QUALCOMM

5G Research

5G NR engineering innovations must address tomorrow's massive connectivity challenges.

Significant cellular challenges are on the horizon as the number of connected things is poised to explode, surging from roughly 8 billion today to more than 25 billion by 2020. 5G is envisioned to support three primary categories of use cases - enhanced Mobile Broadband (eMBB), massive Internet of Things (IoT), and mission critical control. eMBB users will need faster connection speeds and more bandwidth to support evolving applications like UHD video streaming and virtual reality. Massive IoT will demand low power consumption, low device complexity and high network scalability. Mission critical control applications will require ultra-low latency together with high transmission reliability. Learn more about 5G use cases

Cellular innovations introduced with 5G New Radio (NR) will serve as the cornerstone for enabling this new era of connectivity. To make this a reality, 5G NR must overcome significant engineering challenges surrounding reliability, scalability, latency, and much more. Additionally, it must leverage every bit of spectrum available, ranging from sub-6 GHz to above-6GHz, including millimeter wave bands, to satisfy these users. Evolving from today's 4G to tomorrow's 5G represents a major technological leap, requiring the 5G NR air interface design to be validated through simulations, prototyping, and field testing. A global 5G standard is being defined, with demonstrations, tests, and field trials leading to successful deployments by 2019/2020.

Key Research Areas:

- 5G NR air interface and NextGen core network design
- 5G standardization
- 5G NR prototyping
- 5G system trialing

Learn more about our 5G Research Initiatives

Designing the future of 5G NR.

Qualcomm Research began designing a 5G NR unified air interface many years ago, building on our leadership in 3G and 4G LTE. In doing so, we designed our 5G NR air interface to operate across licensed, unlicensed, and shared spectrum, utilizing a highly flexible and scalable framework based on optimized OFDM-based waveforms and multiple access techniques. We also engineered them to operate over multiple spectrum bands from low bands (below 1 GHz) and mid-bands (from 1 GHz to 6 GHz), to high-bands (above 6 GHz, such as the 28 GHz mmWave bands).

Additionally, we natively incorporated numerous advanced wireless air interface techniques such as multi-user massive MIMO, advanced coding, a self-contained integrated sub-frame structure, device-centric mobility, and multi-hop/mesh/vehicle-to-vehicle (V2V) communications. These techniques allow 5G NR to efficiently achieve higher capacity and better coverage across spectrum bands, while also delivering millisecond latency with improved network efficiency and reduced cost per bit. This scalability, together with a forward compatible design, enabled our 5G NR solution to be "future-proofed" against the evolving network requirements coming in 2020 and beyond.

Learn more about 5G technologies

Learn more about 5G NR design

Defining the standard for 5G NR.

Qualcomm Research actively drives 5G standardization activities through close collaboration with other 3GPP participants. We contribute directly to the development of the global 5G NR standardization efforts by generating innovative and impactful designs which will lead to a 5G NR standard specification. Once this is defined, we will begin trials based on 3GPP's 5G NR global standard, with over-the-air trials beginning in 2018 to enable initial 5G rollout and commercialization in 2019.

Our researchers work tirelessly to develop technical contributions for 3GPP meetings frequently held worldwide. They collaborate closely with researchers across multiple companies and geographies and participate in live meetings and teleconferences to discuss and resolve technical issues leading to the standardization of 5G.

Prototyping state-of-the-art 5G NR systems.

We don't just design 5G concepts – we put them to work. Qualcomm Research builds end-to-end hardware, software, and firmware prototypes in conjunction with current 3GPP specifications, enabling us to conduct demonstrations, trials, and interoperability testing with mobile network operators and industry partners. In addition, our 5G prototype systems allow early testing and refinement of key 5G design features, and hasten QCT's effort to bring products to market with significant time-to-market advantage. When designing the 5G NR prototypes, our engineers closely track 3GPP's 5G NR standardization activities, ensuring our prototypes comply with their latest specifications, such as 3GPP's evolving Release 15.

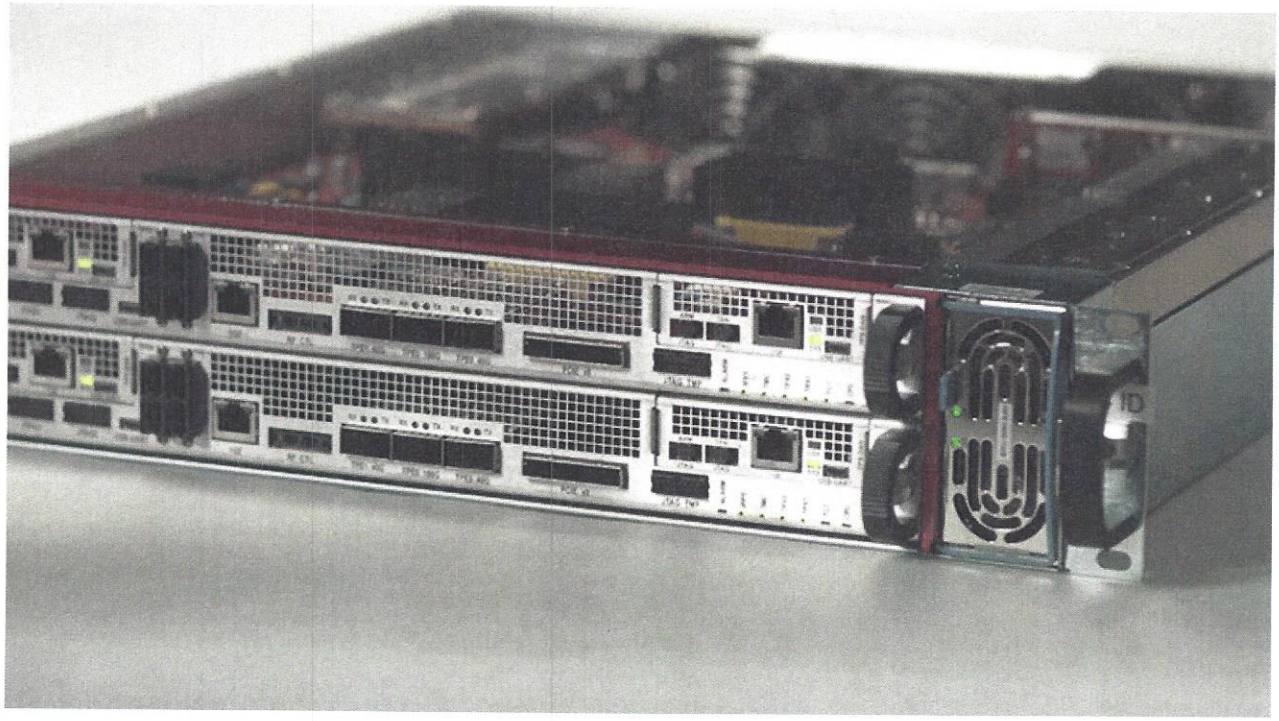
sub-6 GHz 5G NR prototype

Operating in sub-6 GHz spectrum bands, we designed this prototype based on the evolving 3GPP 5G NR specification, including both base station and user equipment (UE) functionalities, to serve as a testbed for verifying 5G NR capabilities. The prototype can achieve multi-Gbps data rates and support ultra-low over-the-air latency (less than a millisecond) than what is possible in today's 4G LTE network. We designed the system to support scalable bandwidth in units of 100 MHz, and incorporate advanced 5G air interface features, including

massive MIMO, advanced coding, and a new self-contained integrated subframe design.

At this year's Mobile World Congress (MWC), we will demonstrate our new 5G sub-6 GHz prototype system, incorporating a number of key 5G NR techniques, including massive MIMO, self-contained integrated subframe, advanced LDPC coding, and scalable OFDM air interface design. These techniques enabled us to significantly improve data rates and coverage while reducing latency for supporting resource-intensive applications, such as UHD video streaming and virtual reality, in typical urban and suburban environments.

Learn more about our sub-6 demonstration



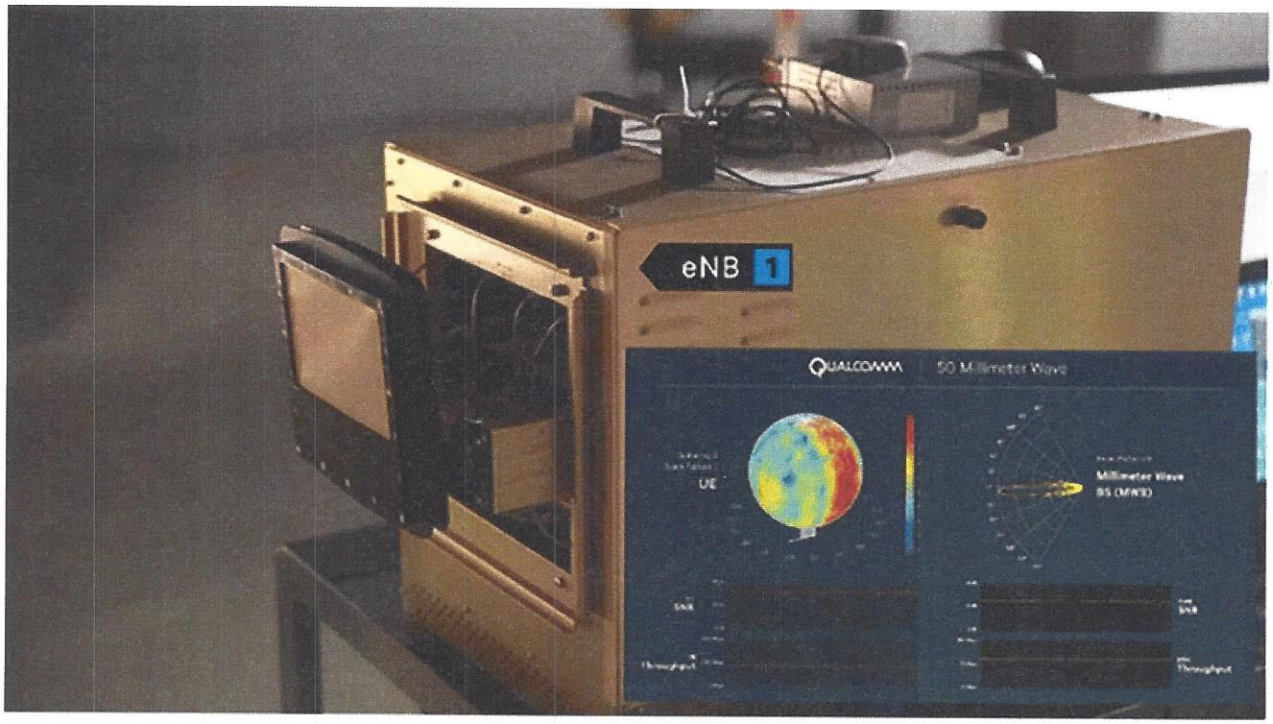
Qualcomm Research's engineering team developed the 5G NR sub-6 GHz prototype system and trial platform to efficiently achieve multi-gigabit per second data rates and low latency.

mmWave 5G NR prototype

Our mmWave prototype operates in the 28 GHz band (one of the candidate mmWave bands for initial 5G deployment) and supports robust mobile broadband communications by leveraging advanced RF techniques that utilize large antenna

arrays to address non-line-of-sight (NLOS) scenarios, improve indoor/outdoor range, and provide seamless mobility.

As we performed extensive mmWave channel measurements and field testing, we demonstrated that reflections (e.g. from nearby buildings) can provide alternative NLOS paths when the line-of-sight path is blocked. Furthermore, our tests demonstrated that the dominant path will be constantly changing based on environment, mobility, and a slew of other factors. To enable sustained broadband communications with mmWave even in NLOS environments, we implemented cutting-edge techniques such as beamforming with continuous **intelligent beam tracking and searching algorithms** to discover and switch to the dominant beam path within and across base stations.



Qualcomm Research demonstrated NLOS operation and robust mobility with its revolutionary 5G NR mmWave prototype system and trial platform, an end-to-end system operating at 28 GHz.

Demonstrating mmWave

In November 2015, Qualcomm Research conducted its first mmWave demonstration for industry analysts in San Diego, where we successfully validated the functionality and performance of our mmWave prototype system. During the

demonstration, we equipped our mmWave base station with 128 antenna elements across 16 controllable RF channels. Additionally, our UE contained four selectable sub-arrays, each with four controllable RF channels. This mmWave demo system supported beamforming and intelligent beam tracking/switching techniques that provided a relatively stable SNR, even when our UE was moved and RF channel conditions changed. Our demonstration GUI clearly showed the system switching between beam patterns (both on uplink and downlink) as our UE moved and environments changed to maintain robust connectivity with the UE.

During the 2016 MWC, we demonstrated that beamforming and intelligent beam tracking/switching could successfully address NLOS scenarios, delivering improved indoor and outdoor coverage.

At this year's MWC demonstration, we proved that mmWave with fast beam tracking can support seamless vehicular and indoor pedestrian mobility of handheld and in-vehicle UEs operating in a real-world environment. During the demonstration, an in-vehicle UE traveled up to 30 mph and successfully maintained robust connectivity using dynamic point (base station) selection in a typical suburban environment while encountering and overcoming various types of obstacles, such as foliage and other vehicles. Learn more about our mmWave demonstration

Shared Spectrum 5G NR prototype

Qualcomm Research designed its 5G NR SS (Shared Spectrum) prototype to maximize usage across all spectrum types (license and unlicensed) and lower bands (sub-6 GHz), and eventually to higher bands (mmWave) to deliver improved mobile broadband performance. We enabled our system to deliver fiber-like experiences and support new types of 5G deployments, such as dedicated 5G networks for enterprise and industrial IoT. We based our design upon our sub-6 GHz end-to-end prototype, and engineered this new prototype with both a base station and UE, allowing it to support Listen-Before-Talk (LBT) technology, wideband waveforms with low latency, and enhancements in radio and network protocols. We designed this as a testbed to drive 5G standardization in spectrum sharing.

Trialing our prototypes.

Qualcomm Research and our collaborators plan to conduct over-the-air field trials and interoperability testing in real-world environments within selected global markets. During the trials, we will demonstrate our prototypes' many features and techniques in concert with our partners' radios and core networks. For example, during mmWave trials, we will utilize adaptive beamforming and beam tracking to enable seamless mobility with extended range even in NLOS environments. We and our partners will also implement a new OFDM-based scalable and flexible air interface framework design that are part of the latest 3GPP 5G NR specifications. The trials are expected to yield valuable insight into the unique challenges of integrating 5G NR technologies into mobile networks and devices.

The data from our joint trials will be shared with 3GPP to support the technical work required for developing the 3GPP Release 15 5G NR specification – the global 5G standard that will make use of both sub-6 GHz and mmWave spectrum bands – which is expected to be completed next year. In order to enable standards-compliant 5G infrastructure and devices to be available shortly after the completion of Release 15, Qualcomm Research and its partners are also driving interoperability in alignment with 3GPP to enable rapid adoption of new 5G standards and timely commercial network launches.

Contact Us

If you find the work we're doing in 5G NR to be exciting, and you have a technical background in 5G NR design, standardization, or prototyping, we'd love to hear from you. Please visit us at www.qualcomm.com/company/careers to submit your resume. When creating your Qualcomm profile, please enter the activity code, "5GNR".

Documents

5G 3GPP-like Channel Models

579 KB | PDF