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

RWS-230431

Agenda Item: 5
Source: Xiaomi
Document for: Discussion

Views on Multi-carrier enhancement in Rel-19

Xiaomi

Evolution of multi-carrier technology in NR

Complete functions on CA and DC:

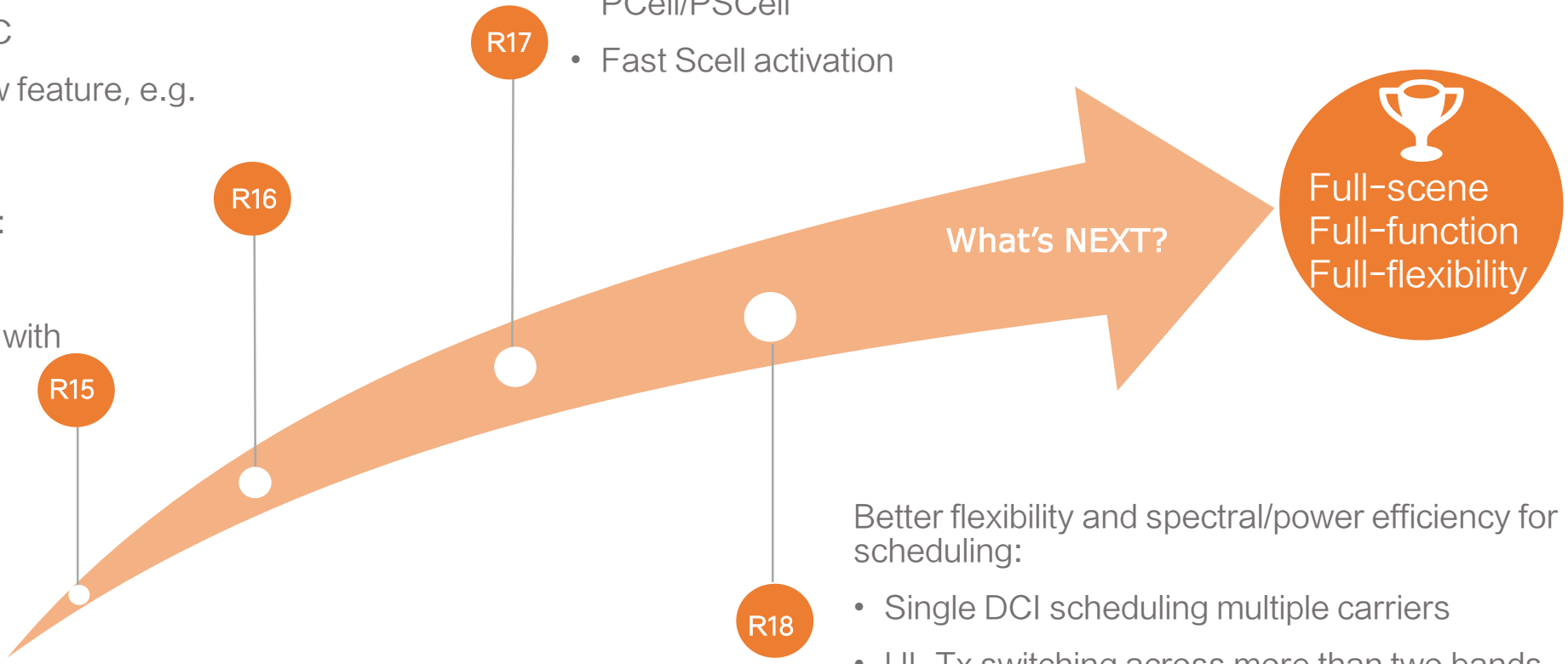
- CCS with different SCS
- Other aspects on MR-DC
- Accommodation with new feature, e.g. URLLC

Basic CA&DC functionality:

- Self-scheduling
- Cross carrier scheduling with same SCS
- Up to 32 carriers
- TDD+TDD, FDD+FDD, TDD+FDD

Improve functionality of CA:

- SCell scheduling PCell/PSCell
- Fast Scell activation



Better flexibility and spectral/power efficiency for scheduling:

- Single DCI scheduling multiple carriers
- UL Tx switching across more than two bands

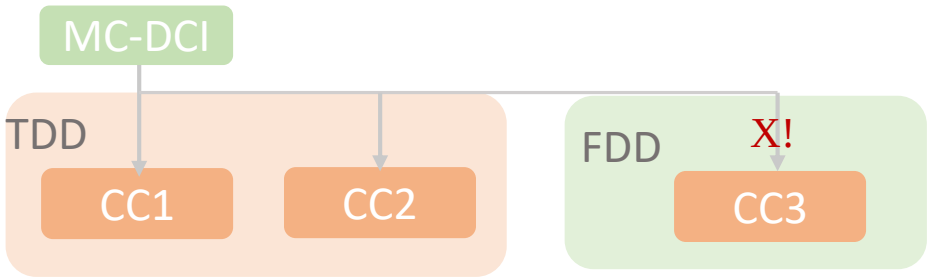
Accordingly, we have the following observation:

Observation 1: Multi-carrier technology can be further enhanced in order to support more scenarios, more functionality and additional flexibility.

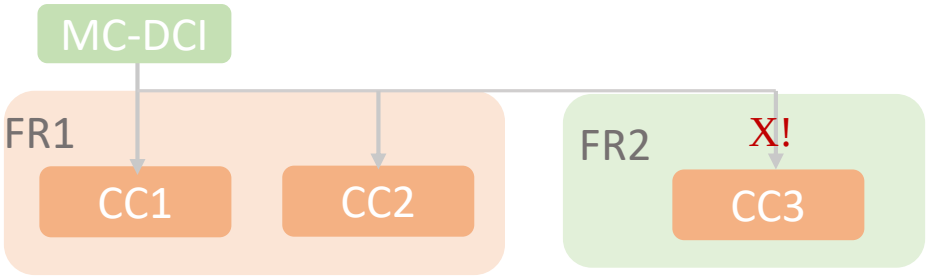
Different carrier type/SCS among co-scheduled cells

What do we have in Rel-18 MC?

- Only same carrier type is allowed among co-scheduled cells due to limited TU.
  - Same duplex mode, i.e., TDD/FDD
  - Same frequency range, i.e., FR1/FR2



TDD+FDD cell set is prohibited



FR1+FR2 cell set is prohibited

Potential restrictions with current mechanism

- The assigned frequency bands for operator are typically various, including TDD band, FDD band, etc.

Assigned bands for Chinese operator

Frequency	duplex	Frequency range	
900MHz	FDD	UL:889-904MHz	DL:934-949MHz
1800MHz	FDD	UL:1710-1735MHz	DL:1805-1830MHz
1.9GHz	TDD	1880-1920MHz	
2GHz	TDD	2010-2025MHz	
2.3GHz	TDD	2300-2370MHz	
2.6GHz	TDD	2515-2675MHz	
4.9GHz	TDD	4800-4900MHz	

Observation 2: Restrictions on carrier type for co-scheduled cells in Rel-18 MC reduce the flexibility on deployment.

Observation 3: Currently, specification has been ready to support different carrier type within co-scheduled cell set.

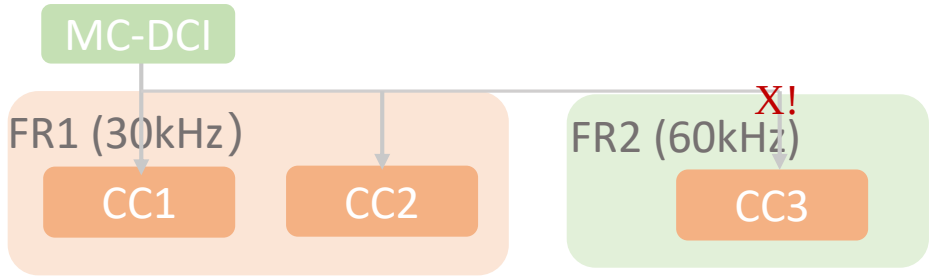
Different carrier type/SCS among co-scheduled cells

Motivation to support different type in Rel-19

- Extend the applicable scenarios.
  - For example, if scheduling cell belongs to the same cell set as the other scheduled cells, it has to have same carrier type as other cells. It makes FR1 scheduling FR2 impossible.
  - For example, mixed carrier types is impossible.

Limitation to support different type in Rel-19

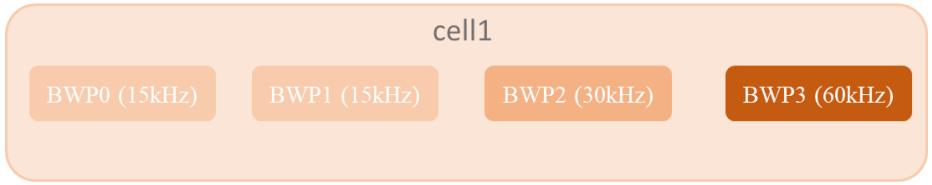
- Different carrier type typically result in different SCS among co-scheduled cells, e.g., (FR1+FR2).
- In Rel-18, only same SCS among co-scheduled cells is allowed.



Different SCS among scheduling cell set is not allowed

Motivation to support different SCS in Rel-19

- Enable co-scheduling of different carrier type.
- Improve scheduling flexibility even with same carrier type.
  - Currently, SCSs among BWPs within one serving cell may be different.



Proposal 1: In Rel-19 multi-carrier scheduling, support different carrier type/SCS among cells scheduled via the same DCI. The following aspects can be further studied:

- HARQ feedback
- Resource allocation
- UE capability

Two stage DCI for multi-carrier(1/2)

What do we have in Rel-18 multi-carrier technology?

- Single DCI scheduling up to 4 carriers per set
- Up to 4 cell sets can be indicated via the DCI
- DCI format 0-3 for uplink and DCI format 1-3 for downlink are specified. Three types of information field are defined in order to control overall DCI payload size
  - Type 1A/1B/1C for common information
  - Type 2 for separate information
  - Type3 for configurable information between Type-1 and Type-2
- Legacy limitation on DCI size is maintained
  - DCI size budget
  - Maximum payload size is 140 bits

What is the challenge for application?

- DCI payload size in different scenarios

Full functionality with assuming 275 RB BW for each carrier and RBG=16 RB

DCI format	1 cell	2 cell	3 cell	4 cell
1-3	100 bit	153	200	247
0-3	100	153	200	243

Full functionality with assuming 1.9GHz/2.3GHz/2.6GHz/4.9GHz TDD band and RBG=16 RB

DCI format	1 cell	2 cell	3 cell	4 cell
1-3	96bit	147	196	245
0-3	96	147	196	241

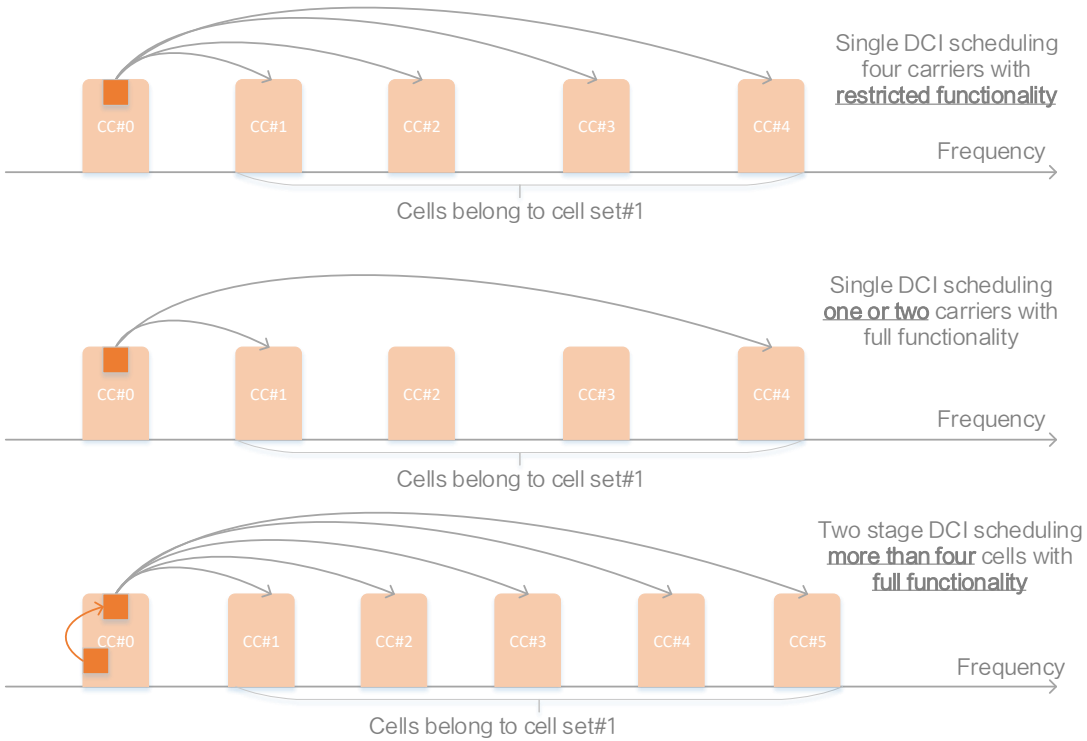
- The forward compatibility is very challenging if not impossible, e.g. more cells, CBG transmission.
- Full functionality is impossible even for two carrier scheduling.
- DCI payload is still an issue.

Observation 4: The limitation on maximum DCI payload size put significant restrictions for application of Rel-18 multi-carrier technology.

Two stage DCI for multi-carrier(2/2)

Motivation of two stage DCI for multicarrier

- Simplicity
- Forward compatibility
- Flexibility on scheduling
- Better performance on data transmission
- Improved PDCCH capacity



Possible designs for two stage DCI

Proposal 2: Two stage DCI can be considered for multi-carrier scheduling so as to further improve the performance. At least the following two schemes can be studied as starting point:

- Downlink control information is split into first DCI and second DCI
  - First DCI indicates how to receive second DCI
  - Second DCI contains scheduling information for each scheduled cell
  - Second DCI can be multiplexed with PDSCH
- Legacy DCI format indicates a PDSCH conveying scheduling information for co-scheduled cells
  - No new DCI format is introduced
  - Legacy mechanisms of PDSCH is fully reused
  - PDSCH acts as a container of DCI

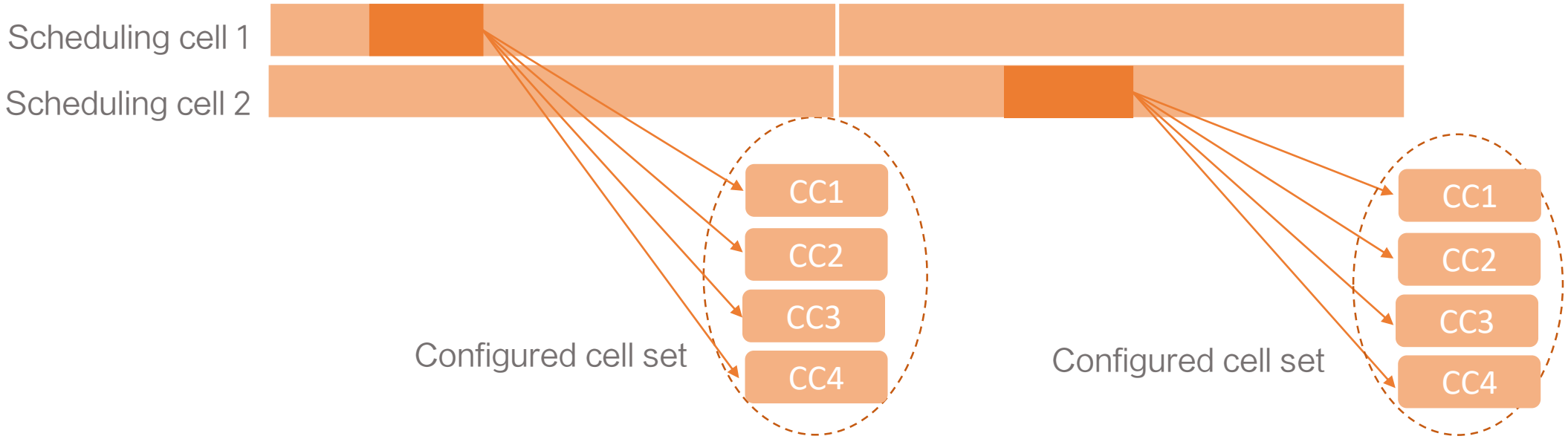
Dynamic scheduling cell switch

Motivation of introducing dynamic scheduling cell switch

- For a scheduled cell in the MC scheduling in Rel-18, only one scheduling cell can be configured with MC-DCI.
- In Rel-19, dynamic switch of the scheduling cell with MC-DCI can be supported to allow efficient scheduling and reduce the control region blocking issue
  - Deactivation of the scheduling cell, e.g, scheduling cell is a SCell
  - Unavailable scheduling cell due to the failure of channel access on shared spectrum

Proposal 3: Dynamic scheduling switch can be consider in Rel-19 in order to improve scheduling flexibility and reduce PDCCH blocking probability:

- More than one scheduling cell configured for one scheduled cell
- Mechanism to support dynamic switch of the scheduling cells
- BD/CCE splitting between two scheduling cells

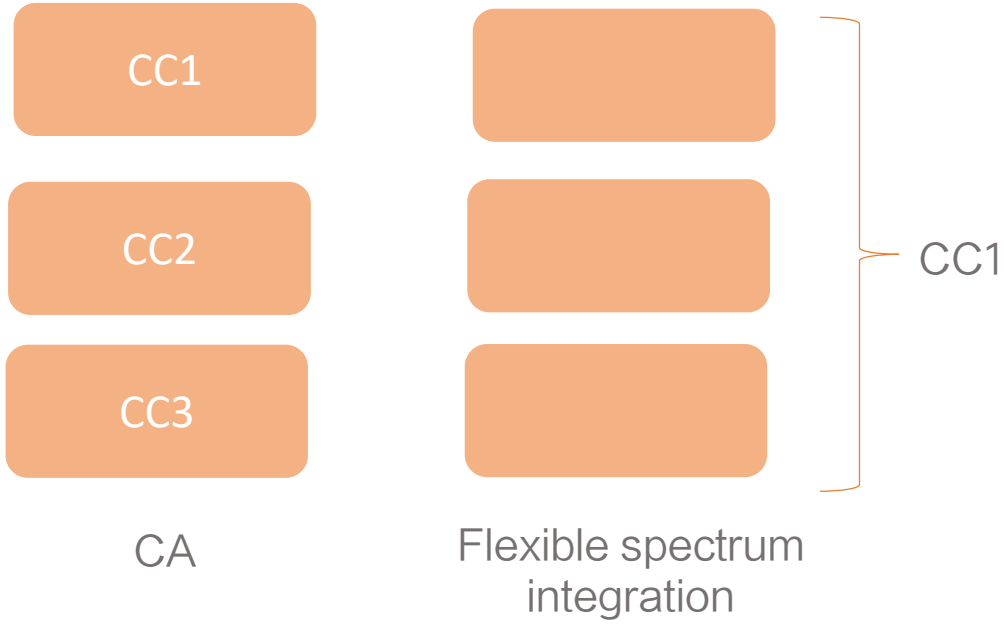


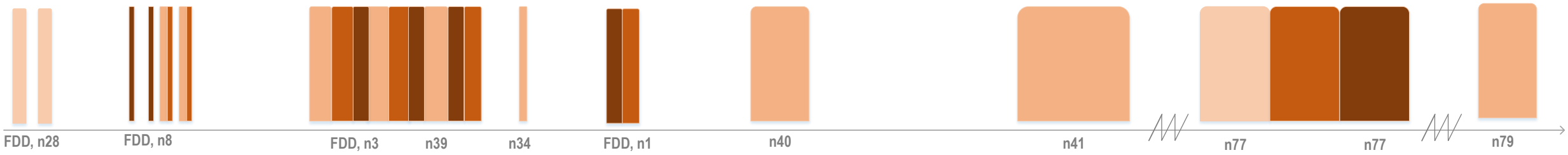
Flexible spectrum integration

- A serving cell can be consisted of multiple carriers within or across frequency bands
  - Reduce the overhead of the common signals such as SSB
  - Flexible HARQ operation

Proposal 4: The flexible spectrum integration can be considered in Rel-19

  - Configuration of the a single cell with multiple carriers
  - Enhancement on the initial access procedure
  - Fast carrier switch mechanism





Band assignment for Chinese operators

Conclusion(1/2)

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Conclusion(2/2)

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Thanks!