



## Study on 5G Wireless Technology

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### Abstract

The 5th generation of wireless technology, known as 5G, has been globally introduced to cater to the rapidly increasing demand for high-speed internet. As individuals rely heavily on the internet for various activities, 5G offers extended features such as high speed, superior reliability, massive network capacity, and negligible latency. This enables next-generation user experiences across three main types of connected services: enhanced mobile broadband, mission-critical communications, and massive IoT. Designed to meet the ever-increasing demands of the future, 5G is capable of fulfilling unknown requirements. This paper provides a brief introduction to the evolution of 5G wireless technology, its pros and cons.

**Keywords :** *6G, connected services, evolution 1G-5G, pros and cons.*

### Introduction

Wireless communication has undergone a remarkable evolution since its inception in the early 1970s. Over the next four decades, mobile wireless technology has progressed from 1G to 5G generations, and now, we are on the cusp of a new era with the emergence of 5G. The fifth generation wireless technology promises to revolutionize the way we interact with our mobile devices, offering unprecedented speeds, capacities, and features. 5G technology is expected to leverage advanced protocols such as CDMA, BDMA, and millimeter wireless to deliver speeds exceeding 1 Tbps (terabit per second) and latency as low as 1 ms (millisecond). With 5G, mobile phone users can expect even more features and efficiency, including seamless connectivity with laptops, tablets, and other devices, and unparalleled broadband internet connectivity. The features of 5G technology that have surfaced so far include ultra-high resolution for extreme mobile users, bidirectional huge bandwidth, higher data rates, and the finest quality of service (QoS)

### The Evolution of Wireless Technologies

The past few years have witnessed a significant surge in the popularity of mobile communication, driven by the rapid evolution of mobile technology. This revolution is largely attributed to the exponential growth in the number of telecom customers. The journey of mobile

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technology has traversed multiple generations, starting from 1G, the first generation, followed by 2G, 3G, and 4G, representing the second, third, and fourth generations, respectively. The latest milestone in this journey is the advent of 5G, the fifth generation of mobile technology.

### **First Generation(1G):**

The 1G wireless network emerged in the 1980s, marking the beginning of mobile communication. This analog system, popularly known as cell phones, introduced several mobile technologies, including Mobile Telephone System (MTS), Advanced Mobile Telephone System (AMTS), Improved Mobile Telephone Service (IMTS), and Push-to-Talk (PTT). The 1G network utilized analog radio signals with a frequency of 150 MHz, and voice call modulation was achieved through Frequency Division Multiple Access (FDMA). However, this first generation of wireless technology had significant limitations, including low capacity and a complete lack of security. Voice calls were transmitted openly through radio towers, making them vulnerable to eavesdropping by unauthorized parties.

### **Second Generation(2G):**

The second generation of mobile communication, introduced in the late 1990s, marked a significant shift towards digital systems. Despite being an older technology, 2G is still widely used in various parts of the world. This generation primarily facilitated voice communication, while also offering additional services such as SMS and email. Two digital modulation schemes were employed in 2G: Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA). The frequency band used in 2G ranges from 850-1900 MHz. In GSM technology, 8 channels are allocated per carrier, with a gross data rate of 22.8 kbps in full-rate channels and a frame duration of 4.6 milliseconds. The 2G family includes 2G, 2.5G, and 2.75G.

### **Third Generation(3G):**

Third-generation (3G) services integrated high-speed mobile access with Internet Protocol (IP)-based services, enabling seamless communication and data exchange. Data transmission occurs through packet switching technology, while voice calls are facilitated through circuit switching. In addition to verbal communication, 3G services provide access to data services, television, video, and news, as well as global roaming capabilities. The 3G system supports high-speed data rates of up to 2 Mbps over a 5 MHz channel bandwidth, depending on mobility velocity and spectrum efficiency. The data rates supported by 3G networks also vary depending on the environment in which the call is made, ranging from 144 kbps in satellite and rural outdoor areas to 384 kbps in urban outdoor environments.



### **Fourth Generation(4G):**

The fourth generation (4G) of mobile technology offers a significant leap in downloading speeds, reaching up to 100 Mbps. Building upon the features of 3G, 4G provides additional services such as multimedia newspapers, TV programs with enhanced clarity, and faster data transmission. Long-Term Evolution (LTE) is widely regarded as a 4G technology.

A 4G system is designed to upgrade existing communication networks, providing a comprehensive and secure IP-based solution. This solution enables users to access a range of facilities, including voice, streamed multimedia, and data, on an "anytime, anywhere" basis, with much higher data rates compared to previous generations. The development of 4G aims to accommodate the Quality of Service (QoS) and rate requirements of forthcoming applications, such as wireless broadband access, multimedia message services (MMS), video chat, mobile TV, HDTV content, and digital video broadcasting (DVB).

### **Fifth Generation(5G):**

5G mobile technology was introduced in 2019. It is the fifth generation of wireless network technology, designed to provide faster data speeds, lower latency, and greater connectivity than its predecessor, 4G.

The speed of 5G is significantly faster than 4G, with download speeds reaching up to 20 Gbps (gigabits per second) and upload speeds reaching up to 10 Gbps. The development of 5G aims to provide a faster, more reliable, and more secure network that can support a wide range of applications and services, including: Ultra-high-speed data transfer (up to 20 Gbps), Ultra-low latency (as low as 1 ms), Massive machine-type communications (supporting IoT devices), Enhanced mobile broadband (eMBB), Ultra-reliable low-latency communications (URLLC), Massive machine-type communications (mMTC)

### **What is 5G Technology?**

"5G technology represents the fifth generation of mobile technology, revolutionizing the way we use cell phones with unprecedented high bandwidth. Users have never experienced such high-value technology before. With increasing awareness of mobile technology among users, 5G technology incorporates advanced features that make it the most powerful and in-demand technology for the future."

The cutting-edge technology integrated into new cell phones is a remarkable example of 5G technology, offering unparalleled power and features. In fact, a single 5G-enabled cell phone has more processing power than 1000 lunar modules. Additionally, users can connect their 5G phone

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to their laptop to access high-speed broadband internet. The features of 5G technology are vast, including high-resolution cameras, MP3 recording, video playback, large phone memory, blazing-fast data speeds, audio players, and many more innovative features that were previously unimaginable.

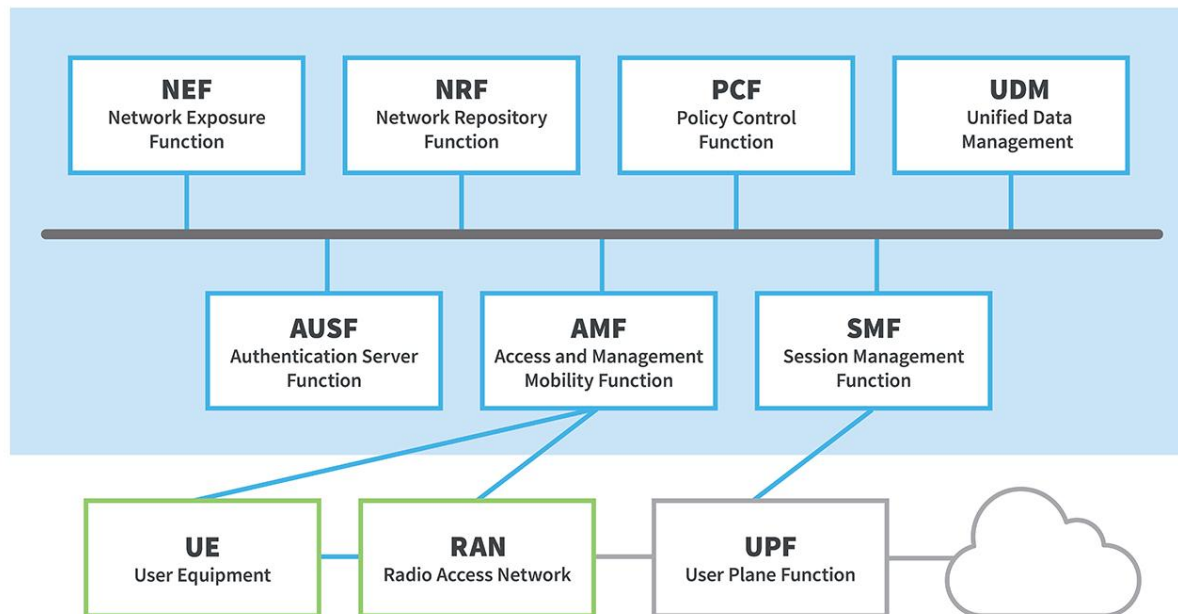
### **5G core Architecture**

The 5G core network is a fundamental component of the 5G system, enabling advanced features and functionalities. It is one of the three primary components of the 5G system, also referred to as 5GS. The other two components are the 5G Access Network (5G-AN) and User Equipment (UE).

The 5G core network utilizes a cloud-aligned, service-based architecture to support authentication, security management, and traffic aggregation from connected devices. This architecture requires the complex integration of network functions. To achieve this, 5G was designed from the ground up, with network functions split into services. This is why it's also known as the 5G cloud-native, service-based architecture (SBA).

#### **The components of the 5G core architecture include:**

- User plane Function (UPF)
- Data network (DN), e.g. operator services, Internet access or 3rd party services
- Core Access and Mobility Management Function (AMF)
- Authentication Server Function (AUSF)
- Session Management Function (SMF)
- Network Slice Selection Function (NSSF)
- Network Exposure Function (NEF)
- NF Repository Function (NRF)
- Policy Control function (PCF)
- Unified Data Management (UDM)
- Application Function (AF)



### How its works:

- User Equipment (UE), such as 5G smartphones or cellular devices, connects through the 5G New Radio Access Network (NR) to the 5G core network and then further to external data networks like the Internet.
- The Access and Mobility Management Function (AMF) serves as the main entry point for UE connections.
- Depending on the type of service requested by the UE, the AMF selects the appropriate Session Management Function (SMF) to handle the user's session.
- The User Plane Function (UPF) is responsible for transmitting the IP data traffic (user plane) between the User Equipment (UE) and external networks.
- The Authentication Server Function (AUSF) enables the AMF to authenticate the UE and grant access to the services provided by the 5G core network.
- Other essential functions, such as the Session Management Function (SMF), Policy Control Function (PCF), Application Function (AF), and Unified Data Management (UDM), work together to manage network policies, enforce policy decisions, and access subscription data to control network behavior.

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## Key Enabling Technologies used in 5G

### Major technologies enabling 5G include:

- **D2D Communication:** D2D communication, devices can communicate with each other directly, using wireless communication protocols such as Wi-Fi, Bluetooth, or cellular networks. This allows for faster and more reliable communication, as well as improved spectral efficiency.
- **MIMO (Multiple-Input Multiple-Output) :** It is a wireless communication technology that uses multiple antennas at both the transmitter and receiver to improve the performance of wireless communication systems.
- **Machine-to-Machine (M2M):** M2M technology communication refers to the direct communication between devices, machines, or sensors without human intervention. M2M communication enables devices to exchange data, instructions, and commands with each other, allowing for automated decision-making, remote monitoring, and control.
- **Millimeter Wave (mmWave) Spectrum:** 5G operates on mmWave spectrum, which offers high-frequency bands and wider bandwidth, enabling faster data transfer rates.
- **Software-Defined Networking (SDN):** SDN technology enables the creation of virtual networks, allowing for greater flexibility and programmability.

### Why 5G?

As a user, I expect the main difference between current generation and expected 5G techniques to go beyond just increasing maximum throughput. Some key requirements include:

1. Enhanced revenue streams for global operators and improved interoperability.
2. Utilization of millimeter wave frequencies for wireless access and backhaul, which would be highly beneficial.
3. A common platform for all radio access technologies to make 5G practical and accessible.
4. Better coverage and high data rates available at the cell edge, ensuring seamless connectivity.
5. Support for multiple concurrent data transfer paths, enabling efficient data transmission.
6. Reduced battery consumption and outage portability, ensuring a reliable and efficient user

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experience.

7. Traffic fees will be more affordable due to lower infrastructure deployment costs.
8. The technology should be designed to be safe for human health.
9. Achieving data rates of 1 Gbps and higher while on the move will be possible.
10. Enhanced security features will be built into the network.
11. The integration of artificial intelligence with mobile devices will enable a wide range of innovative applications, as our daily lives become increasingly surrounded by artificial sensors that can communicate with our mobile phones.

### **Advantages of 5G:**

The 5th generation network aims to provide numerous utilities to customers at high speeds. The applications developed will utilize high-level security and be highly customer-friendly. For instance, integrating speech recognition technology into the user interface will make it easier for each user to use the application.

### **Some key features of the 5th generation network include:**

1. Fire station networks will offer common services, independent of capabilities, also known as service personalization.
2. Pattern network coverage
3. High security
4. More reliability
5. Ability to control PCs using handsets
6. Higher bandwidth
7. Expected to provide wireless download speeds of over 1 Gbps in local area networks and 500 Mbps in wide area networks, approximately 40 times faster than 4G wireless network.
8. Reduced battery consumption and outage portability.
9. More efficient and effective.

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### Disadvantages of 5G:

The 5th generation (5G) of mobile technology is revolutionizing communication networks by delivering unprecedented speed, coverage, and reliability. This innovative network is making the Internet of Things (IoT) a reality by enabling it to handle a significantly large number of devices.

### There are some challenges associated with 5G:

- 1. Asymmetric Speeds :** Upload speeds often don't match download speeds, which can impact applications that require high upload speeds.
- 2. Battery Drain :** The increased processing power and data transmission rates of 5G devices can lead to faster battery drain.
- 3. Rural Access Limitations :** 5G networks may not be readily available in rural areas, which can exacerbate the digital divide.
- 4. High Initial Costs :** The rollout of 5G networks requires significant investment in infrastructure, which can be a barrier to adoption.
- 5. Connectivity Obstructions :** Physical obstructions, such as buildings and trees, can impact 5G connectivity and signal strength.

### Where 5G is being used ?

- 1. Manufacturing :** 5G is being used for manufacturing automation, remote robotic control, and predictive maintenance. For instance, automated guided vehicles (AGVs) are being used on 5G networks to improve efficiency and reduce costs <sup>1</sup>.
- 2. Healthcare :** 5G is being used for telemedicine, remote health monitoring, and personalized medicine. For example, wearable devices like smartwatches and fitness trackers are being connected to 5G networks to monitor patients' health remotely <sup>1</sup>.
- 3. Automotive :** 5G is being used for autonomous vehicles, vehicle-to-everything (V2X) communication, and smart traffic management. For instance, 5G enables Cellular Vehicle-To-Everything (C-V2X) technology, which allows autonomous vehicles to connect to the 5G network and transmit data <sup>1</sup>.
- 4. Energy and Utilities :** 5G is being used for smart grid management, remote monitoring, and predictive maintenance. For example, 5G networks can provide real-time monitoring and control

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of electricity flows, depending on generation and consumption levels <sup>1</sup>.

**5. Public Safety :** 5G is being used for emergency response, surveillance, and smart city management. For instance, 5G networks can provide real-time video streaming and communication for emergency responders <sup>1</sup>.

**6. Media and Entertainment :** 5G is being used for cloud gaming, augmented reality (AR), and virtual reality (VR) experiences. For example, 5G enables cloud gaming services like GeForce Now and Google Stadia to provide low-latency and high-quality gaming experiences <sup>1</sup>.

**7. Agriculture :** 5G is being used for precision farming, livestock monitoring, and smart irrigation systems. For instance, 5G networks can provide real-time monitoring and control of farm equipment and livestock <sup>1</sup>.

**8. Retail :** 5G is being used for smart stores, inventory management, and personalized marketing. For example, 5G networks can provide real-time inventory tracking and personalized marketing messages to customers <sup>1</sup>.

**9. Financial Services :** 5G is being used for mobile payments, digital wallets, and secure transactions. For instance, 5G networks can provide secure and low-latency transactions for mobile payments and digital wallets <sup>1</sup>.

**10. Public Transport :** 5G is being used for smart traffic management, real-time passenger information, and autonomous vehicles. For example, 5G networks can provide real-time information to passengers and enable autonomous vehicles to communicate with infrastructure <sup>1</sup>.

## Conclusion

5G technology represents a significant leap forward in wireless communication, offering unparalleled speeds, lower latency, and greater connectivity. With its ability to support a vast number of devices, 5G is poised to revolutionize various industries, including healthcare, finance, transportation, and education.

**The benefits of 5G technology are numerous, including:**

- Faster data speeds and lower latency
- Increased capacity and connectivity
- Improved reliability and security
- Enhanced mobile broadband experiences

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- New business opportunities and revenue streams

**The deployment of 5G technology also presents challenges, such as:**

- High infrastructure costs
- Limited coverage and availability
- Security concerns and potential vulnerabilities
- Need for standardized regulations and policies

"Work is already underway on 6G in several countries like Japan, China, America, Finland some other countries also working, which will bring numerous benefits to us. The development of 6G is expected to revolutionize the way we live, work, and communicate, and will likely have a significant impact on various industries and aspects of our lives.

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