LightReading LIVE! WEBINAR

The Promise of 5G mmWave – How Do We Make It Mobile?

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Sponsored by Qualcomm

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Today’s Presenters

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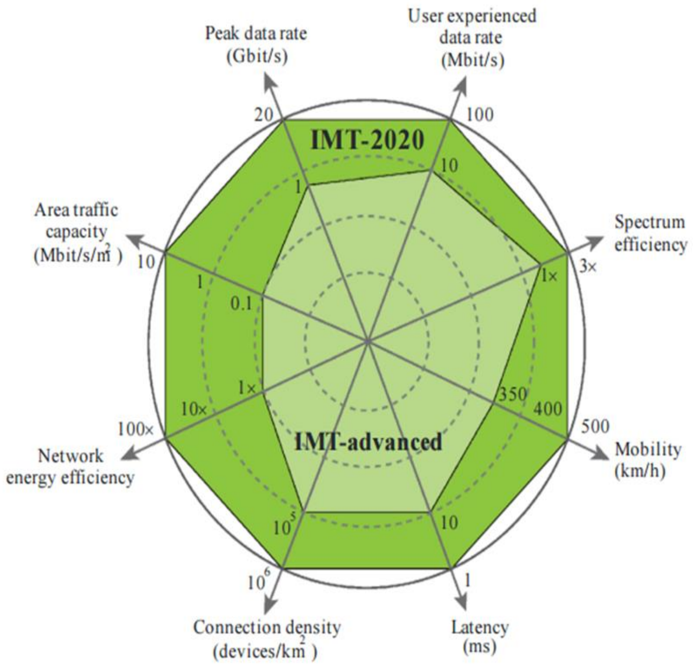
Agenda

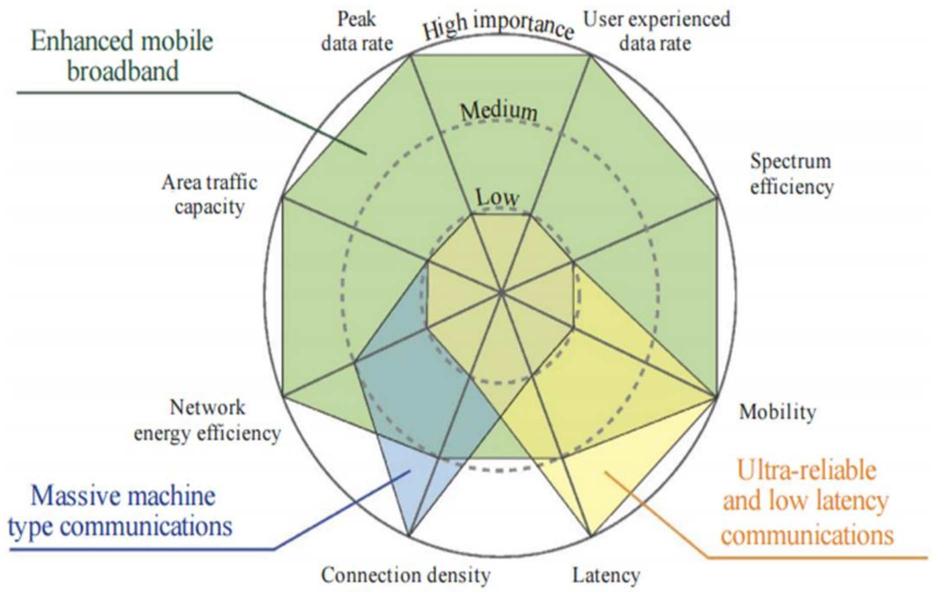
- Background to mmWave in 5G – Heavy Reading
- Mobilizing MmWave – Qualcomm
- A Unified 5G New Radio (NR) – Qualcomm
- Q&A Session

IMT-2020 Performance Targets

Relative to IMT Advanced (4G)

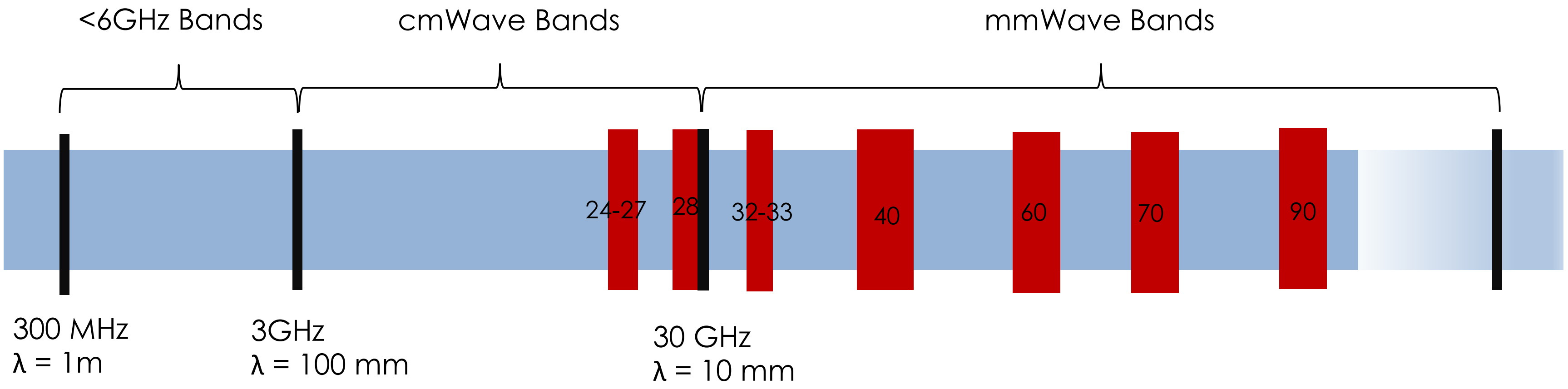


Relative to Major Use Case Categories



Source: ITU Recommendation ITU-R M.2083-0, September 2015

MmWave Bands (>24 GHz)



Massive MIMO possible at shorter λ

Large amount of spectrum above 24 GHz

Wider channels (up to 1GHz)

3G ------- 5 MHz (+CA)
4G ------- 20 MHz (+CA)
5G ------- 500 MHz / 1 GHz

WRC-19 to harmonize internationally

Enabling Mobile MmWave

Better Understanding of MmWave

- Academic research & corporate R&D driving a rethink of mmWave applications
- Previously limited to point-to-point short-range & fixed wireless access

Miniaturization

- Highly complex antenna processing functions embedded in silicon
- Can be integrated into battery-powered handheld devices

Radical Advances in Baseband & RF Processing

- Computation capability embedded in silicon to enable the beam-forming and bream-tracking
- Ability to integrate large number of antenna elements & RF chains into cost effective phased array RFICs

A Halley's Comet Moment

- A once in a lifetime event for RF researchers & engineers
- Opportunity to 'open-up' a vast swath of spectrum for mobile

Operator MmWave Field Tests & Trials

AT&T (U.S.)

- Trials at 15 GHz & 28 GHz
- Test beds at multiple U.S. locations
- Initial focus on fixed access

DOCOMO (Japan)

- Trials at multiple frequencies
- Indoor, outdoor & mobile
  - Results published in DOCOMO Technical Journal

Trials to Inform 3GPP Standards Development

Verizon (U.S.)

- 28 GHz trials with vendors
- Initial focus on fixed-wireless access
- Potential commercial service in 2017 for fixed residential access

National Initiative (Korea)

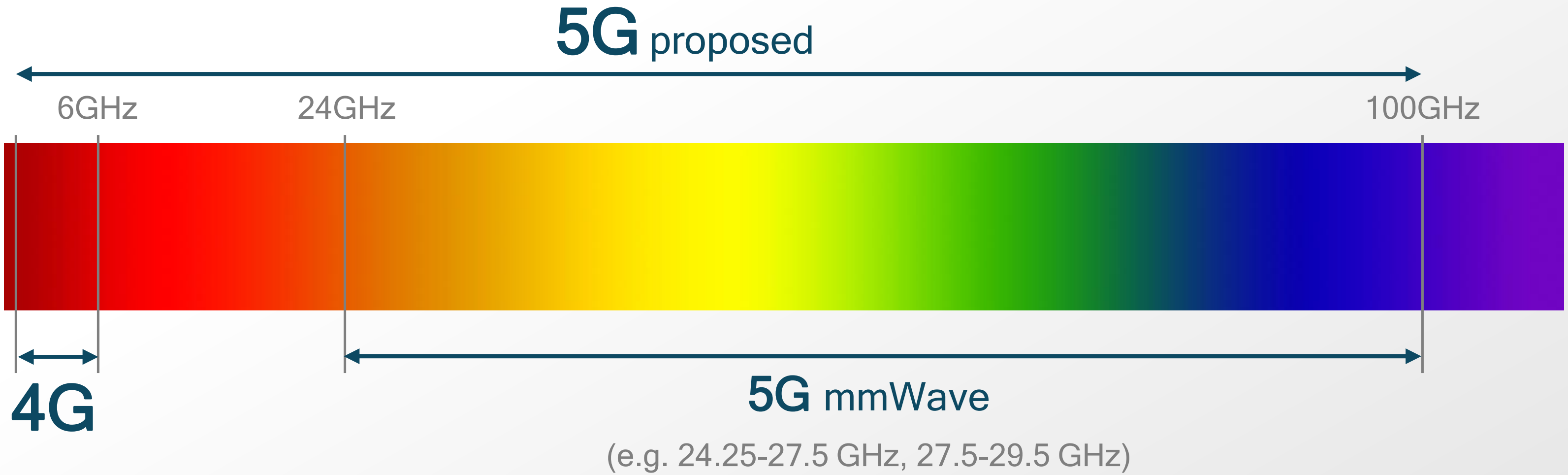
- Consortium of universities, vendors & operators
- Developing mmWave test bed
- Plan to showcase network at 2018 Winter Olympics

Making mmWave a reality for 5G enhanced mobile broadband

With adaptive beamforming and beam tracking

The large bandwidth opportunity for mmWave

The next frontier of mobile broadband for extreme throughput and capacity



Multi-Gbps data rates
With large bandwidths (100s of MHz)

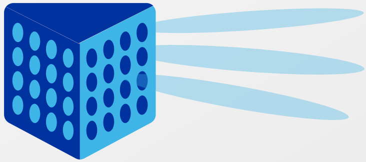
Much more capacity
With dense spatial reuse

Flexible deployments
Integrated access/backhaul

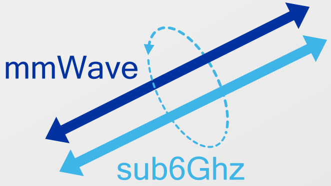
Realizing the mmWave opportunity for mobile broadband

The challenges in mobilizing mmWave

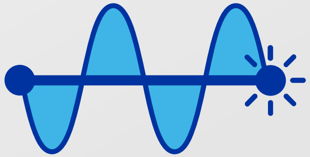
- Robustness due to high path loss and susceptibility to blockage
- Device cost/power and RF challenges at mmWave frequencies



Smart beamforming and beam tracking
Increase coverage and minimize interference



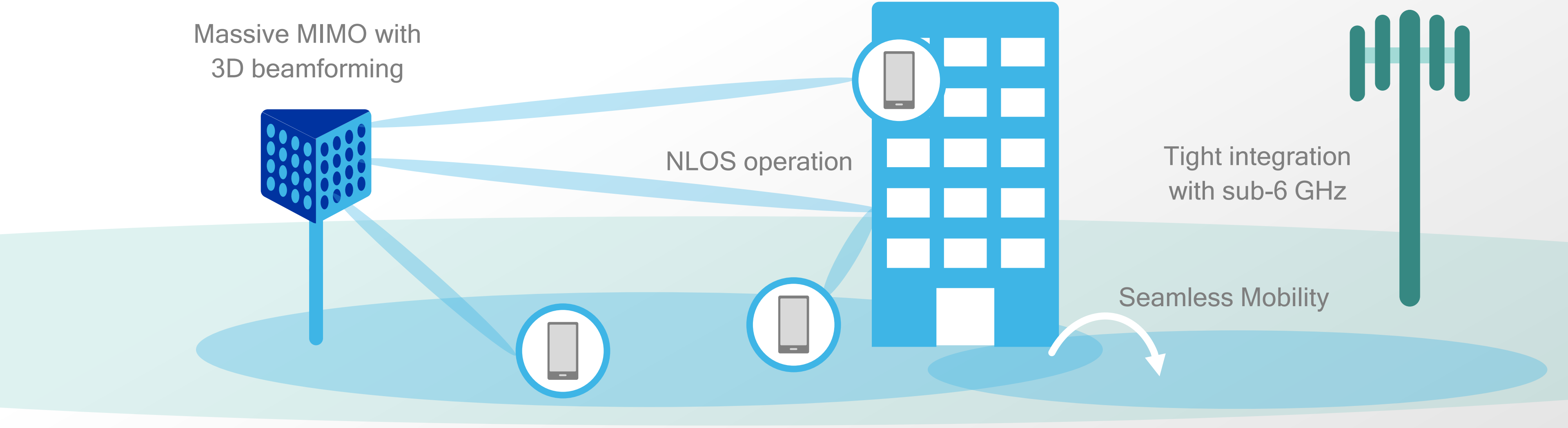
Tight interworking with sub 6 GHz
Increase robustness, faster system acquisition



Optimized mmWave design for mobile
To meet cost, power and thermal constraints

Mobilizing mmWave requires a new system design

Direction antennas with adaptable beamforming and beam tracking

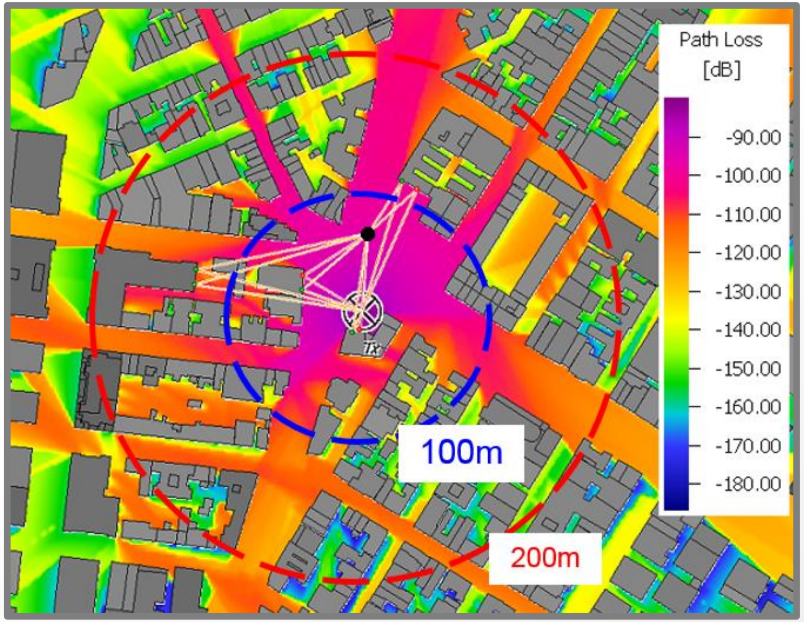


Intelligent beam search and tracking algorithms

Tight integration with LTE or 5G sub-6 GHz

Coordinated scheduling for interference management

Directional beamforming improves mmWave coverage and reduces interference



* Manhattan 3D map, Results from ray-tracing

~150m line-of-sight (LOS) and non-line-of-sight (NLOS) coverage possible in dense urban outdoor deployment

28GHz: Outdoor-to-Outdoor Path Loss & Coverage

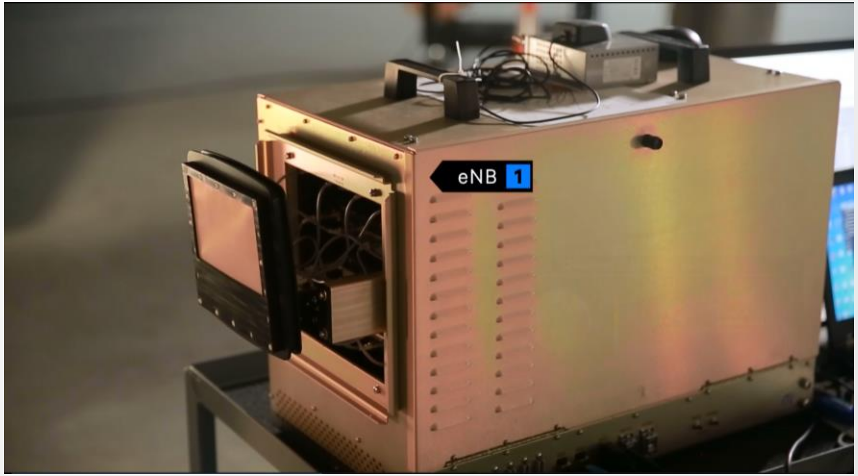
Qualcomm Research 5G mmWave prototype system

TDD synchronous system operating in the 28 GHz band

mmWave User Equipment (UE)

Four selectable sub-arrays, each a phased array with 4 controllable RF channels

mmWave Base Station (eNB)



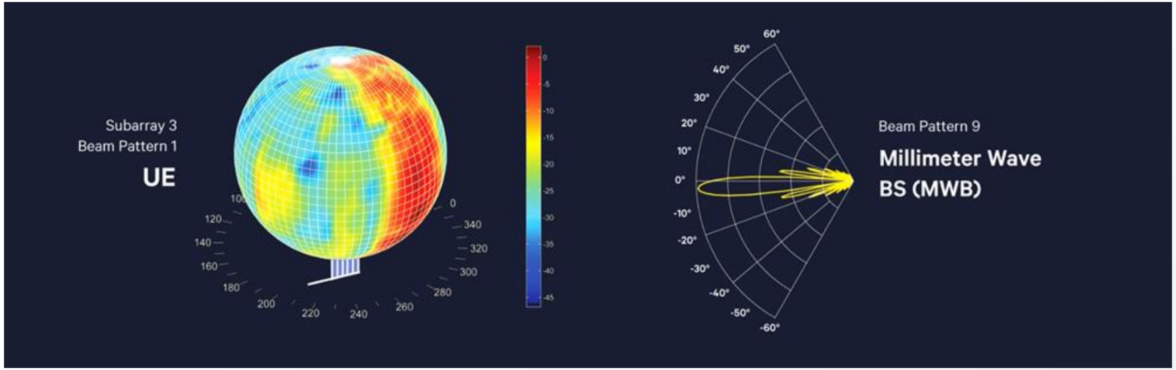
128 antenna elements[1] with 16 controllable RF channels; design to support multiple UEs

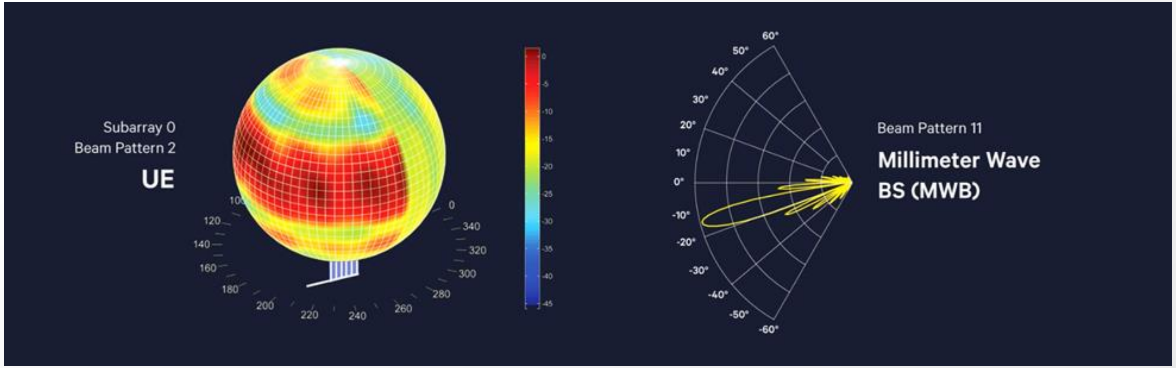
Qualcomm Research is a division of Qualcomm Technologies, Inc.

[1] Commercial base stations could have more antenna elements depending on their size, coverage area, etc.

5G mmWave prototype system GUI

Showcasing adaptive beamforming and beam tracking techniques





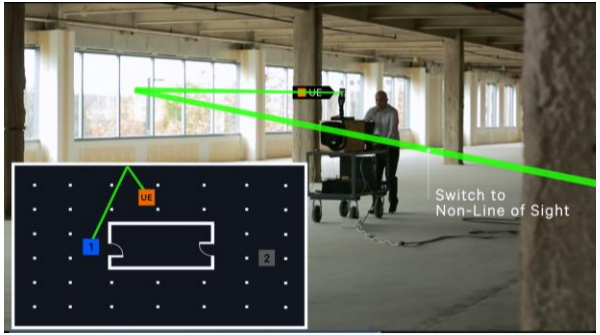
UE intelligently selects the best sub-array on which to receive and transmit

Selected sub-array uses beam-tracking and beam-steering to track the associated beam from eNB

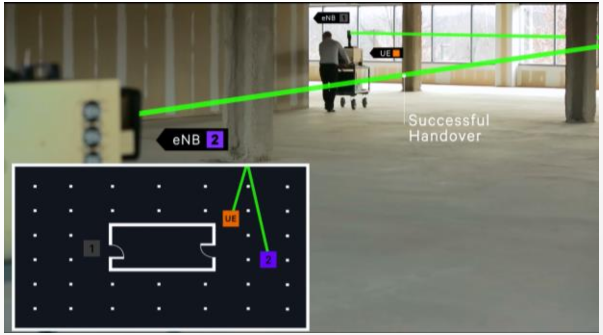
Demonstrates robust mobile broadband communications even under NLOS RF channel conditions and UE mobility

Demonstrating LOS and NLOS coverage

In diverse locations and with device mobility



NLOS coverage through reflection



Indoor mobility and eNB handover

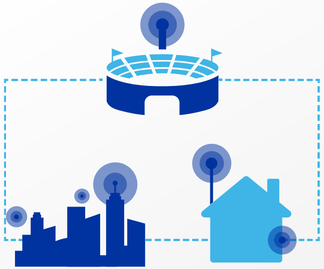
Outdoor mobility

Performing extensive channel measurements & simulations

Across mmWave frequencies

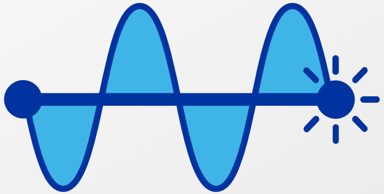
From 22 GHz to 67 GHz, including comparisons with 2.9 GHz

Across deployment scenarios



Outdoor - both high and low density; Indoor - e.g. venue, residential; Outdoor-to-Indoor

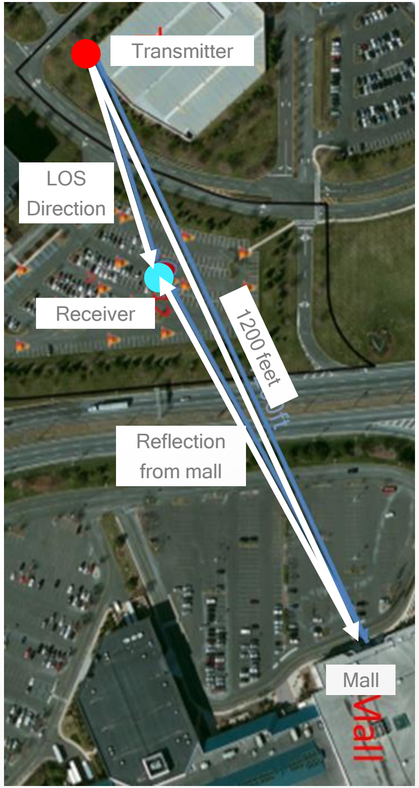
Across different materials



Different foliage/trees, various construction materials, humans, etc.

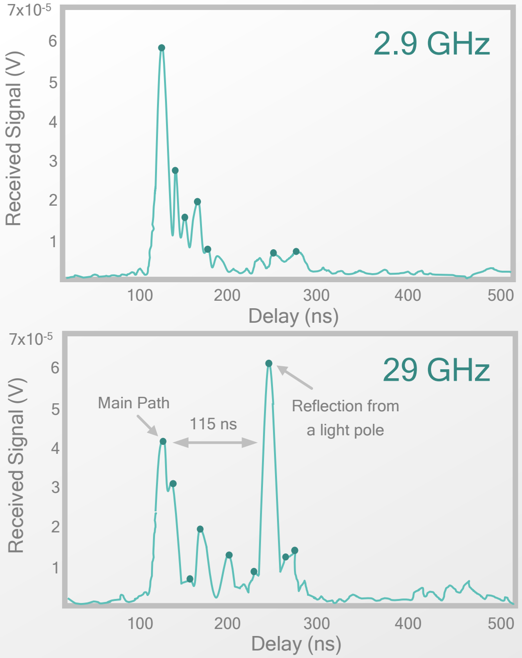
Driving system design/algorithm & 3GPP contributions

Outdoor mmWave propagation measurements



Channel response from omni-directional antennas

(Example measurement)



Key mmWave observations made

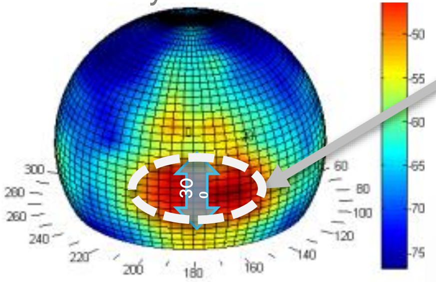
- Additional reflections at mmWave band provide alternative paths when LOS is blocked
- Alternative paths in mmWave can have very large receive signal
- Small objects affect mmWave propagation more than 2.9 GHz[1] (e.g. tree branches)
- mmWave NLOS path loss exponents across frequencies not dramatically different than 2.9 GHz[2]

1 Due to easier diffraction around the objects at lower frequencies; 2 Non-line of sight path loss normalized to 1m antenna distance–actual path loss = [reference loss at 1m for a given frequency] + [normalized Propagation Loss]

Spherical Scan measurements

Indoor Office

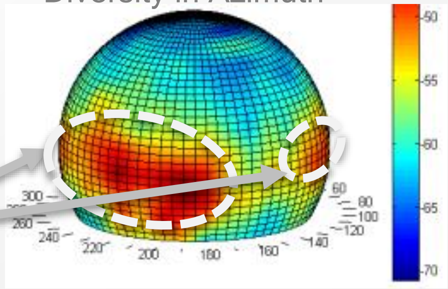
Diversity in elevation



Numerous resolvable paths in elevation

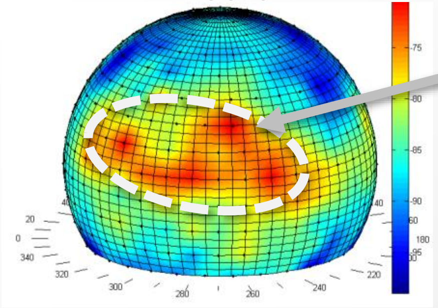
Significant path diversity in azimuth
→ Ability to withstand blockage events

Diversity in Azimuth



Outdoor

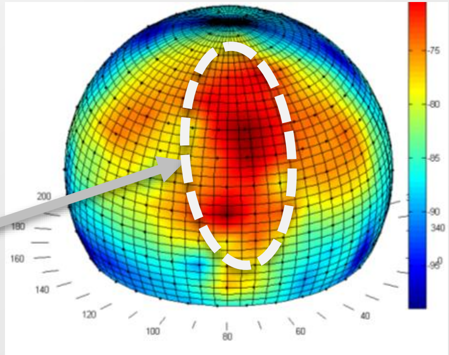
Diffraction



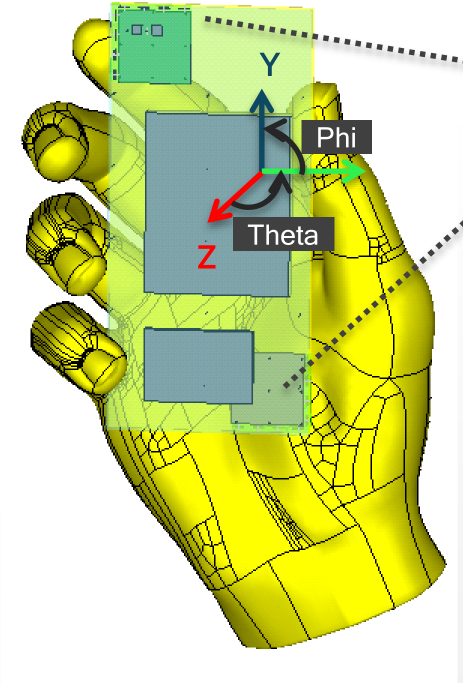
Foliage obstructed diffracted path → Energy spread across wide azimuth

Reflections from tall buildings result in wide elevation spread

Reflection

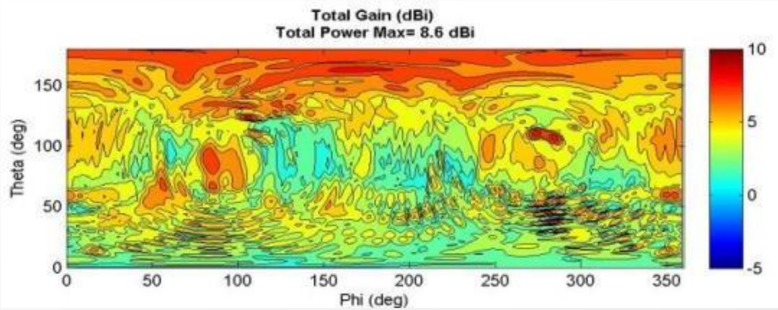


Measuring effect of hand blocking and the role of diversity

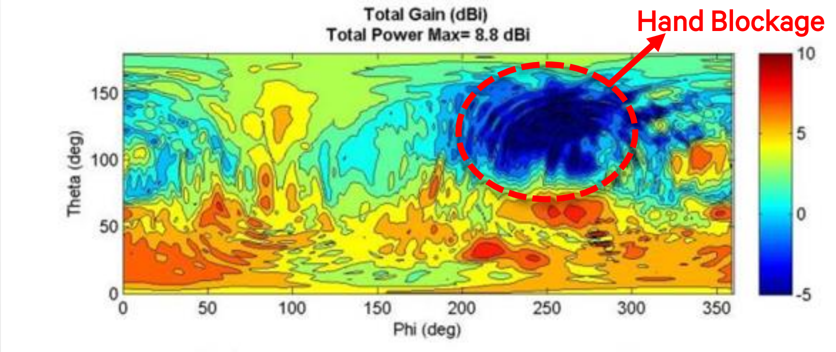


Both corner antennas are operating

No Hand



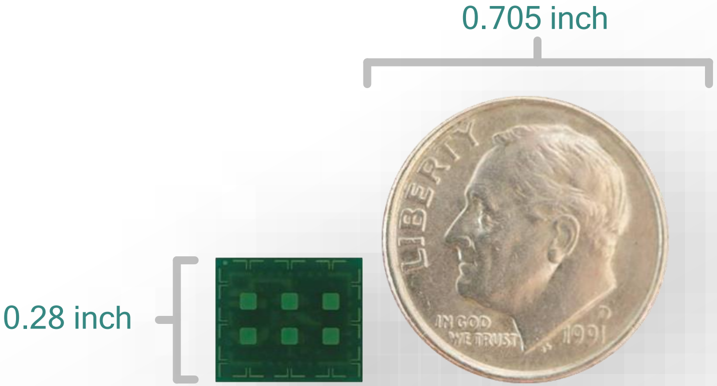
With Hand



Making mmWave a reality for mobile

Qualcomm is driving 5G mmWave

60 GHz chipset commercial today for mobile devices



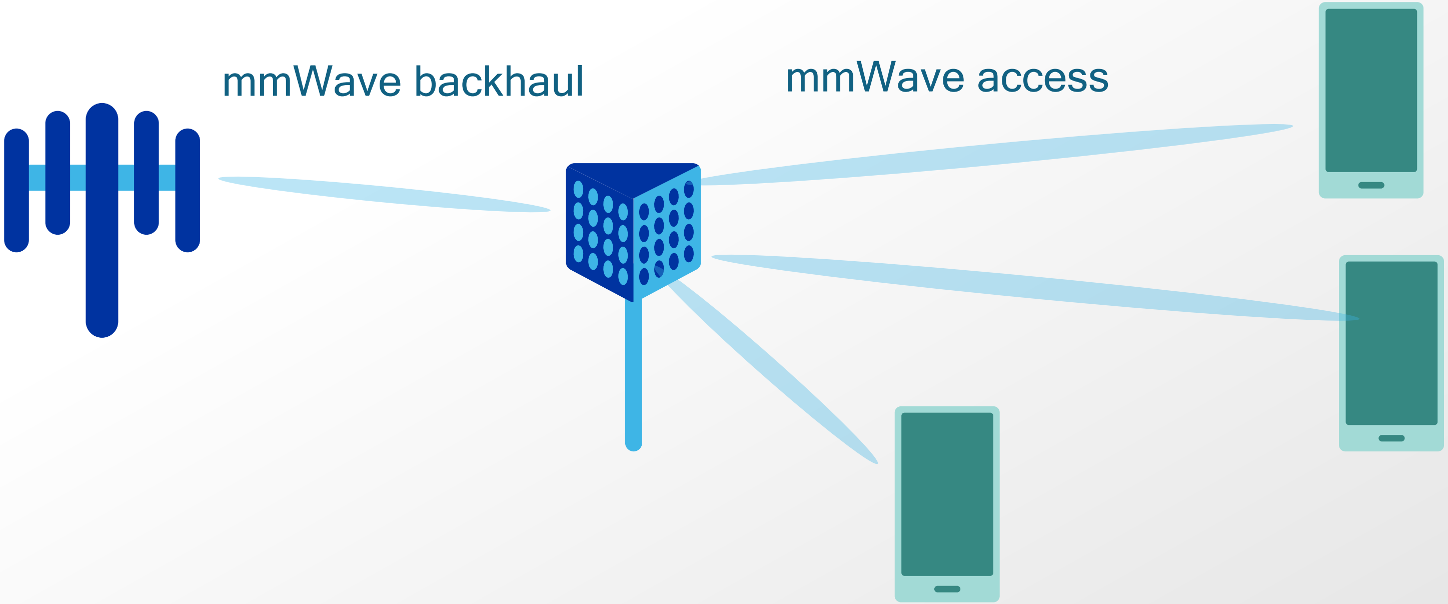
Qualcomm® VIVE™ 802.11ad technology with a 32-antenna array element

Developing robust 5G mmWave for extreme mobile broadband

Qualcomm Research 28 GHz end-to-end prototype system demonstrates beam forming and scanning to address NLOS scenarios, improve indoor/outdoor range, and provide robust mobility

Flexible deployments with 5G mmWave

Integrated access and backhaul simplifies deployment of small cells



Fully flexible resource allocation between access and backhaul

5G mmWave is part of a unified, more capable 5G New Radio (NR)

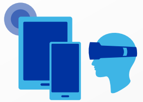
Unified design across all spectrum types/bands

Our 5G vision: a unifying connectivity fabric

5G

Enhanced mobile broadband

- Multi-Gbps data rates
- Extreme capacity
- Uniformity
- Deep awareness

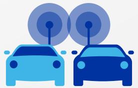


Mobile devices

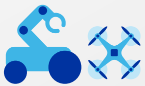
Networking

Mission-critical services

- Ultra-low latency
- High reliability
- High availability
- Strong security



Automotive



Robotics

Health

Massive Internet of Things

- Low cost
- Ultra-low energy
- Deep coverage
- High density

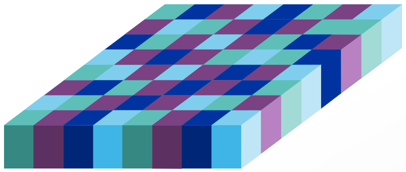
Wearables

Smart cities

Smart homes

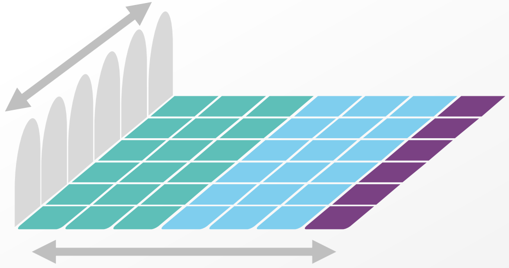
5G NR: A unified air interface for the next decade+

OFDM adapted to an extreme variation of requirements



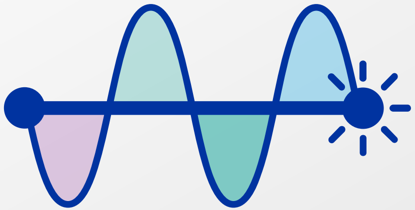
Optimized OFDM-based waveforms

With scalable numerology and TTI, plus optimized multiple access for different use cases



A common, flexible framework

To efficiently multiplex services and features—designed for forward compatibility



Advanced wireless technologies

Such as massive MIMO, robust mmWave and a flexible self-contained TDD design

A unified 5G design for all spectrum types/bands

Addressing a wide range of use cases and deployment scenarios

Licensed Spectrum
Cleared spectrum
EXCLUSIVE USE

Shared Licensed Spectrum
Complementary licensing
SHARED EXCLUSIVE USE

Unlicensed Spectrum
Multiple technologies
SHARED USE

Below 1 GHz: longer range for massive Internet of Things

1 GHz to 6 GHz: wider bandwidths for enhanced mobile broadband and mission critical

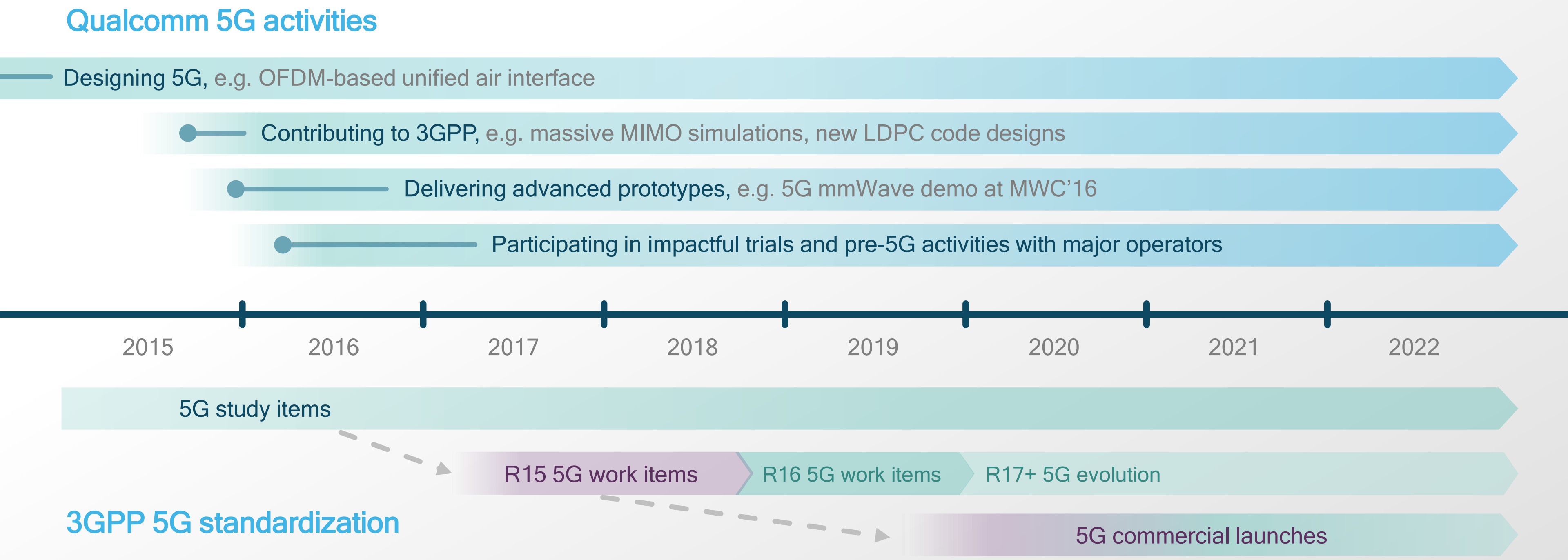
Above 6 GHz, e.g. mmWave: extreme bandwidths, shorter range for extreme mobile broadband

From wide area macro to local hotspot deployments

Also support diverse network topologies (e.g. D2D, mesh)

Qualcomm, leading the world to 5G

Driving 5G from standardization to commercialization



Note: Estimated commercial dates

Thank you

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Q&A