Vehicular Communication Networks - A Stochastic Geometry Viewpoint

François Baccelli

INRIA/ENS and Telecom Paris

This lecture will survey recent work on the system level analysis of large communication networks involving vehicular network elements. Vehicles in this setting may play a variety of roles beyond that of end user: relay, mobile base station, data harvester, etc. The analysis is based on a stochastic geometry model where the clustering of vehicles and other network elements on the road network is represented in terms of Poisson point processes on Poisson lines of the Euclidean plane. This leads to a computational framework allowing one to analyze several important classes of such vehicular communication networks.

The first one is that of classical cellular networks with vehicular end users. This Poisson computational framework allows one to derive the distribution of the Shannon rate of vehicle-to-all communications in a variety of cellular network settings: with or without spectrum sharing with other communications, with or without the addition of static road side units, when adding vehicular relays, etc. This distribution can for instance be used to assess the reliability of safety messages exchanged by vehicles in this setting and to determine network parameters for which this reliability satisfies predefined constraints.

The second class is that of networks using vehicles as mobile gateways to enable large-scale delay-tolerant Internet of Things (IoT) data harvesting. This encompasses both classical single-hop architectures and novel multi-hop architectures based on mesh communications between IoT devices and short range communications between data repositories located along the roads and vehicular harvesters. This computational framework can for instance be used to assess the sensing/harvesting capacity of such vehicular architectures.

This survey is based on joint research with Chang-Sik Choi (Hongik University, South Korea) and Gustavo de Veciana (UT Austin, USA).

F. Baccelli is a senior researcher at INRIA-ENS and an invited professor at Telecom Paris. His research is at the interface between applied mathematics and communication networks. His work on applied mathematics is focused on point processes, max plus algebras, network dynamics, stationary queuing networks, random graphs, and stochastic geometry. His main contributions to communications are centered on congestion control, information theory, and wireless networks. He received the France Télécom Prize of the French Academy of Sciences in 2002, the Math+X Award of the Simons Foundation in 2012, and the ACM Sigmetrics Achievement Award in 2014. He also received the 2014 Rice Prize and the 2014 Abraham Prize Awards of the IEEE Communications Theory Society for his work on wireless network stochastic geometry. He was the Math+X Simons chair in mathematics and ECE at UT Austin between 2012 and 2021. He is a member of the French Academy of Sciences. He is currently in charge of an interdisciplinary ERC advanced NEMO project on communications and network mathematics at INRIA-ENS.