NR RAN1
Rel-15 Update & Rel-16 Highlights

Javier Campos	2019.01.22
NR Physical Layer Architect / RAN1 Delegate	

Content

NR RAN1 REL-15 UPDATE & REL-16 HIGHLIGHTS

- RAN1 Rel-15 Status Update
- L1 Rel-15 Specification Overview
- RAN1 Rel-16 Status Update
- L1 Rel-16 Specification Overview
- Summary

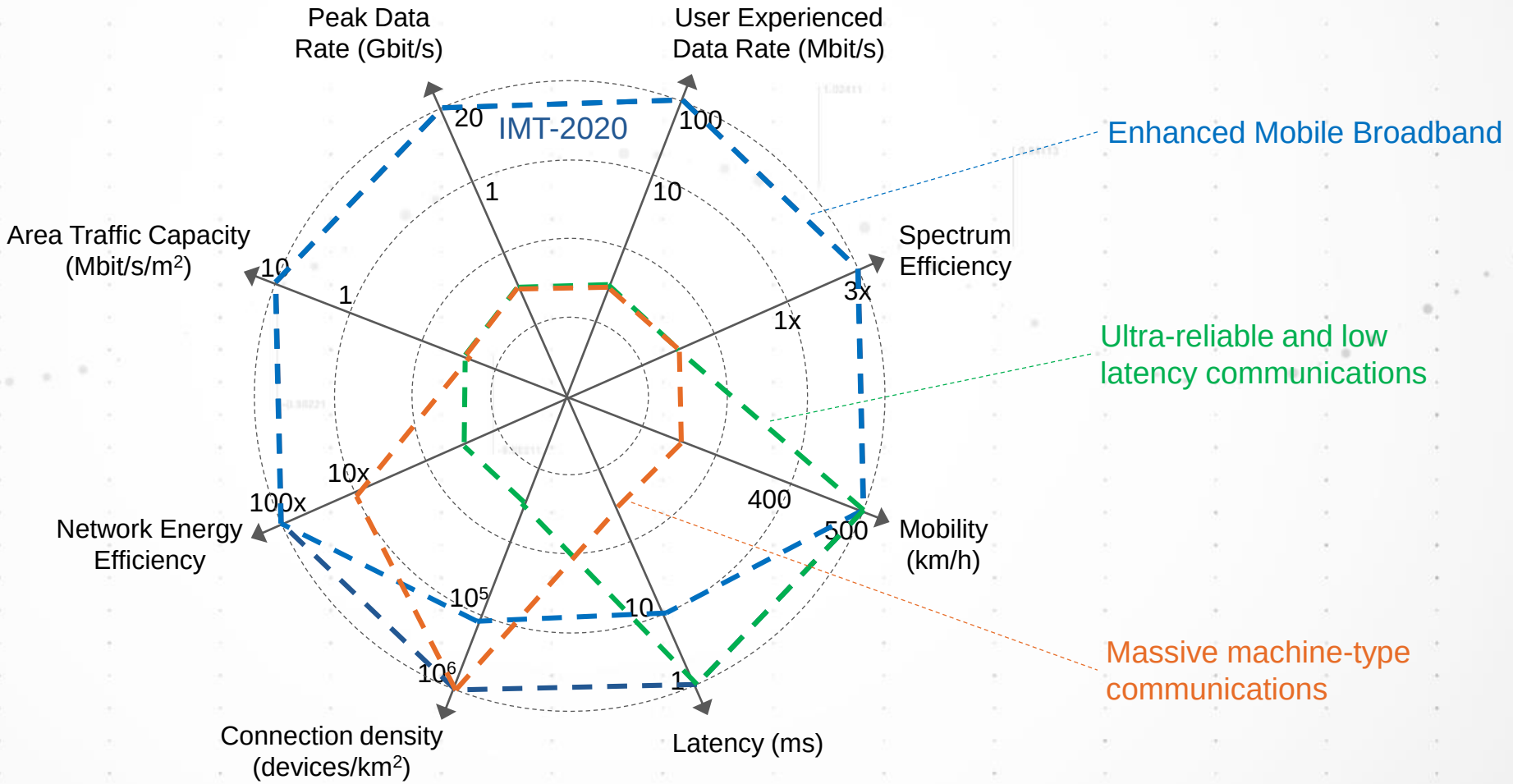
RAN1 Rel-15 Status Update

L1 Rel-15 Specification Overview
RAN1 Rel-16 Status Update
L1 Rel-16 Specification Overview
Summary

5G Use Cases

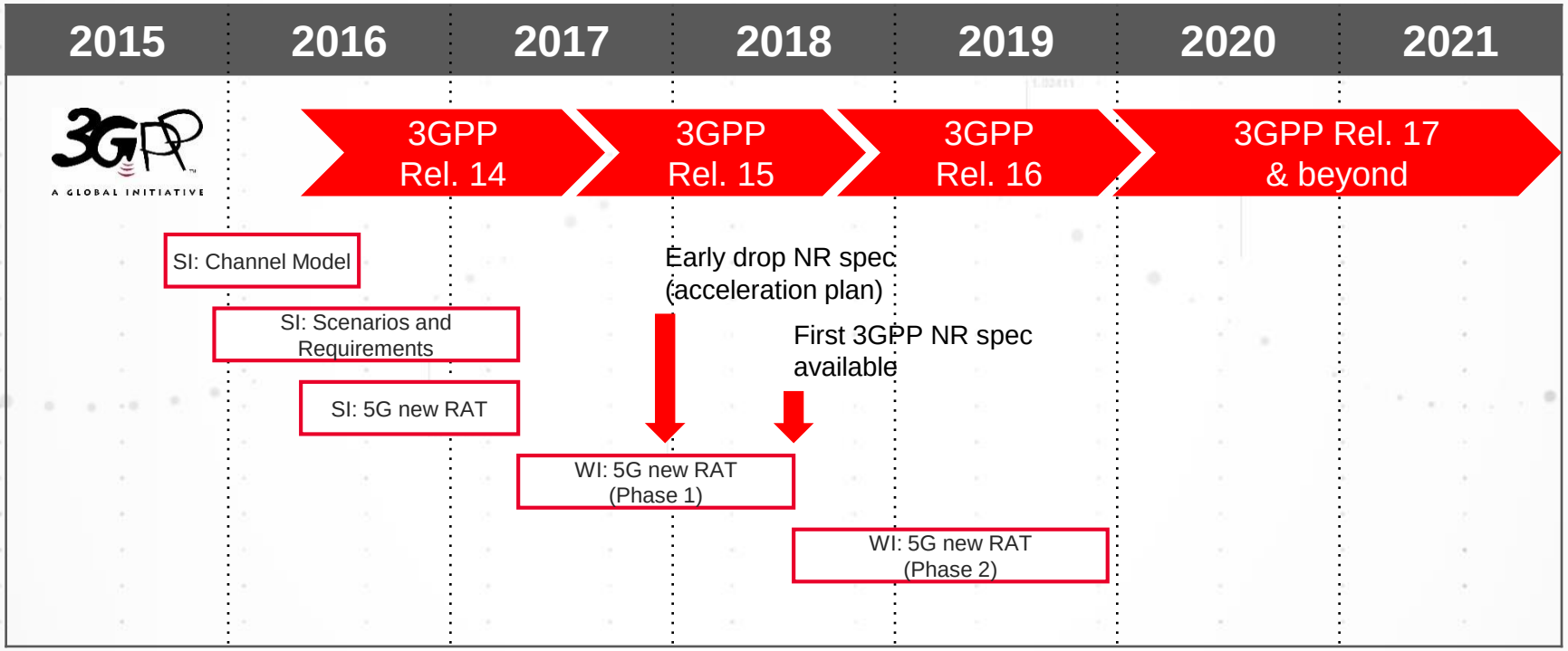
RAN1 REL-15 STATUS UPDATE

- 5G capability perspectives from the ITU-R IMT-2020



3GPP NR Roadmap

RAN1 REL-15 STATUS UPDATE



3GPP NR Rel-15 Scope

RAN1 REL-15 STATUS UPDATE

- Acceleration of eMBB Non-Standalone mode by **December'17**
  - Standalone standardization dates as expected (June'18)
- Use cases:
  - Enhanced Mobile Broadband (eMBB)
  - Ultra Reliable Low Latency Communications (URLLC)
- Carrier aggregation operation
- Inter-RAT mobility between NR and E-UTRA

✓ **IN SCOPE**

- Frequencies beyond 52.6 GHz
  - Other types of waveforms
- mMTC – Machine type communications
- Internetworking with non-3GPP systems (e.g. WiFi)
- Vehicular communications
- Multicast services and multimedia broadcast
- Unlicensed spectrum access

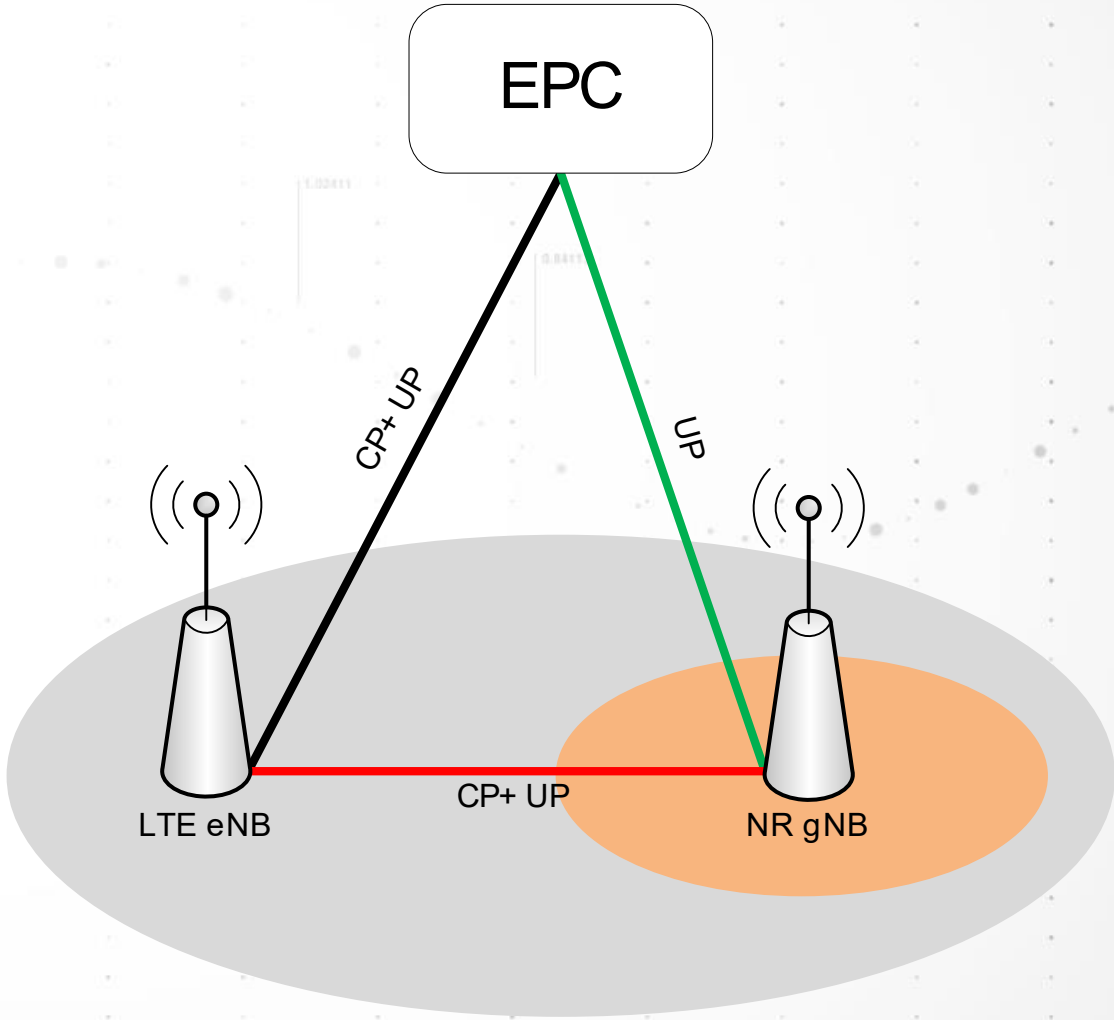
⊘ **OUT OF SCOPE**

Non-Stand Alone Mode

RAN1 REL-15 STATUS UPDATE

Non-Stand Alone Mode

- Specified by **December'17**
- Using LTE core network
- LTE eNB always acts as a master
- NR gNB always acts as a slave

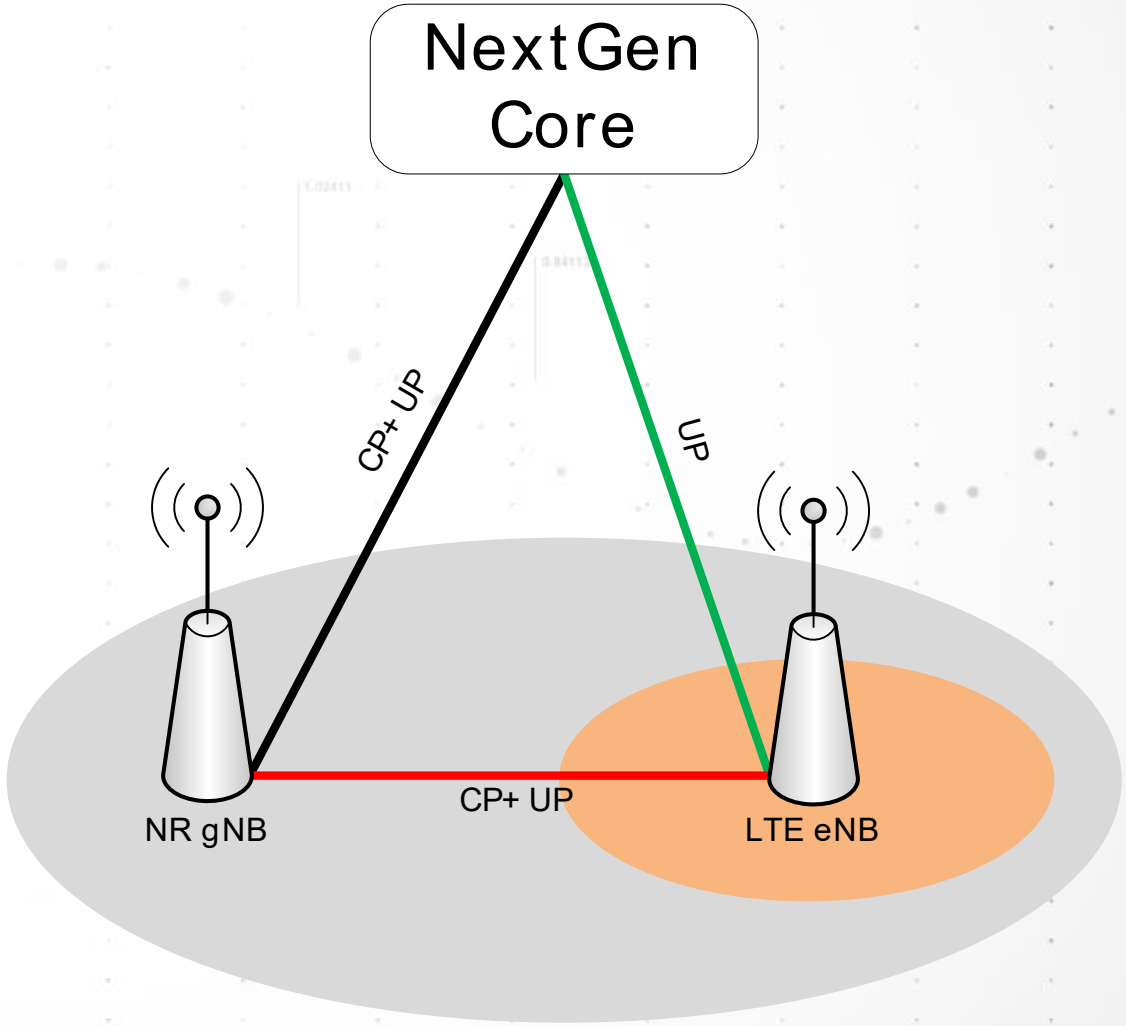


Stand Alone Mode

RAN1 REL-15 STATUS UPDATE

Stand Alone Mode

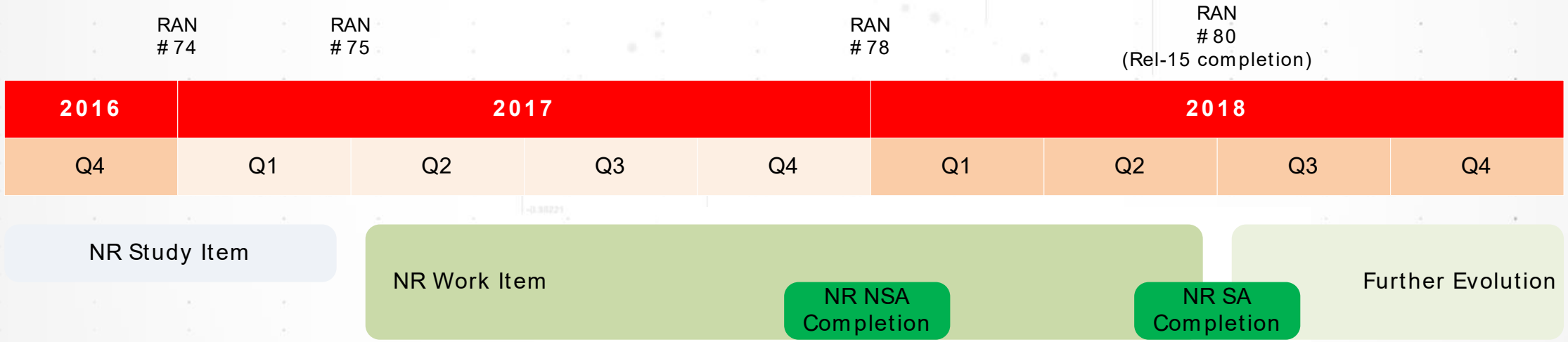
- Specified by **June'18 (Rel-15)**
- Using NextGen core network
- NR gNB acts as a master
- Slave can be LTE eNB or NR gNB



Rel-15 Roadmap

RAN1 REL-15 STATUS UPDATE

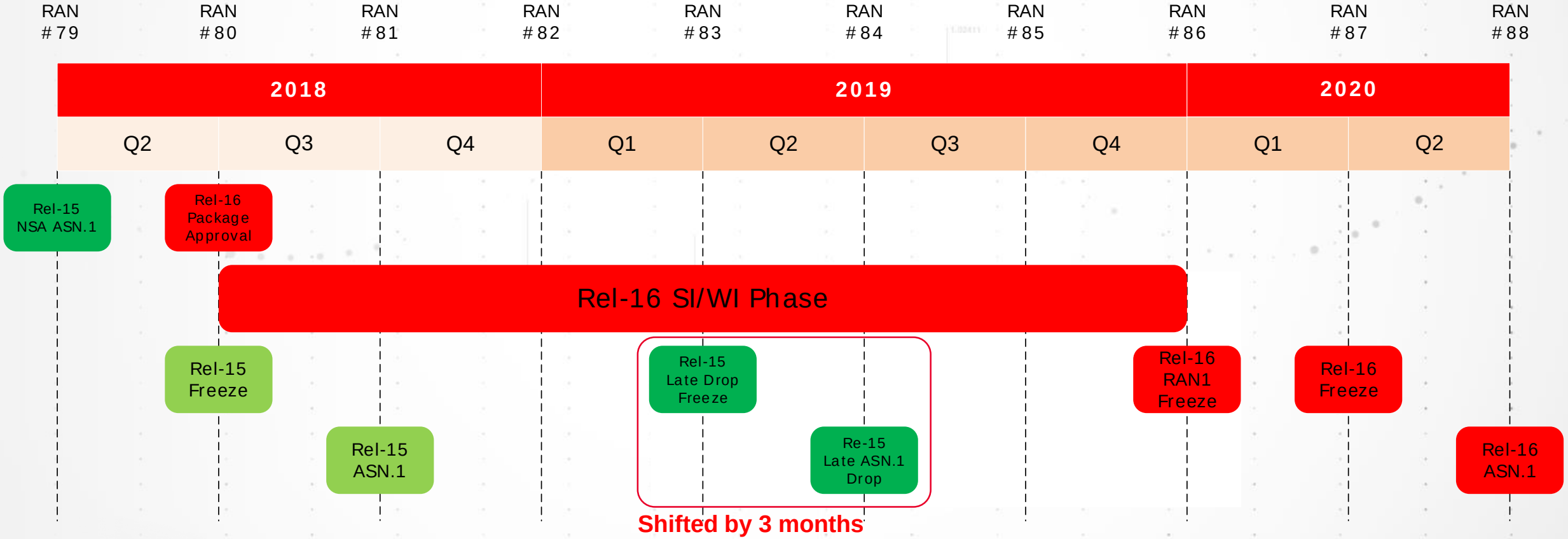
3GPP Release 15 Roadmap



Rel-15 Roadmap

RAN1 REL-15 STATUS UPDATE

3GPP Release 15 Roadmap



Rel-15 RAN1 Meetings

RAN1 REL-15 STATUS UPDATE

Meeting	Date	Allocated Time for CRs
RAN1 #94	August 2018	10 TUs
RAN1 #94bis	October 2018	6 TUs
RAN1 #95	November 2018	4 TUs
RAN1 #96	February 2019	2 TUs
RAN1 #96bis	April 2019	1 TUs
RAN1 #97	May 2019	1 TUs

No Rel-15 topics to be discussed in AH1901 meeting (January 2019)

Rel-15 RAN1 Specifications

RAN1 REL-15 STATUS UPDATE

Spec Number	Title	Current Version
38.201	General Description	15.4.0
38.202	Services Provided by the Physical Layer	15.4.0
38.211	Physical Channels and Modulation	15.4.0
38.212	Multiplexing and Channel Coding	15.4.0
38.213	Physical Layer Procedures for Control	15.4.0
38.214	Physical Layer Procedures for Data	15.4.0
38.215	Physical Layer Measurements	15.4.0

http://www.3gpp.org/DynaReport/38-series.htm

RAN1 Rel-15 Status Update

L1 Rel-15 Specification Overview

RAN1 Rel-16 Status Update

L1 Rel-16 Specification Overview

Summary

Frequency Ranges

L1 REL-15 SPECIFICATION OVERVIEW

- Two different frequency ranges are defined:
  - **FR1 (Frequency range 1)**
    - Below 6 GHz
    - Supports 15, 30 and 60 kHz subcarrier spacing
  - **FR2 (Frequency range 2)**
    - Above 6 GHz
    - Supports 60, 120 and 240 kHz subcarrier spacing
- Physical layer design is common with some minor optimizations for each frequency range (e.g. initial access, subcarrier spacings, bandwidths, …)

Waveform

L1 REL-15 SPECIFICATION OVERVIEW

- **Waveform** (for eMBB/URLLC and < 52.6 GHz)
  - DL Waveform: CP-OFDM
  - UL Waveform: CP-OFDM + DFT-s-OFDM
    - CP-OFDM targeted at high throughput scenarios
    - DFT-s-OFDM targeted at power limited scenarios
- **Multiple Access**
  - Orthogonal Multiple Access
  - Non-Orthogonal Multiple Access (NOMA) is under study for Rel-16
- **Bandwidth**
  - Maximum CC bandwidth is 400 MHz
  - Maximum number of subcarriers is 3300
  - Maximum number of CCs is 16

This is from signaling point of view
Not all combinations are allowed

Numerology

L1 REL-15 SPECIFICATION OVERVIEW

- Scalable subcarrier spacing

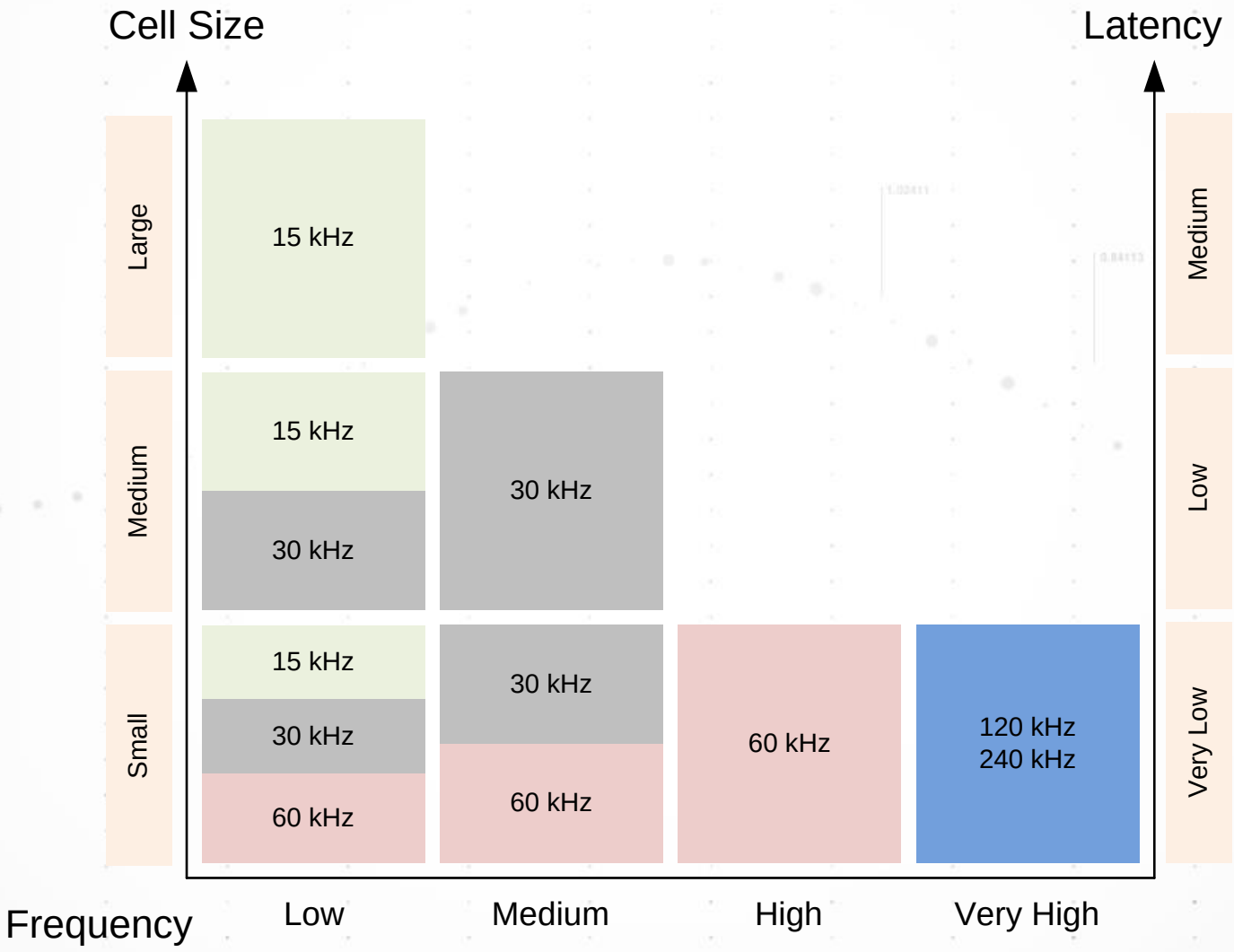
$$\Delta f = 2^{\mu} \cdot 15\ kHz$$

- Parameters defining a numerology:
  - Subcarrier spacing (i.e. μ parameter)
  - Cyclic prefix (i.e. Normal/Extended)

	μ	Δf = 2μ·15 kHz	Cyclic Prefix	
Sync **FR1**	0	15 kHz	Normal	Data **FR1**
	1	30 kHz	Normal	
	2	60 kHz	Normal, Extended	
Sync **FR2**	3	120 kHz	Normal	Data **FR2**
	4	240 kHz	Normal	
	5	480 kHz	Normal	Specified but not supported in Rel-15

Use Cases for Different Subcarrier Spacing

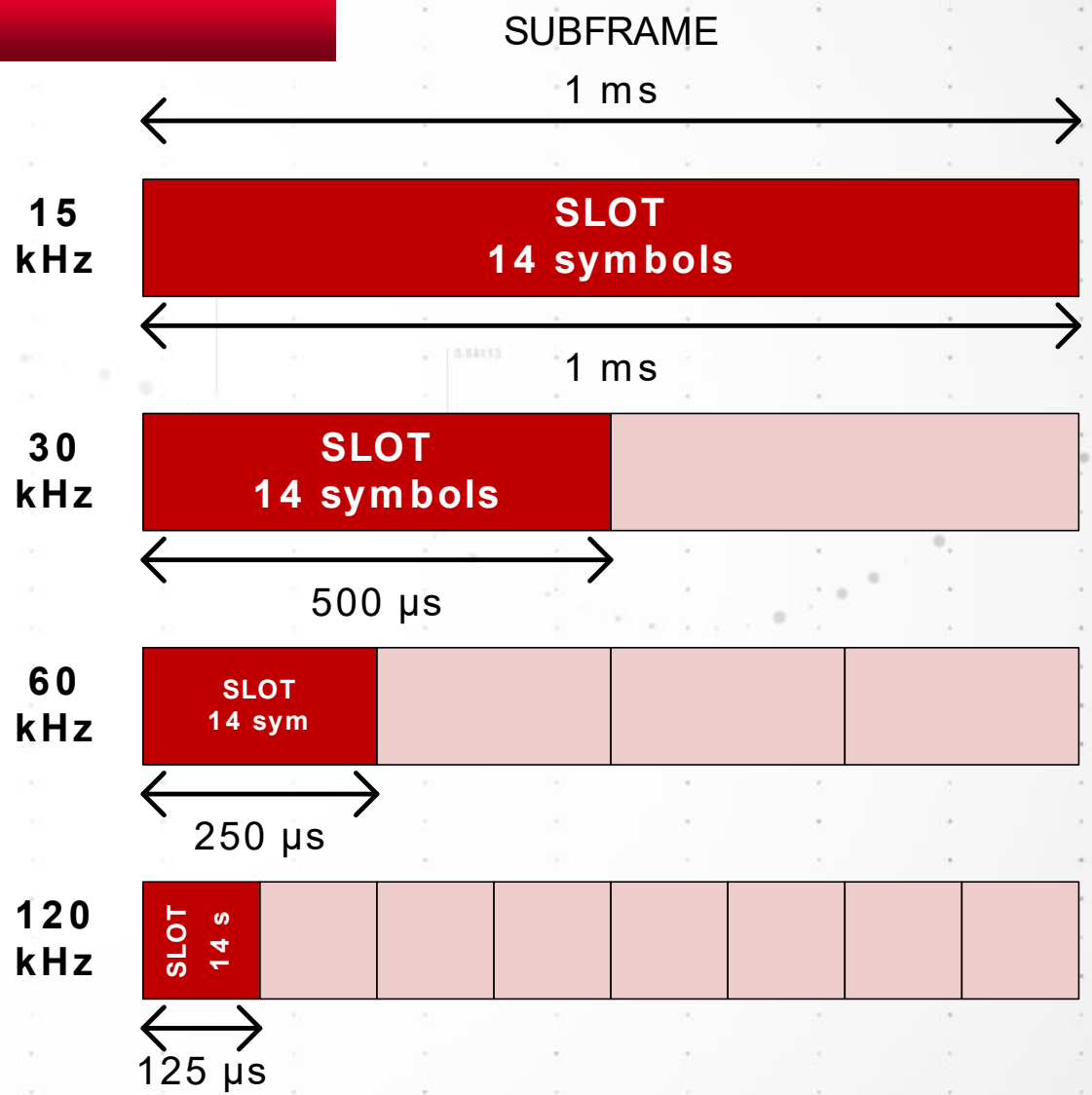
L1 REL-15 SPECIFICATION OVERVIEW



Frame Structure

L1 REL-15 SPECIFICATION OVERVIEW

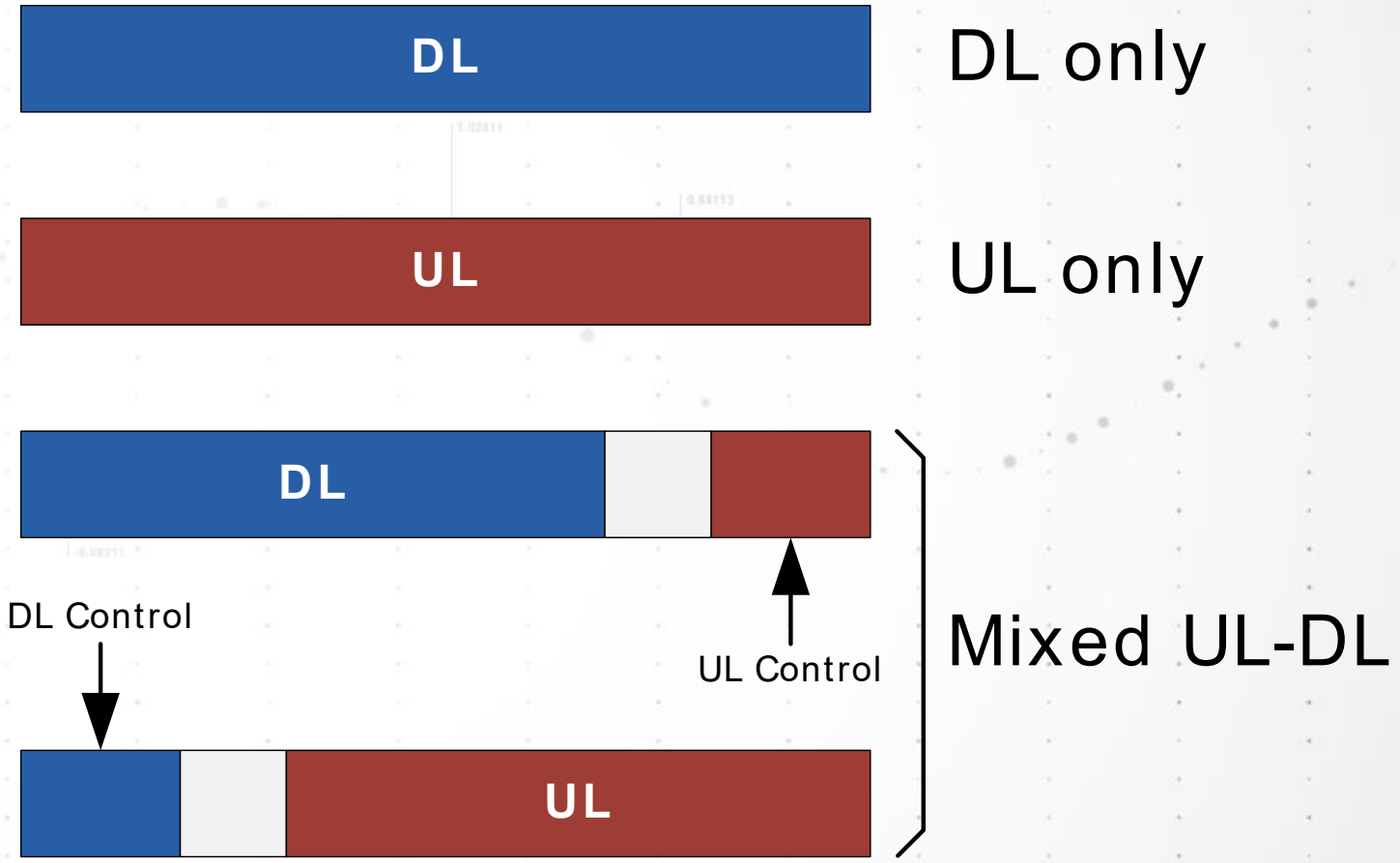
- Frame: 10 ms
- Subframe: Reference period of 1 ms
- Slot (Mapping type A)
  - **14 OFDM symbols**
  - One possible scheduling unit
    - Slot aggregation allowed
  - Slot length scales with the subcarrier spacing
    - $Slot\ length = {}^{1\,ms}/_{2^{\mu}}$
- Mini-Slot (Mapping type B)
  - DL: **7, 4 or 2 OFDM symbols**
  - UL: **1 to 14 OFDM symbols**
  - Minimum scheduling unit



Slot Structure

L1 REL-15 SPECIFICATION OVERVIEW

- A slot can be:
  - All downlink
  - All uplink
  - Mixed downlink and uplink
    - Static, semi-static or dynamic

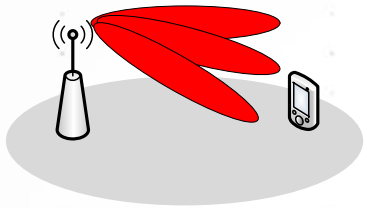


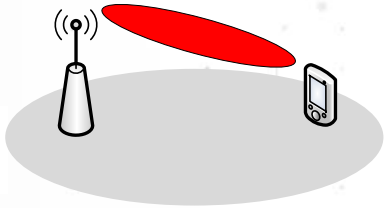
Beam-Sweeping and Initial Access

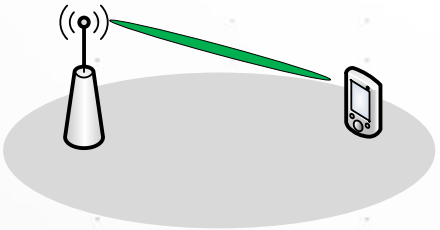
L1 REL-15 SPECIFICATION OVERVIEW

Wide Coverage

UE-Specific Coverage







Beam-sweeping transmission

Beam-sweeping transmission

Beam-sweeping reception

UE-specific selected beam

UE-specific beamforming

Synchronization Signals

System Information

Basic information for all UEs

Random Access Channel

Random Access Response & System Information

Required only for UEs after random access

Data and control channels

Single-beam or Beam-sweeping

Beam Management

L1 REL-15 SPECIFICATION OVERVIEW

- **Beam management:** acquire and maintain a set of TRxP(s) and/or UE beams that can be used for DL and UL transmission/reception
  - **Beam determination:** for TRxP(s) or UE to select its own Tx/Rx beam(s)
  - **Beam measurement:** for TRxP(s) or UE to measure characteristics of received beamformed signals
  - **Beam reporting:** for UE to report information of beamformed signal(s) based on beam measurement
  - **Beam sweeping:** operation of covering a spatial area with beams transmitted and/or received during a time interval in a predetermined way
- Reference signals used for beam management:
  - IDLE mode: **PSS**, **SSS** and **PBCH DMRS** (i.e. SSB)
  - CONNECTED mode: **CSI-RS** (DL) and **SRS** (UL)

No explicit beam refinement procedure defined in Rel-16

Downlink Physical Channels

L1 REL-15 SPECIFICATION OVERVIEW

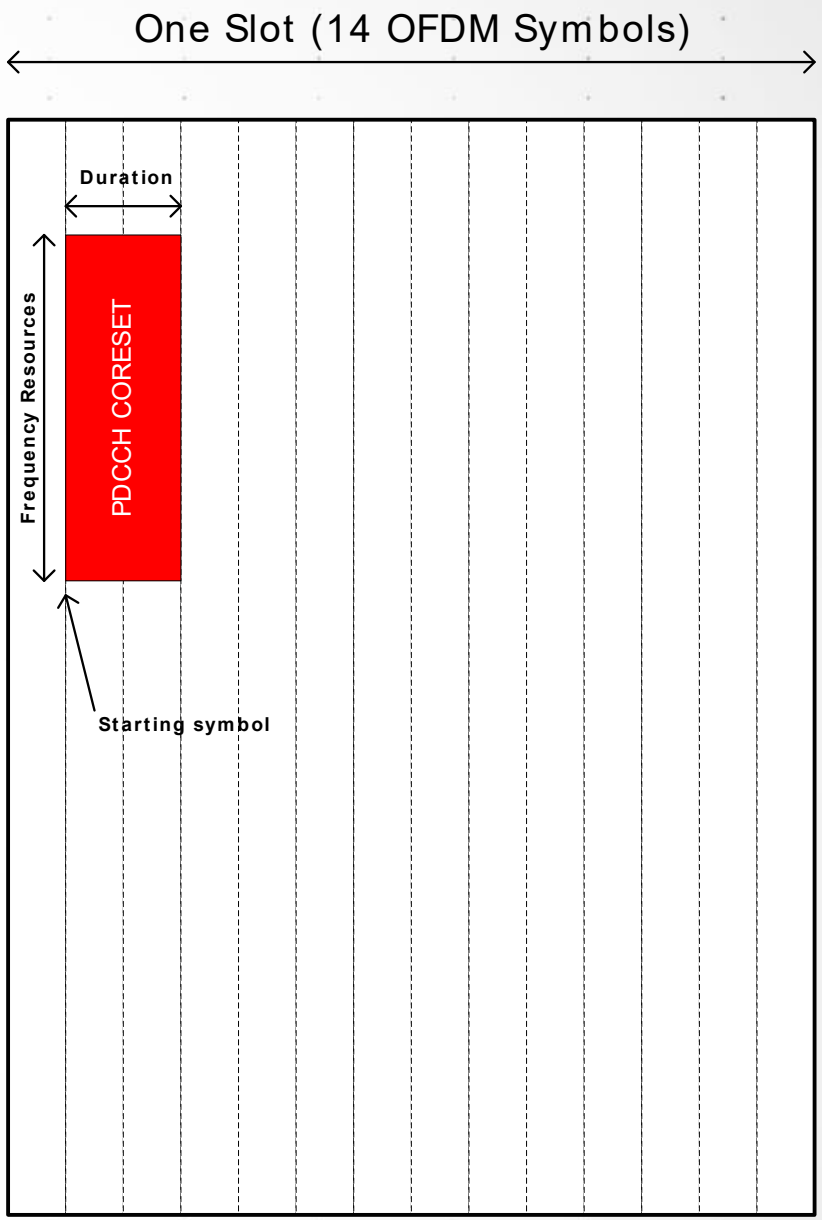
- **Downlink** physical channels:
  - Physical Broadcast channel (PBCH)
  - Physical Downlink Control Channel (PDCCH)
  - Physical Downlink Shared Channel (PDSCH)

– **Downlink** physical signals:
  - Primary Synchronization Signal (PSS)
  - Secondary Synchronization Signal (SSS)
  - Channel State Information Reference Signal (CSI-RS)
  - Tracking Reference Signal (TRS)

PDCCH (CORESET)

L1 REL-15 SPECIFICATION OVERVIEW

- Carries **DCI**
- Modulation: **QPSK**
- A **control resource set** (CORESET) is defined as a set of REGs under a given numerology
- Configured by UE-specific higher-layer signaling:
  - Frequency-domain resources
  - Starting OFDM symbol (OFDM symbol #0, #1 or #2)
  - Time duration (maximum duration of 3 OFDM symbols)

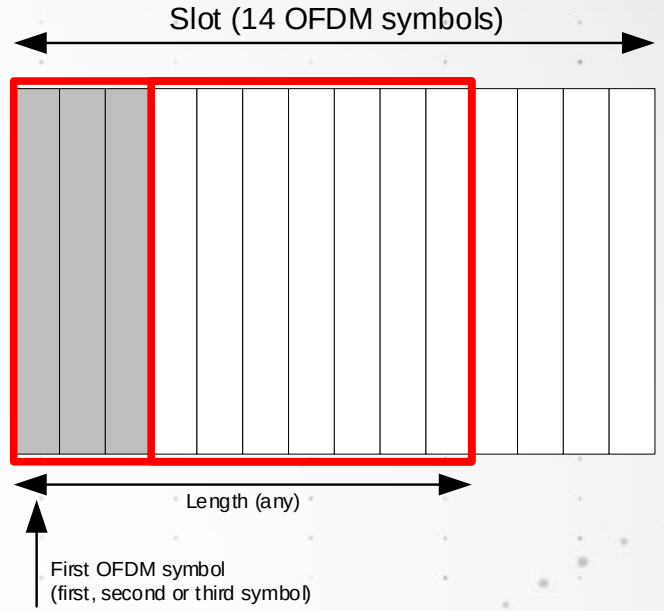


PDSCH

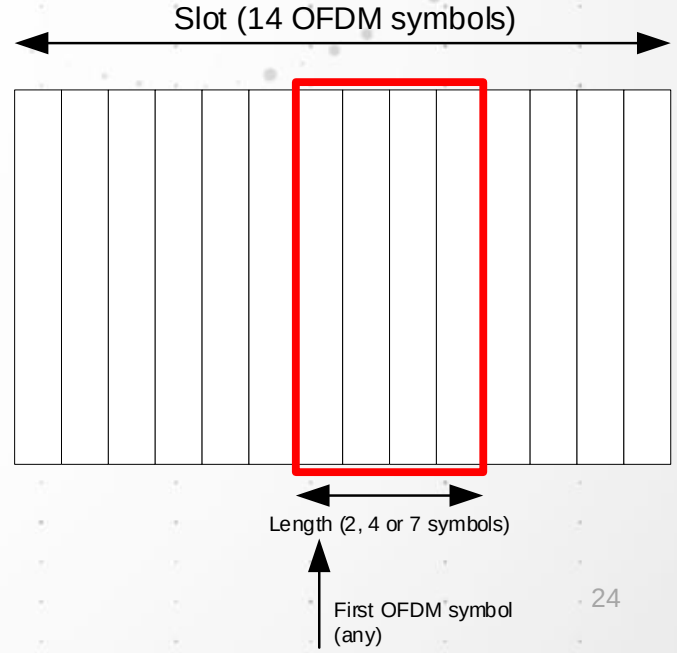
L1 REL-15 SPECIFICATION OVERVIEW

- Carries user **data**
- Modulations: QPSK, 16QAM, 64QAM and 256QAM
- Two mapping types:
  - **Type A**
    - Starting symbol can be 0, 1, 2 or 3 in a slot
    - DMRS symbol is l_0 = {2, 3}
  - **Type B**
    - Starting symbol can be any position within a slot
    - DMRS symbol is the first assigned symbol
    - Slot boundary is not crossed
    - Length can be 2, 4 or 7 OFDM symbols

Type A



Type B



CSI-RS and CSI Reports

L1 REL-15 SPECIFICATION OVERVIEW

- Use cases:
  - CSI acquisition
  - Beam management
  - Tracking reference signals (TRS)
- Two types of CSI feedback:
  - **Type I: NORMAL**
    - Codebook-based PMI feedback with normal spatial resolution
  - **Type II: ENHANCED**
    - Codebook-based feedback with higher spatial resolution

This feature in NR can outperform LTE under the same circumstances

Uplink Physical Channels

L1 REL-15 SPECIFICATION OVERVIEW

- **Uplink** physical channels:
  - Physical Uplink Shared Channel (PUSCH)
  - Physical Uplink Control Channel (PUCCH)
  - Physical Random Access Channel (PRACH)

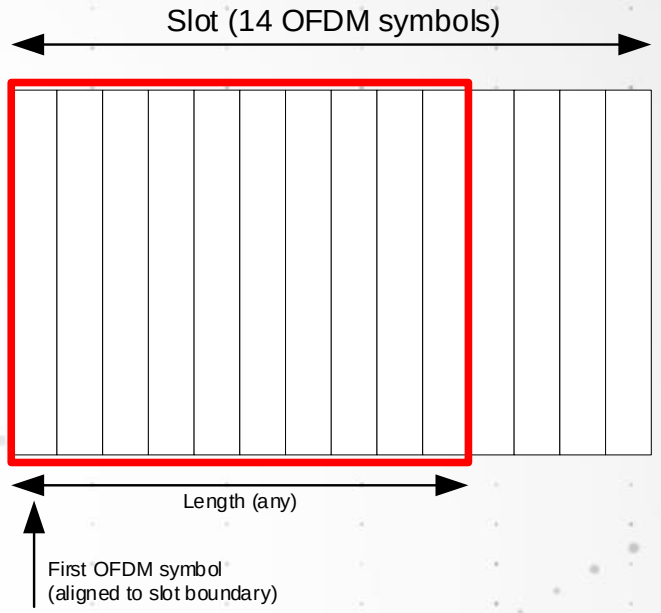
– **Uplink** physical signals:
  - Sounding Reference Signal (SRS)

PUSCH

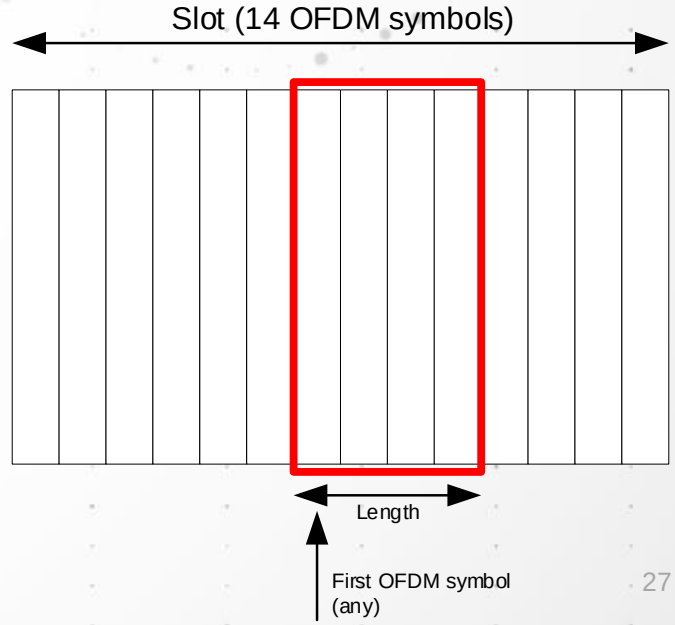
L1 REL-15 SPECIFICATION OVERVIEW

- Carries user **data** and **UCI** (optional)
- Two waveforms:
  - **CP-OFDM**: intended for MIMO
  - **DFT-s-OFDM**: only used with single layer transmissions
- Modulations:
  - **CP-OFDM** (QPSK, 16QAM, 64QAM and 256QAM)
  - **DFT-s-OFDM** (π/2-BPSK, 16QAM, 64QAM and 256QAM)
- Two mapping types:
  - **Type A**
    - Starting symbol is 0
    - DMRS symbol is l_0 = {2, 3}
  - **Type B**
    - Starting symbol can be any position within a slot
    - DMRS symbol is the first assigned symbol
    - Slot boundary is not crossed
    - Length can be any number of OFDM symbols

Type A



Type B



PUCCH

L1 REL-15 SPECIFICATION OVERVIEW

- Carries **UCI**, **HARQ-ACK** and/or **SR**
- Two type of PUCCHs:
  - **Short PUCCH**
  - **Long PUCCH**

PUCCH Format	Length in OFDM Symbols	Number of Bits	Encoding
0 (**SHORT**)	1-2	≤ 2	N/A
1 (**LONG**)	4-14	≤ 2	N/A
2 (**SHORT**)	1-2	> 2	Block (3 ≤ K ≤ 11) or Polar (K > 11)
3 (**LONG**)	4-14	> 2	Block (3 ≤ K ≤ 11) or Polar (K > 11)
4 (**LONG**)	4-14	> 2	Block (3 ≤ K ≤ 11) or Polar (K > 11)

Random Access Preamble (PRACH)

L1 REL-15 SPECIFICATION OVERVIEW

- PRACH sequence is Zadoff-Chu based
- Two different preamble lengths
  - **Long sequence** (L = 839)
    - Only for FR1
    - Subcarrier spacing and bandwidth: **1.25 kHz (1.25 MHz)** and **5 kHz (5 MHz)**
  - **Short sequence** (L = 139)
    - Intended for FR2 (i.e. for beam-sweeping)
    - Can be used for both FR1 and FR2
    - FR1 subcarrier spacing and bandwidth: **15 kHz (2.5 MHz)** and **30 kHz (5 MHz)**
    - FR2 subcarrier spacing and bandwidth: **60 kHz (10 MHz)** and **120 kHz (20 MHz)**

Channel Coding Schemes

L1 REL-15 SPECIFICATION OVERVIEW

- Channel coding for **eMBB**:
  - **LDPC** for eMBB physical data channels
  - **Polar Code** for eMBB physical control channels
- Channel coding for **PBCH**:
  - **Polar Code**
    - Same as for eMBB physical control channels

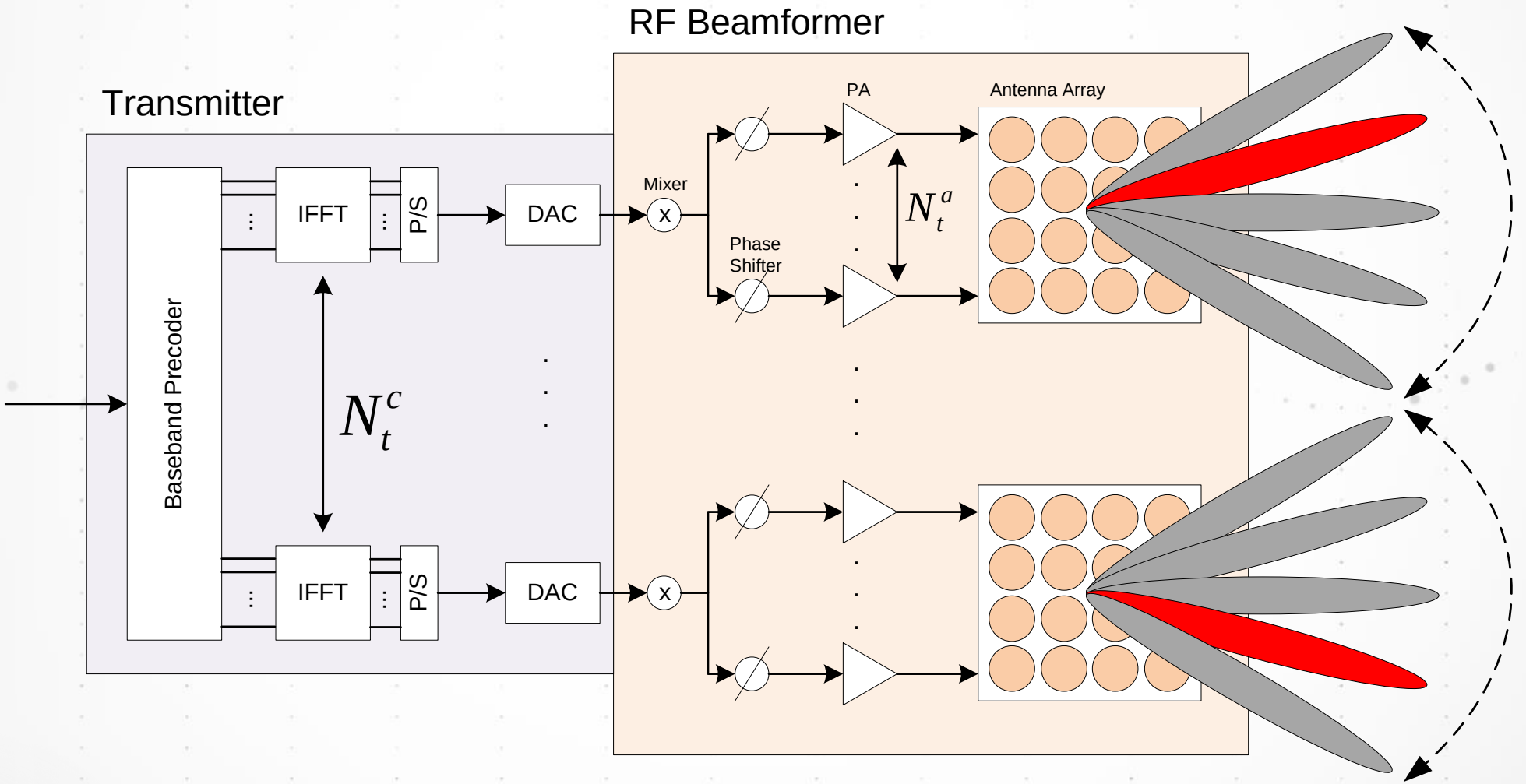
MIMO

L1 REL-15 SPECIFICATION OVERVIEW

- NR supports the following number of codewords for DL and UL per UE:
  - For 1 to 4-layer transmission: **1 codeword**
  - For 5 to 8-layer transmission: **2 codewords** (only in DL)
- Two possible DMRS configurations for the front-loaded case in DL/UL CP-OFDM:
  - **Configuration 1**: Supports up to 8 ports (SU-MIMO)
    - One or two OFDM symbols
  - **Configuration 2**: Supports up to 12 ports (MU-MIMO)
    - One or two OFDM symbols

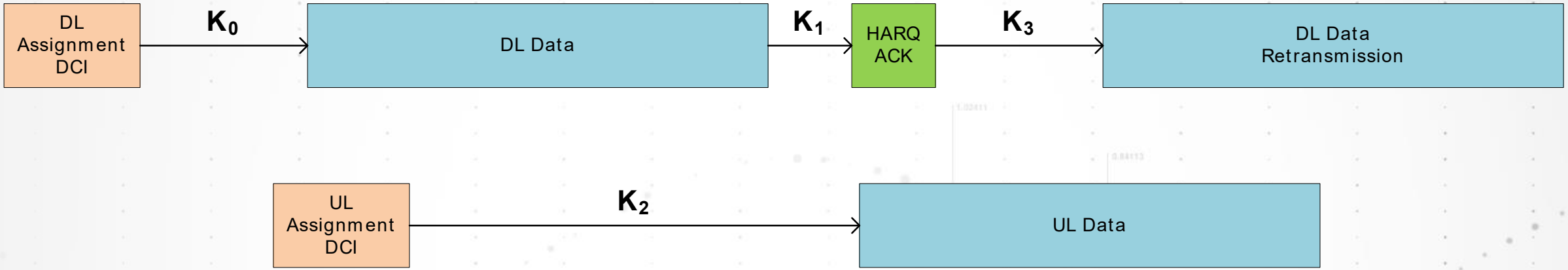
Hybrid Beamforming

L1 REL-15 SPECIFICATION OVERVIEW



Data Scheduling Timing

L1 REL-15 SPECIFICATION OVERVIEW



- **K_0**: Delay between DL grant and corresponding DL data (PDSCH) reception
- **K_1**: Delay between DL data (PDSCH) reception and corresponding ACK/NACK transmission on UL
- **K_2**: Delay between UL grant reception in DL and UL data (PUSCH) transmission
- **K_3**: Delay between ACK/NACK reception in UL and corresponding retransmission of data (PDSCH) on DL
- K_0, K_1 and K_2 are indicated in the DCI
- If $K_1 = 0$ ► **Self-contained slots** (not mandatory to UEs)

Bandwidth Parts

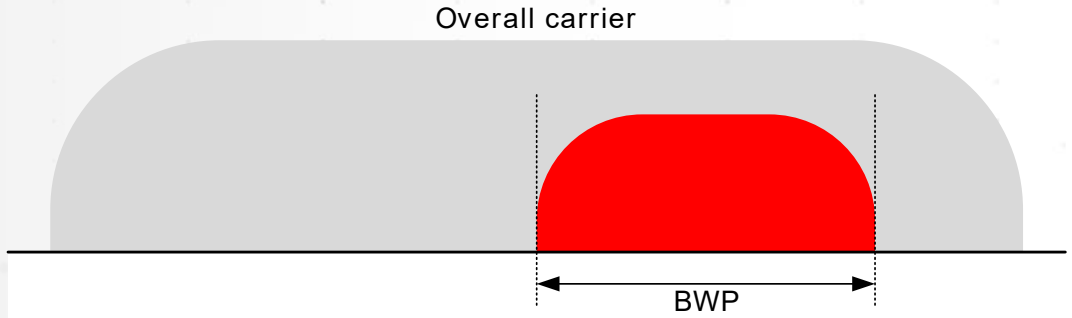
L1 REL-15 SPECIFICATION OVERVIEW

- One or multiple bandwidth part configurations for each component carrier can be semi-statically signaled to a UE
  - **Only one BWP** in DL and one in UL **is active** at a given time instant
- Configuration parameters include:
  - **Numerology**: CP type, subcarrier spacing
  - **Frequency location**: the offset between BWP and a reference point is implicitly or explicitly indicated to UE based on common PRB index for a give numerology
  - **Bandwidth size**: in terms of PRBs
  - **CORESET**: required for each BWP configuration in case of single active DL bandwidth part for a given time instant

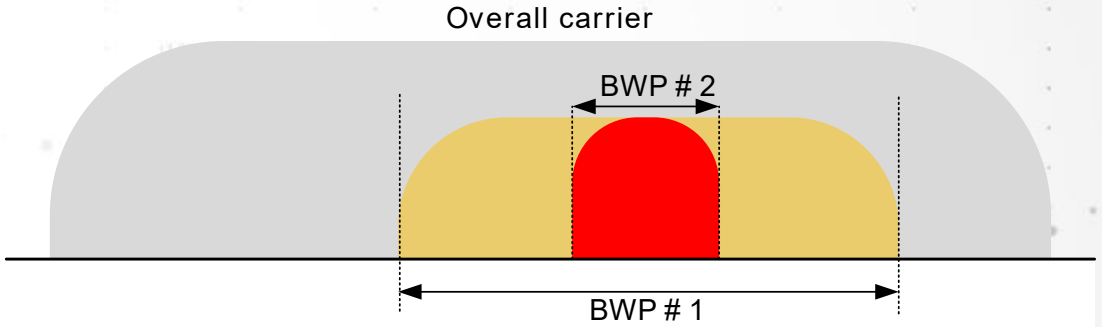
Bandwidth Parts Use Cases

L1 REL-15 SPECIFICATION OVERVIEW

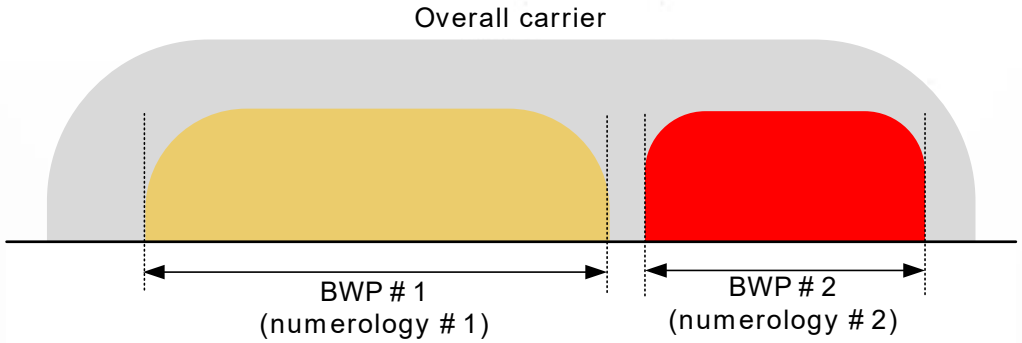
1) Supporting reduced UE bandwidth capability



2) Supporting reduced UE energy consumption



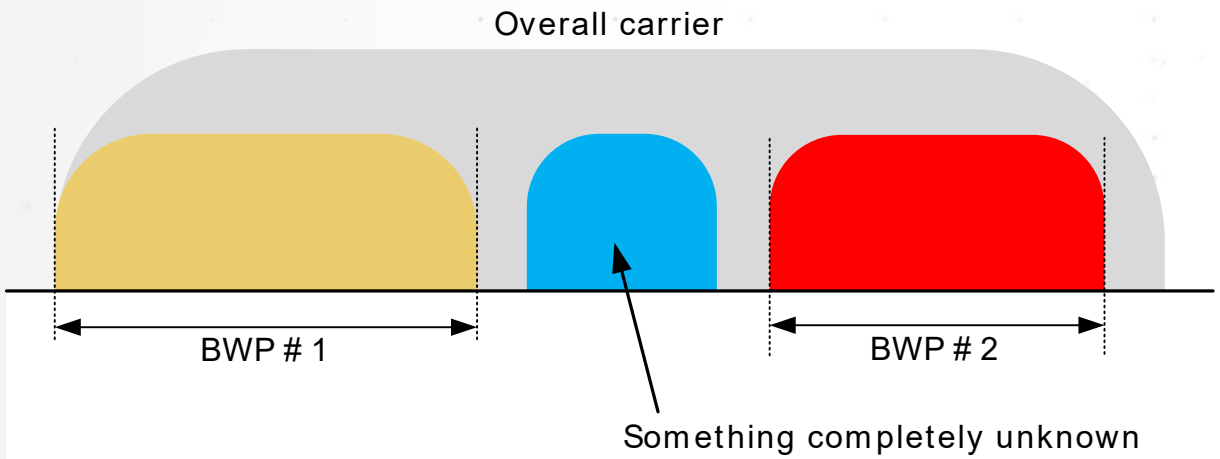
3) Supporting FDM of different numerologies



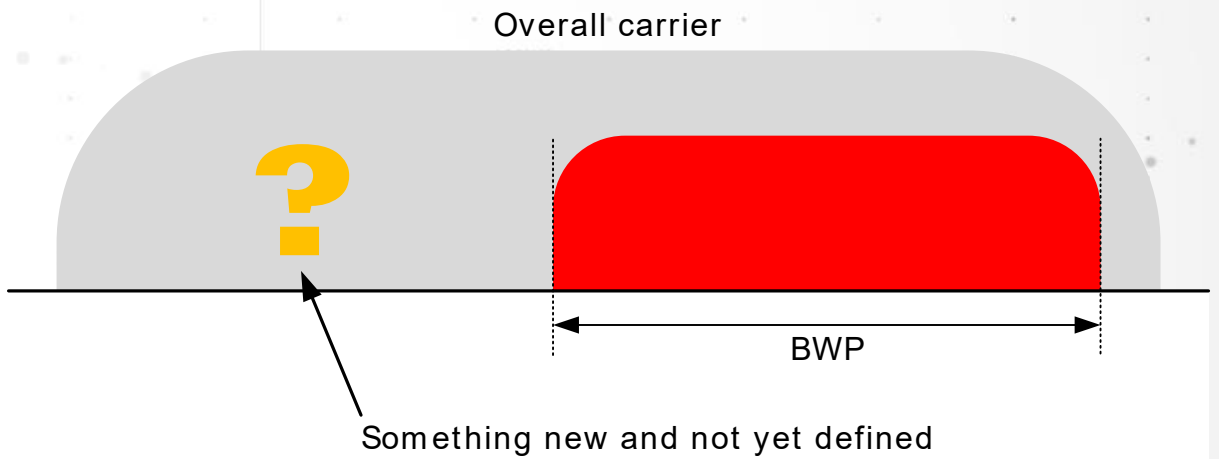
Bandwidth Parts Use Cases

L1 REL-15 SPECIFICATION OVERVIEW

4) Supporting non-contiguous spectrum



5) Supporting forward compatibility



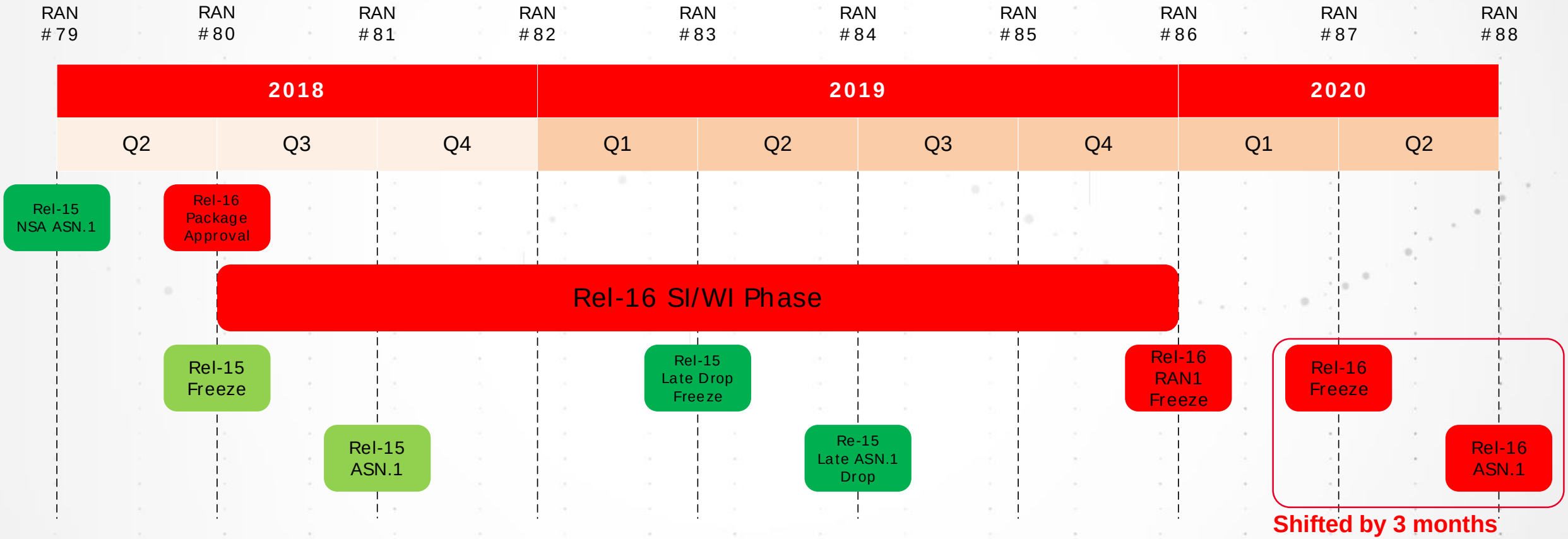
RAN1 Rel-15 Status Update
L1 Rel-15 Specification Overview

RAN1 Rel-16 Status Update

L1 Rel-16 Specification Overview
Summary

Rel-16 Workplan

RAN1 REL-16 STATUS UPDATE



Rel-16 RAN1 Meetings

RAN1 REL-16 STATUS UPDATE

We are here now 

Meeting	Dates	Location
RAN1 #94	20 – 24 Aug 2018	Gothenburg (Sweden)
RANP #81	10 – 13 Sep 2018	Gold Coast (Australia)
RAN1 #94bis	8 – 12 Oct 2018	Chengdu (China)
RAN1 #95	12 – 16 Nov 2018	Spokane (USA)
RANP #82	10 – 13 Dec 2018	Sorrento (Italia)
RAN1 AH1901	21 – 25 Jan 2019	Taipei (Taiwan)
RAN1 #96	25 Feb – 1 Mar 2019	Athens (Greece)
RANP #83	18 – 21 Mar 2019	Shenzhen (China)
RAN1 #96bis	8 – 12 Apr 2019	China
RAN1 #97	13 – 17 May 2019	USA
RANP #84	3 – 6 Jun 2019	USA

Rel-16 RAN1 Study Items

RAN1 REL-16 STATUS UPDATE

Completed study items

Document	Title	Completion
RP-181399	NR Positioning Support	RANP #83 (**March 2019**)
RP-181430	**Remote Interference Management for NR**	Completed
RP-181463	UE Power Saving in NR	RANP #84 (**June 2019**)
RP-181435	NR Beyond 52.6 GHz	RANP #85 (**September 2019**)
RP-181477	Study on Physical Layer Enhancements for NR URLLC	RANP #83 (**March 2019**)
RP-181339	**NR-based access to unlicensed spectrum**	Completed
RP-181403	**Non-orthogonal multiple access for NR**	Completed
RP-181429	Study on NR Vehicle-to-Everything V2X	RANP #83 (**March 2019**)
RP-172290	**Integrated Access and Backhaul**	Completed
-	**NR to support non-terrestrial networks**	Completed

Rel-16 RAN1 Study Item Documents

RAN1 REL-16 STATUS UPDATE

Completed study items

Study Item	TR Document
NR Positioning Support	TR 38.855
Remote Interference Management for NR	**TR 38.866**
UE Power Saving in NR	TR 38.840
NR Beyond 52.6 GHz	TR 38.807
Study on Physical Layer Enhancements for NR URLLC	TR 38.824
NR-based access to unlicensed spectrum	**TR 38.889**
Non-orthogonal multiple access for NR	**TR 38.812**
Study on NR Vehicle-to-Everything (V2X)	TR 38.885
NR to support non-terrestrial networks	**TR 38.811, TR 38.821**
Integrated Access and Backhaul	**TR 38.874**

Rel-16 RAN1 Work Items

RAN1 REL-16 STATUS UPDATE

Document	Title	Completion
RP-181453	Enhancements on MIMO for NR	RANP #86 **December 2019**
RP-182864	Cross Link Interference (CLI) Handling and Remote Interference Management (RIM) for NR	RANP #83 **March 2019**
RP-182882	Integrated Access and Backhaul for NR	RANP #86 **December 2019**
RP-182894	2-Step RACH for NR	RANP #86 **December 2019**
RP-182878	NR-Based Access to Unlicensed Spectrum	RANP #86 **December 2019**

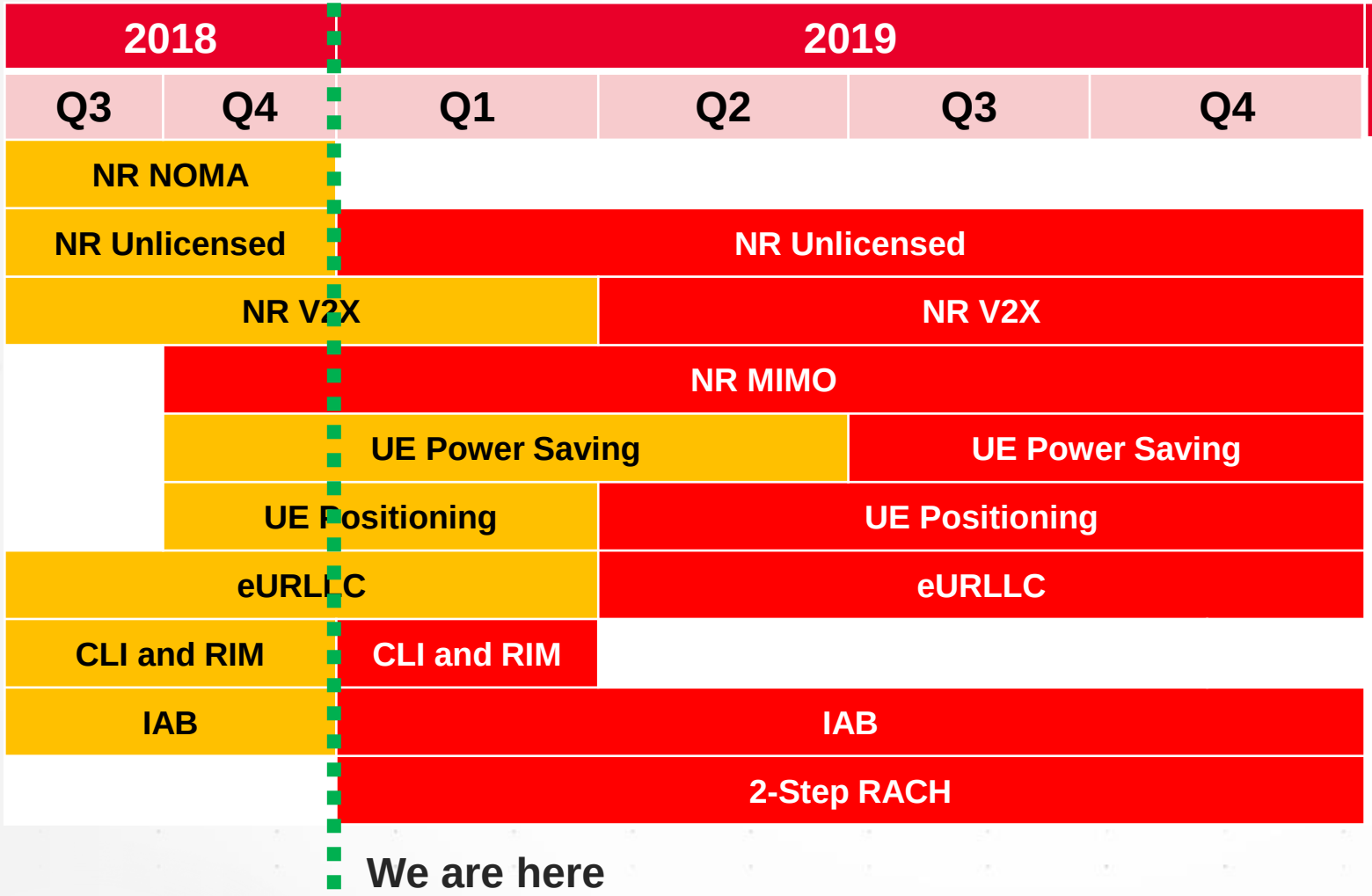
Approved in RANP #82

Rel-16 RAN1 Workplan

Study Item

Work Item

RAN1 REL-16 STATUS UPDATE



SID WID
RP-181403
RP-181339 / RP-182878
RP-181480
RP-181453
RP-181463
RP-181399
RP-181477
RP-181430 / RP-181431 / RP-182864
RP-172290 / RP-182882
RP-182894

Rel-17 RAN1 Workplan

RAN1 REL-16 STATUS UPDATE

- **Release-17** package approval for **December 2019** (i.e. RAN#86)
- Work on the next release in a WG only starts after the freeze of the previous release in that WG
  - Work on Rel-17 in RAN1 will start in **Q1 2020**
  - Work on Rel-17 in RAN2/RAN3 will start in Q2 2020

RAN1 Rel-15 Status Update
L1 Rel-15 Specification Overview
RAN1 Rel-16 Status Update

L1 Rel-16 Specification Overview

Summary

MIMO Enhancements

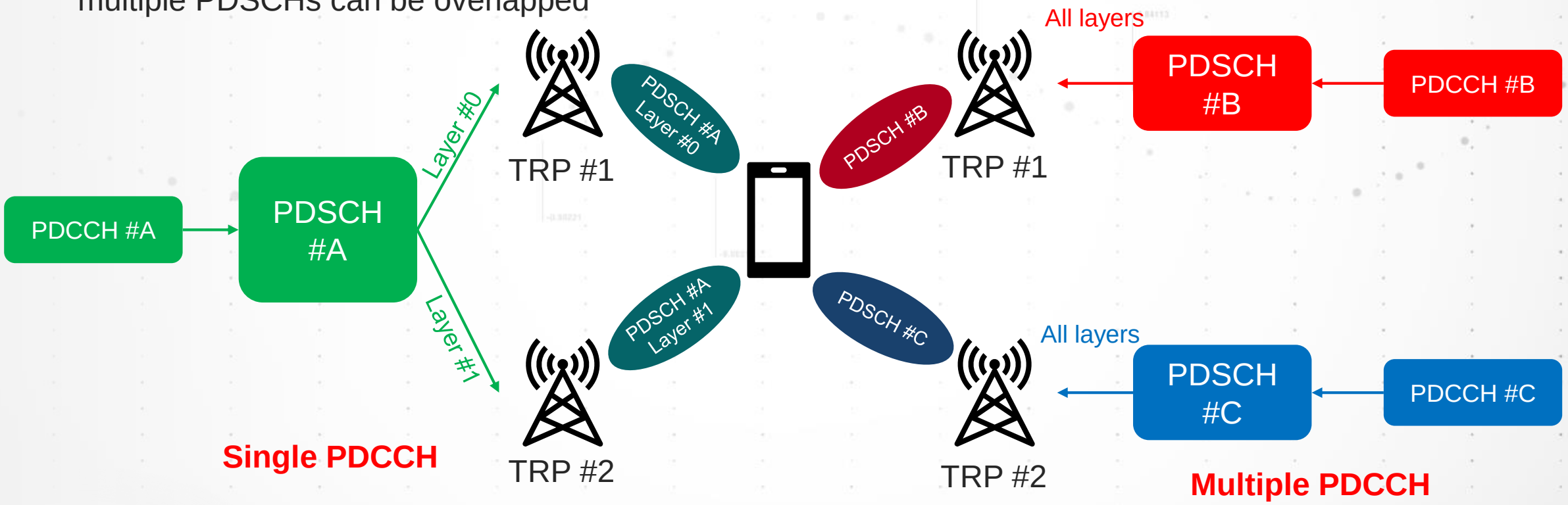
L1 REL-16 SPECIFICATION OVERVIEW

- Enhancements on MU-MIMO support (i.e. CSI report enhancements)
- Enhancements on multi-TRP/panel transmission
- Enhancements on multi-beam operation
  - Primarily targeting FR2 operation
  - UL and/or DL transmit beam selection specified in Rel-15 to reduce latency and overhead
- Specify DMRS enhancement for PAPR reduction  **Already completed**
- CSI report enhancements

Multi-TRP/Panel Enhancements

L1 REL-16 SPECIFICATION OVERVIEW

- For eMBB both **multiple PDCCH** and **single PDCCH** designs are supported in Rel-16
  - **Single PDCCH**: schedules single PDSCH where separate layers are transmitted from separate TRPs
  - **Multiple PDCCH**: schedules different PDSCH where each PDSCH is transmitted from a separate TRP and multiple PDSCHs can be overlapped



Beam Management Enhancements

L1 REL-16 SPECIFICATION OVERVIEW

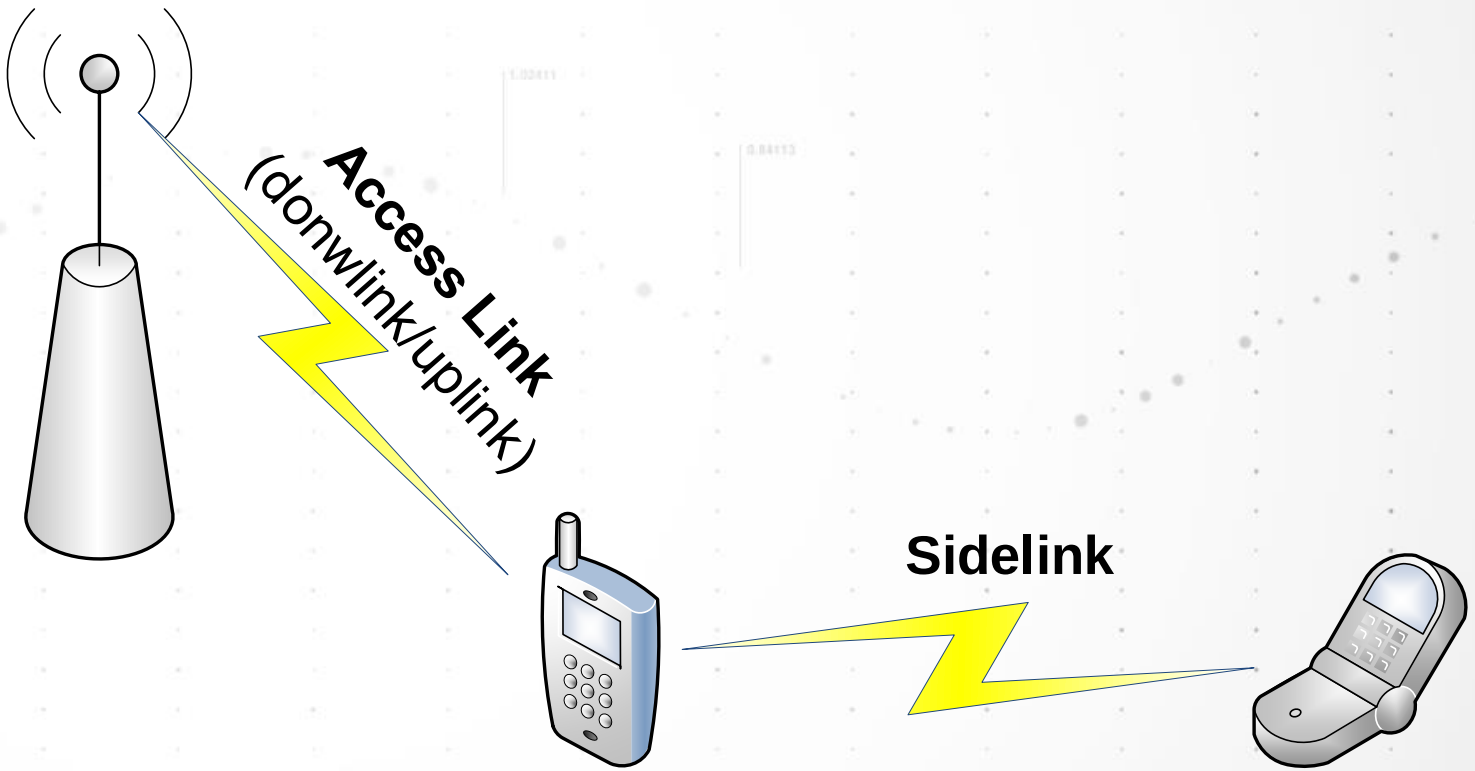
- Possible options for beam refinement RS:
  - **Option 1**: Support sub-time unit for beam management RS shorter than 1 OFDM symbol
    - Similar to BRRS in Pre-5G
    - **No new RS for beam management is introduced in Rel-16**
  - **Option 2**: No support of sub-time unit for beam management RS shorter than 1 OFDM symbol
    - As it is the case in NR Rel-15

To be decided on RAN1 AH1901 meeting

Sidelink

L1 REL-16 SPECIFICATION OVERVIEW

- The **access link** (i.e. DL/UL) is used for communication between gNB and UEs
- The **sidelink** is used for communication between UEs
  - This is the link used for V2X in LTE and NR



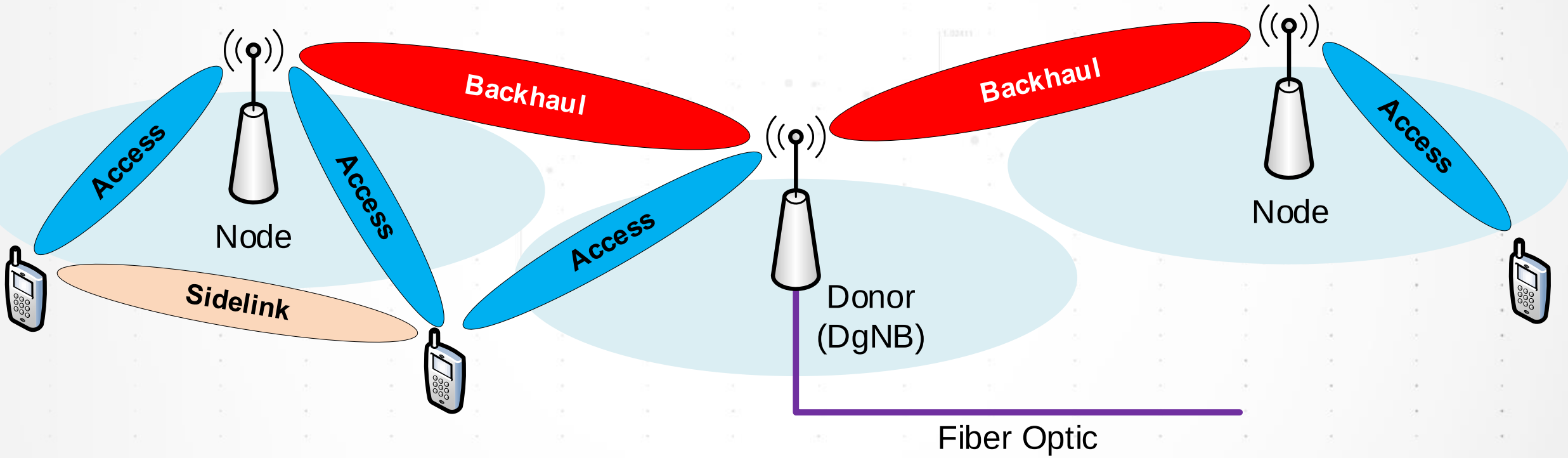
Sidelink

L1 REL-16 SPECIFICATION OVERVIEW

- The following physical channels are defined for NR V2X:
  - **PSSCH**
  - **PSCCH**
  - **PSFCH**
  - **S-SSB**
    - **Sidelink PSS** (S-PSS)
    - **Sidelink SSS** (S-SSS)
    - **PSBCH**
- **CP-OFDM** is supported
  - Support for **DFT-s-OFDM** is under discussion
  - **Only one waveform** is used for all channels in a carrier

Integrated Access and Backhaul

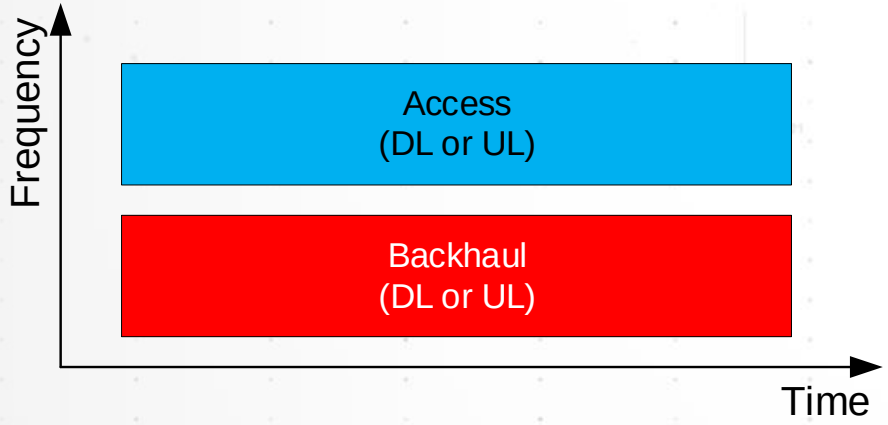
L1 REL-16 SPECIFICATION OVERVIEW



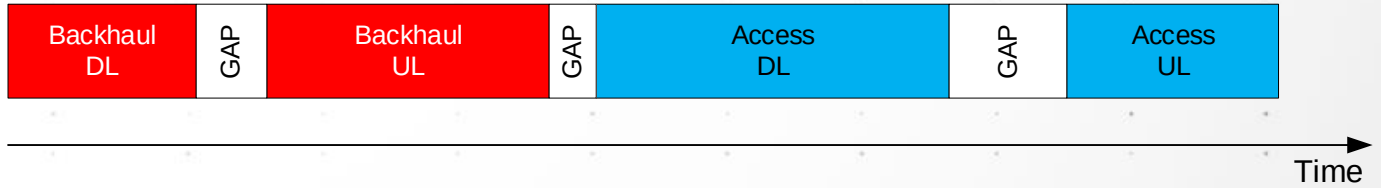
IAB Multiplexing

L1 REL-16 SPECIFICATION OVERVIEW

- The IAB nodes can multiplex the access and backhaul links in time, frequency, or space (e.g. beam-based operation)
- Partitioning can be: **TDM**, **FDM** or **SDM**



TDM Partitioning

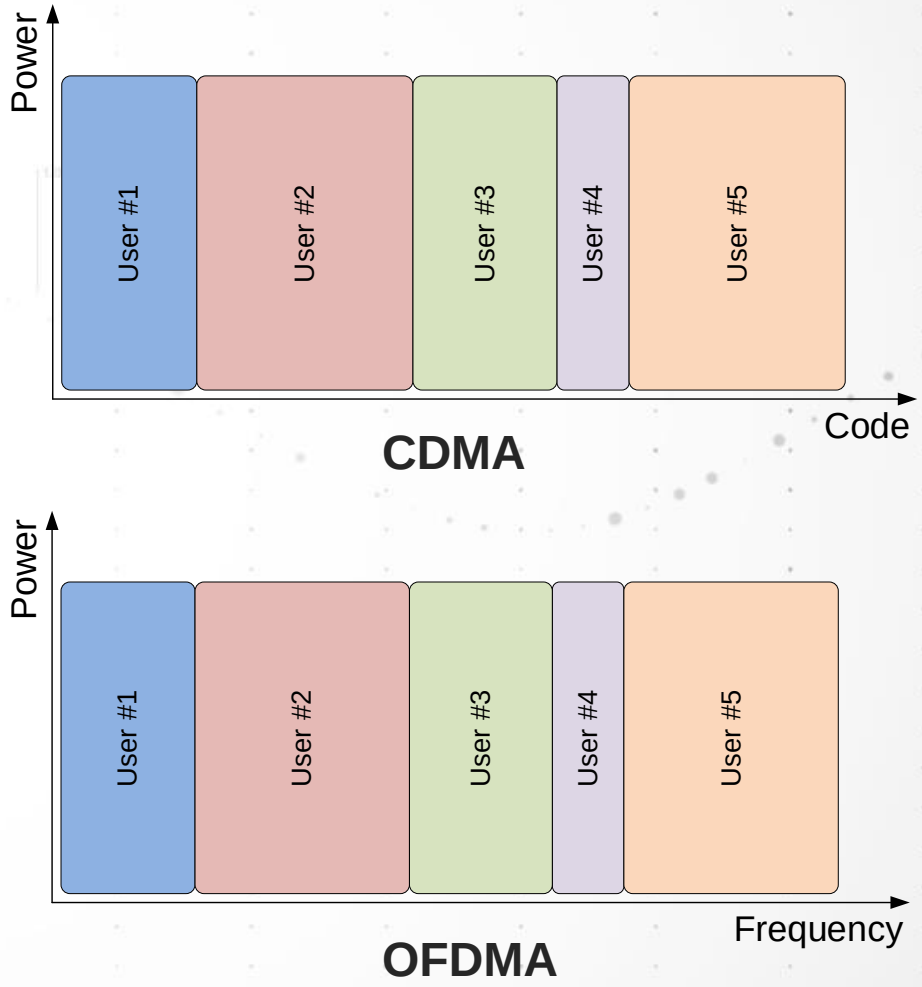


FDM Partitioning

NOMA

L1 REL-16 SPECIFICATION OVERVIEW

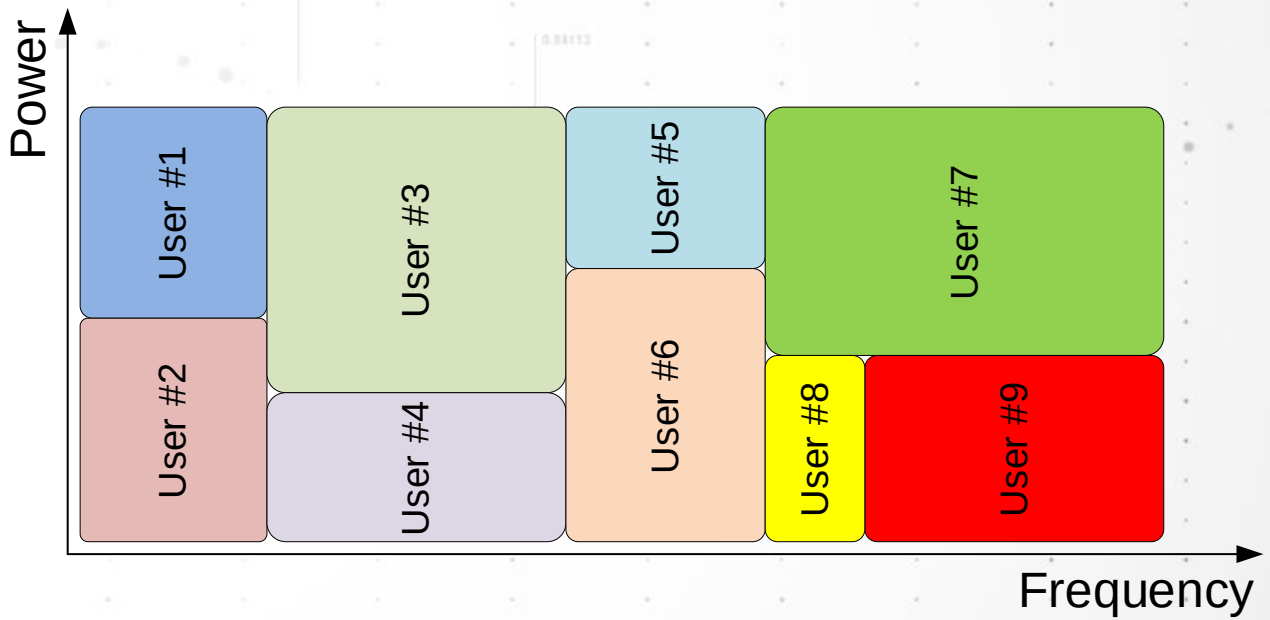
- **Orthogonal Multiple Access**
  - Resource assignment is orthogonal between users
  - **CDMA**
    - All power assigned to users
    - Each user is assigned different codes
  - **OFDMA**
    - All power assigned to users
    - Each user is assigned different frequency resources



NOMA

L1 REL-16 SPECIFICATION OVERVIEW

- **Non-Orthogonal Multiple Access**
  - Resource assignment is not orthogonal between users
  - Users transmit on the same time and frequency resources
  - Power is shared between users
  - **Superposition** and **power allocation**



No work item for NOMA in Rel-16

URLLC Enhancements

L1 REL-16 SPECIFICATION OVERVIEW

- In Release 15 the basic support for URLLC was introduced with:
  - TTI structures for low latency
  - Methods for improved reliability
- Release 15 enabled use case improvements
  - Such as AR/VR (i.e. entertainment industry)
- New **Release 16 use cases** with higher requirements
  - **Factory automation**
    - Motion control
  - **Transport industry**
    - Remote driving
  - **Electrical power distribution**
    - Power distribution grid fault and outage management
    - Differential protection

URLLC Enhancements

L1 REL-16 SPECIFICATION OVERVIEW

- PDCCH enhancements
  - Compact DCI, PDCCH repetition, increased PDCCH monitoring capability
- UCI enhancements
  - Enhanced HARQ feedback methods, CSI feedback enhancements
- PUSCH Enhancements
  - Mini-slot level hopping & retransmission/repetition enhancements
- Enhancements to scheduling/HARQ/CSI processing timeline (UE and gNB)
- Enhanced multiplexing considering different latency and reliability requirements
- Enhanced UL configured grant (grant free) transmissions

2-Step RACH

L1 REL-16 SPECIFICATION OVERVIEW

- This simplified RACH procedure reduces the RACH overhead and access delay/latency (especially when a small packet is to be transmitted)
- A new **msgA** is defined compromising:
  - **Preamble**
  - **Data**
  - The msgA includes both 4-step RACH procedure msg1 and msg3
- In response to the UE request: network sends **msgB** using PDCCH and PDSCH
  - The msgB includes both 4-step RACH procedure msg2 and msg4

msgA (preamble+data)

RAN1 Rel-15 Status Update
L1 Rel-15 Specification Overview
RAN1 Rel-16 Status Update
L1 Rel-16 Specification Overview

Summary

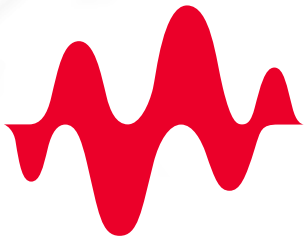
Summary

- **RAN1 Rel-15** specification completed
  - Only small corrections
  - Very limited time to be dedicated to Rel-15 CRs in upcoming meetings
  - Final completion date shifted by 3 months (**mid-2019**)
- **RAN1 Rel-16** specification under way
  - To be completed by December 2019 (only RAN1 aspects)
    - Final completion date shifted by 3 months (**mid-2020**)
  - Content for Rel-16:
    - MIMO enhancements
    - URLLC enhancements
    - Unlicensed spectrum access
    - V2X (i.e. Sidelink)
    - IAB (i.e. Backhaul)
    - Positioning
    - UE power saving
    - CLI and RMI
    - 2-step RACH
- **RAN1 Rel-17** work to begin in Q1 2020

Links

SUMMARY

- 3GPP Webpage (www.3gpp.org)
- 3GPP RAN1 Documents (www.3gpp.org/ftp/tsg_ran/WG1_RL1)
- The METIS 2020 Project (www.metis2020.com)
- The 3G4G Blog (blog.3g4g.co.uk)
- Keysight Solutions (www.keysight.com/find/5G)



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TECHNOLOGIES