NavaJyoti, International Journal of Multi-Disciplinary Research
Volume 7, Issue 1, August 2022

5G Wireless Network Technology: The Evolution From 4G To 5G and Technological Developments Towards the Successor of 5G - Comparison

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ABSTRACT

The mobile industry is developing and preparing to deploy the fifth-generation (5G) networks. 5G's lightning-fast connection and low-latency are needed for the growth of IOT and other intelligent automation applications like driverless cars, digital reality, blockchain, and future breakthroughs. The purpose of this paper is to do a review evolution from 4G to 5G, the importance of 5G revolutionary networks and technological developments towards the successor of 5G and explore how 5G can change this world. Examines its trends and challenges, explores its applications in different manufacturing industries, and highlights its role in shaping the age of unlimited connectivity, intelligent automation, and industry digitization. The convergence of 5G, multi-access edge computing, and the cloud make it possible for operators, managed service providers, and enterprises to create private wireless networks that are ultra-fast, secure, and scalable and that can take advantage of powerful cloud applications for analytics.

Keywords : The power of 5G, Evolution from 4G, 5G Network, 6G, Wireless Technology

1. INTRODUCTION

In 1983, the US approved the first 1G operations and the Motorola's Dyna TAC became one of the first 'mobile' phones to see widespread use stateside. Other countries such as Canada and the UK rolled out their own 1G network a few years later. 3G gave us high-speed data transfer capability for downloading information from the Internet. 4G provided a significant improvement in data capability and speed and made online platforms and high-speed mobile internet services available for the masses. 5G technology will be the most powerful cellular wireless networks with extraordinary data capabilities, unrestricted call volumes, and infinite data broadcast. The second-generation (2G) wireless networks were launched in the early 1990 s and were based on digital standards instead of analog. 2G digital networks enabled rapid phone-to-network signaling and helped the advent of prepaid mobile phones. Additionally, 2G made SMS text messaging possible initially on GSM networks and eventually on all digital networks. Other advantages of 2G digital networks include reduced battery power consumption, voice clarity, and reduced noise in the line. For the first time, people could send text messages (SMS), picture messages, and multimedia messages on their phones. The analog past of 1G gave way to the digital future presented by 2G. This led to mass-adoption by consumers and businesses alike on a scale never before seen.

Although 2G's transfer speeds were initially only around 9.6 kbit/s, operators rushed to invest in new infrastructure such as mobile cell towers. By the end of the era, speeds of 40 kbit/s were achievable and EDGE connections offered speeds of up to 500 kbit/s. Despite relatively sluggish speeds, 2G revolutionized the business seen. The third-generation (3G) wireless networks were introduced in 1998 to provide high-speed data transfer capability for downloading information from the Internet and for sending videos with the speed of 2 Mbps (1Mbit = 1000 kbit). 3G technology uses a network of phone towers to pass signals, ensuring a stable connection over long distances. 3G systems provided a significant improvement in capability over the 2G networks by using packet switching rather than circuit switching for data transmission. The high connection speeds of 3G technology-enabled media streaming of radio and even television content to 3G handsets. 3G + allows networks based on Universal Mobile Telecommunications System (UMTS) to have higher data transfer speeds and capacity

2. EVOLUTION FROM 4G TO 5G

Introduced for commercial use in Norway near the end of 2009, 4G offered today's standard services. when 4G first came out, what you were seeing was 3.9G or 3.95G instead. Today, that's not an issue, though. Starting at a minimum of 12.5 Mbps, 4G provided high- quality video streaming/chat, fast mobile web access, HD videos, and online gaming. Compared to a simple SIM card switch from 2G to 3G, mobile devices needed to be specifically designed to support 4G. However, when 4G first started, it wasn't actually 4G. When the ITU-R set the required minimum speeds for 4G (12.5 Mbps), it wasn't attainable at the time. In response to the amount of money that tech manufacturers were putting into achieving this goal, the ITU-R decided that LTE (Long-term evolution) could be labelled as 4G. But only if it provided a significant improvement over 3G. 4G systems eliminated circuit switching, and instead employed an all-IP network designed primarily for data. 4G enabled users to browse the web and stream HD videos on mobile devices. The 4G network allows users to download gigabytes of data in minutes or even seconds. The Evolution of mobile communications from 1G to 5G Technology shown in figure1.

Figure 1. *Evolution of 1G to 5G Technology*

3. 5G DESIGN INNOVATION ACROSS DIVERSE SERVICES

During the past few years, mobile communication has progressed through various generations from 1G to 4G systems. Several novel techniques, standards and applications have evolved during this progression. Based on this trend, it has been hypothesized in literature that a new generation of mobile phone will emerge in 2020. This new generation is named as 5G mobile communication system. The 5G system can be characterized by a set of enabling technologies, high capability phones and advanced applications supported by the generation. The benefits of 5G technology are High Speed, large broadcasting of data in Gbps, Multi – Media Newspapers, watch T.V programs with the clarity as to that of an HD Quality, Faster data transmission, Large Phone Memory, Dialing Speed, clarity in Audio/Video, Support interactive multimedia, voice and streaming video.

3.1 5G Design and Planning Considerations

The design considerations for a 5G network architecture that supports highly demanding applications is complex. For example, there is no one-size-fits all approach; the range of applications requires data to travel distances, large data volumes, or some combination. So 5G architecture must support low, mid and high-band spectrum – from licensed, shared and private sources – to deliver the full 5G vision. For this reason, 5G is architected to run on radio frequencies ranging from sub 1 GHz to extremely high frequencies, called “millimeter wave” (or mmWave). The lower the frequency, the farther the signal can travel. The higher the frequency, the more data it can carry.5G high-band (mmWave) delivers the highest frequencies of 5G. These range from 24 GHz to approximately 100 GHz. Because high frequencies cannot easily move through obstacles, high-band 5G is short range by nature. Moreover, mmWave coverage is limited and requires more cellular infrastructure. 5G architecture is shown in figure 2. 5G mid-band operates in the 2-6 GHz range and provides a capacity layer for urban and suburban areas. This frequency band has peak rates in the hundreds of Mbps.5G low-band operates below 2 GHz and provides a broad coverage. This band uses spectrum that is available and in use today for 4G LTE, essentially providing an LTE 5g architecture for 5G devices that are ready now. Performance of low-band 5G is therefore similar to 4G LTE, and supports use for 5G devices on the market today.

Figure 2. *5G Network Architecture*

Figure 3. *5G Speed*

Table 1. *The Difference Between 4G and 5G*

SPECIFICATION	4G	5G
Data bandwidth	2mbps to 1 mbps	1 Gaps and higher as per need
TTI(Transmission Time Internal)	1ms	Varying(100min) to 4ms
Frequency Band	2 to 8GH2	3 to 300 GH2
Technologies	Unified, seamless integration of broadband LAN/WAN/PAN/WLAN	Unified, seamless integration of broadband LAN/WAN/PAN/WLAN that advanced technologies based on FDM modulation used in 5G.
Core Network	All IP network	Flatter IP networks,5G network interlacing

3.2 Key features of 5G Network

5G networks provide lower prices, lower battery consumption, and lower latency than 4G wireless networks. It is because 5G uses Ultra-Wide Band (UWB) networks with higher band breadth at low energy levels. Band breadth is 4000 Mbps, which is four hundred times faster than 4G wireless networks.

The 5G networking technology standard is divided into two key parts:

1. Non-Standalone (NSA) The first 5G networks are based on NSA, which is the basis of commercial launches expected by the end of 2019. The NSA standard uses existing 4G LTE infrastructure to handle the Control Plane and the signal traffic.

2. Standalone (SA) The 5G Standalone (SA) comes with entirely new core architecture. It moved the control plane transition over to the 5G Core and made significant changes for the way that networks operate.

The most used 5G technology is mmWave. Carriers will also be using a new spectrum in the sub-6 GHz Wi-Fi region, low bands below 1 GHz, and existing 4G LTE bands.

At present, there is a significant amount of unused high-frequency spectrum, and the higher the frequency, the more bandwidth is available. 5G networking technology also relies on different

wave spectrums shown in figure 4. Wireless networks are composed of cell sites divided into sectors that send data through radio waves. Fourth-generation (4G) Long-Term Evolution (LTE) wireless technology requires high-power, large cell towers to radiate signals over long distances. 5G wireless signals, on the other hand, will be transmitted via large numbers of multiple small cell stations located in places like light poles or building roofs. The use of a large number of small cells is necessary since 5G relies on millimeter wave spectrum between 30 and 300 GHz which can only travel over short distances and is subject to interference from weather and physical obstacles

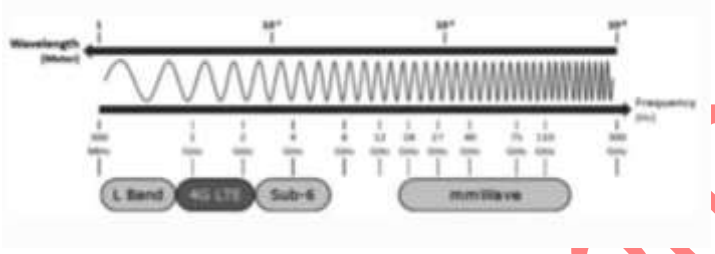

Figure 4. *Spectrum*

5G networks provide improved support of machine to machine communication, aiming at lower prices, reduced battery consumption, and lower latency than 4G instrumentation. 5G uses Ultra-Wide Band (UWB) networks with higher band breadth at low energy levels. Additionally, 5G offers ultra-low latency of 1 ms, 90% more energy efficiency, 99.9% ultra-reliability, 10 Gbps peak data rate transmission speeds, and a mobile data volume of 10 Tb Peak 5G speeds are expected to be up to 100x faster than the speed of 4G LTE networks. Reduced latency will support new applications that leverage the power of 5G, the Internet of Things (IoT), and artificial intelligence. Increased capacity on 5G networks can minimize the impact of load spikes, like those that take place during sporting events and news event.

Figure5 ***5G network***

4. HARDWARE AND SOFTWARE OF 5G

Changing usage models such as automated vehicles, smart factories, streaming video, and cloud-based applications has placed more emphasis on higher bandwidth and shrinking latency. To meet these evolving needs, 5G promises a 100X speed boost compared to 4G LTE, along with latencies that are an order of magnitude or lower. In addition, 5G specifications call for the new network to connect one million devices per square kilometer, more than 100 times as many as before.

Meeting these higher performance levels requires big changes, including a new frequency band and a changed radio access network (RAN) architecture. On the heels of building out 4G LTE, carriers must now deploy an entirely new transport technology with greater complexity and significantly more hardware and software components. The rollout itself will take place on a

massive scale and carriers need solutions that are not just fast and efficient to deploy, but also economical to buy and operate. These components also need to be reliable and minimize power consumption.
As the industry plans for this 5G build out, it is imperative that capital expenditures (CapEx) and operating expenditures (OpEx) are controlled. This has led to an industry-wide shift from 4G's dedicated hardware and proprietary software to open software stacks installed on open and commercial-off-the-shelf (COTS) hardware platforms.

5. DISCUSSIONS

5.1 Advantages of 5G Technology:

1. Higher Download Speed: The 5G network will have the capacity to increase download speeds by up to 20 times (from 200 Mbps (4G) to 10 Gbps (5G)) and decreasing latency (response time between devices). These speeds will maximize the browsing experience by facilitating processes that, although possible today, still present difficulties.
2. Hyper connectivity: The 5G network promises the possibility of having a hyper-interconnected environment to reach the point of having the much desired "smart cities". The correct performance of these new dynamics will depend on the bandwidth of 5G and the Internet of Things (IoT).
3. Process optimization: It is also expected to revolutionize areas such as medicine (remote operations, for example), and traffic management and autonomous vehicles, as well as its
4. Implementation in the construction sector to optimize resources and reduce risks.

5.2 Disadvantages of 5G Technology

1. Immediate Obsolescence: The transition to the 5G network will require devices that can support it; current 4G devices do not have this capability and will become immediately obsolete.
2. Technological exclusion : The implementation of the 5G network also implies a lack of immediate accessibility for average pockets, combined with a delay in its implementation due to a lack of means for its use.
3. Insufficient Infrastructure: For the 5G network to function properly will require a whole ambitious investment in infrastructure to increase bandwidth and expand coverage, and this is not cheap. This situation will necessarily lead to delays in its implementation due to the high costs that governments will have to cover for 5G to function properly
4. Risks in security and proper data handling.

6. CONCLUSIONS

5G is a reality that in a short time will touch our lives like previous technologies, and it would be better to look at it now to take advantage of its benefits and avoid its risks. 5G Wireless will also play a crucial role in a growing number of consumer electronics technologies and companies and will transform the fundamental ways industries conduct business. 5G wireless will enable companies to be on the growing side of the growth wave keeping their investors, customers, and workers happy. So, the very near future will be one of the most exciting times for business in our lifetimes, full of challenges, opportunities, and risks.

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