

3GPP TSG RAN Rel-19 Workshop
Taipei, June 15-16, 2023

RWS-230368



RAN Rel-19 Overview

CATT
2023.06

CICT Mobile

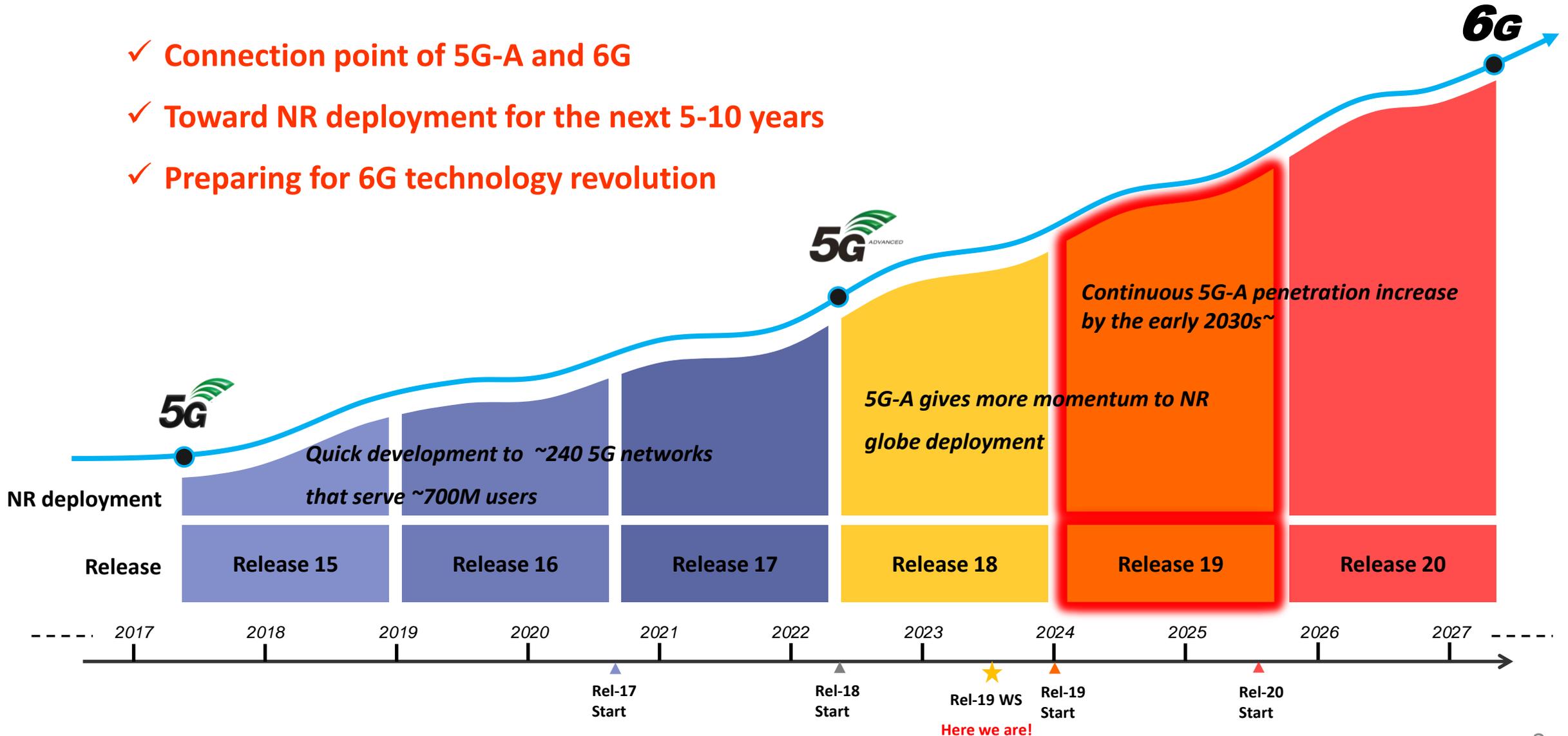
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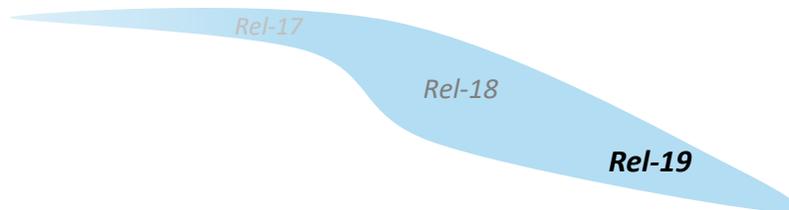
- **Rel-19 drive forces and key topics**
- Initial considerations on selected topics

Rel-19 from timeline point of view

- ✓ Connection point of 5G-A and 6G
- ✓ Toward NR deployment for the next 5-10 years
- ✓ Preparing for 6G technology revolution

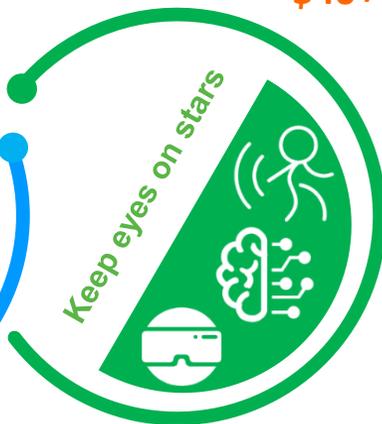
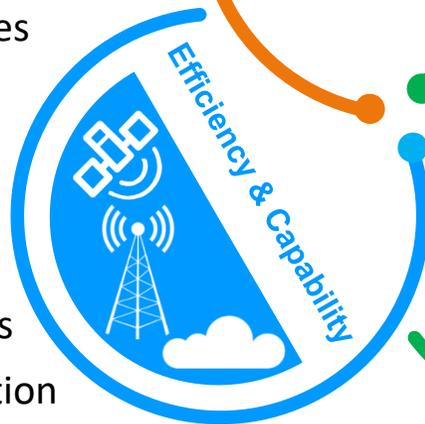


Key drive forces for Rel-19



Unleashing extreme 5G-A capabilities

- ✓ **100+ ZB** data to be delivered in wireless
- ✓ Boosting DL/UL data rates by **multiple times** to meet the requirement of new services
- ✓ Connectivity boosting for **3+ billion** population and **10+ billion** devices
- ✓ **Seamless** coverage for most scenarios, areas or regions
- ✓ **1cm** positioning accuracy for verticals
 - ✓ To tackle 5G gNB power consumption issue, which is **~2 times** of 4G eNB



Achieving universal business success

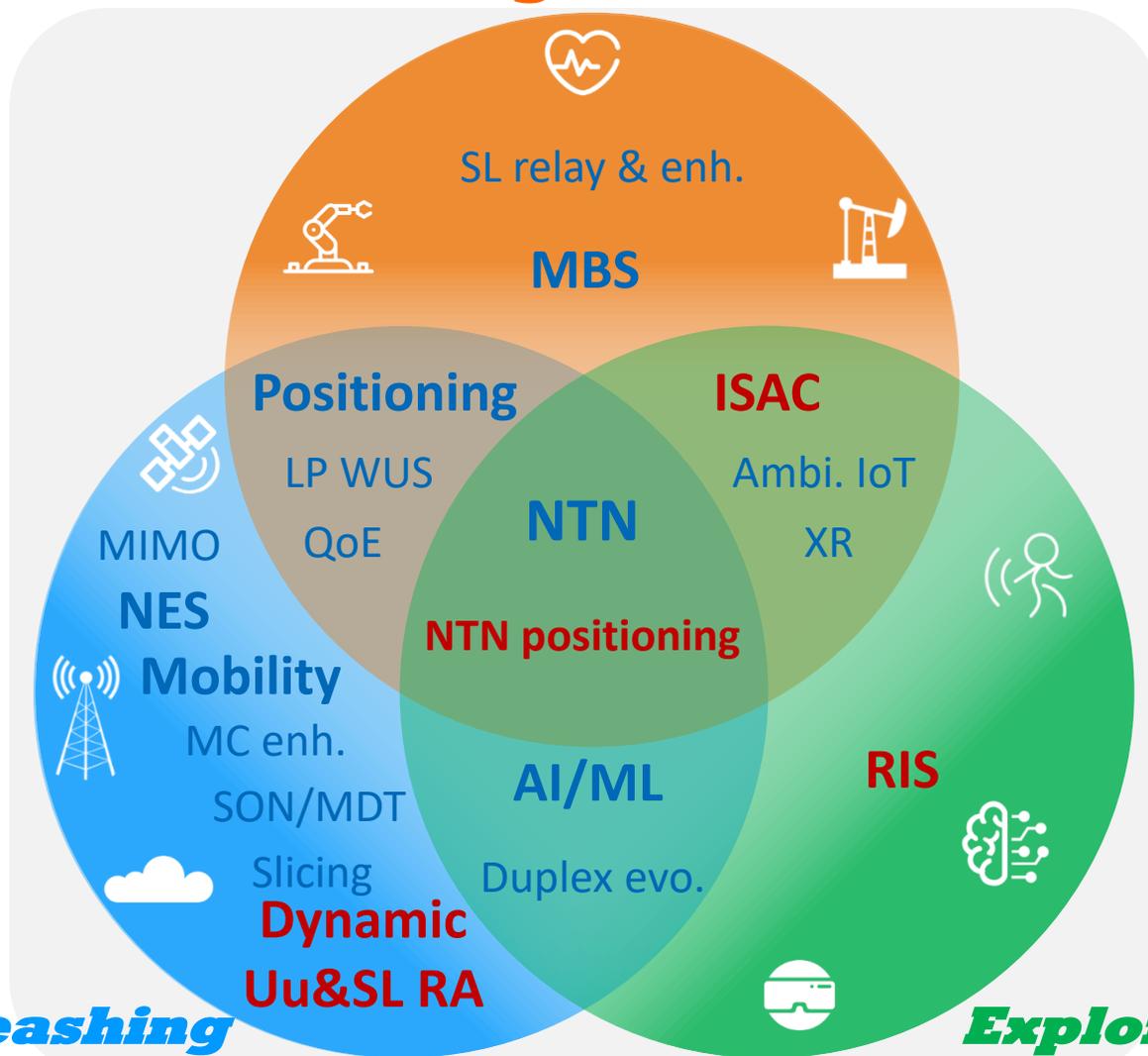
- ✓ Increase **5 times DOU** with immersive user experience in key service types
- ✓ Activate various segments of **\$500+ billion** global IoT market
- ✓ Connecting **200+ million** vehicles in NR network
- ✓ Extend NR to **10+ thousands** sophisticated industry factories worldwide
- ✓ **\$40+ billions** of NTN market to explore

- ✓ Active/passive **sensing** and monitoring
- ✓ **Space-Air-Ground** integrated network
- ✓ **Intelligent** wireless environment & antenna
- ✓ **AI/ML**-based technology for complex network

Exploring future-oriented technology

Topics motivated by the drive forces

Achieving universal business success



Unleashing
extreme 5G-A capabilities

Exploring
future-oriented technology

Potential Rel-19 topics in 3GPP RAN

- | | |
|--------------------|------------------|
| ISAC | Positioning |
| RIS | MBS |
| Dynamic Uu&SL RA | Mobility |
| NTN Positioning | NES |
| Slicing | NTN |
| SL relay & enh. | AI/ML PHY & HL |
| SON/MDT | Ambient IoT |
| QoE | MIMO |
| XR | Duplex evolution |
| Multi-carrier enh. | LP WUS |
| New topics | R18 cont. |

Highlighted topics

ISAC

Prioritize gNB-involved sensing, strive to reuse current hardware/RF framework/waveform.

RIS

Start with NCR framework for RIS and identify necessary enhancement, keep seeking other usages.

Dynamic Uu&SL RA

Study dynamic Uu/SL resource allocation for improving system capacity when UEs are in proximity.

NTN Positioning

3GPP positioning is an added value for NTN, which enables non-GNSS UEs to obtain services via satellite access.

NTN

More architecture options, new functionalities and continuous evolution to allow flexible deployment

Positioning

Support of reliable cm-level carrier phase positioning and enhancement of SL positioning.

AI/ML

WI (materialize supporting AI/ML in NR RAN) + SI (accumulate experience for AI/ML in 6G).

MBS

Fulfill data rate and efficiency for various use cases in the next time period.

Mobility

Minimization of HO delay and thereby improve user experience for mobility.

XR

Multi-modality, power saving and mobility for XR are important issues.

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- Rel-19 drive forces and key topics
- **Initial considerations on selected topics**

ISAC (Integrated Sensing And Communication)

Use case and target band identification

- ✓ To cover different sensing case with different dimensions, e.g., different requirement on sensing accuracy, indoor & outdoor, object-oriented & area-oriented, FR1 & FR2, etc.
- ✓ Potential use cases: Intelligent transportation; Smart factory; Public regulation and safety (e.g. UAV detection); Smart home (e.g. indoor health care).

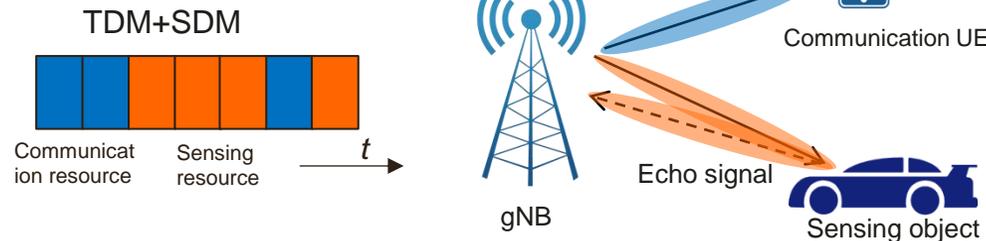


Key aspects in the study

- ✓ [RAN1] Evaluation methodology
 - o Applicable channel model is critical
- ✓ [RAN1] Defining sensing metric & measurement
 - o E.g., delay, strength, angle of echo signal, Doppler, carrier phase, ...
- ✓ [RAN1] Assumption in starting point
 - o Sensing signal and procedure design is separate (e.g. TDM/SDM/FDM) from communication signals
- ✓ [RAN3] RAN3 work is expected for inter-gNB coordination

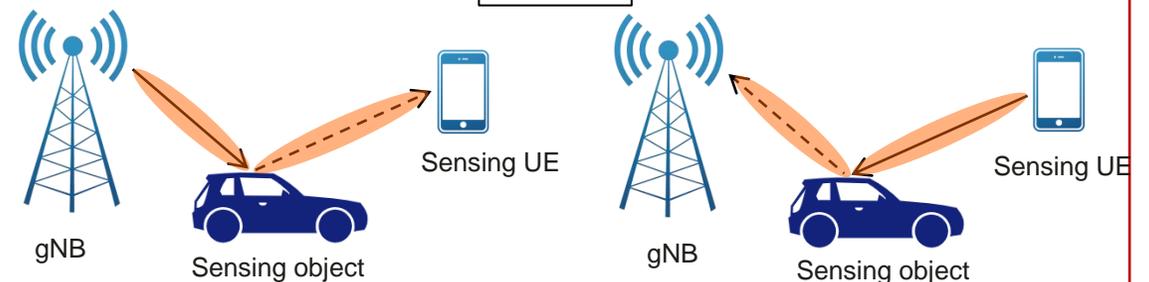
Consideration on sensing mode: higher interest in gNB-involved mode

gNB monostatic



- ✓ Beam sweeping to cover the cell range in angular domain
- ✓ Tx/Rx isolation may be very challenging

Bistatic



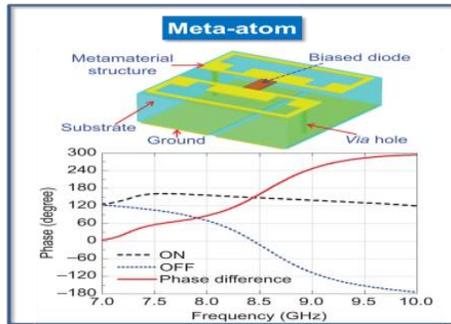
- ✓ NR positioning procedure can be a starting point
- ✓ Challenge on echo signal detection, TA accuracy

At least include gNB-involved sensing. Strive to reuse current hardware/RF framework/waveform.

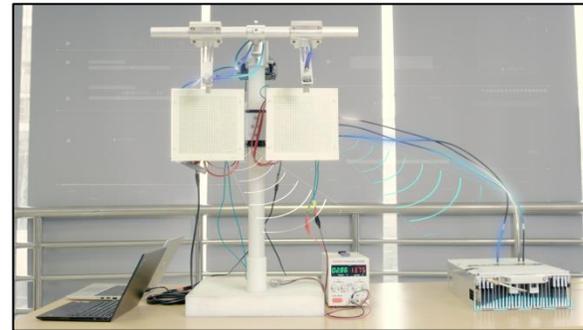
RIS (Reconfigurable Intelligent Surface)

Principle, motivation and use case

- ✓ RIS: Low power, programmable surface, capable to control propagation of EM waves

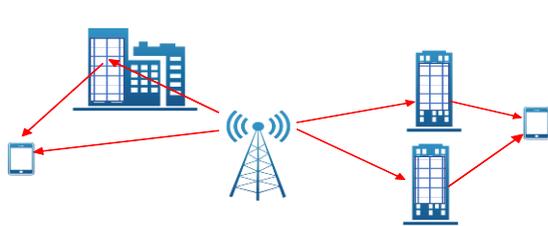


Phase-shifting of meta-atom

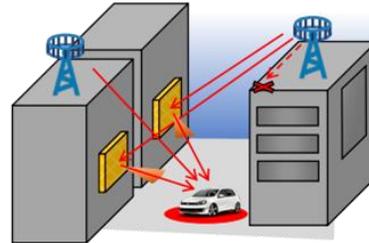


RIS demo from CATT

- ✓ Use cases: **Improving coverage, throughput, positioning accuracy**



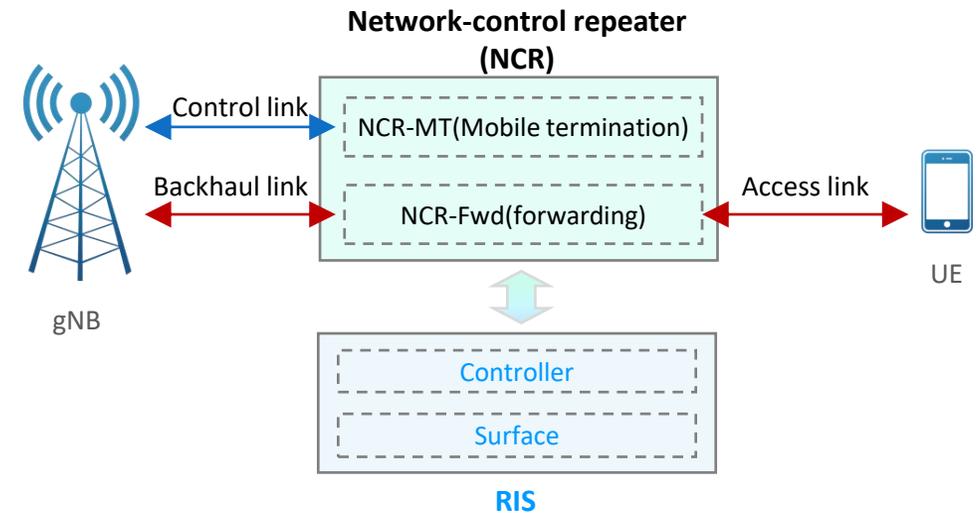
- Address blockage or coverage hole
- Increase transmission rank



- Construct LOS link to improve positioning accuracy

Technical consideration on RIS framework

- ✓ **Reuse Rel-18 NCR design** as much as possible



Key aspects in RAN1 study

- ✓ **Channel modelling** with RIS characteristics
- ✓ **Power** consumption evaluation
- ✓ **Evaluation methodology**, metric, and performance evaluation

Start with NCR framework for RIS and identify necessary enhancement; seek other usage, e.g., MIMO antenna

Motivation 1: Spectrum efficiency improvement

- ✓ Legacy radio resource allocation for Uu link and Sidelink
 - Radio resource is semi-statically configured for Uu link and Sidelink
 - Spectrum is not fully utilized without reuse of radio resources between Uu and SL

Motivation 2: CLI management for dynamic TDD

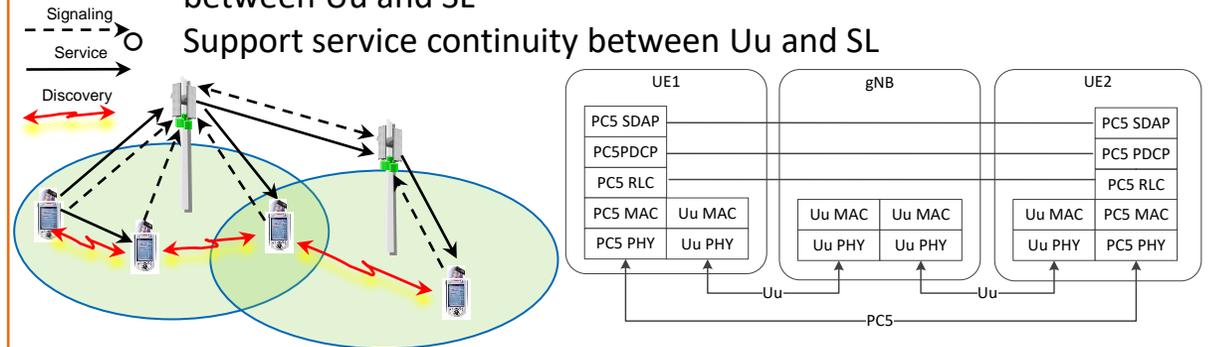
- ✓ gNB can **NOT** exactly know the spatial relationship between UEs
 - gNB needs to identify the interference sources for efficient CLI management
 - The interference sources needs to be measured by UEs in proximity,

Motivation 3: Architecture Enhancement

- ✓ Limitation of Uu/PC5 path switching in Rel-18 UE relay
 - Path switch policy (PC5 permitted, or Uu permitted, or both path) can be (pre-)configured in UE or provided by PCF
 - Uu/PC5 path switching is **semi-statically configured**
- ✓ **Limitation of service continuity** and system capacity optimization

Key points

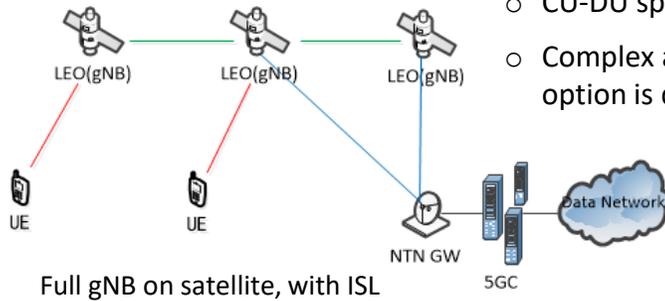
- ✓ **Dynamic resource allocation between Uu and SL is controlled by gNB**
 - Dynamic link adaptation between Uu and SL
 - Dynamic frequency reuse and proximity interference management between Uu and SL
 - L1 discovery of link and interference sources in proximity
 - ✓ **Dynamic interference management between UL and DL in TDD**
 - L1 discovery provides the spatial relationship between UEs and identification of interference sources
 - Dynamic TDD UL/DL interference management based on UE measurements of interference sources
 - ✓ **Dynamic switching between Uu and SL is controlled by gNB**
 - Dynamic switching between Uu and SL based on SL/Uu CSI report
 - UP/CP procedures enhancement to support dynamic switching between Uu and SL
- Support service continuity between Uu and SL



Study dynamic Uu/SL resource allocation for improving system capacity when UEs are in proximity.

✓ **Regenerative Payload + ISL**, which could make radio resource handling and coordination more efficiently, make the deployment more flexible.

- Full gNB on satellite case should be prioritized;
- ISL is treated as transport layer;
- CU-DU split could be considered;
- Complex architecture options, e.g. IAB-like option is de-prioritized.



✓ **Mobility enhancement**

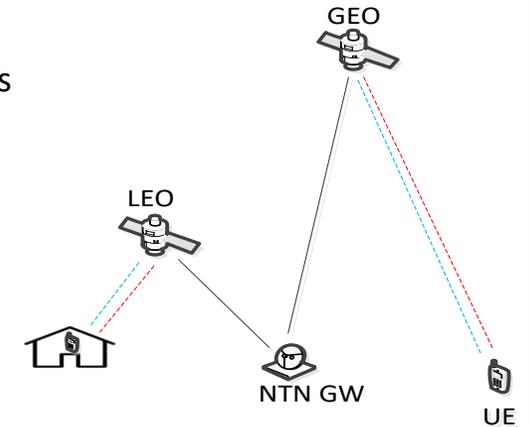
- NTN/TN Mobility enhancement in connected mode (e.g. CHO)

✓ **Support of New functionalities**

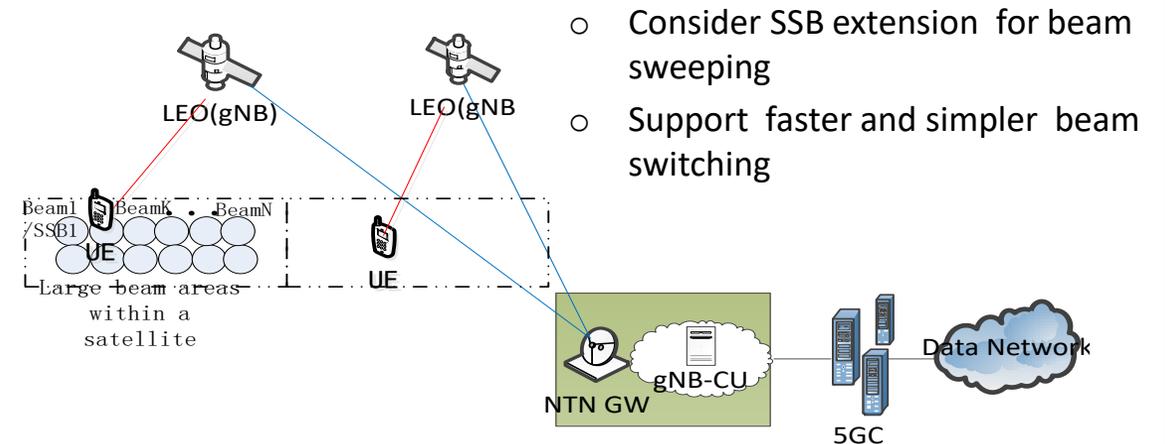
- Support of MBS in NTN, NTN coverage is beneficial for the Broadcasting services (e.g. public safety services, multimedia services).
- Support of Redcap in NTN, which makes better support for various IoT services in NR NTN.

✓ **DL Coverage Enhancement**

- Identify the scenarios and user cases of DL enhancement;
- LEO and GEO should be covered;
- Indoor and outdoor scenarios should be covered.
- Determine suitable SINR target and DL channels to be enhanced



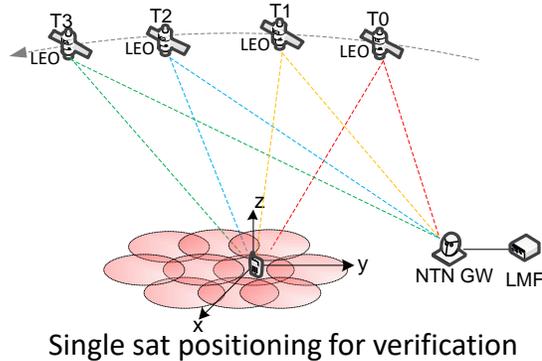
✓ **Beam enhancement** on initial access and **beam switching** in RRC connected state should be considered to enable NTN deployment more flexible.



More architecture options, new functionalities and continuous evolution to allow flexible deployment

R17/18 Status

- ✓ Only the UE with GNSS capability is assumed to access to NTN.
- ✓ UE location(GNSS) is reported to NG-RAN if corresponding user consent is configured.
- ✓ Network based verification may be performed to verify if the reported UE location is reliable for regulation purpose.



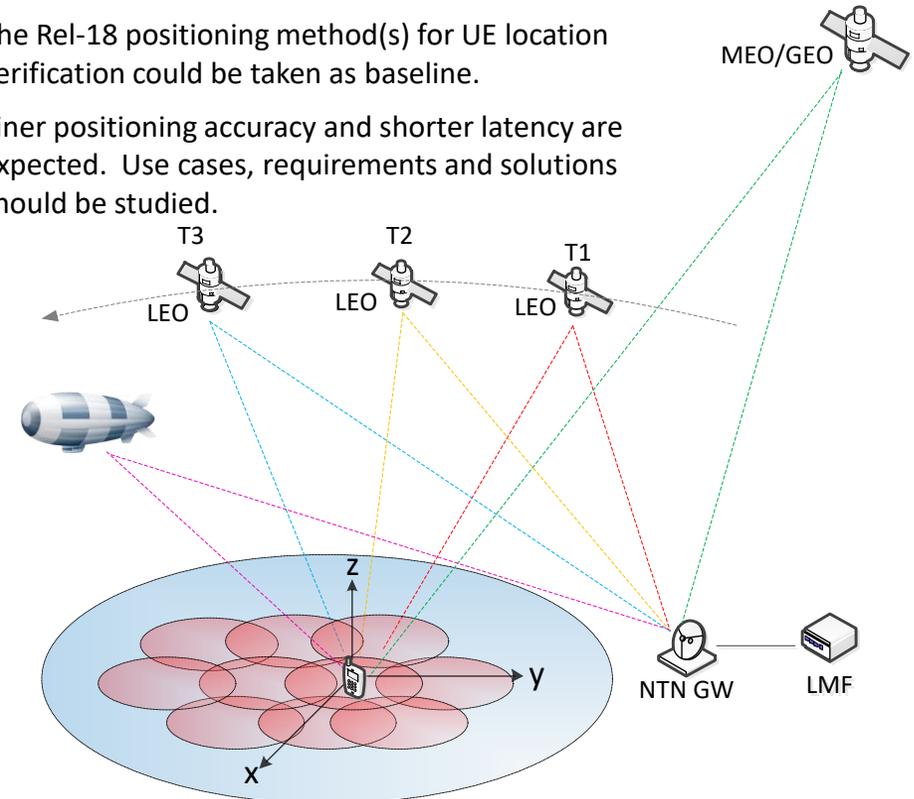
SA1 use cases

- ✓ SA1 Rel-19 study item “Study on satellite access – - Phase 3”, some use cases related to positioning are raised, refer to TR 22.865.
 - Use Case 1 Service differentiation for UEs via satellite access
 - Use case 2 UAVs using Satellite Access
 - Use case 3 Positioning Service using Satellite Access



Enable non-GNSS UEs to obtain services via satellite access

- ✓ Study and specify the solutions to allow the access for the non-GNSS capable UEs.
- ✓ Study 3GPP positioning methods for UEs using only satellite access, irrespective of the GNSS capability.
 - The Rel-18 positioning method(s) for UE location verification could be taken as baseline.
 - Finer positioning accuracy and shorter latency are expected. Use cases, requirements and solutions should be studied.



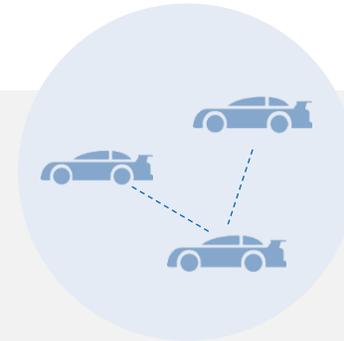
3GPP positioning is an added value for NTN, which enables non-GNSS UEs to obtain services via satellite access.

High accuracy positioning in variable scenarios and use cases indoor/outdoor
-- Continue enhancements



Carrier Phase Pos. in Rel-18

- ✓ Only basic CPP would be supported
- ✓ Existing DL PRS and UL SRS for positioning are used for NR carrier phase measurements.
- ✓ Carrier phase measurements are limited to a single carrier/PFL.



Sidelink Pos. in Rel-18

- ✓ In coverage, partial coverage and out of coverage;
- ✓ SL PRS, resource allocation, measurements to support RTT-type solutions etc.
- ✓ Related procedure and signalings.

Enhancements of Carrier Phase Pos. in Rel-19

- ✓ Accuracy and resource efficiency improvement:
 - DL PRS/UL SRS/SL-PRS enhancements, multipath mitigation, integer ambiguity resolution, multiple DL PFLs/UL carriers, etc.
- ✓ Extended use cases: RedCap devices, SL pos.

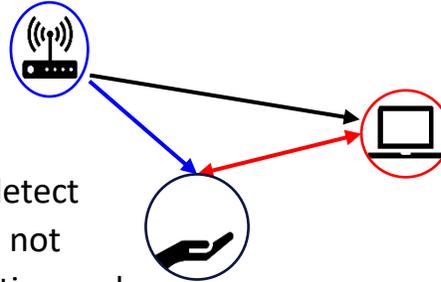
Enhancements of Sidelink Pos. in Rel-19

- ✓ V2X, public safety, commercial scenarios;
- ✓ Reduce power consumption for SL UEs;
- ✓ Achieve dm-level accuracy for SL pos.;
- ✓ Supporting more pos. methods: CPP etc.

Support of reliable cm-level carrier phase positioning and enhancement of SL positioning

Use case approved in SA1

- ✓ **Gesture Recognition for Application Navigation and Immersive Interaction**, for touchless control and immersive (i.e. XR) application.
- ✓ **NR-based RF sensing** Certain RF signals can detect small body movements and the RF signals are not susceptible to the ambient illumination condition and occlusions in the environment



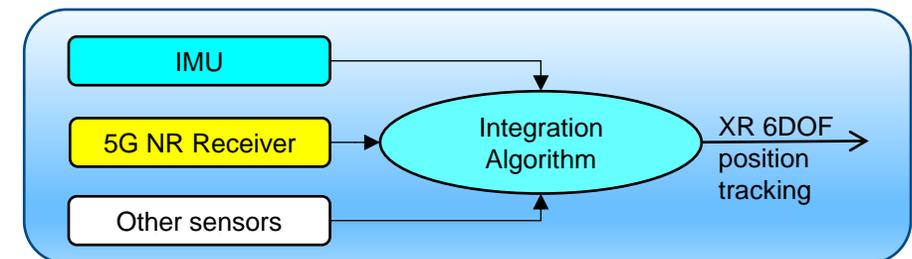
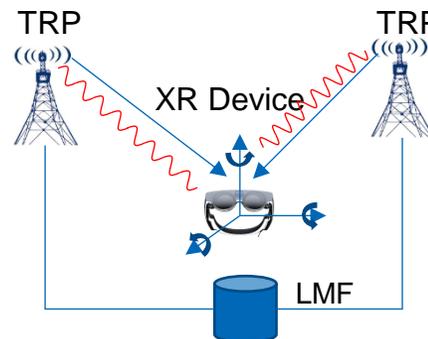
Performance requirements

- ✓ **XR positioning requires:**
 - Very high accuracy: < 1cm
 - Very low latency: < 20ms
 - 6DOF information: 3D coordinate and 3D orientation
 - Sensing resolution (< a fraction of carrier phase cycle)
 - Refreshing rate [s]
 - Low Missed detection [%]
 - Stable False alarm [%]



Potential work in Rel-19

- ✓ **NR carrier phase measurements combined with the measurements from IMU**, installed in smart phones, to support 6DOF XR positioning
- ✓ Study the potential benefits of supporting XR 6DOF position tracking in terms of position tracking accuracy, latency and reliability **based on NR positioning signals**



- ✓ The enhanced IMU measurements for supporting integrated NR/IMU positioning for XR positioning

Hand tracking in XR applications requires 6DOF information with higher performance

Motivations

- ✓ NR positioning and data communication are **traditionally developed separately in 3GPP**
- ✓ Intelligent integration of NR data communication and NR positioning may bring significant benefits of **improving the accuracy, latency, UE/gNB efficiency**, etc. for positioning
- ✓ Increasing the **reliability, spectrum efficiency**, reducing **power consumption**, etc. for data communication

NR communication

Physical Layer:

- Beam management, channel estimation, radio environment maps, etc.

Higher Layer:

- Initial access
- mobility

Communication-aided positioning

Positioning-aided Data communication

NR positioning

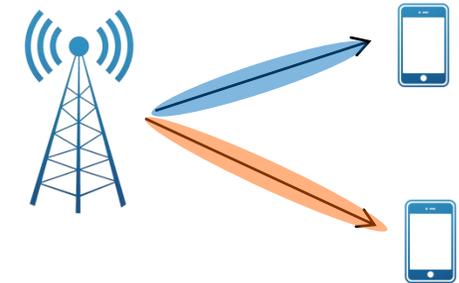
UE positioning measurements

(RSTD, RTOA, AoA, AoD, RSRP, Carrier Phase, etc. in DL-TDOA, ULDOA, Multi-RTT, CPP, etc.)

Potential Benefits

- ✓ Positioning-aided communication
 - Reducing the overhead for Tx/Rx beam alignment
 - Improving channel estimation accuracy
 - Improving initial access and mobility management
 - Optimizing radio resources management based on both UE channel information and position

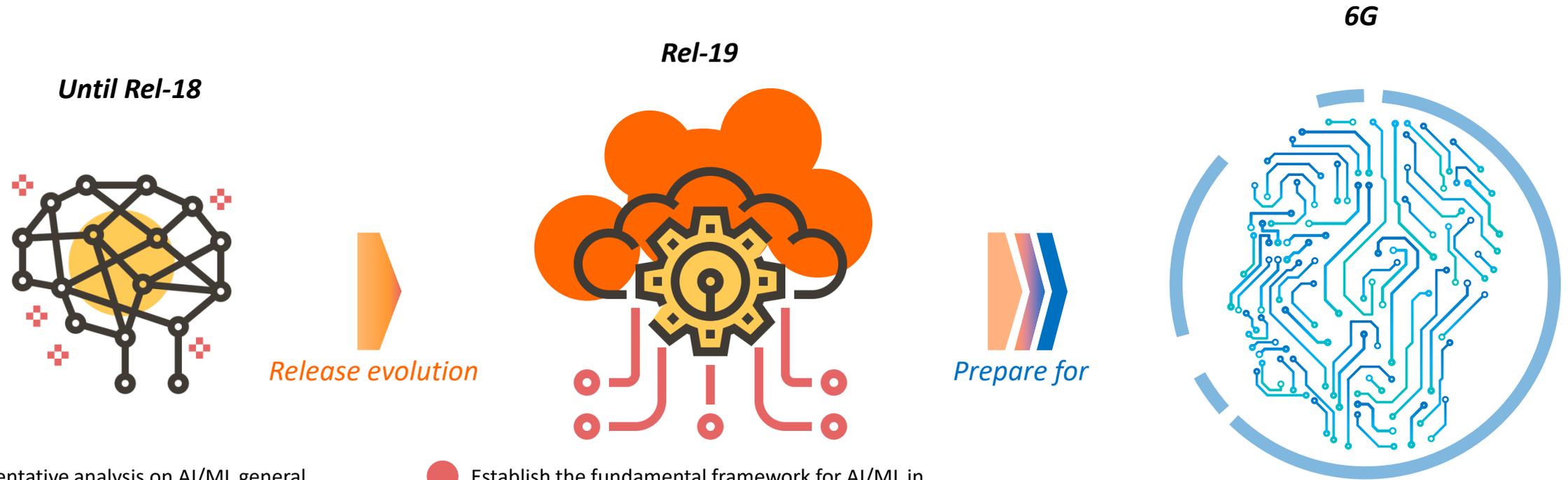
- ✓ Communication-aided positioning
 - Improving positioning accuracy
 - Reduce positioning delay
 - Increase positioning reliability



Resource sharing of NR positioning and data communication

Study the benefits of integrated NR positioning and data communication

AI/ML towards future



- Tentative analysis on AI/ML general framework in NR air interface
- To understand the gain/spec impact via first set of 3 use cases in air interface
- First attempt at normative work for 3 high-layer use cases in NG-RAN
- Establish the fundamental framework for AI/ML in NR air interface
- First step on supporting selected (sub) use cases from Rel-18 SI in NR air interface
- Further improve the efficiency and performance of AI/ML for NG-RAN
- Accommodate more new use cases, study feasibility /gains of AI/ML in various aspects for NR

Model management maturation

Use case expansion

Native support for AI/ML in 6G network

Rel-19 should materialize supporting AI/ML in NR RAN, and accumulate experience for AI/ML in 6G.

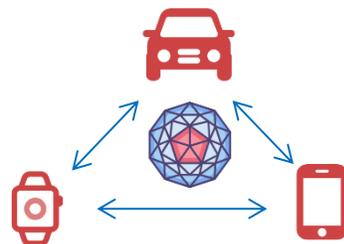
Rel-18 SI in NR air interface

- ✓ Study on **general framework**
 - ✓ Life cycle management, terminology, collaboration level...
 - ✓ Study performance and spec impact of first three use cases
 - ✓ **CSI feedback** - compression & prediction
 - ✓ **Beam management** - spatial domain & time domain
 - ✓ **Positioning** – direct & AI-assisted
- ✓ Study interoperability and testability in RAN4



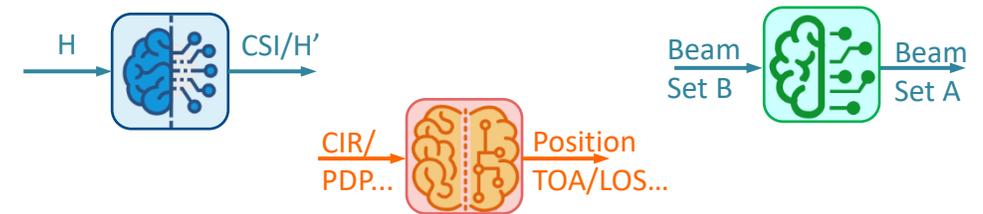
Rel-19 SI in air interface

- ✓ Leftover of LCM procedures, if any
- ✓ RAN1-lead use case
 - Leftover from Rel-18 SI use case, if any
 - New use case for other features (e.g. SL)
 - **No more than 6 sub use case should be handled/led in RAN1 (SI + WI)**
- ✓ RAN2-lead use cases, e.g., UE mobility.



Rel-19 WI in air interface

- ✓ Support **LCM (life cycle management)** for AI/ML model
- ✓ RAN1/RAN2 to select, e.g. **4~5 sub use cases**, for Rel-19 standardization in air interface, considering:
 - ✓ Try to **cover all three use cases** in Rel-18 SI



- ✓ **Reasonable workload to balance WI and SI**
- ✓ Consensus on **trade-off between gain/spec impact** of sub use cases during Rel-18 study
- ✓ Completion level of **LCM (e.g. model transfer, training)** and related dependency with sub use cases during Rel-18 study
- ✓ Specifying RAN4 requirement/test for AI/ML model in air interface
- ☺ Clear work splitting between WGs will be beneficial

WI + SI: Build up the framework of supporting AI/ML in air interface, accommodate more use cases for future.

More efficient AI/ML enabled RAN

Disadvantage of current AI/ML enabled RAN:

- ✓ AI training is located in CU or OAM
- ✓ AI inference is located in CU
- ✓ Difficult to accommodate low layer related AI/ML cases

Targeted deployment scenario:

- ✓ AI training is located in CU, DU or OAM
- ✓ AI inference is located in DU



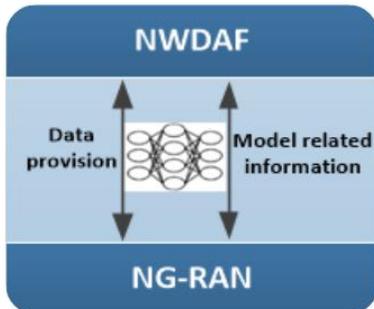
Support of more use cases



Apply to more use cases:

- ✓ Slicing
- ✓ QoE
- ✓ New ES strategies

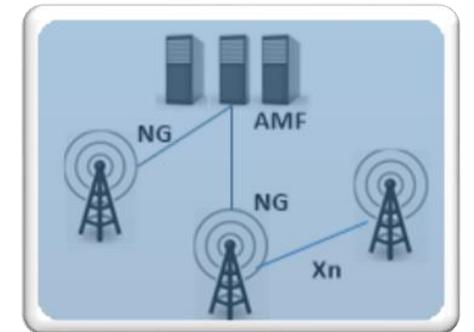
Performance improvement



- ✓ Data collection: Lack of long term data in Rel-18 degrades the performance of AI/ML Function
- ✓ Model related information transfer: Model related information retrieval from NWDAF which relieves the effort of OAM

Rel-18 Leftover

- ✓ NG interface based prediction information transfer
- ✓ MR-DC scenario (if not supported in Rel-18)



R17/18 NR MBS, Now and Next?



NR MBS demonstration @2022 Beijing Winter Olympics

- ✓ NR MBS has been introduced from Rel-17, triggered by high industrial interests and ambitions to expand the NR business models.
- ✓ Basic functionalities exist for multicast and broadcast, with limited enhancements. Still, there are some leftovers from R17/18. And, what's next?

We need to meet the requirements given by various use cases and scenarios in the next time period!



Various deployment scenarios including dense cellular and high tower



High mobility with good performance at cell edge



Data rate requirements of tens or hundred of Mbps



High load scenarios, or cells with large number of UEs

Topic 1 – ECP, SFN

- ✓ ECP for 15Khz extend the distance of the SFN transmission to ~5km, had extensive support in R18 discussions.
- ✓ SFN with coordination and synchronization across gNBs/DUs can give ~10dB SINR increase in the cell edge.

Topic 2 – RAN sharing enh. for MC

- ✓ Efficiency improvement for RAN sharing scenario already supported in Rel-18 for broadcast, and there is similar motivation for multicast. It is concluded as feasible and currently pending in R18.

Topic 3 – MBS with CA and/or DC

- ✓ Higher data rate e.g., ~10 Mbps to 100Mbps, for gaming, video in car, and live broadcasting in stadium, etc.
- ✓ Gap between unicast and multicast services will become even larger in the 5.5G era.

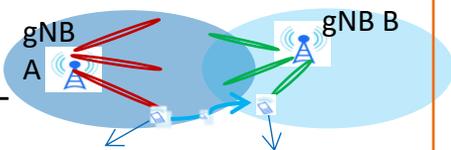
Mobility enhancement

Inter-CU LTM	
✓	Traditional inter-gNB HO procedure leads to large HO delay due to the inter-node message transfer during HO procedure.
✓	Large HO delay would seriously impact the User experience especially for UEs with URLLC service.

	latency	Bandwidth
DAPS	0ms	1 CC
Legacy HO	Upon receive HO command to complete RACH procedure	Maximum to 32 CC
CHO	Upon execution CHO to complete RACH procedure	Maximum to 32 CC
Inter-CU LTM	DL/UL sync latency is possible to be avoided	Maximum to 32 CC

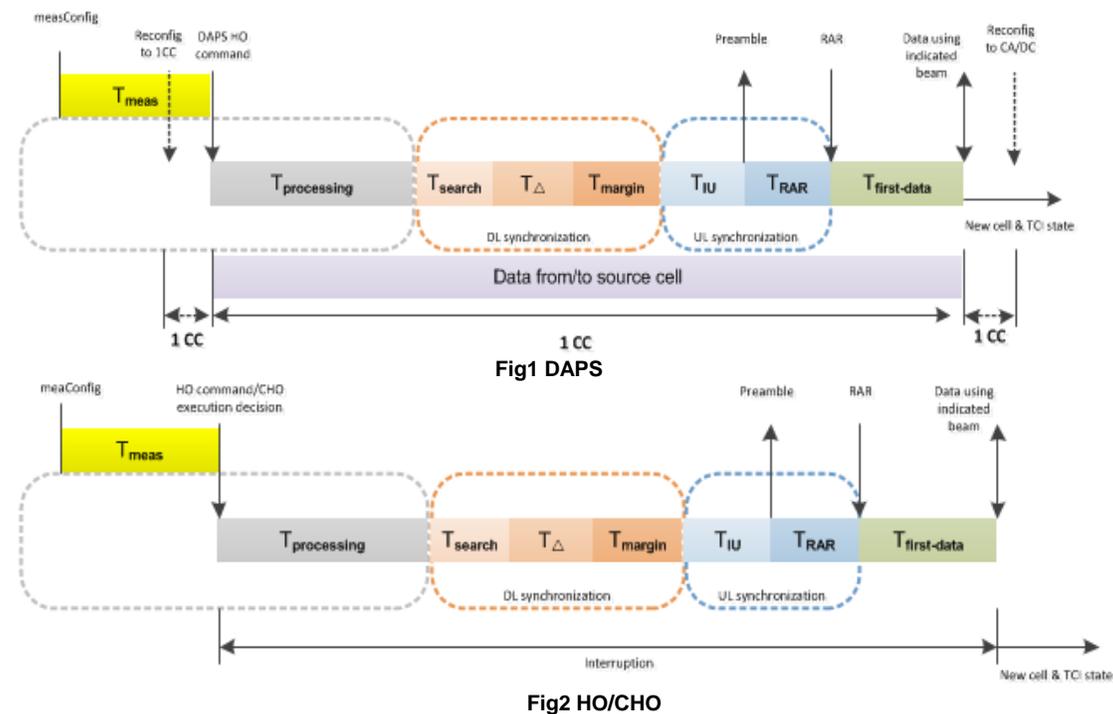
Objective for inter-CU LTM

- ✓ Configuration and maintenance for multiple inter-CU candidate cells
- ✓ Uu enhancement to support inter-CU LTM, if needed
- ✓ Signaling support in both aggregated scenario and disaggregated scenario



At T1: UE is in beam x belong to cell in gNB A

At T2: UE is in beam y belong to cell in gNB B

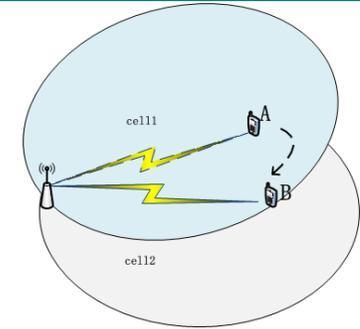


LTE and NR interworking

- ✓ Currently LTE and NR are coexisted widely
- ✓ UE goes to idle mode from inactive mode upon inter-RAT reselection, however UE may move back to NR in a short while
 - Cause redundant signaling overhead and access latency

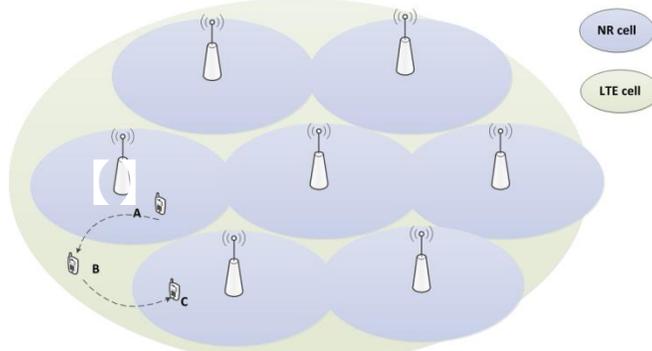
Role change

- ✓ Role change between activated SCell and SpCell
- ✓ Minimize interruption caused by partial MAC Reset



Objective for LTE and NR interworking

- ✓ Support of LTE and NR interworking in inactive state



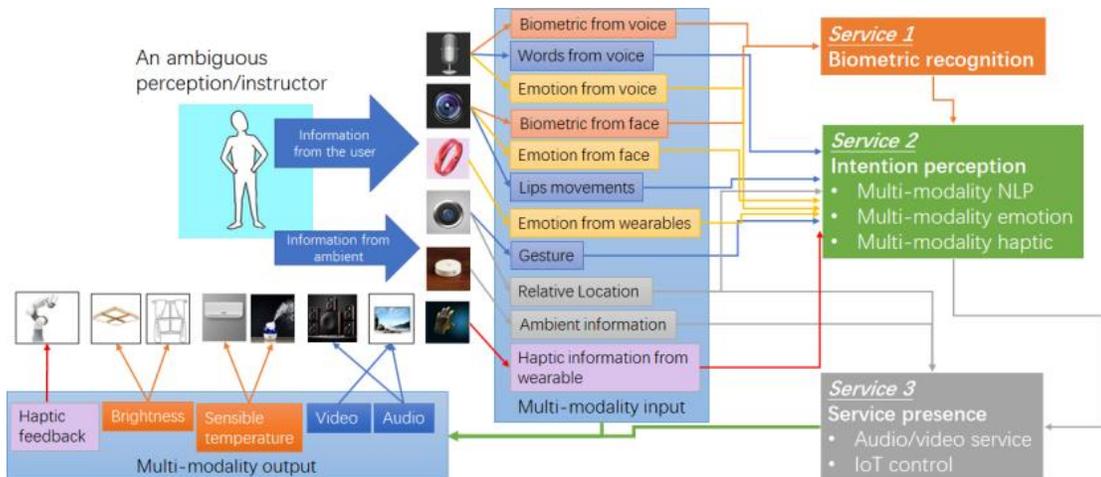
Objective for role change

- ✓ Dynamic switch mechanism among active serving SCell with SpCell based on L1/L2 signalling without L2 reset
- ✓ CU-DU interface signaling to support L1/L2 mobility, if needed

Minimization of HO delay and thereby improve user experience for mobility.

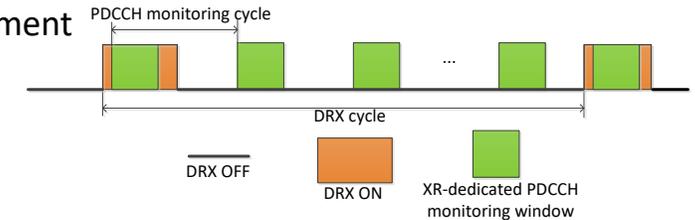
Further Consideration from SA2 works

- ✓ Multi-modality for single UE/ multiple UEs (23.700-60, 22.261)
 - Will not reopen multi-stream traffic model discussion for capacity improvement in RAN1
 - Minor gain is observed (mostly 5% ,up to 13.77% in TR 38.838)
 - Address higher layer issues for real deployment, such as coordination among multi-modality
 - Flow/traffic synchronization, for example, user plane coordination based on SA2 progress (e.g. GTP header)
 - Coordinated scheduling/transmission
 - Identification of UL correlated flow/traffic
 - UL-DL RTT based on different stream (e.g. remoter-headset)



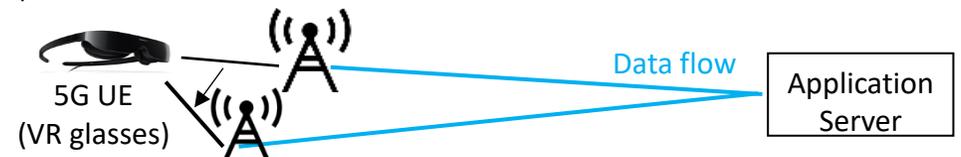
XR Power saving - a data burst containing multi-PDU sets

- ✓ XR power saving with consideration of XR capacity
 - Discussed in R17/18, but no consensus on essential techniques
- ✓ Support the following schemes:
 - XR-specific dynamic scheduling scheme
 - No DRX – Rel-15 SearchSpace configuration could achieve the alignment of PDCCH monitoring cycle to the XR packet generation cycle and the monitoring duration based on the delay jitter
 - With DRX configuration – XR specific PDCCH configuration monitoring cycle and window at both DRX ON and OFF
 - PDCCH skipping enhancement



Mobility

- ✓ Continuity and packet loss performance improvement
 - SA1 R19 XR Mobility (S1-230593): service continuity and connectivity for XR services under high UE mobility
 - For single packet model, small packet loss (<3%) during HO is already achieved in TR 38.838
 - For PDU set, further enhancement during cell change can be considered after XR-awareness completed in Rel-18



UL MIMO enhancement

- ✓ **UL frequency selective precoding**
 - Wideband precoding leading to low precoding and scheduling gain
 - Up to 13% average and 22% edge SE gain by frequency-selective precoding with 4Tx
 - The gain is more remarkable if UL 8Tx is used

- ✓ **UL antenna selection for xTyR UE to improve UL coverage**
 - Commercial UEs are typically equipped with Tx RF chains less than antennas, e.g., 2Tx chains and 4 antennas
 - Selecting x antennas from y antennas for transmission provides additional diversity gain

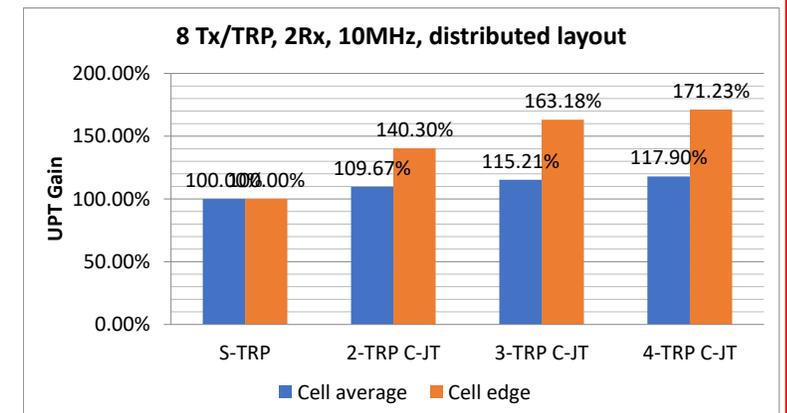
- ✓ **Enhancement to UL STxMP operation for more signal/channel combinations**



DL MIMO enhancement

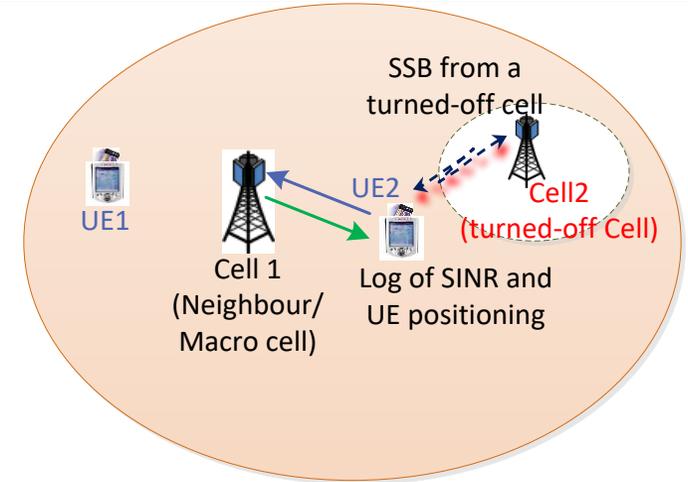
- ✓ **OTA inter-site antenna calibration for coherent-JT**
 - Inter-site coherent-JT provides significant performance gain
 - It is difficult to implement self-calibration across different TRPs
 - OTA calibration with UE assisting information reporting is a promising candidate solution

- ✓ **Asynchronous multi-TRP operation**
 - Enable large area cooperation
 - Relax network synchronization requirement



NES techniques in Time Domain

- ✓ **Adaptation of common control channels/Signals**
 - SSB
 - PDCCH with common search space for SI, paging, RACH procedure
 - RS for RLM/RRM and mobility management
- ✓ **Dynamic channel/signals adaptation in support of Cell ON/OFF in PCell**
 - On-demand SSB/RS transmission triggering Cell ON/OFF
 - Network assisted Cell ON/OFF
- ✓ **Dynamic Cell ON/OFF for multi-carrier operation**
 - SSB-less operation on SCell



NES Techniques in Spatial Domain

- ✓ **Dynamic adaptation of TRP ON/OFF in multi-TRP operations**
 - Dynamic ON/OFF of TRP in multi-TRP operation
 - Energy saving gain 19.7 – 28.7 % with TRP ON/OFF in 2 TRP configurations
 - 160 ms periodicity of TRS/CSI-RS for UE channel tracking

The evaluation scheme	System load = 8%	System load = 16%	System load = 32%
Average ESG of TRP muting/adaptation in m-TRP operation	28.4%	28.7%	19.7%

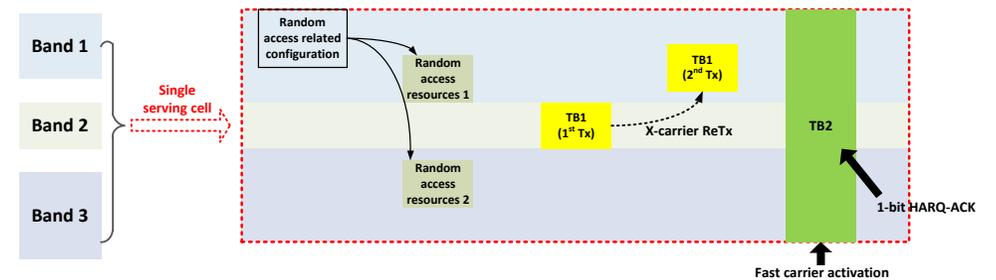
Objective 1: Multi-carrier scheduling enhancement

- ✓ Due to limited TU of WI, the case of different SCS among co-scheduled cells was excluded from multi-cell PDSCH/PUSCH scheduling in Rel-18.
- ✓ Support multi-cell PUSCH/PDSCH scheduling with different SCS for co-scheduled cells.



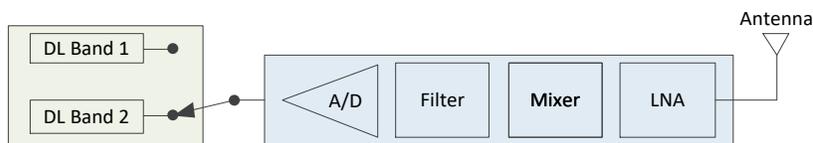
Objective 2: Single Cell over Multiple Bands

- ✓ Fragmented spectrum with limited bandwidth
 - Enhanced single cell operation over multiple bands to improve the spectrum efficiency and data rate.



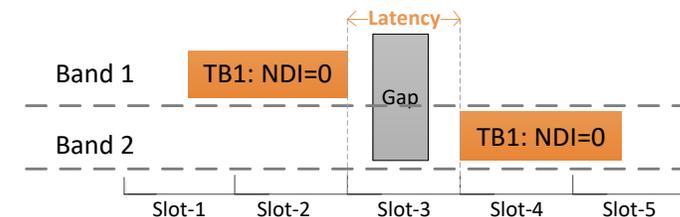
Objective 3: Dynamic DL Rx band(s) switching

- ✓ UL Tx switching among 3 or 4 UL bands supported up to Rel-18
- ✓ With the increased number of fragment spectrum resource(s), DL Rx band(s) switching is also useful to achieve higher DL throughput

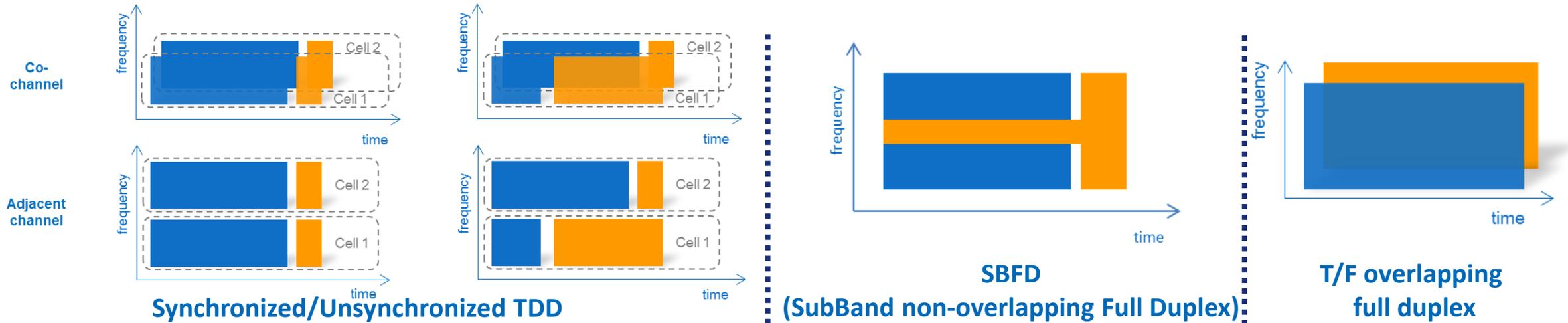


Objective 4: Cross-carrier HARQ retransmission

- ✓ UL/DL Tx/Rx switching may interrupt TB retransmission of 'switch-from' band due to limitation of HARQ retransmission on the same carrier
- ✓ Study cross-carrier HARQ retransmission in case of UL/DL Tx/Rx switching.



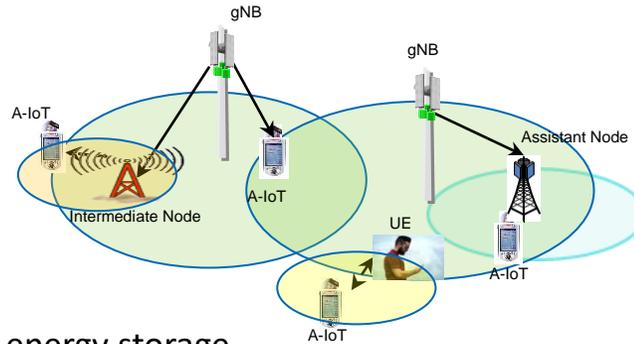
Duplex evolution



Rel-15	Flexible TDD UL-DL configuration/indication		
Rel-16	UE-UE CLI measurement and reporting & network coordination mechanism		
Rel-18	UE-UE CLI handling and gNB-gNB CLI handling study: <ul style="list-style-type: none"> • Identification of possible schemes • Feasibility, performance and co-existence study 	SBFD study: <ul style="list-style-type: none"> • Feasibility, performance and co-existence study • SBFD scheme study 	
Rel-19	UE-UE/gNB-gNB CLI handling scheme specification: <ul style="list-style-type: none"> • Potential UE-UE CLI handling schemes • Potential gNB-gNB CLI handling schemes 	SBFD specification: <ul style="list-style-type: none"> • Subband location indication • SBFD aware UE Tx/Rx behavior • Potential interference handling schemes 	
Rel-19+			Feasibility and benefit study (SI)

Rel-18 RAN Study of Ambient IoT

- ✓ Categorize SA1 use cases to indoor/outdoor and inventory/sensor/positioning
- ✓ Design targets
 - Device power consumption
 - Device complexity
 - Coverage
 - Data rate
 - Maximum message size
 - Latency
 - Positioning accuracy
 - Connection/device density
 - Device speed
- ✓ Device types – capability of energy storage
 - Device A: No energy storage, no independent signal generation, i.e. backscattering transmission
 - Device B: Has energy storage, no independent signal generation, i.e. backscattering transmission. Use of stored energy can include amplification for reflected signals
 - Device C: Has energy storage, has independent signal generation, i.e. active RF component for transmission
- ✓ Deployment scenarios and Connectivity Topologies
 - Topology (1): BS <-> Ambient IoT device
 - Topology (2): BS <-> intermediate node <-> Ambient IoT device
 - Intermediate node can be relay, IAB, UE, repeater
 - Topology (3): BS <-> assisting node <-> Ambient IoT device <-> BS
 - Assisting node can be relay, IAB, UE, repeater
 - Topology (4): UE <-> Ambient IoT device
- ✓ Operation spectrum & duplex – Licensed/Unlicensed, FDD/TDD

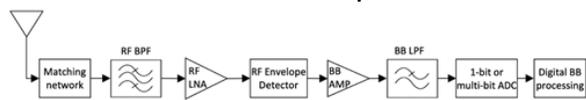
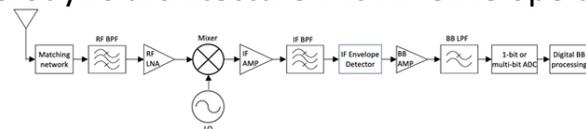
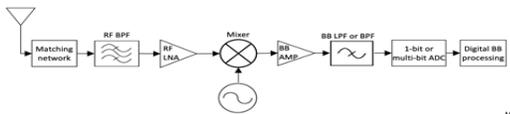
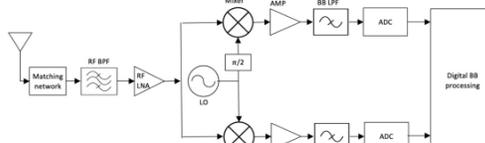


Rel-19 Study of Ambient IoT

- ✓ Study of the characteristics of ambient IoT devices
 - Device power consumption and the receiver sensitivity
 - Device capabilities in minimum data rate and coverage
 - Energy storage and sustainability for power supply
- ✓ Study the deployment scenarios with different connectivity topologies
 - Study the functions of intermediate and assistant nodes for interconnection for different type of Ambient IoT device to the gNB
 - Study the feasibility and function of UE direct link to the ambient IoT devices
- ✓ Study the physical signals/channels for the communication with ambient IoT device
 - Study the signals and waveform for the communication, sensing and positioning to the ambient IoT devices
 - Study the physical layer procedure for the communication with ambient IoT devices with different connectivity topologies
- ✓ Study the enhancement of higher layer protocol for ambient IoT device
 - Control of communication and sensing with/without intermediate/assistant nodes
 - Control function and interface for UE communication to the ambient devices

Continue study the new dimension of IoT in RAN

Rel-18 RAN1 Study of LP-WUR

- ✓ Evaluation Methodology of LP-WUR and NR in ultra-deep sleep mode
 - Power model for LP-WUR and NR in ultra-deep sleep
 - Transition time and energy
- ✓ LP-WUR architecture
 - Architecture with RF envelope detection
 
 - Heterodyne architecture with IF envelope detection
 
 - Homodyne/zero-IF architecture with baseband envelope detection
 
 - OFDM architecture
 
- ✓ L1 signal/channel design for LP-WUR
 - OOK, FSK, and OFDM waveform
 - LP-WUR synchronization
 - UE behavior in monitoring LP-WUS
 - LP-WUS with Potential use for RRM

Rel-19 Work of LP-WUR

- ✓ Specify the signals for the UE low-power wakeup receiver (LP-WUR) in achieving further UE power saving for CONNECTED and IDLE/Inactive UEs (RAN1)
 - The waveform of the low-power wakeup signals (LP-WUS)
 - The information carried by LP-WUS
 - The physical procedure of LP-WUS
- ✓ Specify the LP-WUS functions used by UE LP-WUR for IDLE/Inactive and CONNECD mode UEs in achieving UE power saving (RAN1, RAN2)
 - Specify the LP-WUS as the paging indication IDLEL/Inactive mode UEs
 - Specify the LP-WUS as DRX wakeup indication for CONNECTED mode UEs
 - Study and specify whether LP-WUS is used for UE mobility management
- ✓ Higher Layer Procedure enhancement for LP-WUR [RAN2]
 - Configuration and procedure of LP-WUS signals
 - MAC procedure in supporting wakeup indication by LP-WUS
 - UE behavior of receiving LP-WUS
- ✓ Performance of low-power wakeup receiver [RAN4]
 - Specify the minimum performance of LP-WUR
 - Specify the ACL of LP-WUS while it is transmitted with NR signals/channel in the same carrier

Rel-18 SI for enhanced sidelink on FR2

- ✓ Study enhanced sidelink operation on FR2 licensed spectrum
- ✓ Updating the evaluation methodology for commercial deployment scenario
- ✓ limited to the support of sidelink beam management by reusing existing sidelink CSI framework and reusing Uu beam management concepts wherever possible

Rel-18 WI for sidelink CA operation

- ✓ Specify mechanism to support NR sidelink CA operation based on LTE sidelink CA operation
 - ✓ Support only LTE sidelink CA features for NR
 - ✓ Restriction on operation mode, subcarrier spacing, per-carrier basis

Note: CA objective has not started yet and is likely to be removed from final Rel-18 scope due to TU constraint

SI → WI



Rel-19 WI : Build on Rel-18 SI/WI and with extension

Normative work for enhanced sidelink on FR2

- ✓ Based on the result of the SI, finish normative work on sidelink beam management (including initial beam-pairing, beam maintenance, and beam failure recovery, etc)
- ✓ Resource allocation enhancement for beam-based transmission
- ✓ Groupcast & broadcast support
- ✓ Multi-beam support

Normative work for enhanced sidelink on CA operation

- ✓ Support necessary CA features for NR, including SL carrier (re-)selection, synchronization of aggregated carriers, power control for simultaneous sidelink TX, packet duplication
 - ✓ Including both mode 1 and mode 2 operation
 - ✓ Support of cross-carrier scheduling

Disadvantages of current Public Safety communication

- ✓ When a disaster occurs, UAVs, emergency telecommunication vehicles and satellites can be used in current PS communication
 - **High cost, large delay and difficulty** in deployment
- ✓ R18 Relay UE only supports **unicast forwarding**



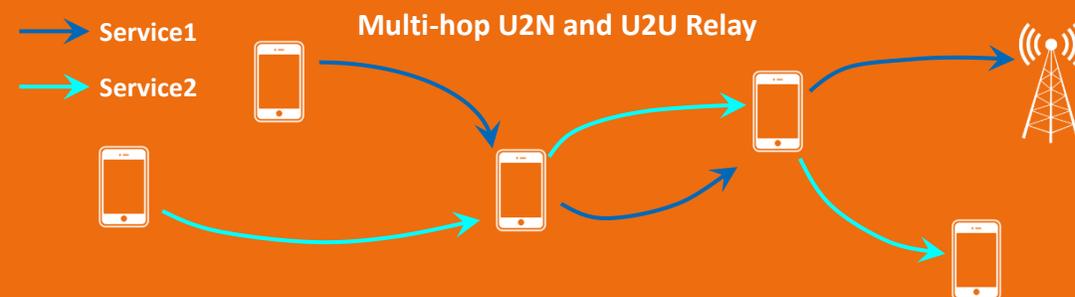
Requirements of vertical applications

- ✓ **Multi-hop and MBS is supported for SL relay by SA1 TS 22.261**
 - Multi-hop relay can be used in many different scenarios and verticals, e.g., SmartTransportation, SmartMine, SmartFactories, Public Safety
 - Groupcast/broadcast service is supported for indirect network connection



Objectives

- ✓ The following aspects can be specified in Rel-19 SL relay
 - **Multi-hop U2N relay and Multi-hop U2U relay**
 - Relay UEs can be used to improve the energy efficiency and coverage of the system
 - Relay UE is easier deployment than mobile base station relay in Public Safety communication
 - **MBS over SL Relay**
 - At least U2N Relay should support groupcast/broadcast service forwarding for Public Safety



Support Multi-hop U2N relay and U2U relay, and groupcast/broadcast service forwarding.

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