What is 5G NR?

Steve Taranovich - April 25, 2017

While listening to the many excellent technical 5G presentations at the Brooklyn 5G Summit held at NYU Tandon School of Engineering and co-hosted by NYU WIRELESS and Nokia this year, I heard the term 5G NR mentioned. For those of you who are not familiar with 5G NR, it refers to 5G New Radio. Qualcomm commented that NR is a complex topic as it relates to a new OFDM-based wireless standard.

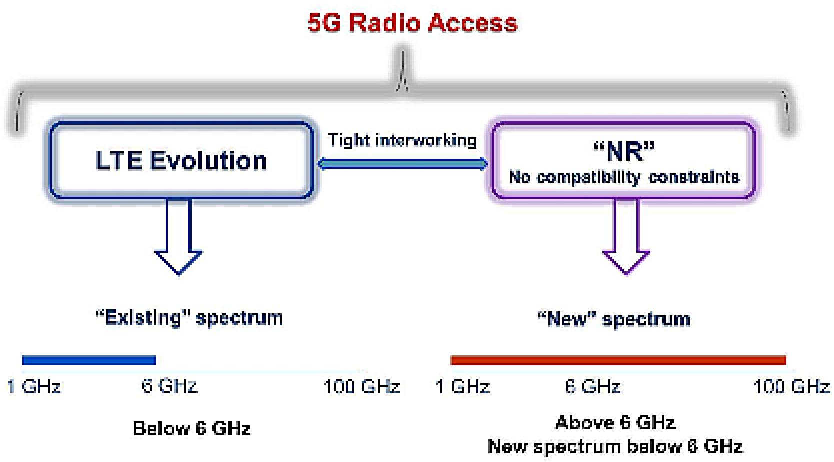

Figure 1 The 5G Radio Access architecture is composed of LTE Evolution and a New Radio Access Technology (NR) which is not backwards compatible with LTE and is operable from sub-1 GHz to 100 GHz. (Image courtesy of Reference 5)

OFDM refers to "a digital multi-carrier modulation method" in which "a large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels." With 3GPP adopting this standard going forward, the NR name has stuck, just as LTE (long term evolution) caught on to describe the 4G wireless standard.

A new Radio Access Technology (RAT), beyond LTE is needed; it must be flexible enough to support a much wider range of frequency bands from less than 6 GHz to millimeter wave (mmWave) bands as high as 100 GHz. An OFDM[4]-based unified and more capable air interface has been chosen for this task going forward.

OFDM is a very well-defined and familiar waveform design principle. Both 4G (LTE and its evolutions so far) and IEEE 802.11 (WiFi) use OFDM as their basic signal format for sending data wirelessly. Basically, OFDM uses a large number of parallel, narrow-band subcarriers instead of a single wide-band carrier to transport information[4].

Here is a timeline for implementation given by Durga Malladi, Sr. VP of Qualcomm at the Brooklyn 5G Summit 2017:

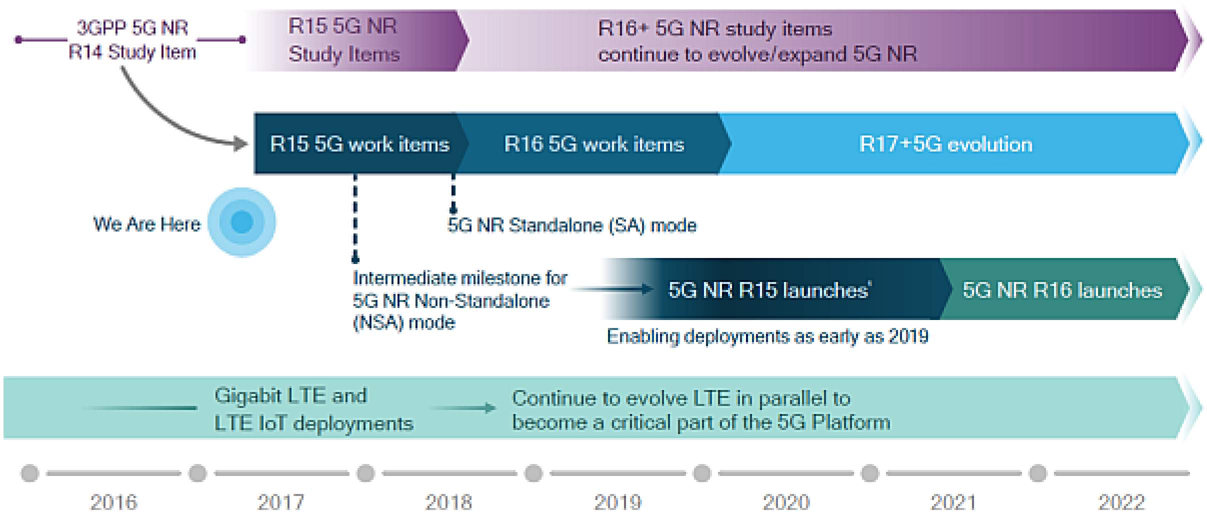

Figure 2 5G NR accelerating towards being the global standard for 5G (Image courtesy of Qualcomm)

Why OFDM[2]?

Some reasons that OFDM has been chosen are:

- OFDM is a scalable waveform with lower complexity receivers
- OFDM has a more efficient framework for MIMO spatial multiplexing which means higher spectral efficiency
- OFDM allows enhancements like windowing/filtering for enhanced localization
- SC-FDM/SC-FDMA is well-suited for uplink transmissions in macro deployments

The challenges that 5G is facing push the limits of communication technology and in order to meet the aggressive schedule and technical aspirations of 5G NR, standards bodies and designers will need to squeeze the most out of every bit of the diverse spectrum planned for the 5G air interface[1].

3GPP is focusing upon three key 5G use cases:

1. enhanced mobile broadband (eMBB)
2. massive machine type communications (mMTC)
3. ultra-reliable low latency communications (URLLC).

There are important key performance indicators (KPI) with priorities on things like increased network capacity and higher peak data rate for eMBB, connection density and energy efficiency for mMTC, and high reliability and low latency for URLLC.

Adopted waveform

Dr. Peiying Zhu, a Huawei Fellow commented that choosing a cyclic prefix-based OFDM (CP-OFDM) waveform enables better spectrum confinement than LTE (filtered or windowing). The downlink (DL) and uplink (UL) have symmetric waveforms and there is a complementary DFT-OFDM for UL; single stream only (**Figure 3**).

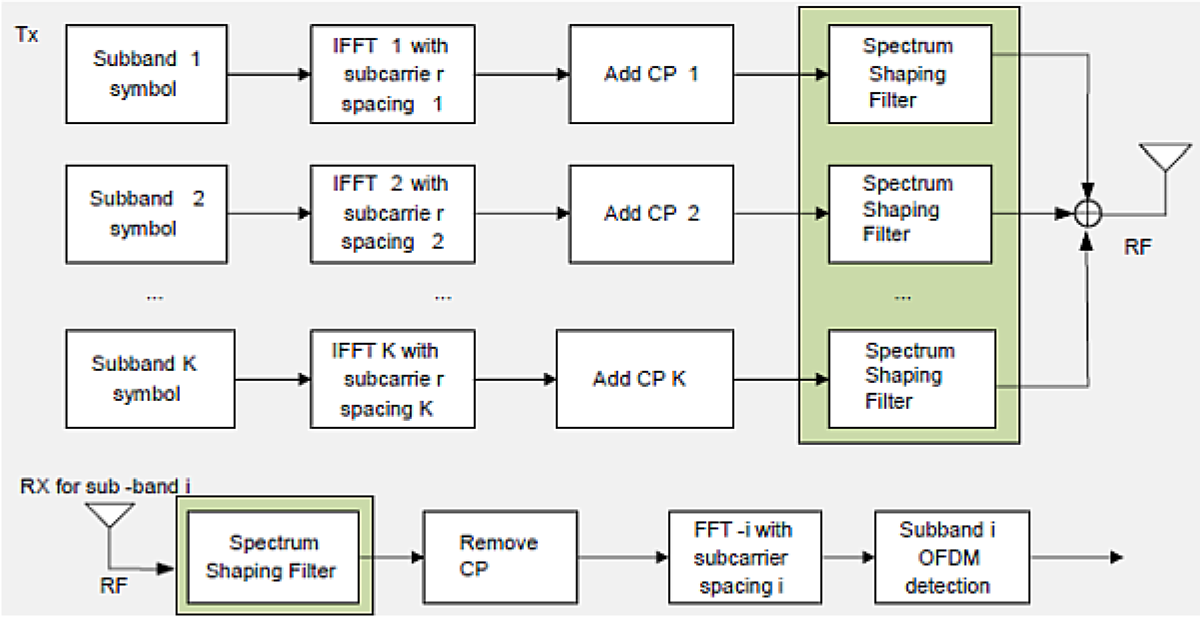

Figure 3 The adopted waveform for 5G NR (Image courtesy of Huawei)

Comparing OFDM to [LTE today] we find a better scalability to a much lower latency (an order of magnitude lower round-trip time [RTT] than LTE today) in OFDM. The OFDM has a self-contained TDD subframe design that enables a faster and more flexible TDD switching and turn-around with support for new deployment scenarios (**Figure 4**).

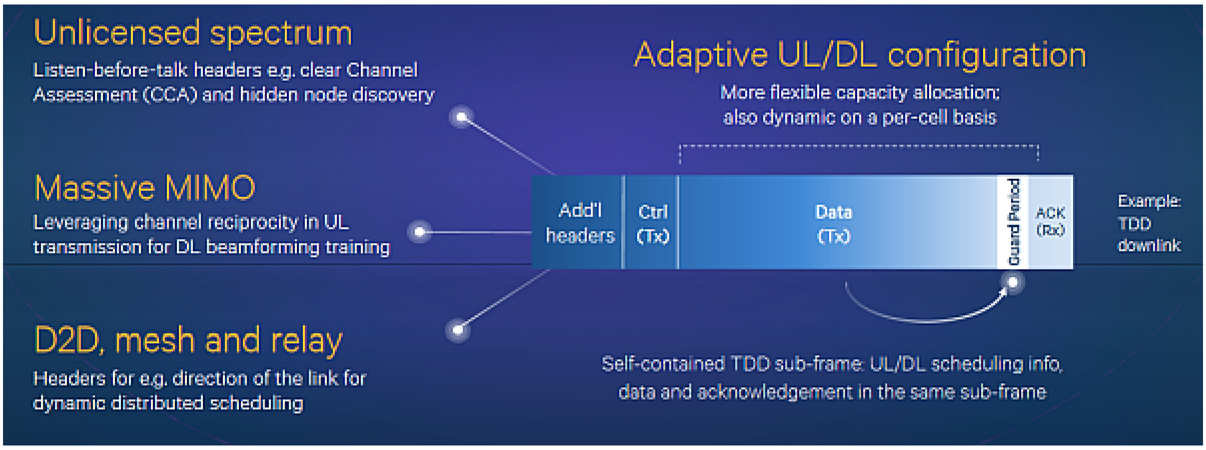

Figure 4 OFDM's self-contained TDD subframe design is faster and more flexible for TDD switching and turn around than LTE's 8 HARQ interfaces[3] (Image courtesy of Reference 2)

Scalability

Scalability

OFDM can be scaled to much lower latency as compared to LTE today (**Figure 5**).

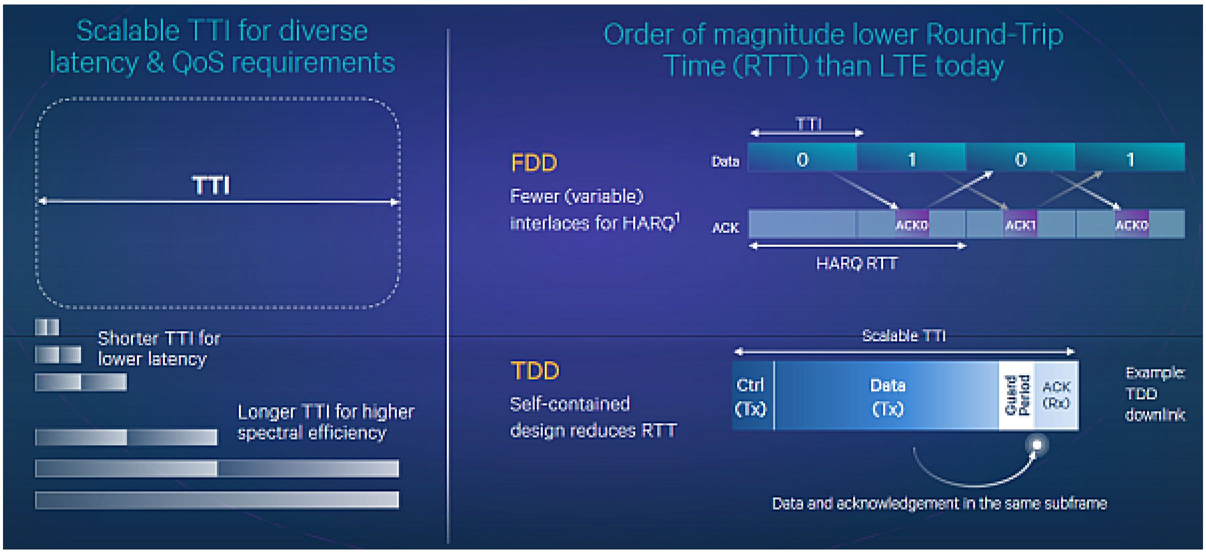

Figure 5 OFDM is more scalable to lower latency than LTE's 8 HARQ interfaces (Image courtesy of Reference 2)

Forward compatibility must be designed into 5G so that we can flexibly phase in future features and services (**Reference 2** slides 12, 13, and 14). 5G NR must be scalable enough to address diverse services and devices. These include massive IoT, mission critical control, and enhanced mobile broadband. See the following band allocation examples:

Low bands

Allocated in the low band area of 1 GHz are such bands as 600 MHz, 700 MHz, and 850/900 MHz. These bands are typically for longer range such as in massive IoT (An example: Ericsson for AT&T) and mobile broadband.

Mid bands

The mid band area is from 1 GHz to 6 GHz with such bands as 3.4-3.8 GHz, 3.8-4.2 GHz, and 4.4-4.9 GHz. These bands are typically used for such uses as mission-critical applications and eMBB.

High bands

The high band area lies above 24 GHz (mmWave) and these are denoted to be used as 'extreme bandwidths' like 24.25-27.5 GHz, 27.5-29.5 GHz, 37-40 GHz, and 64-71 GHz.

New technologies will need to be developed to meet 5G NR requirements. Watch EDN's 5G Design Center for more technical and educational articles coming soon.

References

1. "Making 5G NR a reality," Qualcomm
2. 5G Vision and Design, Dr. John Smee, Sr. Director of Engineering, Qualcomm Technologies, Inc.,

IEEE 5G Summit Silicon Valley, Nov. 15, 2015
3. LTE Radio Interface Part 1, Eduardo Del Valle
4. E225C – Lecture 16 OFDM Introduction, Berkeley Wireless Research Center
5. Waveform and Numerology to Support 5G Services and Requirements, Ali A. Zaidi, Robert Baldemair, Hugo Tullberg, Håkan Björkegren, Lars Sundström, Jonas Medbo, Caner Kilinc and Icaro Da Silva, Ericsson Research, Sweden
6. Signal Chain Basics #81: OFDM Basics, Planet Analog

Steve Taranovich is a senior technical editor at EDN *with 45 years of experience in the electronics industry.*

Also see:

- ZTE kickstarts NSA 5G NR tests: What is it and why should we care?
- NYU emulator advances 5G technology towards reality
- The 5 best 5G use cases
- Brooklyn 5G Summit 2017 wrap-up
- Struggling towards 5G
- Intel discusses 5G on the road to WRC-19
- Introduction to OFDM
- 802.11ax: Not just another higher data rate