5G

5G is the fifth generation wireless technology for digital cellular

5G networks began wide deployment in 2019. As with previous standards, the covered areas are divided into regions called "cells", serviced by individual antennas. Virtually every major telecommunication service provider in the developed world is deploying antennas or intends to deploy them soon. The frequency spectrum of 5G is divided into millimeter waves, midband and low-band. Low-band uses a similar frequency range as the predecessor, 4G.

5G logo

Introduced	Late 2018

5G millimeter wave is the fastest, with actual speeds often being 1–2 Gbit/s download. Millimeter waves have difficulty traversing many walls and windows, so indoor coverage is limited.

5G mid-band is the most widely deployed, in over 20 networks. Speeds are usually 100–400 Mbit/second. download. In the lab and occasionally in the field, speeds can go over a 1 gigabit per second.

5G low-band offers similar capacity to advanced 4G. In the United States, T-Mobile and AT&T launched low-band services on the first week of December 2019. T-Mobile CTO Neville Ray warns that speeds may be as low as 25 Mbit/s down.[1] AT&T, will also usually deliver less than 100 Mbit/second in 2019. The performance will improve, but cannot be significantly greater than robust 4G.

Overview

5G networks are digital cellular networks, in which the service area covered by providers is divided into small geographical areas called *cells*. Analog signals representing sounds and images are digitized in the telephone, converted by an analog to digital converter and transmitted as a stream of bits. All the 5G wireless devices in a cell communicate by radio waves with a local antenna array and low power automated transceiver (transmitter and receiver) in the cell, over frequency assigned “channels”. The cell phone towers are connected to the Internet by a high bandwidth optical fiber. When a mobile device is moving across land the connection is automatically "handed off" seamlessly to the new tower. Verizon and a few others are using millimeter waves which have trouble passing through building walls.[4] Millimeter wave antennas are smaller than the large antennas used in previous cellular networks. Each cell will have multiple antennas communicating with the wireless device. Multiple streams of data will be transmitted simultaneously, in parallel. In a technique called *beamforming*, the base station computer will continuously calculate the best route for radio waves to reach each wireless device, and will organize multiple antennas to work together to create beams of millimeter waves to reach the device.[4][5]

Over 20 networks are deployed using mid-band spectrum. Mid-band networks have better reach, bringing the cost close to the cost of 4G.

T-Mobile USA and AT&T are announced low-band 5G in December 2019. The performance, reach, and cost will be similar to 4G in the same band when the 5G systems are fully developed and can access more carrier frequencies.

The new 5G wireless devices also have 4G LTE capability, as the new networks use 4G for initially establishing the connection with the cell, as well as in locations where 5G access is not available.[6]

LTE means Long Term Evolution and is the first 4G technology. Most all networks and geographical areas cover 4G LTE, however they may be instances were your 4G phone will switch to just 4G which is considerably slower.

5G can support up to a million devices per square kilometer, while 4G supports only up to 100,000 devices per square kilometer.[7][8]

Drones will aid in disaster recovery efforts, providing real-time data for emergency responders.[10] Smart cities will monitor air and water quality through millions of sensors, giving them insights needed to provide a better quality of life.[10] Most cars will have a 4G or 5G cellular connection for many services. Autonomous cars do not require 5G, as they have to be able to operate where they do not have a network connection.[11] While remote surgeries have been performed over 5G, most remote surgery will be performed in facilities with an optical fiber connection, usually faster and more reliable than any wireless connection.

Speed

5G speeds will range from ~50Mbit/second to over 2Gbit/second at the start, and is expected to grow to even 100Gbit/second, 100x faster than 4G.[12] The fastest 5G, known as mmWave, delivers speeds of up to and over 2Gbit/second. As of July 3, 2019, mmWave had a top speed of 1.8Gbit/second[13] on AT&T's 5G network, much faster than 4G's top speed of 23.6Mbit/second[14] on T-Mobile's network. The problem with this though is that mmWave cannot go through walls, trees, etc. because of the high frequency.

5G mid-band, by far the most common, will usually deliver between 100 & 400 Mbit/second, but will have a much farther reach than mmWave, not being limited by walls, trees, and other obstacles which interfere with mmWave transmission.[13]

Low-band spectrum offers the farthest area coverage but is slower than the others, though still faster than 4G.

5G speeds in the less common millimeter wave spectrum, with its much more abundant bandwidth and shorter range, and hence greater frequency reuseability, can be substantially higher.[19]

Implementation/Rollout

5G 3.5 GHz Cell Site of Deutsche Telekom in Darmstadt, Germany

5G 3.5 GHz Cell Site of Vodafone in Karlsruhe, Germany

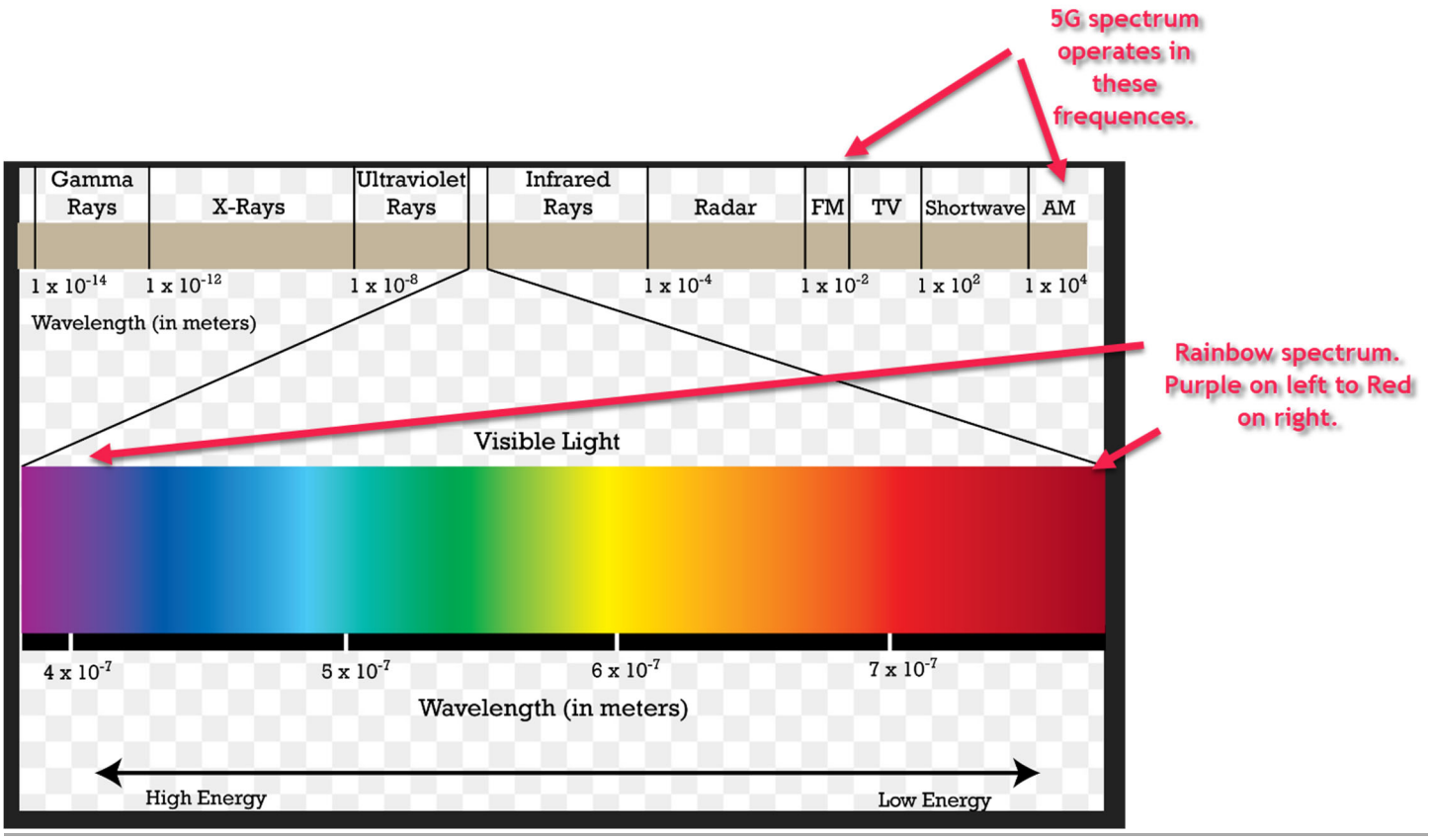
Beyond mobile provider networks, 5G is also expected to be widely used for private networks with applications in industrial, commercial and critical communications.

As of April 2019, the Global Mobile Suppliers Association had identified 224 operators in 88 countries that are actively investing in 5G (i.e. that have demonstrated, are testing or trialling, or have been licensed to conduct field trials of 5G technologies, are deploying 5G networks or have announced service launches).[35] The equivalent numbers in November 2018 were 192 operators in 81 countries.[36] The first country to adopt 5G on a large scale was South Korea, in April 2019. Swedish telecoms giant Ericsson predicted that superfast 5G internet will cover up to 65% of the world's population by the end of 2025.[37] Also, it plans to invest 1 billion reais ($238.30 million) in Brazil to add a new assembly line dedicated to 5th generation technology
(5G) for its Latin American operations.[38]

When South Korea launched its 5G network, all carriers used Samsung, Ericsson, and Nokia base stations and equipment, except for LG U Plus, who also used Huawei equipment.[39][40] Samsung was the largest supplier for 5G base stations in South Korea at launch, having shipped 53,000 base stations at the time, out of 86,000 base stations installed across the country at the time.[41]

Nine companies sell 5G radio hardware and 5G systems for carriers: Altiostar, Cisco Systems, Datang Telecom, Ericsson, Huawei, Nokia, Qualcomm, Samsung, and ZTE.[45][46][47][48][49][50][51]

Spectrum



Large quantities of new radio spectrum have been allocated to 5G[52] in order to enable its increased throughput when compared with 4G. For example, in July 2016, the U.S. Federal Communications Commission (FCC) freed up vast amounts of bandwidth in underused highband spectrum for 5G. The Spectrum Frontiers Proposal (SFP) doubled the amount of millimeterwave unlicensed spectrum to 14 GHz and created four times the amount of flexible, mobile-use spectrum the FCC had licensed to date.[53] In March 2018, European Union lawmakers agreed to open up the 3.6 and 26 GHz bands by 2020.[54]

Research has been done into the most suitable candidates for spectrum ranges for 5G.[56] Due to the demand for spectrum resources and wide frequency range of 5G technology, it is necessary to plan high, medium and low frequency bands in stages in frequency planning, gradually release frequency resources and guarantee the frequency requirements of 5G.[57] The frequency spectrum became a focus due to predictions that the 3G/4G frequency spectrum would not suffice to accommodate the amount of traffic that 5G will need to handle.[56]

5G networks will need to tap into the vast amount of spectrum available in spectrum frequencies that are not utilized by other radio devices to offload traffic in heavily congested areas and provide connectivity for billions of devices.

5G devices

In March 2019, the Global Mobile Suppliers Association released the industry's first database tracking worldwide 5G device launches.[59] In it, the GSA identified 23 vendors who have confirmed the availability of forthcoming 5G devices with 33 different devices. There were seven announced 5G device forms: (mobile phones (×12 devices), hotspots (×4), indoor and outdoor customer home equipment (×8), modules (×5), Snap-on dongles and adapters (×2), and USB terminals (×1)).[60]

By October 2019, the number of announced 5G devices had risen to 129, across now 15 forms, from 56 vendors.[61]