

## 5G Network in Telecommunications

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### ABSTRACT

In today's fast-paced digital world, mobile communication has become an integral part of our daily lives. 5G represents a significant leap forward in the evolution of mobile communications, unlocking new possibilities for connectivity, productivity, and technological innovation worldwide. It is the latest innovation in wireless technology that promises to deliver faster speeds, lower latency, and greater reliability than its predecessors. Central to its appeal is its capacity to handle vast volumes of data generated by increasingly complex devices connected to its networks. It is a game-changer across various industries including telecommunications. Although this upgrade will be expensive, it is essential to beat the competition. This paper explores the applications of 5G networks in telecommunications.

**KEYWORDS:** 5G network, telecommunications industry, 6G, 7G

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### INTRODUCTION

The introduction of 5G technology is set to revolutionize the way we communicate, work, and live. 5G stands for the fifth generation of cellular networking, surpassing 4G LTE. 5G technology is developing rapidly to enable the next generation of wireless communications and pave the way for more than just super-fast data transfer. The 5G wireless technology will usher in an era of gigabit speeds for everyone, reducing latency for customers and organizations. The advent of 5G technology will not only transform our devices but will also significantly change the way businesses operate, communicate, connect, and share data. 5G is expected to be a game-changer in the business world [1]. Figure 1 shows the symbol of 5G [2].

5G is the newest generation in wireless networking, with greater capacity and higher speed. It will integrate with infrastructure, buildings, and appliances, creating an Internet of things (IoT). It supports interactive multimedia, voice, video, Internet, and other broadband services. To support increased throughput requirements of 5G, a new

spectrum has been assigned to 5G in mmWave bands. 5G will use multiple inputs multiple outputs (MIMO) to significantly increase network capacity [3,4].

The telecom industry continues to be a beacon of digital transformation, integrating innovative technologies to enhance connectivity and communication. The telecom infrastructure is known for its complexity, as typically shown in Figure 2 [5]. 5G connectivity promises to break traditional data delivery paradigms by providing network connectivity almost everywhere. The capabilities of 5G have opened opportunities for the telco industry to serve customers closer to the edge of the network with more solutions. Americans all over the nation are using 5G to create the future and enhance America's economic competitiveness. 5G is connecting students to learning opportunities, making farms more sustainable, fighting wildfires, making manufacturing smart, and driverless cars a reality.

### OVERVIEW OF 5G NETWORK

5G is the fifth-generation wireless cellular technology that will provide faster and more reliable

communication with low latency. Compared to its predecessor, it is estimated that the 5G mobile network allows 1,000 times more data transmission compared to 4G.

Like its predecessors—3G, 4G, and 4G—5G utilizes radio waves to transmit data.

Evolution from 1G to 5G is depicted in Figure 3 [6], while the relationship between 3G, 4G, and 5G is portrayed in Figure 4 [7]. Like any other cellular network, 5G networks send data through radio waves and operate on a cellular infrastructure, where geographic regions are partitioned into cells, each supported by an antenna and a base station. Each cell is connected to a network backbone through a wired or wireless connection. 5G may transmit data over the unlicensed frequencies currently used for Wi-Fi. It promises a smarter, faster, and more efficient network. The goal of 5G is to have far higher speeds available, at higher capacity per sector, and at far lower latency than 4G. To increase network efficiency, the cell is subdivided into micro and pico cells [8]. 5G will be a new mobile revolution as it is expected to provide gigabit-per-second data rates anytime, anywhere. 5G uses towers, as typically shown in Figure 5 [9]. 5G towers are telecommunications sites capable of transmitting 5G signals for wide-area coverage. 5G cell towers use a combination of low, mid, and high-frequency bands for various connectivity use cases. Towers themselves are not 5G; it is the equipment on the tower that makes it 5G. Figure 6 shows how 5G works [10].

In a 5G wireless network, every mobile phone will have an IPv6 address depending on the location and network being used. 5G utilizes the user-centric network concept World Wide Wireless Web (WWW) instead of operator-centric as in 3G or service-centric as in 4G [11]. WWW will be capable of supporting applications and services and interconnecting the whole world. 5G includes the latest technologies, such as cognitive radio, the Internet of things, nanotechnology, and cloud computing.

The key features of 5G include high throughput, improved spectrum efficiency, reduced latency, better mobility support, and high connection density. 5G technology has the following advanced features [12]:

- Architecture will be device-centric, distributed, programmable, and cloud-based
- High data rates
- One to 10 Gbps connections to endpoints
- One millisecond end-to-end round trip delay
- Low battery consumption

- Better connectivity irrespective of location
- Larger number of supporting devices
- Lower cost of infrastructure development

Some of these features are illustrated in Figure 7 [13]. The development of 5G will not be from scratch but will gradually build on 4G LTE. Major technologies enabling 5G include:

- *D2D Communication:* Direct connectivity is achieved through device-to-device (D2D) technology. 5G cellular network will implement D2D mm wave communication technology to provide high-speed data rate, improve coverage, and offer peer-to-peer services. Much research has been invested in characterizing D2D connections as part of LTE [14].
- *M2M Communication:* While D3D communication targets mobile radios, machine-to-machine (M2M) expands the scope and facilitates ubiquitous connectivity among mobile devices. It is estimated that there will be over 100 billion connected devices using M2M communications in the 5G backbone [15].
- *MIMO:* Multiple-input-multiple-output (MIMO) technology plays a crucial role in 4G and is expected to play an important function in 5G. Massive MIMO extracts the benefits of MIMO on a large scale by increasing the throughput and spectrum efficiency.

Other enabling technologies of 5G include mmWave communication, ultra-dense network (UDN), all-spectrum access (ASA), OFDM (orthogonal frequency division multiplexing), and the Internet of things. Industries that use 5G technology are shown in Figure 8 [6].

This section would be incomplete without mentioning the successors of 5G [16]:

- *6G Network:* Fifth-generation cellular technology is replaced by sixth-generation wireless or 6G. The bandwidth and latency of 6G networks will be significantly higher than those of 5G networks due to their ability to operate at higher frequencies. The main purpose of 6G internet is to provide communications with one-microsecond latency. 6G will employ satellites to connect the current 5G networks.
- *7G Network:* Globally, the 7G Network provides a faster means of communication. The advanced cellular technology that will be the successor for 5G and 6G. A 7G network is the quickest way to make a call, whether it is local or international. Voice over Internet Protocol (VoIP), or 7G, requires access to all local and international

telecommunications. 7G will be able to satisfy the requirements of extremely high bandwidth, almost zero latency, and universal integration. Although 7G will not be generally available until 2030, a handful of countries are currently using it. These include Norway, Netherlands, South Korea, and Hungary. They are the nations in the world to provide the fastest Internet speeds.

### 5G NETWORK IN TELECOMMUNICATIONS

5G technology is one of the main forces behind the ongoing change and evolution of the telecom sector. It is positioned to become the standard for mobile communications technology, ushering in a new era of connectivity, speed, and possibility. 5G is poised to connect businesses, people, and processes at enormous scale. It will enable new and creative use cases that are not feasible with today's wireless networks.

5G signifies a significant advancement for the telecom sector. It provides greater reliability, reduced latency, and faster speeds, all of which are necessary for the upcoming creation of new services and apps. The telecom sector needs to engage in 5G if it wants to remain competitive. Figure 9 shows a telecom field engineer [17].

### APPLICATION OF 5G NETWORK IN TELECOMMUNICATIONS

5G is the fifth generation technology standard for broadband in the telecommunications industry and the successor to the 4G networks. 5G networks support applications requiring low latency, like industrial automation, augmented reality, and autonomous vehicles, with unprecedented efficiency and responsiveness. 5G in telecommunications can be applied in the following ways [18]:

- *Smart Roads:* Telecommunications companies can collaborate with municipalities to implement the smart roads project. This is a technological plan that enhances road safety by using special sensors placed on crosswalks to inform passing cars that a pedestrian is approaching. This is made possible due to 5G technology. By reducing latency times to a minimum, information can be immediately exchanged between multiple devices simultaneously.
- *Smart Cars:* The advent of 5G technology has revolutionized the field of autonomous vehicles, encompassing everything from self-driving cars to drones. With the unparalleled connection speeds of 5G, transport systems for various modes of transportation, including cars and trains, have experienced a substantial acceleration in performance. For the automotive industry to

implement smart cars, it needs to collaborate with telecommunications companies. Autonomous driving vehicles need to rely on the 5G network since it is the most efficient technology for transferring large amounts of data quickly, constantly, and in a stable way. These vehicles will be able to communicate with each other to avoid accidents and ease traffic, thanks to the quick and reliable data 5G can send.

- *Smart Cities:* City life will become more efficient as 5G helps manage traffic flows, public transport, and energy use, making cities cleaner and less congested.
- *Home Automation:* 5G in the telecommunications sector is key to expanding home automation. This includes the installation and usage of smart home devices such as refrigerators, blinds, doors, light bulbs, heaters, ovens, and other home appliances that can communicate with each other and mobile devices for control and monitoring. Many countries in Europe have implemented a home automation tax benefit that is available, which provides tax deductions for smart home devices.

### BENEFITS

5G will usher in a transformative era, particularly unlocking new possibilities in urban settings where over two-thirds of the global population is estimated to reside by 2050. There are many ways that telecommunications companies can reap the benefits from 5G's low latency and higher transmission speeds. As the benefits of 5G have become more accessible, businesses are planning to use 5G in their operations, particularly in rural and field connectivity. Other benefits include the following [2,19]:

- *Increased Speed:* One of the most exciting benefits of 5G is its faster upload and download speeds. We can expect to see 5G reach up to 10 Gbps, up to 100 times faster than 4G. The increased speed of 5G mobile networks introduces exciting possibilities for both consumers and businesses alike. This will enable activities like streaming video, downloading audio, browsing the web, and using social media.
- *Enhanced Capacity:* One of the significant benefits of 5G is its ability to support a massive number of connected devices simultaneously. This capability is crucial for the growth of the Internet of things (IoT) and the deployment of smart devices. With the ability to provide up to 1,000 times more capacity than 4G, 5G will take IoT development to the next level and pave the way for smart cities and homes. 5G's increased capacity has huge potential for industry.



- *Lower Latency:* A standout feature of 5G is its substantially reduced latency, which measures the time required for data to travel from its original to its target location. Each generation of cellular communications technology has strived to reduce latency, and 5G is no different. 5G is expected to transmit data in less than five milliseconds — virtually no time at all. This dramatic latency reduction enhances real-time responsiveness, facilitating tasks such as file downloads and cloud-based operations with remarkable speed and efficiency. 5G's lower latency will also enable users to control devices remotely in real-time. Reduced latency will transform how we create, store, use, and share data in the business sector. 5G's lower latency will also enable users to control devices remotely in real-time, offering enormous benefits for businesses with multiple or remote locations.
- *Increased Bandwidth:* By increasing speeds and network capacity, 5G will also open up the doors to greater bandwidth than with 4G. This enables them to optimize network traffic better. For businesses, 5G's increased bandwidth will help them gain access to big data.
- *Improved Coverage:* One of the subtler benefits of 5G is its frequency, which can provide speeds much faster than 4G and even pass through buildings to provide greater coverage indoors and outdoors. Although many telecommunications providers are rapidly expanding coverage across the country, 5G is not yet available everywhere. By combining the latest 5G technology with satellite Internet, you can rest easy knowing your systems will stay online 24/7, even when cellular connections are not possible.
- *Enhanced Communication:* For businesses that already use IoT, AI, and machine learning, the introduction of 5G will be a massive boost to their efficiency. Cloud computing is a critical part of any modern business's IT infrastructure, allowing for the simple storage and transfer of large amounts of data between devices. With the addition of 5G, the cloud will become even more integral to how businesses rely on their networks.
- *Improved Connectivity:* 5G is the new standard in mobile wireless networking that brings improved Internet connectivity in a digital-first world. 5G technology will allow for more devices to connect to the Internet simultaneously, with improved network coverage and capacity. This will enable the Internet of things (IoT) to become more widespread, with a greater number of connected devices and sensors. There is no need for cables or fiber optic lines when using 5G to provide high-speed Internet connectivity to homes and businesses. 5G network seamlessly connects everyone and everything worldwide.
- *Increased Revenue:* The increased speed, connectivity, and capacity of 5G networks will create new revenue opportunities for telecom operators, such as offering premium services to businesses or charging for access to high-speed networks.
- *Customer Satisfaction:* With market saturation and a high average churn rate, telcos have been under increased pressure over the past decade to reinvent themselves as digital service providers. Customers are looking for a unified digital experience from a single trusted provider who can offer services and products in a one-stop shop. This is opening an opportunity for providers to complement core services with digital services. For example, a T-Mobile customer can get mobile service, along with subscriptions to streaming services for shows and music, on one bill.
- *Enabler for Emerging Technologies:* The demand for faster speeds to support emerging technologies such as artificial intelligence (AI), the Internet of things (IoT), and machine learning (ML) has escalated beyond the capabilities of 4G network. Those technologies will be fully developed through the realization of 5G. This is because these technologies require much higher processing powers for the constant streaming of massive volumes of data. 5G is expected to enable new applications such as augmented reality, virtual reality, and smart cities, and transform industries such as healthcare, transportation, and manufacturing.
- *Investing In the Future:* With 5G, telcos can take advantage of three distinct markets faster — cybersecurity, cloud services, and the Internet of things (IoT). Telcos aiming to thrive in these markets have used a two-pronged approach of freeing up cash, then re-investing those funds into low-latency infrastructure (fiber optic network and 5G) and cloud services companies.

## CHALLENGES

The implementation of 5G is not without its challenges, including the need for significant investment in infrastructure, cost to consumers, spectrum availability, security concerns, interoperability, infrastructure investment, spectrum availability, network security, and regulatory considerations. Besides, the challenges that hinder 5G infrastructure development include intense

competition for higher spectrum bands, the need for numerous antennas and base stations due to interference issues, the high costs of upgrading infrastructure, navigating complex government regulations for cybersecurity and spectrum availability, and ensuring ultra-secure cloud-based and data virtualization services to defend against cybersecurity threats associated with increased connectivity [20]. Other challenges include the following [21]:

- **Security:** 5G network is managed by software, which is easily susceptible to vulnerabilities. And this creates a path that is accessible by hackers to breach privacy, systems, data and much more. Due to the growing number of connected devices and the use of new technologies, 5G networks are susceptible to security risks like cyberattacks and hacking. New security protocols and steps are needed to ensure the security of 5G networks.
- **Regulatory Compliance:** Telecommunications firms may find it difficult and time-consuming to comply with the stringent regulatory compliance standards that apply to the rollout of 5G. This covers observing data privacy laws, network security requirements, and other rules pertaining to the installation and use of 5G networks.
- **Cost:** Consumers may pay more for 5G technology than for earlier wireless technology generations. This may limit the use of 5G in some markets and make it impossible for some users to finance the new technology.
- **Confusion:** Although the “race to 5G” has been widely publicized, the fundamental issues and realities underpinning the transition to 5G technology are still widely misunderstood. Many people find the transitions by the broadband cellular networks from 3G to 4G and now to 5G confusing and do not understand the reasons behind these changes. This issue of EUC will address some of this confusion and discuss a number of ways that new generations cellular broadband networks and devices are important to virtually every industrial and commercial business.
- **Deployment:** Deploying 5G infrastructure is challenging because high-frequency waves, which can carry lots of data, are easily blocked by buildings, trees, and weather. To overcome this, a dense network of small antennas needs to be installed on streetlights, buildings, and other structures, rather than relying on traditional cell towers. In the hardware segment, radio access network (RAN) dominated the 5G infrastructure market with a share of 50%. The trend of

deploying virtual and centralized RAN is rapidly increasing among network service providers to reduce the overall infrastructure costs and network complexities.

- **Decline:** The telecoms industry is arguing that a “perpetual decline in terms of profitability” and this is affecting the sector’s ability to deliver high-speed connectivity - an issue that big tech can help ameliorate by contributing to the costs of network infrastructure. Recent figures illustrate how the industry has been displaying symptoms of a longer-term decline.

## CONCLUSION

5G represents a monumental leap forward in wireless technology, offering unparalleled capabilities to meet the escalating demands of the digital era. It is positioned to become the standard for mobile communications technology, ushering in a new era of connectivity, speed, and bandwidth. Businesses and consumers may finally have it all: high capacity, ultra-reliability, low latency, reduced energy usage, and massive connectivity.

Many nations are launching 5G networks, making services increasingly available to consumers. The integration of 5G with other emerging technologies such as artificial intelligence, machine learning, and the Internet of things (IoT) will unlock new opportunities for innovation and disruption. We can expect to see greater advances in areas such as virtual and augmented reality, smart cities, and autonomous vehicles.

The future of 5G in the telecommunications industry is highly promising and holds immense potential to revolutionize multiple industries including healthcare, transportation, manufacturing, entertainment, and telecommunications. More information on the implementation of 5G networks in the telecommunications industry is available from the books in [22-25].

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Figure 1 The symbol of 5G [2].



Figure 2 The telecom infrastructure is known for its complexity [5].

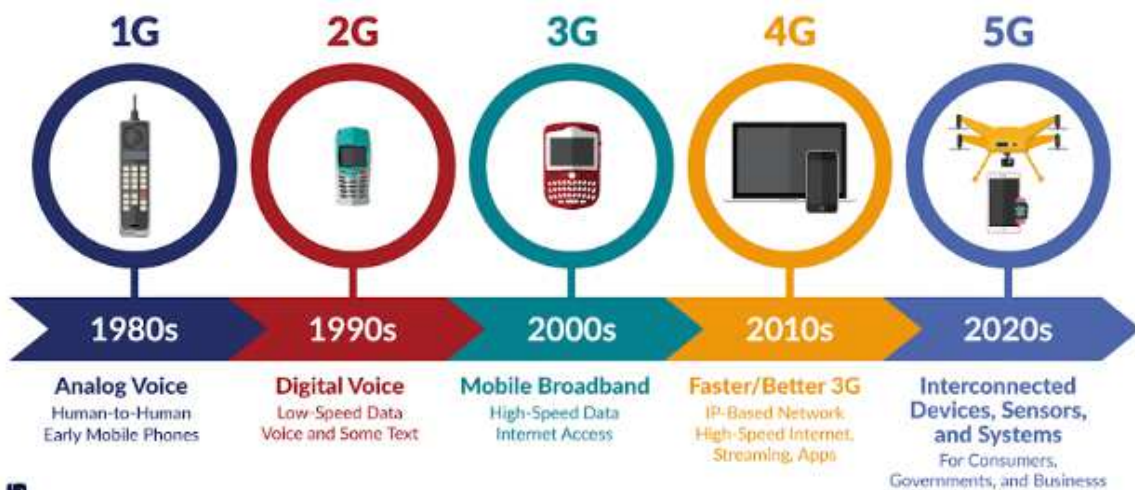


Figure 3 Evolution from 1G to 5G [6].

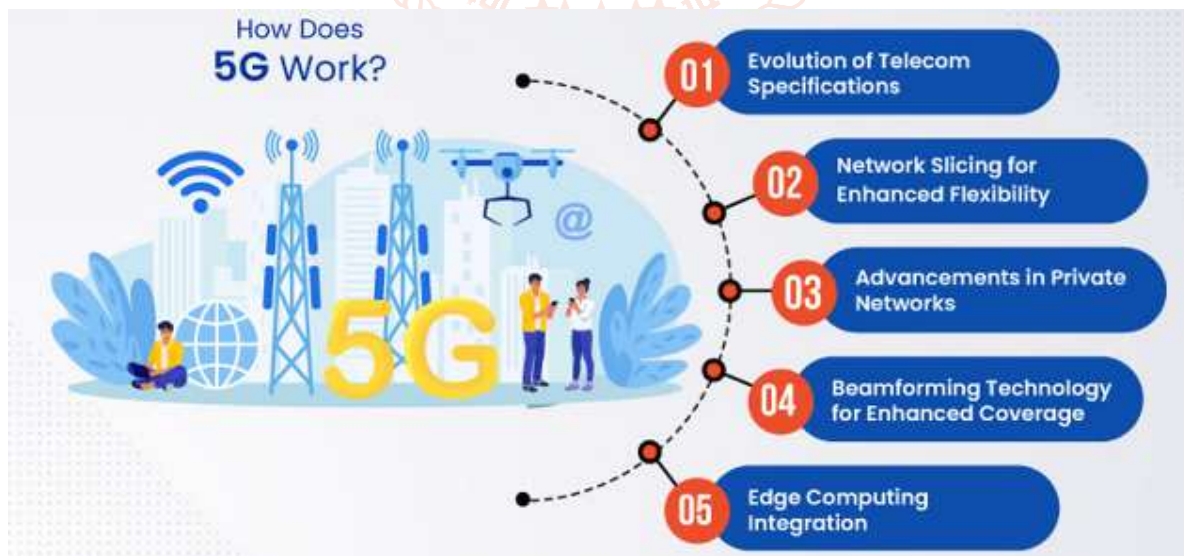




**Figure 4 Relationship between 3G, 4G, and 5G [7].**

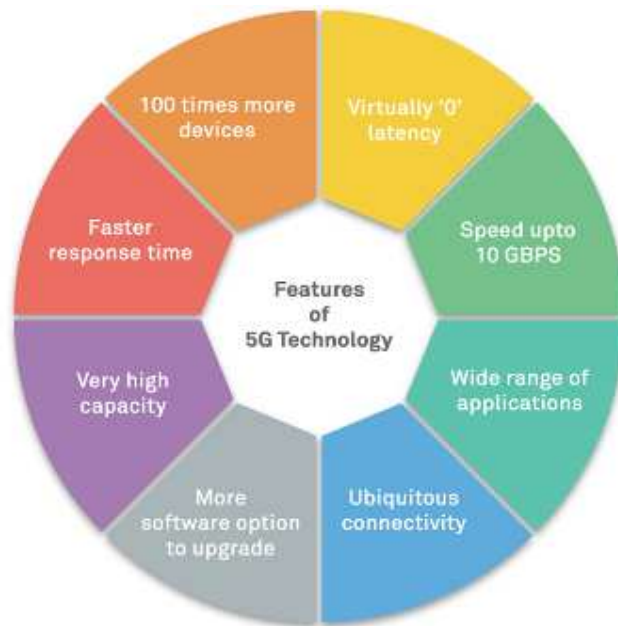


**Figure 5 A typical 5G towers [9].**

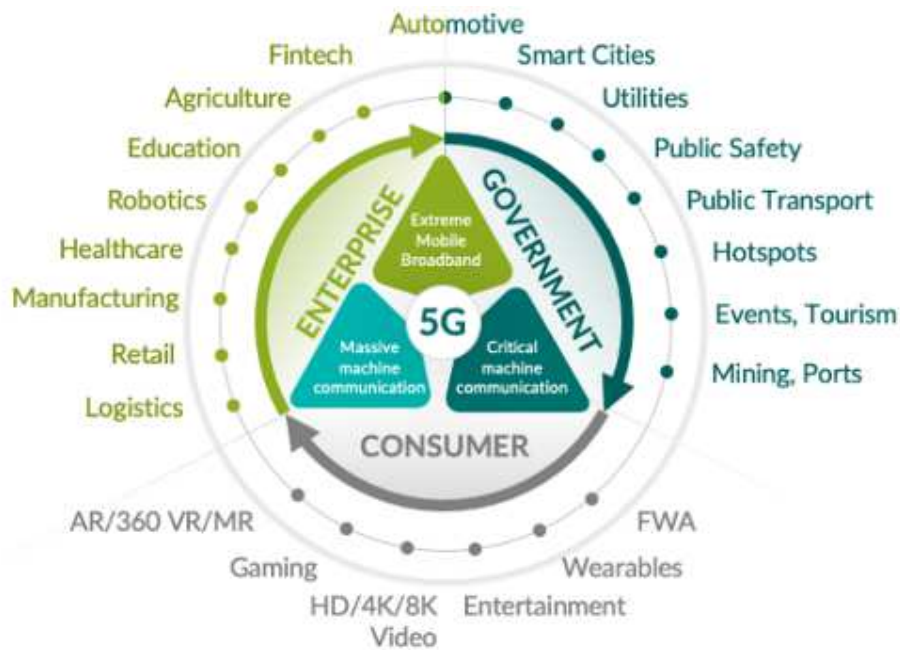


**Figure 6 How 5G works [10].**





**Figure 7** Some of the features of 5G [13].



**Figure 8** Industries that use 5G technology [6].



**Figure 9** A telecom field engineer [17].