5G Standards Developments in 3GPP Release 16 and Beyond

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September 24, 2020

Agenda

Opening/Overview

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Services

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Systems Architecture and Core Networks

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3GPP SA2 Chairman

Radio Access Network

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Long Term Outlook

Q&A: *Please submit questions via chat during the webinar*

ATIS and 3GPP

- ATIS is a founder of, and the North American Organizational Partner (OP) for, the 3rd Generation Partnership Project (3GPP)
  - Recognizing the value of globally aligned mobile standards that meet regional needs
- Broad ecosystem of members addressing the information and communications (ICT) industry's top challenges
- History of advancing cooperative solutions between industry and government
- Supports members in incorporating regional requirements and technology proposals in 3GPP specifications

Managing 3GPP's Work During Covid-19

- Since May 2020, 3GPP replaced all face-to-face meetings with online working
  - Expected to continue in to 2021
- Productivity is better than many people expected, but not as good as face-to-face meetings
  - Corridors and bars are very effective locations for technical discussions!
- We are still improving the tools and working methods.
  - Some degree of online work will likely outlast the current crisis

Delivering on the 5G vision

$13.2 Trillion in global economic value by 2035*

* The 5G Economy, an independent study from IHS Markit, Penn Schoen Berland and Berkeley Research Group, commissioned by Qualcomm

Slide source: Qualcomm

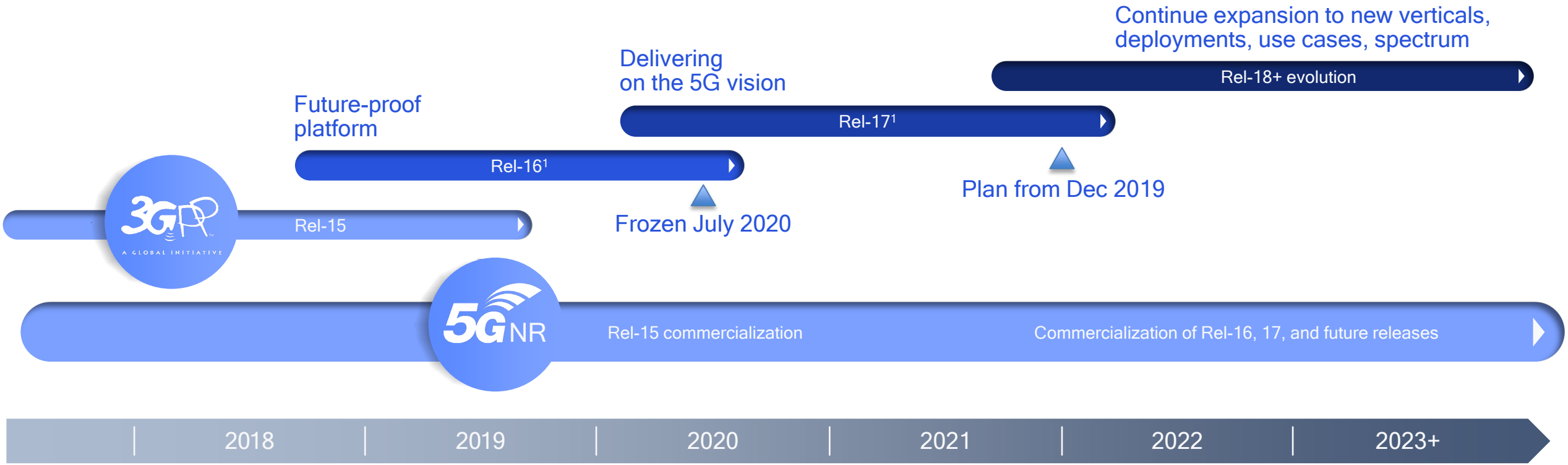
Slide source: Qualcomm

Sources - 5G commercial networks and operators investing in 5G: GSA and operator announcements, Apr. '19; 5G device shipment projections: Qualcomm estimates (2020 projection is at mid-point of guidance range), Nov. '19; 5G connection projections: 2023 - GSMA Intelligence (Dec. '19); ABI (Nov. '19); 2025 - ABI (Oct. '19), CCS Insight (Oct. '19), Ericsson (Nov. '19)

5G momentum accelerating globally

Driving 5G Technology Evolution

Slide source: Qualcomm



Rel-15 eMBB focus

- 5G NR foundation
- Smartphones, FWA, PC
- Expanding to venues, enterprises

Rel-16 industry expansion

- eURLLC and TSN for IIoT
- NR in unlicensed (NR-U)
- Positioning
- 5G V2X sidelink multicast
- In-band eMTC/NB-IoT

Rel-17+ long-term expansion

- Lower complexity NR-Light
- Boundless extended reality (XR)
- Higher precision positioning and more…

1 3GPP start date indicates approval of study package (study item → work item → specifications), previous release continues beyond start of next release with functional freezes and ASN.1

atis

Services

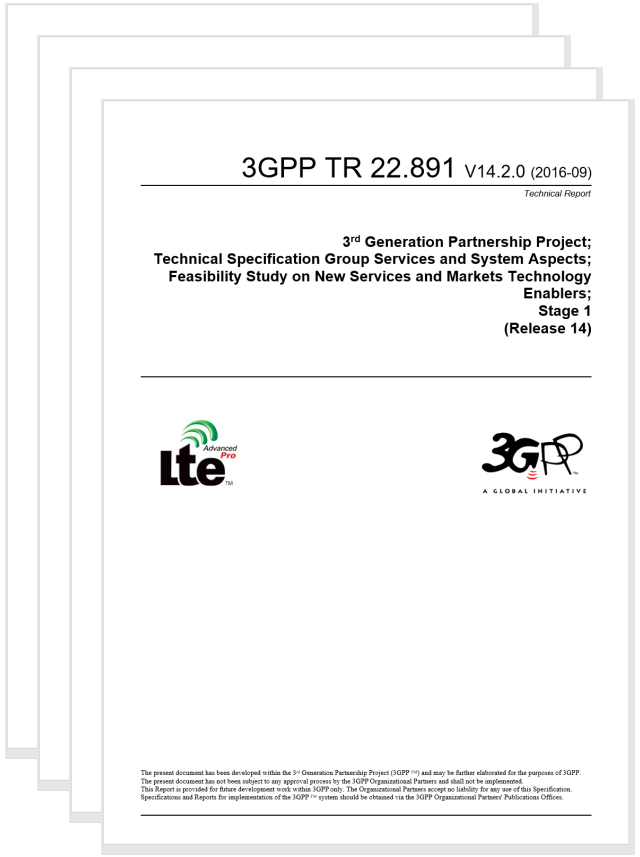
Greg Schumacher
Global Standards

T-Mobile™

September 24, 2020

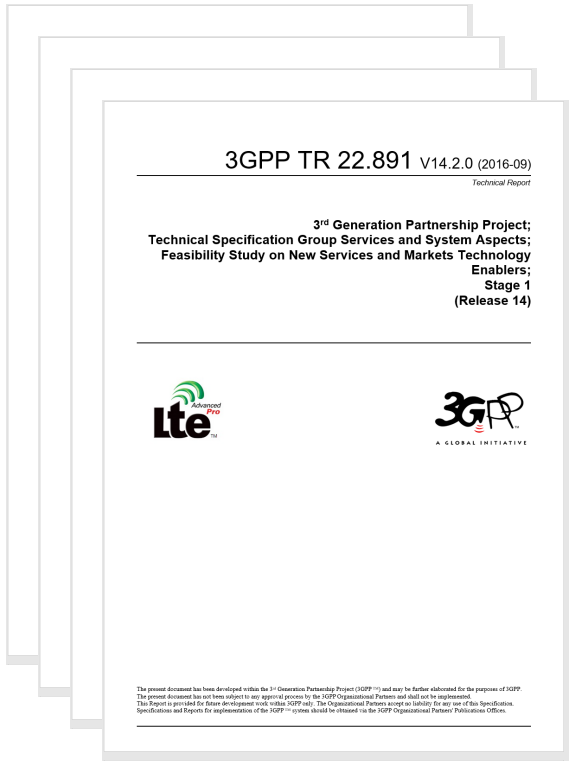
3GPP SA 1
SMARTER (5G Services)
- Initial effort
Release 14 & 15

SMARTER Study – Release 14



- Started in 2015
- Based on 5G whitepapers and company contributions
- Consolidated into 74 use cases with potential requirements

SMARTER Study – Release 14

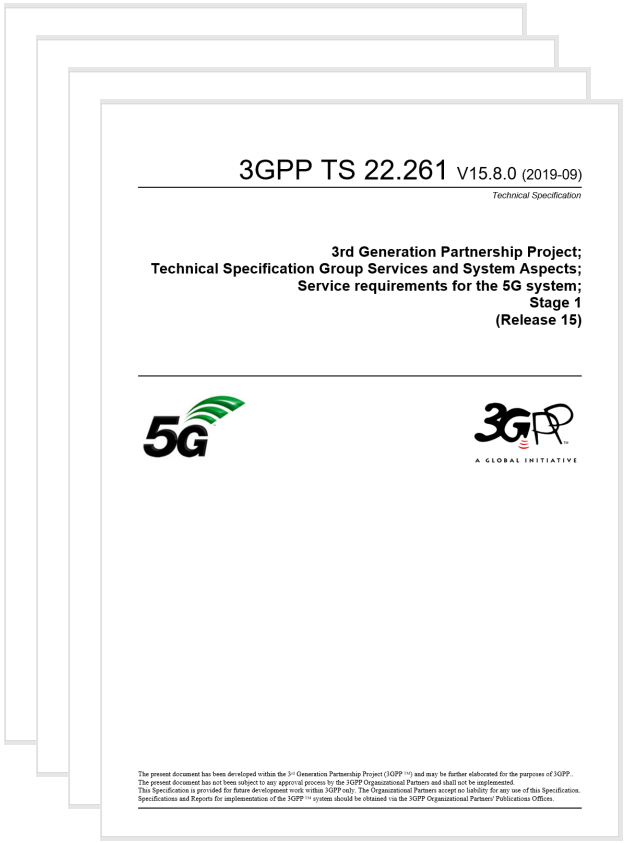


- Conclusions and recommendations
  - Organized into 4 areas
  - Massive IOT
  - Critical Communications
  - Enhanced Mobile Broadband
  - Network Operations

Initial 5G Services - Summary

- Massive IOT
  - Supporting larger numbers of IOT devices ranging from simple to complex communication
  - Non-time critical communication such as smart wearables
- Critical Communications (commercial and public safety)
  - Factory and process automation/VR/AR/Mission Critical
  - Range from higher reliability, availability and lower latency to ultra high reliability, availability and ultra low latency
- Enhanced Mobile Broadband
  - Larger range of data rates
  - Larger density ranges (very sparse to very dense)
  - Increased coverage in challenging environments such as indoors
  - Higher user mobility speeds
- Network Operations
  - Increased flexibility such as slicing for serving market segments and verticals
  - Increased scalability
  - Support for an increased variety of mobility scenarios
  - Self back hauling
  - Increased access options such as by satellite

5G Services – Release 15


3GPP TS 22.261 V15.8.0 (2019-09)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Services and System Aspects;
Service requirements for the 5G system;
Stage 1
(Release 15)

5G

3GPP
A GLOBAL INITIATIVE

The present document has been developed within the 3rd Generation Partnership Project (3GPP™) and may be further elaborated for the purposes of 3GPP.
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This Specification is provided for future development work within 3GPP only. The Organizational Partners accept no liability for any use of this Specification.
Specifications and Reports for implementation of the 3GPP™ system should be obtained via the 3GPP Organizational Partners' Publications Offices.

- 5G phase 1 – normative specification of 5G service requirements
- Incorporated into TS 22.261
- Following releases enhance and extend 5G services as additional services and verticals are identified

3GPP SA 1 5G Services - Enhancement Release 16 - Today

3GPP SA 1 Service Development Approach

- Identify a feature, capability or vertical segment for 5G support
- Collect illustrative use cases along with proposed service requirements and KPIs
- Consolidate proposed service requirements and KPIs and categorize by support/not supported by current 5G specifications
- Based on the study, add the normative service requirements and KPIs not supported by current 5G specifications to new or existing normative stage 1 specifications

5G Services – Release 16

- Additional verticals
  - Vertical industries using cyber-physical control (real-time) – such as industrial processes and factories
  - Railways
  - Maritime communication
  - Extending business role models supported by slicing and non-public networks
  - Satellite access
  - Non-public networks - dedicated networks such as used by factories, enterprise campus, building automation
- Additional service capabilities
  - Enhanced messaging to support 5G IOT
  - V2X enhancements in 5G
  - Precise location services for factory and industrial processes
  - Support user centric identifiers and authentication
  - VR (KPIs)

5G Services – Release 17

- Release 17 features were prioritized, stage 1 work is complete, stage 2 & 3 is under development. Further feature reduction is possible but not currently planned
- Additional verticals
  - AV production such as sports events
  - Asset tracking such as warehouse or container port
  - Critical medical applications
- Additional service capabilities
  - Network controlled interactive services

5G Services – Release 18

- Stage 1 on Release 18 just started, if more projects are agreed, SA 1 will undertake prioritization and this list may change
- Additional verticals
  - Access to localized services such as in arena sport event broadcasts
  - Timing and synchronization as a service
  - Smart power grid
- Additional service capabilities
  - Vehicle mounted relays
  - AI/ML model transfer and distribution
  - Personal IOT networks (home IOT/wearables)

Further Reading

- High level summary of the major changes and additions in a 3GPP release
  - 3GPP TR 21.915 Release 15 Description; Summary of Rel-15 Work Items
  - 3GPP TR 21.916 Release 16 Description; Summary of Rel-16 Work Items
  - Newer release summaries will be made available around the time of release completion

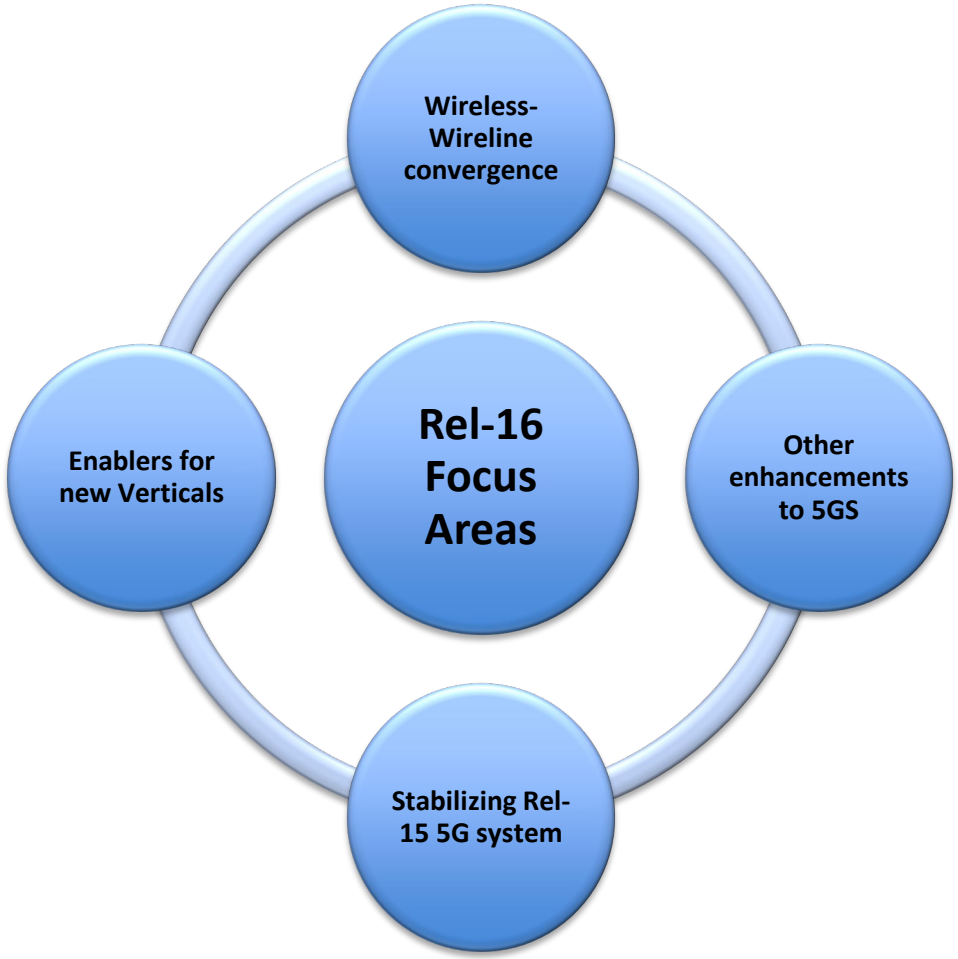
System Architecture and Core Network

Puneet Jain
Principal Engineer and Director of Technical Standards
3GPP SA WG2 Chairman

September 24, 2020

Rel-16 Focus Areas

- The Rel-16 work can be informally grouped into several "focus areas":
  - **5G System (5GS) enablers for new verticals** e.g.
    - Cellular Internet of Things (CIoT)
    - Industrial IoT, including 5G LAN Type service, Time Sensitive Networking (TSN), Non-Public Networks (NPNs), and Ultra Reliable and Low Latency Communication (URLLC)
    - Vehicle-to-Anything (V2X) communication
  - **Wireless Wireline Convergence** (5WWC), including support for Access Traffic Steering, Switching and Splitting (ATSSS)
  - **Other 5GS enhancements** e.g. enhancements for Network Analytics (eNA), optimized UE radio capability signaling (RACS), enhanced Network Slicing (eNS), enhanced Service Based Architecture (eSBA), Single Radio Voice Call Continuity (5G-SRVCC), enhanced Location Services (eLCS)
  - **Stabilizing the Rel-15 5G System specifications**

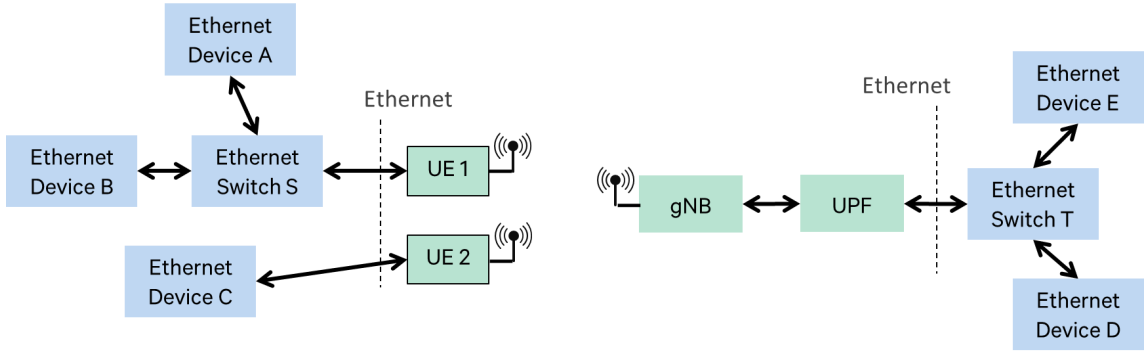


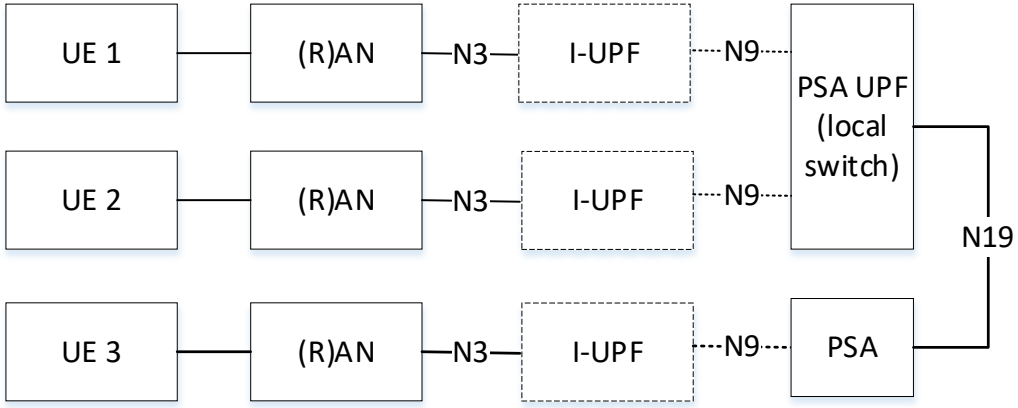
Cellular IoT Support and Evolution for the 5G System

- Control Plane CIoT 5GS Optimisation
- User Plane CIoT 5GS Optimisation
- Early Data Transmission (EDT)
- Preferred and Supported Network Behaviour
- The Non-IP Data Delivery (NIDD)
- Reliable Data Service (RDS)
- Extended Discontinuous Reception (DRX) for CM-IDLE and CM-CONNECTED with RRC-INACTIVE
- Enhancements for the Mobile Initiated Connection Only (MICO) mode
- High Latency Communication
- Support for Monitoring Events
- Enhanced Coverage
- Serving PLMN rate control
- Small Data Rate Control
- Congestion control
- Service Gap Control
- Inter-UE QoS for NB-IoT

5G LAN-Type Service

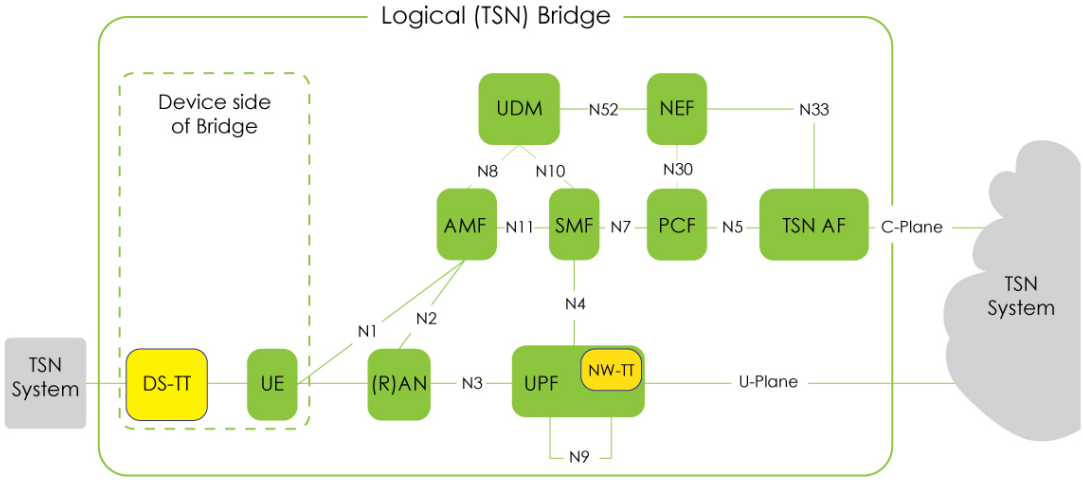
- **5G LAN-type service** provides services with similar functionalities to Local Area Networks (LANs) and VPN's but improved with 5G capabilities (e.g., high performance, long distance access, mobility and security).
- The 5G LAN type service enables **management of 5G Virtual Network (**VN) Group identification, membership and group data.
- 5GS supports optimized routing by enabling support for local switching at the UPF without having to traverse the data network for UE-UE communication when the two UE(s) are served by the same User Plane Function.





Support for Time-Sensitive Communication

- **Support of the fully centralized IEEE TSN configuration model (IEEE 802.1Qcc)**
  - The 5GS architecture for TSN support is largely over-the-top because the TSN-related functionality is primarily confined to TSN Translator (TT) functions at the 5GS ingress points (AF, UPF, UE).
- **IEEE 802.1AS-based time synchronization**
  - Rel-16 supports only "downlink synchronization" i.e. scenarios with TSN GM clock residing on the network side.
- **QoS support for TSN traffic**
  - 5GS supports Time-aware scheduling (IEEE 802.1Qbv) and PFSP (Per Stream Filtering and Policing) capabilities (IEEE 802.1Qci).

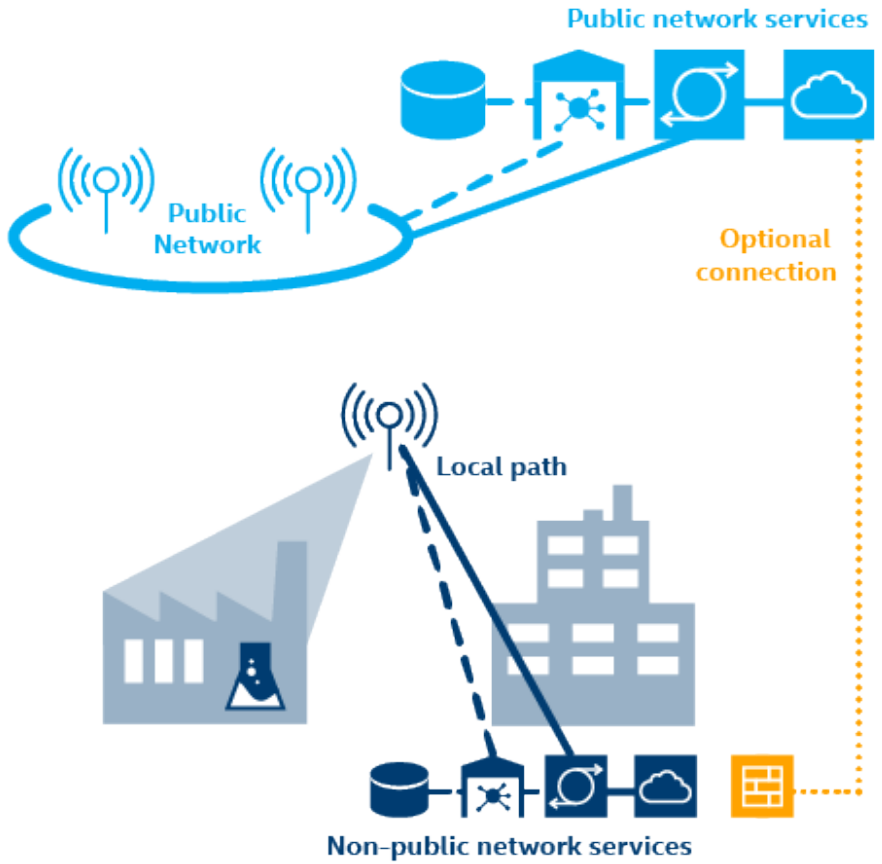


System architecture view with 5GS appearing as a Time-Sensitive Networking bridge

TS 23.501

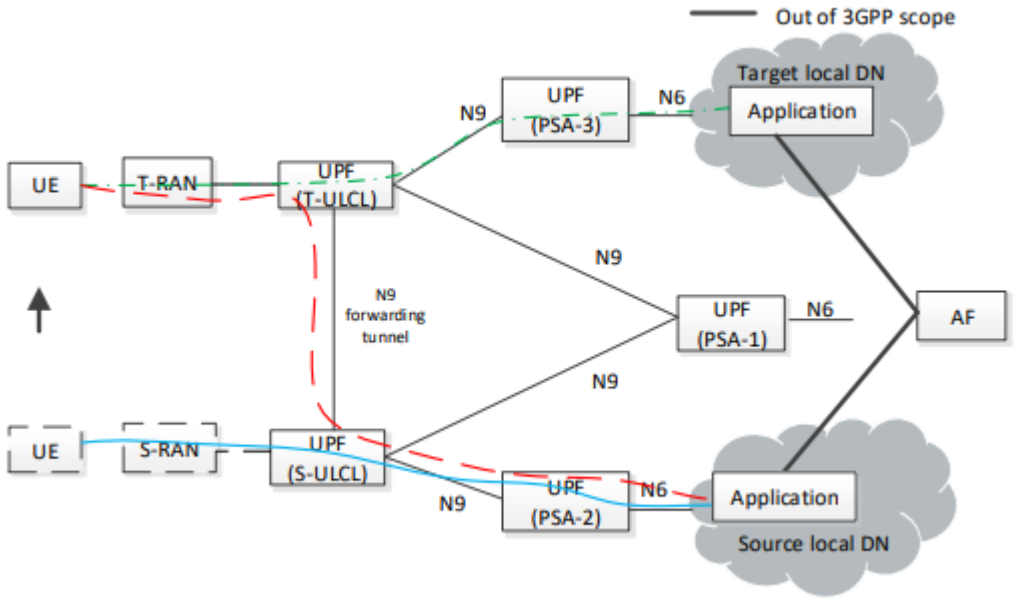
Support for Non-Public Networks

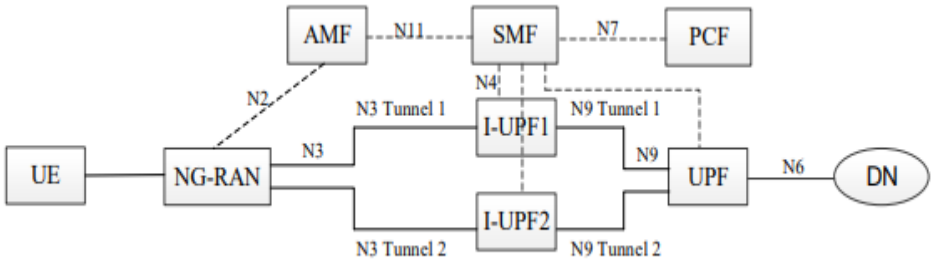
- A **Non-Public Network (NPN)** enables deployment of 5G System for private use. An NPN may be deployed as:
  - a **Stand-alone Non-Public Network (SNPN)**: operated by an NPN operator and not relying on network functions provided by a PLMN, or
  - a **Public Network Integrated NPN (PNI-NPN)**: a non-public network deployed with the support of a PLMN.
- An SNPN is identified by a combination of PLMN ID and NID (Network identifier).
- SNPN RAN broadcasts PLMN ID and NID in the System Broadcast enabling network (re-)selection, overload control, access control and barring.
- **PNI-NPNs** are NPNs made available via PLMNs e.g. by means of dedicated DNNs, or by one (or more) Network Slice instances allocated for the NPN. Closed Access Groups (CAG) may optionally be used to apply access control.

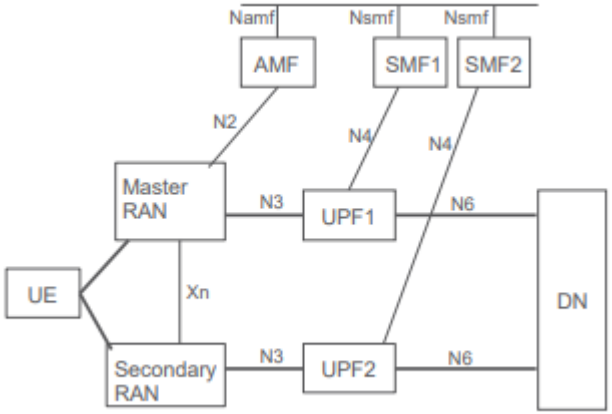


Enhancement of Ultra-Reliable Low-Latency Communication

- **Enhancements of session continuity**
  - PSA relocation for Ethernet PDU Session.
  - Enhancements for ULCL relocation
  - Enhancements to AF-influenced traffic routing mechanism
- **QoS Monitoring**
- **High reliability by redundant transmission in user plane**
  - Dual-connectivity-based end-to-end redundant user plane paths
  - Support of redundant transmission on N3/N9 interfaces
  - Support of redundant transmission at transport layer

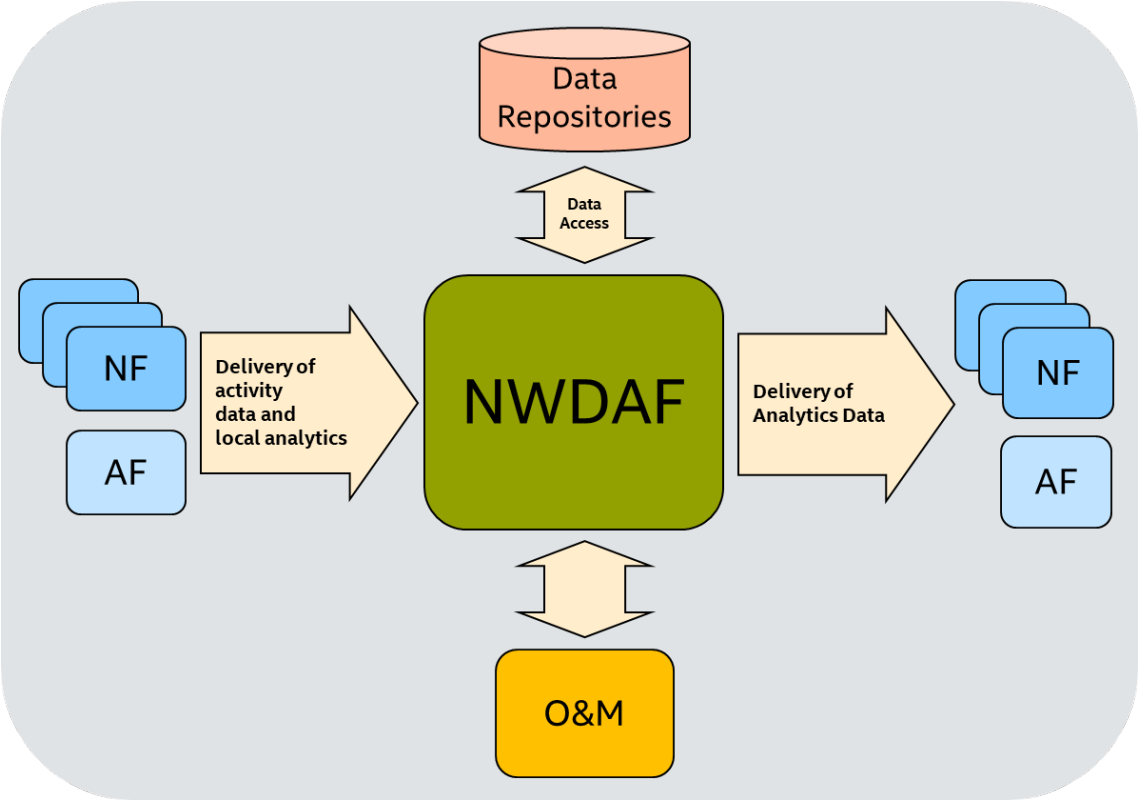






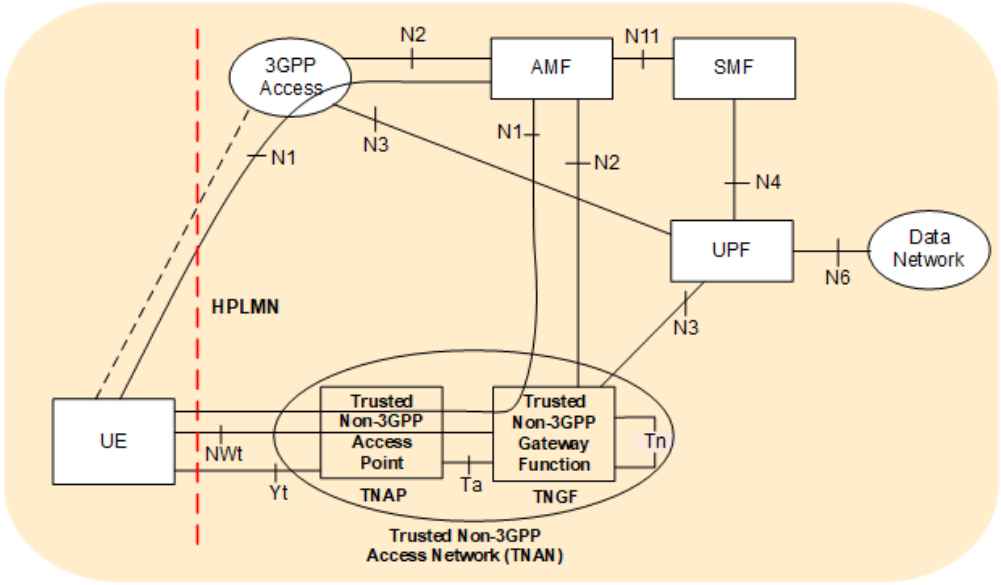
Enablers for Network Automation for 5G

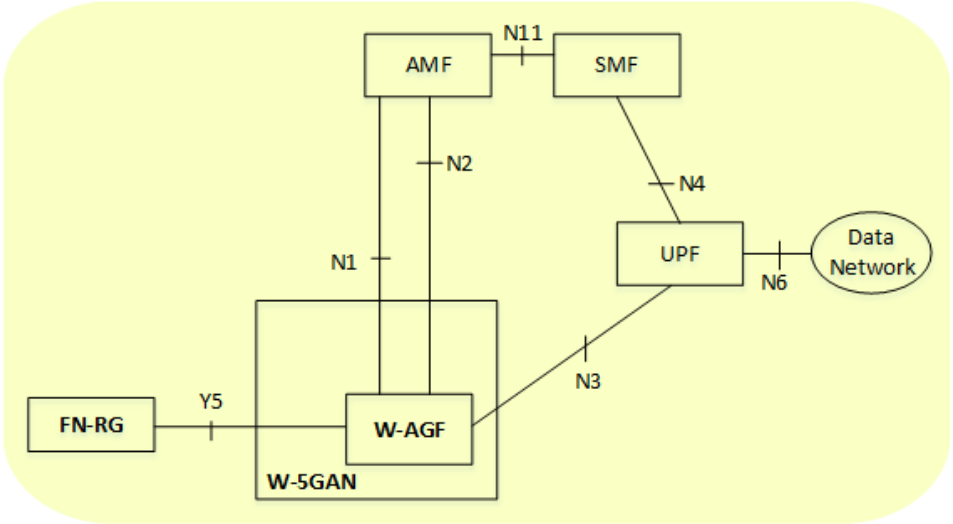
- **Network Data Analytics Function** (NWDAF) was defined to provides analytics to 5GC Network Functions (NFs), and OAM.
- The **NWDAF** supports of following services in Rel-16:
  - Slice load level related network data analytics
  - Observed Service experience related network data analytics
  - NF load analytics
  - Network Performance analytics
  - UE related analytics
  - User Data Congestion analytics
  - QoS Sustainability analytics

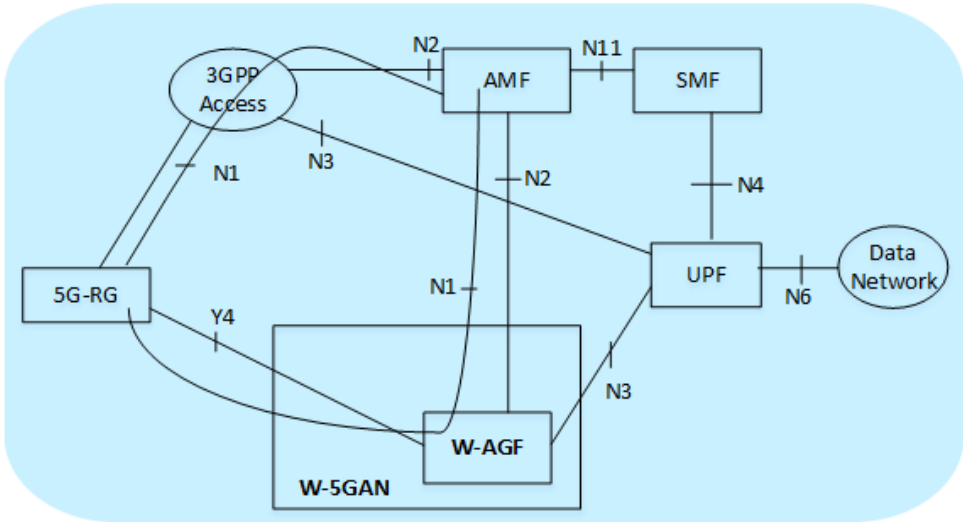


Wireless and Wireline Convergence for 5G System

- Support for **Trusted Non-3GPP Access Network** (TNAN).
- Residential Gateway (5G capable and legacy RG) capable of connecting via wireline access networks defined by BBF to the 5GC.
- Residential Gateway capable of connecting via NG RAN to the 5GC.
- Residential Gateway capable of connecting simultaneously via both 5G RAN and wireline access to 5GC.
- 5GC capable UE and UE not supporting NAS behind Residential Gateway capable of connecting via wireline access network or NG RAN to the 5GC.
- IPTV service defined by BBF for Residential Gateway connected to Wireline Access Network and to NG RAN.

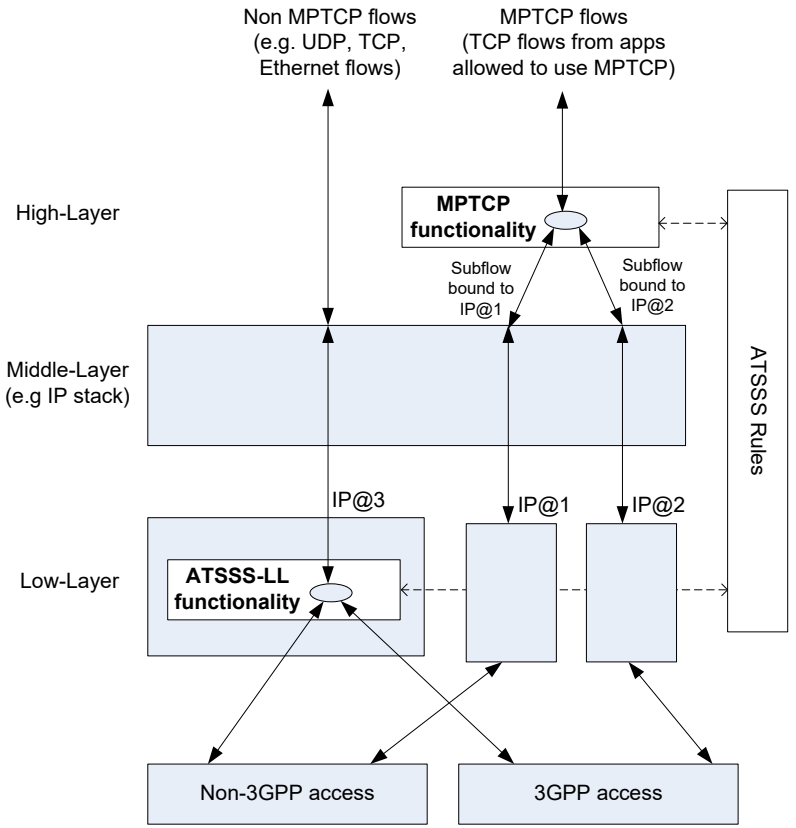






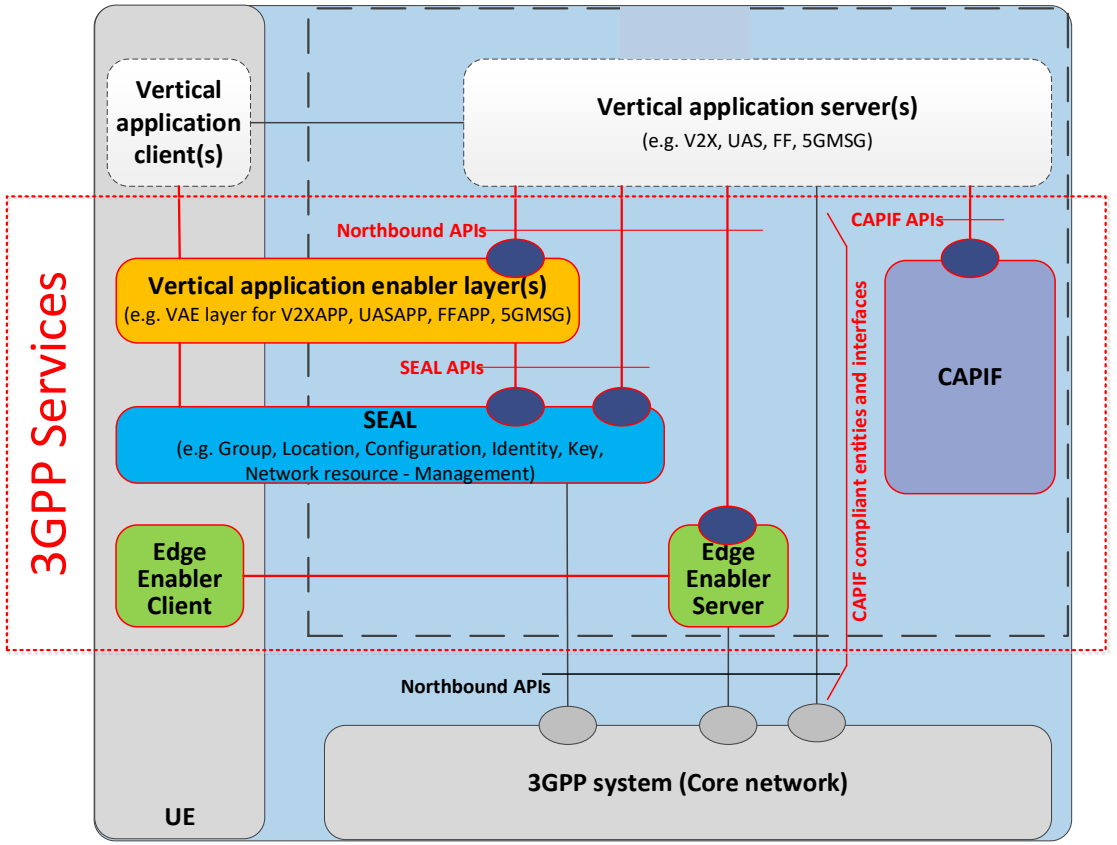
Access Traffic Steering, Switch and Splitting Support

- **Support for Multi-access PDU Session**
- **Support for Two ATSSS steering functionalities** :
  - **MPTCP functionality**, for TCP traffic, with MPTCP proxy in UPF, by using the MPTCP protocol over the 3GPP and/or the non-3GPP user plane; and
  - **ATSSS-LL functionality** for all types of traffic, including TCP traffic, UDP traffic, Ethernet traffic, etc. ATSSS-LL functionality is mandatory for MA PDU Session of type Ethernet.
- **Support of Performance Measurement Function (PMF)**



Enabling 5G Vertical Application and Network APIs

- Middleware between the vertical applications and the underlying infrastructure
- Common API Framework (CAPIF) – unified 3GPP northbound API Framework
- Service Enabler Architecture Layer (SEAL) – offers common application enabling layer for verticals e.g. V2X
- EDGEAPP – Architecture for enabling Edge applications



5G System Evolution in Rel-17

Release 15

Basic features for eMBB

- Service Based Architecture
- End to End Network slicing
- Enhanced QoS
- Network Capability Exposure to 3rd party application service providers
- Session and Service Continuity (SSC) modes
- Location Services support
- Emergency and IMS Services support
- Support for untrusted non-3GPP access (aka untrusted WiFi integration)

Release 16

Support for URLLC, mIoT/IIoT

- Support for Cellular IoT
- Support for 5G LAN, Non-Public Networks (NPN) and IEEE Time Sensitive Networks (TSN)
- URLLC Enhancements
- Network Automation/Data Analytics
- Wireless and Wireline convergence (including support for trusted non-3GPP access network)
- Access Traffic Steering, Switching, and Splitting
- Advanced V2X services
- UE capability signaling optimizations
- Enhanced Location Services
- Single radio voice call continuity from 5GS to 3G

Release 17

More Vertical use cases

- Support for Multi-USIM devices
- Support for Unmanned Aerial System (UAS)
- 5G D2D/Proximity services
- 5G Multicast-Broadcast services
- Support for Satellite systems
- Interactive cloud services support
- Support for Edge Computing
- Enhancements for Non-Public Networks (NPN)
- Time Sensitive Communication (TSC) enhancements
- Access Traffic Steering, Switching, and Splitting Phase-2
- Further enhancement for Network Automation, 5G Location services.

Radio Access Network

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Senior Director, Technology
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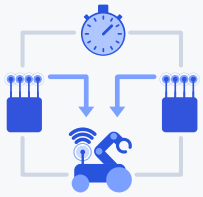
3GPP RAN1 Chairman

Qualcomm

September 24, 2020

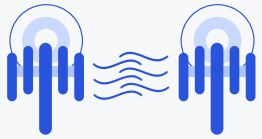
Building on the Technology Foundation for the 5G Expansion

High-precision positioning
Accurate indoor and outdoor positioning



Mission-critical design
Ultra-high reliability of up to 99.9999%

Unlicensed spectrum
Improved capacity and new use cases



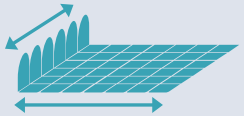
New deployment models
New deployments e.g., IIoT and enterprise

Advanced power saving and mobility
Better device performance and coverage

Expanded 5G foundation in Release 16

Sidelink
Advanced safety use cases

5G NR Release 15 technology foundation

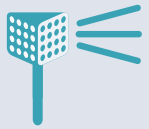


Flexible slot-based framework

Scalable numerology

Advanced channel coding

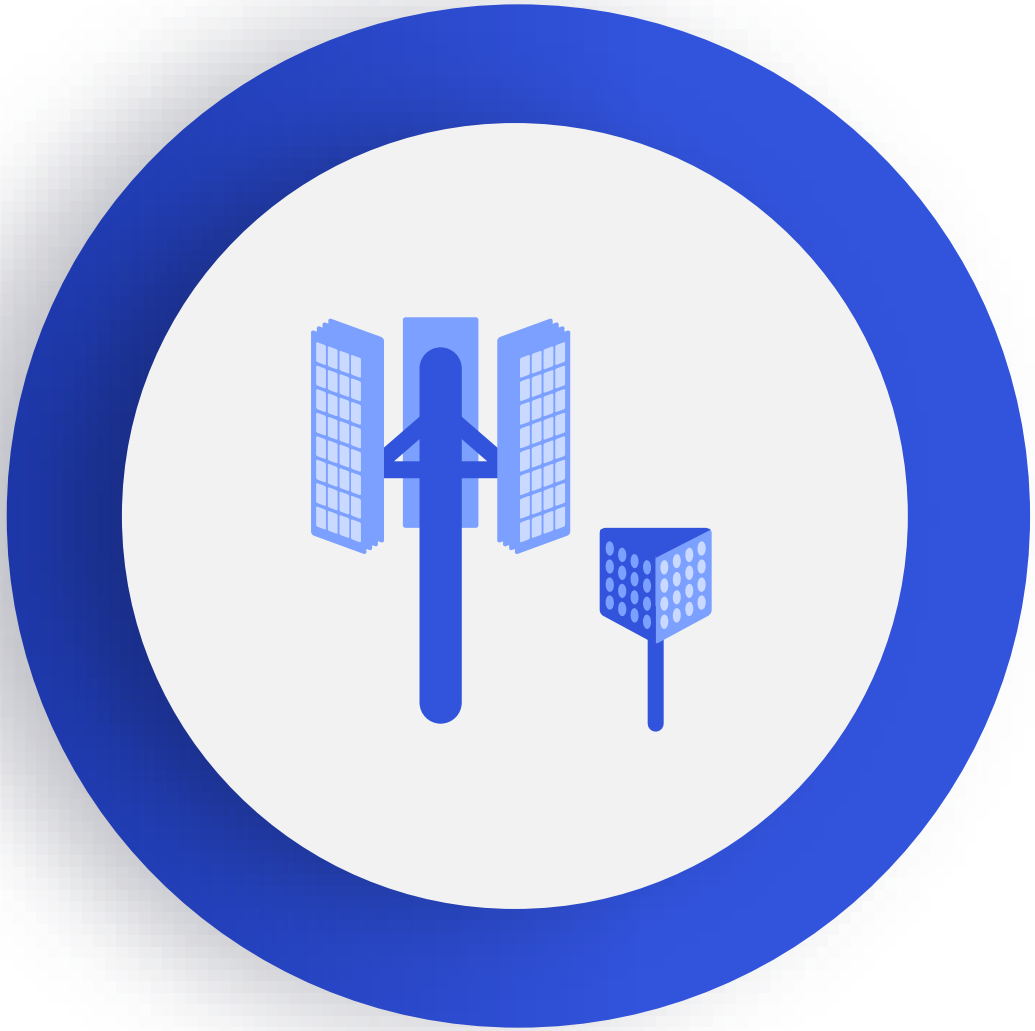
Massive MIMO



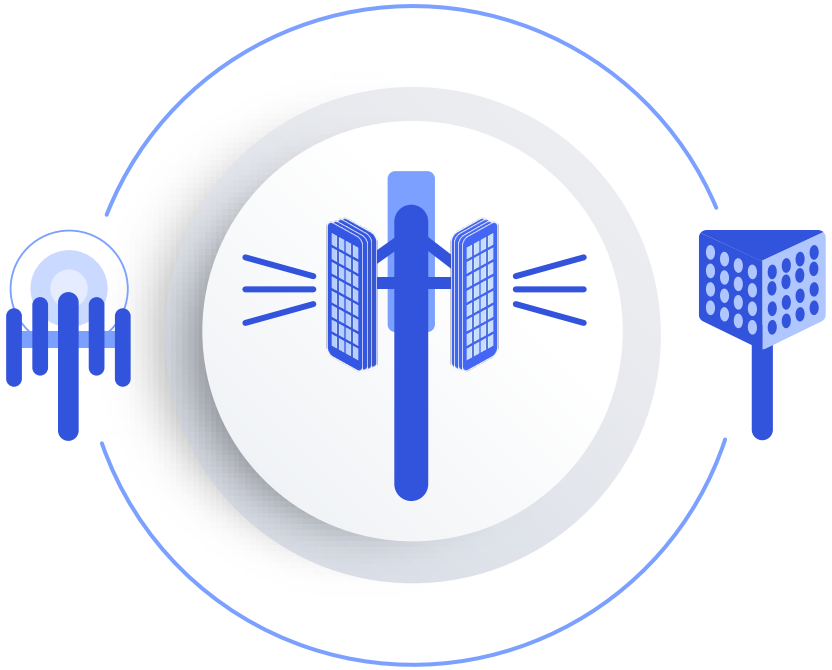
Mobile mmWave

Driving foundational enhancements

3GPP Release 16



Enhancing 5G NR massive MIMO performance



Release 16 MIMO Enhancements[1]

Improving performance, efficiency, reliability

Enhanced multi-user MIMO

Reducing overhead and supporting Rank 4 MIMO, finer quantization and PMI[2] granularity by improving Type II CSI[3]

Multi-transmission/reception points

Improving reliability by allowing device to transmit and receive[4] data to/from multiple base stations

Better multi-beam management

Supporting secondary cell beam failure recovery, interference-aware beam selection, overhead reduction

Improved power efficiency

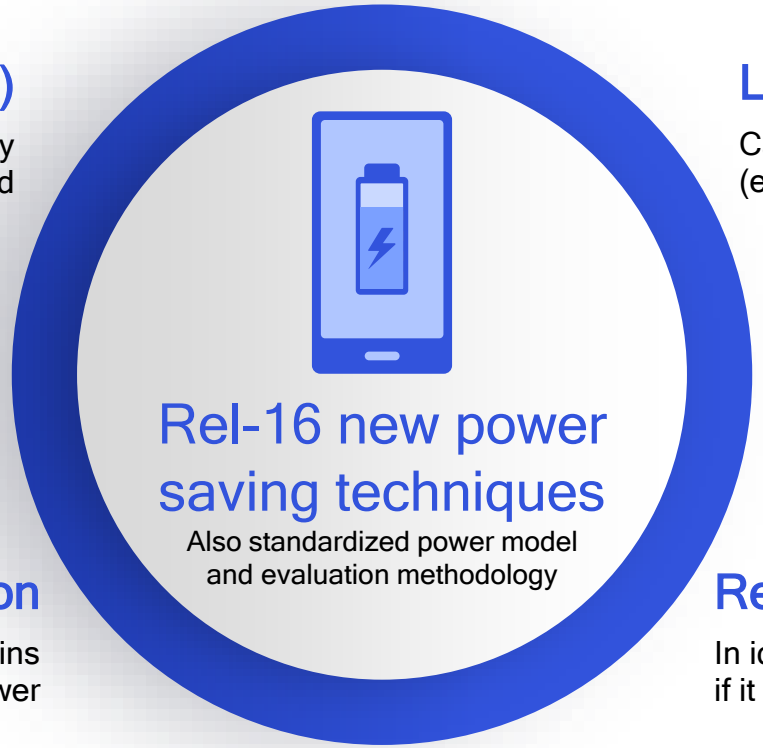
Reducing PAPR (peak-to-average ratio) with improved uplink and downlink reference signal[5]

Extended uplink coverage

Achieving full-power uplink for all MIMO capable devices[6]

1 Also includes LTE MIMO enhancements, such as improved SRS capacity and coverage; 2 Precoding Matrix Indicator; 3 Channel State Information, similar overhead yields 15% improvement in CSI performance compared to R15 Type II CSI design; 4 Supporting SDM, FDM, and TDM transmissions with single or multi DCI (DL control information); 5 OFDM for PDSCH & PUSCH and DFT-S for PUSCH & PUCCH; 6 For single layer MIMO, for low-complexity MIMO non-/partially coherent devices

Further enhancing device power efficiency



Rel-16 new power saving techniques

Also standardized power model and evaluation methodology

Wakeup signal (WUS)

A low-power control channel to indicate activity or lack thereof in the corresponding DRX[1] period

Low power mode groups

Carriers can be configured with different DRX duration (e.g., shorter active time for mmWave vs. sub-7 GHz)

Enhanced cross-slot scheduling

Such as introducing explicit minimum scheduling offset parameter and better support for BWP[2] switching

Device-assisted power saving

Devices can request preferred power saving parameters (e.g., DRX, # of carriers, max bandwidth)

Adaptive MIMO layer reduction

Supporting turning off transmit/receive chains (e.g., from 4 to 2) to save power

Relaxed radio resource management

In idle or inactive mode, device can relax measurements if it has low mobility or is not at the cell edge

Low-power carrier aggregation control

Efficient activation and deactivation of secondary cell is controlled by the primary cell

1 Discontinued reception; 2 Bandwidth part; 3 Carrier aggregation

Rel-16 brings 5G NR mobility enhancements

Also further enhancing LTE mobility management

Reduced interruption time

0ms handover enabled by dual active protocol stack with concurrent source/target cell transmissions/reception

Improved mobility robustness

Device-driven conditional handover for single and dual connectivity, and fast handover failure recovery

Sub-7 GHz and mmWave

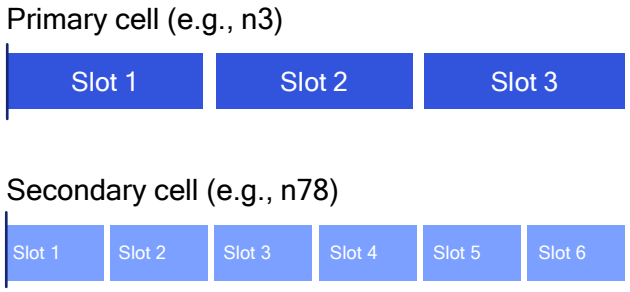
Both inter- and intra-frequency handovers

Beneficial to high-mobility use cases (e.g., train, aerial)

Further improving 5G NR spectrum aggregation

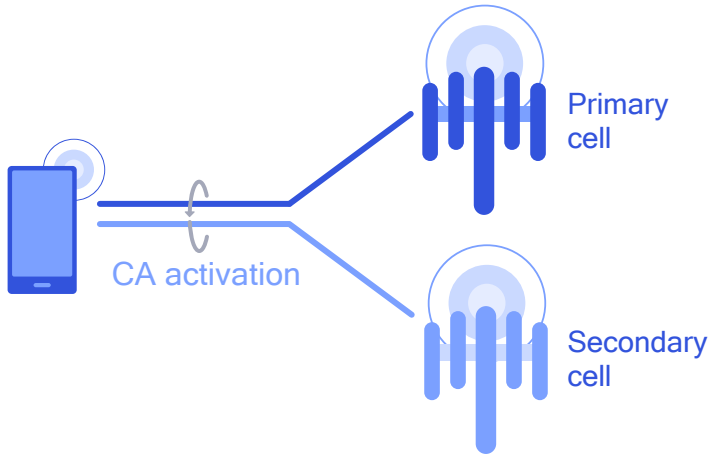
Carrier aggregation (CA) and dual connectivity (DC)

Enhancing Rel-15 CA/DC capability and performance



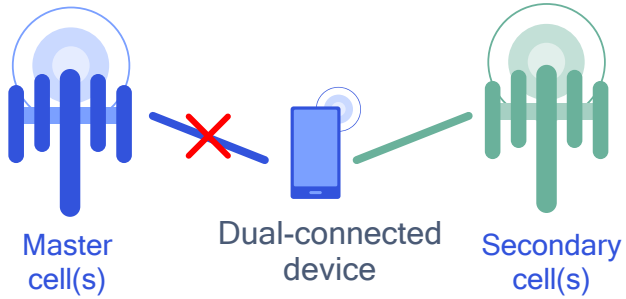
Supporting cross-carrier scheduling & CSI trigger w/ different numerologies, enhanced single Tx switching, async DC with NR power sharing, and unaligned CA

Early measurements and faster CA/DC activation



Defining configuration, signaling, reporting procedure for early measurement, and blind resume, faster activation for secondary cell(s)

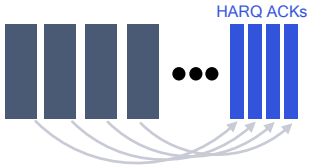
Faster link recovery in dual connectivity



Improving robustness in case of master cell(s) failure when link to secondary cell(s) is still available

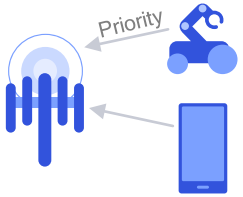
Enhancing ultra-reliable, low-latency communication

Rel-16 eURLLC builds on Rel-15 URLLC foundation



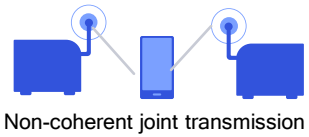
Improved HARQ

Multiple HARQ-ACK feedbacks per slot for latency reduction



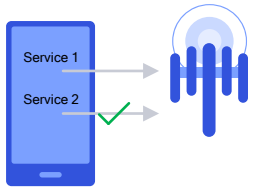
Inter-device service multiplexing

Uplink cancellation indicator and power boosting



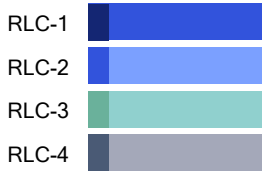
Coordinated multi-point (CoMP)

Multi-TRP[1] for redundant communication paths with spatial diversity



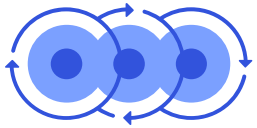
Intra-device channel prioritization

Concurrently supporting differentiated levels of service (e.g., eMBB & mission-critical)



Increased redundancy

Number of PDCP[2] packet duplicates increasing to 4 from 2



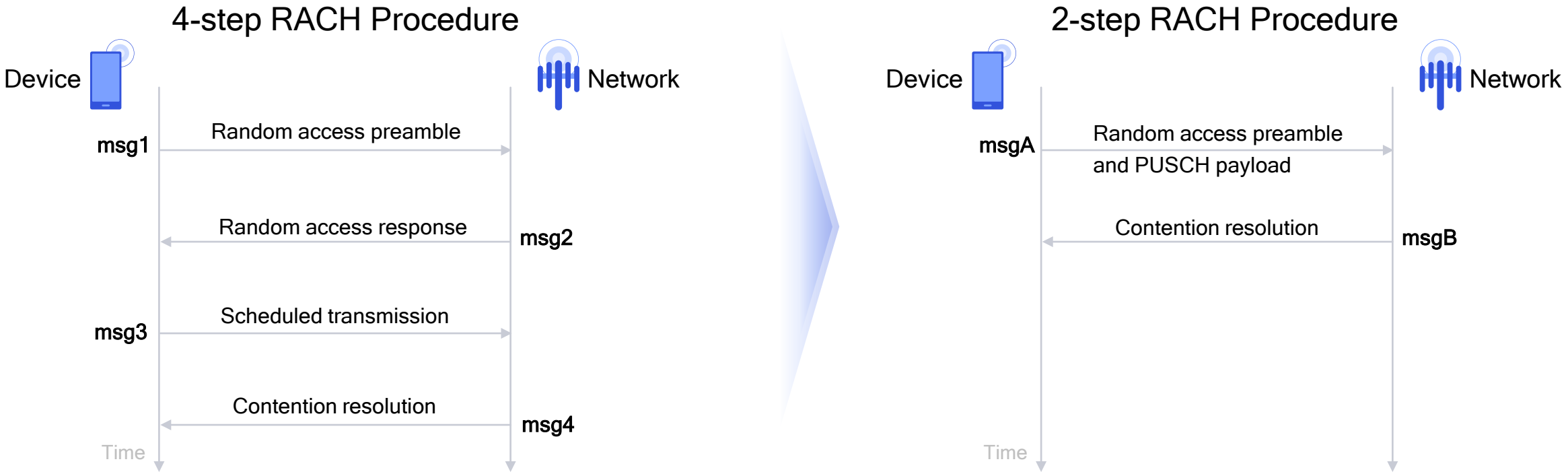
More flexible scheduling

Multiple active SPS[3] configurations & reduced periodicity, more efficient DL control monitoring, UL repetition with cross-slot boundaries

1. Multiple transmission and reception points; 2 Packet Data Convergence Protocol; 3 Semi-persistent scheduling

Two-step random access (RACH) procedure enhances efficiency

Over existing 5G NR Rel-15 four-step RACH procedure



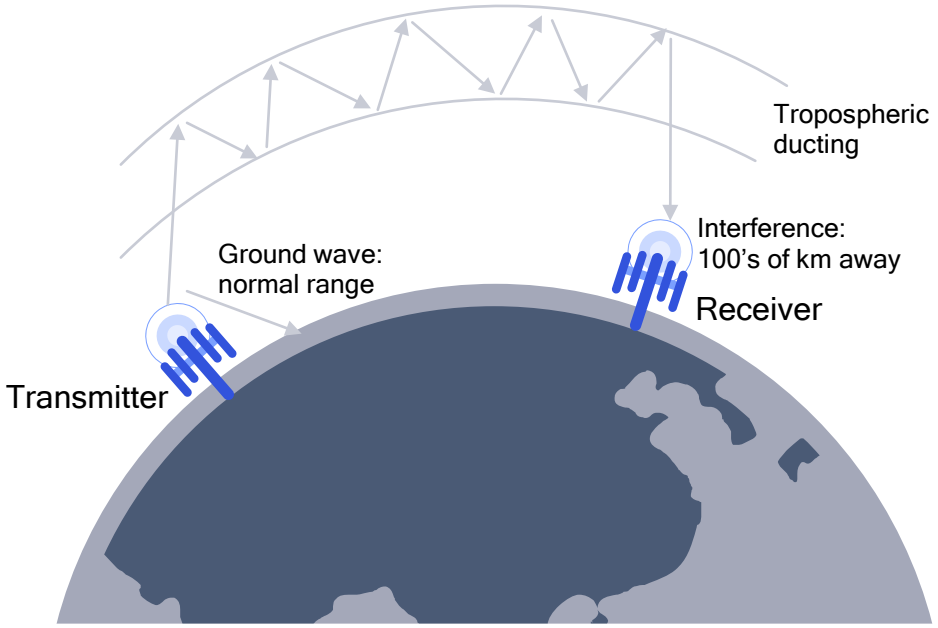
Reduces signaling overhead and latency

Improves capacity and power efficiency

Supports small grant-free uplink

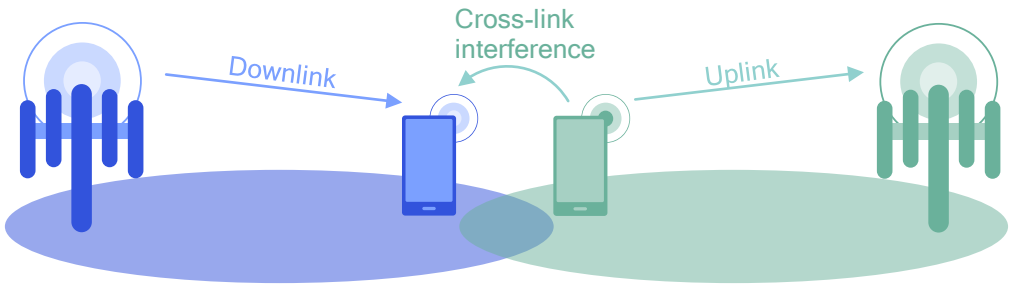
Addressing interferences to improve system reliability

Remote Interference Mitigation (RIM)



Base stations can communicate and coordinate[1] mitigation of base station TDD DL-to-UL ducting interferences[2]

Cross-Link Interference (CLI)

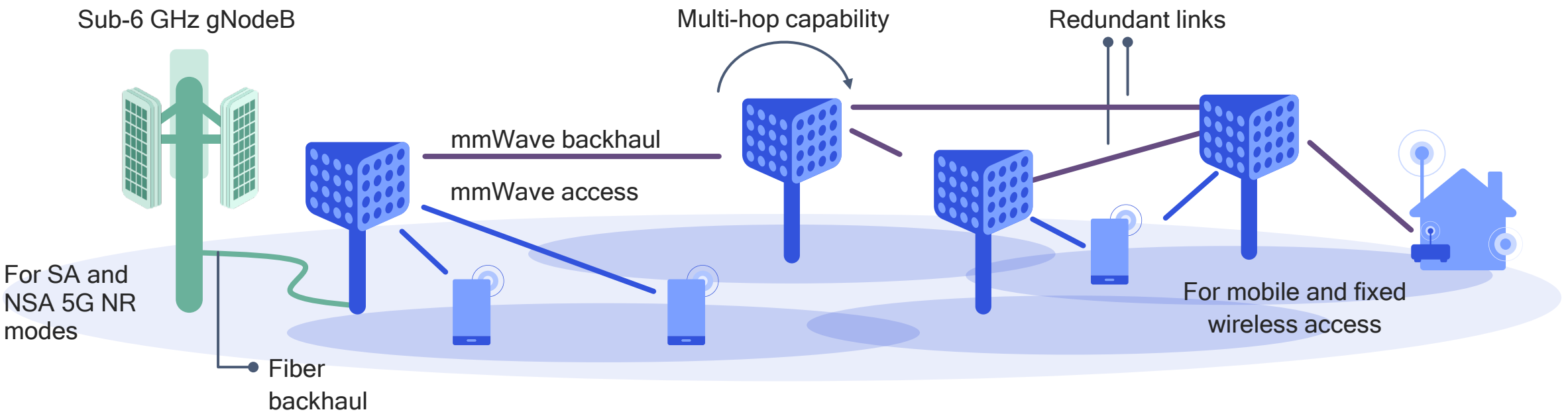


Devices can measure and report inter-/intra-cell interferences[3] caused by neighboring devices with different TDD configurations

1 Via reference signals (RIM-RS) over-the-air or in combination with backhaul signaling; 2 To indicate the presence of interference and whether enough mitigation is in place; 3 Inter-cell: when devices have semi-static TDD scheduling, Intra-cell: when devices support dynamic TDD

5G NR mmWave IAB[1] for cost-efficient dense deployments

Improves coverage and capacity, while limiting backhaul cost



1 Integrated Access and Backhaul

Traditional fiber backhaul can be expensive for mmWave cell sites

- mmWave access inherently requires small cell deployment
- Running fiber to each cell site may not be feasible and can be cost prohibitive
- mmWave backhaul can have longer range compared to access
- mmWave access and backhaul can flexibly share common resources

Improving uplink performance in higher bands

Single and dual uplink switching

Device can switch between 2 modes of uplink transmission

- Mode 1[1]: 1 Tx on carrier 1 and 1 Tx on carrier 2
- Mode 2: 0 Tx on carrier 1 and 2 Tx on carrier 2

Rel-16 Single/dual Uplink Switching

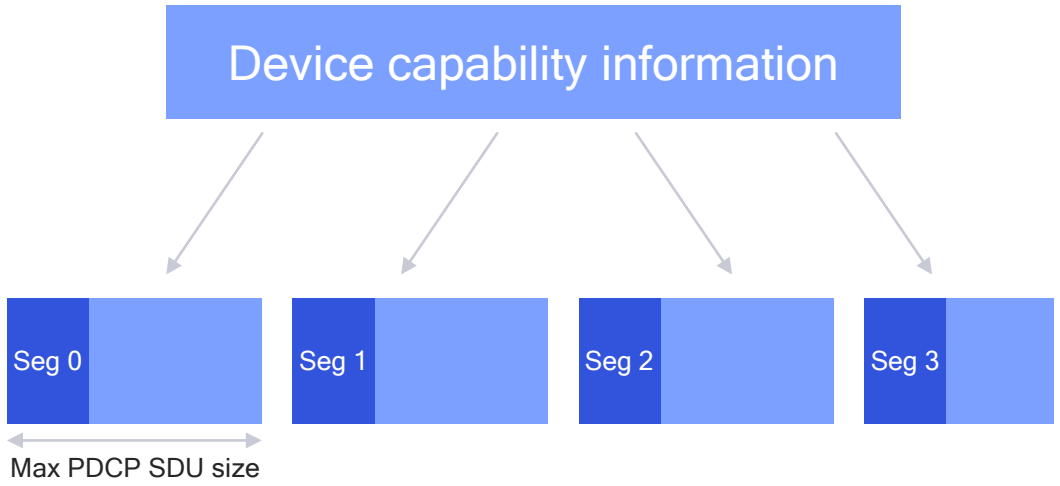
Supporting inter-band aggregation

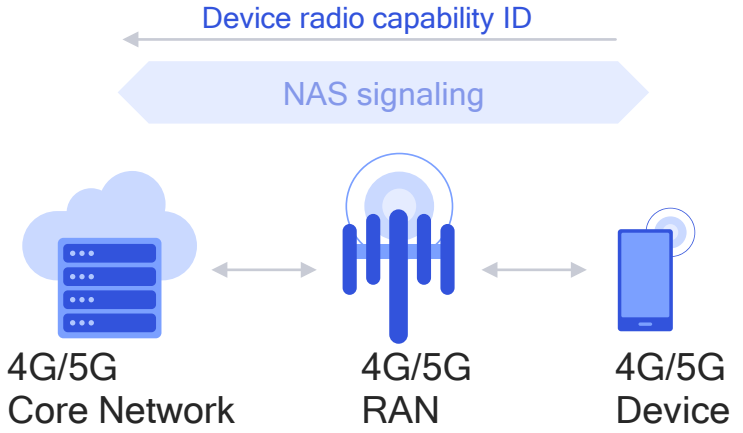
- Uplink carrier aggregation
- Supplemental uplink (SUL) without LTE/NR DC
- LTE/NR DC without SUL

1 Applicatble to UL CA and LTE/NR DC; for SUL, 1 Tx in carrier 1 and 0 Tx in carrier 2

Improving efficiency of radio access capability signaling

To address rapid increase in device capability size due to more band combinations and features





Uplink RRC message segmentation

Overcoming the maximum PDCP SDU[1] size (i.e., 9kB defined in 5G NR) by dividing device capability information into multiple smaller segments

Device radio capability ID

Identifying device's radio capability, stored in the network, which can be assigned by device manufacturer or serving network

1. Packet Data Convergence Protocol Service Data Unit

Maintaining call continuity with circuit-switched fallback

Defining fallback procedures from 5G NR to circuit-switched 3G FDD network

Applying to also emergency (E911) calls

Excludes 3G TDD network support, packet switched and video service continuity

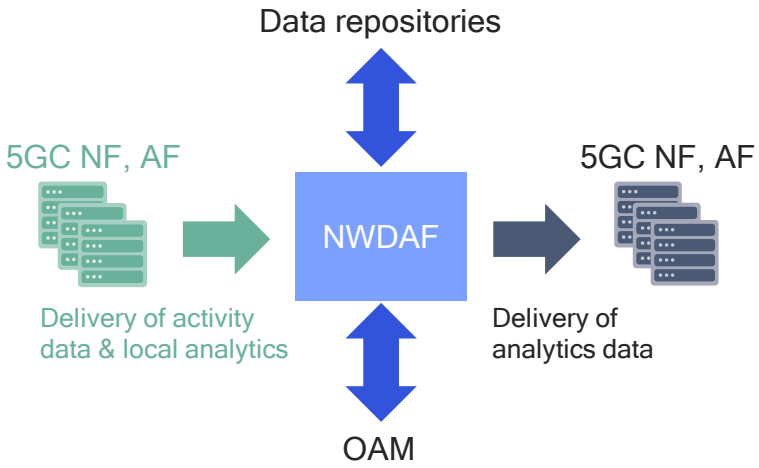
For VoNR deployments with limited or no VoLTE coverage

Data collection for network performance enhancements

Part of 3GPP Release 16

Enhanced Network Automation (eNA)

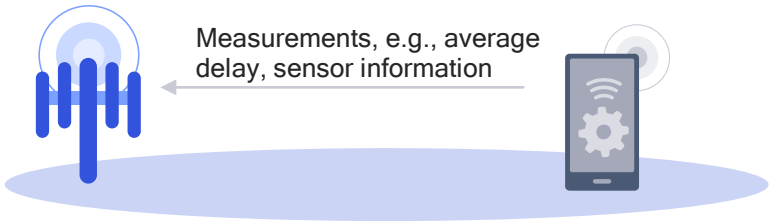
New enhanced core network function for data collection and exposure



Expanding NWDAF[1] from providing network slice analysis in Rel-15 to data collection and exposure from/to 5G core NF, AF, OAM[2], data repositories

Minimization of Drive Testing (MDT)

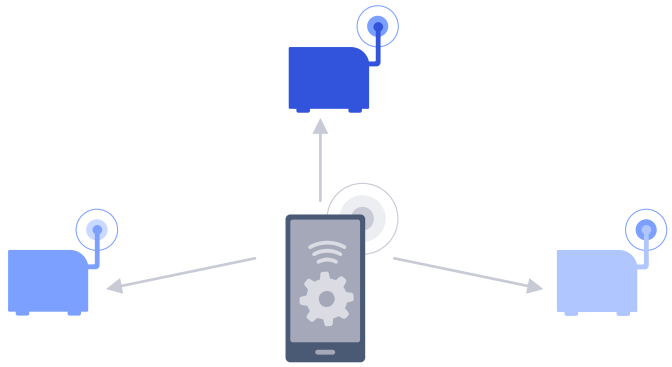
Logged and immediate MDT, mobility history information, accessibility & L2 measurements[3]



Specifying features for identified use cases, including coverage, optimization, QoS verification, location information reporting, sensor data collection

Self Organizing Network (SON)

Mobility robust optimization (MRO), mobility load balancing (MLB), and RACH optimization



Specifying device reporting needed to enhance network configurations and inter-node information exchange (e.g., enhancements to interfaces like N2, Xn)

1 NWDAF – Network Data Analytics Function; 2 Network Function, Application Function, Operations Administration and Maintenance; 3 For standalone and dual connected 5G NR systems

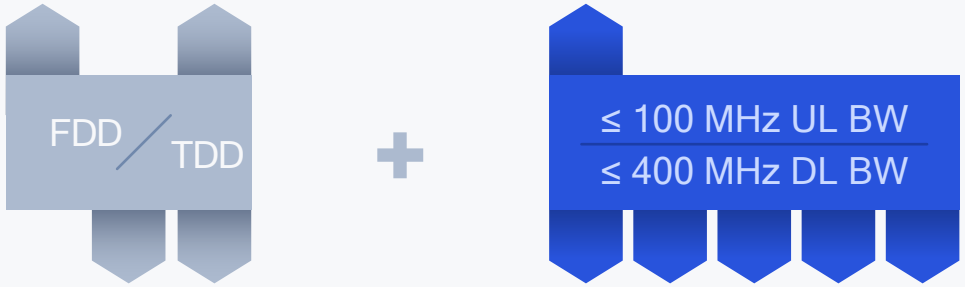
Expanding the reach of 5G

3GPP Release 16

Rel-16 introduces NR in unlicensed spectrum

Anchored NR-U

Unlicensed spectrum is combined with other licensed or shared spectrum as anchor



Licensed or shared anchor spectrum

Unlicensed NR-U spectrum*

Standalone NR-U

Only unlicensed spectrum is used

Unlicensed NR-U spectrum*

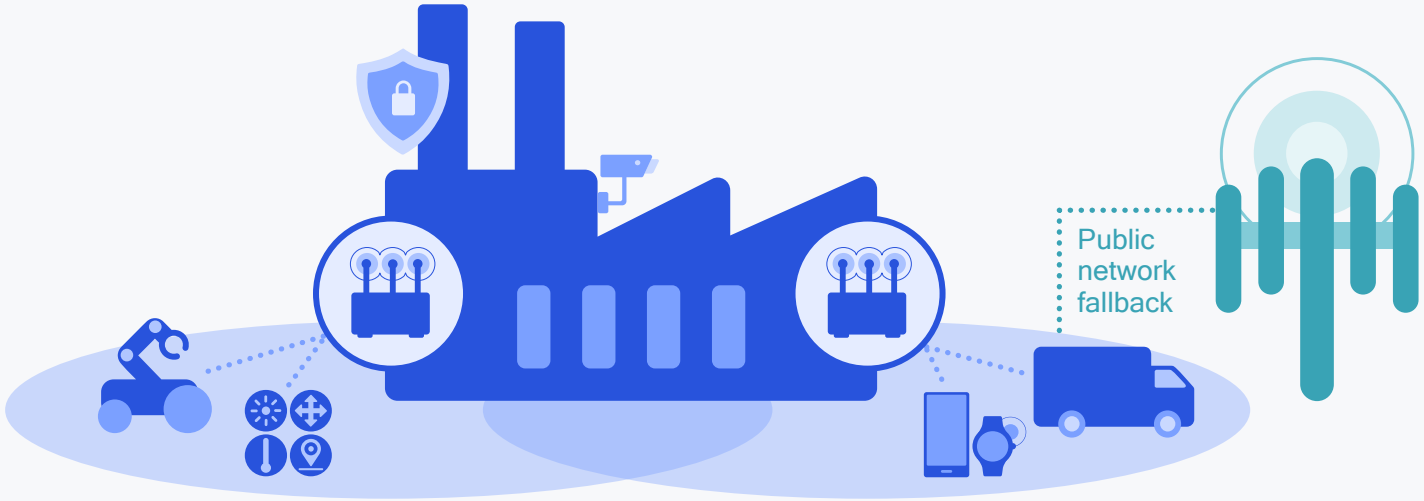
* Still under discussion in Rel-16

Unlock more spectrum globally

New markets and verticals

New deployment scenarios

5G private networks brings benefits to industrial IoT



Private network[1]

Dedicated

Local network, dedicated resources, independently managed

Secure

Cellular grade security, sensitive data stays on-premise

Optimized

Tailored performance for local applications, e.g., low latency, QoS[2], APIs for managed 3rd party access

5G

Coverage, capacity, and, mobility

Outdoor/indoor, high data speeds, seamless handovers, public network fallback

Reliability and precise timing

Industrial grade reliability, latency and synchronization (eURLLC[3] and TSN[4])

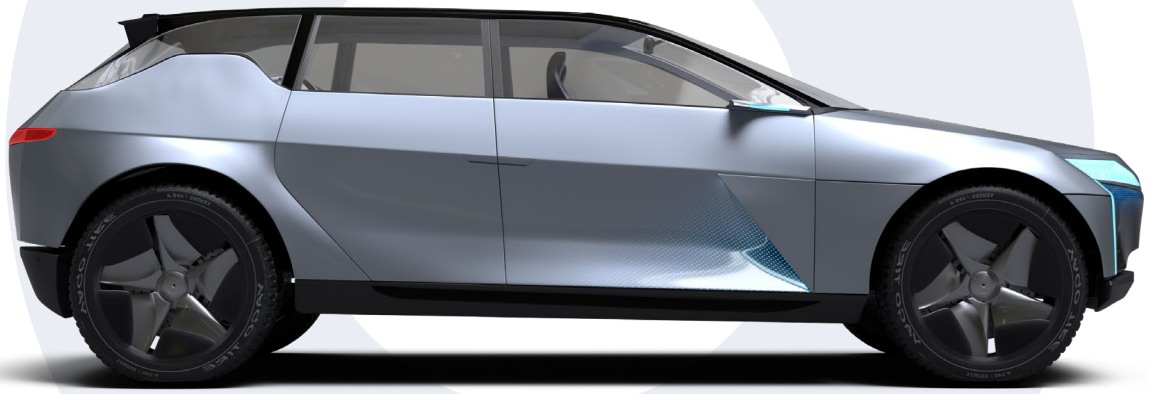
Interoperability

Global standard, vast ecosystem, future proof with rich 5G roadmap

1. Also referred to as non-public network (NPN); 2. Quality of service; 3. Enhanced ultra-reliable low-latency communication; 4 Time sensitive network

5G V2X sidelink

Release 16 brings new benefits for automotive use cases



Sidelink communications

Vehicle to vehicle (V2V)

Vehicle to infrastructure (V2I)

Other communication modes coming in future releases

Enhanced autonomous driving

Real-time situation awareness and sharing of new kinds of sensor data enhances autonomous driving

Faster travel / energy efficiency

More coordinated driving for faster travel and lower energy usage

Accelerated network effect

Sensor sharing and infrastructure deployment bring benefits, even during initial deployment rollouts

Sidelink also essential for other use cases such as public safety, data offload

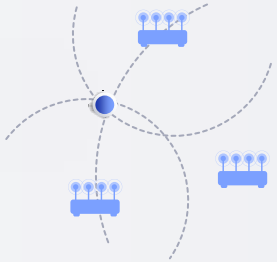
Rel-16 established the baseline for 5G-based positioning

New PRS[1] for devices to detect/measure more neighboring TRPs[2]

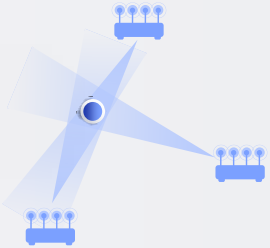
Meeting initial 5G positioning accuracy requirements[3]

3m (indoor) to 10m (outdoors) for 80% of time

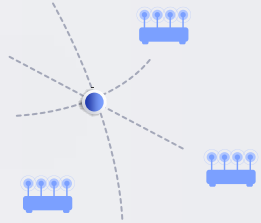
Multi-cell positioning



Roundtrip time (RTT)



Angle of arrival / departure (AoA/AoD)



Time difference of arrival (TDOA)

+

Single-cell positioning

Position along circumference based on UL AoA

Radius based on RTT

New evaluation scenarios

Supporting new channel models for industrial IoT environment

Enhancing positioning accuracy, latency, and capacity in Rel-17+

1 Positioning Reference Signal; 2 Transmission Points; 3 5G positioning requirements defined in TS 22.261

enTV is evolving in Rel-16 to become 5G broadcast

Fulfilling all 5G requirements[1] defined for broadcast

enTV evolution timeline

- **2017** – Rel-14 completed new broadcast design that met many 5G requirements
- **2018** – 5G broadcast included as part of the Rel-16 project package in RAN#78
- **2019** – Rel-16 Study Item – a gap analysis – was completed in March
- **2020** – Rel-16 Work Item was completed in June
- **2021+** – Rel-17+ will further broaden 5G broadcast / multicast capabilities

Rel-16 enTV – 5G Broadcast – focuses on supporting more diverse deployments

- Add support for MPMT[2] and HPHT[3] deployments with rooftop reception (CP[4] of 300µs)
- Enhance support for high speed (~250km/h) in car-mounted LPLT[5] deployment (CP of 100µs)
- Other potential enhancements are captured in TR 36.776 (SI) and RP-190732 (WI).

1 Defined in 3GPP TS 38.913; 2 Medium Power Medium Tower (50km ISD, 60 dBm, 100m height); 3 High Power High Tower (125km ISD, 70 dBm, 300m height); 4 Cyclic Prefix; 5 Low Power Low Tower (15km ISD, 46 dBm, 35m height)

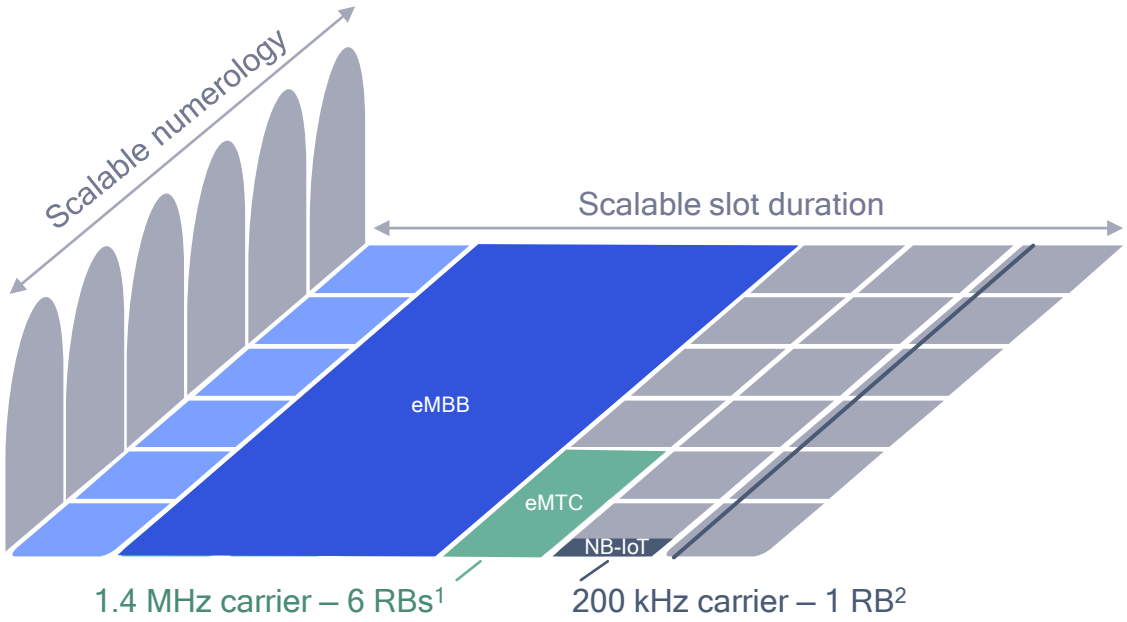
Wide ecosystem support in 3GPP

List of supporting individual members in RP-193050

Academy of Broadcasting Science, BBC, Bittium Wireless, BMWi, British Telecom, Cellnex Telecom, CHTTL, Dish, European Broadcast Union, European Space Agency, ENENSYS Technologies, Expway, Fraunhofer IIS, Fraunhofer HHI, IRT, Nomor, Nokia, Nokia Shanghai Bell, One2many, Qualcomm, Rohde & Schwarz, Samsung, Shanghai Jiao Tung University, Telstra, University of the Basque Country

Evolving eMTC & NB-IoT for 5G massive IoT

Part of 3GPP Release 16



In-band eMTC / NB-IoT in 5G carrier

5G NR 2^n scaling of 15 kHz subcarrier spacing is natively compatible with eMTC and NB-IoT numerologies

5G core network support

For deploying eMTC and NB-IoT in networks operating in 5G NR standalone mode (SA) with a common core network

Further enhanced efficiency

Group wakeup signal, preconfigured uplink, multi-block scheduling, early data transmission, mobility enhancements

1. Cat-M1 uses 6 Resource Blocks (RBs) with 12 tones per RB at 15 kHz SCS; 2. Cat-NB1 uses 1 Resource Block (RB) with 12 tones with 12 tones per RB at 15 kHz SCS, single-tone option also available

Flexible framework designed to support future evolution addressing even broader IoT use cases

Intelligently connecting

our world in the 5G era

A unified connectivity fabric this decade

5G

Continued evolution

Rel-15
eMBB focus

Rel-16 and 17
Expanding to new industries

Rel-18, 19. 20 and beyond
Continued 5G proliferation

?

Next technology leap for new capabilities and efficiencies

Historically 10 years between generations

Strong 5G momentum sets the stage for the global expansion

Qualcomm

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Long-Term Outlook

Iain Sharp

Principal Technologist

September 24, 2020

5G Evolution in Response to Market Demands

- Full capabilities of 5G are evolving over several 3GPP releases
- ATIS work program and members are shaping 3GPP requirements and solutions based on North American experience and market needs
- U.S. spectrum
  - e.g. CBRS, new channel bandwidths
- 5G vertical market support
  - e.g. Vehicle Communication, Mission Critical Communications, Smart Cities, UAVs
- Enhanced system capabilities
  - e.g. Satellite as 3GPP accesses, IoT optimizations
- Regulatory features
  - e.g. Wireless Emergency Alert, E911 positioning

6G Development Cycles are Commencing

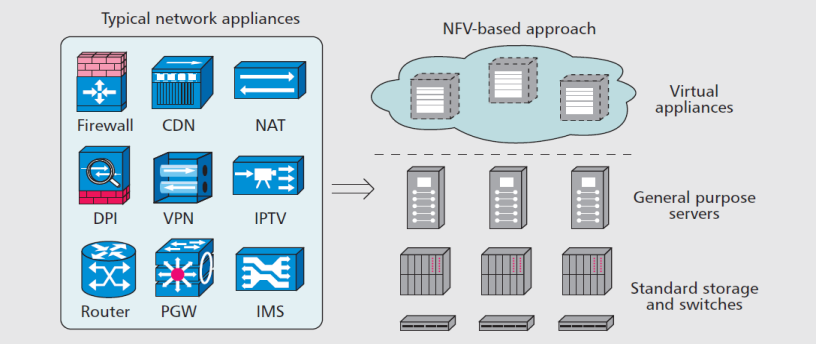
While 5G is already delivering powerful solutions to the North American market, the 6G "game" has already begun:

- Regions are undertaking coordinated 6G research programs with industry and academia
- Global standards groups are already developing next generation requirements and roadmaps (e.g., ITU-R IMT Technology Trends, and planned Vision Beyond IMT-2020)
- In May 2020, ATIS issued a "**Call to Action to Promote U.S. 6G Leadership**"
- As we define the vision for "next G", we want leadership from a broad set of regional stakeholders including industry, academia and government

ATIS Proposed Architectural Principles for Next-Gen Networks

- Highly-distributed and customizable:
  - Required to support different applications and usage models

- Software-driven, dynamic and elastic:
  - Required to support distribution and customization cost effectively



- Data powered, AI-driven network automation:
  - Required to support management and monitoring at scale with dynamics
  - To become a fully autonomous network with closed loop control and policy governance for dynamic behavior

ONAP
OPEN NETWORK AUTOMATION PLATFORM
openstack.
OPEN DAYLIGHT
Acumos AI
AKRAINO EDGE STACK

atis

Concluding Remarks

- Like all organizations, 3GPP has had to adapt its working methods due to Covid-19
  - The drive for innovation is undiminished
  - Learnings from this experience will persist after the crisis
- 3GPP is delivering a rich roadmap of 5G specifications to enhance their range of use-cases and operational capabilities
- Thanks to our speakers for making time in their schedules to share their expertise

Q&A

Thank you for attending the
5G Standards Developments in 3GPP Release 16 and Beyond
Webinar

All registered attendees will receive a follow up email containing links to a recording and the slides from this presentation.

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