

## **Tutorial T-13: Emerging Concepts and Technologies towards 5G Wireless Networks**

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### **Tutorial Overview**

Despite the recent advances in wireless technologies, the wireless community faces the challenge of enabling a further traffic increase of around 1,000 times, latency reduction of around 100 times, device increase of around 100 times in the next 15 years or so, while no customer is willing to pay more for the wireless pipe itself: the so called “traffic-revenue decoupling”. Moreover, many experts warn that the low-hanging fruits in wireless research (especially in information theory, communications theory, and signal processing) have already been collected. While the research community is full of ideas (as usual), many of these ideas are either not-too-relevant (i.e., not in the bottleneck areas) or they are in areas in which progress toward a tangible implementation is too slow.

The overall goal of the tutorial is to identify

- the emerging concepts and technologies, and
- the necessary analytical tools to study them (such as optimization, game theory, dynamic feedback control, and artificial intelligence).

Towards that end, a number of important components will be presented in the single coherent framework of 5G cellular networks with a “systems” scope and approach.

In the first part of this tutorial, the following topics will be covered:

- Fundamental dynamics of cellular communications
- 3GPP operation
- Key technologies in LTE and LTE-Advanced
- Challenges and opportunities as we move forward
- Revisiting the theoretical basics: What we know and what we don’t know
- Enabling technologies in layer-1 and layer-2 as well in network architecture
- Bottleneck problems in beyond-2020 wireless networks

In the second part of the tutorial, the potential research directions towards coping with the bottleneck problems, especially in the context of radio access network (RAN), resource allocation, layers 1, 2, and 3, will be discussed; the underlying mathematical tools will also be highlighted:

- Thoughts on 5G PHY
- Non-Coherent Communications
- Terminal Relaying
- Quality of Experience (QoE)
- New Frontiers in Resource Allocation
- Virtual Cells in Cloud RAN
- Massive Uncoordinated/Autonomous/Distributed Multiple-Access for MTC
- Heterogeneous Traffic Models
- Intercell Load Coordination (ICLC) for Non-Uniform Traffic
- Layer 8: User-in-the-Loop (Demand Shaping in Space and Time)
- Interdisciplinary Approaches in Decision Making

- Cell Switching Off in Dense Small Cell Deployment
- Robust Algorithms and Protocols
- Millimeter Wave Communications
- Advanced Antenna Technologies

In the absence of a clear technology roadmap towards 5G, the tutorial has, to a certain extent, an exploratory view point to stimulate further thinking and creativity. We are certainly at the dawn of a new era in wireless research and innovation; the next twenty years will be very interesting.

### **Presenter Biography**

Halim Yanikomeroglu was born in Giresun, Turkey, in 1968. He received the B.Sc. degree in electrical and electronics engineering from the Middle East Technical University, Ankara, Turkey, in 1990, and the M.A.Sc. degree in electrical engineering (now ECE) and the Ph.D. degree in electrical and computer engineering from the University of Toronto, Canada, in 1992 and 1998, respectively. During 1993–1994, he was with the R&D Group of Marconi Kominikasyon A.S., Ankara, Turkey. Since 1998 he has been with the Department of Systems and Computer Engineering at Carleton University, Ottawa, Canada, where he is now a Full Professor. His research interests cover many aspects of wireless technologies with a special emphasis on cellular networks. He coauthored over 60 IEEE journal papers, and has given a high number of tutorials and invited talks on wireless technologies in the leading international conferences. In recent years, his research has been funded by Huawei, Blackberry, Samsung, Telus, Communications Research Centre of Canada (CRC), and Nortel. This collaborative research resulted in about 20 patents (granted and applied). Dr. Yanikomeroglu has been involved in the organization of the IEEE Wireless Communications and Networking Conference (WCNC) from its inception, including serving as Steering Committee Member as well as the Technical Program Chair or Co-Chair of WCNC 2004 (Atlanta), WCNC 2008 (Las Vegas), and WCNC 2014 (Istanbul). He was the General Co-Chair of the IEEE Vehicular Technology Conference Fall 2010 held in Ottawa. He has served in the editorial boards of the IEEE TRANSACTIONS ON COMMUNICATIONS, IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, and IEEE COMMUNICATIONS SURVEYS & TUTORIALS. He was the Chair of the IEEE's Technical Committee on Personal Communications (now called Wireless Technical Committee). He is a Distinguished Lecturer for the IEEE Vehicular Technology Society since 2011.

Dr. Yanikomeroglu is a recipient of the IEEE Ottawa Section Outstanding Educator Award in 2014, Carleton University Faculty Graduate Mentoring Award in 2010, the Carleton University Graduate Students Association Excellence Award in Graduate Teaching in 2010, and the Carleton University Research Achievement Award in 2009. Dr. Yanikomeroglu spent the 2011–2012 academic year at TOBB University of Economics and Technology, Ankara, Turkey, as a Visiting Professor. He is a registered Professional Engineer in the province of Ontario, Canada.