

[RAN1 led] Further Multi-Carrier enhancements

[WI]

General

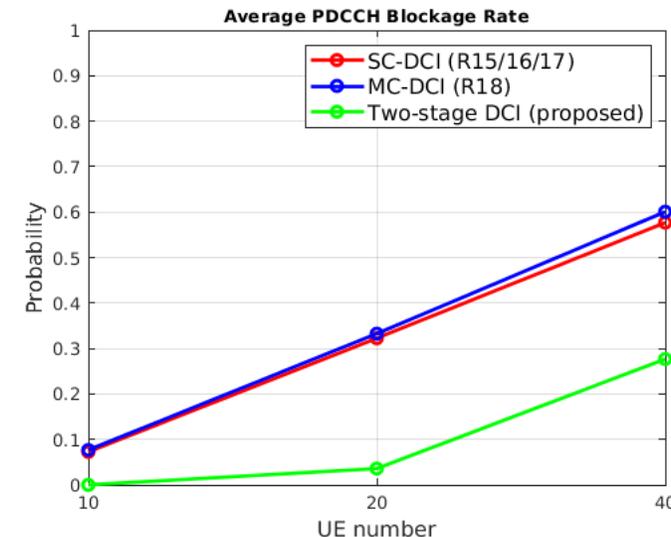
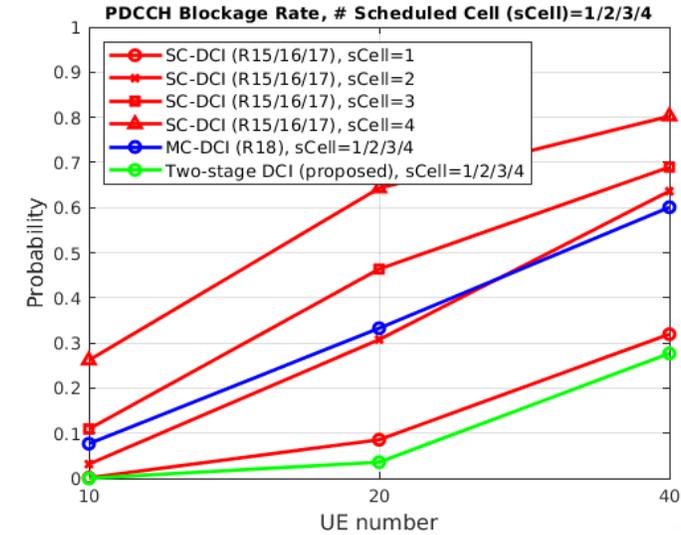
- This Tdoc provides motivations and proposals for
 - [Further PDCCH enhancement](#) to address issues with multi-carrier DCI leading to PDCCH blockage
 - [Multi-Carrier cell](#) to address growing inefficiencies with the current CA framework

Motivation – Further PDCCH Enhancement

[1/n]

Problem Statement

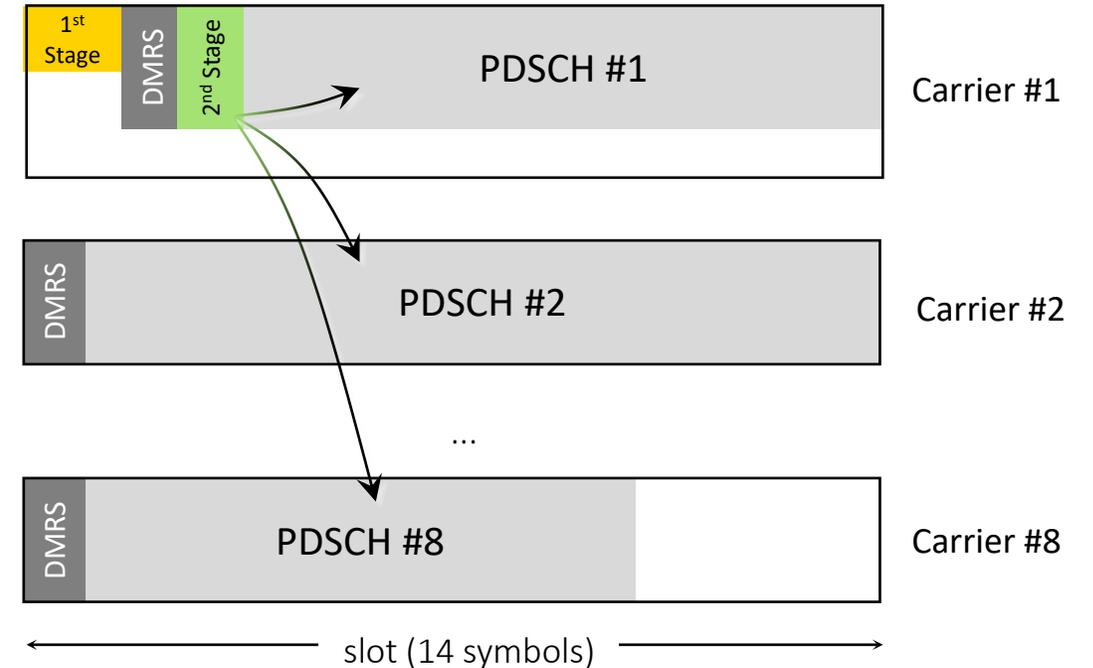
- For Multi-Carrier operation, Rel-18 MC-DCI lowers DCI overhead by consolidating DCI for scheduling up to 4 component carriers (CCs)
- **Issue:** The MC-DCI size is not scalable
 - Redundant bits exist in DCI when scheduled CCs are fewer than the maximum RRC-configured aggregated CC number
 - Higher aggregation level for non-scalable DCI size adversely affects PDCCH blockage rate
 - Higher PDCCH blockage rate leads to user throughput loss



Proposal – Further PDCCH Enhancement

Two-stage DCI

- Support 2-stage DCI to achieve enhanced scheduling flexibility and minimal DCI overhead
 - Unified non-fallback DCI (1st stage) in PDCCH to schedule PDCCH or DCI-only PDSCH for aggregated DCIs across 4+ CCs (2nd stage)
 - 1st stage DCI (example)
 - PHY channel: PDCCH with very compact DCI size
 - Modulation: QPSK only
 - 1-CC PDCCH blind decoding
 - Provide scheduling information for 2nd stage DCI
 - 2nd stage DCI (example)
 - PHY channel: dedicated CORESET or DCI-only PDSCH
 - Modulation: QPSK or 16 QAM
 - NO PDCCH blind decoding
 - Provide scheduling info for PDSCH/PUSCH in scheduled carriers
 - *Lower PDCCH blockage rate* in comparison to Rel-18 MC-DCI



Motivation – Multi-Carrier Cell

[1/2]

Problem Statement: Legacy CA inefficiencies

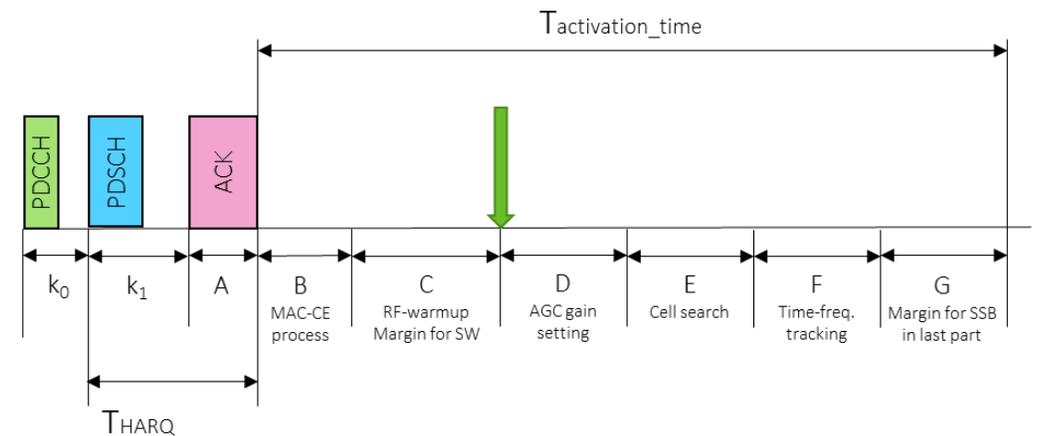
- One carrier is associated with one cell and PHY/RRC complexity/overhead scales with cell number
- Resource utilization across carriers is not efficient enough
 - **Slow, inflexible Carrier activation/de-activation**
e.g. taking up to 45-85ms in FR1
 - **Long HARQ latency for TDD**
The inability to schedule packet retransmissions on a different carrier to first transmission affects latency, particularly in TDD bands

- **Warm activation**

- For FR1, up to $(5\text{ms} + T_{\text{FirstSSB_Max}} + T_{\text{rs}})$
e.g. 45ms

- **Cold activation:**

- For FR1, up to $(5\text{ms} + T_{\text{FirstSSB_Max}} + T_{\text{SMTC_Max}} + 2 * T_{\text{rs}})$
e.g. 85ms



- **Long CC (de-)activation time impacts XR QoS**

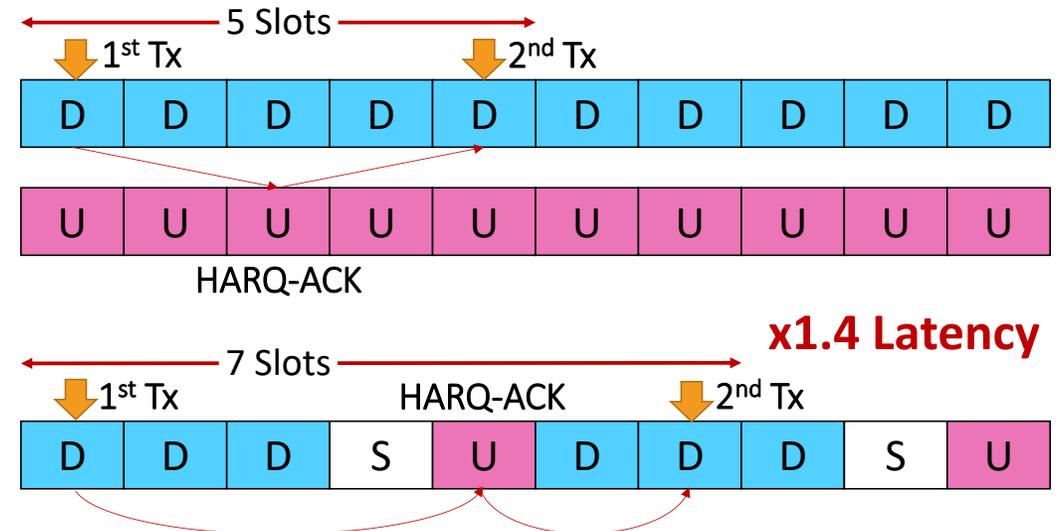
Motivation – Multi-Carrier Cell

[2/2]

Problem Statement: Legacy CA inefficiencies

- One carrier is associated with one cell and PHY/RRC complexity/overhead scales with cell number
- Resource utilization across carriers is not efficient enough
 - Slow, inflexible Carrier activation/de-activation e.g. taking up to 45-85ms in FR1
 - **Long HARQ latency for TDD**
The inability to schedule packet retransmissions on a different carrier to first transmission affects latency, particularly in TDD bands

- TDD config. limits the lower bound of HARQ latency



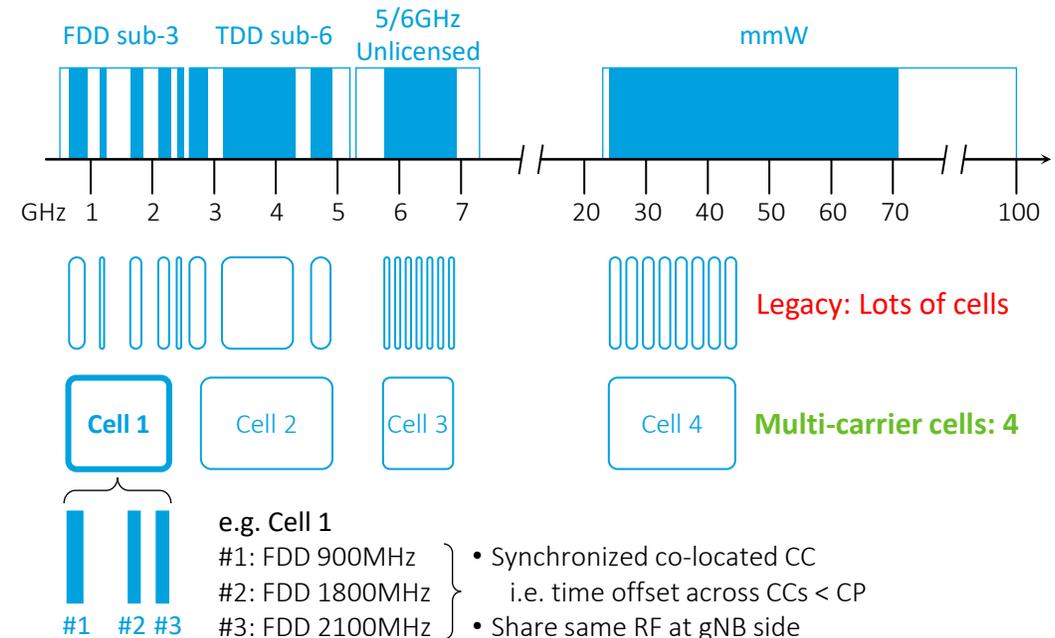
- Long HARQ latency impacts XR capacity in TDD bands

Proposal – Multi-Carrier Cell

Cell with multiple Component Carriers

- Enable multiple CCs for a cell, in UL and DL
 - All CCs are co-located at the same gNB site and assumed to share the same RF
 - CCs may be intra-band contiguous or non-contiguous, or inter-band
- Enhanced HARQ operation to avoid TDD latency bottlenecks
 - Allow HARQ feedback and retransmissions on other carrier (complementary TDD)
 - PUCCH transmission for HARQ-ACK feedback across carriers within a cell
- Fast carrier activation/deactivation within a cell
 - Across those CCs for which the same time/frequency/AGC reference can be assumed

- Enable joint RRC (re)configuration & L1/L3 processing (e.g. measurement, time/freq sync, CSI) operations (e.g. FR2) for a multi-carrier cell



Proposal

SA/CT Dependency: No

To further improve the efficiency and effectiveness of Multi-Carrier operation via introduction of 2-stage DCI and Multi-Carrier cells

Objective I: Specify a 2-stage DCI framework for multi-carrier PUSCH/PDSCH scheduling for up to 16 cells in FR1 and FR2 bands [RAN1]

- The 1st stage DCI is used to schedule the 2nd stage DCI
 - Strive for a compact DCI size to avoid blockage, i.e. DCI size is the same as the fallback DCI
- The 2nd stage DCI is used to carry the scheduling information of the co-scheduled cells

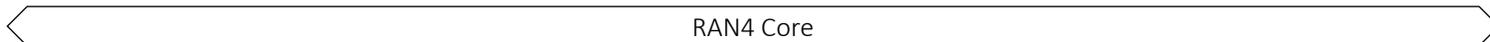
Objective II: Specify mechanisms for supporting multiple carriers on contiguous or non-contiguous (intra-band or inter-band) spectrum blocks at same gNB site as one multi-carrier cell [RAN1, RAN2, RAN4]

- Cross-carrier HARQ operation [RAN1]
- Efficient BWP design [RAN1]
- Joint L1/L3 processing, measurement, and report for the cell (covering all carriers) rather than per carrier operation [RAN1, RAN4]
- Design of cell configuration, system information, and other related settings for a multi-carrier cell [RAN2]

Expected TU

	2024												2025 [Calendar TBC at the time of writing]												2026		
	Q1			Q2			Q3			Q4			Q1			Q2			Q3			Q4			Q1		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
RAN	103			104			105			106			107			108			109			110			111		
R1	115b	116		116b	117			118		118b	119		119b	120		120b	121			122		122b	123		123b	124	
R2	124b	125		125b	126			127		127b	128		128b	129		129b	130			131		131b	132				
R3	122b	123		123b	124			125		125b	126		126b	127		127b	128			129		129b	130				
R4	109b	110		110b	111			112		112b	113		113b	114		114b	115			116		116b	117		117b	118	
R1		1		1	0.5			1.5		1	0.5			1.5		1	0.5										
R2				0	0			1		0.5	0.5			1		0.5	0.5			1							
R3				N/A	N/A			N/A		N/A	N/A			N/A		N/A	N/A			N/A							
R4 RD				0	0			0		0	0			0		0	0			0							
R4 RF				0	0			0		0.25	0.25			0.5		0.25	0.25			0.5							

Study TU
Feature TU



Thank you!