THE EVOLUTION OF ARTIFICIAL INTELLIGENCE IN 6G NETWORKS

Half-day tutorial (3 hours)

ORGANIZERS AND SPEAKERS

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ABSTRACT

6G will not only expand data rates and connectivity but also redefine the foundations of communication by fusing Artificial Intelligence (AI) with novel paradigms such as semantic and goal-oriented communications. In this tutorial, we first set the stage by presenting the **vision of 6G networks as introduced by Dr. Emilio Calvanese Strinati**, highlighting the pivotal role of AI in shaping new services, enabling intelligent network orchestration, and supporting disruptive concepts such as semantic communication, Reconfigurable Intelligent Surfaces (RIS), and Integrated Sensing and Communications (ISAC). Special attention will be given to the **convergence of AI with semantic and goal-oriented communications**, illustrating how meaning-aware transmissions can dramatically reduce bandwidth usage, increase robustness to noise, and align communication with the intent of applications.

Dr. François Rivet will present how semantic communication principles can be translated into **hardware architectures and waveforms**. In particular, the tutorial will explore Walsh-domain processing and the design of Orthogonal Semantic Sequency-Division Multiplexing (OSSDM), a waveform tailored for semantic transmission. Experimental demonstrations will showcase the energy efficiency, resilience, and spectral compliance of these approaches, while also revealing how semantic principles relax constraints on circuit design and open new possibilities for AI–hardware co-design.

By combining a system-level vision with practical realizations, this joint tutorial aims to provide attendees with both the **why** and the **how** of semantic communications for 6G and beyond: from theoretical drivers and network intelligence to hardware implementation and real-world prototypes.

STRUCTURE

- Part I (Emilio Calvanese Strinati):
  - 6G vision, KPIs, and enabling technologies
  - From Shannon to Weaver: semantic vs. traditional approaches
  - Semantic and goal-oriented communications
  - RIS and ISAC as disruptive enablers
  - AI-driven orchestration and edge intelligence
- Part II (Francois Rivet):
  - Walsh-domain hardware architectures
  - OSSDM waveform: principles and experiments
  - Energy efficiency, spectrum compliance, and hardware co-design

AUDIENCE

The tutorial will be particularly appropriate and beneficial for students, researchers and engineers who already are or will be becoming active in the areas of AI, 5G ,and 6G systems field and need to understand the basics beyond 5G principles and solutions in the literature. Besides describing technical concepts, the tutorial incorporates many additional general ideas that are also helpful for a wider audience, for example, people with an interest in socio-economics as well as business executives.

PRE-REQUISITES

The tutorial is addressed to academia, industry, and consumers. No specific prerequisite knowledge is required for participation in this tutorial, as all basics will be clearly explained. It is helpful to have a basic understanding of concepts of networking, communications, and management. Knowledge on information theory and machine learning techniques is a plus. The public of IEEE LASCAS is perfectly fitting with the content and format of this tutorial. A comprehensive literature review will be provided to the audience.

SPEAKERS BIO

Dr. Emilio Calvanese Strinati obtained his Engineering Master degree in 2001 from the University of Rome 'La Sapienza' and his Ph.D in Engineering Science in 2005. He then started working at Motorola Labs in Paris in 2002. Then in 2006 he joint CEA/LETI as a research engineer. From 2007, he becomes a PhD supervisor. From 2010 to 2012, Dr. Calvanese Strinati has been the co-chair of the wireless working group in GreenTouch Initiative focused on future energy efficient communication networks. From 2011 to 2016 he was the Smart Devices & Telecommunications European collaborative strategic programs Director. Between December 2016 and January 2020 is was the Smart Devices & Telecommunications Scientific and Innovation Director.

Since February 2020 he is the Nanotechnologies and Wireless for 6G (New-6G) Program Director, focusing on future 6G technologies. Between 2016 and 2018 he was the coordinator of the H2020 joint Europe and South Korea 5GCHAMPION project that showcased at the 2018 winter Olympic Games, 5G technologies in realistic operational environments. Since July 2018 he is the coordinator of the H2020 joint Europe and South Korea 5G-AllStar project. Since 2018 he holds the French Research Director Habilitation (HDR). In 2018 he co-founded the Como Lake 6G summer School. In 2021 he started the coordination of the H2020 European project RISE-6G, focusing on the design and operation of Reconfigurable Intelligent Surfaces in future high frequency 6G networks and he is the principal investigator for CEA/LETI in the Flagship Hexa-X project. He is also the coordinator of the first worldwide collaborative project on semantic and goal oriented communications (6G-GOALS) and of the 6G-DISAC project focused on distributed intelligent integrated sensing and communications systems for 6G.

E. Calvanese Strinati has published around 200 papers in international conferences, journals and books chapters, given more than 200 international invited talks, keynotes and tutorials. He is the main inventor or co-inventor of more than 80 patents. He has organized more than 100 international conferences, workshops, panels and special sessions on green communications, heterogeneous networks and cloud computing hosted in international conferences as IEEE GLOBCOM, IEEE PIMRC, IEEE WCNC, IEEE ICC, IEEE VTC, EuCnC, IFIP, EUCNC and European Wireless. He is the general chair of EUCNC 2022.

Dr. François Rivet is an Associate Professor at the University of Bordeaux and a senior researcher at the IMS Laboratory, France. He received his Ph.D. in Electrical Engineering from the University of Bordeaux, where he now leads research on RF circuits and disruptive wireless architectures. His work has focused on (Walsh-domain) RF front-ends design and on semantic communications.

Dr. Rivet is the principal investigator of the European H2020 HERMES project, which designs CMOS-based transceivers for sub-THz cognitive radios using Walsh mathematics and AI-based optimization. He has pioneered the use of Walsh-domain processing to create novel RF front-ends, including Walsh-based digital-to-analog and analog-to-digital converters, enabling new waveforms such as Orthogonal Semantic Sequency-Division Multiplexing (OSSDM). His experimental prototypes have demonstrated disruptive gains in energy efficiency, spectral compliance, and robustness.

He has authored numerous IEEE journal and conference papers, co-authored state-of-the-art reports on RF architectures, and collaborates actively with industrial partners. Through his work, Dr. Rivet aims to connect mathematical innovations, hardware implementations, and semantic communication principles to pave the way for 6G and beyond.