

6G: The Next Horizon

The first book on 6G wireless presents an overall vision for 6G – an era of intelligence-of-everything – with drivers, key capabilities, use cases, KPIs, and the technology innovations that will shape it. These innovations include immersive human-centric communication, sensing, localization, and imaging, connected machine learning and networked AI, Industry 4.0 and beyond, with connected intelligence, smart cities and life, and the satellite mega-constellation for 3D full-Earth wireless coverage. Also covered are new air interface and networking technologies, integrated sensing and communications, and integrated terrestrial and non-terrestrial networks. In addition, novel network architectures to enable networked AI, user-centric networks, and native trustworthiness are discussed. Essential reading for researchers in academia and industry working on B5G wireless communications.

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Edited by Wen Tong , Peiyong Zhu

Frontmatter

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“This is the first comprehensive book on 5G, beyond 5G, and 6G written by experts in the field. It elaborates very clearly the potential of 5G and future enhancements before outlining the 6G vision and technical challenges. I highly recommend this book to all in academia and industry who are interested in advanced research.”

Rahim Tafazolli, University of Surrey, UK

6G: The Next Horizon

From Connected People and Things to Connected Intelligence

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Preface

Wireless revolutions certainly necessitate the development of innovative, disruptive technologies and groundbreaking applications. When these two forces meet, a new generation of wireless technology emerges. This is exactly what happened when mobile voice and digitalized radio transmission converged, and when the mobile Internet came together with highly spectral efficient radio technology tailored towards the IP protocol. The recent 5G wireless network seeks to achieve wireless connectivity for both massive and ultra-high reliable links, ultimately connecting everything as we know it, and accelerating the digital transformation of every business. Building on the steps of 5G, the 6G wireless network has set a ubiquitous intelligence revolution as the goal. In actuality, 6G will serve as our society's neural network, and as the link between the physical and cyber worlds. Artificial intelligence (AI) based on machine learning will power 6G, and within this realm, our future will fully transform from connected people, connected things to connected intelligence. Phrased differently, the 6G wireless network aims to deliver intelligence to every person, home, and business, which in turn will bring the Intelligence of Everything into existence. From the wireless technology perspective, we are presented with the opportunity to sense the environment and things by exploiting wireless communication radio waves. As such, in addition to transferring bits, the 6G wireless network could serve as networked sensors that extract real-time knowledge and big data from the physical world. This extracted information will not only go a long way in enhancing data transmission, but will also facilitate machine learning for AI services. Another novel aspect, which is definitely worth remembering, is the expansion of VLEO satellites, which orbit the earth at very low altitude in very large constellations, ultimately creating 6G wireless networks "in the sky." As a result, wireless services and applications that are covered anywhere and everywhere on our planet will not be beyond imagination. Without doubt, this vision is immensely ambitious and will impact both our society and economy substantially. On top of that, the creation of the 6G wireless network will seize the opportunities offered by technological innovations in communications, computing, materials, and algorithms. That said, this decade-long journey will not be accomplished overnight.

In this book, we provide a comprehensive view of the 6G wireless network through a technology lens. Our motivation is to introduce some of the initial research results and critical thinking on the 6G wireless network. Not only do we review cutting-edge wireless services and technologies; we also explore the requirements, capabilities, and

applications of this network, with an emphasis on the new radio air interface and network architecture. This book serves as a collective result of our research team's quest to define 6G. With that in mind, it should be viewed as a starting point, especially due to the fact that innovation never stops. Along those lines, 6G's trajectory will eventually be shaped by experts around the globe, as we hold firmly that open innovation and a single, globally unified standard are the foundation upon which 6G's success will be built. Just like its predecessors, the success of the 6G wireless network will translate into the success of the open and global ecosystem.

Finally, the wireless revolution we are familiar with today has been in progress for over four decades, with a widespread impact that continues to surpass all expectations. As such, we can neither underestimate nor overestimate the potential of the wireless future. With this spirit, let's recall that Guglielmo Marconi once asserted in 1932 that "it is dangerous to put limits on wireless."