Game Theory for Wireless Communication Networks

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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 – December 2017

Place and time: Weekly three-hour lectures will be given [redacted] lecture room (to be announced). There might be two lectures in one or two weeks of early December.

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