Chapter 2
Enabling 6G Technology: Opportunity, Targets, Applications, and Challenges

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ABSTRACT

While 5G still in its early deployment phase and far from realizing its full potential, the introduction of 6G may appear to be yet another instance of relentless technological advancement—one that seems more focused on entertainment and consumer-driven benefits rather than broader societal well-being. In fact, the shift from one generation to the next is not merely a push for innovation but is driven by the need for synchronization and standardization, just as it was for previous generations and will be for the transition from 5G to 6G. One of the frequently asked questions is whether replacing 5G with 6G is necessary beyond simply improving communication speeds. This chapter explores the development of 6G, focusing on its technical justifications, target performance, and challenges. It emphasizes the need for enhanced connectivity, the adoption of new frequency bands, and advanced technologies such as MIMO and beamforming. Additionally, it discusses key applications, including autonomous transportation and IoT, while highlighting energy efficiency as a crucial concern.

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INTRODUCTION

It is estimated that it takes around five years for a new generation of mobile networks to emerge. As a result, initial discussions, seminars, and white papers have already been launched to define what 6G could be (Yu et al. (2024), Jahandar et al. (2025), Van-Tam et al. (2024)The United States has initiated the Next-G Alliance research project under the oversight of the ATIS standardization body, bringing together major industry players (excluding Chinese companies) Maier (2023), Lee et all (2022), Döhler (2021). The main European 6G project is Hexa-X Merluzzi et al (2023), Kerboeuf et al. (2024), Uusitalo et al (2021). The Hexa-X project presents its vision of 6G in its second report, immediately addressing the existential threats facing humanity, such as climate change, pandemics, social inequalities, and declining trust in democracy. Their proposed solution lies in greater digitalization of society, with mobile networks as the cornerstone of this transformation. Once again, the United Nations' goals are highlighted, and the digital industry emphasizes its contributions to economic growth and CO_2 emission reductions, citing the controversial GSMA study on the matter.

In their description of potential 6G use cases, the authors of the Next-G project suggest that 6G is "likely to expand North American markets and could virtually impact all aspects of life, society, and industries" in Next G Alliance Report (2022). In everyday life, the focus is on robotic services, particularly assisting the elderly, which is seen as a major business opportunity. Human-machine interactions are expected to be enhanced through multi-sensory virtual reality and telepresence. Additionally, 6G could help achieve societal goals, such as those outlined in the United Nations' 2030 Agenda for Sustainable Development. There is an emphasis on bridging the digital divide and reducing CO_2 emissions through improved energy efficiency, renewable energy harvesting technologies, and long-lasting battery solutions. In its report, the Next-G Alliance addresses environmental concerns, acknowledging the growing share of digital industries in global energy consumption. According to the authors, this increase is driven by population growth and society's rising demand for digital services. However, the industry has committed to achieving net-zero greenhouse gas emissions by 2050. Other environmental impacts are also mentioned, including e-waste, mining activities, and intensive water usage. As a result, the Next-G Alliance recommends that digital companies commit to clear targets, establish metrics, collect data, and improve energy efficiency. They argue that 6G will support the circular economy and help other sectors reduce emissions. However, it is explicitly stated that energy efficiency gains will not offset the effects of increasing data traffic, meaning that overall energy consumption will continue to rise.

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