Chapter 10
A Summary on 5G and Future 6G Internet of Things

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ABSTRACT

This chapter comprehensively surveys the six aspects of the 5G and future 6G internet of things (IoT). First, most of the 5G- and 6G-IoT usage scenarios and key performance indicators are summarized in the forms of tables, pictures, and diagrams to facilitate readers to understand and compare current and future IoT technologies more easily and quickly. Second, 5G- and 6G-IoT access networks, protocols, and standards were briefly analyzed and compared, such as coverage, transfer data speed, energy consumption, operating frequency, and the number of device connectivity. Third and fourth, the impact of 6G-IoT on society's daily life and industry operation, as well as its underlying research were described. Fifth, five types of 6G-IoT challenges were analyzed and discussed in detail in this chapter, namely transmission path loss at THz, wireless network coverage, transfer data rate, latency, security, privacy protection, and energy-efficient and reliable devices/services. Finally, the latest nine IoT business models are described and summarized in tabular form.

INTRODUCTION

Around 2008 and 2009, the 'Internet of Things' term began to be mentioned in academia and industry. The 'Internet of Things' was normally represented by short form of 'IoT' and originally defined as (International Telecommunication Union, 2012):

A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

Over the past decade, a great deal of studies and research related to the Internet of Things (IoT) has been conducted, as well as commercial IoT products already exist in the market. Therefore, academic

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circles, industry circles, and manufacturers now have a clearer understanding of the infrastructure form and business model of the IoT compared to the initial proposal. As a result, recently, more specific and explicit terms have been used in the definition of the IoT (Riazul Islam *et al*., 2015, IoT for all, 2021, Wikipedia, 2021):

A physical object that is embedded with sensors, processing ability, software, and other technologies, and that connects and exchanges data with other devices and systems over the Internet or other communications networks.

or

A system of interrelated computing devices, mechanical, and digital machines provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

or

A device embedded with electronics, software, sensors, actuators, and network connectivity that are capable of covering a variety of protocols, domains, and applications, which include the automotive industry, public safety, emergency services, and medical field.

In short, IoT is an infrastructure where the use involves people, devices, and services connected by wireless communication technology. For instance, the implementation of future sixth generation wireless technology (6G) in IoT assisted by artificial intelligence (AI) features is called 6G-IoT.

At present, the IoT applications have been widely implemented in the industrial field and our daily lives, covering eight main infrastructures, namely smart wearables, smart home, smart city, smart agriculture, smart vehicle, smart health care, industry automation, smart energy as shown in Figure 1. In 2018, the utilize of the IoT is expanded through the evolution of fifth generation wireless technology (5G). When 5G wireless technology is used, predictions and preliminary studies related to future 6G wireless technology have already begun, with operating frequencies above 95 GHz to 3 THz. For example, since 2018 until Jan 2023, up to thousands of studies and recommendations related to 6G communications and IoT have been documented (Huang et al., 2019, Letaief et al., 2019, Saad et al., 2019, Zhang et al., 2019a, Zhang et al., 2019b, Zong et al., 2019, Akhtar et al., 2020, Alsharif et al., 2020, Ian et al., 2020, Lee et al., 2020, Michailidis et al., 2020, Sekaran et al., 2020, Barakat et al., 2021, Chen and Okada, 2021, Dao et al., 2021, De Alwis et al., 2021, Dinh et al., 2021, Guo et al., 2021, Imoize et al., 2021, Ji et al., 2021, Jiang et al., 2021, Padhi & Charrua, 2021, Schroeder, 2021, Spyridis et al., 2021, You et al., 2021).

A comprehensive review of 6G-IoT can be found in several literatures (Kim, 2021; Chen & Okada, 2021; Barakat et al., 2021; Guo et al., 2021; Padhi & Charrua-Santos, 2021; Pattnaik et al., 2022; Dinh et al., 2022; Hosseinzadeh et al., 2022; Pajooh et al., 2022; Qadir et al., 2022). Figure 2 shows the number of publications indexed in the Web of Science (WoS) platform using the search keywords of '6G' and '6G IoT', respectively. Most of the documents are published by IEEE, Elsevier, Springer Nature, Wiley, MDPI, and other publishers. Based on WoS results using the search keyword '6G IoT', a total of 794 indexed publications are recorded from 2018 to January 2023, of which IEEE publishers contributed 526 (66%). On the other hand, Elsevier, Springer Nature, MDPI, and Wiley had 61 (7.7%), 56 (7.1%),