3rd IEEE International Conference on Industrial Cyber-Physical Systems (ICPS)

ICPS Tutorial on

"Machine-type communication in 5G and its application to build the energy Internet"

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Keywords: energy internet, IoT, machine-type communications, smart grids, packetized energy, energy management, 5G

Aim and Learning Objectives:

The future of industrial cyber-physical systems is closely related to the technological evolution of wireless systems, particularly machine-type communications. The 5th generation of cellular networks (the 5G) covers those applications, enabling massive connectivity, ultra-reliability and low latency to fulfill diverse needs of different industries. In the first part of this tutorial, we will cover the advances of 5G related in this domain in comparison with previous generations and other competing technologies. We will demonstrate the potential of 5G and beyond for different range of vertical cases, namely healthcare, logistics, manufacturing, process automation and energy. In the second part, we will focus on the energy domain to present how the 5G is a key enabler to build the Energy Internet as a large-scale cyber-physical system to manage distribution grids via packets.

After the tutorial, the audience will be able to

- Differentiate operation modes of the Internet of Things (IoT) based on 5G and beyond technologies in relation to latency, reliability, number of users and data rates.
- Analyze the extreme modes covered by 5G, namely Ultra-reliable Low-latency Communications (URLLC), massive Machine-type Communications (mMTC) and enhanced broadband communications.
- Define Packetized Energy Management (PEM) based on its history and differentiate its physical and cyber-physical implementations.
- Present how the cyber-physical variation of PEM depends on the advances of machine-type communications (MTC), which have strikingly different characteristics from human-type communications.

- Assess how PEM enabled by MTC can be integrated in the existing European electricity market based on virtual micro-grids so that it would scale up to build the Energy Internet.

Content Summary

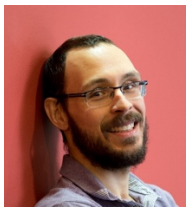
- Basics of machine-type communications (MTC) for IoT applications
- Operation modes for MTC in 5G and beyond
- Introduction to Packetized Energy Management (PEM) and its variations
- Cyber-physical PEM and the need for communications
- Energy Internet: Scaling up cyber-physical PEM
- 100%-renewable-based Energy Internet: Is it a feasible future?
- Open discussions, incl. existing solutions, barriers from regulatory bodies, differences between countries, development of 5G and beyond.

Note: This tutorial will follow the recently published paper: P. H. J. Nardelli, H. Alves et al., "Energy Internet via Packetized Management: Enabling Technologies and Deployment Challenges," in IEEE Access, 2019 (https://ieeexplore.ieee.org/abstract/document/8629864).

Target Audience

Persons working in the digitalization of energy systems, either from academia or industry. No background in communications engineering is needed.

CV of the proposers



Pedro H. J. Nardelli received the B.S. and M.Sc. degrees in electrical engineering from the State University of Campinas, Brazil, in 2006 and 2008, respectively. In 2013, he received his doctoral degree from University of Oulu, Finland, and State University of Campinas following a dual degree agreement. He is currently Assistant Professor (tenure track) in IoT in Energy Systems at LUT University, Finland, and holds a position of Academy of Finland Research Fellow with a project called *Building the Energy Internet as a large-scale IoT-based cyber-physical system that manages the energy inventory of distribution grids as discretized packets via machine-type communications* (EnergyNet). He leads the Cyber-Physical Systems Group at LUT and is Project Coordinator of the CHIST-ERA European consortium *Framework for the Identification of Rare Events via Machine Learning and IoT Networks* (FIREMAN). He is also Adjunct Professor at University of Oulu in the topic of “communications strategies and information processing in energy systems”. His research focuses on wireless communications particularly applied in industrial automation and energy systems. He received a best paper award of *IEEE PES Innovative Smart Grid Technologies Latin America 2019* in the track “Big Data and Internet of Things”. He is also IEEE Senior Member. More information: https://sites.google.com/view/nardelli/

Hirley Alves (S'11–M'15) received the B.Sc. and M.Sc. degrees from the Federal University of Technology-Paraná (UTFPR), Brazil, in 2010 and 2011, respectively, both in electrical engineering, and the dual D.Sc. degree from the University of Oulu and UTFPR, in 2015. In 2017, he was an Adjunct Professor in machine-type wireless communications with the Centre for Wireless Communications (CWC), University of Oulu, Oulu, Finland. In 2019, he joined CWC as an Assistant Professor and is currently the Head of the Machine-type Wireless Communications Group. He is actively working on massive connectivity and ultra-reliable low latency communications for future wireless networks, 5GB and 6G, full-duplex communications, and physical-layer security. He leads the URLLC activities for the 6G Flagship Program. He is a co-recipient of the 2017 IEEE International Symposium on Wireless Communications and Systems (ISWCS) Best Student Paper Award, and 2019 IEEE European Conference on Networks and Communications (EuCNC) Best Student Paper Award and a co-recipient of the 2016 Research Award from the Cuban Academy of Sciences. He has been the organizer, chair, and TPC and tutorial lecturer for several renowned international conferences. He is the General Chair of the ISWCS'2019 and the General Co-Chair of the 1st 6G Summit, Levi 2019, and ISWCS 2021.More information: https://sites.google.com/site/hyalves/

Together Dr. Nardelli and Dr. Alves co-chaired the First Workshop on Enabling Energy Internet via Machine-type Communications, collocated with IEEE VTC-Spring'2018, Porto, and co-organized the second version of this workshop, collocated with IEEE WCNC'2019, Marrakech, also focusing on critical and massive machine-type communications. In addition, they have together more than 20 recent publications on this topic and related areas.