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Abstract

This book chapter explores the critical role of low-latency networks in enhancing the performance of Internet of Things (IoT) applications, specifically focusing on the advancements enabled by 5G technologies. The rapid evolution of IoT has introduced new challenges related to latency, bandwidth, and reliability, which are crucial for the successful implementation of real-time, mission-critical applications. The chapter examines the potential of 5G networks, with their ultra-low latency and high throughput, in addressing these challenges while supporting emerging applications such as Augmented Reality (AR), Virtual Reality (VR), and industrial automation. Special attention was given to the synergy between 5G and edge computing, which collectively reduce latency and enhance data processing capabilities at the network edge. The chapter investigates the impact of network slicing, mobile edge computing, and advanced backhaul and fronthaul solutions on optimizing latency for IoT systems. The implementation of these technologies and techniques offers unprecedented opportunities for the development of intelligent and responsive IoT ecosystems, transforming industries ranging from healthcare and transportation to manufacturing and smart cities. This chapter provides a comprehensive analysis of the technical solutions for latency reduction and the future direction of 5G-enabled IoT applications, highlighting the essential factors for achieving seamless, real-time interactions in a connected world.

Keywords:

Low-latency networks, 5G technologies, Internet of Things (IoT), Augmented Reality (AR), Virtual Reality (VR), edge computing.

Introduction

The integration of 5G networks with IoT systems marks a significant leap forward in modern technology, reshaping how data was processed, transmitted, and utilized across industries [1,2]. The rapid expansion of IoT applications, from smart cities and connected healthcare to industrial automation and intelligent transportation systems, has introduced unprecedented demands for faster and more reliable data transmission [3-5]. Central to meeting these demands was the reduction of latency, which was crucial for real-time interactions and decision-making processes

[6-9]. The 5G network, with its enhanced data rates, high bandwidth, and ultra-reliable low-latency communication (URLLC), addresses these challenges, enabling IoT ecosystems to achieve seamless, immediate responses critical for various applications [10].

A primary advantage of 5G technology in the context of IoT lies in its ability to support the low-latency requirements of real-time systems [11]. Applications such as autonomous vehicles, remote surgery, and industrial robots rely heavily on the swift exchange of data to function effectively [12]. The traditional 4G networks, while capable of supporting basic IoT functions, often fall short when it comes to ultra-low latency, which was typically below one millisecond [13,14]. This chapter explores the advancements that 5G offers, not only in reducing latency but also in creating an environment where real-time data processing was enhanced through intelligent network management and distributed computing solutions [15,16].

One of the key enablers of latency reduction in 5G was mobile edge computing (MEC), which positions computational resources closer to the data source [17]. By processing data at the edge of the network, rather than relying solely on centralized cloud servers, MEC minimizes the distance data must travel, effectively reducing latency and improving response times [18]. This shift was essential for IoT applications where milliseconds can determine the difference between success and failure [19]. For example, in AR and VR applications, even minimal latency can disrupt user experience and impact system performance [20]. The integration of edge computing with 5G creates a robust platform that supports real-time data analysis and faster decision-making [21].

The combination of 5G's low-latency capabilities and edge computing was complemented by other innovations such as network slicing and advanced backhaul solutions [22]. Network slicing allows for the creation of virtual network segments tailored to the specific needs of various IoT applications [23]. This ensures that mission-critical applications receive the necessary resources and low-latency pathways, separate from other data traffic [24]. By optimizing backhaul and fronthaul networks, latency was further reduced, allowing IoT applications to perform consistently, even under heavy network load [25]. These technologies provide the foundational infrastructure that enhances network performance, making it possible to meet the stringent demands of real-time applications.