



# Special Topic on Digital Twin Online Channel Modeling for 6G and Beyond

## Guest Editors



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Channel characterization and modeling are fundamental to communication system design, development, testing, and deployment. As the innate digital twins of wireless channels, channel models replicate real-world channel behaviors, e.g., large-scale/small-scale fading, spatio-temporal-frequency non-stationarity, through mathematical and data-driven methods. This enables simulation-based validation across system development stages—from protocol design to network optimization—without costly physical testing.

In 6G/B6G, new frequency bands (e.g., centimeter wave and millimeter wave) and new scenarios (e.g., integrated sensing and communication (ISAC), unmanned aerial vehicle (UAV) communications) have introduced highly dynamic, complex channel characteristics. The critical task is to conduct channel measurements and modeling for diverse bands/scenarios, challenged by technological advancements: Larger antenna arrays and higher resolution have driven transitions from traditional static measurements to dynamic ones, generating massive datasets. In such cases, AI has become an essential method to process big data, improve model accuracy, and enable real-time channel adaptation, overcoming bottlenecks in high-frequency and dynamic scenario analysis.

In this special issue, a series of articles are presented to address the challenges in channel measurement and modeling for next-generation wireless networks, offering innovative solu-

tions to advancing the field. These articles cover a diverse range of topics, including novel measurement methodologies for complex scenarios, machine learning-enhanced channel data processing technologies, digital twin-enabled modeling frameworks, and applications in emerging 6G use cases such as ISAC and UAV communications. The call for papers of this special issue has received many high-quality submissions, reflecting strong academic and industrial interest in overcoming the technical bottlenecks of channel characterization across frequency bands and scenarios. After two rounds of rigorous peer review, six excellent papers have been selected for publication in this special issue, which are presented as follows.

The first paper, titled “Channel Measurement and Analysis of Human Body Radar Cross Section in 26 GHz ISAC Systems”, proposes a systematic approach to characterizing electromagnetic scattering from human bodies in ISAC systems, leveraging multi-angle measurements and ray-tracing analysis to optimize joint communication-sensing performance in urban micro-cellular environments.

The second paper, titled “Space Network Emulation System Based on a User-Space Network Stack”, presents a novel user-space network stack (Nos)-based framework to realistically emulate satellite and aerial network channels, enabling validation of space-air-ground integrated communication systems under dynamic propagation conditions and reducing development complexity through technologies like Open vSwitch (OVS) and traffic control (TC).

The third paper, titled “A Machine Learning-Based Channel Data Enhancement Platform for Digital Twin Channels”, introduces a generative adversarial network (GAN)-driven platform to address channel data scarcity, demonstrating how AI can generate statistically realistic channel samples from sparse measurements to accelerate digital twin channel devel-

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opment for 6G networks.

The fourth paper, titled “6G Digital Twin Enabled Channel Modeling for Beijing Central Business District”, proposes a scenario-specific digital twin framework that integrates light detection and ranging (LiDAR) point clouds, RGB images, and crowdsourced data to characterize ultra-dense urban channels, providing insights for network deployment in high-rise commercial zones by mimicking channel non-stationarity and consistency.

The fifth paper, titled “Channel Knowledge Maps for 6G Wireless Networks: Construction, Applications, and Future Challenges”, establishes a knowledge graph based architecture to systematically organize channel data, models, and engineering experiences, facilitating intelligent decision-making in multi-band and multi-scenario communication systems through the concept of channel knowledge maps (CKMs).

The sixth paper, titled “Air-to-Ground Channel Measurement and Modeling for Low-Altitude UAVs: A Survey”, synthesizes recent advancements in low-altitude UAV air-to-ground channel research, providing a comprehensive overview of measurement campaigns, modeling approaches, and future directions critical to 6G aerial network design, with a focus on millimeter-wave scenarios beyond suburban environments.

In conclusion, we hope this special issue serves as a valuable resource for researchers, practitioners, and students engaged in 6G/B6G channel measurements and modeling. It aims to inspire innovative solutions for dynamic channel challenges and drive advancements in AI-integrated channel modeling. We sincerely thank all authors, reviewers, and editorial staff for their contributions, which are crucial to curating this collection. We trust these articles will offer insightful guidance and foster new perspectives in wireless channel characterization for next-generation networks.

### Biographies

**WANG Chengxiang** received his BS and ME degrees in communication and information systems from Shandong University, China in 1997 and 2000, respectively, and PhD degree in wireless communications from Aalborg University, Denmark in 2004. He was a research assistant with the Hamburg University

of Technology, Germany from 2000 to 2001, a visiting researcher with Siemens AG Mobile Phones, Germany in 2004, and a research fellow with the University of Agder, Norway from 2001 to 2005. He was with Heriot-Watt University, UK from 2005 to 2018, where he was promoted to professor in 2011. He has been with Southeast University, China, as a professor since 2018, and he is now the Dean of the School of Information Science and Engineering. He is also a professor with the Pervasive Communication Research Center, Purple Mountain Laboratories, China. He has authored 4 books, 3 book chapters, and over 620 papers in refereed journals and conference proceedings, including 28 highly cited papers. He has also delivered 32 invited keynote speeches/talks and 21 tutorials in international conferences. His current research interests include wireless channel measurements and modeling, 6G wireless communication networks, and electromagnetic information theory. Dr. WANG is a member of the Academia Europaea (The Academy of Europe), a member of the European Academy of Sciences and Arts (EASA), a Fellow of the Royal Society of Edinburgh (FRSE), IEEE, and IET. He was an IEEE Communications Society Distinguished Lecturer in 2019 and 2020, and a highly-cited researcher recognized by Clarivate Analytics in 2017 – 2020. He is currently an Executive Editorial Committee Member of the *IEEE Transactions on Wireless Communications*. He has served as an editor for over sixteen international journals, including the *IEEE Transactions on Wireless Communications*, from 2007 to 2009, the *IEEE Transactions on Vehicular Technology*, from 2011 to 2017, and the *IEEE Transactions on Communications*, from 2015 to 2017. He was a guest editor of the *IEEE Journal on Selected Areas in Communications*, *IEEE Transactions on Big Data*, and *IEEE Transactions on Cognitive Communications and Networking*. He has served as a TPC Chair and General Chair for more than 30 international conferences. He received the IEEE Neal Shepherd Memorial Best Propagation Paper Award in 2024. He also received 19 Best Paper Awards from international conferences.

**HUANG Chen** received his PhD degree from Beijing Jiaotong University, China in 2021. From 2018 to 2020, he was a visiting scholar with the University of Southern California (USC), USA, and with the Universite Catholique de Louvain (UCLouvain), Belgium. From April 2021 to April 2023, he was a postdoctoral research associate at the Pervasive Communication Research Center, Purple Mountain Laboratories (PML), China, and also at the National Mobile Communications Research Laboratory, School of Information Science and Engineering, Southeast University (SEU), China. Since April 2023, he has been a research associate professor at the Pervasive Communication Research Center, PML, and an extramural supervisor at the National Mobile Communications Research Laboratory, School of Information Science and Engineering, SEU. Dr. HUANG was selected for Young Elite Scientists Sponsorship Program by China Association for Science and Technology, “333” High-Level Talent Program and Outstanding Postdoctoral Fellow Program in Jiangsu, received the Best Paper Awards from IEEE ICC 2025, IEEE/CIC ICC 2024, IEEE ICCT 2023, WCSP 2018, IEEE/CIC ICC 2018, and serves as the chair of the AI Channel Modeling subgroup at IEEE P1499 Standard Group, associate editor for *IEEE Transactions on Vehicular Technology* and Technical Program Committee (TPC) member for several conferences, including GlobeCom, ICC, VTC-Fall, VTC-Spring, etc. His research interests include 6G channel measurements, characterization, and modeling, machine learning-based channel prediction, and localization. He has authored/co-authored 1 book chapter, over 70 journal and conference papers, and 17 patents.