

5G lighting speed and the Challenges of mm-Waves

lighting speed

Jeff Fitih and Steven Jenkins | Comp Networking | 04/23/2019

**What's the Frequency?**

5G primarily runs in two kinds of airwaves: below and above 6GHz.

Low-frequency 5G networks, which use existing cellular and Wi-Fi bands, take advantage of more flexible encoding and bigger channel sizes to achieve speeds 25-50% better than LTE, according to a presentation by T-Mobile exec Karri Kuoppamaki. Those networks can cover the same distances as existing cellular networks and generally won't need additional cell sites. Sprint, for example, is setting up all of its new 4G cell sites as 5G-ready, and it'll just flip the switch when the rest of its network is prepared.

The real 5G innovation is happening at higher frequencies, known as millimeter wave. Down in the existing cellular bands, only relatively narrow channels are available because that spectrum is so busy and heavily used. But up at 28Ghz and 39Ghz, there are big, broad swathes of spectrum available to create big channels for very high speeds.

Those bands have been used before for backhaul, connecting base stations to remote Internet links. But they haven't been used for consumer devices before, because the handheld processing power and miniaturized antennas weren't available. Millimeter wave signals also drop off faster with distance than lower-frequency signals do, and the massive amount of data they transfer will require more connections to the landline Internet. So cellular providers will have to install more, smaller, lower-power base stations rather than use existing powerful macrocells to offer the multi-gigabit speeds that millimeter wave networks promise.

|  |  |  |  |
| --- | --- | --- | --- |
| **Capability** | **Description** | **5G target** | **Usage scenario** |
| Peak data rate | Maximum achievable data rate | 20 Gbit/s | eMBB |
| User experienced data rate | Achievable data rate across the coverage area | 1 Gbit/s | eMBB |
| Latency | Radio network contribution to packet travel time | 1 ms | URLLC |
| Mobility | Maximum speed for handoff and QoS requirements | 500 km/h | eMBB/URLLC |
| Connection density | Total number of devices per unit area | 106/km2 | MMTC |
| Energy efficiency | Data sent/received per unit energy consumption (by device or network) | Equal to 4G | eMBB |
| Spectrum efficiency | Throughput per unit wireless bandwidth and per network cell | 3–4x 4G | eMBB |
| Area traffic capacity | Total traffic across coverage area | 1000 (Mbit/s)/m2 | eMBB |

**Deployment ?**

Development of 5G is being led by companies such as [Huawei](https://en.wikipedia.org/wiki/Huawei), [Intel](https://en.wikipedia.org/wiki/Intel) and [Qualcomm](https://en.wikipedia.org/wiki/Qualcomm) for modem technology and [Lenovo](https://en.wikipedia.org/wiki/Lenovo), [Nokia](https://en.wikipedia.org/wiki/Nokia), [Ericsson](https://en.wikipedia.org/wiki/Ericsson), [ZTE](https://en.wikipedia.org/wiki/ZTE), [Cisco](https://en.wikipedia.org/wiki/Cisco_Systems), and [Samsung](https://en.wikipedia.org/wiki/Samsung) for infrastructure. [AT&T](https://en.wikipedia.org/wiki/AT%26T) is supporting the current roll-out of the 5G mobile communications generation with high frequency (HF) optimized interconnect solutions by developing and producing hybrid-[printed circuit board](https://en.wikipedia.org/wiki/Printed_circuit_board) (PCB) structures.

Worldwide commercial launch is expected in 2020. Numerous operators have demonstrated 5G as well, including Korea Telecom for the [2018 Winter Olympics](https://en.wikipedia.org/wiki/2018_Winter_Olympics) and Telstra at the [2018 Commonwealth Games](https://en.wikipedia.org/wiki/2018_Commonwealth_Games). In the United States, the four major carriers have all announced deployments: AT&T's millimeter wave commercial deployments in 2018, Verizon's 5G [fixed wireless](https://en.wikipedia.org/wiki/Fixed_wireless) launches in four U.S. cities and millimeter-wave deployments,Sprint's launch in the 2.5 GHz band, and T-Mobile's 600 MHz 5G launch in 30 cities. Vodafone performed the first UK trials in April 2018 using mid-band spectrum, and China Telecom's initial 5G buildout in 2018 will use mid-band spectrum as well.

Beyond mobile operator networks, 5G is also expected to be widely utilized for private networks with applications in industrial IoT, enterprise networking, and critical communications.

**Hetnets (Heterogenous Approach)**

Another way to handle the wireless traffic explosion, expected in 5G communication, is deployment of large number of small cells giving rise to HetNets(Heterogenous Networks). HetNets are typically composed of small cells, having low transmission power, besides the legacy macrocells. By deploying low power small BSs, network capacity is extended to coverage holes. Moreover, the overlap of all small, pico, femto cells with the existing macro cells, leads to improved and efficient frequency reuse. It calls for a coordinate operation between traditional macro cells and small cells for mutual interference reduction.

**mm-wave Wireless Channel**

mm-waves frequencies raise many new challenges in mobile wireless communication. 1) is Propagation Loss. The free space loss is estimated by the equation

Where primarily accounts for the transmission loss of mm-waves, R represents transmitter-receiver distance and f is the carrier frequency. It seems that losses are prominent at higher frequencies. Shorter wavelengths enable dense packing of smaller antennas in a small area.

2) Penetration and LOS Communication, For an effective system design, there is an impending need to understand mm-wave propagation characteristics in indoor and outdoor environment, it is essential to determine the behavior of the propagating signals through and around common structures, foliage and human beings.

3) Multipath and NLOS: In wireless communications, multipath is the effect of signal reception in antenna by more than one point. Multipath characteristics of channel is well described by choosing the delay spread as a validation parameter. (RMS)Root Mean Square of Power in mm-waves communication. Understanding of multipath is likely to enable NLOS problem mitigation. LOS link might not always be possible in dynamic outdoor environment. Hence, it is important to explore possibilities of partially obstructed LOS and NLOS links. Reflection coefficients for different surfaces suggest the possibility of reasonable signal levels in shadow area. Building corners, edges and human activities might not always completely attenuate LOS link. Rather, these often cause shadowing. Reflection coefficients for different surfaces suggest the possibility of reasonable signal levels in shadow area. It is also observed that wider beam-width antennas give accurate estimation of received signal. On the other hand, smaller beam width antennas have advantages of spatial directivity. The **SNR** is defined as the average over time of the peak signal divided by the **RMS** noise of the peak signal over the same time. In order to get an accurate result for the **SNR** it is generally required to measure over 25 - 50 times samples of the spectrum.