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RP-233539

Views on Multi-carrier enhancements for NR in Rel-19 onwards

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Background

- "Multi-carrier Enhancements" is categorized as one of "Additional Candidate Topics for further consideration during RAN#101 and till RAN#102" in RP-231540
- There are 16 contributions submitted to RAN#101 on Multi-carrier Enhancements from 19 sources, and the moderator's summary in RP-232626 captures followings.

Potential areas for Rel-19	Supportive companies
Enhancements on multi-cell scheduling via single DCI	Nokia, OPPO, vivo, Huawei, CATT, Xiaomi, China Telecom, Lenovo, China Unicom, New H3C, TCL – 11 sources **Multi-slot scheduling**: Ericsson, DOCOMO **Multi-UE scheduling**: CMCC
Single cell with multiple carriers	CATT, CMCC, Xiaomi, China Telecom, MTK, TELUS, Lenovo, China Unicom, New H3C, TCL – 10 sources
Fast downlink carrier switching	Huawei, CATT, MTK (DL/UL), Lenovo, China Unicom, New H3C, TCL, Xiaomi – 8 sources
Cross cell HARQ retransmission	Huawei, CATT, MTK, Lenovo, China Unicom, New H3C, TCL, Xiaomi – 8 sources
Two-stage DCI	Xiaomi, China Telecom, MTK – 3 sources
SUL enhancement	Huawei, CMCC, Qualcomm – 3 sources
Other multi-carrier enhancements	**Simplified CA operation and/or UE architecture**: Fujitsu, CMCC **Complementary UL-DL config**: China Telecom **Flexible DL-UL association**: ZTE **UL only SCell**: Nokia, ZTE **Improve MPR for intra-band CA in FR2**: DOMOMO **Joint CSI measurement across multiple carriers**: Huawei **Simultaneous scheduling via multi-cell DCI and legacy DCIs**: Huawei/CATT **UE capability sharing**: ZTE **Flexible cross carrier scheduling**: ZTE

General consideration on Multi-carrier Enhancements

- For eMBB use cases, utilizing multiple carriers for a UE has been a baseline operation for a long time
  - But NR design seems to be still based on single carrier operation, and there is a large room to improve efficiency of multi-carrier operation
  - Therefore, there are multiple proposed enhancements for multi-carrier operation from many companies as summarized in RP-232626

- According to RAN chair's summary in RP-232745, potential Rel-19 item for Multi-carrier enhancements is NOT included in RAN Rel-19 RAN1/2/3-led package
  - RP-232745 provides a guidance that "additional smaller RAN1/2/3-led projects may be further discussed and approved at a later stage of Rel-19 (Sept. 2024 or later)"
  - So, if RP-232745 is endorsed, potential Rel-19 item for Multi-carrier enhancements need to be small project which can be completed in 9 months (from Sept. 2024 to June 2025 for RAN1 completion) with potentially 0.5~1 TU per meeting

- Based on above, we believe that potential Rel-19 item for Multi-carrier enhancements should focus on one or two small scopes that have real benefits in commercial operation and can be good step towards multi-carrier native design which may be realized in 6G

Proposed objectives for potential Rel-19 Multi-carrier enhancements

- **Specify enhancements for multi-cell scheduling for supporting multi-cell + multi-slot scheduling via single DCI for the case of scheduling cell with lower SCS than that of scheduled cells [RAN1]**
  - Motivation: Multi-cell scheduling from cell with lower SCS to cells with higher SCS is beneficial in terms of UE power consumption and reliability for PDCCH monitoring, and the combination with multi-slot scheduling can achieve efficient scheduling of multiple cells having higher SCS than that of scheduling cell. This could be main use-case of multi-cell scheduling via single DCI and specifying this in Rel-19 would be beneficial for 6G multi-carrier design.

- **Specify UL only SCell operation for UL CA [RAN1, RAN2, RAN4]**
  - Motivation: UL only carrier in lower frequency which is associated with DL carrier(s) in higher frequency would be beneficial in terms of UL performance such as coverage and capacity. There is a large commercial demand on UL performance improvement, and more flexible association between DL and UL carriers including UL only SCell would be beneficial for 6G multi-carrier design.

- **[Study and specify FR2 CA MPR improvement (e.g., based on UL CBW only) [RAN4]]**
  - Motivation: In current RAN4 specification, FR2 CA MPR is defined based on not only UL CBW but also DL CBW and hence even if there is only one UL carrier configured for a UE, MPR is very high when UE is configured with multiple DL carriers in FR2. So, in practice, UE needs to be re-configured with reduced number of DL carriers (e.g., single DL carrier) when UL power is not sufficient due to large MPR. Such a restriction makes multi-carrier operation in FR2 totally difficult. This item may be part of RAN4 RF enh in Rel-19 if exists.

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