Title: Flexible Radio Access Beyond 5G: A Future Projection

Speaker: Huseyin Arslan

Today's wireless services and systems have come a long way since the rollout of the conventional voice-centric cellular systems. The demand for wireless access in voice and multi-media applications has increased tremendously. In addition to these, new application classes like extreme mobile broadband communication, ultra reliable and low latency communications, massive machine type communications, and Internet of Things have gained significant interest recently for 5G. The trend on the variety and the number of mobile devices along with the mobile applications will certainly continue beyond 5G, creating a wide range of technical challenges such as cost, power efficiency, spectrum efficiency, extreme reliability, low latency, robustness against diverse channel conditions, cooperative networking capability and coexistence, dynamic and flexible utilization of wireless spectrum. In order to address these technical challenges, 5G waveforms and radio access technologies (RATs) should be much more flexible. The current 4G systems rely on the orthogonal frequency multiple access (OFDM) waveform, which is not capable of supporting the diverse applications that 5G and beyond will offer. This is because the traffic generated by 5G and beyond is expected to have radically different characteristics and requirements when compared to current wireless technology. For 5G to succeed, numerous waveform alternatives have been explored to best meet its various technical requirements. However, none of the alternatives were able to address all the requirements at the same time.

During the standardization of 5G, one thing has become certain: there is no single enabling technology that can achieve all of the applications being promised by 5G networking. This will be even more pronounced beyond 5G. For this purpose, the concept of using multiple OFDM numerologies, i.e., different parameterization of OFDM based subframes, within the same frame has been proposed in 3GPP discussions for 5G. This concept will likely meet the current expectations in multiple service requirements to some extent. However, since it is almost obvious that quantity of wireless devices, applications, and heterogeneity of user requirements will keep increasing towards the next decade(s), the sufficiency of the aforementioned flexibility level remains quite disputable considering future expectations. Therefore, novel RATs facilitating much more flexibility are needed to address the aforementioned technical problems.

In this tutorial, we will discuss the potential directions to achieve further flexibility in RATs beyond 5G. In this context, a framework for developing flexible waveform, numerology, and frame design strategies will be discussed along with sample methods in this direction. We will also discuss their potential role to handle various issues in the upper system layers. The tentative outline of the tutorial will be as follows:

- Channel and waveform
- Application and waveform
- Introduction to OFDM and Multi-Carrier Modulation
- OFDM advantages and problems
- Adaptive, Flexible & Cognitive OFDM
- Other Important Waveforms (SC-FDE, SC-FDMA, DFT-s-OFDM, UW-OFDM etc.)
- Numerology and OFDM (OFDM variants from OFDM baseline)
- Future concepts in Waveform:
    - mmWave waveform design (SC versus MC in mmWave)
    - Hybrid waveforms
    - Flexible waveforms

- Non-orthogonal waveform design
- Differential modulation (non-coherent modulation) in OFDM (minimal pilot OFDM design)
- PHY security in OFDM (secure OFDM design)

Speaker Bio: Huseyin Arslan

Dr. Arslan (*IEEE Fellow*) has received his BS degree from Middle East Technical University (METU), Ankara, Turkey in 1992; MS and Ph.D. degrees in 1994 and 1998 from Southern Methodist University (SMU), Dallas, TX. USA. From January 1998 to August 2002, he was with the research group of Ericsson Inc., NC, USA, where he was involved with several projects related to 2G and 3G wireless communication systems. Since August 2002, he has been with the Electrical Engineering Dept. of University of South Florida, Tampa, FL, USA, where he is a Professor. In December 2013, he joined Istanbul Medipol University to found the Engineering College, where he has worked as the Dean of the School of Engineering and Natural Sciences. He has also served as the director of the Graduate School of Engineering and Natural Sciences at the same university. In addition, he has worked as a part-time consultant for various companies and institutions including Anritsu Company, Savronik Inc., and The Scientific and Technological Research Council of Turkey.

Dr. Arslan's research interests are related to advanced signal processing techniques at the physical and medium access layers, with cross-layer design for networking adaptivity and Quality of Service (QoS) control. He is interested in many forms of wireless technologies including cellular radio, wireless PAN/LAN/MANs, fixed wireless access, aeronautical networks, underwater networks, in vivo networks, and wireless sensors networks. His current research interests are on 5G and beyond, physical layer security, interference management (avoidance, awareness, and cancellation), cognitive radio, small cells, powerline communications, smart grid, UWB, multi-carrier wireless technologies, dynamic spectrum access, co-existence issues on heterogeneous networks, aeronautical (High Altitude Platform) communications, in vivo channel modeling and system design, and underwater acoustic communications. He has served as technical program committee chair, technical program committee member, session and symposium organizer, and workshop chair in several IEEE conferences. He is currently a member of the editorial board for the IEEE Surveys and Tutorials and the Sensors Journal. He has also served as a member of the editorial board for the IEEE Transactions on Communications, the IEEE Transactions on Cognitive Communications and Networking (TCCN), the Elsevier Physical Communication Journal, the Hindawi Journal of Electrical and Computer Engineering, and Wiley Wireless Communication and Mobile Computing Journal.

Contact information:
University of South Florida, Electrical Engineering Dept.
4202 E. Fowler Ave., ENB118, Tampa, Fl, 33620
Tel: (813) 974-3940 Fax: (813) 974-5250
E-mail: arslan@eng.usf.edu
http://wcsp.eng.usf.edu/

Related Research and Teaching Activities by the speaker:

Dr. Arslan has published several papers and book chapters in waveform design for wireless communication systems. He has developed a graduate-level course on “5G and beyond waveforms” in the Electrical Engineering department of USF (the course is being offered once in every two years).

Previous tutorials and invited talks:

TUTORIALS:

- H. Arslan, “5G and Beyond Waveform Design Strategies,” IEEE 24th Signal Processing and Communications Applications Conference, 2016, Zonguldak, TR (Half day tutorial).
- H. Arslan, “Cognitive radio, Software defined radio, and Adaptation of wireless mobile radio systems,” IEEE Globecom 2013, Atlanta, Georgia (Half day tutorial).
- H. Arslan, “Cognitive radio, Software defined radio, and Adaptation of wireless mobile radio systems,” IEEE VTC 2012, Quebec City, Canada (Half day tutorial).
- H. Arslan, “Cognitive radio, Software defined radio, and Adaptation of wireless mobile radio systems,” IEEE PIMRC 2012, Sydney, Australia, (Half day tutorial).
- H. Arslan, “Cognitive radio, Software defined radio, and Adaptation of wireless mobile radio systems,” IEEE CCNC 2012, Las Vegas, USA (Half day tutorial).
- H. Arslan, “Cognitive radio, Software defined radio, and Adaptation of wireless mobile radio systems,” IEEE WCNC 2012, Paris, France (Half day tutorial).
- H. Arslan, “Cognitive radio, Software defined radio, and Adaptation of wireless mobile radio systems,” IEEE Globecom 2010, Miami, USA (Half day tutorial).
- H. Arslan, “Cognitive radio, Software defined radio, and Adaptation of wireless mobile radio systems,” IWCMC 2011, Istanbul, Turkey (Half day tutorial).
- H. Arslan, "Ultra-Wideband and Impulse Radio for Wireless Communications", IEEE SoutheastCON, Fort Lauderdale, FL, April 9th, 2005 (Half day tutorial).
- H. Arslan, "UWB and impulse radio for wireless communications" IEEE Sarnoff Symposium, Princeton, NJ, April 18th, 2005 (2-hours tutorial).
- H. Arslan, "Ultra-Wideband and Impulse Radio for Wireless Communications", Wireless Technology Symposium (WTS 2005), Pomona, CA, April 28th, 2005 (half day tutorial).
- H. Arslan, "Ultra-wideband and Impulse Radio for Wireless Communications" in IASTED Circuits, Signals, and Systems Conf., Clearwater Beach, FL. November 2, 2004 (Half day tutorial)
- H. Arslan, "Adaptation techniques and the enabling parameter estimation algorithms for the evolution of wireless mobile radio systems", The 6th international Symposium on Wireless Personal Multimedia Communications, Yokasuka, Kanagawa, Japan, October 2003 (Half day tutorial).
- H. Arslan, "Adaptation techniques and the enabling parameter estimation algorithms for the evolution of wireless mobile radio systems", 3rd IASTED International Conference on Wireless and Optical Communications (WOC), Banff, Alberta, Canada, July 2003 (Half day tutorial).
- H. Arslan, "An overview of the recent trend toward adaptation of the new generations of wireless communication systems", Tutorial, IEEE Southeastcon'04, Greensboro, NC, March 2004 (Half day tutorial).

INVITED TALKS:

- H. Arslan, “Communications When Most Needed: Wireless in Emergency and Disaster Situations”, Device-to-Device and Public Safety Communications (WDPC) workshop ın conjunction with IEEE WCNC conference, 2014.
- H. Arslan, “Cognitive and Adaptive Radios as a Solution to Mobility Issues in Wireless Networks”, IEEE LCN 2012, Keynote speaker.
- H. Arslan, "UWB receiver architectures", Workshop speaker for "UWB Technology: Components, Systems and Architectures", In conjunction with IEEE Rawcon, September 19th, 2004, Atlanta, GA.
- H. Arslan, "Cognitive radio, software defined radio, and adaptation of wireless communication systems", Florida West Coast Section of the IEEE meeting, September 20th, 2005.
- H. Arslan, "Ultra-Wideband and Impulse Radio for Wireless Communications" IEEE Melbourne Section ComSoc/SP (Communications/Signal processing) Chapter meeting.
- H. Arslan, Florida West Coat Section of the IEEE meeting: "Ultrawideband and Impulse Radio for Secure Wireless Communications", September 1st, 2004.
- H. Arslan, IEEE Palm Beach/ComSoc Lecture, Palm Beach: "Ultrawideband Communications", October 8th, 2004.

Intended audience and importance of the topic:

This tutorial is intended for technical professionals in the communications industry, technical managers, and researchers in both academia and industry. Therefore, the key audience for the tutorial is: graduate students (Master or PhD), postdoctoral scholars, researchers, faculty members, scientists, and engineers in academia as well as in the public and private sectors in the broad area of wireless telecommunications.

Intended length of the tutorial: Half-day