

Critical Enabling Technologies for 5G Mobile Communication Networks: Architecture, Performance Optimization, and Deployment Strategies

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Abstract: *In the context of rapid development in modern scientific and information technology, communication network technology has undergone comprehensive upgrades, and the widespread adoption of mobile internet has effectively driven the advancement of mobile communication technology. The application of 5G mobile communication technology has led to a significant improvement in mobile communication efficiency, representing an innovation over traditional mobile communication technologies. Therefore, it is essential to understand the key technologies involved and to strengthen technological optimization and innovation. This will further propel the development of 5G mobile communication technology to meet the demands of societal progress. As a result, this paper will delve into the critical aspects of network technology in 5G mobile communication, combining practical experience to summarize some measures in the hope of assisting relevant personnel.*

Keywords: 5G technology; Mobile communication; Key network technology; Heterogeneous network; D2D technology.

1. INTRODUCTION

The innovative development of mobile communication network technology is of great significance for social construction. Mobile communication networks have penetrated into various aspects of people's lives, so it is necessary to ensure the quality of mobile communication networks. The development of 5G mobile communication technology has comprehensively improved communication speed, increased communication capacity, and has multiple advantages such as fast speed, large capacity, and good stability. In order to promote the construction of 5G mobile communication engineering, it is necessary to strengthen the research and application of key technologies, improve the level of key technologies, master core technologies, so as to promote the construction and development of communication engineering, provide people with higher quality mobile communication network services, and ensure communication security.

2. OVERVIEW OF 5G MOBILE COMMUNICATION TECHNOLOGY

5G mobile communication technology refers to the fifth generation of mobile communication technology, which is an upgrade and optimization of 4G technology. It is the next generation of mobile communication standards, which will further improve the performance of data transmission rate, connection quantity, network delay, device interconnection and security on the basis of existing mobile communication networks. It can better meet users' needs for high-speed, low latency, high-capacity and reliable communication. 5G mobile communication technology adopts a series of new technologies and standards, such as massive MIMO, small waveform adaptive modulation, dual band carrier aggregation, etc. Among them, massive MIMO technology is one of the core technologies of 5G, which can achieve the deployment of a large number of antennas, improve network capacity and data rate; Small waveform adaptive modulation technology can better adapt to the needs of different frequency bands and users, thereby improving network efficiency and stability; Dual band carrier aggregation technology can integrate signals from different frequency bands, improving network coverage and signal quality. In addition, 5G mobile communication technology also supports more types of devices, including smart home devices, vehicle networking, industrial automation, etc., to achieve intelligent interconnection and interoperability between devices; 5G technology supports more sophisticated network slicing technology, which finely allocates network resources to meet the needs of different users and businesses for the network.

3. ANALYSIS OF THE CHARACTERISTICS OF 5G MOBILE COMMUNICATION

Compared to previous generations of mobile communication technologies, 5G mobile communication has the following characteristics:

3.1 Higher network speed and capacity

5G mobile communication has higher network speed and capacity, reaching a data transmission speed of GB/s, which is tens of times faster than 4G mobile communication. Moreover, 5G mobile communication has higher capacity and can support more devices to connect simultaneously.

3.2 Lower latency

The latency time of 5G mobile communication will be lower, usually not exceeding 1ms, which means that in the 5G network environment, users can respond and process data more quickly, meeting the requirements of efficient information processing.

3.3 Greater coverage

The signal coverage of 5G mobile communication technology is wider than previous mobile communication technologies, and can be used in a wider range of areas and environments, such as urban areas, rural areas, and tunnels.

3.4 More device connections

5G mobile communication technology can support more devices to connect simultaneously, enabling more devices to be connected in the same area without compromising network quality due to an increase in the number of devices.

3.5 Safer Communication

5G mobile communication has a more secure communication method, which can ensure data security by adopting encryption technology and authentication mechanisms.

4. ANALYSIS OF KEY NETWORK TECHNOLOGIES IN 5G MOBILE COMMUNICATION

4.1 MIMO technology

MIMO technology, also known as Multiple Input Multiple Output, is one of the key technologies in 5G mobile communication networks. It can simultaneously use multiple antennas for communication transmission and reception, and significantly improve the channel capacity and performance of communication systems through spatial multiplexing technology and signal processing technology. The core concept of MIMO technology is to increase the number of antennas to multiple, using multiple antennas to receive and transmit signals at different temporal and spatial positions, thereby improving the system's throughput, reliability, and anti-interference ability. Compared to traditional single input single output (SISO) technology, MIMO technology can significantly improve the data transmission rate and spectrum utilization of the system under the same frequency bandwidth; MIMO technology mainly includes two techniques: space-time coding (STC) and spatial multiplexing (SM). STC technology mainly achieves spatial multiplexing of signals through signal encoding and decoding, which can simultaneously transmit multiple signals to the receiving end, thereby improving the transmission rate and reliability of signals; SM technology distributes multiple signals to different antennas for transmission, maximizing the system's channel capacity and signal-to-noise ratio to improve signal transmission rate and quality. MIMO technology has a wide range of applications, not only in 5G mobile communication systems, but also in wireless communication fields such as WiFi and Bluetooth. In 5G mobile communication systems, MIMO technology can further improve the signal quality and transmission rate of the system by increasing the number of antennas, using higher frequencies, optimizing coding algorithms, and other means; Through continuous optimization and innovation of MIMO technology, 5G mobile communication systems will be able to better support big data applications such as high-definition videos, virtual reality, and smart homes, bringing users a more convenient, efficient, and intelligent communication experience.

4.2 Self Organizing Network Technology

Self organizing network technology is a network organization and management method that does not require manual intervention, and can automatically complete tasks such as topology construction, link quality management, and network resource allocation in the network. In 5G mobile communication networks, self-organizing network technology can help achieve better coverage and capacity, and improve network reliability and flexibility; Self-organizing network technology can automatically adjust the topology of the network based on changes in nodes and link quality, thereby improving the flexibility and scalability of the network; Self-organizing network technology can dynamically allocate network resources, including spectrum resources, power resources, bandwidth resources, etc., to ensure the optimal utilization of network resources and maximize network performance [3].

4.3 Millimeter wave communication technology

Millimeter wave communication technology is a high-frequency wireless communication technology, with frequencies generally between 30GHz and 300GHz, of which 24.25GHz to 86GHz are considered the main frequency bands for 5G millimeter wave communication. Millimeter wave communication technology has obvious advantages over traditional mobile communication technology, such as supporting higher data transmission rates, larger spectrum bandwidth, lower latency, etc., making millimeter wave communication technology widely applicable in 5G networks. Millimeter wave communication technology has a higher frequency than traditional mobile communication technology and can support higher data transmission rates. Millimeter wave communication technology can utilize a large amount of unused spectrum resources, provide greater spectrum bandwidth, and further improve data transmission rates. In 5G networks, latency is an important factor. Millimeter wave communication technology reduces signal transmission latency by providing higher frequencies and shorter wavelengths, enabling 5G networks to complete data transmission in a shorter time and improve data transmission efficiency. The growth of data traffic requires mobile communication networks to provide higher capacity to meet user needs. Millimeter wave communication technology can provide larger spectrum bandwidth, improve network capacity, and meet future network demands.

4.4 D2D technology

D2D communication technology, also known as Device to Device Communication, is an important technology in 5G mobile communication networks. Its core concept is to enable direct communication between adjacent devices without passing through base stations, thereby enhancing network capacity and coverage. Traditional mobile communication networks mainly rely on base stations for signal transmission, but in high-density user areas, the capacity of base stations may encounter bottlenecks, which can affect the communication quality and network coverage of users. D2D communication technology, through direct device to device communication, can effectively reduce network congestion and channel interference, thereby improving network capacity and coverage. The traditional mobile communication method is mainly based on the connection of base stations, while D2D communication technology can enable direct communication between devices, making communication more flexible. For example, when users are in an environment with weak signals, D2D communication technology can enable direct communication between devices, thereby improving the communication quality of users. D2D communication technology can enable direct communication between devices, thereby reducing the number of communications between devices and base stations and improving device energy efficiency; Due to the fact that D2D communication technology involves direct communication between devices rather than relay through base stations, it can effectively prevent information from being eavesdropped or hacked, thereby enhancing network security [4]. The following table shows the basic characteristics of D2D technology.

Table 1: Basic Characteristics of D2D Technology

Number	Features	Performance
1	Direct communication	Networking, resource sharing, security
2	Self-organization	High reliability, efficiency, compatibility
3	Low latency	Energy saving, high-density, and flexible

4.5 Ultra dense network technology

Ultra dense network is a technology that significantly increases the density of user devices or base stations, which can improve network capacity and coverage. In traditional networks, the service range of each base station is

usually a cell, while in ultra dense networks, the service range of each base station usually only covers a few user devices. Therefore, ultra dense networks can divide the service range into smaller areas, thereby achieving higher spectral efficiency. The basic principle of ultra dense networks is to increase the total throughput and capacity of the system by increasing the density of base stations under the same spectrum resources and system bandwidth. This is mainly achieved by increasing the number of base stations in a small area. This method can effectively improve network throughput and reliability because users can connect to closer base stations faster, thereby reducing latency and network congestion; Ultra dense networks can also provide better network coverage, especially in urban and high-density population areas, making ultra dense network technology the core technology of 5G networks.

5. CONCLUSION

In summary, this article briefly expounds the basic connotation of 5G mobile communication technology, analyzes its characteristics, and finally proposes and summarizes several key technologies in 5G mobile communication, hoping to provide certain reference and assistance for the development of communication engineering and continuously improve the level of communication technology.

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