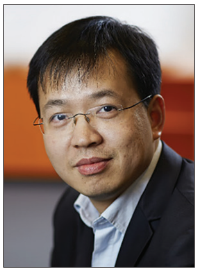
AI for Network Traffic Control


Yan Zhang


Pascal Lorenz

Network traffic control is a key enabler for network systems as it helps achieve significant information delivery efficiency as well as resource utilization through monitoring, inspecting, and regulating data flows. In light of evolving IoT technology and the coming of the beyond fifth generation (5G) era, powerful smart mobile devices and ubiquitous ultra-dense radio networks have greatly enlarged network scale while bringing explosive amounts of data traffic, which impose considerable pressure on the management of the Internet. Moreover, the advances in central cloud and smart edge services have substantially changed the traffic flow models and the service architecture of the Internet. New technologies are thus required to handle traffic control in a highly scalable and adaptive mode.

Artificial intelligence (AI), which carries human-like capabilities in environment perception, data analysis, and strategy decision, is currently a promising approach to deal traffic control with dynamic and large-scale topology. However, despite the power offered by AI in addressing complex difficulties, vast challenges are presented in implementing AI-inspired approach for intelligent network traffic control in a flexible and efficient fashion. This Special Issue was aimed at soliciting high-quality unpublished work regarding the latest advances in the area of AI-inspired network traffic control. Under a rigorous review process, 14 papers were selected for publication in this Special Issue.

The issue opens with the article "Label-less Learning for Traffic Control in an Edge Network." Aiming to maintain cloud intelligence while reducing network traffic, the authors in this article propose a traffic control algorithm based on label-less learning on edge cloud, which significantly alleviates wireless transmission and improves task offloading efficiency.

Facing unreliable vehicular ad hoc networks, the second article, "AI-Based Malicious Network Traffic Detection in VANETs," designs a real-time jamming detection mechanism for vehicle-to-everything safety-critical applications through statistical network traffic analysis and data mining with the aid of AI technology.

The third article, "An Improved Stacked Auto-Encoder for Network Traffic Flow Classification," presents an improved stacked auto-encoder to learn the complex relationships of multi-source network flows, where Bayesian posterior distribution is utilized for handling the uncertainty of data in a natural way.

Leveraging deep learning to make localized prediction of the traffic load at ultra-densely deployed base stations, the fourth article, "A Deep-Learning-Based Radio Resource Assignment Technique for 5G Ultra Dense Networks" proposes an efficient algorithm that intelligently executes the appropriate action policy a priori for alleviating network congestion.

To model and control the dynamic multimedia traffic in SDN environment, the fifth article, "Deep Reinforcement Learning for Multimedia Traffic Control in Software Defined Networking" studies adaptive control in a deep reinforcement learning approach, which solely learns from rewards by trial and error and significantly optimizes the quality of experience for multimedia applications.

The sixth article, "Improving Traffic Forecasting for 5G Core Network Scalability: A Machine Learning Approach," focuses on the scalability of a 5G core network, and introduces a machine-learning-based resource scaling mechanism in a virtualized environment, which helps remove the network performance bottleneck and reduces attachment duration.

Encountering the upcoming edge intelligence era, the seventh article, "Deep Reinforcement Learning for Mobile Edge Caching: Review, New Features, and Open Issues," gives a comprehensive review on the key issues in incorporating AI into mobile edge caching, and illustrates trace-data-driven simulation results to validate the effectiveness of learning-based edge caching schemes.

Triggered by the traffic scheduling requirements for 5G networks, the eighth article, "Artificial Intelligence to Manage Network Traffic of 5G Wireless Networks," extensively investigatesthe characteristics, challenges, and potential solutions for managing 5G traffic in an AI empowered approach.

To manage the incoming traffic of vehicular cyber-physical networks, the authors of the ninth article, "SeDaTiVe: SDN-enabled Deep Learning Architecture for Network Traffic Control in Vehicular Cyber-Physical Systems," design an SDN-enabled deep learning architecture to reveal the hidden patterns in the data packets and obtain optimal delivery routes.

Driven by the requirements of scalable, efficient, and reliable vehicular communications, the 10th article, "Intelligent Context-Aware Communication Paradigm Design for IoVs

Based on Data Analytics," proposes a context-aware Internet of Vehicles paradigm that greatly improves communication performance through utilizing high-level contextual information learning in scheme design.

To fully exploit AI technologies in heterogeneous network operation, the 11th article, "Artificial Intelligence Inspired Multi-Dimension Traffic Control for Heterogeneous Networks," introduces an AI-inspired traffic control scheme that realizes fine-grained and multi-dimensional data transmission management.

The 12th article, "Living with Artificial Intelligence: A Paradigm Shift toward Future Network Traffic Control," presents a selective survey on AI empowered network traffic control paradigms, including challenges, opportunities, architectures, and mechanisms.

To guarantee the quality of multimedia data delivered to subscribers, the authors of the 13th article, "Multimedia Data Flow Traffic Classification Using Intelligent Models Based on Traffic Patterns," design a pattern-based multimedia traffic classification model, which differentiates the types of traffic through learning video streams and network characteristics.

The last article, "DeepTP: An End-to-End Neural Network for Mobile Cellular Traffic Prediction," studies mobile cellular traffic forecasting in a large-scale real system. Through capturing two key characteristics of cellular communications, the authors propose a deep traffic predictor that accurately predicts traffic demands from spatial-dependent and long-period data in a deep learning approach.

To conclude this editorial, we would like to express our appreciation to all the authors who submitted their research work for this Special Issue. Also, we would thank all the reviewers for their dedicated work and high-quality reviews. Last but not least, we would like to express our deepest thanks to the Editor-in-Chief of *IEEE Network* for his valuable guidance and support. We hope that this Special Issue gives a comprehensive view of the state of the art in AI-empowered network traffic control, and will serve and promote new research in this area.

Biographies

Yan Zhang [SM] (yanzhang@ieee.org) received his Ph.D. degree from the School of Electrical & Electronics Engineering, Nanyang Technological University, Singapore. He is currently a full professor with the Department of Informatics, University of Oslo, Norway. His current research interests include next generation wireless networks leading to 5G, and green and secure cyber-physical systems (e.g., smart grid, healthcare, and transport). He has served as a TPC member for numerous international conferences, including IEEE INFOCOM, IEEE ICC, IEEE GLOBECOM, and IEEE WCNC. He is an Associate Technical Editor of *IEEE Communications Magazine*, an Editor of *IEEE Network*, *IEEE Transactions on Green Communications and Networking*, *IEEE Communications Surveys & Tutorials*, the *IEEE Internet of Things Journal*, and *IEEE Vehicular Technology Magazine*, and an Associate Editor of *IEEE Access*. He has served as the Chair of a number of conferences, including IEEE CloudCom 2015, IEEE SmartGridComm 2015, IEEE PIMRC 2016, IEEE CloudCom 2016, IEEE ICCC 2016, IEEE CCNC 2016, IEEE GLOBECOM 2017, and IEEE VTC-Spring 2017. He is the IEEE Vehicular Technology Society Distinguished Lecturer.

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