BATTERYLESS BACKSCATTER RADIO FOR THE MASSES: Low-cost, Large-scale RFID and Backscatter Radio systems for Monitoring, Indoor RF Shaping and Localization Applications

Backscatter radio dates back to World War II and lies at the heart of commercial, batteryless radio frequency identification (RFID) tags and technology. This talk will showcase new technology and applications, relevant to backscatter radio and RFIDs, including: a) large-scale but low-cost deployment of Gen2 RFID using commodity software-defined radios, connected over Ethernet, b) precise indoor RFID localization with a mobile robot, c) implementation of a batteryless, RF-powered, reconfigurable intelligent surface (RIS) using commodity RFIDs and finally, d) batteryless, low-cost soil moisture monitoring for precision agriculture using bistatic and ambient backscatter radio.

Backscatter radio is grounded on RF reflection principles that simplify communicator design to a single switch, connected to an antenna, offering ultra-low power consumption per tag, at the expense of reduced communication range and coverage. Bistatic or multistatic architectures, where illuminator and receiver of the tag-backscattered information are placed at distant locations, have been proposed to extend range and coverage, compared to conventional monostatic, at the expense of increased (installation) cost. In this talk, a real-time (less than 0.5 msec delay), near-optimal, noncoherent sequence detection technique will be presented, tailored to the Miller line coding of commercial RFIDs and tested, using commercial, off-the-self, software-defined radios (SDR), connected over Ethernet. Experimental results show that doubling the number of transmitting antennas can double indoor coverage, compared to the (commercial) monostatic architecture, allowing for scalable, low-cost RFID interrogation in warehouses and buildings. Work on cm-accuracy RFID tag indoor localization with a mobile robot, will also be shown. Next, design and implementation of a batteryless, RF-powered, reconfigurable intelligent surface (RIS) using RFIDs, will be presented. This is perhaps the first completely wireless RIS in the world (in conjunction with optimal configuration algorithms with loglinear complexity in the number of elements). Finally, the talk will present work on dense, batteryless, low-cost soil moisture monitoring for precision agriculture using bistatic and ambient backscatter radio principles. A patented, low-cost, 30 μWatt batteryless soil moisture sensor, interrogatable by any FM radio-equipped device, will be shown. Cloud services and inference techniques for missing measurements, currently tested from deployment at the island of Crete in Greece, will be discussed.

Aggelos Bletsas (Senior Member, IEEE) received the Diploma degree (Hons.) in Electrical and Computer Engineering from the Aristotle University of Thessaloniki, Greece, in 1998, and the M.Sc. and Ph.D. degrees in Media Arts & Sciences from the Massachusetts Institute of Technology (MIT), Cambridge, MA, USA, in 2001 and 2005, respectively. He has worked with Mitsubishi Electric Research Laboratories (MERL), Cambridge, MA, USA and the RadioCommunications Laboratory (RCL), Department of Physics, Aristotle University of Thessaloniki, Greece. He currently serves as a Full Professor with the School of Electrical and Computer Engineering, Technical University of Crete, Greece. His research interests span the broad area of scalable wireless communications and sensor networking, with emphasis on ultra-low power/cost environmental sensing, backscatter radio & RFID, wireless localization and ambiently-powered inference networks. His current focus and contributions are relevant to wireless, batteryless, backscatter sensors for precision agriculture that cost a few Euros, consume a few microwatts and can be read with commodity receivers and smartphones. He currently serves as Area Editor, area of Antennas, Channel Models and Location (ACML) of IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS. He has served as an Associate Editor for IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS from 2015 to 2021 and IEEE WIRELESS COMMUNICATIONS LETTERS from 2011 to 2016. He has also served as a Technical Program Committee

(TPC) member for major IEEE conferences. He was a co-recipient of the IEEE Communications Society 2008 Marconi Prize Paper Award in Wireless Communications, and various Best (Student) Paper Awards, e.g., in IEEE RFID-TA 2011, IEEE ICASSP 2015, IEEE RFID-TA 2017, MOCAST 2018 and IEEE WCNEE 2021. Prof. Bletsas received the 2012-2013 Technical Univ. of Crete Research Excellence Award. In December 2020, his students won the Second Prize in the 2020 IEEE ComSoc "Communications Technology Changing the World" Student Competition. He is also proud of his students who were winners for two consecutive years of the 2009-2011 and 2011-2012 best Diploma Thesis contest among all Greek Universities on "Advanced Wireless Systems", awarded by IEEE VTS/AES joint Greek Chapter. He is regularly listed in the Top 2% Scientists worldwide annual list compiled by Prof. Ioannidis' group at Stanford Univ. and has been included in the Highly Cited Greek Scientists, as well as 45 Highly Cited Greek Scientists under 45 list. One of his articles is ranked 1st in Google Scholar Classic Papers in Computer Networks and Wireless Communication list.