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Editorial

Special issue on "Wireless Multi-Hop Networking for Infrastructure Access"

Multi-hop wireless networks in all their different forms continue to receive much attention. Multi-hop techniques are viewed as an important component of next generation radio access networks, in which end user terminals may be multiple wireless hops from the wired infrastructure. Most of these multi-hop radio access deployments are characterized by intermediate nodes with limited mobility which differentiates these problems from those arising in an ad hoc domain. This approach provides a number of advantages over more typical single-hop networking solutions: firstly, it can provide increased coverage at low cost, which is very important in initial network rollout; secondly, it can support increased network capacity as the network matures; thirdly, such systems are typically much more flexible than previous variants with greater support for self-configuration and system adaptation, which leads to management and maintenance cost savings. However, realizing these benefits is highly non-trivial, requiring an excellent understanding of all aspects of a radio system.

There are a number of interesting initiatives in this space. The IEEE 802.16j standard is in the very final stages of ratification and new standards are considering how multi-hop capabilities can be incorporated, e.g., LTE-A and 802.16 m. Hence, work in this area can have a significant impact in a standardization context and it is well positioned to ultimately be adopted by the market.

While considerable energy has been expended on some of these problems, there are still many open challenges. In this special issue, we selected articles which span the breadth of research in multi-hop wireless networking, ranging from security issues, autoconfiguration issues, development of scheduling mechanisms and analytical models for performance analysis – the contexts also vary from single radio 802.11, multi-radio 802.11, CDMA relay, to 802.16 mesh mode type contexts. This wide spectrum of contributions shows how rich this particular research vein is and it is quite clear that there remain many unsolved problems.

A total of 49 papers were submitted to the special issue out of which 13 papers could be accepted, yielding an acceptance rate of about 25%. The articles of this special issue are organized as follows.

In "Augmenting predictive with oblivious routing for wireless mesh networks under traffic uncertainty" Wellons et al. conduct a systematic comparison of two routing strategies for mesh networks: predictive routing and oblivious routing. Predictive routing infers traffic demand and optimizes routing strategy for the predicted demand, while oblivious routing makes no assumption on demand and selects the strategy that optimizes worst-case performance. Following the performance study conducted, the authors propose a novel composite algorithm which employs an oblivious or a predictive algorithm depending on the erraticity of the traffic.

In "MAC-Layer Proactive Mixing for Network Coding in Multi-hop Wireless Networks," Zhang et al. present a novel MAC-layer mixing method which proactively seizes opportunities for coding in a mesh network. The proposed method allows each node in the mesh to be a potential coder and forwarder, and yields a significant increase in the number of coding opportunities by taking advantage of redundant copies of a packet in the neighborhood coding repository. This performance improvement is shown by means of simulation studies.

In "Complexity Results on Labeled Shortest Path Problems from Wireless Routing Metrics", Ward and Wiegand analyze routing in multi-radio, multi-hop wireless networks from the point of view of formal language constrained path problems, and describe the labeled path problems corresponding to the Weighted Cumulative Expected Transmission Time (WCETT) and Metric for Interference and Channelswitch (MIC) routing metrics. For the first, it is proven that calculating shortest WCETT paths is strongly NP-Complete for a variety of graph classes, and shown that the existing heuristic is an approximator. For the second, it is shown that calculating loop-free (simple)

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shortest MIC paths is NP-Complete and only poorly approximable in the worst case.

In "A Global Security Architecture for operated hybrid WLAN Mesh Networks," Toubiana et al. investigate the main security issues focusing on the most vulnerable part of the hybrid WLAN mesh infrastructure and identify the new challenges and opportunities posed by this emerging technology. Based on the analysis of strengths and weaknesses, the authors design a new robust routing structure called MacroGraph (MG), which is based on a node-disjoint path routing scheme and dynamic trust management that can be adapted to respond to applications' security requirements. A performance analysis of the approach is presented and its behaviour under two attach scenarios (packet dropping and route error attacks) is analyzed.

In "Joint Gateway Placement and Spatial Reuse Problem in Wireless Mesh Networks," Targon, Sansò and Capone address the problem of gateway placement, that consists of minimizing the number of gateways while satisfying system performance requirements. The proposed formulation includes jointly routing and scheduling to account for the problem of interference and to enable spacial reuse to allow for a more efficient use of the available resources and reduce overall gateway costs. The article presents a mathematical formulation of the problem and discusses advantages and limitations with respect to other approaches.

In "A Topology Control Approach for Utilizing Multiple Channels in Multi-Radio Wireless Mesh Network," Marina et al. consider the problem of channel assignment for multi-radio mesh nodes while minimizing the interference arising in the network. They demonstrate that their problem formulation is NP-hard and propose a greedy heuristic to solve the problem in a centralized manner. They demonstrate that multi-radio solutions which employ this mechanism can have significantly higher throughput than the single radio case and better performance than another multi-radio approach.

In "Application-aware scheduling for VoIP in Wireless Mesh Networks," Bayer et al. observe that having uncoordinated nodes in a multi-hop network is problematic for some traffic, VoIP in particular. They propose a mechanism which enables nodes to co-operate in a TDMA multi-hop network such that the latency for VoIP traffic is reduced. More specifically, they assume that the VoIP traffic characteristics (frame size, packet interval) are known and they schedule resources in the multi-hop system accordingly. Interestingly, their results show that it is possible to deliver acceptable VoIP performance in multi-hop networks even for large numbers of hops.

In "Identifying the Capacity Gains of Multi-hop Cellular Networks," Hassanein et al. study the performance that can be achieved by multi-hop CDMA-based relay systems. The authors first develop an analytical model to determine the interference arising in the multi-hop context and use this to determine the overall system capacity. Their results show that a CDMA-based relay system can deliver significant performance gains over their single hop counterparts.

In "Building an IP-based Community Wireless Mesh Network: Assessment of PACMAN as an IP Address Autoconfiguration Protocol," Bernados et al. investigate issues associated with automated address assignment in mesh networks. They perform an experimental analysis of the behaviour of the PACMAN protocol in the mesh context providing results on the configuration time and system convergence time for the protocol. Their analysis shows that the protocol is adequate for autoconfiguration of community mesh networks.

In "A Scalable Delay Based Analytical Framework for CSMA/CA Wireless Mesh Networks," Zhou and Mitchell propose a novel model to determine delays and throughput that can be attained at any node within a mesh. They decompose the problem such that they can focus on individual nodes and thus determine the delay and throughput at each node; the decomposition does incorporate hidden nodes and interference issues and hence their model is a reasonable reflection of the behaviour of such networks.

In "Gateway Selection and Routing in Wireless Mesh Networks," Papadaki and Friderikos address the issue of network planning and optimization in multi-hop Wireless Mesh Networks (WMNs). In particular, they propose algorithms for joint gateway selection and routing both for the uncapacitated and capacitated cases. The authors provide an optimal solution for the uncapacited case, and a solution that performs within a small optimality gap for the capacited case, and evaluate the performance and computational costs of the proposed solutions.

Last but no least, in "Link-State Routing without Broadcast Storming for Multi-Channel Mesh Networks," Kim, Ko and Vaidya propose a link-state routing protocol tailored for multi-channel mesh networks that minimizes the broadcast overhead by means of set of special nodes called cluster-heads. The approach has been implemented in a testbed and compared to an AODV-like reactive routing protocol, and shown to provide a comparable or better performance than this protocol.

The guest editors would like to thank all authors and reviewers for their valuable contributions to this special issue.

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