

ULTRA-LOW-LATENCY AND RELIABLE COMMUNICATIONS FOR FUTURE WIRELESS NETWORKS



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Ultra-low-latency and reliable communications is perhaps the most challenging task in future wireless networks because of its demanding requirements of low latency combined with ultra-high reliability. The number of connected devices and data traffic is increasing exponentially every day, and future data-intensive applications like augmented/virtual reality (AR/VR), holographic communications, vehicle-to-everything (V2X), autonomous driving, high precision manufacturing, and ultra-massive machine-type communications will demand high throughput, ultra-reliable transmission, extremely low latency, and high energy efficiency. This Series issue introduces four high-quality articles presenting discussions on new techniques and concepts, standards, future applications, network architectures, challenges, and promising solutions for ultra-high-speed, low-latency, and reliable communications in future networks. In the following, we introduce these articles and highlight their main contributions.

In the article “An Edge-Computing-Enabled Trust Mechanism for Underwater Acoustic Sensor Networks,” Du *et al.* present an edge-computing-enabled architecture for underwater acoustic sensor networks (UASNs). A trust mechanism and autonomous underwater vehicle (AUV) deployment strategy to provide ultra-low-latency and reliable communications (URLLC) for UASNs is then discussed in detail. The AUVs are regarded as the edge devices to provide low-latency and high-reliability service access. Edge computing technology offloads tasks to AUVs located at the edge of the network, which can reduce the latency of trust evaluation by shortening the transmission distance and reducing the routing hops. As a result, the edge-computing-enabled UASNs architecture alleviates the problem of latency and improves the network efficiency. Further, the authors discuss thermocline as a carrier to assist AUVs with hiding by analyzing the characteristics of the thermocline in the ocean, and propose a security strategy of deploying two AUVs at the upper and lower sides of the thermocline separately. The deployment strategy ensures reliable communication among sensor nodes or between sensor nodes and AUVs.

In the article “Customized 5G and Beyond Private Networks with Integrated URLLC, eMBB, mMTC, and Positioning for Industrial Verticals,” Guo *et al.* provides a detailed discussion on customized 5G and beyond private networks (C5GBPNs). The authors construct a mapping between industrial vertical functional requirements and 5G key performance indicators (KPIs), and point out the limitations and constraints in

existing telecommunication standards. To meet heterogeneous requirements and provide satisfactory services, the authors discuss three types of C5GBPNs with integrated URLLC, enhanced mobile broadband (eMBB), massive machine-type communications (mMTC), and positioning for industrial verticals. The advantages and disadvantages for these three types are discussed in depth, and also some solutions to deal with foreseeable design challenges of C5GBPNs in terms of operating spectrum, network control, network access, and administration of user data are also presented.

The article “Secure 5G-Assisted UAV Access Scheme in IoBT for Region Demarcation and Surveillance Operations” proposes a generic scheme that integrates blockchain (BC) and UAVs through a 5G Tactile Internet (TI) service to leverage responsive and secure communications in Internet-Of Battlefield-Things (IoBT)-based ecosystems. UAVs are deployed with camera sensors to monitor and transfer ultra-high resolution (UHR) images and real-time live video feeds of region demarcation and surveillance to ground control stations (GCSs). In the article, the performance of the proposed architecture is compared to a baseline 4G/LTE scheme and cloud GCS servers highlighting the scheme’s viability over parameters like processing latency, frame loss, and throughput computation.

In the article “6G-Enabled Ultra-Reliable Low-Latency Communications in Edge Networks,” Adhikari and Hazra discuss the emerging 6G technology and its benefits toward edge networks for processing real-time applications. The article also discusses several challenging issues for collaborative 6G and edge computing based on a review of 5G deployment, network coverage, technology requirements, and challenges. Further, future research directions of 6G-based edge computing are also discussed in order to integrate ultra-reliable 6G technology into the edge networks for processing real-time applications.

We would like to express our sincere thanks to all the authors for submitting their articles and to the reviewers for their valuable comments and suggestions that significantly enhanced the quality of these articles. We are also grateful to Prof. Zander Lei for the great support throughout the whole review and publication process of this Series, and of course, all the editorial staff. We hope that this Series issue will serve as a useful reference for researchers, scientists, engineers, and academics in the field of ultra-low-latency and reliable communications for future wireless networks.

BIOGRAPHIES

MUHAMMAD IKRAM ASHRAF (ikram.ashraf@nokia-bell-labs.com) received his M.Sc. and Ph.D. degrees in telecommunication systems and communication engineering, respectively, from the University of Oulu, Finland. He is working as a senior research specialist, 5G Advanced, at Nokia Bell Labs, Espoo Finland. Prior to that, he worked as an experienced researcher in Network Architecture and Protocols at Ericsson Research in Jorvas, Finland. He has contributed to several technical papers, invention disclosures, and 3GPP. His research interests include 5G Advanced, AI/ML, Industry 4.0, XR, positioning, IoT, V2X, UAV, URLLC, and TSN. He is serving as a Series Editor of *IEEE Communication Standards Magazine* on Ultra-Low-Latency, and Reliable Communications for Future Wireless Networks, an Associate Editor of *IET Quantum Communication*, and a Guest Editor of Elsevier's *Journal of Industrial Information Integration* Special Issue on Data/Information Integration Techniques in Industry 4.0/5.0. Prior to that, he served as an Editor of *IEEE Communication Standards Magazine*, a Guest Editor of *IEEE Wireless Communications*, an Editor of *IEEE Transactions on Cognitive Communications and Networking*, and a Guest Editor of *IEEE Network*.

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