5G eMBB is Here! More 5G is Coming!

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2nd Workshop on 5G Technologies for Tactical and First Responder Networks
The Johns Hopkins University Applied Physical Laboratory
7 October 2019
5G global rollout

30+ launched in 6 months
Faster than 4G
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<th>3.7-4.2GHz</th>
<th>5.9-7.1GHz</th>
<th>24.25-24.45GHz</th>
<th>24.75-25.25GHz</th>
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**Designed for diverse spectrum bands/types**

Global snapshot of 5G spectrum bands allocated or targeted.
5G smartphones

- Lenovo Z6 Pro 5G
- LG V50 ThinQ 5G
- Motorola moto z²/z³ + 5G moto mod
- Nubia Mini 5G
- OnePlus 7 Pro 5G
- OPPO Reno 5G
- Samsung Galaxy S10 5G
- Samsung Galaxy Fold
- Samsung Galaxy Note10+ 5G
- Samsung A90 5G
- Vivo iQOO 5G Edition
- Vivo NEX 3 5G
- Xiaomi Mi MIX 5G
- ZTE Axon 10 Pro 5G

Hotspots and CPEs

- Askey
- Inseego
- HTC
- Netcomm
- Netgear
- Nokia
- WNC
- ZTE

5G modules

- Compal
- Fibocom
- Longsung
- Quectel
- Sierra Wireless
- SIMcom
- Telit

150+ 5G devices launched or in development

Qualcomm Snapdragon is a product of Qualcomm Technologies, Inc. and/or its subsidiaries.
Comprehensive 5G modem-RF solutions

Qualcomm Snapdragon X50 5G modem-RF system

1st gen
- Sub-6 and mmWave
- NSA, TDD, Multi-SIM
- Qualcomm® 5G PowerSave
- Qualcomm® Smart Transmit
- Qualcomm® Signal Boost

Early 2019
First wave of devices

Qualcomm Snapdragon X55 5G modem-RF system

2nd gen
Added features
- Integrated 5G to 2G
- Standalone (SA), FDD
- Dynamic Spectrum Sharing
- Qualcomm® Wideband Envelope Tracking
- Platforms for PC, fixed wireless access, automotive, and more

Late 2019
Second wave

Snapdragon 8,7,6 Series Mobile Platforms

1st half 2020
Broader, faster adoption

System-level integration delivers best-in-class power-efficiency and performance

Qualcomm 5G PowerSave, Smart Transmit, Signal Boost and Wideband Envelope Tracking are products of Qualcomm Technologies, Inc. and/or its subsidiaries
Optimization through co-design of hardware and software

Qualcomm 5G PowerSave, Qualcomm Wideband Envelope Tracking and Qualcomm Signal Boost are products of Qualcomm Technologies, Inc. and/or its subsidiaries.
A technology; a state of mind
A platform for new applications and innovations

Scalable to extreme simplicity

On-device intelligence

Multi-gigabit speed

Extreme reliability

Ultra-low latency

Virtually unlimited capacity
Designing a unified, more capable 5G air interface

Diverse services

High-bands
Above 24 GHz (mmWave)

Mid-bands
1 GHz to 6 GHz

Low-bands
Below 1 GHz

Licensed/shared/unlicensed

Existing, emerging, and unforeseen services - a platform for future innovation
The 5G expansion

- Rel.15 eMBB expansion
- Rel.16-17

- Private networks
- 5G massive IoT
- 5G broadcast
- mmWave evolution, indoor, enterprises
- Sub-6 GHz evolution, new use case
- Fixed wireless access
- Smartphones
- Laptops
- Automotive
- Industrial IoT with eURLLC
- 5G NR C-V2X, smart transportation
- Future verticals, services, devices
- Shared / unlicensed spectrum
- New device classes like tethered XR
- New device classes like boundless XR
5G is the innovation platform for the next decade

- A unified future-proof platform
- Delivering on the 5G vision
- New deployments, new spectrum, new use cases, new verticals...
- Some future requirements only possible on a new platform

Market needs: enhanced/emerging/unknown services to 5G

- Vision forming
- Historically 10 years between generations
- Next technology leap for new capabilities and reduced cost
- Continued evolution

Research: for 5G enhancements and for next gen. leap

Technology breakthroughs, hardware progress, new architectures, distribution of processing/AI/content...
Continuous research, industry first over-the-air LAA, eLAA, MulteFire demos, interoperability with Wi-Fi
Multiple spectrum options
For private 5G networks

**Licensed spectrum by mobile operators**
Operators can allocate spectrum in a specific area

**Dedicated regional spectrum**
Regional spectrum such as 3.7GHz in Germany for IIoT

**Unlicensed spectrum with async sharing**
NR-U with asynchronous sharing work for many applications

**Unlicensed spectrum with synch sharing**
Synchronized sharing can provide reliability and eURLLC for IIoT
Accelerating the expansion of 5G network with small cells

Powered by Qualcomm® FSM™ small cell platforms

Capable of being developed to utilize mmWave and sub-6 GHz

Supporting uniform 5G speeds and experiences, indoors and outdoors

Expected to begin sampling in 2020
Disaggregated Radio Access Networks

- Industry focused on **disaggregation of the radio access network** for 4G+5G
- Goals are to lower cost of network and lessen dependence on traditional infrastructure suppliers
  - Encouraging new suppliers + open source development
- **RAN disaggregation:**
  - Monolithic RAN functions moved to a new disaggregated design allowing the underlying RAN to be more efficiently and flexibly deployed. e.gNB software decoupled from white box hardware.
  - Open standardized interfaces with multiple vendor support.
- Key industry groups are 3GPP, Open RAN Alliance (O-RAN), Telecom Infra Project (TIP) and the Small Cell Forum (SCF)
3GPP and Public Safety

What happened so far, what will happen next..

- 3GPP did extensive work developing public safety related enablers since Rel.12 (for LTE/EPS):
  - New QoS parameters for public safety application
  - Group communication using MBMS
  - Sidelink communication/Proximity Services inc. sidelink relays
  - Mission critical applications (MC PTT, MC Data, MC Video)

- NR and 5G system already supports the related QoS framework for unicast Mission critical applications (since Rel.15) but does not yet support any of the more “advanced” enablers

- For the Rel.17 package which is currently being scoped in 3GPP several of the more advanced enablers required for public safety are considered, namely sidelink communication using NR, multicast/broadcast architecture using NR and 5GS, various forms of sidelink relays
  - Work on sidelink done for V2X in rel.16 will be used as baseline

- 3GPP already has an ongoing activity to adapt existing MC applications to 5GS and potentially expand to new ones also
Enhanced network communication
Faster access to cloud for in-vehicle experiences, car OEM services and telematics

New direct communication
V2V, V2I, and V2P communications for latency-sensitive use-cases, e.g. collision avoidance

Massive Internet of Things
Deeper coverage to connect road infrastructure (e.g. sensors and traffic cameras)

3GPP is Enhancng C-V2X (Rel. 14/15 LTE-V2X) by NR-V2X
**Rel-14 C-V2X**
Broadcast without feedback, which can’t ensure reliability.

**Rel-16 5G NR C-V2X**
Multicast with feedback for higher reliability; if signal can’t be decoded, NACKs are sent on the same radio resources (SFN-like approach).

**Multicast support for higher reliability**
HARQ feedback to achieve higher reliability | Introducing efficiency by sending only NACKs using SFN
Connectionless ‘on-the-fly’ distance-based groups

Vehicles within a certain distance and interested in same services form a group
5G NR C-V2X builds on existing frameworks and facilitates a new paradigm of communication design.

Facilitating a new paradigm of communication design
- Efficient sidelink link level design for optimized performance at all speeds
- Connectionless ‘on-the-fly’ distance-based groups
- Multicast with distance-based reliability and application relevancy

Adapting R15 5G NR flexible framework to vehicles
- Scalable OFDM-based air interface
  - Such as wideband carrier support (>20 MHz) and different sub-carrier spacing
- Flexible slot-based framework
  - Such as adding sidelink and dynamic reference signal for various speed
- Advanced channel coding
  - State of the art LDPC/polar coding to deliver performance

Building on R14/15 C-V2X framework with backward compatibility
- Such as frequency division multiplexing, guaranteed latency performance and prioritization support
Expanding 5G with the flexible slot-based framework

- Dynamic spectrum sharing (Rel-15+)
- Broadcast/enTV (Rel-16+)
- Cellular V2X–network side shown (Rel-16+)
- Wide-area mission-critical (Rel-15/16+)
- Massive IoT (Rel-16+)

- 5G NR eMBB
- LTE
- Sidelink
- Blank subcarriers
- C-V2X
- Blank slot
- Broadcast/enTV
- Cellular V2X
- Integrated access and backhaul (Rel-16+) for mmWave only (not shown)

- Enhanced mobile broadband (Rel-15+)
- Sidelink (Rel-17+), e.g., for offload
- Unknown service not yet defined

- Expanding 5G with the flexible slot-based framework

- NR-Light
- eMTC
- NB-IoT
- Massive IoT

- NR-Light (Rel-17+)
Thank you

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