

# Emerging Concepts and Technologies Toward 5G Wireless Networks

**Abstract:** Despite the recent advances in wireless technologies, the wireless community faces the challenge of enabling a further traffic increase of up to 1,000 times in the next 10 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 fruit 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 (i) the emerging concepts and technologies, and (ii) 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 Autonomous/Distributed Multiple-Access in Cellular
- 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:** Halim Yanikomeroglu, Carleton University (Canada)

**Halim Yanikomeroglu** received the B.Sc. degree in Electrical and Electronics Engineering from the Middle East Technical University, Turkey, in 1990, and the M.A.Sc. and Ph.D. degrees in Electrical and Computer Engineering from the University of Toronto, Canada, in 1992 and 1998, respectively. He was with the R&D Group of Marconi Kominikasyon A.S., Turkey, during 1993-1994.

Since 1998 Dr. Yanikomeroglu 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. Dr. Yanikomeroglu coauthored about 60 IEEE journal papers and has given more than 20 tutorials in leading international conferences on wireless technologies. In recent years, Dr. Yanikomeroglu's research has been funded by Huawei, BlackBerry, Samsung, Communications Research Centre of Canada (CRC), Telus, and Nortel. This collaborative research resulted in about 20 patents (applied and granted).

Dr. Yanikomeroglu has been involved in the organization of the *IEEE Wireless Communications and Networking Conference (WCNC)* since its inception in 1998 in various capacities including serving as a Steering Committee member and the Technical Program Chair or Co-Chair in *WCNC 2004* (Atlanta), *WCNC 2008* (Las Vegas), and *WCNC 2014* (Istanbul). Dr. Yanikomeroglu was also the General Co-Chair of the *IEEE 72nd Vehicular Technology Conference (VTC2010-Fall)* held in Ottawa. Dr. Yanikomeroglu 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.

Dr. Yanikomeroglu is a recipient of various research and teaching awards at Carleton University. He is a registered Professional Engineer in the province of Ontario, Canada.

