Preface – Recent advances in telecommunications networks planning and operation

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This special issue of *Networks* is devoted to recent research for the planning and operation of telecommunications networks. It contains a selection of papers presented or related to topics presented at the *13th INFORMS Telecommunications Conference* that was held on March 20–22, 2016 in Boca Raton, Florida, USA.

To ensure the high quality of this special edition, each paper was reviewed by at least two recognized peer experts in the field. All the reviewers were selected and assigned by the Guest Editors. After revision by authors, the papers were then further reviewed by the Editors of *Networks*.

The papers submitted and accepted for inclusion for this special issue are organized as follows.

In addition to packet forwarding equipment such as switches and routers, service providers are instantiating Virtualized Network Functions (VNF), e.g., firewalls, application layer gateways, to facilitate the deployment and reconfiguration of network services with reduced time-to-value. In this context, providing a cost-efficient VNF deployment over the network for a set of Service Function Chains (SFC), where a customer demand has to traverse service functions in a pre-defined specific order, is a key technical challenge. Allybokus et al. [1] addresses the joint VNF Placement and Routing (VNF-PR) problem for Service Function Chaining in the case of partially ordered SFCs satisfying the anti-affinity rules. A heuristic based on the linear relaxation of the integer linear program formulation is proposed and its computational performance is evaluated on a realistic network topology.

Data centers today consume a considerable amount of energy and produce a significant amount of emissions. Energy efficiency is therefore an important problem to be addressed. Cho and Ko [2] develop an algorithmic strategy for clustering servers in an energy efficient way, and provide new insights into the use of clustering, powering on/off and bang-bang control operational strategies.

Open Shortest Path First (OSPF) was proposed as a computer backbone network routing protocol in which data packets follow a minimum arc weight path subject to a pre-determined set of arc weights. Liu and Dimitrov [3] consider a variant of OSPF that accounts for Random Early Detection (RED). In this version of OSPF the authors only require a single network path be available between each origin and destination, a simplification of the OSPF protocol. A mixed integer non-linear program is formulated to determine the data paths or routing policy. They prove that determining an optimal OSPF routing policy that accounts for RED is NP-hard. For the routing policy to be real-world implementable, or realizable, weights for all arcs in the network must be determined such that solving the all-pairs shortest path problem using these weights reproduces the routing policy. The authors also show that determining the routing policy when there is a path carrying traffic between every origin and destination node in the network is NP-hard. However, using an off-the-shelf solver, they are able to find realizable routing policies that account for RED for three real-world backbone networks. Furthermore, these policies perform better than those used in each network at the time the data was collected.

A degree-based γ-quasi-clique (often simply referred to as a quasi-clique) is a subgraph in which the degree of each vertex is at least γ times the maximum possible degree of any vertex in the subgraph. Pastukhov et al. [4] consider the problem of finding a degree-based γ-quasi-clique of maximum cardinality in a given graph for some fixed real-valued $\gamma \in (0, 1]$. The authors prove that the problem is NP-hard

for any fixed $\gamma \in (0, 1]$, which answers an open problem in the literature. Furthermore, they also develop new exact solution methods for solving the problem and demonstrate their advantages and limitations in extensive computational experiments with both random and real-world networks.

Observing that the most expensive and time-consuming part of Fiber-to-the-Home (FTTH) networks deployment is trenching and other labor involved in cable installation, Żotkiewicz [5] defined an optimization problem of rational selection of splitters in the process of connecting new customers to a network. To handle and solve the problem, the paper presents two methods, named *SpliSeals* (Splitter Selection Algorithms), that take into account the actual take-up rate and customer arrival patters to minimize the total expected cost of installed splitters. Numerical evaluation using actual real-world network designs, obtained for a small city inhabited by more than $250k$ potential customers grouped into almost $11k$ access points, shows that the average cost savings of the presented algorithms over rational, computer unaided methods exceed 10%, reaching almost 20% in some groups of cases, or even 40% in particular test cases.

We would like to thank the authors for submitting top-quality papers and the referees for their excellent reviews.

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Guest editors

References

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[2] Yongkyu Cho and Young Myoung Ko, *Energy efficiency of data center operating practices: Server clustering, powering on/off, and bang-bang control*, in this issue.

[3] Jiaxin Liu and Stanko Dimitrov, *Open shortest path first routing under random early detection*, in this issue.

[4] Grigory Pastukhov, Alexander Veremyev, Vladimir Boginski, and Oleg A. Prokopyev, *On maximum degree-based γ-quasi-clique problem: Complexity and exact approaches*, in this issue.

[5] Mateusz Żotkiewicz, *Uncertainty in FTTH splitter installation*, in this issue.