

Agenda Item: 8

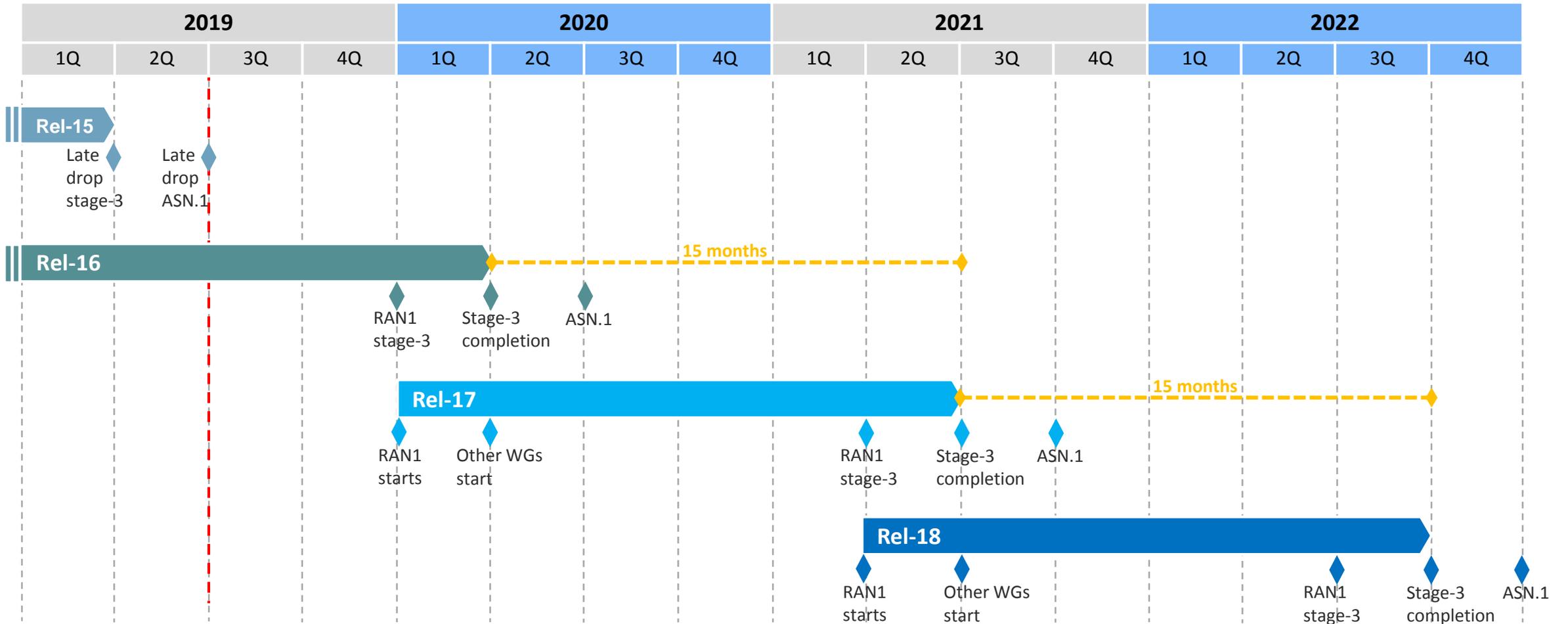
Source: Samsung

Title: Overall view on NR evolution in Rel-17

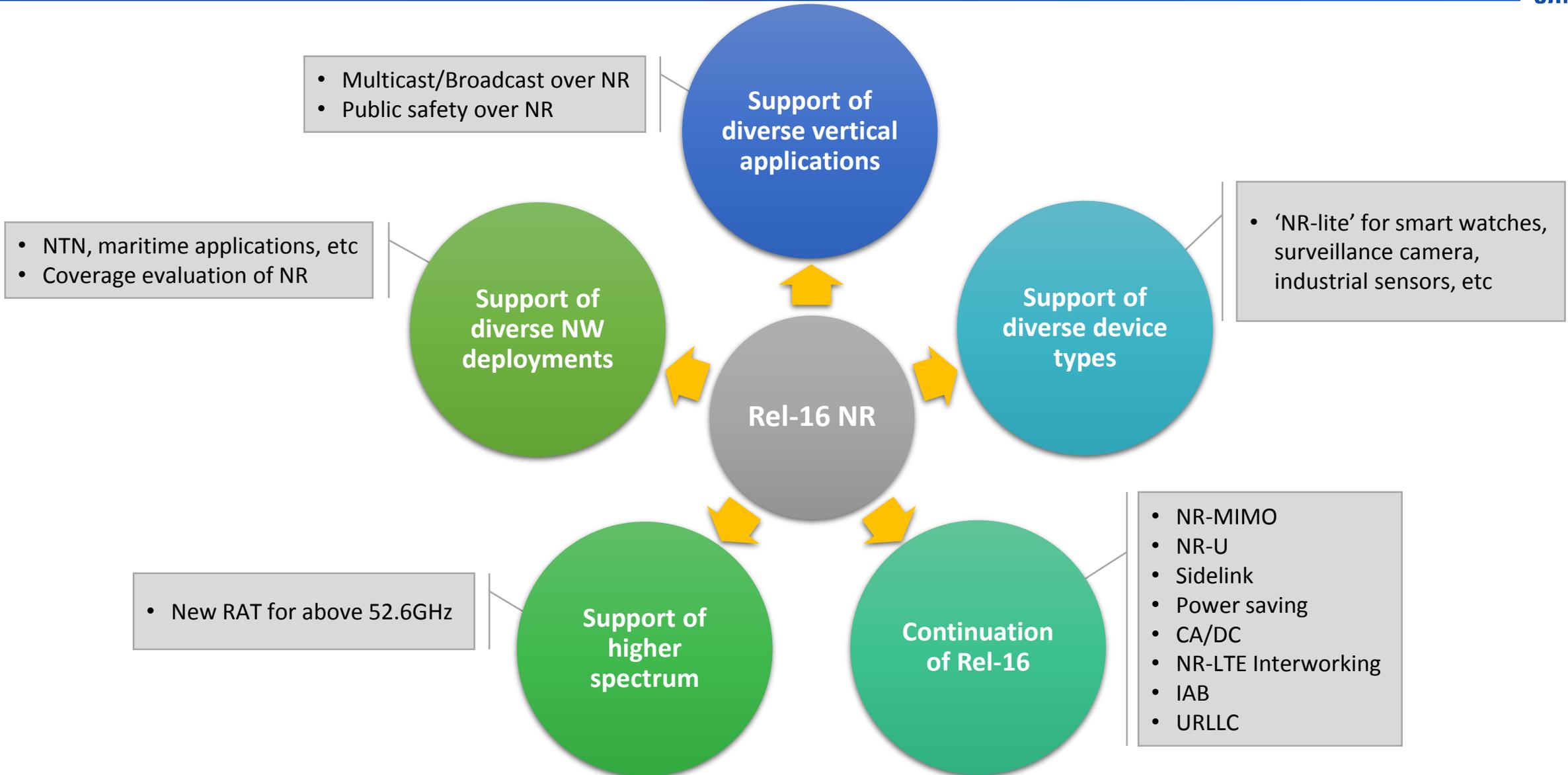
Document for: Discussion

RAN Schedule

◇ Rel-17 stage-3 completion by June of 2021, assuming 15-month release cycle



General Direction of NR Evolution in Rel-17



Overall Picture from RAN WG Perspective

RAN1

- Coverage enhancement
- *NR-lite* (IoT over NR)
- Broadcast/multicast over NR
- New RAT for above 52.6 GHz
- Sidelink enhancement
- NR-U enhancement
- MIMO enhancement
- Others? (depending on Rel-16 outcome)

RAN2

- FR2 SCell enhancement
- UE power saving enhancement
- Inter-RAT enhancement
- Others (depending on Rel-16 outcome)

RAN3

- RAN architecture enhancement for URLLC
- IAB enhancements
- Support of the items led by other WGs

RAN1-Leading

◇ Motivation

- ◆ A thorough understanding of NR coverage is needed considering the latest NR specification support
 - For FR1, a coverage comparison with legacy RAT including eMBB and VoIP is essential
 - FR2 coverage was not evaluated during the self-evaluation campaign towards IMT-2020 submission
- ◆ As per email discussion on NR coverage (RP-180753) after RAN#79, various scenarios, e.g., urban macro, rural/low mobility large cell, urban micro/dense urban, are of interest for NR coverage

◇ Key technical areas

- ◆ Technologies for increasing coverage for both FR1 and FR2, e.g., enhancements on PRACH, PUCCH, and PUSCH
 - Rel-15/16 PRACH design for FR2 can only support up to 1.2km for SCS=120kHz
 - Rel-15/16 PUCCH repetitions mechanism is from LTE, is practically inoperable in NR, while PUCCH repetitions are more important for NR due to higher SCS, and possibility for fewer than 14 symbols and for UCI more than 1 bit
 - Rel-15/16 uplink DMRS and power control do not allow channel estimation across multiple slots at least due to absence precoding restrictions (unlike in DL) and possibility to accumulate TPC commands during repetitions
 - May also consider PDCCH coverage for LTE-NR coexistence (as the available symbol for NR-PDCCH can be limited)
- ◆ Evaluate Rel-16 NR coverage taking into account key coverage related aspects such as $\pi/2$ -BPSK, higher density DMRS (compared to LTE), tighter HARQ timing, overhead, etc
 - Especially for voice coverage which requires vocoder data to be delivered within a certain time window (~50msec for one direction)

◇ RAN timeline

- ◆ Initiate Rel-17 study item for the evaluation of NR coverage and to identify the coverage enhancement technologies
- ◆ Follow-up work item in Rel-17

◇ Motivation

- ◆ Rel-15/16 NR focused mainly on the performance aspects such as throughput, latency, and reliability requiring high level of implementation complexity on the UE side (e.g. on 3.5GHz, UE is mandated to support a BW of 100MHz and 4 RX antennas)
- ◆ To expand the NR market, the specification needs to be tailored for UEs such as smart watches, video surveillance cameras, industrial sensors, etc

◇ Key technical areas

- ◆ IoT targeted specification within NR framework considering, e.g., lower complexity, better power saving
- ◆ Consider two different types of NR-lite depending on whether Rel-15 NR SSB can be reused or not
 - Type-1 *NR-lite* : Reuse Rel-15 NR SSB with UE bandwidth at least equal to or larger than that of Rel-15 SSB (e.g. 5MHz for SCS=15kHz)
 - Type-2 *NR-lite* : Introduce new SSB with UE bandwidth smaller than that of Rel-15 SSB → Need to make sure no overlap with NB-IoT

	NB-IoT	eMTC	LTE Cat1	Type-1 <i>NR-lite</i> *	Type-2 <i>NR-lite</i> *
UE RF bandwidth	200kHz	1.4MHz	20MHz	5MHz (for SCS=15kHz)	1MHz (for SCS=15kHz)
Peak data rate	≤160kbps	≤1Mbps	10Mbps	[10Mbps]	1Mbps

*Note: The values are provided as examples only for the purpose of further discussions

- ◆ Coverage to compensate coverage loss due to complexity reduction, e.g., reduced number of Rx antennas and RF bandwidth
- ◆ Power consumption reduction, e.g., UP data in Idle/Inactive mode, Reduced PDCCH monitoring requirements

◇ RAN timeline

- ◆ Prioritize Type-1 *NR-lite* for Rel-17 and consider Type-2 *NR-lite* in Rel-18 or later

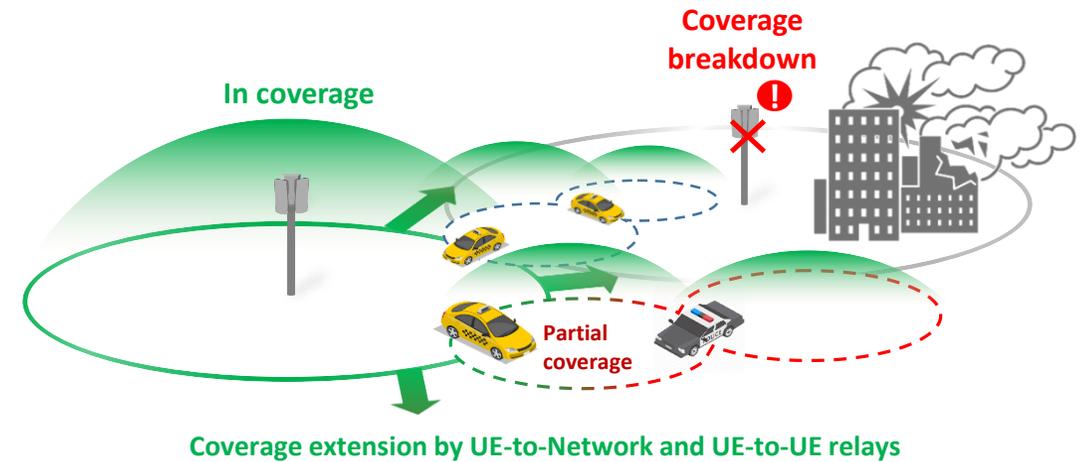
Sidelink Enhancement

◇ Motivation

- ◆ Enhance NR sidelink for V2X in terms of coverage, latency, reliability, efficiency to support both FR1 and FR2
- ◆ Expand the NR sidelink for applications other than V2X such as public safety, maritime communications, etc

◇ Key technical areas

- ◆ Enhancement on NR sidelink coverage
 - Support the extension of network coverage using UE-to-Network relays including new PRACH preamble format(s)
 - Support the extension of sidelink coverage using UE-to-UE relays
- ◆ Study and if necessary, support for NR sidelink discovery
 - Physical layer signals and related procedures for sidelink discovery
 - Resource allocation mechanisms for sidelink discovery
 - Specify sidelink discovery in the presence of multiple carriers and PLMNs
- ◆ Support for multi-antenna transmission/reception schemes including multi-beam operation for sidelink
 - MIMO operation with more than rank 2
 - Enhancement on sidelink CSI feedback mechanism
- ◆ Any leftover issues from Rel-16



	Rel-13 LTE D2D	Rel-15 LTE V2X	Rel-16 NR V2X	Rel-17 sidelink
Peak data rate	≤13 Mbps	≤74Mbps	≤160Mbps*	≤1Gbps

*20MHz BW, 64-QAM, No CA

◇ RAN timeline

- ◆ Rel-17 work item

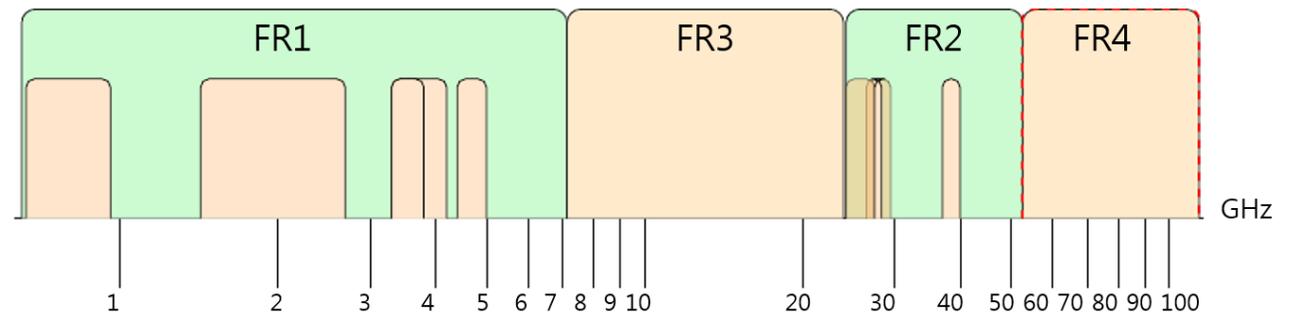
New RAT for above 52.6 GHz

◇ Motivation

- ◆ Expand 3GPP specification support for unlicensed spectrum on 60GHz and future licensed/lightly-licensed spectrum on 66~76GHz and 81~86GHz for application in industrial, private network scenarios for in-building, local area environments
- ◆ Ensure sufficient coverage can be achieved while maintaining acceptable PA efficiency

◇ Key technical areas

- ◆ Downlink/uplink waveform
- ◆ Downlink/uplink signals and channels
- ◆ Faster beam control/adaptation mechanism to support narrower/larger number of beams
- ◆ New numerology including resource units, channelization, bandwidth, etc



◇ RAN timeline

- ◆ Rel-17 study item with follow up work item for completion in Rel-18 (2022.2H)

Note: Expansion of existing NR air interface to 60GHz unlicensed spectrum can be addressed as part of Rel-17 NR-U (if there is immediate market demand)

NR-Unlicensed Enhancement

◇ Motivation

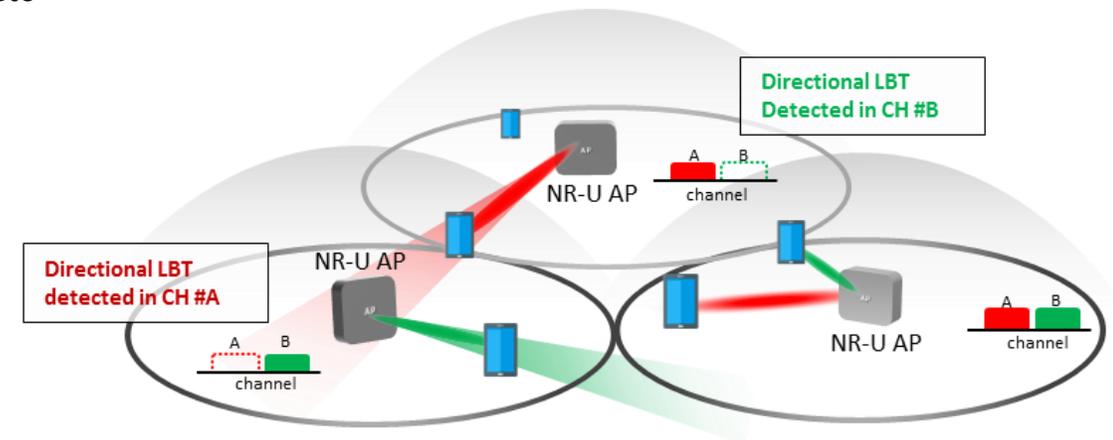
- ◆ Rel-16 NR-U is not designed for optimized coexistence performance in newly available unlicensed spectrum such as 6GHz
- ◆ Market demand for higher frequency unlicensed bands (such as 60GHz) for enhanced data capability

◇ Key technical areas

- ◆ Enhancements towards better NR-U/NR-U coexistence mechanism including channel access procedures and relevant signal/channel design for improving coexistence among intra/inter-operator NR-U gNBs
- ◆ Consider expansion of the existing NR air interface for support of 60GHz unlicensed band
 - If specified, this feature should be independent of 'Above 52.6GHz new RAT' and target WI completion in Rel-17
 - If specified, focus on reusing existing NR specification without any change on fundamental NR features such as waveform or frame structure
 - Possible specification change: Larger subcarrier spacing, directional LBT, etc

◇ RAN timeline

- ◆ Start with SI with possible WI for completion in Rel-17



◇ Motivation

- ◆ NR multi-beam (beam management) support in the current specifications requires very high overhead, latency, and complexity in terms of overall operation
- ◆ Although multi-TRP operation for URLLC is part of ongoing work item in RAN1, it is highly likely that this feature will not be applicable for all of PDSCH, PUSCH, PDCCH, and PUCCH
- ◆ Uplink MIMO is a key area where NR could be differentiated from LTE but due to lack of time during Rel-15, many of the features have been over-simplified

◇ Key technical areas

- ◆ Enhancements on multi-beam operation aiming to minimize latency and higher-layer overhead especially @ FR2
- ◆ Enhancements for extending multi-TRP operation to all of PDSCH, PUSCH, PDCCH, and PUCCH
- ◆ Enhancements of precoding/codebook and control channels for uplink MIMO to improve DL-UL reciprocity operation and to support frequency-selective precoding
- ◆ Enhancements on UL multi-beam operation for the UEs with multiple TX panels capable of fast panel switching and simultaneous transmission, including the leftovers from Rel-16

◇ RAN timeline

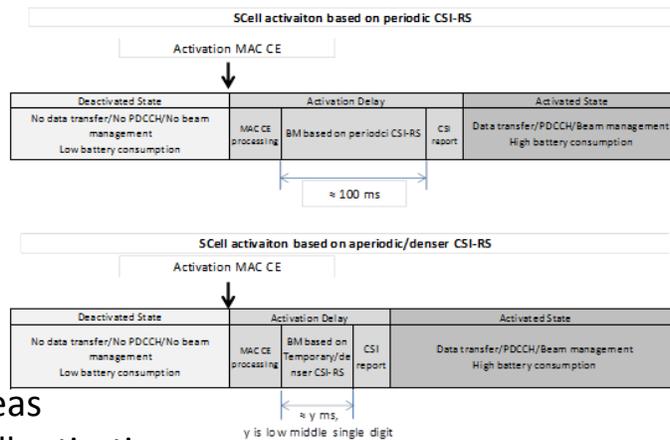
- ◆ Rel-17 work item

RAN2-Leading

FR2 SCell Enhancement

◇ Motivation

- ◆ FR2 is a distinctive feature of NR extending the spectrum usage far beyond what was available in LTE. Nonetheless, the major functions like carrier aggregation, RLM/BFD and random access were not designed with necessary consideration on FR2
- ◆ In CA, the activation delay for a FR2 SCell could be around 100 ms, four times longer than FR1 SCell activation delay
- ◆ For RLM/BFD, due to DRX cycle dependency, it is effectively impossible to configure long DRX cycle for FR2 serving cells (too long delay until recovery is triggered)
- ◆ Random access procedure takes very long if beam correspondence does not exist
- ◆ Configured Grant is valid only for a single beam; hence whenever beam changes new CG should be allocated



◇ Key technical areas

- ◆ Fast FR2 SCell activation **<FR2 SCell Activation>**
- ◆ Enhancements on RLM/BFD
- ◆ Random Access Enhancements
- ◆ Configured Grant Enhancements

◇ RAN timeline

- ◆ Initiate Rel-17 work item

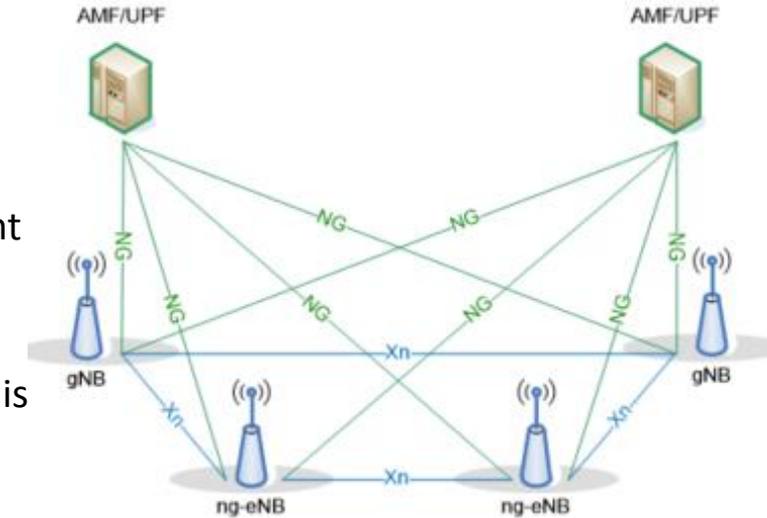
	RLM	BFD
Phase 1	L1 evaluates whether the resources are below threshold or not. > 20 * DRX cycles	L1 evaluates whether the resources are below threshold or not. > 10 * DRX cycles
Phase 2	L1 indicates the problem to L2 predefined consecutive times. ≈ 10 * DRX cycles	L1 indicates the problem to L2 predefined consecutive times. ≈ 10 * DRX cycles
Phase 3	L1 try to find the suitable resource for recovery ≈ 1000 ms	L1 try to find the suitable resource for recovery ≈ n * DRX cycles, n is low single digit
Phase 4	Recovery action is triggered	Recovery action is triggered

<RLM/BFD in FR2>

Inter-RAT Enhancements

◇ Motivation

- ◆ 5G rollouts (NSA or SA mode) lead to interim situation to maintain both EPC and 5GC.
- ◆ In long term, operators may completely migrate to 5GC connected with ng-eNB and gNB
- ◆ LTE and NR specs support common features like INACTIVE state but no support for efficient inter-RAT procedures like IRAT re-selection, IRAT resume and IRAT re-establishment
- ◆ When a UE camped on NR cell declares RLF and no neighbour NR cells are suitable, UE selects a cell belonging to LTE RAT and performs connection setup. If re-establishment is supported for inter-RAT RLF recovery, it will provide better user experience and reduce service/ data interruption etc



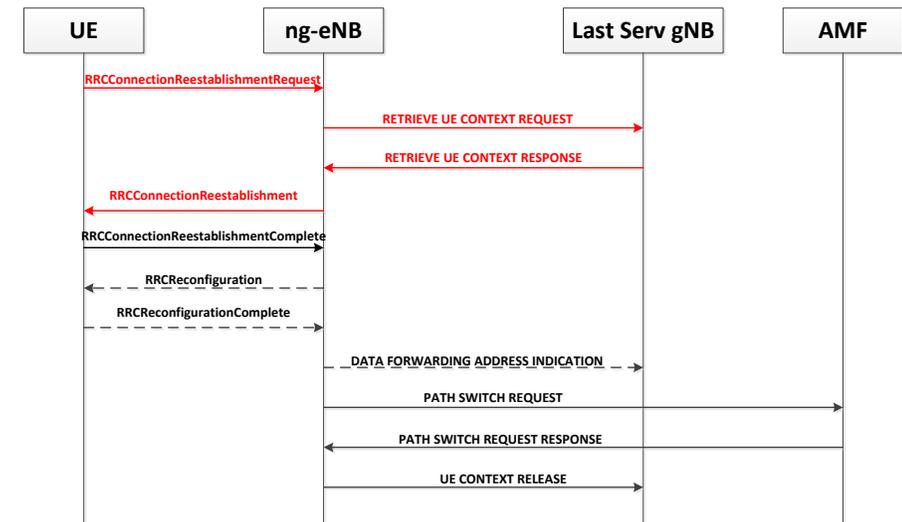
Deployment after migration to 5G

◇ Key technical areas

- ◆ IRAT re-selection between NR and E-UTRA
 - Stored UE INACTIVE AS context to be valid while re-selecting on EUTRA/NR cell
- ◆ IRAT resume between NR and E-UTRA
 - Resuming UE INACTIVE AS context across EUTRA/NR
- ◆ IRAT re-establishment between NR and E-UTRA

◇ RAN timeline

- ◆ Initiate Rel-17 work item

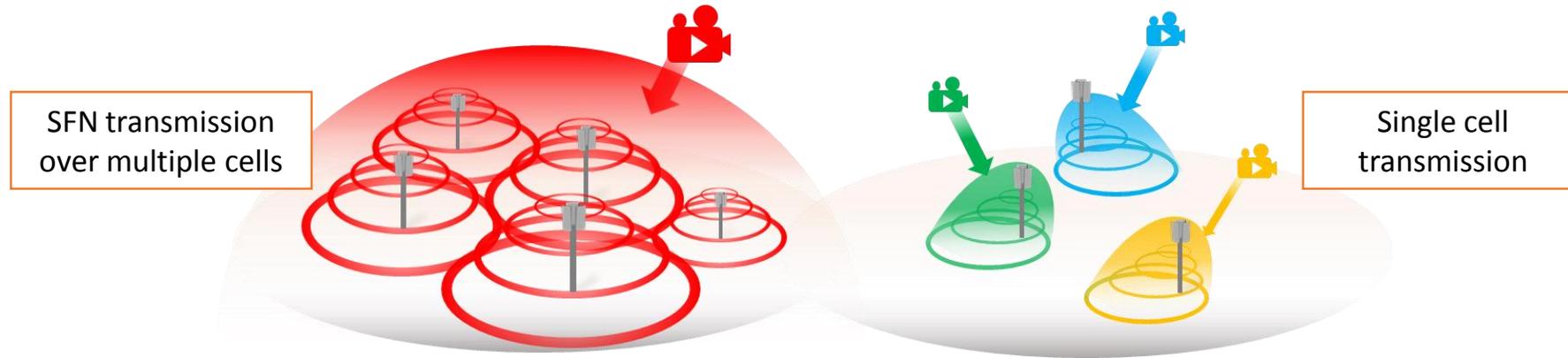


Inter-RAT Re-establishment

Broadcast / Multicast over NR

◇ Motivation

- ◆ Support multi-media broadcast/multicast and public safety applications by single cell or SFN-based multi-cell transmission
- ◆ Common structure for single cell and multi-cell transmissions in terms of UE RX operation



◇ Key technical areas

- ◆ Numerologies and resource multiplexing between unicast, broadcast, multicast in time and frequency domain
- ◆ Procedures/ Signaling support over Uu, F1 and NG
- ◆ Provide specification support at least for FR1 and study feasibility for FR2

◇ RAN timeline

- ◆ Rel-17 study item with follow up work item for completion in Rel-17 (2021.1H)

◇ Motivation

- ◆ Multi-SIM is gaining more and more grounds due to both emerging new service scenarios and new enabler like e-SIM
- ◆ Multi-SIM support has been so far based on implementation which bear limitations for user experience

◇ Key technical areas

- ◆ Paging collision in Dual SIM Dual Standby
 - PO collision between two SIMs can happen in the current UE ID specific PO calculation
- ◆ Active service interruption in Dual SIM Single Active
 - Receiving IDLE mode paging for a SIM while active service is ongoing in another SIM

◇ RAN timeline

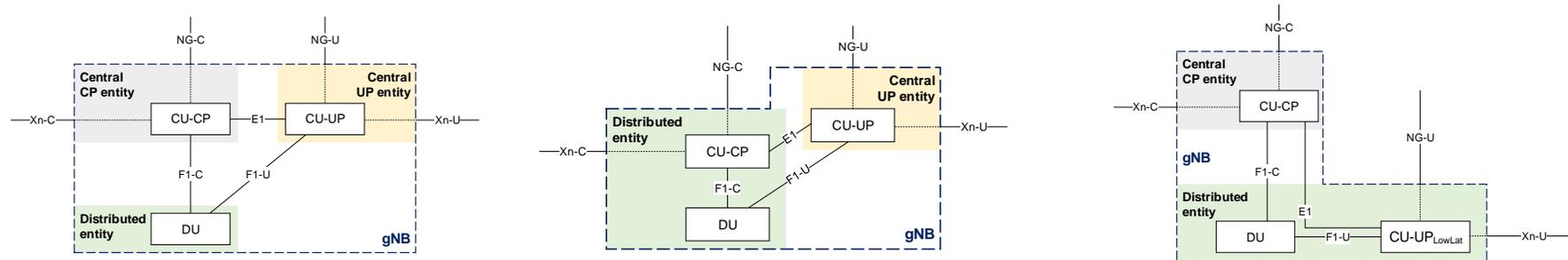
- ◆ Initiate Rel-17 study item and following up WI

RAN3-Leading

RAN Architecture Enhancements for URLLC

◇ Motivation

- ◆ The requirements of low latency and higher reliability continue growing with new verticals e.g. V2X, IIOT.
- ◆ Several solutions were identified and discussed for higher reliability e.g. duplicated PDU sessions.
- ◆ In Rel-15/Rel-16, how to reduce the latency for URLLC is mainly considered from the air interface perspectives.
- ◆ To reduce the latency, making the shortest traffic path and reducing the number of intermediate processing nodes are also important.

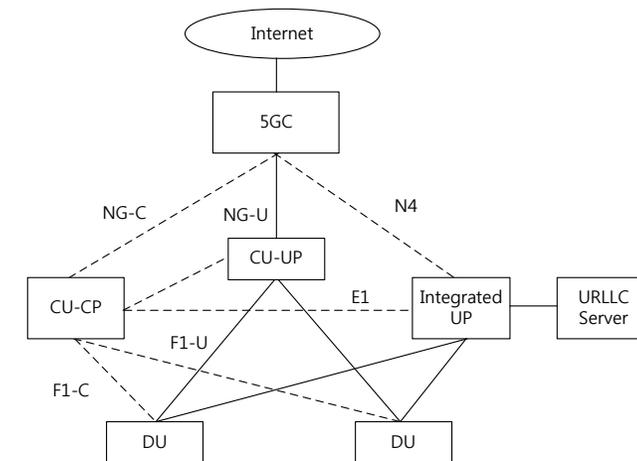


◇ Key technical areas

- ◆ Selection of gNB-CU-UP adjacent to the UPF
- ◆ Support of integrated gNB-CU-UP/UPF
- ◆ Support of local network access connected to aggregated gNB

◇ RAN timeline

- ◆ Initiate Rel-17 study item and follow-up Rel-17 work item

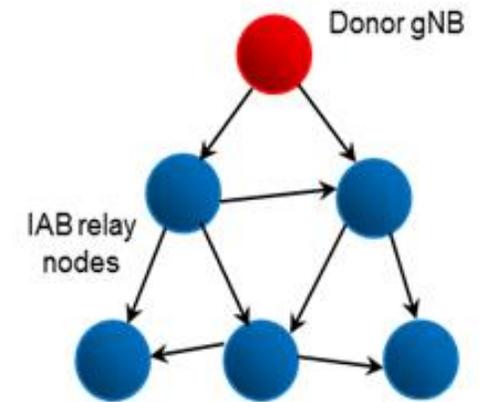
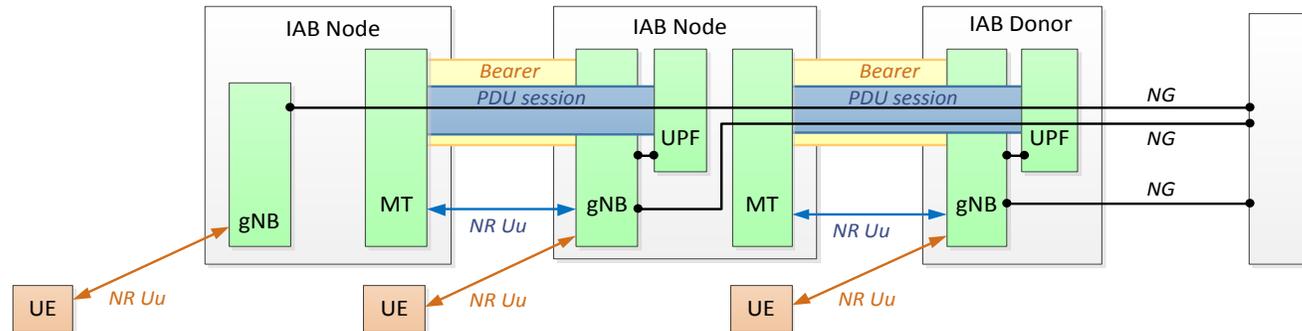


◇ Motivation

- ◆ Rel-16 IAB supports only the basic operation (e.g. spanning tree topology only, no IAB node mobility support)
- ◆ Rel-16 IAB is based on CU-DU split architecture and hence can't be used for aggregated gNBs.
 - For 5G small cells, which most likely will follow the aggregated gNB architecture, it would be a perfect choice for the IAB 2a architecture

◇ Key technical areas

- ◆ Support of NEDC (architecture option 4) and NG-ENDC (architecture option 7)
- ◆ Support of mesh topology for multi-hop backhauling enhancements
- ◆ Support of mobile IAB
- ◆ Support of aggregated IAB nodes based on architecture 2a



◇ RAN timelines

- ◆ Initiate Rel-17 work item

Thanks!