Special issue on models and algorithms for wireless mesh networks

The increasing demand of wire-free connectivity has been driving the development of new and easy-to-deploy wireless networking solutions. Within this field, Wireless Mesh Networks (WMNs) provide an effective solution for several services and applications domains, such as community networks and municipal networks. On the other hand, WMN deployments pose several challenges to the network designers and operators. First, WMNs often feature large scales in terms of the number of network devices, users, and services to be supported, and in terms of their geographical dimensions. Further, communication support in WMNs is carried out through the cooperation of wireless devices in a multi-hop manner, and it requires different algorithms and protocols (medium access control, routing, transport) that interact in a nontrivial manner. The network designers and operators often do not have complete control over the environment, and hence WMNs must be able to self-configure and adapt to unpredictable changes automatically.

Such distinctive features and intrinsic complexity of WMNs call for a deeper understanding on the fundamental principles governing these networks. To this extent, the design, analysis and deployment of WMNs require quantitative methods to plan/optimize the network structure, to assess the network performances (e.g., in terms of throughput, delay and energy consumption), as well as to steer the design of low-complexity centralized/distributed algorithms and communication protocols. This special issue is aimed to present novel research contributions on the theoretical foundations of wireless mesh networking with special emphasis on performance evaluation and algorithm design. This special issue is comprised of ten papers covering various aspects within these fields. Each submitted paper has been reviewed by at least two independent reviewers and the accepted papers went through two or more review rounds.

The first paper, "Combining Stochastic Geometry and Statistical Mechanics for the Analysis and Design of Mesh Networks," employs tools form stochastic geometry and statistical mechanics to derive the throughput and end-to-end delay performances of multi-hop wireless networks under two different channel access mechanisms: Carrier Sense Multiple Access (CSMA) and ALOHA.

The second paper, "Robust Resource Allocation for Multi-hop Wireless Mesh Networks with End-to-end Traffic Specifications," targets the design of multi-hop, multi-radio, multi-channel wireless networks with guaranteed end-to-end achievable transmission rate. The problem is formalized as a mixed-integer nonlinear programming (MINLP) formulation and heuristic algorithms are finally proposed to get suboptimal solution in reasonable time.

Mathematical programming is used also in the following paper, "On max–min fair flow optimization in wireless mesh networks," which is devoted to modeling WMNs through mixed-integer programming (MIP) formulations. The exact joint optimization modeling of the WMN capacity and the max–min fairness traffic objectives is the main contribution of the paper.

Multi-channel wireless networks are also addressed in "On Channel-Discontinuity-Constraint Routing in Wireless Networks," which introduces novel distributed algorithms to design WMNs under the "Channel-Discontinuity-Constraint" (CDC).

Multicast routing is addressed in the fifth paper, "Multicast with Cooperative Gateways in Multi-Channel Wireless Mesh Networks," which targets the design of high-throughput multicast routes to overcome interference and bandwidth limitation. A cross-layer approach is introduced to properly set the channels and the power levels used to support multicast flows.

The paper, "An analytical framework for Distributed Coordinated Scheduling in IEEE 802.16 Wireless Mesh Networks," proposes a queuing-based model to assess the link-layer performance of IEEE 802.16 networks. The proposed model, originally developed for a single network node, is then leveraged to calculate the end-to-end delay and the throughput.

The following paper, "Analytical Modeling of Context-Based Multi-Virtual Wireless Mesh Networks," studies the case where a single physical wireless mesh network can be logically partitioned into several virtual networks. An analytical model is introduced to evaluate the impact of network virtualization and the complexity of the discovery and extension mechanisms defined for reconfiguring the virtual networks.

The paper, "The Robust Joint Solution for Channel Assignment and Routing for Wireless Mesh Networks With Time Partitioning," introduces a novel algorithm to jointly solve the routing and channel assignment problem.

The problem of routing information in WMNs is also addressed in paper "Probing-based Anypath Forwarding Routing Algorithms in Wireless Mesh Networks." However, the authors consider here a network topologies with link quality uncertainties. In this scenario, an optimal anypath routing scheme is introduced, which is shown to reduce, in reference network scenarios, the end-to-end delay and improve the packet delivery ratio with respect to deterministic routing schemes.

The paper, "A Theoretical Analysis of Multi-hop Consensus Algorithms for Wireless Networks: trade off among Reliability, Responsiveness and Delay Tolerance," addresses the problem of reaching a consensus in network of mesh nodes under m-hop protocols where each node-agent can access to the state of its m-steps neighboring agents. The stability of the consensus protocol is studied in presence of heterogeneous transmission delays between neighboring nodes.

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