for  
Unlicensed and Radar Bands

Zaheer Khan, J.J Lehtomäki, R Aguilar, R Vuohtoniemi, E Hossain, LA DaSilva  
IEEE Transactions on Cognitive Communications and Networking, to appear in  
2017

vi) Incentivizing Selected Devices to Perform Cooperative Content Delivery: A  
Carrier Aggregation-Based Approach

B Barua, Z Khan, Z Han, AA Abouzeid, M Latva-aho  
IEEE Transactions on Wireless Communications, 2016

## **Preliminary Schedule:**

**Lecture 1: Introduction to basic game theoretic concepts with examples**

**Lecture 2) : Static and dynamic coalition game concepts**

**Lecture 3: Use of Coalition Games for spectrum sharing and cooperative  
coalition formations with emphasis on externalities, altruistic and selfish  
coalitions**

**Lecture 4) Repeated and Dynamic game models**

**Lecture 5) Repeated Games, Finite Automata and monitoring concepts**

**Lecture 6) Perfect and Imperfect monitoring models of repeated games for  
dynamic spectrum access**

**Lecture 7) Introduction to Learning in Games**

**Lecture 8) Potential games and learning**

**Lecture 9) Wireless cloud Networks and potential game models.**

**Lecture 10) Adverse selection and Moral Hazard concepts**

**Lecture 11) Contract Design under moral hazard and adverse selection**

**Lecture 12) Adverse selection and moral Hazard game models for Network  
sharing**