University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Master of Applied Science

of

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BSc (University of Jordan, 2016)

"Analysis and Design of IoT-Capable Cellular Networks with Spatiotemporal Modelling"

Department of Electrical and Computer Engineering

Friday August 9, 2019
2:00 P.M.
Engineering Office Wing
Room 230

Supervisory Committee:
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Abstract

A plethora of application scenarios are rapidly emerging within the context of the Internet of Things (IoT) in possibly every industrial and market vertical. Accordingly, the wireless infrastructure should be able to accommodate unprecedented traffic levels that are essentially a blend of human-type and machine-type communications. As such, the large-scale nature of the IoT stems not only from the massive number of devices but also from the amount of the uplink (UL) traffic. There are few natural technology contenders for addressing the challenges of the IoT era. While each may have its own potentials, cellular communications are better positioned to handle key tradeoffs pertinent to ubiquity, mobility, and latency. Articulated differently, the IoT is expected to exert tremendous pressure on cellular networks particularly in the uplink direction. Consequently, several studies report scalability issues in cellular networks for supporting massive UL devices.

This thesis discusses the need to rigorously study the spatiotemporal dynamics of the IoT based on the spatial density of the IoT devices as well as the traffic requirement per device. Hence, a spatiotemporal framework that combines stochastic geometry and queueing theory is developed. Stochastic geometry takes care of topo logical aspects while queueing theory incorporates protocol state as well as queue state awareness into the model. This combined model abstracts the IoT network to a network of spatially distributed and interacting queues, in which the interaction resides in the mutual interference between the devices.

The developed framework is utilized to assess two general approaches to handle the surge in UL traffic that the IoT is expected to generate, namely, Grant-Based Uplink (GB-UL) and Grant-Free Uplink (GF-UL) transmissions. Moreover, the developed framework is used to analyze and optimize self-powered IoT network in which the devices harvest energy from BSs' downlink (DL) signaling.

Keywords: Internet of Things (IoT), Uplink transmission, Grant-based access, Grant-free access, Energy harvesting, Stochastic geometry, Queueing theory, Spatiotemporal model, Stability analysis, Interacting queues, Two-dimensional discrete time Markov chain.