Agenda Item: **5.1.7**
Source: **Huawei, HiSilicon**
Title: **Overview of wider bandwidth operations**
Document for: **Discussion and decision**

1 Introduction

In RAN1#89 meeting, the following agreements on bandwidth part and co-existence of different UE types in the wideband carrier are achieved [1].

Agreement:
- *Confirm the WA of RAN1#88bis.*
- *Each bandwidth part is associated with a specific numerology (sub-carrier spacing, CP type)*
  - *FFS: slot duration indication if RAN1 decides to not to downselect between 7 symbol and 14 symbols for NR slot duration*
- *UE expects at least one DL bandwidth part and one UL bandwidth part being active among the set of configured bandwidth parts for a given time instant.*
  - *A UE is only assumed to receive/transmit within active DL/UL bandwidth part(s) using the associated numerology*
    - *At least PDSCH and/or PDCCH for DL and PUCCH and/or PUSCH for UL*
      - *FFS: down selection of combinations*
  - *FFS if multiple bandwidth parts with same or different numerologies can be active for a UE simultaneously*
    - *It does not imply that it is required for UE to support different numerologies at the same instance.*
    - *FFS: TB to bandwidth part mapping*
- *The active DL/UL bandwidth part is not assumed to span a frequency range larger than the DL/UL bandwidth capability of the UE in a component carrier.*
- *Specify necessary mechanism to enable UE RF retuning for bandwidth part switching*

Agreement:
- *Support single and multiple SS block transmissions in wideband CC in the frequency domain*
  - *For non CA UE with a smaller BW capability and potentially for CA UE, the measurement gap for RRM measurement and potentially other purposes (e.g., path loss measurement for UL power control) using SS block is supported (if it is agreed that there is no SS block in the active BW part(s))*
  - *UE can be informed of the presence/parameters of the SS block(s) and parameters necessary for RRM measurement*
    - *FFS: via either RMSI, other system information, or RRC signaling*
  - *FFS: number of SS blocks in wideband*
  - *FFS: number of SS blocks for RRM measurement*
  - *FFS: Details of measurement configuration*

Agreement:
- *Same PRB grid structure for a given numerology is assumed for narrow band UEs, CA UEs and wideband UEs within a wideband NR carrier*
  - *FFS: PRB indexing*

In this contribution, we discuss the remaining issues on wideband operation, including configuration of bandwidth part, scheduling schemes of active bandwidth parts, mechanisms of bandwidth adaptation, initial access for wideband carrier and co-existence of wideband UEs and CA UEs. More details could be found in our companion papers [2][3][4][5].

2 Configuration of bandwidth part

2.1 Types of BWP

It was agreed in RAN1#89 that single and multiple SS block transmissions are supported in wideband CC. For some SS blocks, there may be no corresponding RMSI. Therefore, three types of BWPs could be considered:

- BWP with SS block and corresponding RMSI, e.g. BWP1 in Figure 1.
- BWP with SS block and no corresponding RMSI, e.g. BWP3 in Figure 1.
- BWP without SS block and corresponding RMSI, e.g. BWP2 in Figure 1.

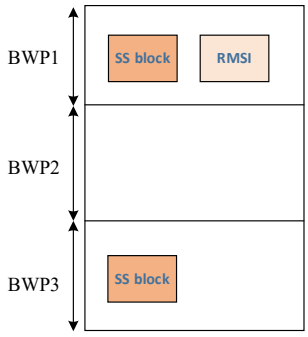

Figure 1 Three types of bandwidth part

2.2 The number of configured BWPs

For the number of configured BWPs, at least two and three BWPs for one UE should be supported. The scenarios are:

- As shown in Figure 2(a), the UE receives both DL control information and DL data within the 1st bandwidth part during slot n while the UE switches to the 2nd bandwidth part during slot n+1 for DL control information and DL data.
- As shown in Figure 2(b), the UE receives DL control information within the 1st bandwidth part and is scheduled to the 2nd bandwidth part for DL data reception during slot n.
- As shown in Figure 2(c), , the UE receives DL control information within the 1st bandwidth part in both slots n and n+k and is scheduled to the 2nd and the 3rd bandwidth parts respectively during slot n and slot n+k for DL data reception.

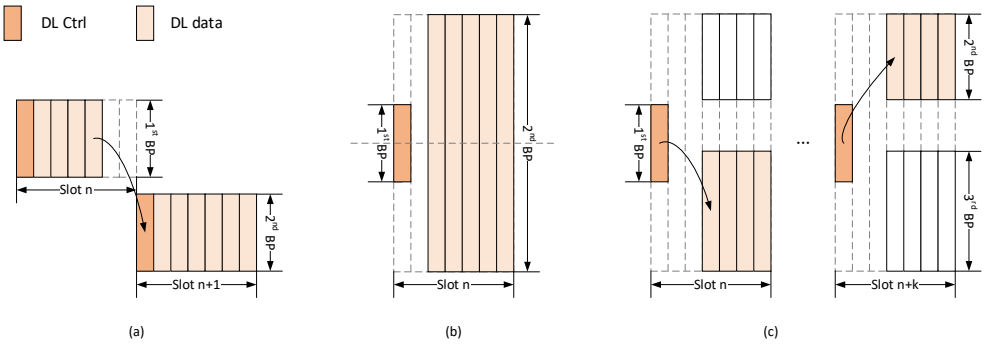

Figure 2 Potential use cases for bandwidth adaptation among multiple bandwidth parts

2.3 The number of active BWPs

Multiple active BWPs with same or different numerologies for one UE at a given time instant may be needed in NR. The scenarios are:

- Multiple active BWPs with same numerology

- In the scenario that a LTE SCell is activated/deactivated dynamically within a NR carrier, as shown in Figure 3(a), non-contiguous BWPs with the same numerology should be activated simultaneously to efficiently use NR resources.
- For the two BWPs around the SS block in the frequency domain, as illustrated in Figure 3(b), if the numerology of the two BWPs is the same, and is different with that of SS block, the two BWPs should be aggregated.

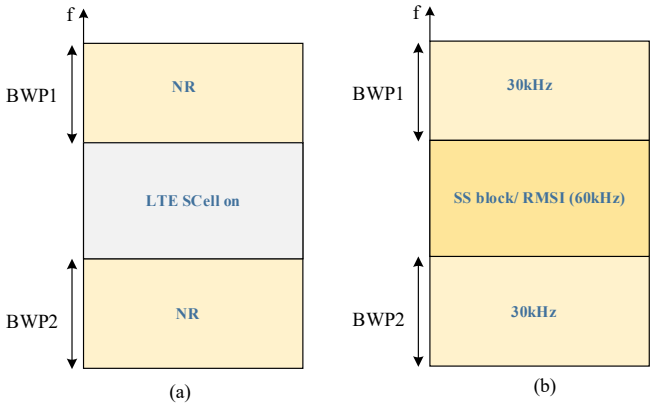

Figure 3 Scenarios of multiple active BWPs with same numerology

- Multiple active BWPs with different numerologies
  - For simultaneously transmissions of eMBB and URLLC services for one UE, multiple BWPs with different numerologies should be activated. In addition, to schedule different traffic types dynamically for one UE, multiple active BWPs with different numerologies could be considered to achieve fast numerology adaptation.

Proposal 1: *Multiple active bandwidth parts with same or different numerologies for one UE at a given time instant should be supported.*

3 Scheduling schemes BWPs

3.1 TB mapping

Different TB mapping schemes could be considered for multiple active BWPs with same and different numerologies, details could be found in our companion paper [2]:

- In case of multiple active BWPs with same numerology, if the multiple active BWPs are associated to the same CORESET, it is beneficial for reducing of signalling overhead that only one TB is scheduled and mapped to the multiple BWPs. If multiple active BWPs are associated to different CORESETs, one or multiple TBs can be transmitted over the multiple BWPs.
- In case of multiple active BWPs with different numerologies, to facilitate product implementation, per-BWP TB mapping should be supported.

Proposal 2: *Per-bandwidth part and cross-bandwidth part TB mapping should be supported for multiple active bandwidth parts with same numerology; Per-bandwidth part TB mapping should be supported for multiple active bandwidth parts with different numerologies.*

3.2 Dynamic resource allocation of different numerologies

In RAN1#87, it was agreed that NR strives for efficient support of dynamic resource allocation of different numerologies in FDM/TDM fashion. One feasible approach is illustrated in Figure 4, only one CSI-RS numerology is supported in a carrier in one frequency band, data channel and control channel could have multiple numerologies and different numerologies are FDMed. Since the numerology of CSI-RS and data channel is independently configured, the channel state information is gotten irrespectively of the numerology of the BWP.

For UEs with different numerology requirement, e.g. UE1 and UE2 in Figure 4, the configured BWPs for the two UEs could be overlapped in the frequency domain. Since the CSI information over the BWPs is known at gNB side by the reporting of the two UEs, dynamic resource allocation with different numerologies in a FDM manner could be achieved by gNB scheduling. Furthermore, same approach could be used for SRS numerology configuration for dynamic UL resource allocation of different numerologies.

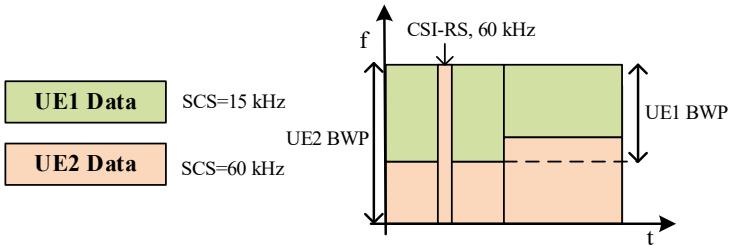

Figure 4 Dynamic resource allocation of different numerologies

Proposal 3: *CSI-RS/SRS numerology should be independently configured for the bandwidth part, which may be different with the associated numerology for this bandwidth part for data and control.*

4 Bandwidth adaptation

In our companion paper [3], mechanisms of bandwidth adaptation, e.g. indication of BWP activation, RF retuning and fallback mechanism, are discussed. Compared with MAC-CE, DCI is preferred to indicate the activation of BWPs due to its low latency. In addition, the time pattern option is necessary for both receiving the periodic common information and supporting the fall back mechanism.

Proposal 4: *Support both DCI and time pattern to indicate the activation of bandwidth part, e.g., explicit UE-specific or group common DCI.*

If DCI is adopted to indicate the BWP activation/deactivation, there is a possibility that the gNB and UE may not be aligned in the current active BWPs. To deal with this problem, a fall back mechanism can be considered. One example is illustrated in Figure 5.

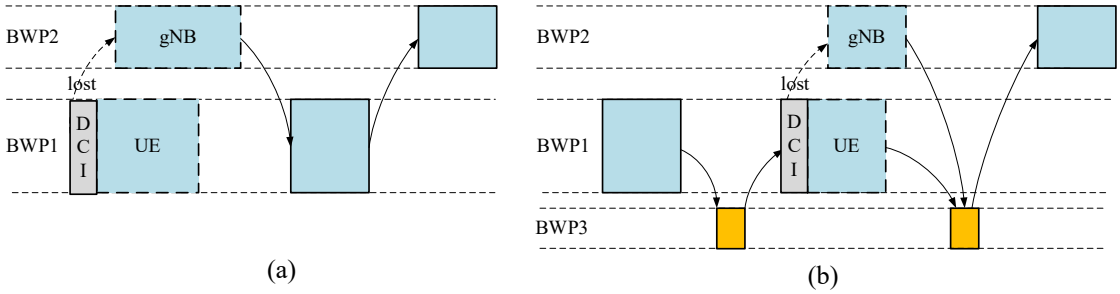

Figure 5 Example of BWP activation fall back

Proposal 5: *Support fall back mechanism for bandwidth part activation/de-activation.*

The impact of RF retuning should be considered in bandwidth adaptation. If the time for retuning is not consistent for gNB and UE, the gNB may schedule the UE when the UE is retuning. Consequently, it is necessary for the gNB and the UE to get aligned on the location of the retuning time. Both predefined and explicit indication of the guard period for RF retuning could be considered.

Proposal 6: *The starting/ending position of the guard period for UE RF retuning should be predefined and/or signalling in DCI.*

5 Initial access for wideband carrier

For multiple RMSIs in a wideband carrier, the PRACH configuration in different RMSIs should be excluded, if a PRACH configuration is configured by two RMSI in a wideband carrier, the gNB will be confused about the frequency location of the control for RAR as illustrated in the Figure 6, and the

frequency location of control for RAR may be same as the control for RMSI which is indicated in the PBCH.

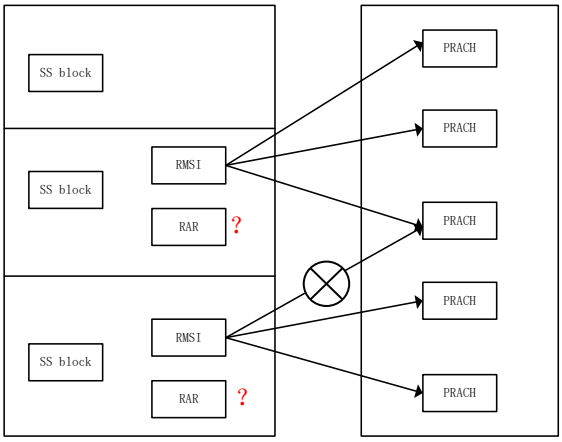

Figure 6 PRACH configuration in wideband CC

Proposal 7: *When multiple RMSIs are present in one wideband CC, each RMSI shall contain its unique PRACH configuration.*

It has been agreed in previous meeting that the maximum bandwidth for CORESET for RMSI scheduling and NR-PDSCH carrying RMSI should be equal to or smaller than a certain DL bandwidth. To avoid frequency retuning during initial access, SS block, CORESET for RMSI and NR-PDSCH carrying RMSI should be confined within a certain DL bandwidth, which could be regarded as common bandwidth part, and the bandwidth of the common bandwidth part should be supported by all UEs [4].

Proposal 8: *SS block, CORESET for RMSI scheduling and NR-PDSCH carrying RMSI should be confined within a certain DL bandwidth that is equal to or smaller than minimum UE receive bandwidth.*

6 Co-existence for different UE types for wideband carrier

Let us define Type A UEs as those operating in intra-band contiguous CA mode and Type B UEs as those operating in single wideband mode. To improve the resource efficiency, flexible MU-MIMO multiplexing of Type A and Type B UEs should be supported. In LTE, the reference signal sequence is independently generated and mapped per CC. In a given time-frequency resource, if the sequence is not the same for Type A and Type B UEs, the orthogonality may be degraded and RS with OCC could not be utilized. To tackle this issue, as illustrated in Figure 7, in each CC within the wideband CC, Type A and Type B UEs should use the same sequence, so the orthogonality of whole RS within the wideband CC can be obtained.

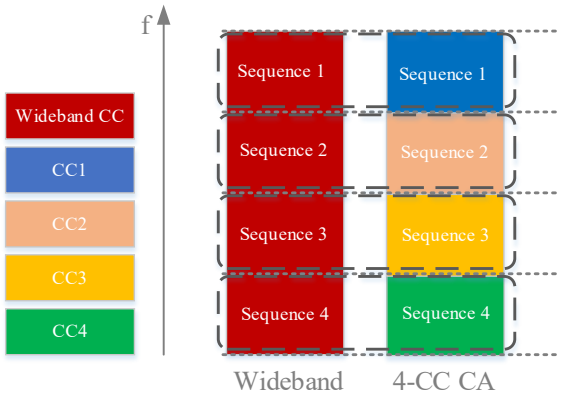

Figure 7. Reference signal generation and mapping

Proposal 9: *MU-MIMO multiplexing of Type A and Type B UEs should be supported for both DL and UL. The same reference signal sequence should be mapped in the same time-frequency resource for Type A and Type B UEs.*

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