6G Network AI Architecture for Customized Services and Applications


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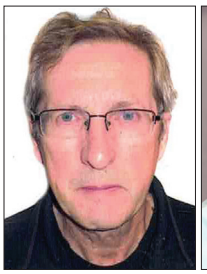
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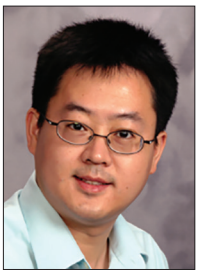
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The Fifth Generation (5G) mobile systems have adopted cloud computing and edge computing to support customized services in different application scenarios, such as smart cities, metaverse, interactive Virtual Reality (VR) games, intelligent manufacturing, and autonomous driving. The current 5G network architecture decouples the basic functions of data sensing, communication, and computing at user terminals, mobile networks, and cloud/edge, respectively. Cross-domain resource coordination and service orchestration require in-depth domain knowledge and rich experiences, and hence are very complicated and time-consuming. It is, therefore, very challenging to effectively coordinate heterogeneous resources in distributed facilities for providing agile, stable, and customized services with guaranteed Quality of Experience (QoE) for everyone in dynamic mobile environments.

Thanks to the advancements of different Artificial Intelligence (AI) technologies, the Sixth Generation (6G) mobile systems will develop an intelligent, collaborative, and adaptive network architecture with pervasive AI capabilities inside 6G systems to address this big challenge. Specifically, a service-oriented approach should be applied to the design and evaluation of such a 6G network AI architecture, which incorporates ubiquitous sensing, storage, communication, computing, control, and AI (S2C3A) resources from the cloud to the edge. In light of this, the ambitious goal of 6G is to satisfy every user's individual, integrated, and dynamic service requirements in different application scenarios, network conditions, operation situations, and security environments. This motivates us to conduct active research, developments, and experiments on 6G network AI architecture.

This Special Issue (SI) aims at bringing together recent advances on 6G network architecture, pervasive and collaborative AI algorithms, cross-domain service requirements, and security issues. After a rigorous review process, only seven articles have been selected out of a total of 28 submissions. They can be divided into three parts, i.e., 6G network AI architecture, AI-enabled algorithms and applications, and practical testbed design, respectively.

Three articles are focused on the design of 6G network AI architecture. The first article, "Integrating Satellites and Mobile Edge Computing for 6G Wide-Area Edge Intelligence: Minimal Structures and Systematic Thinking," by Lin *et al.* proposes three minimal integrating structures and discusses some unique characteristics and key problems in different network structures. Besides, the authors establish an on-demand network orchestration framework to enrich the hierarchy of network management. The second article, "AI-SPACE: A Cloud-Edge Aggregated Artificial Intelligent Architecture for Tiansuan Constellation-assisted Space-Terrestrial Integrated Networks," by Xu *et al.* proposes a cloud-edge aggregated AI architecture to tackle the challenges of Space-Terrestrial Integrated Networks (STINs) for 6G, such as unreliable data transmissions, untimely data processing, and low utilization of satellite resources. The third article, "AI-Enabled Network Virtualization and Software-Defined Architectures for Customized Statistical QoS Over 6G Massive MIMO Mobile Wireless Networks," by Zhang *et al.* proposes the AI-enabled network architecture that integrates three 6G-candidate techniques to support customized services. In addition, the authors develop a set of AI-enabled techniques, such as multi-agent AI-plane architectures, edge-AI frameworks, and federated learning mechanisms for efficiently implementing the massive-MIMO-NFV-SDN integrated schemes.

Based on potential 6G network AI architectures, four papers are devoted to AI-enabled algorithms and applications. The fourth article, "Optimization Design for Federated Learning in Heterogeneous 6G Networks," by Luo *et al.* investigates the optimization approaches that can effectively address the challenging heterogeneity issues from three aspects, i.e., incentive mechanism design, network resource management, and personalized model optimization. The fifth article, "Hierarchical Adaptive Collaborative Learning: A Distributed Learning Framework for Customized Cloud Services in 6G Mobile Systems," by Shi *et al.* proposes a distributed learning framework for customized cloud services to improve the training efficiency and resource utilization by dynamically adjusting the collaborative training process according to the existing services and resources. The sixth article, "Decentralized AI-enabled Trusted Wireless Network: A New Collaborative Computing Paradigm for Internet of Things," by Shao *et al.* combines blockchain and AI to establish a decentralized trusted wireless network and a collaborative computing paradigm for various IoT applications. Last but not least the seventh article, "Everyone-Centric Heterogeneous Multi-Server Computation Offloading in ITS with Pervasive AI," by Song *et al.* proposes an MEC-based network AI architecture with heterogeneous servers and pervasive AI capabilities to provide customized services in intelligent transportation systems (ITS). Specifically, the authors develop a federated deep reinforcement learning approach to optimize the computation offloading process in ITS.

In summary, 6G network AI architecture will effectively facilitate and promote cross-domain resource sharing, network element collaboration, and intelligent service orchestration in the future. We believe the readers of this SI will find these articles quite informative and inspiring. Finally, we would like to express our gratitude to the Editor-in-Chief, Dr. Chonggang Wang, for his guidance and support throughout the editorial process.

Besides, we like to thank many anonymous reviewers for their valuable comments and suggestions, as well as all the authors for contributing their latest research work and valuable insights on 6G networks.

Biographies

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Frank Eliassen is a Professor emeritus at University of Oslo, Norway. He is an experienced researcher in the areas of distributed computer systems and energy informatics. His research interests include service-oriented IoT/edge/fog computing in application areas such as smart cities and smart grids, adaptive software systems, peer-to-peer systems, and smart energy communities. He received his academic degrees from University of Tromsø, Norway.

Xiliang Luo [SM] received the B.Sc. degree in physics from Peking University, Beijing, China, in 2001, and the M.Sc. and Ph.D. degrees in electrical engineering from the University of Minnesota, Minneapolis, MN, USA, in 2003 and 2006, respectively. He is currently with Apple and advancing the designs of wireless technologies for diverse ranging, connectivity, and sensing applications.