3GPP TSG RAN Rel-18 workshop
Electronic Meeting, June 28th – July 2nd, 2021

RWS-210268

Source: NTT DOCOMO, INC.
Agenda item: 4.1

Views on Rel-18 MIMO

NTT DOCOMO, INC.

Introduction

- **UL MIMO enhancement is important in Rel-18, due to the following reasons:**
  - 1) UL throughput improvement is getting more important, due to customers demand (e.g. video uploading in stadium).
  - 2) Rel-16/17 NR MIMO has focused on DL performance improvement, however, UL performance improvement was behind.

Rel-18 MIMO: Docomo's interested topics

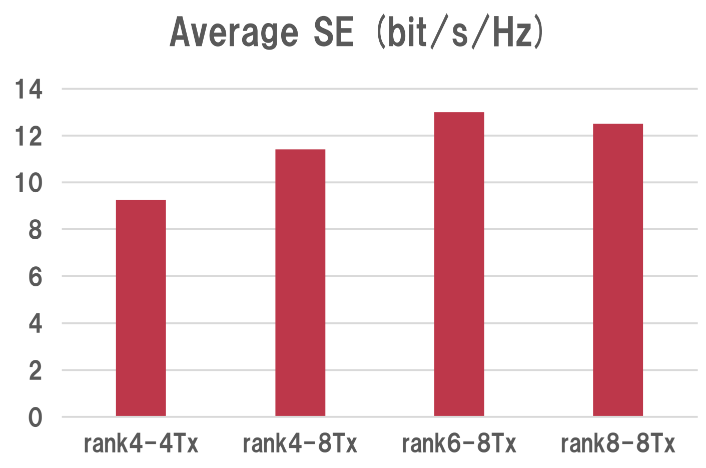
Motivation	Potential enhancements	Details
UL enhancement	UL MIMO	**UL MIMO enhancement** <u>Mainly for FR2:</u> • Multi-panel UE: - Simultaneous multi-panel TX by UE - 1) For diversity: same TB is repeated on multiple panels (also applied for HST for UL) - 2) For multiplexing: different MIMO layer is transmitted on different panels - BM enhancement for multi-panel UE - Explicit UE panel ID and UE panel control by gNB based on Rel-17 progress, e.g., for fast panel selection/indication <u>Mainly for FR1:</u> • Higher-order UL MIMO, i.e. >4 layers • Frequency-selective precoding (Low priority)
	UL dense deployment	• To support UL dense RX only deployment, potential enhancements include TPC, UL BM, etc.
Mobility enh.	L1/L2 mobility	• L1/L2 inter-cell mobility with SpCell change to a cell with different PCI, for both single cell transmission and MTRP scenario
SE enhancement	CSI enhancement	• Transform domain (i.e. Angular-Delay domain) precoding and CSI feedback for overhead reduction
		• Doppler domain CSI precoder and feedback, on top of Spatial-Delay domain CSI precoder or Angular-Delay domain CSI precoder, for high speed UEs
High Speed Train	3-symbol gap TRS	• To support 500km/h@2.15GHz (FDD band, 15kHz SCS) in bi-directional SFN

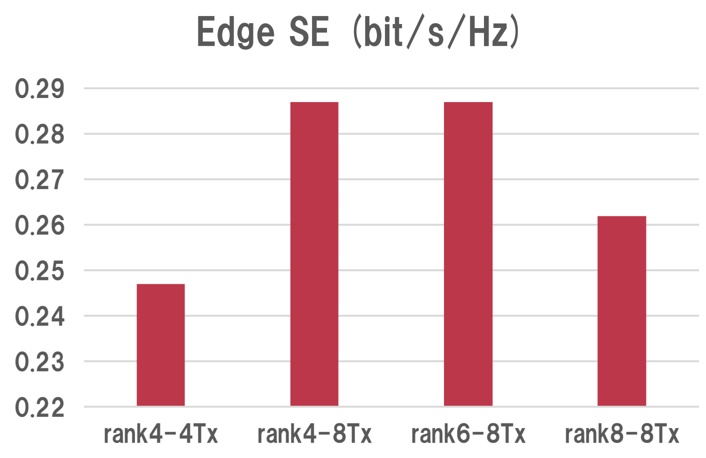
UL evaluation result (1/3)

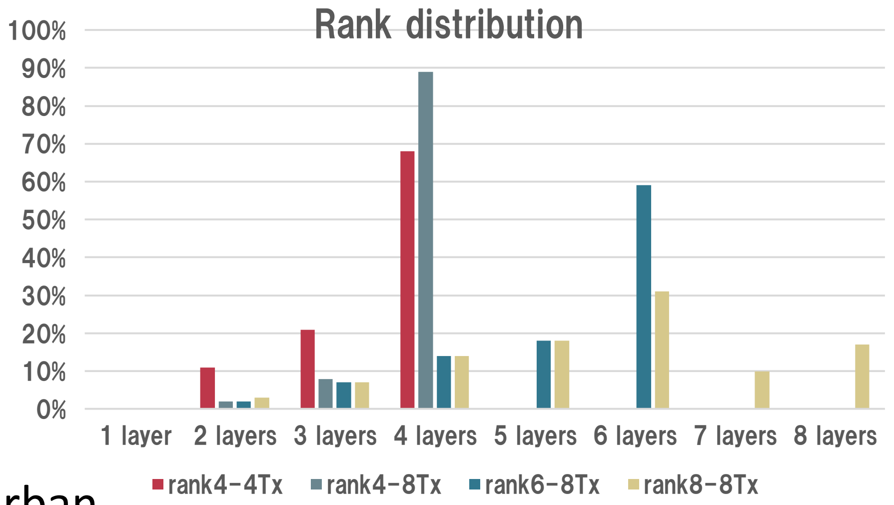
- **Performance gain of > 4 rank UL MIMO**
  - Only certain scenarios (e.g., indoor, dense urban) can provide the gain.
  - Highest throughput performance for case of rank6-8Tx.
  - Highest scheduling probability for 5 and 6 layers for cases of rank6-8Tx and rank8-8Tx.
  - Note: rank"n”-”m”Tx means “m” Tx antenna is used, but the max rank is limited with “n”.

Simulation assumption

Scenario	Parameters
Carrier frequency	4GHz
Bandwidth	20MHz
SCS	15KHz
Network layout	Dense urban, 1 layer macro
Channel model	ITU Channel model B
BS antenna structure and TXRU	128Tx/Rx = (M,N,P,Mg,Ng) = (8,8,2,1,1), (dH,dV) = (0.5, 0.8)λ. TXRU: 32TXRU=(Mp,Np,P,Mg,Ng) =(2,8,2,1,1)
UE antenna structure and TXRU	4Tx/Rx = (M,N,P,Mg,Ng) = (1,2,2,1,1), (dH,dV) = (0.5, 0.5)λ TXRU: 4TXRU=(Mp,Np,P,Mg,Ng)=(1,2,2,1,1) 8Tx/Rx = (M,N,P,Mg,Ng) = (1,4,2,1,1) TXRU: 8TXRU=(Mp,Np,P,Mg,Ng)=(1,4,2,1,1)
Number of UE TXRU	4 / 8
CSI-T	One analog beam at both BS and UE side + SVD precoding
Channel estimation	Real
Scheduling	Subband PF
MIMO receiver	MMSE-IRC
Traffic model	Full buffer
ISD	200
Number of average UEs per macro sector	10
Subband number	20
Max. UE power	23dBm
UE mobility	80% indoor (3 km/h), 20% outdoor (30 km/h)
UL power control	Open Loop TPC
Modulation	Up to 64QAM
Layer mapping	NR
TDD frame structure	DSUUD





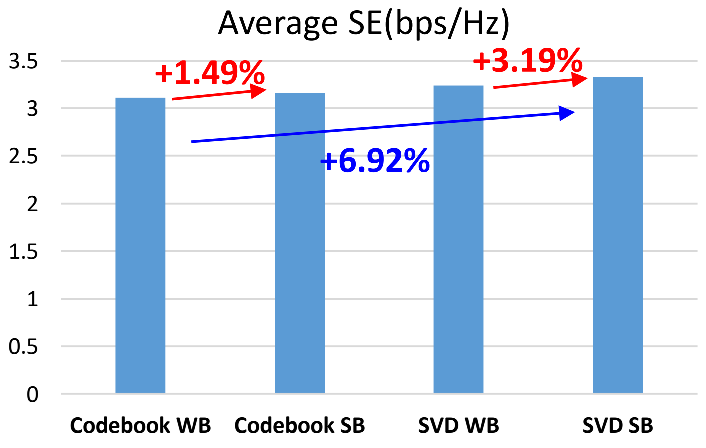


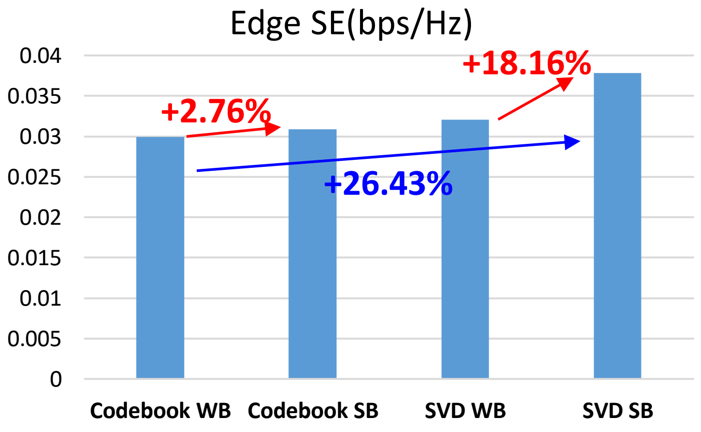
Performance of >4 layers UL MIMO in Dense urban

UL evaluation result (2/3)

Wide-band (WB) pre-coding vs. Sub-band (SB) pre-coding

- Gain of SB precoding over WB precoding for UL MIMO: Average gain: 2%-3%; edge gain: 3%-18%
- If we consider SB precoding should take enhanced UL codebook into account, then the performance gain of 'SVD+SB precoding over CB+WB' can be regarded as the up-bound performance gain of SB precoding with enhanced UL codebook over WB precoding: Average gain: 7%; edge gain: 26%.



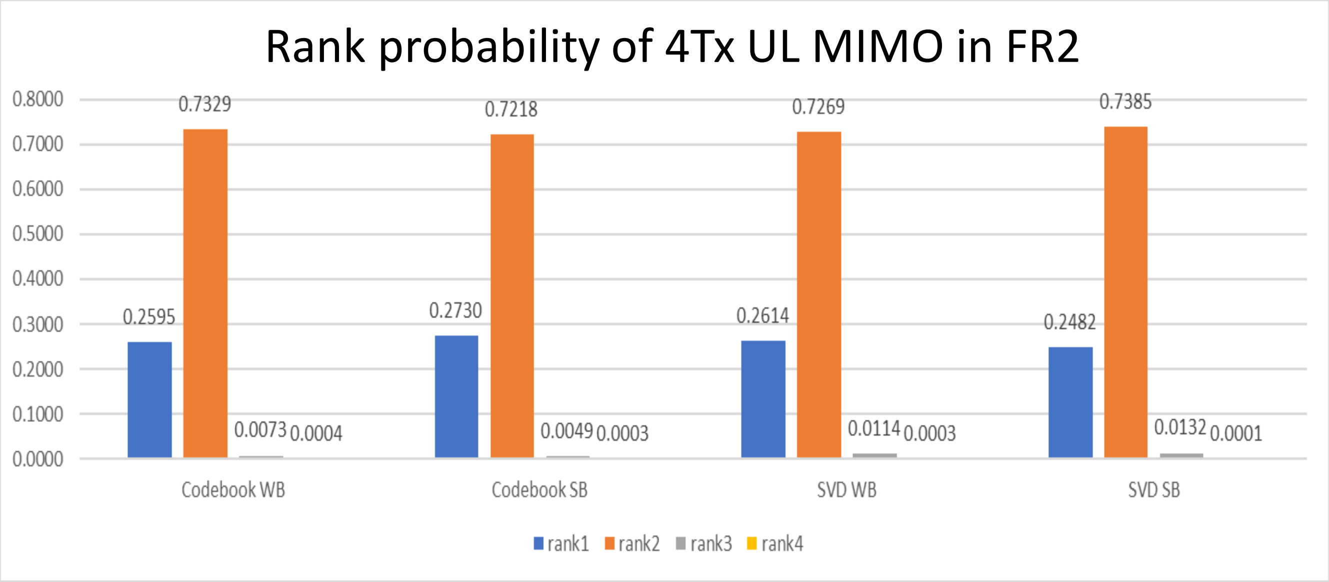


Simulation assumption

Parameter	Values
Carrier frequency	4GHz
Bandwidth	80MHz
SCS	30KHz
Network layout	Dense urban, 1 layer macro
Channel model	ITU Channel model B
BS antenna structure and TXRU	4Tx/Rx = (M,N,P,Mg,Ng) = (1,2,2,1,1), (dH,dV) = (0.5, 0.8)λ TXRU: 4TXRU=(Mp,Np,P,Mg,Ng)=(1,2,2,1,1)
UE antenna structure and TXRU	4Tx/Rx = (M,N,P,Mg,Ng) = (1,2,2,1,1), (dH,dV) = (0.5, 0.5)λ TXRU: 4TXRU=(Mp,Np,P,Mg,Ng)=(1,2,2,1,1)
Number of UE TXRU	4
CSI-T	DFT based analog beam sweeping + CB
Channel estimation	real
Scheduling	Subband PF
MIMO receiver (CSI/data)	BS side analog beam selection + MMSE-IRC
Traffic model	Full buffer
ISD	200m
Number of average UEs per macro sector	10
Subband number	10
UE power	23dBm
UE mobility	80% indoor (3 km/h), 20% outdoor (30 km/h)
UL power control	Open Loop TPC
Modulation	256QAM
Rank number	1,2
Layer mapping	NR

UL evaluation result (3/3)

- **The necessity of simultaneous multi-panel UL TX in FR2**
  - In FR2, it is difficult to utilize more than rank2 in Single TRP UL transmission in the following assumption.
  - Multi panel simultaneous UL Tx would improve the rank prob.

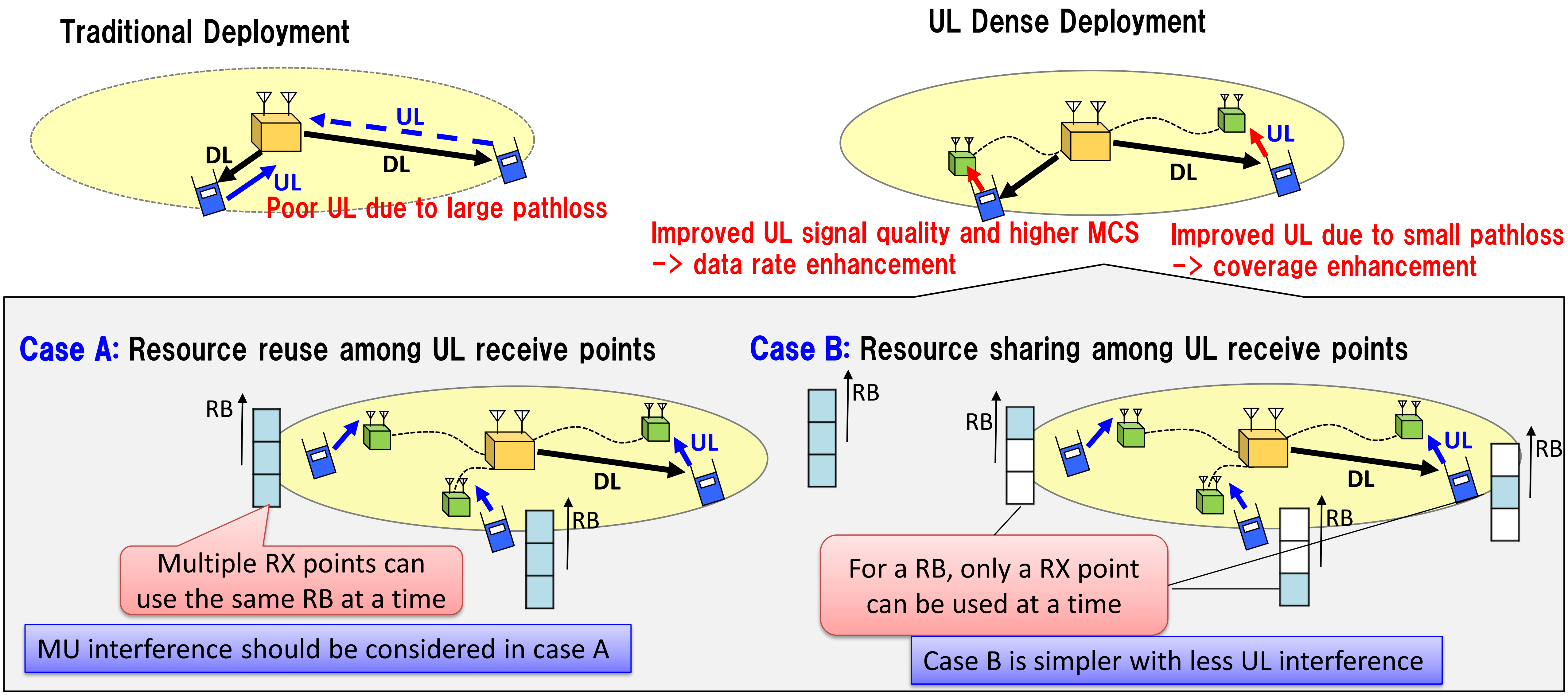


Simulation assumption

Parameter	Values
Carrier frequency	30GHz
Bandwidth	80MHz
SCS	120KHz
Network layout	Dense urban, 1 layer macro
Channel model	ITU Channel model B
BS antenna structure and TXRU	4 x 4: 64Tx/Rx = (M,N,P,Mg,Ng) = (4,8,2,1,1), (dH,dV) = (0.5, 0.5)λ. TXRU: 4TXRU=(Mp,Np,P,Mg,Ng) =(1,2,2,1,1)
UE antenna structure and TXRU	4 x 4: 32Tx/Rx = (M,N,P,Mg,Ng) = (2,4 ,2,1,2), (dH,dV) = (0.5, 0.5)λ TXRU: 8TXRU=(Mp,Np,P,Mg,Ng)=(1,2,2,1,2) (Panel selection is used)
Number of UE TXRU	Pannel selection is used then only 4 TxRU for Tx.
CSI-T	DFT based analog beam sweeping + CB
Channel estimation	real
Scheduling	Subband PF
MIMO receiver (CSI/data)	BS side analog beam selection + MMSE-IRC
Traffic model	Full buffer
ISD	200m
Number of average UEs per macro sector	10
Subband number	10
UE power	23dBm
UE mobility	80% indoor (3 km/h), 20% outdoor (30 km/h)
UL power control	Open Loop TPC
Modulation	256QAM
TDD frame structure	DSUUD

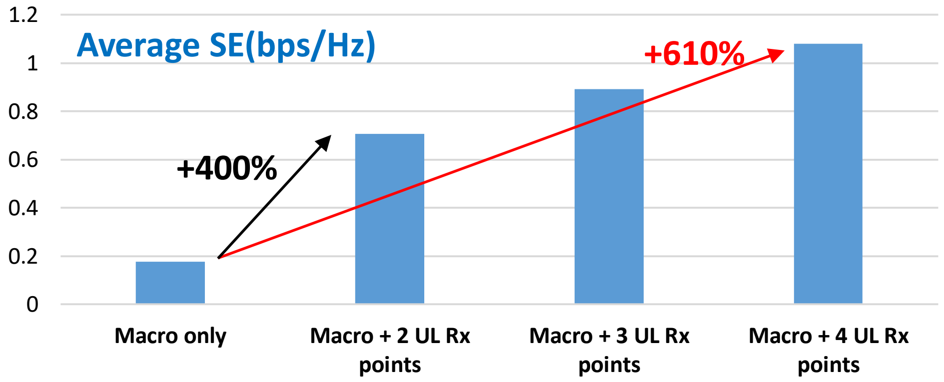
UL dense deployment (1/2)

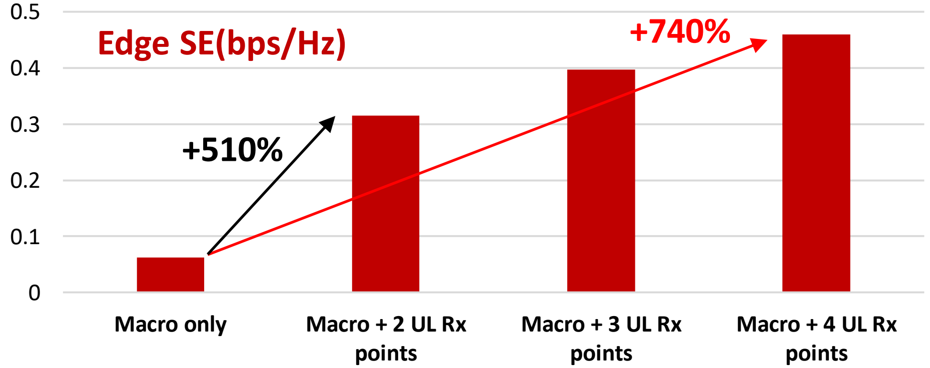
- To support UL dense RX deployment, potential enhancements: UL TPC, TA, UL BM, etc.



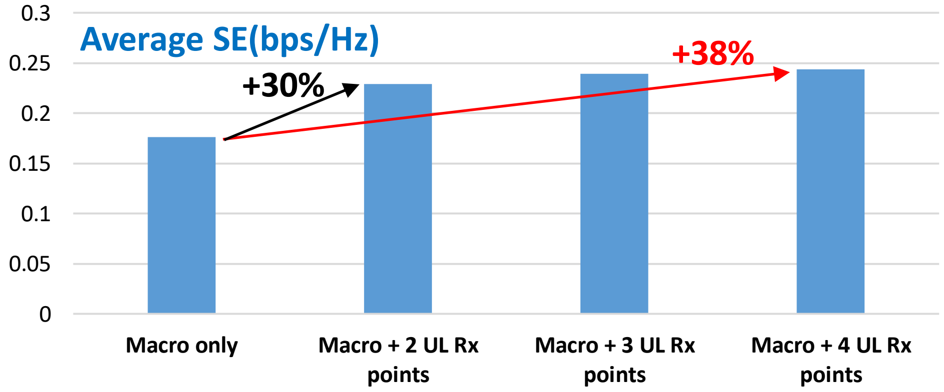
UL dense deployment (2/2)

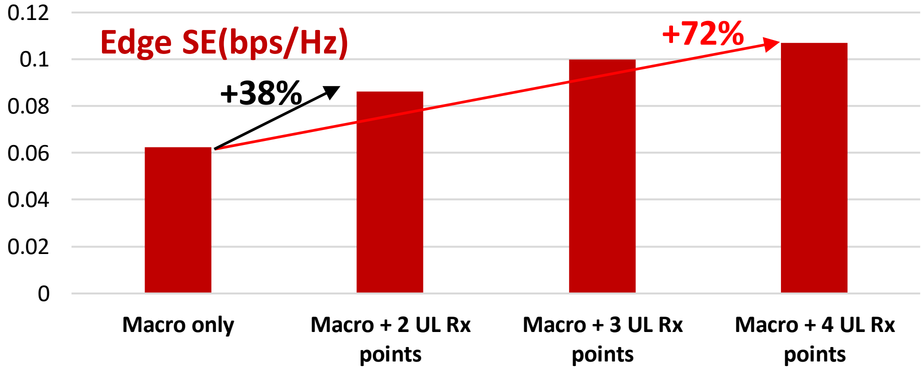
- SLS results for UL dense deployment.
- Observation: Large performance gain of UE dense deployment over Macro deployment
  - For Case A, 610% cell average and 740% cell edge gain can be achieved
  - For Case B, 38% cell average and 72% cell edge gain can be achieved
    - » The performance difference between Case A and Case B comes from different resource reuse.





Case A: Resource reuse among UL receive points





Case B: Resource sharing among UL receive points

Rel-18 HST (High Speed Train)

Rel-18 HST: Motivation

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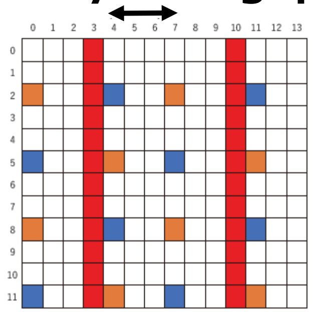
- In Japan, we will have new HST from Tokyo to Nagoya on 2027 or later, whose commercial max speed is 500km/h.
  - We would like to deploy 5G NR with carrier frequency of 2.15GHz (15kHz SCS FDD band) in bi-directional SFN.
- However, Rel-16 RAN4 does not support 500km/h@2.15GHz with 15kHz SCS in bi-directional SFN.
  - Rel-16 RAN4 supports 870Hz as the maximum Doppler shift for HST-SFN with FDD 15KHz SCS.
  - The value of 870Hz comes from 4-symbol gap TRS in NR (LTE CRS has 3-symbol gap).

Max. carrier frequency in LTE and NR

UE Speed	DL/UL	Deployment	LTE	NR
500km/h	DL	・Single-tap	2.1 GHz	**2.1 GHz with 15kHz SCS**
				3.6 GHz with 30kHz SCS
		・HST-SFN ・DPS **Docomo's interest**	2.1 GHz	**1.88 GHz with 15kHz SCS**
				3.6 GHz with 30kHz SCS
	UL	・No differentiation	2.1 GHz	**1.88 GHz with 15kHz SCS**
				3.6 GHz with 30kHz SCS

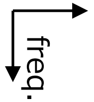
870 Hz = 1.88*10^9[Hz] * 138.888[m/s] / 299792458[m/s]

3-symbol gap

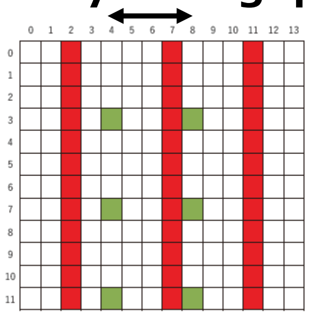


LTE CRS

➔ **Max. Doppler shift = 972 Hz**



4-symbol gap

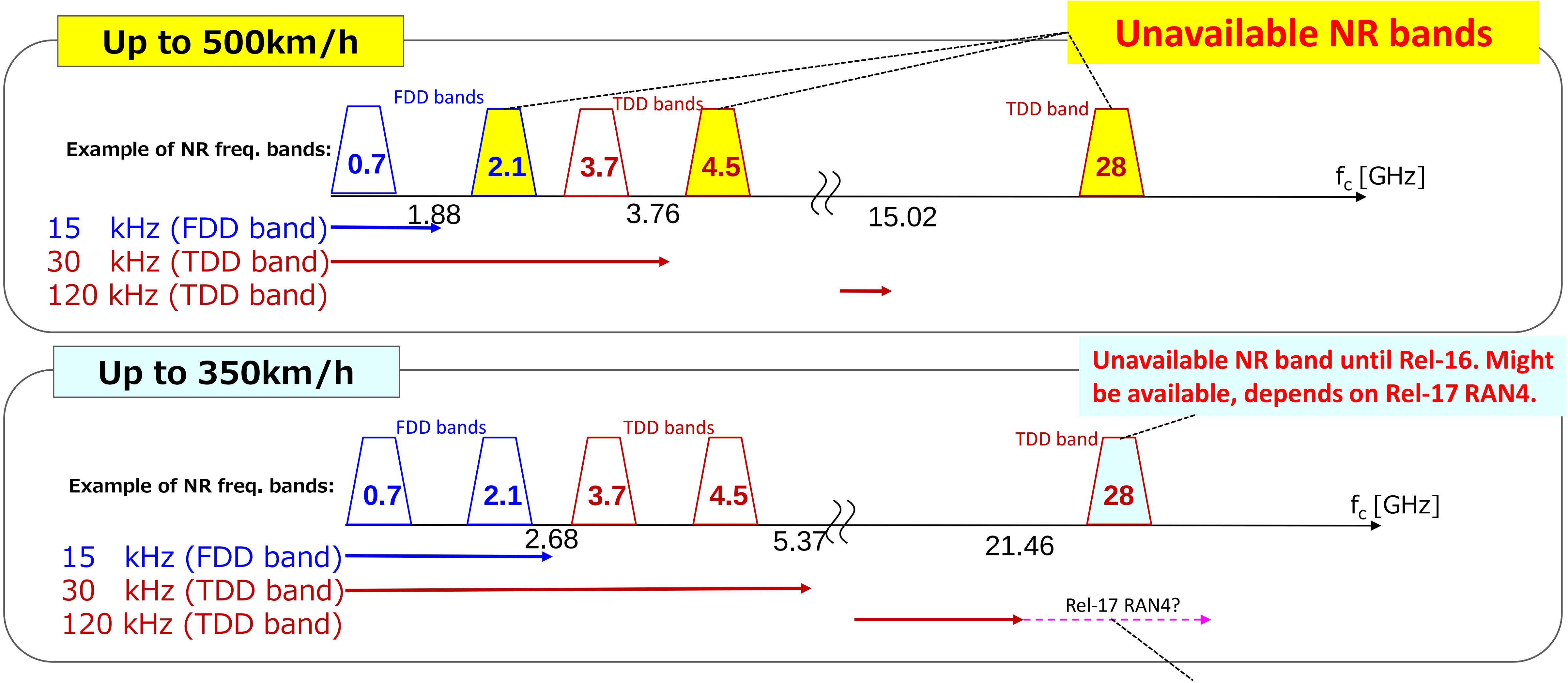


NR TRS

➔ **Max. Doppler shift = 870 Hz**

Rel-18 HST: Motivation

- Available NR frequency bands with Max. Doppler shift = 870 Hz (in bi-directional SFN).



Rel-17 RAN4 will support 350km/h@30GHz for CPE. However, whether to support it in bi-directional SFN is not decided yet.

Rel-18 HST: Proposal

- Rel-16 RAN4 decided Max. Doppler shift, based on Rel-15 RAN1 specification.
- Rel-17 RAN1 HST-SFN supports Scheme1 (TRP specific TRS and SFN-PDSCH) and Doppler pre-compensation scheme.
  - Based on Rel-17 RAN1 HST-SFN, we expect larger Doppler shift is supported in Rel-17/18 RAN4.
  - Otherwise, TRS enhancement (i.e. 3-symbol gap TRS) is needed in Rel-18 RAN1.

- **Proposal: RAN4 Rel-17/18 supports NR with 996Hz Doppler shift (e.g. 500mk/h@2.15GHz) with 15kHz SCS in bi-directional SFN.**
  - **Alt.1: Rel-17/18 RAN4 specifies demodulation requirement based on Rel-17 RAN1 HST-SFN. No RAN1 work is expected in Rel-18.**
  - **Alt.2: Rel-18 RAN1 specifies 3-symbol gap TRS, and Rel-18 RAN4 specifies its demodulation requirement.**