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GUEST EDITORIAL

Guest Editorial: Special issue on network/traffic optimisation towards 6G network

1 | INTRODUCTION

An even faster and more heterogeneous communication infrastructure is planned for the 6G network, based on 5G in a way that leads us to much more deeply connected, programmable, intelligent, and sensing devices, with excellent network performance and coverage, and new dimensions of functionality. Therefore, 6G brings even greater challenges to network/traffic engineering and optimisation.

This virtual collection on Network/Traffic Optimisation towards 6G Network brings together the best six research papers submitted from academia, and reflects some of the latest and original achievements, concentrating on the performance of a mobile hotspot in vehicular communication, on the mobility modelling and ad hoc routing in Flying Ad-hoc NETworks (FANETs), on the performance of a joint antenna and relay selection Multiple-Input Multiple-Output (MIMO) system for cooperative Non-Orthogonal Multiple Access (NOMA) networks, on optimal resource optimisation based on multi-layer monitoring and Machine Learning (ML), on Voice over Wi-Fi Security Threats—Address Resolution Protocol (ARP) attacks and countermeasures—and on the management of 5G and Beyond networks through cloud-native deployments and end-to-end monitoring.

Although the rapid and substantial changes in networking technologies towards the 6G Network over the recent years could readily justify this virtual issue, our real motivation was the 13th event of the International Symposium of Communications Systems, Networks and Digital Signal Processing, held in Porto, Portugal (20–22 July 2022), and the IET's open call.

2 | TOPIC A: HOTSPOT PERFORMANCE IN VEHICULAR COMMUNICATION

We begin with the first paper where Marinos Vlasakis et al theoretically analyse the performance of a mobile hotspot with limited bandwidth capacity and a Connection Admission Control functionality which provides Quality of Service (QoS) support for handover voice calls by serving them in priority over new voice calls. An interesting application example of vehicular communication is presented by considering a vehicle (say a bus), which alternates between stop and moving phases. In the stop phase, the vehicle can service both new and handover calls, while in the moving phase, only new calls (originating from the vehicle) are supported. Obviously, when passengers enter the vehicle while talking on their mobile phone, a handover should occur, that is, the Access Point must support handover connections in priority over new call connections. To this end, the capacity of the mobile hotspot is probabilistically reserved during the stop phase to benefit handover calls. In this case, new calls are accepted with a probability. This is called probabilistic bandwidth reservation policy. The system is modelled based on three-dimensional Markov chains. Moreover, the traffic is assumed quasi-random (originating from a finite traffic source population). This consideration is the first for loss/queueing models applied in a mobile hotspot and is proven to be very essential.

3 | TOPIC B: AD-HOC NETWORKS–FANETs

In the second paper by G. Amponis et al, a novel approach is presented to model the movement of aerial nodes in ad hoc networks in general, but in particular it is presented in FANETs. Considering application-aware and mobility-aware routing for the representation of three-dimensional, anchored, and self-similar swarm mobility (drones) modelling, the so-called Anchored Self-Similar 3D Gauss-Markov Mobility Model (ASSGM-3D) is proposed to accurately capture the complex dynamics of aerial nodes (such as wind, turbulence, and changes in altitude) that significantly affect the communication performance in FANETs. The proposed model incorporates a set of spatio-temporal statistical metrics taking into account previously known metrics. Moreover, ASSGM-3D is designed using experimental data from experiments conducted with a set of routing protocols, namely Optimised Link State Routing and Ad-hoc On-demand

Distance Vector Routing, as well as traditional mobility models, including the Gauss–Markov model and the Random Walk model. The proposed mobility model achieves an improved ad hoc routing performance in emergency communication scenarios for 6G applications, where a fast and reliable communication is crucial.

4 | TOPIC C: COOPERATIVE RELAYING USING MIMO-NOMA TECHNOLOGY

In the third paper, V. Balyan observes that (1) proper selection of relays can substantially improve both the QoS offered to users and the network coverage, especially when multiple antennas are used, as in the case of MIMO relay 5G-and-Beyond network, (2) the distinction of network users in two types, good channel quality, and poor channel quality, usually in the centre and edge of a cell respectively, fits well with the concept of Cooperative NOMA (a technology available in the 5G-and-Beyond network), whereby both the QoS offered to users and the network coverage are also substantially improved. In NOMA, multiple users can transmit in different power levels at the same time, code, and frequency. In Cooperative NOMA, users of good-channel quality decode the messages destined to poor-channel quality users, and therefore, the good-channel quality users are used as relays to improve the QoS support of the poor-channel quality users (a short-range communication system is needed in order for the messages to be sent from the good-channel quality users to poor-channel quality users). For this modern networking environment, the author proposes an Antenna Selection scheme, aiming at maximising the instantaneous rate of poor-channel condition users while providing better QoS. Then, a Relay Selection scheme follows that selects the least loaded relay. Thus, by this combined scheme, named ASRS, the best antenna of Base Station (BS), relay node, and antenna at relay are selected. The outage probability of the proposed scheme is simulatively evaluated with respect to the Signal-to-Noise Ratio, the number of antennas in the BS, the number of relays etc. Other performance metrics are also presented. The scheme is compared with other schemes found in the literature to show its superiority.

5 | TOPIC D: ML FOR NETWORK RESOURCE ALLOCATION

In the fourth paper, D. Uzunidis, P. Karkazis, and H. Leligou shed fresh light on optimal network resource optimisation by leveraging ML. First, in practice, it is much easier to minimise the distance between the overallocation of network resources and the optimal allocation, called the "critical point" (where the allocated resources ensure the SLA with zero underutilisation). Second, decisions on resource allocation per service become more complex than ever because fast decisions are required at a finer level while knowing the profile of each service is necessary and a difficult task, since new types of services emerge every day. Third, an unavoidable consideration is the critical issue of high degree of heterogeneity in a modern networking environment and the virtualisation technologies that are used; to cope with them, monitoring and managing the allocated resources are mandatory not only at the application layer but at all layers. Taking all three points into account, the authors propose a novel architecture/mechanism to minimise the allocated resources per service while ensuring QoS. Data are monitored and collected from heterogeneous resources and used to train ML models, while being tailored to each service in real time. A holistic per-service resource optimisation is performed through ML, emphasising that the data that feed the ML models are collected from all layers. For validation and evaluation of the proposed mechanism, it is applied to real-life services, namely Hadoop (handling Big Data) and a Backend service. Service profiling and performance predictions are performed by collecting and analysing a list of monitoring data coming from the physical layer, CPU, memory usage, network throughput etc., as well as other performance metrics from the running services. The results show very good accuracy in predicting the required resources for many operational configurations.

6 | TOPIC E: CYBER ATTACKS AND COUNTERMEASURES IN VoWi-Fi

In the fifth paper, Lu Kuan-Chu et al propose a method to protect the Voice over Wi-Fi (VoWi-Fi) service from cyber-attacks in Beyond 5G or 6G Network. The motivation was the fact that Taiwan's major telecom operators have introduced VoWi-Fi calling services, which provide cellular calls and text messages to mobile users through home/public Wi-Fi networks based on 3GPP IP Multimedia Subsystem technology, instead of cellular base stations. These services are potential threats if they pass through untrusted Wi-Fi networks. To defend against possible attacks, an attack defence algorithm is proposed for future app developers or device manufacturers that can detect whether the user's calling environment is safe or not. In addition, referring to 3GPP standards, the authors recommend that telecom companies boost observation mechanisms to detect abnormalities and provide new design knowledge towards the development of the network to the 6G network. Moreover, to examine the VoWi-Fi attacks, specifically ARP attacks, the authors deployed real-world experiments to confirm their feasibility, assess their potential damage, and evaluate the proposed anti-attack algorithm.

7 | TOPIC F: NETWORK MANAGEMENT

In the latest paper, S. Barrachina-Munoz et al examine three critical aspects of 5G-and-Beyond network management: cloud-native deployments, end-to-end monitoring, and

network intelligence. After a thorough review of the current literature, the authors present how the proposed fully functional experimental framework (testbed) is constructed and complements existing research. The proposed framework uses containerised network operations on a Kubernetes cluster in a multi-domain network spanning clouds and hosts, as well as containerised end-to-end monitoring. For the latter, both infrastructure resources and radio metrics are presented using two scenarios, which involve User Plane Function reselection and user mobility; in a third scenario, it is shown how a decision engine interacts with the testbed to perform zero-touch containerised application relocation, highlighting the potential for enabling dynamic and intelligent management. In conclusion, the proposed testbed employs cutting-edge open-source networking technologies widely used in the industry, making it a highly suitable platform for realistic 5G-and-Beyond experiments. The presented use cases not only validate the capabilities of the testbed but also reflect real-life scenarios. However, in order to ensure a simple, safe, and controlled testing environment, traffic is originated from emulated User Equipments.

KEYWORDS

5G mobile communication, access protocols, Big Data

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We would like to congratulate the authors on their valuable research results and the succeeding publication in the framework of the present IET Networks virtual issue on Network/Traffic Optimisation towards the 6G Network. Besides, we sincerely hope that the above paper selection among the submitted papers satisfies the expectations of the readers. Finally, we would like to express our deepest thanks to the reviewers for their invaluable and timely remarks on the technical content of the papers, and, of course, the IET-Networks editorial team for giving us the opportunity in putting together this virtual collection, as well as for their advice and guidance.

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DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data was created or analyzed in this study.

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