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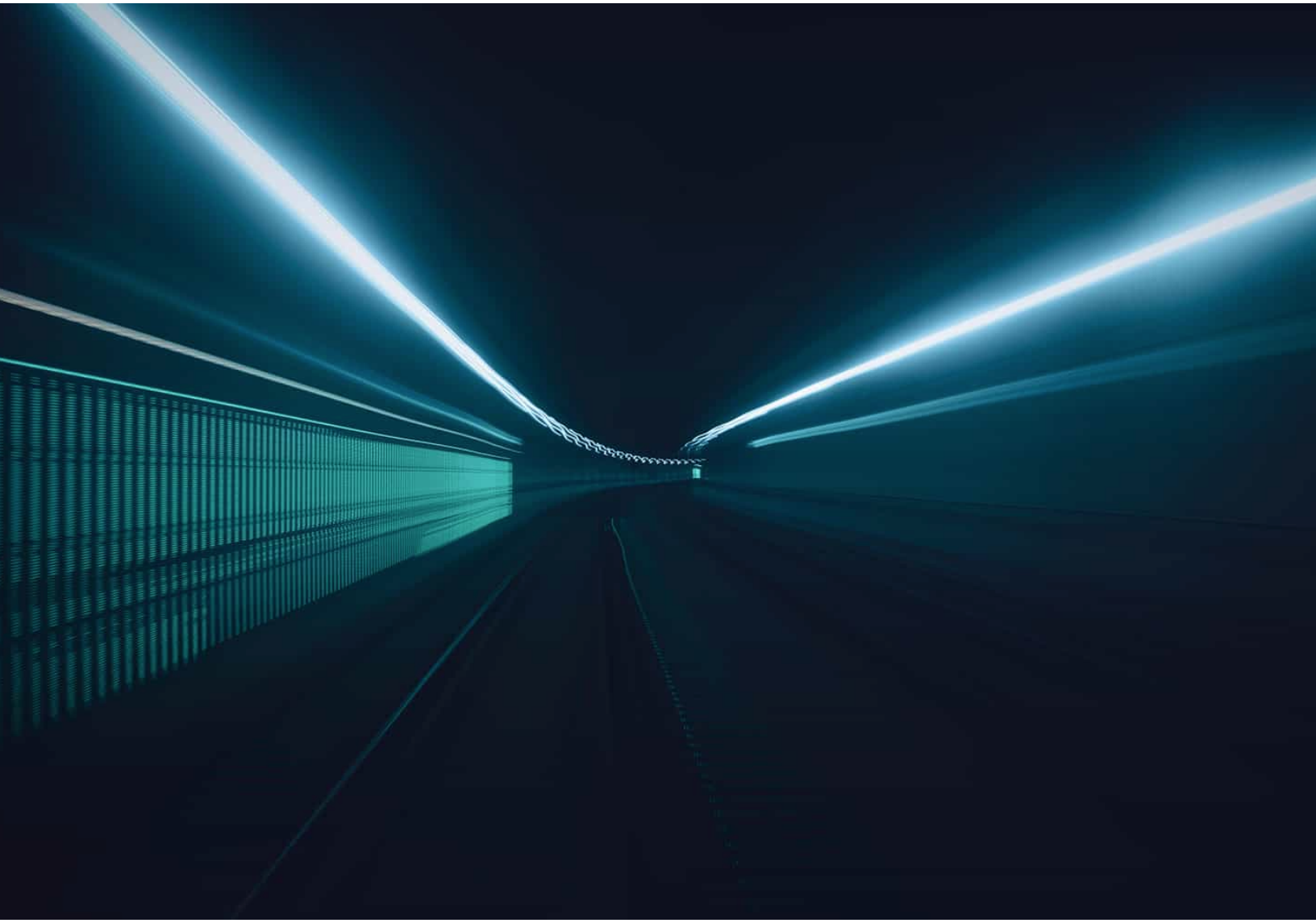
TELCOMA Global Whitepaper

5G Multiple Access Techniques



Introduction

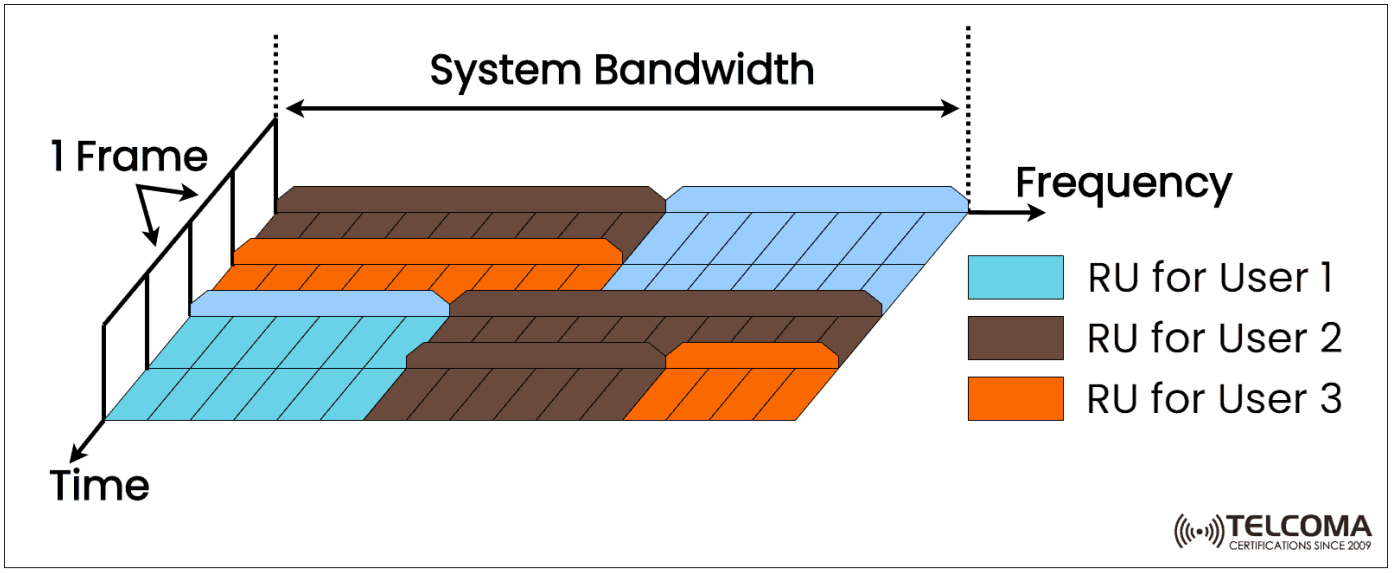
5G is the fifth generation of wireless networks which is a new global standard after 4G. This technology is designed in such a way that it can connect everything and everyone virtually into one frame. It will offer data rates in multi-Gbps data speeds, more reliability than the previous generation, and is able to connect massive devices together, increased availability, and can give a good user experience. 5G will have an impact on every business and industry because it will offer more data rates, high reliability, and low latency which will be beneficial for various industries like logistics, remote healthcare, precision agriculture, and many more. 5G is designed to have the ability so that it can have the flexibility to support future services which are yet to be discovered. 5G will provide enhanced mobile broadband access, mission-critical communications, and massive IoT(Internet of things). 5G can also deliver much lower latency for uniform user experience so that the data rates stay constantly high even when the users are moving.

Multiple Access techniques used in 5G

- **OFDM (Orthogonal Frequency Division Multiple Access):** It is an efficient modulation format that is used in wireless communication systems in 5G. It combines the benefits of Quadrature Amplitude Modulation (QAM) and Frequency Division Multiplexing (FDM) to produce a high-data-rate communication system. QAM refers to a variety of specific modulation types like BPSK (Binary Phase Shift Keying), QPSK (Quadrature Phase Shift Keying), 16 QAM, 64 QAM. Using OFDM can create an array of subcarriers that all work together to transmit information over a range of frequencies. These Subcarriers must be orthogonal functions. A key enabler for OFDM is the use of the IFFT (Inverse Fast Fourier Transform) to efficiently create the time domain waveform from the array of modulated subcarriers. The resulting OFDM signal is in the digital form which drives the DAC (Digital to Analog converters) to an analog signal. An analog down converter (DN) shifts the OFDM signal back to the baseband. The ADC (Analog-to-Digital Converter) converts the signal to the digital form and passes it on the FFT block. The FFT block transforms the time domain signal back to the array of subcarriers carrying QAM modulation, in the frequency domain. The guard interval is provided for some time separation between symbols. This is to prevent interference in the

signals. When the CP (Cyclic Prefix) is inserted in the Guard period, it is known as CP-OFDM. Wireless systems use OFDM to achieve high bandwidth channels. The modulation on the subcarriers can be QPSK, 16QAM, or 64QAM.

The 5G NR standard uses OFDM on both the uplink and the downlink. The New Radio Specification is designed with a high degree of flexibility to cover a diverse set of applications. In this, the carrier spacing is flexible (15 kHz, 30 kHz, 60 kHz, 120 kHz, 240 kHz, and 480kHz) with up to 3300 subcarriers. The subcarrier modulation used can be QPSK, 16 QAM, 64QAM, or 256 QAM.



- **Optimized OFDM**: The specific version of OFDM used in the 5G NR downlink is cyclic prefix OFDM and DFT-S OFDM. CP-OFDM is used as the access technology for 5G NR, it is similar to the access technology used in LTE however CP-OFDM features variable subcarrier spacing termed numerology. It can utilize 15 kHz, 30 kHz, 60 kHz, and 120 kHz, etc subcarrier separation. When the SC spacing is changed, the cyclic prefix duration per symbol also changes. DFT-S OFDM is a discrete Fourier transform spread OFDM is a single carrier-like transmission scheme that is combined with OFDM. It is commonly known as SC-OFDM (Single carrier OFDM). The transmission scheme of SC-FDMA is very similar to

OFDMA. For each user, the sequence of bits transmitted is mapped to a complex constellation of symbols. Then different transmitters are assigned different Fourier coefficients.

- **CP-OFDM (Cyclic Prefix OFDM):** It is used as the access technology for 5G NR. In LTE, it uses a fixed 15kHz subcarrier separation, CP-OFDM can utilize 15kHz, 30kHz, 60kHz, and 120kHz, etc. when the subcarrier spacing is changed, the CP symbol duration also changes. The cyclic prefix is used in Orthogonal frequency division multiplexing schemes including OFDM to primarily acts as a guard band between the successive symbols to overcome intersymbol Interference (ISI).