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Editorial

Mobile Multi-Hop Ad Hoc Networks: From Theory to Reality

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It is a great pleasure to introduce this special issue. Multi-hop ad hoc networks are collections of (mobile) nodes connected together over a wireless medium. These nodes can freely and dynamically self-organize into arbitrary and temporary, "ad hoc" network topologies. A mobile ad hoc network (MANET) is probably the most well-known example of this networking paradigm having been around for over twenty years, mainly exploited to design tactical networks. Recently, emerging wireless networking technologies for consumer electronics (e.g., Bluetooth and IEEE 802.11) are pushing MANET outside the military domain and also contributed to the MANET evolution towards mesh and opportunistic networks. Furthermore, the multi-hop ad hoc networking paradigm is often used for building sensor networks to study, control, and monitor events and phenomena.

Multi-hop ad hoc networking technologies have big potentialities for innovative applications of great impact on our everyday life. To exploit these potentialities, simulation modeling and theoretical analyses have to be complemented by real experiences (e.g., experiences/measurements on real prototypes), which provide both a direct evaluation of ad hoc networks and, at the same time, precious information for a realistic modeling of these systems. The availability of prototypes will also make possible to start creating communities of users that, by experimenting with ad hoc networking technologies, will provide feedbacks on its usefulness and stimulate the development of applications tailored for the ad hoc environment.

The aim of this special issue is to present a collection of papers that contribute to move mobile ad hoc networking from theory to reality by presenting application scenarios for these networks and/or results from real ad hoc networks testbeds and prototypes. In response to an open call for papers, we received thirty-six submissions out of which, after an in-depth review process, we finally selected the eleven papers presented in this issue.

The first three papers in this special issue present a set of results on design, implementation, and experimental evaluation of mobile ad hoc networks achieved in the framework of the MobileMAN project funded by the European Commission under the FET-IST Programme. The MobileMAN project combined theoretical studies with experiences gained by implementing real ad hoc networks, and therefore it represents a relevant step in moving MANETs from theory to reality. The three MobileMAN papers presented in this issue address three different aspects of a MANET protocol stack: medium access control (MAC) protocol, routing protocols, and application-layer multicasting.

Specifically, in the first paper of this issue "Design and implementation of an enhanced 802.11 MAC architecture for single-hop wireless networks," Ralph Bernasconi et al. present a testbed implementation of mechanisms that have been defined in previous works in the important field of IEEE 802.11 MAC optimization. Experimental results confirm the theoretical analyses.

In the next paper, "Effects of unstable links on AODV performance in real testbeds," Eleonora Borgia and Franca Delmastro present an experimental study to investigate the impact of unidirectional/unstable links on the behavior of two well-known routing protocols for ad hoc networks: OLSR and AODV. The presented results are relevant because the impact of unidirectional links is generally neglected in simulation studies of the routing protocols, where symmetric links conditions are generally assumed. On the other hand, the authors, by performing measurements on a real testbed, point out the poor behavior of AOVD with unstable links, and explain the reasons for this behavior. Furthermore they show that, in the same conditions, OLSR is typically more stable.

Following this, Andrea Passarella and Franca Delmastro in their paper "Usability of legacy p2p multicast in multi-hop ad hoc networks: an experimental study" evaluate p2p

multicast solutions in mobile ad hoc networks. Specifically, the authors investigate how Scribe (a solution based on Pastry) performs in MANET environments. First, the authors contrast the performance of Scribe when running over proactive and reactive routing protocols. Then, they compare different versions of Pastry, showing that Pastry 1.4 generally decreases the packet loss rate and the average delivery delay, thus highly improving the usability of the target application.

MANET is the topic also of the next three papers of the issue. In the first paper, "TCP-friendly bandwidth sharing in mobile ad hoc networks: from theory to reality," Evgeny Osipov and Christian Tschudin study the unfairness between multiple TCP flows in wireless multi-hop networks. Specifically, the authors adapt to this problem the max-min fairness model, and present an algorithm for load distribution between TCP connections that guarantees the max-min fairness between multiple flows. Finally, the authors propose a rate throttling mechanism to enforce the fairness.

Modeling users' mobility in multi-hop ad hoc networks is the subject of the paper "A Markovian model representation of individual mobility scenarios in ad hoc networks and its evaluation" by Carlos Alberto Campos and Luis Felipe Moraes. Specifically, the authors investigate how to provide a realistic model describing nodes' mobility in ad hoc networks. To better characterize the mobile nodes movement, the authors propose to use Markov models. By exploiting the Markovian random path model, they develop a model that is more suitable to take into account the real-life mobility features than, for example, the random waypoint model. The analysis of mobility models' impact on routing protocols performance completes the paper.

Next, Miguel Almeida et al. in "Experimental evaluation on the usage of ad hoc networks as stubs for multiservice networks" study the performance of an ad hoc network when used as a wireless extension of the Internet. In the paper the authors present an experimental study of this scenario by investigating the performance of services like unicast and multicast routing, legacy multimedia, and security that would be interesting to have on this type of networks.

Using multi-hop ad hoc networks as an Internet extension is the main objective of mesh networks, which are analyzed, in the following two papers. In the first paper, "Evaluation of cross-layer rate-aware routing in a wireless mesh network test-bed," Luigi Iannone et al. present the performance evaluation, in a wireless-mesh-network testbed, of a routing protocol that exploits a cross-layer rate metric for identifying the best routes. The authors show that the approach with cross-layer information can improve the stability and throughput of the routes. Furthermore, experiments with TCP-flows show marked improvements in terms of delivery rate compared to routes built using the minimum-hop metric.

In the next paper, "Wireless mesh networks to support video-surveillance: architecture, protocol and implementation issues," Francesco Licandro and Giovanni Schembra report practical experiences gathered during the implementation and operation of a large-scale video-surveillance system in which they use wireless mesh networks to interconnect the video cameras with the monitoring servers. Preliminary experimental results advocate that multipath routing algorithms can provide much higher performance than traditional single-path routing based on the shortest paths.

The last set of papers of this special issue deal with sensor networks. This is a special case of multi-hop ad hoc networks. Indeed the aim of a sensor network is to collect information about events occurring in the sensor field, rather than supporting the communications between nodes. This, coupled with the constraints of the sensor devices, requires solutions tuned on sensor networks characteristics.

In "Wireless sensor networks: performance analysis in indoor scenarios," Gianluigi Ferrari et al. analyze the performance of two wireless sensor networks technologies, ZigBee and Z-Wave, in indoor scenarios. Single and multihop topologies are experimentally characterized by means of RSSI, throughput, and end-to-end delay. In addition, analytical and simulation results are provided to validate the ZigBee-related experiments.

The management of the software-configuration in wireless sensor networks is the topic of the next paper "Profile-matching techniques for on-demand software management in sensor networks" by Falko Dressler et al. This is becoming a prominent challenge due to the heterogeneity and dynamics of hardware and software configurations. To tackle this problem, the authors have developed a profile-based software management scheme that consists of an algorithm to identify current hardware and software configurations, an on-demand code generation module, and mechanisms for dynamic network-centric reprogramming of sensor nodes.

In the last paper of this issue, "Optimal and approximate approaches for deployment of heterogeneous sensing devices," Rabie Ramadan et al. apply multiple sets of heterogeneous sensors for large-scale surveillance operations. Specifically, the authors propose a modeling framework for the problem of deploying a set of heterogeneous sensors in a field with time-varying surveillance requirements. The problem is formulated as mixed integer mathematical program with the objective of maximizing the coverage of a given field. To solve the problem the authors have proposed two heuristic-based on genetic algorithm and simulated annealing.

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As a Guest Editor it has been a great pleasure to put together this issue. I would like to thank the authors for their contributions and the reviewers for their time, energy, and comments that helped shape this special issue.

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