Autonomous Networks: Opportunities, Challenges, and Applications


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Researchers and standardization bodies have been paying increasing attention to the network management automation issue in 5G systems. Autonomous solutions for managing network resources are required in the present era of flexible and dynamic cloud-based settings. Operators strive for efficiency by optimizing network resources. The next step in network evolution, which can go beyond automation capabilities, is autonomousness.

With autonomy, the network is able to learn from its experiences and adapt to its changing environment, rather than merely managing its resources. In networks, self-healing, self-diagnosing, and self-provisioning are all considered autonomous tasks. Autonomous activities can be accomplished in the present network with the aid of developing technologies, like artificial intelligence (AI), the Internet of Things (IoT), and blockchain.

Existing networks are made up of several heterogeneous devices that need to be connected in order to provide smooth automated end-to-end services. Planning, implementing, and managing this combination of services has traditionally been a labor-intensive, mostly manual process with little automated support. In other words, it is acknowledged that these services can no longer be controlled using such ways, regardless of the level of improvement. In order to meet the new expectations, a transformation supported by the integration of new technologies is required. These include virtualization, 6G, blockchain, AI/ML/DL, etc., to reach a new level of automation and intelligence.

Vehicular networks are summoned by the newly emerged (semi-)/autonomous vehicles (AVs) which introduce new features and challenges in communication networks. Context-aware networks of vehicles can be built on Information-centric networking (ICN) to overcome the shortcomings of conventional information-sharing operations to realize autonomous, pervasive, and ubiquitous vehicular networking. The article by Chaudhry *et al.* makes the case for an information-sharing system based on ICN primitives and presents a new contextual-sharing model. The article motivates the need for autonomous networking for vehicles and details its design. In effect, the article provides an ICN naming solution for a use case: context awareness and information-sharing between networks of vehicles. Through this use case, the authors explain how context awareness works in autonomous networks and evaluate it using simulations. The authors argue that similar information services are partially researched but require significant infrastructural deployments to operate. The proposed solution, instead, can prove more efficient and adaptable to fit in the current infrastructure by reducing unnecessary packet overheads without compromising the network performance in data delivery and delay in comparison to existing solutions.

The manuscript authored by Zeydan *et al.* provides a flexible, secure, transparent, and efficient framework for network service provisioning for next generation cellular networks. The main objective of the paper is to develop a blockchain-based framework for network management and orchestration that enables multiple stakeholders to manage the lifecycle of network services. The analysis focuses on the Industry 4.0 use case and leverages blockchain technology to evaluate different operational and management logs for service instantiation, based on blockchain and service instantiation-related metrics. A standardization roadmap for the application of blockchain technologies in network service provisioning is also established.

Non-Public Networks (NPNs) are dedicated mobile networks for private entities and businesses that are gaining attention in various vertical industries. Multiple deployment options, with different advantages and requirements, are possible based on the desired level of integration with the public land mobile network. With the help of a research testbed, Bellin *et al.* provided some insight on the challenges in the automation and the orchestration of an open, multi-vendor, and standard-complaint NPN.

The manuscript by Babbar *et al.* proposed to use a web server-based edge architecture to manage a large number of IoE devices that are based on 6G technology, which enables autonomous networks and a smart distribution of resources. The suggested system utilizes the Boltzmann machines approach to allocate workloads from IoE devices based on their flexible service requirements, ensuring energy-efficient communications. Additionally, an Artificial Intelligence (AI)-driven method, specifically the Support Vector Machines (SVM) retrieval model, is implemented at the edge network to assess the data and obtain precise results.

The study by Li *et al.* focuses on the fundamental principles of autonomous fault detection in smart grids, which plays a crucial role in enhancing the state awareness, maintenance, and operation of grid systems. The study highlights new prerequisites, including advanced sensing and communication technologies, Artificial Intelligence (AI) and Machine Learning (ML), edge computing, and cloud-edge collaboration. Additionally, the authors present a preliminary case study in a real-world smart substation. The proposed methodology optimizes the detection accuracy, throughput, and processing delay.

Biographies

Kapal Dev (kapal.dev@ieee.org) is currently serving as Assistant Lecturer and was formerly he was a senior researcher at Department of Computer Science, Munster Technological University (MTU), Irelan. He was a postdoctoral research fellow with the CONNECT Centre, School of Computer Science and Statistics, Trinity College Dublin (TCD). He was recently awarded as an IEEE ComSoc EMEA Outstanding Young Researcher 2022 for promising research activities for the benefit of the Society. He is very active in leading successful projects as Principal Investigator under Horizon Europe MSCA Staff exchange, Erasmus + International Credit Mobility (ICM), Capacity Building for Higher Education, and H2020 CO-FUND projects, and has won over 1.2 million Euros funding in total. He is serving as Funded Investigator (FI) at one of top European research centres — CONNECT, Trinity College Dublin (TCD), funded by Science Foundation. Recently, he is working towards the standardisation. He is serving as an Associate Editor in *IEEE Consumer Electronics Magazine*, *NATURE*, *Scientific Reports*, *Springer Wireless Networks*, *IET Quantum Communication*, *IET Networks*, and *Springer Human-centric Computing and Information Sciences*. He is an Area Editor in *Elsevier Physical Communication*, Technical Committee Member in Elsevier COMCOM and a board member of IEEE Future Directions Newsletter: Technology, Policy and Ethics, and Review Editor in Frontiers in Communications and Networks. He performed duties as a guest editor (GE) in several Q1 journals, such as *IEEE Network*, *IEEE Transactions on Industrial Informatics*, *IEEE Transactions on Network Science and Engineering*, *IEEE Transactions on Green Communications and Networking*, *IEEE Standard Communication Magazine*, *Elsevier Computer Communication*, and *Elsevier Computer Networks*, and *Computers and Electrical Engineering*. He has been serving as a Lead Workshop Chair in one of ACM Mobicom 2022, IEEE Globecom 2022, IEEE Blockchain 2022, IEEE ICDCS 2022, IEEE CCNC 2021, IEEE Globecom 2021, IEEE PIMRC 2021, and ACM MobiCom 2021 workshops. He is a TPC member of IEEE Smart Cities 2022, IEEE BlackSeaCom 2022, IEEE Globecom2022, IEEE ICC 2021, IEEE ICBC 2021, IEEE VTC2021. His research interests include wireless communication networks, blockchain, and artificial intelligence targeting applications majorly towards industry 4.0/5.0 and supervised more than 22 students at masters and Ph.D. level in the same areas. He has published over 70 research papers majorly in top IEEE Transactions, Magazines, and Conferences.

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