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Editorial

Simulators and Experimental Testbeds Design and Development for Wireless Networks

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In the context of wireless networking, performance evaluation of protocols and distributed applications is generally conducted through simulation or experimentation campaigns. An efficient and accurate simulation of wireless networks raises various issues which generally need to be addressed from several research domains simultaneously. As examples, we can consider the wireless physical layer modeling and simulation, the support of large-scale networks, the simulation of complex RF systems such as MIMO ones, the emulation of wireless nodes or the interconnection of simulators and experimental test-beds, and so forth. Reliable and trustworthy experimentations require the setup of experimental test-beds where complex parameters must be mastered for experiments to be reproduced and correctly analyzed.

In this special issue we bring together academic and industry researchers and practitioners from both the wireless networking and the simulation and experimentation communities to discuss trends in simulation and experimentation techniques, models, and practices for future communication systems and to foster interdisciplinary collaborative research in this area. The collection of papers in hand focuses on recent design, development, and cooperation among researchers coming from the fields of simulation, radio medium modeling, ad hoc networking, and wireless sensor networking. The importance of this topic has produced a long list of high-quality manuscripts that, in the following, we categorize in several subtopics dealing with the main aspects of wireless network simulators and testbeds, and with the inclusion of novel technologies such as multiple antenna, multi-channel radios, or new air interfaces.

The first part of papers is dedicated *Radio medium modeling and cross-layer simulation.* The paper by N. Baldo et al. presents Miracle, a novel framework which extends ns2 to facilitate the simulation and the design of beyond 4G networks, with the objective to provide an efficient and embedded engine for handling cross-layer messages and, at the same time, enabling the coexistence of multiple modules within each layer of the protocol stack. The paper by J. Lei et al. proposes a link gain Matrix estimation in distributed large-scale w*ireless networks, with the goal to devise a methodology that measures a fraction of the links and* accurately estimates the rest. The model is derived using gain measurements on only a small fraction of the links, selected on the basis of an maximum entropy. Finally, accurate simulation of 802.11 indoor links: a "bursty" channel model based on real measurements is studied by R. Agüero et al.

Validation of simulators and simulation results are addressed hereafter. The paper by R. Massin et al. introduces a new simulation framework based on the OMNeT++ simulator whose goal is to enable the study of data and multimedia content transmission over hybrid wired/wireless

ad hoc networks as well as the design of innovative radio access schemes. A cooperative congestion control approach within VANETs with formal verification and performance evaluation is analyzed by M. S. Bouassida and M. Shawky to ensure reliable and safe communication architecture within VANET. Also focusing on experimental evaluation of simulation abstractions for wireless sensor network MAC protocols, the paper of G. Halkes and K. Langendoen provide an analysis of what the main sources of deviation are and thereby how the simulations can be improved to provide even better results.

A couple of papers focused their works on *simulators benchmarking and comparisons*. The paper by J. Haydar et al. describes ABCDecision with a simulation platform for access selection algorithms in heterogeneous wireless networks, the simulator implements the different parts of an Always Best Connected (ABC) system, including Access Technology Selector (ATS) and Radio Access Networks (RANs), and then propose a new selection algorithm in heterogeneous networks. Also hybrid wired/wireless PROFIBUS architectures performance is analysed and studied based on simulation models by P. B. Sousa, and L. Ferreira; the main objective is to describe the role of simulation tools on the validation and performance analysis of two wireless extensions for the PROFIBUS protocol. In one of them, the Intermediate Systems, which connect wired and wireless network segments, operate as repeaters. In the other one the Intermediate Systems operate as bridge.

Support of new emerging technologies (WiMax, 3.5G, Wireless Mesh Networks, 802.11x, etc.) in simulators constitutes important part of this special issue. The paper by Z. Ji et al. describes a wireless billboard channels (WBCs) over DVB-H testbed design, development, and results associated with the "best" services following the user-driven "always best-connected and best-served" paradigm. Design and implementation of a single-frequency mesh network using OpenAir interface is described by F. Kaltenberger et al.; implementation provides a full open-source software modem comprising physical and link layer functionalities for cellular and mesh network topologies (PHY with MIMO and MAC).

The following set of papers is devoted to *multiple antenna testbeds and simulators*. The paper by P. Greisen et al. describes a testbed and verification environment for the development of new wireless transceivers, with the objective to streamline the design flow down to an ASIC implementation. The paper by Gómez et al. describes a MIMO-OFDM simulator that includes the main physical and link layer functionalities of 3GPP Long-Term Evolution (LTE). The paper by V. P. Gil Jiménez et al. describes a MIMO-OFDM testbed with channel measurements and system considerations for outdoor-indoor WiMAX; the testbed includes a real-time flexible 2×2 MIMO-OFDM scheme based on IEEE 802.16 standard. Also focusing on multiple antennas, the paper by Villemaud et al. evaluates the performance of concurrent radio links on overlapped channels through a combination of measurements and performance evaluation.

Specific aspects in the implementation of simulators are addressed next. The paper by E. Conchon et al. describes W-NINE, a network emulation platform which increases the accuracy of emulation parameter modeling. The paper by P. Pagano et al. focuses on simulating real-time aspects of wireless sensor networks and presents RTNS, a publicly available extension of NS-2 to model delays in the CPU and operating system of sensor nodes.

A large number of papers describe *experimental testbeds for different kinds of wireless networks*. The paper by L. Angrisani et al. provides cross-layer performance measurements of video streaming over an 802.11g network. The paper by L.-Benítez et al. describes the AROMA testbed, a real-time emulation tool for all-IP heterogeneous wireless networks. The paper by P. Casey, et al. reports on performance measurements of a Zigbee sensor network testbed over several deployment scenarios including home, industrial, and vehicular. The paper by A. Silva, and M. Can Vuran describes the implementation of an outdoor wireless underground sensor network testbed. The paper by F. Granelli et al. describes WING/WORLD, a testbed based on open source software and 802.11 commodity hardware designed for easy replication by other research groups. The paper by M. Portoles-Comeras, M. Bafalluy, and R. Esteso highlights common pitfalls of using experimentation with off-the-shelf hardware to obtain network performance measures and provides guidelines on the proper use of experimentation. Finally in this group, the paper by P. Serrano et al. describes FloorNet, a wireless mesh network deployed under the false floor of a building, providing extensive performance measurements of this 802.11-based network.

The last two papers of this special issue focus on the study of *routing in wireless networks* through network simulation. The paper by S. Kajioka et al. describes the implementation of a routing protocol based on OLSRv2 control messages and evaluates its performance on an 802.11g mesh network. Finally, the paper by V. Loscri et al. describes the design and implementation of a routing protocol that exploits controlled and predictable mobility of wireless nodes to improve the performance of a wireless network.

We would like to take this opportunity to thank the authors for their efforts in the preparation of their manuscripts and in keeping to the deadlines set by editorial requirements. We are also very grateful to the reviewers who refereed the manuscripts in a timely manner and provided valuable feedback to the authors. Finally, we would like to thank the editor-in-chief, Professor. Luc Vandendorpe, and Mr. Mostafa Salem for their support during the preparation of this special issue. We hope that the focus of this special issue on simulation and experimentation methodology will highlight the importance of these tools that are crucial in assessing the performance of our research but are sometimes not given the attention they deserve.

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