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Editorial
Opportunistic and Delay-Tolerant Networks

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Today, people predominately rely on the Internet and cellular network, as well as the plain old telephone system, to communicate with each other. Typically, these communication services are built from fixed wired or wireless infrastructure, where the "next hop" is known in advance, well engineered and its performance in terms of delay, throughput, and loss characteristics has been well studied. Over the last decade, a new paradigm in end-to-end communications has emerged, mostly in academia and industrial research laboratories, based on the notion that the next hop between a sender and receiver is not known in advance. These networks, typically called *opportunistic and delay-tolerant networks,* are characterized as opportunistic because, like nodes in mobile ad hoc networking infrastructure, the forwarding nodes are mobile and dynamic—they come and go in unpredictable ways. In this case, it is very hard to make strong statements about the type of service opportunistic networks will offer the user. Opportunistic nodes collectively form dynamic networks that are built from short unpredictable contact times as nodes move in and out of connectivity. Unlike mobile ad hoc networks, which aim to offer a frequently available connected path through a dynamic network, opportunistic networks only offer a store and forward service in a mostly disconnected network comprised of infrequent contact times between nodes—therefore, these networks aim to find the next "storage node" toward the destination as a primary communications service. Because of this, most applications have to be delay tolerant in nature, hence the name: opportunistic and delay-tolerant networks.

Many applications of opportunistic and delay-tolerant networks are being actively studied, for example, networks purely comprised of people carrying devices that only use short range radios, wildlife-based mobile low-power sensor networks, and interplanetary networks. While this new form of communication has created great interest in the research community, it is still in its infancy in terms of emerging communications architectures, algorithms, protocols, tools, modeling, and standards. As yet there has been "no killer app" that has emerged other than the grand challenge of interplanetary communications or niche deployments in sensor networks or mobile human-centric experimental networks. However, these networks show great promise in terms of their fully decentralized design making them extremely robust. They also offer the potential for huge bandwidth gains in contrast to other forms of networks (e.g., MANETs or the existing cellular network) but at the cost of higher end-to-end delays.

The duality of higher bandwidth gains over short-lived next-hop connections and longer end-to-end delays, coupled with the spontaneous creation of dynamic networks, has captured the imagination of networking researchers. The papers in this special issue, which was promoted under the auspices of the EC-funded Network of Excellence in Wireless Communications (in particular, the Work Package WPR.11 on Opportunistic Networks), address a number of the issues and challenges discussed above. We received a total of 23 high-quality submissions. The papers came from different regions around the world and addressed many different aspects of research. Each paper was reviewed by three or more experts, who evaluated the technical content and suitability of the paper for publication in this special issue. As Guest Editors of the special issue we had the very difficult job of selecting only 10 papers from those submitted.

The papers of this special issue cover both practical and theoretical aspects of opportunistic and delay-tolerant networking.

The first group of papers addresses several implementation issues ranging from deployments in real situations to improvements of communication techniques. Quwaider et al. propose a new modeling framework for routing in wireless body-area networks (WBANs). The idea is to consider possible disconnections due to postural partitioning. Several experimentations and simulation studies show that the model is representative of situations found in reality. In the context of natural sciences, Rutishauser et al. propose a monitoring system to observe wildlife in their natural habitat. The system, named CARNIVORE, consists of a set of sensors carried by animals and static collectors whose role is to gather readings to be sent on the Internet. The particularity of the proposed architecture is to deal with intermittent connectivity in an efficient way. Soares et al. address the problem of data collection when the network does not have sufficient density to operate using traditional communication solutions. The authors propose an original strategy that relies on replication to circumvent the constraints introduced by disconnections. Through implementation and simulation, the authors show that the proposed strategy leads to improved delivery ratios. Wang et al. focus on the especially challenging DTN scenario of interplanetary communications. Extreme distances that translate into long link delays and frequent link disruptions characterize such a scenario. The authors investigate the DTN architecture with a bundle protocol (BP) running over the TCP-based convergence layer (TCPCL) protocol and show that the goodput rate is more dictated by disruption delays than bit error rate. Pérennou et al. present the last paper of this first group. They propose triggers on top of the KauNet emulator to evaluate the reaction of applications and protocols to lower layer events. The main contributions of this work are the integration of the DTN reference implementation and the emulation of a DTN data-mule scenario.

The second group of papers reports recent advances on theoretical aspects of opportunistic and delay-tolerant networks. Castro et al. consider the interesting scenario of peer-to-peer file sharing in delay-tolerant rural scenarios. The authors compare two schemes initially conceived for general wireless networks and show that they apply to an opportunistic situation when replication is used as a substrate for lookup. Through a number of simulations, the authors show the suitability of the schemes under a number of situations. Kubo et al. also consider peer-to-peer networking but in the case of multicast communications running on mobile nodes. They propose a new strategy for resource allocation at nodes that considers a single parameter called relay ability, which is in fact a combination of available bandwidth, disconnection rate, and remaining battery capacity. Simulation results show the interest of the proposed scheme. Also in the context of resource optimization, Zhang et al. analyze the efficiency of opportunistic relaying under different realistic radio channel conditions. In particular, the authors provide the lower bound that corresponds to the best tradeoff between energy and latency minimization. Fabbri et al. focus on the most fundamental problem of opportunistic and delay-tolerant networking, that is routing. The authors propose to rely on social information to derive efficient forwarding rules. More specifically, they suggest the use of a scalar parameter that captures a node's social behavior in terms of frequency and types of encounters. The interest of the proposed scheme is confirmed through the examination of vehicular traces. Finally, Samuel et al. address routing from the point of view of self-organizing structures. They propose an improvement over a companion work on the use of super nodes to provide seamless communications for roaming users over interconnected heterogeneous wireless networks. The improvement consists in including a better understanding of node mobility into the model, which leads to a better strategy as shown by the authors in the paper.

Acknowledgments

We would like to take this opportunity to thank the authors of all submitted papers for considering our special issue for disseminating their work. We are also very grateful to the numerous referees who spent their own time to review the manuscripts in a responsive and accurate way: this definitely helped improve the quality of the papers that have been eventually accepted. We would also like to thank the staff of Hindawi for their valuable assistance through the entire editing process, and the Editor-in-Chief of the journal, Luc Vandendorpe, for trusting us with this important assignment and helping us to fulfill it successfully. Last but not least, we thank the members of NEWCOM++ for their collaboration in submitting high-quality papers to this special issue.

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