applied sciences

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Editorial

Special Issue: Novel Algorithms and Protocols for Networks

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Today, applications can be instantiated in a number of data centers located in different segments of the network, from the core to the edge. Users accessing these applications have stringent requirements in terms of the latency, reliability, mobility, and security. Therefore, application orchestration frameworks must be agile enough to deploy different instances of applications in multiple locations in real-time, following the requirements and sometimes the location of users. From this perspective, new critical enabling technologies have recently arisen, such as the recent introduction of softwarization and virtualization at different levels of the network segments. In such a new panorama, the network must be highly dynamic; support multihoming and high user mobility rates; provide a low latency; and secure access, versatility, and automation. Consequently, the development of novel strategies, algorithms, and protocols is fundamental to reaching the required optimization of the overall system performance.

This special issue on the "Novel Algorithms and Protocols for Networks" brings together the latest proposals and results of algorithms and protocols employed to guarantee the required level of performance and Quality of Service (QoS) by the upcoming applications envisioned in this 5G era. In response to the Call for Papers, 17 articles were submitted to this special issue, and 11 were accepted for publication. In the following paragraphs, a summary of these papers, including their most relevant contributions, is presented.

In the first paper included in this issue, Walkowski et al. [1] focus on vulnerability management and assessment. It is reported that a large delay preceding the elimination of a critical vulnerability presents a significant risk to the network security and increases the probability of sustained damage in corporate networks. The authors present their solution, which is called the Vulnerability Management Centre (VMC). This is a distributed system that performs automatic calculations of the vulnerability score vector by combining the data obtained from a vulnerability scanner with the data retrieved from an organizational inventory database. The obtained results show that the developed VMC is capable of presenting results to stakeholders—almost in real-time—thus accelerating the process of vulnerability identification and prioritization, helping to reduce the probability of a successful cyberattack.

Wang et al. [2] deal with the problem of fairly allocating the network resources among the Virtual Data Centers (VDCs) in multi-tenant cloud data centers. This a well-known problem and many researchers are proposing different strategies to guarantee a minimum bandwidth, work-conservation, and congestion control across VDCs while optimizing the use of the overall data center resources. In this paper, the authors present their novel architecture, which is called NXT-Freedom. The reported results of a prototype show that the proposed NXT-Freedom can achieve a fair network bandwidth across tenants in a flexible and efficient manner, while providing work-conserving allocations with minimum bandwidth demands.

As previously stated, the deployment of 5G will lead to a revolutionary transformation of telecommunication networks. The third paper in this special issue [3] focuses on the

Citation: Careglio, D.; Klinkowski, M.; Palmieri, F. Special Issue: Novel Algorithms and Protocols for Networks. *Appl. Sci.* **2021**, *11*, 2296. https://doi.org/10.3390/app11052296

Received: 18 February 2021
Accepted: 25 February 2021
Published: 5 March 2021

problem of placing the different baseband processing units on processing pool facilities spread over the network, taking into account the latency requirements of the traffic flows. Klinkowski presents a mixed integer linear programming (MILP) formulation to optimally solve this problem. As stated by the author, his formulation is feasible for network instances with few units and nodes where good-quality solutions are found; the development of heuristics or more advanced MILP techniques is required for larger network scenarios.

The routing and spectrum allocation (RSA) planning problem related to designing optical networks has been the focus of many studies in the last 10 years. Since the complexity of the optimization problem is NP-complete, heuristic and meta-heuristic solutions have been proposed to solve it in a reasonable period of time with good-quality results. In the fourth paper, Kozdrowski et al. [4] compare several nature-inspired metaheuristic optimization algorithms to minimize the capital expenditure in optical networks. The comparison is performed using the same solution model for different network topologies.

Giral et al. [5] propose a collaborative decision-making process for cognitive radio networks. The novelty of this work is the proposal and structure of the developed collaborative model that acts as a bidirectional source of information. The decision-making process was carried out with multi-criteria techniques, namely Feedback Fuzzy, the Analytical Hierarchical Process, and Simple Additive Weighting, which have shown excellent results.

Manzanares-Lopez et al. [6] contribute to this special issue with a paper dealing with the Virtual Network Function (VNF) placement problem in Micro Data Center (MDC)/Cloud Data Center (CDC) edge computing networks. In particular, the authors propose a VNF placement solution that takes into account the latency and resource requirements imposed by the service function chains (SFC), the bandwidth and resource restrictions imposed by the network and micro data centers, and the instantiation cost of VNFs. The authors formulate a formal Integer Linear Programming (ILP) model and propose a heuristic solution, obtaining the target cost similarly to state-of-the-art approaches and, at the same time, a better performance in terms of non-allocated SFCs.

In the context of next-generation wireless communications systems, Dewa et al. [7] propose a distributed cell clustering algorithm that maximizes the overall downlink throughput of the Joint Processing Coordinated Multipoint Transmission (JP-CoMP) scheme. The proposed algorithm consistently provides a higher performance compared to conventional methods in terms of both average user equipment throughput and average edge user throughput. Despite all of the advantages, the message update procedure in the proposed algorithm causes latency issues; however, for most typical applications of JP-CoMP, the latency issue would not be critical.

Blockchain technology is essentially a decentralized database maintained by the collective, and it is now widely applied in various fields. Chen et al. [8] propose a blockchain-based secure inter-hospital Electronic Medical Report (EMR) sharing system. Through the programmatic authorization mechanism by smart contracts, the security of EMR is guaranteed. In addition to the essential mutual authentication, the proposed scheme also provides and guarantees data integrity, nonrepudiation, user un-traceability, forward and backward secrecy, and resistance to replay attacks.

The spectrally–spatially flexible optical network (SS-FON) combines the adaptive use of different modulation formats and multi-carrier transmission with the parallel transmission of a number of co-propagating spatial modes in appropriately designed optical fibers. In the context of this new evolution of optical networks, Walkowiak et al. [9] address the problem of the optimal placement of transponders operating in a so-called back-to-back configuration. The novelty of the proposed algorithm is the use of a data analytics approach which decides on the transponder placement by exploiting information about network traffic characteristics and the evaluated network performance. The authors show that their solution provides much better performance results than the reference methods for two representative network topologies and under several different traffic profiles.

Tan et al. [10] present Sonum, which is a software-defined solution for long flow detection and load balancing in data centers. Instead of employing the usual solution of

minimizing the flow completion time by equalizing link utilization, the authors propose a sampling and detection approach for long flow, and an optimal network utilization mechanism for long flow scheduling based on the packet loss rate. According to the authors' simulation results, Sonum can detect long flows and schedule long flows more efficiently than existing methods and, at the same time, performs better in terms of the flow completion time and throughput.

Internet traffic monitoring is a crucial task for the security and reliability of Internet of Things (IoT) infrastructure. Intruders and cybercriminals can use different techniques to bypass existing intrusion detection systems based on signature detection and anomalies. In order to more effectively detect new attacks, Dymora et al. [11] propose a model of anomaly detection using the Hurst exponent vector and the multifractal spectrum. The proposed multifractal analysis shows a great sensitivity to any deviation of traffic properties, which helps to detect unusual behavior of the network, possibly related to a cybercrime attack. Such a solution can be ideal for protecting critical data and maintaining the continuity of IoT services.

Acknowledgments: This Special Issue would not be possible without the contributions of various talented authors, hardworking and professional reviewers, and dedicated editorial team members of the Applied Sciences journal. We would like to take this opportunity to thank both authors and reviewers for their valuable contribution to this collection. Finally, we place on record our gratitude to the editorial team of Applied Sciences, and special thanks to Sara Zhan, Section Managing Editor for Applied Sciences.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Walkowski, M.; Krakowiak, M.; Oko, J.; Sujecki, S. Efficient Algorithm for Providing Live Vulnerability Assessment in Corporate Network Environment. *Appl. Sci.* **2020**, *10*, 7926. [CrossRef]
2. Wang, S.; Zhou, Z.; Zhang, H.; Li, J. Nxt-Freedom: Considering VDC-Based Fairness in Enforcing Bandwidth Guarantees in Cloud Datacenter. *Appl. Sci.* **2020**, *10*, 7874. [CrossRef]
3. Klinkowski, M. Latency-Aware DU/CU Placement in Convergent Packet-Based 5G Fronthaul Transport Networks. *Appl. Sci.* **2020**, *10*, 7429. [CrossRef]
4. Kozdrowski, S.; Żotkiewicz, M.; Wnuk, K.; Sikorski, A.; Sujecki, S. A Comparative Evaluation of Nature Inspired Algorithms for Telecommunication Network Design. *Appl. Sci.* **2020**, *10*, 6840. [CrossRef]
5. Giral, D.; Hernández, C.; Rodríguez-Colina, E. Spectrum Decision-Making in Collaborative Cognitive Radio Networks. *Appl. Sci.* **2020**, *10*, 6786. [CrossRef]
6. Manzanares-Lopez, P.; Muñoz-Gea, J.P.; Malgosa-Sanahuja, J. VNF Placement for Service Function Chains with Strong Low-Delay Restrictions in Edge Computing Networks. *Appl. Sci.* **2020**, *10*, 6573. [CrossRef]
7. Dewa, G.R.R.; Park, C.; Sohn, I. Distributed Cell Clustering Based on Multi-Layer Message Passing for Downlink Joint Processing Coordinated Multipoint Transmission. *Appl. Sci.* **2020**, *10*, 5154. [CrossRef]
8. Chen, C.-L.; Deng, Y.-Y.; Weng, W.; Sun, H.; Zhou, M. A Blockchain-Based Secure Inter-Hospital EMR Sharing System. *Appl. Sci.* **2020**, *10*, 4958. [CrossRef]
9. Walkowiak, K.; Klinkowski, M.; Włodarczyk, A.; Kasprzak, A. Predeployment of Transponders for Dynamic Lightpath Provisioning in Translucent Spectrally–Spatially Flexible Optical Networks. *Appl. Sci.* **2020**, *10*, 2802. [CrossRef]
10. Tan, L.; Su, W.; Cheng, P.; Jiao, L.; Gai, Z. Sonum: Software-Defined Synergetic Sampling Approach and Optimal Network Utilization Mechanism for Long Flow in a Data Center Network. *Appl. Sci.* **2020**, *10*, 171. [CrossRef]
11. Dymora, P.; Mazurek, M. Anomaly Detection in IoT Communication Network Based on Spectral Analysis and Hurst Exponent. *Appl. Sci.* **2019**, *9*, 5319. [CrossRef]