



UNIVERSITÀ DI PISA
DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

“Game Theory and Optimization in communications and Networking”

Prof. Marco LUISE – Dr. Luca SANGUINETTI

Università di Pisa - Italy

Short Abstract: The ever-increasing demand for reliable and ubiquitous high-speed data communications and environment sensing services calls for new challenges in the design and the optimization of wireless networks, which may benefit from the adoption of sophisticated signal processing techniques at large. Recently, game theory has emerged as an effective framework for the network design, since it provides analytical tools to predict the outcome of interactions among rational entities.

This tutorial provides an overview of the relevant applications of game theory, focusing on state-of-the-art techniques for resource allocation in wireless and wired communication networks. In the first part, the very basics concepts are introduced by means of many simple examples, and special emphasis is put on how to translate a real-world problem to an analytical game model. In the second part, relevant applications of game theory to wireless networks design are reported, including power and rate control, bandwidth allocation, and spectrum sensing. Some clues will be given on how to extend such methods to MIMO, cognitive radio, and relay-assisted communications. The main focus will be on noncooperative techniques, although recent advances in the field of cooperative game theory will be also included in the discussion to provide a different perspective on certain classes of problems.

Course Contents in brief:

- Introduction and Motivation;
- Basics of noncooperative game theory:
 - historical notes
 - finite and infinite static games
 - potential games
 - supermodular games
 - generalized Nash games
 - dynamic games
 - repeated games

- Bayesian games
- Basics of cooperative game theory:
 - Nash bargaining problems
 - Canonical coalitional games
 - Coalition formation games
- Discussion and perspectives

Total # of hours: 16

References:

- [1] A. B. MacKenzie and S. B. Wicker, "Game theory in communications: Motivation, explanation, and application to power control," in Proc. IEEE Global Telecommunications Conference (GLOBECOM), San Antonio, TX, Nov. 2001, pp. 821–826.
- [2] V. Srivastava, J. Neel, A. B. MacKenzie, R. Menon, L. A. DaSilva, J. E. Hicks, J. H. Reed, and R. P. Gilles, "Using game theory to analyze wireless ad hoc networks," IEEE Commun. Surveys & Tutorials, vol. 7, no. 4, pp. 46–56, 4th Quarter 2005.
- [3] A. B. MacKenzie and L. A. DaSilva, Game Theory for Wireless Engineers. San Rafael, CA: Morgan & Claypool, 2006.
- [4] E. Altman, T. Boulogne, R. El-Azouzi, T. Jiménez, and L. Wynter, "A survey on networking games in telecommunications," Computers & Operations Research, vol. 33, no. 2, pp. 286–311, Feb. 2006.
- [5] M. Félegyházi and J.-P. Hubaux, "Game theory in wireless networks: A tutorial," École Polytechnique Fédérale de Lausanne (EPFL), Tech. Rep. EPFL LCA-REPORT-2006-002, June 2007. [Online.] Available: <http://infoscience.epfl.ch/record/79715/files/>
- [6] G. Bacci, M. Luise, and H. V. Poor, "Game theory and power control in ultrawideband networks," Physical Communication, vol. 1, no. 1, pp. 21–39, March 2008.
- [7] S. Lasaulce, M. Debbah, and E. Altman, "Methodologies for analyzing equilibria in wireless games," IEEE Signal Process. Mag., vol. 26, no. 5, pp. 41–52, Sept. 2009.
- [8] W. Saad, Z. Han, M. Debbah, A. Hjørungnes, and T. Başar, "Coalitional game theory for communication networks," IEEE Signal Process. Mag., vol. 26, no. 5, pp. 77–97, Sept. 2009.
- [9] K. Akkarajitsakul, E. Hossain, D. Niyato, and D. I. Kim, "Game theoretic approaches for multiple access in wireless networks: A survey," IEEE Commun. Surveys & Tutorials, vol. 13, no. 3, pp. 372–395, 3rd Quarter 2011.
- [10] T. Alpcan, H. Boche, M.L. Honig, and H.V. Poor, Mechanisms and Games for Dynamic Spectrum Access. Cambridge, UK: Cambridge University Press, 2013.

CV of the Teachers

Marco LUISE is a Full Professor of Telecommunications at the University of Pisa, Italy, where he also serves as the Coordinator of the PhD program in Ingegneria dell' Informazione (Automation/Robotics, Biomedical, Electronics, and ICT Engineering). Passionate about music, he is the President of the Music School "Pietro Mascagni" in Leghorn (Livorno), Italy.

He was born in Livorno, Italy, in 1960 and received his MSc (cum Laude) and PhD degrees in Electronic Engineering from the University of Pisa, Italy. In the past, he was a Research Fellow of the European Space Agency (ESA) at the European Space Research and Technology Centre (ESTEC), Noordwijk, The Netherlands, a Researcher of CNR, the Italian National Research Council, at the Centro Studio Metodi Dispositivi Radiotrasmissioni (CSMDR), Pisa, and an Associate Professor at the Dipartimento di Ingegneria dell'Informazione (Department of Information Engineering) of the University of Pisa.

He chaired the V, VI, VII, and IX editions of the Tyrrhenian International Workshop on Digital Communications, respectively, and he was the General Chairman of the URSI Symposium ISSSE'98. He's been the Technical Co-Chairman of the 7th International Workshop on Digital Signal Processing Techniques for Space Communications and of the Conference European Wireless 2002. Prof. Luise was the General Chairman of EUSIPCO 2006 held in Florence, Italy, in September 2006, and more recently the general co-chair of European Wireless 2010 and Technical Program Chair of the Future Network and Mobile Summit 2010 of the European Commission. In 2014, he was the General Co-chair of ICASSP 2014 that was held in

Florence, Italy, and the co-chair of the ASMS/SPSC Conferences in Livorno. He's currently the Coordinator of the EC FP7 Network of Excellence on Wireless Communications NEWCOM#.

Prof. Luise is an IEEE Fellow, was an Editor of the IEEE Transactions on Communications and of the European Transactions on Telecommunications (of which he's now in the Advisory Board). He was the co-founder and first co-Editor-in-Chief of the International Journal of Navigation and Observation, and is the Division Editor for Communication Theory and Systems of the Journal of Communications and Networks. He was the General Secretary of the Italian Association GTTI, Gruppo Telecomunicazioni Tecnologie dell'Informazione, and sits in the Executive Board of CNIT. He has also been the Chairman of the URSI's Commission C and is a member of the International Committee on Global Navigation Satellite Systems (ICG) of the UNO. He has contributed to establish the Association ToscanaSpazio, which is currently chairing.

His main research interests lie in the broad area of communication theory, with particular emphasis on wireless communications, and mobile and satellite communication and positioning systems.

Luca SANGUINETTI is an Assistant Professor at the Dipartimento di Ingegneria dell'Informazione of the University of Pisa. He received the Telecommunications Engineer degree (cum laude) and the Ph.D. degree in information engineering from the University of Pisa, Italy, in 2002 and 2005, respectively. Since 2005 he has been with the Dipartimento di Ingegneria dell'Informazione of the University of Pisa. In 2004, he was a visiting Ph.D. student at the German Aerospace Center (DLR), Oberpfaffenhofen, Germany.

During the period June 2007 - 2008, Dr. Sanguinetti was a postdoctoral associate in the Department of Electrical Engineering at Princeton. During the period June 2010 - Sept. 2010, he was selected for a research assistantship through the DAAD STIBET funding at the Technische Universitat Munchen. He was the co-recipient of the Best Paper Awards at the 2013 and 2014 International Conference on Wireless Communications and Networking Conference (WCNC) and the recipient of the FP7 Marie Curie International European Fellowships for career development (IEF) 2013 Dense4Green "Dense deployments for green cellular networks". He's currently serving as an Associate Editor for IEEE Trans. Wireless Commun. and IEEE Signal Process. Lett., as well as a guest Editor for IEEE JSAC - Series on Green Commun. and Networking.

His main research interests lie in the broad area of Signal Processing, Game Theory and Random Matrix Theory for Wireless Communications.

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule:

- 01 February 2016 – 9.00 to 13.00 (M. Luise)
- 02 February 2016 – 9.00 to 13.00 (L. Sanguinetti)
- 03 February 2016 – 9.00 to 13.00 (L. Sanguinetti)
- 04 February 2016 – 9.00 to 13.00 (L. Sanguinetti)