Autonomous Networks: Opportunities, Challenges, and Applications


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The network management automation problem in 5G systems has been gaining attention from standardization organizations and researchers. The current age of agile and dynamic cloud-based environments demands autonomous systems for managing network resources. Operators aim to optimize the network resources to achieve minimalism with efficiency. Autonomousity in networks is the next leap of evolution that is capable of going beyond automation capabilities. With autonomousity, it is not just making the network capable of managing resources but rather making the network learn and adapt itself with respect to the dynamic environment. Autonomous tasks in networks refer to self-healing, self-diagnosing, and self-provisioning. With the help of emerging technologies such as artificial intelligence (AI), Internet of Things (IoT), and Blockchain, autonomous tasks can be realized in current network systems.

To offer seamless automated end-to-end services, existing networks are made up of diverse heterogeneous devices that need to be integrated. Until very recently, the planning, implementation, and management of this mix of services has been a largely manual activity with some automated assistance. In short, no matter the degree of refinement, it is recognized that these services can no longer be managed using such approaches. The fresh demands need a transformation supported by integrating new technologies, such as virtualization, 6G, Blockchain, AI/ML/DL, etc., to attain a new level of automation and intelligence to manage the networks efficiently.

The study by Thaliath *et al.* presents a machine learning based intelligent closed-loop SLA assurance technique for O-RAN based network slicing. The intelligent SLA assurance scheme automates proactively balancing and re-orchestrating the network resources amongst different slices. A high-level architecture and the design flow have been illustrated. The authors prove the effectiveness of their proposal using real world traffic data sets. The proposed scheme can help operators manage a wide variety of network issues like network congestion, QoS/QoE management, mobility management, etc. well before time which can help operators save capital and operational expenses.

An autonomous network framework that can adapt to dynamic network environments is introduced in the study proposed by Lin *et al.* to improve the efficiency of network resource management in 5G application scenarios. To achieve stable interconnection within 5G systems, a hypergraph-based network topology is proposed, and an RL algorithm is used to optimize the management of network resources. Then, a BERT model is adopted for resource state awareness from the user satisfaction perspective, and a fuzzy decision based collaborative resource scheduling algorithm is designed to improve service quality. Finally, challenges that need to be further solved in the future development of 5G autonomous networks are explored.

Effective resource optimization and standardization in future wireless networks are challenging because of massive resource-constrained devices, diverse quality-of-service (QoS) requirements, and a high density of heterogeneous devices. The study proposed by Khalid *et al.* provides a review of autonomous aerial networks (AANs) with wireless power transfer (WPT) that can autonomously modify radio parameters and sustain their resource usage and management (power transfer, exploiting spectrum). A summary of standardization activities for the success of AANs with WPT is provided. A case study is presented to maximize the computing efficiency of AANs with WPT as a proof of concept.

The study by Kumari *et al.* proposes an autonomous network system for transmitting smart building data. Incorporating an autonomous network into a sensing system allows it to make decisions depending on the present situation, increasing its intelligence. The system is comprised of numerous compression-decompression models with varying compression ratios. To choose the best compression model for the sensory data, the autonomous network calculates the amount of data that can be transmitted in a given amount of time.

Existing distributed denial of service attack (DDoS) solutions cannot handle highly aggregated data rates. Therefore, they are unsuitable for Internet service provider (ISP) core networks. To address this problem, the study by Yigit *et al.* proposes a digital twin-enabled intelligent DDoS detection mechanism using an online learning method for autonomous core networks. A yet another next generation (YANG) model and an automated feature selection (AutoFS) module to handle core network data are implemented. The proposed solution successfully detects DDoS attacks and updates the feature selection method and learning model. Moreover, it can estimate the attack approximately fifteen minutes after the DDoS attack starts.

Biographies

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