spectrum will 5G technology use and how does this compare to 4G?

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RF Evolution 4G to 5G

Reliable cables and

Robotics a…

For decades, the cellular telephone system has continually grown in adoption and has evolved from simple calling and messaging to an enabling technology for universal wireless connectivity. This evolution has

Millimeter-wave radar

Infrared or …

5G technologies.This article illuminates details regarding the shift in performance, frequency and requirements from 4G LTE to 5G systems.

Emerging Applications Changing Spectrum Use and Cellular Network Performance

Though earlier cellular wireless generations served applications other than mobile broadband, the bulk of 2G, 3G, and now 4G LTE cellular services are designed and dedicated to mobile broadband. The standards and technologies for previous cellular generations have predominantly supported mobile broadband cellular users in urban and suburban regions, with less of an emphasis in rural regions. The goal of 5G technologies, however, goes beyond merely serving mobile broadband, but offers key improvements that enable a much wider range of applications: enhanced mobile broadband (eMBB), ultra-reliable and low latency communications (URLLC), massive urban users experience less than 10 Mbps speeds with latencies in the tens of milliseconds. Beyond rapid video downloads, 5G eMBB will enable use cases that open the door to augmented reality and virtual reality applications in real-time, throughout and urban environment.

This performance requires upgrades throughout the cellular networking stack, as well as technology enhancements for handsets. Much of the change in network architecture is currently happening, as major telecom companies are deploying more small cells to enable eMBB performance, where traditional homogeneous macro-cell architectures have proven incapable, especially in densely cluttered urban environments.

Ultra-reliable and Low Latency Communications (URLLC)

Though some areas experience cellular

include new waveforms, lower latency hardware, and likely wireless networking approaches that enable frequency-agility, redundancy, and alternative network architecture types than a star network.

Massive Machine-type Communications (MMC)

Most cellular wireless users today are individuals using mobile handsets, but future cellular networks will likely be dominated by Internet of Things (IoT) devices intercommunicating, reporting sensor information, and acting on control data throughout modernized urban areas, factories, industrial installations, and transportation networks. Much, and maybe the majority, of future cellular communications will be between machines, which pose very different requirements than human users.

Dispersed IoT and machine devices are likely to require a very diverse range of communication requirements, making a single one-size-fits-all wireless

(FWA)

Though sparsely used, 3G and 4G cellular networks have supported a range of pseudo-fixed wireless access systems, with hotspots and cellular modems. However, the enhanced data rate and low latency capability of 5G networks enables an attractive business use case of providing FWA to compete with other last-mile internet service. With greater bandwidth and advanced antenna technologies, many experts predict that 5G networks will be able to provide fiber-like performance and enable developed and developing markets with accessible internet and connectivity. Beyond massive multi-input multi-output (mMIMO) and beamforming capable antennas, FWA services also require bandwidth beyond what is available in the sub-6 GHz spectrum driving current cellular networkings. Large amounts of bandwidth, likely exceeding 1 GHz, will be necessary to provide fiber-like service. Hence, 5G cellular networks are including millimeter-wave frequency bands to enable new applications and dramatic increases in data rates compared to previously generations previous cellular network frequencies are based on licenses (Table 1).

The 5G frequency band plans are much more complex, as the frequency spectrum for sub-6 GHz 5G spans 450 MHz to 6 GHz, and millimeter-wave 5G frequencies span 24.250 GHz to 52.600 GHz, and also include unlicensed spectrum. Additionally, there may be 5G spectrum in the 5925 to 7150 MHz range and 64 GHz to 86 GHz range. Therefore, 5G will include all previous cellular spectrum and a large amount spectrum in the sub-6 GHz range, and beyond sub- 6 GHz is many times current cellular spectrum (Table 2 and Table 3). The initial 3GPP release of 5G New Radio Non-standalone (5G NR) standards included several sub-6 GHz frequency bands, designated FR1 (Table 2). The second 3GPP 5G release after IMT-2020 will include FR2 frequency bands in the millimeter-wave spectrum (Table 3).

As with previous cellular generations and 3GPP releases, various regions and countries will also likely adopt unique

GHz to 38.6 GHz, 38.6 GHz to 40 GHz, and 47.2 GHz to 48.2 GHz. Most other developing countries are undergoing similar considerations of spectrum allocation for 5G use cases.

One of the main reasons that additional spectrum is being made available for 5G uses, is the physical limitations associated with throughput and bandwidth. 4G band plans accounted for between 5 MHz and 20 MHz of bandwidth per channel, where the 5G FR1 standard allows for between 5 MHz and 100 MHz of bandwidth per channel. As bandwidth is directly proportional to maximum throughput, the 5X increase in bandwidth relates to roughly a 5X increase in throughput. Moreover, 3GPP Release 15 established new waveforms and the addition of π/2 BPSK as a modulation method. The additional waveforms are discrete fourier transform spread orthogonal frequency division multiplexing (DFT-S-OFDM) for FR1 and cyclic prefix OFDM (CP-OFDM) for FR2.

Though RF hardware, technology, and the communications infrastructure are available and operational modes. This is no different with the development of 5G technologies. What is different, however, is the amount of new frequency spectrum being added, and where in the regime of the electromagnetic spectrum these frequencies reside. Moreover, the hunger for greater bandwidth is also leading policy makers and device manufacturers to eek as much performance out of the crowded sub-6 GHz cellular frequency bands with a variety of techniques that aggregate multiple cellular bands and increase single channel bandwidth. Emerging applications, such as the Internet of Things (IoT) and Machine to Machine (M2M) communications are also encouraging industry to investigate a variety of operating modes for 5G to fit the multitude of applications. In many ways, 5G is being designed to become a modular solution to the challenges of universal wireless connectivity.

Table 1

2G, 3G, 4G Frequency Bands in th

4	4G LTE	700 MHz (B17, B12, B13)
		850 MHz (B26, B5)
		1.7/ 2.1 GHz AWS (B4)
		1.9 GHz (B2, B25)
		2.3 GHz (B30)
		2.5 GHz (B41)

Table 2

5G NR (5G1) Operat	
NR Operating	Uplink (MHz)

n70	1695	1710
n71	663	698
n74	1427	1470
n75	N/A	
n76	N/A	
n78	3300	3800
n77	3300	4200
n79	4400	5000
n80	1710	1785
n81	880	915
n82	832	862
n83	703	748
n84	1920	1980
n86	1710	1780

Table 3

Standalone 5G (Millimeter-wa		
Band	*ƒ* (GHz)	Common name

4G	SC-FDMA	QPSK, 16QAM, 64QAM, 256QAM
5G1 (FR1)	DFT-S-OFDM	$\pi/2$ BPSK, QPSK, 16QAM, 64QAM, 256QAM
	DFT-S-OFDM	$\pi/2$ BPSK, QPSK, 16QAM, 64QAM, 256QAM
5G2 (FR2)	CP-OFDM	$\pi/2$ BPSK, QPSK, 16QAM, 64QAM, 256QAM
	CP-OFDM	$\pi/2$ BPSK, QPSK, 16QAM, 64QAM, 256QAM