

Tutorial T-18: Game Theory for Future Wireless Networks: Challenges and Opportunities

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Tutorial Overview

Next-generation wireless systems are characterized by three key features: heterogeneity, in terms of technology and services, dynamics, in terms of rapidly varying environments and uncertainty, and size, in terms of number of users, nodes, and services. The need for smart, secure, and autonomic network designs has become a central research issue in a variety of applications and scenarios. One example is next-generation heterogeneous wireless small cell networks in which a myriad of devices must be able to interact, co-exist, meet stringent QoS requirements, and self-adapt to uncertainties and time-varying environments. Another example is cognitive radio networks, which are envisioned as a large-scale wireless system with multiple stakeholders that must interact, operate, and control wireless operations such as spectrum sharing, at both technical and economic levels. Incorporating self-organizing capabilities along with smarter security solutions in heterogeneous wireless systems motivates the development of innovative analytical techniques. In this respect, game theory is expected to play a critical role towards deploying intelligent, distributed, and flexible networked systems in which devices can make independent and rational strategic decisions, smartly adapting to their environment.

To this end, this tutorial will focus on the confluence of seemingly disparate disciplines: game theory, economics, and networking; while presenting the state of the art in this interdisciplinary area. In particular, this tutorial will provide a comprehensive introduction to game theory in its two branches: non-cooperative and cooperative games, as it applies to the design of future networks. We will also discuss new emerging types of games such as matching theory. For each type of games, we present the fundamental components, introduce the key properties, mathematical techniques, solution concepts, and we describe the challenges and methods for applying these games in two emerging fields: (i)- The design and analysis of heterogeneous and cognitive 5G wireless networks and (ii)- the development of innovative wireless security solutions in a variety of settings. The tutorial concludes by shedding some light on future opportunities and challenges in this area.

Presenter Biographies

Walid Saad received his B.E. degree in Computer and Communications Engineering from the Lebanese University, in 2004, his M.E. in Computer and Communications Engineering from the American University of Beirut (AUB) in 2007, and his Ph.D degree from the University of Oslo in 2010. Currently, he is an Assistant Professor at the Electrical and Computer Engineering Department at Virginia Polytechnic Institute and State University where he will lead the Network Science, Wireless, and Security (NetSciWiS) laboratory as part of the Wireless@VT research group.

Prior to joining VT, he was an Assistant Professor at the Electrical and Computer Engineering Department at the University of Miami and he has held several research positions at institutions such as Princeton University and the University of Illinois at Urbana-Champaign. His research interests include wireless and 5G small cell networks, game theory, smart grid, network science, cognitive radio, wireless security, and self-organizing networks. He has co-authored one book and over 100 international conference and journal publications in these areas.

In 2013, Dr. Saad received the NSF CAREER award for his research on self-organizing wireless systems. He was the author/co-author of the papers that received the Best Paper Award at the 7th International Symposium on Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks

(WiOpt), in June 2009, at the 5th International Conference on Internet Monitoring and Protection (ICIMP) in May 2010, and at IEEE WCNC in 2012. He has been a tutorial and invited speaker at several leading conference and workshop venues. Dr. Saad is an Associate Editor for the IEEE Transactions on Communications and the IEEE Communications Tutorials & Surveys, as well as a Guest Editor for the IEEE Journal on Selected Areas in Communications (JSAC) and the IEEE Communications Magazine.

Mehdi Bennis received his M.Sc. degree from the Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland and the Eurecom Institute, France in 2002. He obtained his Ph.D. degree in electrical engineering December 2009 on spectrum sharing for future mobile cellular systems. He was the co-PI of the Broadband Evolved FEMTO (FP7-BeFEMTO) project, and is currently the PI of the European CELTIC project SHARING (2013-2015). His main research interests are in radio resource management, heterogeneous networks, game theory and machine learning. He has published more than 50 research papers in international conferences, journals, book chapters and patents.

Dr. Bennis is currently an editor for the IEEE Transaction of Wireless Communications. Further, he was a co-chair at the 1st international workshop on small cell wireless networks (SmallNets) in conjunction with IEEE ICC 2012, the 2nd Workshop on Cooperative Heterogeneous Networks (coHetNet) in conjunction with ICCCN 2012, the international workshop on cooperative and heterogeneous cellular networks in conjunction with IEEE PIMRC 2012 (Sydney, Australia), the 2nd international workshop on small cell wireless networks (SmallNets) in conjunction with IEEE ICC 2013, and the forthcoming 3rd workshop on small cell wireless networks (SmallNets) in conjunction with IEEE ICC 2014. Recently, he gave tutorial presentations at IEEE PIMRC 2012 (Sydney, Sep. Australia) and IEEE GLOBECOM 2012 (Anaheim, CA, Dec. 2012), IEEE DySPAN (McLean, VA, Apr. 2014) and IEEE WCNC (Istanbul, Turkey, Apr. 2014), and IEEE GLOBECOM 2014 (Austin, Texas, Dec. 2014). Finally, Dr. Bennis is an editor of TWC.