



## Game Theory for Wireless Communications

**Scheduled:**

Monday 15 September 2008, afternoon

**Presenter:**

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**Abstract:**

It is a fact that more and more people from the community of wireless communications are using concepts like artificial intelligence, cognitive radio, ad hoc and distributed networks in their research. Wireless networks implementing these concepts contain three ingredients that make game theory a fruitful theory for their analysis and design: 1. terminals have a certain degree of intelligence or cognition; 2. terminals share common resources (spectrum, time, power, space, etc) which implies interaction between them; 3. wireless networks are highly structured which favors the success of game theoretic analysis. One of the purposes of the proposed tutorial is precisely that the attendees acquire a rigorous methodology and appropriate mathematical tools to analyze and design such future wireless networks. The tutorial will characterize itself by several original features:

1. The presentation of the different mathematical concepts will be made very rigorously.
2. A quite significant part of the tutorial will rely on three key theories: game theory of course but also Shannon theory and random matrix theory. These theories will be shown how to harmoniously interact in order to gain more insights into the addressed situation.
3. Both the engineer and theorist standpoints will be considered. In particular a clear mapping between practical problems in wireless networks and game theoretic approaches will be established. Example: it is known that channel state information (CSI) is always imperfect whereas almost all the papers available in the literature assume perfect CSI. It will be shown how the most recent and advanced concepts from stochastic games and games with incomplete information can be used to address this problem.

4. From the application point of view an emphasis on cognitive radio and dynamic spectrum management will be made.
5. A list of challenging problems will be provided and discussed.

**Outline:**

The planned content is as follows:

Part 1: Fundamentals of game theory (main historical milestones, mathematical definition of a game, difference between a game and an optimization problem, etc).

Part 2: Classification of games relevant for wireless networks (static/dynamic games, finite/non atomic games, etc). Key equilibria and key theorems of existence and uniqueness (Debreu, Rosen, Glicksberg, Nash, etc).

Part 3: Useful tools for game theory: information theoretic metrics, key results from random matrix theory, optimization theory.

Part 4: Study of cases: power allocation, medium access control, routing protocols, cognitive radio systems, scheduling, spectrum sharing. Summary providing a general methodology to tackle the study of future networks.

**Biographical Sketch:**

Prof. Mérouane Debbah was born in Madrid, Spain. He entered the Ecole Normale Supérieure de Cachan (France) in 1996 where he received the M.Sc and the Ph.D. degrees respectively in 1999 and 2002. From 1999 to 2002, he worked for Motorola Labs on Wireless Local Area Networks and prospective fourth generation systems (OFDM and MC-CDMA). From 2002 until 2003, he was appointed Senior Researcher at the Vienna Research Center for Telecommunications (ftw., Vienna, Austria) working on MIMO wireless channel modeling issues. From 2003 until 2007, he joined the Mobile Communications department of the Institute Eurecom (Sophia Antipolis, France) as an Assistant Professor. He is presently a Professor at Supélec (Gif-sur-Yvette, France), holder of the Alcatel-Lucent Chair on flexible radio. His research interests are in information theory, signal processing and wireless communications.

Samson Lasaulce is a former student from École Normale Supérieure and École Nationale Supérieure de Télécommunications (PhD defense, end of 2001). He has been working with Motorola Labs for three years (1999, 2000, 2001) and with France Télécom R&D for two years (2002, 2003). Since 2004, he has joined the CNRS and Supélec. Since 2004, he is also Chargé d'Enseignement at École Polytechnique. His broad interests lie in the areas of communications, signal processing and information theory with a special emphasis on game theory for wireless communications.