Electromagnetic Field Based Wireless Channel Propagation Models: Fundamental Advances and Integration with Network Protocol Design

Costas Sarris, PhD
Professor of Electrical and Computer Engineering
The Eugene V. Polistuk Chair in Electromagnetic Design
University of Toronto
costas.sarris@utoronto.ca

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LECTURE ABSTRACT

Transforming metropolitan areas into "smart" cities requires the large-scale deployment of enabling information and communication technologies. From smart-grid monitoring to wireless control of mass transit systems, point of care and public safety applications, these technologies are based on geographically distributed wireless access points.

The financial feasibility of installing and maintaining such networks of access points, meeting standards for "green" (energy efficient) and safe (in terms of radiation exposure of the population and compatibility with other systems) operation, depends on the availability of accurate computational planning tools. The importance of such computational tools increases as a plethora of new wireless services is being deployed, notably in the IoT and 5G areas, alongside legacy systems.

A prominent example of interest is Communication Based Train Control (CBTC), which is aimed at providing control and signaling for rail transportation systems. These operate in environments that combine tunnel and open air sections, as well as busy stations, coexisting with Wi-Fi and cellular communication networks. Characterizing electromagnetic wave propagation and interference in such diverse environments is most efficiently achieved by hybridizing several computational electromagnetic techniques rather than relying on a single one.

This talk will present our research on hybrid techniques, combining the vector parabolic equation (VPE) method, ray-tracing and FDTD, to model wireless propagation across entire railway networks, reserving the ray-tracer for complex station geometries, while applying the VPE method to long tunnel sections and FDTD to interference problems including models of the train and its interior. We discuss practical aspects such as modeling arbitrary antenna patterns, accounting for surface roughness and evaluating geometric and material uncertainties.

Validation data have been provided by a 2.4 GHz measurement campaign in the complex environment of the London (UK) underground -one of the largest and most successful validation studies ever reported in the relevant literature.

Beyond a conventional accuracy analysis of our propagation models, we ask the question: what if we entirely relied on those models, instead of measured data, to choose the position of access points and even configure network-level protocols for CBTC? How good are electromagnetic field based propagation models as decision making tools all the way to the network level? We show that our accuracy is sufficient to drive such decisions, paving the way for integrating field solvers with network planning tools.

SPEAKER BIOSKETCH

Costas Sarris received the Ph.D. degree in electrical engineering and M.Sc. degree in applied mathematics from the University of Michigan, Ann Arbor, in 2002. He is currently a Professor and the Eugene V. Polistuk Chair in Electromagnetic Design at the Department of Electrical and Computer Engineering, University of Toronto, Toronto, ON, Canada.

His research interests are in the area of computational electromagnetics, with emphasis on high-order, multiscale/multi-physics computational methods, modeling under stochastic uncertainty, as well as applications of numerical methods to wireless channel modeling, wave-propagation in complex media and meta-materials, biomedical imaging and hyperthermia, wireless power transfer and electromagnetic compatibility/interference (EMI/EMC) problems.

Prof. Sarris was a recipient of the IEEE MTT-S Outstanding Young Engineer Award in 2013 and an Early Researcher Award from the Ontario Government in 2007. He is the Editor-in-Chief of the IEEE Journal on Multiscale and Multiphysics Computational Techniques (JMMCT) and the Chair of the MTT-S Technical Committee on Field Theory and Computational EM (MTT-1).

He was the Technical Program Committee Chair for the 2015 IEEE AP-S Int. Symposium on Antennas and Propagation, an associate editor for the IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES (2009-2012), the Technical Program Committee Vice-Chair for the 2012 IEEE MTT-S International Microwave Symposium and an Associate Editor for the IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS (2007-2009).

Please contact Dr. Jiefu Chen (jchen84@uh.edu) to request further information.