**3GPP TSG-RAN WG4 Meeting #94-e R4-200xxxx**

**Electronic Meeting, Feb.24th – Mar.6th 2020**

**Agenda item:** 8.1.15

**Source:** Moderator (Intel Corporation)

**Title:** Email discussion summary for RAN4#94e\_#62\_NR\_RRM\_Enh\_RRM\_Part\_1

**Document for:** Information

# Introduction

The email discussion is intended to cover topics in AI 8.1.15.4 (BWP switching on multiple CCs), 8.1.15.8 (UL spatial relation info switching) and 8.1.15.9 (Non-simultaneous UL carrier operation in FR2)

# Topic #1: BWP Switching on multiple CCs

In RAN4#93 the following agreements were made for BWP switching on multiple CCs.

Definition of Simultaneous triggering of BWP switching on multiple CCs

* For DCI based switching:
  + The timing difference among the first symbol of slot carrying DCI for all CCs is received within the MRTD for inter-band CA
* For Timer based switching
  + The timing difference among the beginning of the slot where timer based BWP switching starts for all CCs is within MRTD inter-band CA
* For RRC based switching
  + RRC based BWP switching on multiple CCs for NR-CA is triggered by 1 RRC command
    - FFS for NR-DC operation

Requirements for Simultaneous triggering

* Requirements are defined for BWP switching on all CCs triggered by the same method (DCI, Timer or RRC)
  + RRC based BWP switching on multiple CCs for NR-CA is triggered by 1 RRC command
    - FFS for NR-DC operation
* For BWP switching delay requirements companies are encouraged to bring analysis on BWP switching delay components that can be done in parallel and sequentially
  + Option 1: BWP switching on multiple CCs would be N times delay of single CC
    - Where 1 < N < Number of CCs
      * FFS if BWP switching delay requirements are scaled for subset of CCs or for all CCs.
  + Option 2: BWP switching delay 1 CC + ; Where D is the incremental processing delay on additional CCs; N is number of CCs; K is number of CCs that can be processed simultaneously
  + Other options are not precluded
* Interruption requirements are FFS

Requirements for partial overlap triggering

* For BWP switching on multiple CCs with partial overlap:
  + Requirements are defined for BWP switching on all CCs triggered by the same method (Timer or RRC)
  + DCI based switching is not considered for CA; FFS for NR-DC
  + RRC based switching shall be considered for NR-DC only
  + Timer based switching shall be considered for CA and NR-DC
* FFS on BWP switching delay with partial overlap triggering
* FFS on interruption requirements for BWP switching with partial overlap triggering

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2000155 | vivo | Proposal 1: For the simultaneous BWP switch on multiple CCs case, the type 2 switch delay requirement consists of two parts, the RF part and the baseband part. The value of RF related part is scaled by the number of total involved CCs and the value of baseband processing part is the same as the BWP switch delay on single CC.  Proposal 2: For a CC among involved CCs, if its BWP switch does not require related RF change, it does not need to be included in the scaling factor N.  Proposal 3: For the simultaneous BWP switch on multiple CCs case, if the BWP switch on multiple CCs results in the change of the SCS on any CC among involved CCs, the BWP switching delay should be expressed in the time unit of slots corresponding to the largest SCS among all involved SCS value of all involved CCs.  Proposal 4: For RRC based simultaneous BWP switch on multiple CCs, at least is not scaled by the number of involved CCs.  Proposal 5: Within the same frequency range, partial overlapping BWP switch is not allowed.  Proposal 6: For a UE is not capable of per-FR gap, the case where partially overlapping BWP switch happens over different frequency range is not allowed.  Proposal 7: For a UE is capable of per-FR gap, the case where partially overlapping BWP switch happens over different frequency range is allowed.  Proposal 8: For a UE is capable of per-FR gap, at each frequency range, each individual BWP delay requirement among all partial overlapping BWP switches can follow either the single or the simultaneously multiple BWP switch delay requirement, depending on whether that BWP switch happens on a single CC or simultaneous multiples CCs. |
| R4-2000156 | vivo | Proposal 1: For the interruption period of simultaneous BWP switch on multiple CCs case, its duration should be extended and the value could depend on the number of simultaneous BWP switches.  Proposal 2: For the simultaneous BWP switch on multiple CCs case, the interruption period due to BWP switch is determined by the smallest SCS among all the SCS before all BWP switches and all the SCS after all BWP switches.  Proposal 3: For per-FR capable UE with partial overlapping BWP at different frequency range, the interruption period of a particular BWP switch at any frequency range will either follow the already existing Rel-15 interruption period requirement, for BWP switch over single CC case or follow the interruption period requirement defined for simultaneous BWP switches over multiple CCs case, where all CCs are within the same frequency range. |
| R4-2000372 | Intel Corporation | Proposal 1: For NR-DC operation no requirements shall be defined for RRC based simultaneous BWP switching on multiple CCs  Proposal 2: The switching delay for simultaneous timer and DCI based, BWP switching delay on multiple CCs is defined as:  Proposal 3: The switching delay for RRC based BWP switch on multiple CCs is defined as:  Proposal 4: For simultaneous BWP switching on multiple CCs, the interruption is defined as:  Proposal 5: BWP switching with partial overlap triggering on multiple CCs is only defined when BWP switching on each CC doesn’t cause interruption on other CCs  Proposal 6: The BWP switching requirements for partial overlap triggering on multiple CCs is the same as that of single CC |
| R4-2000459 | MediaTek inc. | Proposal 1: The definition for simultaneous RRC triggering in NR-DC is not considered. Once the RRC processing time of 2 RRC messages overlap fully or partially in time, UE is allowed to conduct the required BWP switch sequentially.  Proposal 2: For simultaneous DCI-based or timer-based BWP switch, the delay requirement for BWP switch in multiple CCs is sum of R15 single-CC delay requirement and , where N is the total number of CCs of which the BWPs are switched simultaneously.  Proposal 3: For simultaneous DCI-based or timer-based BWP switch, the interruption requirement BWP switch in multiple CCs is considered for each CC separately.  Proposal 4: For non-simultaneous BWP switch, except for those scenarios that are already precluded in RAN1 spec, UE should be allowed to conduct the BWP switch for different request sequentially in a first-come-first-serve manner.  Proposal 5: For non-simultaneous BWP switch, the interruption requirement BWP switch in multiple CCs is considered for each CC separately. |
| R4-2001013 | NEC | Proposal 1: BWP switch on multiple CC (simultaneous) is BWP switch delay of 1 CC + D \* ceil ((N÷K) -1). Where, D= BWP switching delay without processing delay of DCI or RRC and N is the number of CCs and K= [4].  Proposal 2: RAN4 to confirm DCI based non-simultaneous BWP switching is not considered for NR-DC.  Proposal 3: In NR-DC, BWP switch delay on each CG should be independent for simultaneous or non-simultaneous BWP switch triggering.  Proposal 4: Timer based BWP switch delay on multiple CC (non-simultaneous) = M× BWP switch delay on multiple CC (simultaneous) + M × Interruption due to each BWP switch.  Proposal 5: RRC based BWP switch delay on multiple CC (non-simultaneous) for each CG is equal to BWP switch delay on multiple CC (simultaneous). |
| R4-2001548 | Huawei, HiSilicon | Observation 1: The implementation and the capability for parallel processing may different.  Proposal 1: Define the BWP switching delay by counting the extra process delay of each additional CC.  Proposal 2: It is suggested to calculate the total absolute time delay regardless of SCSs of each CCs and then transforming the delay to the number of slots according to the SCSs of each CCs.  Proposal 3:  *For DCI and timer triggered BWP switching:*  For Type 1 UE, the incremental delay for each additional CC is 100 us. The BWP switching delay of a CC where there are simultaneous triggered BWP switching delay on other CCs is: 600 + 100 (N-1) us, where N ≤8 is the total number of CCs where the BWP switching is triggered by the same method (DCI or timer).  For Type 2 UE, the incremental delay for each additional CC is 200 us. The BWP switching delay of a CC where there are simultaneous triggered BWP switching delay on other CCs is: 2000 + 200 (N-1) us, where N ≤8 is the total number of CCs where the BWP switching is triggered by the same method (DCI or timer).  *For RRC-based switching:*  The existing delay requirements for single CC can be reused for on each individual CC when the BWP switching is simultaneously triggered on multiple CCs by 1 RRC command in each CG provided that the total number of CCs is less than 8.  Proposal 4: For the requirements of interruptions, for BWP switching on multiple CCs, the existing interruption requirements for a single CC shall apply for each BWP switching separately.  Proposal 5: It is suggested that the existing delay requirements for single CC can be reused for on each individual CC when the BWP switching is non-simultaneously triggered on multiple CCs by 1 RRC command in each CG for NR-DC provided that the total number of CCs is less than 8.  Proposal 6: The total delay for non-simultaneous DCI-based BWP switching on multiple CC for NR-DC is defined as:  Where ­ is the total BWP switching delay of a CC; is the existing delay requirements for BWP switching on a single CC. N is the total number of the non-simultaneous DCI-based BWP switching processes in different CG which overlap with . D is the incremental delay which is same as the simultaneous case.  Proposal 7: The total delay for non-simultaneous Timer-based BWP switching on multiple CC for CA and NR-DC is defined as:  Where ­ is the total BWP switching delay of a CC; is the time delayed by ongoing timer-based BWP switching with in the same frequency range. is the existing delay requirements for BWP switching on a single CC. N is the total number of the non-simultaneous timer-based BWP switching processes in different frequency range which overlap with . D is the incremental delay which is same as the simultaneous case.  Proposal 8: For the requirements of interruptions, for BWP switching on multiple CCs, the existing interruption requirements for a single CC shall apply for each BWP switching separately. |
| R4-2002090  R4-2001851 | Ericsson | *For simultaneous triggering*  Proposal 1: For DCI-based triggering, the requirements shall assume that reception of PDCCH and parsing of DCI can be carried out fully in parallel on the monitored component carriers.  Proposal 2: For software reconfiguration, i.e. CPU providing new configurations to hardware accelerators and DSPs at BWP change, requirements may consider additional time proportional to the number of component carriers for which a change is carried out. We may further discuss whether it is needed for type1, type2, or both.  Proposal 3: For radio reconfiguration, the requirements may consider additional time proportional to the number of component carriers for which BWP change is carried out, as writing to registers may be serial.  Observation 1: The point in time at which the UE detects that BWP changes are triggered simultaneously on multiple component carriers differ between Timer-based and DCI-based triggering, resulting in a tighter timeline for the latter.  Observation 2: In mixed numerologies and DCI-based triggering, the point in time at which the UE detects whether BWP changes are triggered on multiple component carriers simultaneously via DCI-based depends on the lowest numerology among the component carriers. The lower the numerology, the later the DCI parsing is completed.  Proposal 4: Separate requirements shall be introduced for Timer-based and DCI-based BWP change on multiple component carriers, as the margins in the respective timelines differ.  Observation 3: In Timer-based or DCI-based triggering, the location of the interruption window depends on the numerology of the carrier for which BWP change is carried out. If not accounted for when defining BWP change delay requirements for simultaneous triggering in mixed numerologies, it may lead to undesirable performance degradation on component carriers for which switching is not carried out.  Proposal 5: Performance impact by interruptions on other component carriers shall be taken into account when defining Timer-based and DCI-based BWP change delay requirements for simultaneously triggered BWP change of multiple component carriers.  *For partial overlap triggering*  Observation 1: Serving cells in different CGs can independently perform DCI based BWP switching and coordination between CGs may not be possible.  Proposal 1: BWP switching requirements are also specified for partial overlap triggering of DCI-based BWP switching on multiple CC.  Observation 2: When the BWP switching is non-simultaneously triggered on multipe CCs over partially overlapping time, then the ongoing BWP switching on one CC can be interrupted due to the BWP triggering on the other CC(s).  Observation 3: When numerologies of CCs involved in BWP switching are different then BWP switching on CC with larger SCS may cause interruption on CC with smaller SCS spanning across successive slots.  Proposal 2: UE shall trigger the BWP switching on a CC at slot boundary of the other CC with the smallest SCS where there is an ongoing BWP switching for CA and synchronous DC.  Proposal 3: For the case when BWP switching does not cause any interruption then the total BWP switching delay for one serving cell shall be the same as defined in section 8.6 of TS 38.133.  Proposal 4: For the case when BWP switching causes interruption, then the existing BWP switching delay defined in section 8.6 of TS 38.133 needs to be extended, in order to account for the interruption caused by the triggering of BWP switching on one or more CCs on the ongoing BWP switching on another CC.  Proposal 5: In proposal # 4, the total BWP switching delay for one serving cell can be expressed by:  Where:  : It is the total time to switch BWP on a serving cell.  : It is the BWP switching delay specified in section 8.6.2 for timer or DCI-based BWP switching, or in section 8.6.3 for RRC-based BWP switching.  : It is the interruption on a serving cell while switching its BWP due to the BWP switching on another *i*th serving cell. It is expressed in slots. CC where interruption occurs. The interruption defined in sections 8.2.2.2.5 for CA and 8.2.4.2.5 for NR-DC can be reused.  N (2 ≤ N≤ TBD): It is the maximum number of serving cells supported by the UE. |
| R4-2002047 | Nokia, Nokia Shanghai Bell | 1. For SA and NR-DC, interruption requirements in SA and NR-DC defined for single CC case can be reused for each BWP switch in multiple CC case. 2. In EN-DC and NE-DC, BWP switch on multiple carriers means that among the victim cells there are always both NR and E-UTRA cells, if the UE does not support per-FR gap or if the BWP switching involves SCS changing.   When the UE supports per-FR gap, the victim cells may also be only E-UTRA cells if other NR cells are on different FR than the aggressor cell.   1. For EN-DC and NE-DC, interruption requirements in EN-DC and NE-DC defined for single CC case can be reused for each BWP switch in multiple CC case, and the clarification has to be made in both TS 38.133 and TS 36.133. |
| R4-2002054 | Qualcomm Incorporated | Proposal 1: BWP switching delay for N cells would be *BWP switching delay 1 CC + D∗(N−1),* where D is 450us for Type1 and 1.5 ms for Type 2.  Proposal 2: For timer based simultaneous switch, same requirements as simultaneous DCI based switch to apply.  Proposal 3: For simultaneous BWP switch triggered via RRC, the delay would be composed of two components and , where remains the same as that for single CC and would scale with number of CC’s.  Proposal 4: For a timer based BWP switch on Cell2 when another timer based BWP switch is already ongoing on Cell1, the Cell2 timer based switch to start when the BWP switch on Cell1 is complete and the time for BWP switch on Cell 2 to be 450us for Type1 and 1.5 ms for Type 2 |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1: Simultaneous BWP switch on multiple CCs

*Sub-topic description: Requirements for simultaneous BWP switch on multiple CCs*

*Open issues and candidate options before e-meeting:*

**Issue 1-1-1: RRC based simultaneous triggering for NR-DC operation**

* Proposals
  + Option 1 (Intel, MediaTek, Apple, QC, Vivo, Ericsson, NEC, Nokia): Not considered
* Recommended WF
  + RRC based simultaneous triggering for BWP switch on multiple CCs for NR-DC operation is not considered

**Issue 1-1-2: Delay requirements for DCI/timer based BWP switch**

* Proposals
  + Option 1 (Intel): ; N: Number of CCs with simultaneous BWP switch; K: Number of CCs that can be processed simultaneously
    - Options 1-1
      * K=1 (Intel)
  + Option 2 (MediaTek, Qualcomm, Huawei, NEC, Vivo, Ericsson, Nokia): ; N: Number of CCs with simultaneous BWP switch
    - Options 2-1
      * D=250 us ()
      * D=100us for Type 1; 200 us for Type 2 (Huawei, MediaTek)
      * D = 450us for Type 1; 1.5ms for Type 2 (Qualcomm, Apple)
    - Options 2-2
      * K=1 (Huawei, Apple)
      * K=2 (MediaTek)
      * K=4 (NEC)
  + Option 3 (vivo) Ttotal = Tbaseband + D\*N
    - D = 500us for Type 2
    - N (BWP switchs within the same FR and need RF parameters updates: SCS, bandwidth, central frequency change etc.)
* Recommended WF
  + TBA

**Issue 1-1-3: Delay requirements for RRC based BWP switch**

* Proposals
  + Option 1a ( Intel, Vivo, Apple): ; N: Number of CCs with simultaneous BWP switch; K: Number of CCs that can be processed simultaneously
    - Options 1a-1
      * K=1 (Intel, Apple, Vivo)
  + Option 1b (NEC, Qualcomm, Nokia?) : ; D= BWP switching delay without processing delay of RRC
    - Options 1b-1
      * K=Based on UE capability discussion (NEC)
      * K=1 (QC)
  + Option 2 (Huawei, MTK): on each individual CC

Notes: If it is assumed that D = , Option 1a and 1b are the same.

* Recommended WF
  + ; K=1

**Issue 1-1-4: Interruption requirements for simultaneous BWP switch**

* Proposals

For interruption length

* + Option 1(Huawei, Nokia): Use same interruption requirements as single CC case on each CC
  + Option 2 (Vivo, Ericsson): Extend interruption compared to single CC case; Extension depends on number of CCs undergoing simultaneous BWP switch
  + Option 3a (Vivo): Interruption length is determined by smallest SCS among all CCs before and after BWP switch
  + Option 3b (Intel):
    - Option 3b-1
      * K=1 (Apple, Intel)

For interruption definition

* + Option 1 (MediaTek, Vivo): Consider interruption on each CC separately
* Recommended WF
  + Consider interruption on each CC separately

### Sub-topic 1-2: Partial overlap BWP switch on multiple CCs

*Sub-topic description : Requirements for partial overlap BWP switch on multiple CCs*

*Open issues and candidate options before e-meeting:*

**Issue 1-2-1: DCI based partial overlap BWP switch for NR-DC**

* Proposals
  + Option 1 (NEC, MTK, QC, Vivo): Not considered
  + Option 2 (Huawei, Ericsson, Intel, Nokia): Considered
* Recommended WF
  + TBA

**Issue 1-2-2: Conditions when requirements for partial overlap BWP switch are defined**

* Proposals
  + Option 1 (Vivo, Intel, Apple, MTK): When UE is capable of per FR gap and BWP switch is on different FR/When BWP switch on one CC doesn’t cause interruption on other CCs (with partial overlap BWP switch)
  + Option 2 (Ericsson, NEC): No restriction
* Recommended WF
  + When BWP switch on one CC doesn’t cause interruption on other CCs (with partial overlap BWP switch)

**Issue 1-2-3: Delay requirements for DCI/Timer/RRC based BWP switch**

* Proposals

Applicable to all types of switching

* + Option 1 (Intel): Same as single CC
  + Option 1a (Vivo): Same as simultaneously triggered on multiple BWPs if the trigger on a group of CCs is simultaneous
  + Option 2 (MediaTek, Apple): UE processes BWP switch sequentially on each CC
  + Option 3 (Ericsson, Nokia):

: It is the total time to switch BWP on a serving cell.

: It is the BWP switching delay specified in section 8.6.2 for timer or DCI-based BWP switching, or in section 8.6.3 for RRC-based BWP switching.

: It is the interruption on a serving cell while switching its BWP due to the BWP switching on another *i*th serving cell. It is expressed in slots. CC where interruption occurs. The interruption defined in sections 8.2.2.2.5 for CA and 8.2.4.2.5 for NR-DC can be reused.

N (2 ≤ N≤ TBD): It is the maximum number of serving cells supported by the UE.

DCI Based

* + Option 1 (Huawei): For NR-DC Where ­ is the total BWP switching delay of a CC; is the existing delay requirements for BWP switching on a single CC. N is the total number of the non-simultaneous DCI-based BWP switching processes in different CG which overlap with . D is the incremental delay which is same as the simultaneous case.

Timer based

* + Option 1 (Huawei):  Where ­ is the total BWP switching delay of a CC; is the time delayed by ongoing timer-based BWP switching with in the same frequency range. is the existing delay requirements for BWP switching on a single CC. N is the total number of the non-simultaneous timer-based BWP switching processes in different frequency range which overlap with . D is the incremental delay which is same as the simultaneous case.
  + Option 2 (NEC): M× BWP switch delay on multiple CC (simultaneous) + M × Interruption due to each BWP switch
  + Option 3 (Qualcomm): when another timer based BWP switch is already ongoing on Cell1, the Cell2 timer based switch to start when the BWP switch on Cell1 is complete and the time for BWP switch on Cell 2 to be 450us for Type1 and 1.5 ms for Type 2

RRC based

* + Option 1 (NEC): Same as simultaneous trigger on multiple CCs
  + Option 2 (Huawei): Same as single CC when multiple CCs are triggered by 1 RRC command in each CG for NR-DC
* Recommended WF

**Issue 1-2-4: Interruption requirements for partial overlap BWP switch**

* Proposals
  + Option 1 (Intel, Huawei, MTK, Ericsson, Nokia): Same as single CC, considered on each CC separately
  + Option 1a (Vivo): Same as simultaneously triggered on multiple BWPs if the trigger on a group of CCs is simultaneous
  + Option 1b (Vivo): considered on each CC separately
  + Option 1c (QC): separate interruptions due to each CC
  + Option 2 (Apple): Considered on each CC separately, total interruption could be up to N\* Tinterrption\_single\_CC
* Recommended WF
  + Same as single CC, considered on each CC separately

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Sub topic 1-1:  Issue 1-1-1: we are also fine with option 1.  Issue 1-1-2: Support Qualcomm proposal on D value since SW processing needs to be considered as well. We support K=1 with the worst case for UE implementation.  Issue 1-1-3: In the worst case we assume D = , and we support Option 1a with K=1.  Issue 1-1-4: UE may have different timing to adjust the RF, and therefore we support to consider interruption on each CC separately, and therefore the total interruption in worst case is Option 3B with K=1.  Sub topic 1-2:  Issue 1-2-2: Agree with Intel and Vivo  Issue 1-2-3: Since the processing capability is UE implementation and the requirement shall be defined based on the worst case, so we support MediaTek proposal of “UE processes BWP switch sequentially on each CC”.  Issue 1-2-4: we agree to consider on each CC separately and the total interruption during multiple BWP switching could be up to N\*Tinterrption\_single\_CC |
| QC | Sub topic 1-1:  Issue 1-1-1:  We are fine with not defining requirements for NR-DC simultaneous switch.  Issue 1-1-2  We obviously support our proposal.  Issue 1-1-3:  We would agree with K=1 in this case too.  Issue 1-1-4:  Interruptions happened when UE switches its RF. Since that may happen at different points for different CC’s there would need to be different interruptions.  Sub topic 1-2:  Issue 1-2-1:  Agree with NEC on Option 1. Non-simultaneous DCI is precluded by RAN1.  Text from 38. 213 “A UE does not expect to detect a DCI format 1\_1 indicating an active DL BWP change or a DCI format 0\_1 indicating an active UL BWP change for a scheduled cell within FR1 (or FR2) in a slot other than the first slot of a set of slots for the DL SCS of the scheduling cell that overlaps with a time duration where the UE is not required to receive or transmit for an active BWP change in a different cell from the scheduled cell within FR1 (or FR2).”  Issue 1-2-2:  Precluded by RAN1  Issue 1-2-3:  There are three cases for which we need to define requirements   1. Simultaneous DCI: Delay discussed in Issue 1-1-2 2. Timer based: Simultaneous would be the same as simultaneous DCI. Partial would be done sequentially 3. RRC based: Single command in a CG, follows the same timeline as single CC.   Issue 1-2-4:  Separate interruptions due to each CC  --02/27/2020  *Issue 1-1-2*  *For K we support option 2: K =1*  Issue 1-1-3  *WE don’t quite understand the options. Or at least ours isn’t captured correctly. We think for RRC based switching in EN-DC and NR SA we shold have the same timeline as in single CC case. No relaxation is needed.* |
| Mediatek | **Issue 1-1-1: RRC based simultaneous triggering for NR-DC operation**:  Support Option 1  It is not always guaranteed that the PHY, MAC and RRC processing of 2 CGs can be finished at the same time for a UE operating in DC. Simultaneous RRC triggering does not make sense to UE.  **Issue 1-1-2: Delay requirements for DCI/timer based BWP switch**  Support Option 2  Huawei’s proposal is also agreeable to us. One minor comment is that it will be better to have D equals a multiple of the slot duration of 120KHz SCS. If so, the spec can be even simpler and clearer. Since simultaneous BWP switch on multiple CC is one key feature for FR2 power saving, it is desired to finish this as early as possible. D ≥ 250us with K=1 (or other equivalent/longer proposals) is not desirable.  **Issue 1-1-3: Delay requirements for RRC based BWP switch**  Support Huawei’s proposal <Option 2>.  We removed ourselves from Option 1b (with track change)  **Issue 1-1-4: Interruption requirements for simultaneous BWP switch**  Support Option 1 for interruption length and interruption definition  The interruption duration on multiple CC caused by 1 CC should be the same Rel-15. When considering multiple CCs, each CC should be allow to cause independent and separated interruptions. In other words, the interruptions caused by multiple CCs can be fully, partially, or fully non-overlapped in time domain.  **Issue 1-2-1: DCI based partial overlap BWP switch for NR-DC**  Support Option 1 for same FR and Option 2 for cross FR  Since RAN1 spec is generic and NR-DC has already been introduced in Rel-15, we believe that RAN1 spec already covers NR-DC. Following RAN1 spec, UE does not expect DCI-based BWP requests during BWP switch on another CC in the same FR. RAN4 can consider to send an LS to RAN1 for confirmation.  **Issue 1-2-2: Conditions when requirements for partial overlap BWP switch are defined**  Support Option 1  There should be no problem on this agreed Rel-15 principle.  **Issue 1-2-3: Delay requirements for DCI/Timer/RRC based BWP switch**  We need to discuss this issue for DCI, Timer and RRC cases separately.   * For timer, we should follow RAN1 spec that UE will postpone the BWP switch which comes late. We believe that network doesn’t really have to care about the switch delay here because there is no data transmission to this UE. * For RRC, as we commented in Issue 1-1-1, UE processing for 2 CGs are independent. Therefore, it is not guaranteed that only extending the delay by the interruption duration could be feasible. * For DCI, Ericsson’s proposal (Option 3) could be the starting point. But we need more time to check.   **Issue 1-2-4: Interruption requirements for partial overlap BWP switch**  Support Option 1  Same comment as Issue 1-1-4 |
| Intel | Sub-topic 1-1: Simultaneous BWP switch on multiple CCs  Issue 1-1-2: K=1 assuming worst case UE implementation  Issue 1-1-3: K=1 assuming worst case UE implementation  Issue 1-1-4: Consider interruption on each CC separately. Option 3b with k=1  Sub-topic 1-2: Partial overlap BWP switch on multiple CCs  Issue 1-2-1: Option 2 as RAN1 spec doesn’t preclude the condition if condition in Issue 1-2-2 is agreeable  Issue 1-2-2: If proposal is agreeable, we have permitted combinations of partial overlap switch only for FR1+FR2 for NR-DC and NR-CA.  Issue 1-2-3: BWP switching delay is same as single CC on each of the CCs with partial overlap switch. If condition in issue 1-2-2 is agreeable, then UE might not need sequential processing  Issue 1-2-4: Interruption on each CC separately, due to each BWP switch |
| vivo | Sub topic 1-1:  Issue 1-1-1: we are ok with the recommended WF.  Issue 1-1-2: We support option 3, solutions based on principles of option 2 is also ok for us.  Issue 1-1-3: We agree with the recommended WF.  Issue 1-1-4: We can consider interruption on each CC separately if this procedure will help to work out the total interruption time in the end.  Sub topic 1-2:  Issue 1-2-1: Agree with NEC on option 1.  Issue 1-2-2: support recommended WF,  Issue 1-2-3: We think this item is related to Issue 1-2-2 and the discussion on this item could be more clear after we get a conclusion on Issue 1-2-2.  Issue 1-2-4: “considering on each cc separately” could be considered firstly. |
| Ericsson | **Issue 1-1-1**: Agree with Option 1 (i.e., do not consider RRC-based simultaneous triggering for NR-DC)  **Issue 1-1-2**: Preference for Option 2, but also need to consider impact of CCs with mixed numerologies. The interpretation of TBWPswitchDelay is unclear in mixed numerologies – this needs to be addressed. We also first need to sort out what capabilities can be expected by the UE in terms of D and K.  **Issue 1-1-3**: The net switching delay for RRC-based switching (i.e. after RRC processing delay) is already 6ms, and using K=1 would mean that another 6ms is added per additional CC for which BWP is changed. This seems a bit much unless there is a good technical justification.  **Issue 1-1-4**: **Interruption length:** Support Option 2. Radio reconfigurations shall be bundled to minimize impact on carriers for which BWP change is not triggered. The length of the interruption may increase (e.g. in the order of ~100us) for each additional carrier that is reconfigured. **Interruption definition:** Do not agree with Option 1 (Consider interruption on each CC separately) as the consequence may be scattered interruptions that negatively impact CCs for which BWP change is not triggered.  **Issue 1-2-1:** Support Option 2 (consider partial overlap of DCI-based triggering for NR-DC).  **Issue 1-2-2:** The proposal would mean that requirements are excluded for UEs with per-UE gap capability when operating in NR-DC. We think this may be too limiting.  **Issue 1-2-3:** **All types of switching**, Option 3 (Ericsson), is preferred.  **Issue 1-2-4:** Option 1 is acceptable (separate interruptions on CCs at partial overlap BWP switching). Also consider the case of mixed numerology (different SCS on different CCs involved in BWP switching). To minimize interruption the UE shall trigger the BWP switching on a CC at slot boundary of the other CC with the smallest SCS where there is an ongoing BWP switching for CA and synchronous DC. |
| Huawei, HiSilicon | Issue 1-1-1:  We have concerns about the WF. Does it means when the RRC commands are received in difference CGs in NR-DC, they are treated as non-simultaneous switching?  Issue 1-1-2:  Option 2.  K=1, D = 200us for type 1, D = 200us for type 2.  For the simultaneous BWP switching, there are some processes could be conducted in parallel and only the parts in sequential should be considered as the additional delay compared with the switching delay on single CC. It is more reasonable to consider the additional delay per CC even the UE is capable of parallel processing. Because the implementations are different among companies, it may be difficult for define the exact number of CCs could be processed simultaneously (K in the formula). And also, when define a large K, e.g. K=4, it means the simultaneous BWP switching on 1 to 4 CCs have the same delay requirements. So based on our understanding, the additional delay per CC (K = 1) should be considered and scaled by the number of CCs.  Issue 1-1-3:  Option 2  For the RRC based BWP switching, it seems to be a common understanding that the time for RRC process should not be extended. The legacy delay requirements for BWP switching TBWPswitchDelayRRC  is 6 ms which is much more than the requirements for DCI and timer based BWP switching. So there is no need to further extend the delay for BWP switching on multiple CCs.  Issue 1-1-4:  Option 1  Though the some processes (RF retuning, DSP etc.) can be scheduled for multiple CCs, it still hard to specify the interruptions for each CC because it difficult to locate the exact location of the interruption. So it is more reasonable to define the interruption on each CC separately. The interruption should be the same as the single CC BWP switching, and the starting time of the interruption is only allowed within the extended switching delay.  Issue 1-2-1:  Option 2.  Per the agreement in the last meeting, the DCI based partial overlapping switching will not be considered for CA case. According to the description in TS 38.213, it could only happened in NR-DC case where within the BWP switching delay on a CC, there are BWP switching on a CC in different frequency range or simultaneous BWP switching on multiple CCs in different frequency range. From our standing, the requirement for this case should be defined.  Issue 1-2-2:  With respect to the interruption for the UE supporting per-FR gap, the requirements should be consistent with the existing requirements for single CC BWP switching.  Issue 1-2-3:  DCI: Option 1 with minor modification  As mentioned in our comments to Issue 1-2-1, in NR-DC case, the BWP (simultaneous) switching on CCs in different frequency range that overlaps with the switching times of the target CC shall be considered as partial overlapping switching. The delay shall be extended as the simultaneous case, where the total delay is extended by adding the additional delay per CC and scaled by the number of CCs. Considered the realistic implementation, the scalar (number of CCs) could be further limited to CCs in different CG and frequency range.  Timer: Option 1 with minor modification  Per RAN1 description, for both CA and DC case, the timer-based BWP switching on multiple CCs won’t partially overlaps within the same frequency range. Compared with the single CC delay, it should be extended with 2 parts. The delay caused by the ongoing switching in the same frequency range; otherwise, this part is 0. The second part is the additional delay as in the simultaneous case, where the scalar should be the timer-based BWP switching in different CCs.  RRC: Option2 (the option 1 and option 2 are actually the same if the Option 2 in the Issue 1-3-3 are adopted)  As mentioned in our comment to Issue 1-1-3, the requirements for partial overlapping switching is the same as simultaneous case.  Issue 1-2-4:  Option 1  For the interruption requirements, it should be considered on each CC separately in the same way in our comments for Issue 1-1-4. |
| NEC | Sub topic 1-1:  Issue 1-1-1: we are ok with Option 1.  Issue 1-1-2: Considering multiple formulas/options on the table, we think we should finalize on the formula first. In the next round we can discuss D and K based on expected UE parallel processing capabilities (agree with Ericsson).  Issue 1-1-3: K value needs to be decided based on UE capability discussion.  Sub topic 1-2:  Issue 1-2-1: We support option 1.  Issue 1-2-2: we think it is too limiting. In NR-DC, when there is no co-ordination between CGs, it is still possible. Only issue may be UE may not receive BWP switch command as interruption may occur at any time during BWP switching delay. However, if UE can receive BWP switch request, then it should be supported.  Issue 1-2-3: since it may depend on the decision of previous issues, we can discuss after decision on other issues. |
| Nokia | Issue 1-1-1: We are fine with option 1, RRC based simultaneous triggering for BWP switch on multiple CCs for NR-DC operation is not considered  Issue 1-1-2: This is simultaneous, even though UE may have limitation on processing on the same time, current requirement for single CC can be applied. For the sake of progress, option2 is acceptable and need to figure out what D and K will be.  Issue 1-1-3: Same comment as 1-1-2.  Issue 1-1-4: We have proposal but not captured in the summary. The interruption requirements defined for single CC case can be reused for each BWP switch in multiple CC case.  Issue 1-2-1: we are fine with option 2.  Issue 1-2-3: all types switching can share the same rule, and we support option 3 from Ericsson.  Issue 1-2-4: We have proposal but not captured in the summary. The interruption requirements defined for single CC case can be reused for each BWP switch in multiple CC case. |

### CRs/TPs comments collection

*Major close-to-finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic 1-1: Simultaneous BWP switch on multiple CCs** | Issue 1-1-1: RRC based simultaneous triggering for NR-DC operation  *Tentative agreements: RRC based simultaneous triggering for BWP switch on multiple CCs for NR-DC operation is not considered*  Issue 1-1-2: Delay requirements for DCI/timer based BWP switch  *Tentative agreements:; N: Number of CCs with simultaneous BWP switch; K is number of CCs that can be processed simultaneously; D is incremental delay for BWP switch processing on additional CCs*  The above tentative agreement is based on majority view from companies  *Recommendations for 2nd round: Agree on formula and discuss options for D and K*   * Options for D   + D=100us for Type 1; 200 us for Type 2 (Huawei, MediaTek)   + D = 450us for Type 1; 1.5ms for Type 2 (Qualcomm, Apple) * Options for K   + K=1 (Huawei, Apple, Intel, QC)   + K=2 (MediaTek)   + K=4 (NEC)   Issue 1-1-3: Delay requirements for RRC based BWP switch  *Candidate options:*   * Option 1a ( Intel, Vivo, Apple): ; N: Number of CCs with simultaneous BWP switch; K: Number of CCs that can be processed simultaneously   + Options 1a-1     - K=1 (Intel, Apple, Vivo) * Option 1b (NEC, Qualcomm, Nokia?) : ; D= BWP switching delay without processing delay of RRC   + Options 1b-1     - K=Based on UE capability discussion (NEC)     - K=1 (QC) * Option 2 (Huawei, MTK): on each individual CC   *Recommendations for 2nd round:* Can we have either 1a or 1b moving forward? Discuss the options  Issue 1-1-4: Interruption requirements for simultaneous BWP switch  For interruption definition  *Tentative agreements: Consider interruption on each CC separately*  Interruption length  *Candidate options:*   * Option 1(Huawei, Nokia): Use same interruption requirements as single CC case on each CC * Option 2 (Vivo, Ericsson): Extend interruption compared to single CC case; Extension depends on number of CCs undergoing simultaneous BWP switch * Option 3a (Vivo): Interruption length is determined by smallest SCS among all CCs before and after BWP switch * Option 3b (Intel):   + Option 3b-1     - K=1 (Apple, Intel)   *Recommendations for 2nd round: Discuss options further* |
| **Sub-topic 1-2: Partial overlap BWP switch on multiple CCs** | Issue 1-2-1: DCI based partial overlap BWP switch for NR-DC  *Candidate options:*   * Option 1 (NEC, QC, Vivo): Not considered * Option 2 (Huawei, Ericsson, Intel, Nokia, MTK): Considered   *Recommendations for 2nd round: Discuss options further. To clarify NR-DC is for FR1+Fr2 and NOT same FR. Can proponents of Option 1 agree with option 2 given the clarification?*  Issue 1-2-2: Conditions when requirements for partial overlap BWP switch are defined  *Candidate options:*   * Option 1 (Vivo, Intel, Apple, MTK): When UE is capable of per FR gap and BWP switch is on different FR/When BWP switch on one CC doesn’t cause interruption on other CCs (with partial overlap BWP switch) * Option 2 (Ericsson, NEC): No restriction   *Recommendations for 2nd round: Can the proponents of Option 2 provide additional comments on why option 1 is not agreeable. How can DCI or RRC command for BWP switch be guaranteed to be decoded on CC2 while BWP switch on CC1 causes interruption on CC2*  Issue 1-2-3: Delay requirements for DCI/Timer/RRC based BWP switch  *Candidate options:*  DCI Based: Depends on outcome of Issue 1-2-1, 1-2-2  RRC Based: Depends on outcome of Issue 1-2-2  Timer Based: Depends on outcome of Issue 1-2-2  *Recommendations for 2nd round: Discuss after Issue 1-2-1, 1-2-2 have agreement*  Issue 1-2-4: Interruption requirements for partial overlap BWP switch  *Tentative agreements:* *Same as single CC, considered on each CC separately*  The above tentative agreement is based on majority view from companies |

*Recommendations on WF/LS assignment*

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| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 | Way forward on BWP switching on multiple CCs | Intel |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

### Sub-topic 1-1: Simultaneous BWP switch on multiple CCs

**Issue 1-1-2: Delay requirements for DCI/timer based BWP switch**

Delay for DCI/timer based BWP switch is ; N: Number of CCs with simultaneous BWP switch; K is number of CCs that can be processed simultaneously; D is incremental delay for BWP switch processing on additional CCs

*Candidate options:*

* Options for D
  + D=100us for Type 1; 200 us for Type 2 (Huawei, MediaTek)
  + D = 450us for Type 1; 1.5ms for Type 2 (Qualcomm, Apple)
* Options for K
  + K=1 (Huawei, Apple, Intel, QC)
  + K=2 (MediaTek)
  + K=4 (NEC)

*Recommendations for 2nd round: Discuss options for D and K*

**Issue 1-1-3: Delay requirements for RRC based BWP switch**

*Candidate options:*

* Option 1a ( Intel, Vivo, Apple): ; N: Number of CCs with simultaneous BWP switch; K: Number of CCs that can be processed simultaneously
  + Options 1a-1
    - K=1 (Intel, Apple, Vivo)
* Option 1b (NEC, Qualcomm, Nokia?) : ; D= BWP switching delay without processing delay of RRC
  + Options 1b-1
    - K=Based on UE capability discussion (NEC)
    - K=1 (QC)
* Option 2 (Huawei, MTK): on each individual CC

*Recommendations for 2nd round:* Can we have either 1a or 1b moving forward? Discuss the options

**Issue 1-1-4: Interruption requirements for simultaneous BWP switch**

Interruption length

*Candidate options:*

* Option 1(Huawei, Nokia): Use same interruption requirements as single CC case on each CC
* Option 2 (Vivo, Ericsson): Extend interruption compared to single CC case; Extension depends on number of CCs undergoing simultaneous BWP switch
* Option 3a (Vivo): Interruption length is determined by smallest SCS among all CCs before and after BWP switch
* Option 3b (Intel):
  + Option 3b-1
    - K=1 (Apple, Intel)

*Recommendations for 2nd round: Discuss options further*

### Sub-topic 1-2: Partial overlap BWP switch on multiple CCs

**Issue 1-2-1: DCI based partial overlap BWP switch for NR-DC**

*Candidate options:*

* Option 1 (NEC, QC, Vivo): Not considered
* Option 2 (Huawei, Ericsson, Intel, Nokia, MTK): Considered

*Recommendations for 2nd round: Discuss options further. To clarify NR-DC is for FR1+Fr2 and NOT same FR. Can proponents of Option 1 agree with option 2 given the clarification?*

**Issue 1-2-2: Conditions when requirements for partial overlap BWP switch are defined**

*Candidate options:*

* Option 1 (Vivo, Intel, Apple, MTK): When UE is capable of per FR gap and BWP switch is on different FR/When BWP switch on one CC doesn’t cause interruption on other CCs (with partial overlap BWP switch)
* Option 2 (Ericsson, NEC): No restriction

*Recommendations for 2nd round: Can the proponents of Option 2 provide additional comments on why option 1 is not agreeable. How can DCI or RRC command for BWP switch be guaranteed to be decoded on CC2 while BWP switch on CC1 causes interruption on CC2*

**Issue 1-2-3: Delay requirements for DCI/Timer/RRC based BWP switch**

*Candidate options:*

DCI Based: Depends on outcome of Issue 1-2-1, 1-2-2

RRC Based: Depends on outcome of Issue 1-2-2

Timer Based: Depends on outcome of Issue 1-2-2

*Recommendations for 2nd round: Discuss after Issue 1-2-1, 1-2-2 have agreement*

## Companies views’ collection for 2nd round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | Sub-topic 1-1: Simultaneous BWP switch on multiple CCs  Issue 1-1-2:  This may need more analysis. We can keep the two options in WF and down select in next meeting. Issue 1-1-3:  We would be fine with Option 1a too esp. with K=1. To HW/MTK, can you elaborate the difference between your proposal and Option1a with K=1?  Issue 1-1-4:  Need a bit more clarification on Option1, does this mean each CC that is undergoing a BWP switch gets an independent interruption. Eor example, if there are two CC’s underdoing BWP switch there would be two interruptions where each interruption length is as defined in Rel-15. If so, then we can support option 1. Else, we would need that option too. We believe that was what we mentioned in our comments in round 1 and so did MTK.  Sub-topic 1-2: Partial overlap BWP switch on multiple CCs  Issue 1-2-1 and Issue 1-2-2:  Due to interruption from one BWP switch on other CC’s and the fact that BWP switch times are small, there is a strong chance that BWP switch command is not received due to interruption if they are not simultaneous. We would prefer not defining requirements for cases which may not normally happen. We are willing to compromise to define requirements only for UE’s that support pre-FR gap.  Issue 1-2-3: |
| vivo | Sub-topic 1-1: Simultaneous BWP switch on multiple CCs  Issue 1-1-2:  For this issue, we think parts which can processed parallelly are mainly absorbed into TBWPSwitchDelay and the second term of the formula focuses on parts which cannot be processed parallelly. Hence we support K=1. The value of D need more study, maybe firstly try to define the D for type 2.  Issue 1-1-3:  We support option 1. Particularly we support k= 1.  Issue 1-1-4:  We support option 2 and 3a.  Issue 1-2-1 and Issue 1-2-2:  We think that DCI or timer based partial overlap BWP switch over multiple CCs, within one particular FR, should not be considered and RAN4 needs not define requirements on these items.  On the other hand if DCI/timer based partial overlap BWP switch happens at different RF, it can be considered.  We support option 1 for 1-2-1 and option 1 for 1-2-2  Issue 1-2-3:  Depends on conclusion of 1-2-1 and 1-2-2. |
| Intel | Sub-topic 1-1: Simultaneous BWP switch on multiple CCs  Issue 1-1-2: We think Option 2 for D is more reasonable, especially for Type 2; We don’t think option for D=200 us for Type 2 UE is reasonable. We tentatively support D = 450us for Type 1; 1.5ms for Type 2, but need to further check  Issue 1-1-3: We still support option1a. For option 2 we don’t think its possible for all UE to process BWP switching on all CCs simultaneous within  Issue 1-1-4: We support option 3b with K=1. A CC may be allowed interruption by BWP switching on up to N CCs, hence the interruption length should scale based on the number of CCs with simultaneous BWP switch  Sub-topic 1-2: Partial overlap BWP switch on multiple CCs  Issue 1-2-1: Option 2. NR-DC is only for FR1+FR2 in Rel-15, hence we propose to consider DCI based partial overlap BWP switch for NR-DC.  Issue 1-2-2: Option 1. Question to Ericsson and NEC - How can DCI or RRC command for BWP switch be guaranteed to be decoded on CC2 while BWP switch on CC1 causes interruption on CC2. Just extending the delay requirement by interruption length wouldn’t suffice as the command might not have been decoded in the first place. Hence, we believe we should have the restriction proposed in option 1.  Issue 1-2-3: To be discussed when there is conclusion on Issue 1-2-1, 1-2-2 |
| Huawei, HiSilicon | Issue 1-1-2  As mentioned in the 1st round, we support option D = 100 us for type 1 UE and 20 us for type 2 UE and K=1  Issue 1-1-3  For option3, we think the BWP switching delay should reuse the delay requirement for the switching on single CC, which means no extension is needed.  Issue 1-1-4  For option1, the interruption should be considered separately on each CC. In details, the length of the interruption is the as single CC BWP switching and the starting time of interruption is allowed within the switching delay.  Issue 1-2-1 and Issue 1-2-2  According to RAN1 description, for DCI-based and RRC-based BWP switching, we support that the requirement should be defined for per-FR gap supported UE only. But the description of Option 1 needs further clarification. For the case where there are m simultaneous BWP switchings on FR1 and n simultaneous BWP switchings in FR2, and there are partially overlapped, is it the case should be excluded or not?  For timer-based partial overlapping BWP switching, We don’t think it needs to be limited to per-FR gap supported only. |
| MTK | **Issue 1-1-2: Delay requirements for DCI/timer based BWP switch**  Option 1 is more reasonable, especially in FR2 when 8 CCs have to switch the BWP at the same time for the best power saving gain. D=1.5ms will result in more than 10ms switch time for 8 CCs. This prohibits network to enable simultaneous BWP switch on multiple CCs and eventually UE losses the power saving opportunity.  **Issue 1-1-3: Delay requirements for RRC based BWP switch**  Option 2. No extension due to multiple CCs  In our view extra 6ms is already sufficient for UE to switch the BWP ON 8CCs. We are open to the case when more CCs are considered. But again, we do not think it is good to see that 8CCs will require 10+6\*8 = 58ms to finish the RRC processing  **Issue 1-1-4: Interruption requirements for simultaneous BWP switch**  Option 1  The root cause for interruption is exactly the same as single CC case. Therefore the interruption duration should also be the same. The overall interruption is the time union of the interruption caused by individual CCs.. On this issue we think QC, HW and MTK are aligned.   * In the worst case, Option 1 becomes Option 3b because we already agreed to consider the interruption caused by different CCs separately. So in our view, option 1 already covers Option 3b   **Issue 1-2-1: DCI based partial overlap BWP switch for NR-DC**  If the concern from companies is about the chance that UE may miss the DCI due to interruption caused by other CC, we can add a condition that the requirement is only applicable if UE has already successfully decoded the DCI on multiple CCs. Then if the DCI is interrupted, we do not have requirement for the interrupted one.  **Issue 1-2-2: Conditions when requirements for partial overlap BWP switch are defined**  Option 1.  This is what we already did for Rel-15  **Issue 1-2-3: Delay requirements for DCI/Timer/RRC based BWP switch**  OK to moderator’s Recommendations |
| Ericsson | **Issue 1-1-2:** We agree that some additional time is needed when multiple carriers are reconfigured. If looking at the RF reconfiguration alone, some 100-125us may be needed per carrier. On top of this there may be additional CPU processing time for each additional carrier. However, reasonable numbers are in our view closer to the D = 100us than to D = 450us for a type1 UE. We assume K = 1.  **Issue 1-1-3:** We support Option 2 (HW, MTK). There is already 6ms net switching time for RRC based switching of single carrier – we think this should be enough also when multiple carriers are switched.  **Issue 1-1-4:** Our preference here is Option 2, but it very much depends on what assumptions we make for e.g. **Issue 1-1-2.** If we end up with something that essentially looks like sequential BWP switching with recurrent interruptions, then there is little point in extending the duration of each individual interruption. Option 2 is based on that radio reconfigurations are bundled into a single activity.  **Issue 1-2-1:** We support Option 2, i.e., consider partially overlapping DCI-triggered BWP switching for NR-DC  **Issue 1-2-2:** For DCI-based triggering, at least when UE has per-FR gap capability. For timer-based triggering both for per-UE and per-FR capable UE. |

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #2: UL Spatial Relation Info Switching

In RAN#86 the WID for NR RRM enhancement in R16 was updated to include spatial relation info switch for uplink. The Core part objective was updated to include:

* Introduce the delay requirements for spatial relation switch for uplink channels and SRS

RAN4#94e is the first meeting for discussion on this topic.

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2000373 | Intel Corporation | Observation #1: The spatial relation info for SRS, PUCCH or PUSCH could be associated with a DL RS – SS/PBCH or CSI-RS or with a UL RS – an SRS  Observation #2: The network could configure the spatial relation info for SRS using RRC or MAC CE, for PUCCH using RRC or MAC CE and for PUSCH using DCI  Observation #3: The network could indicate a spatial relation switch to the UE by MAC-CE (for PUCCH and SP-SRS) or via RRC reconfiguration – for SRS or PUCCH configured with only 1 resource spatialRelationInfoToAddModList.  Observation #4: The TCI state of the DL RS associated with spatial relation info should be known to the UE in order to transmit SRS or PUCCH or PUSCH with the configured TX beam  Proposal #1: When UL transmission is configured with spatial relation info associated with DL RS and the TCI state of the DL RS is unknown, the UE shall (1) drop UL transmission until TCI state is known or (2) use best known beam or (3) use arbitrary beam for UL transmission  Observation #5: The spatial relation info switching delay for UL transmission associated with DL RS would depend DL command decoding time and UE processing time  Proposal #2: The UE shall select arbitrary TX beam for UL transmission if the TX beam for SRS associated with spatial relation info is not known.  Observation #5: The spatial relation info switching delay for UL transmission associated with SRS would depend DL command decoding time  Observation #6: For SP-SRS MAC CE is configuring the spatial relation info rather than switching. For PUCCH MAC CE could switch the spatial relation info  Proposal #3: Define MAC CE based spatial relation switch requirements for PUCCH  Observation #7: MAC CE based spatial relation switch requirements could be defined like MAC CE based TCI state switching requirements when spatial relation info is associated with DL RS  Proposal #4: MAC CE based spatial relation info switching delay when associated with DL RS is defined as: THARQ +3ms for known TCI state ; THARQ + 3ms + TL1-RSRP for unknown TCI state  Proposal #5: MAC CE based spatial relation info switching delay when associated with SRS is defined as: THARQ +3ms  Proposal #6: No requirements are defined for RRC based spatial relation info switching |
| R4-2001036 | MediaTek inc. | Observation 1: When active spatial relation is configured to switch to a SRS, it means after some QCLed links, the spatial relation shall be QCLed with SRS with its usage configured as ‘beamManagement’.  Observation 2: The spatial relation of PUSCH will follow PUCCH when configured by DCI format 0\_0 or follow SRS when configured by DCI format 0\_1.  Observation 3: The time interval between DCI command and aperiodic SRS transmission is very short and hasn’t considered the additional beam sweeping time in RAN1 specification.  Proposal 1: When active spatial relation is configured to switch to a DL RS, the known and unknown condition shall be defined.  Proposal 2: When active spatial relation is configured to switch to a DL RS, Rx beam sweeping shall be also considered in unknown condition.  Proposal 3: For unknown spatial relation switch, UE is allowed to transmit signals with previous spatial domain transmission filter during the Rx beam training phase.  Proposal 4: When active spatial relation is configured to switch to a SRS, the UE will directly follow the same beam with this uplink SRS without the differentiation between known and unknown condition.  Proposal 5: RAN4 shall define the MAC based active spatial relation switch for PUCCH.  Proposal 6: For PUSCH spatial relation switch RAN4 either does not define the requirement or directly refers to the requirements for SRS and PUCCH.  Proposal 7: RAN4 shall define   * the RRC based active spatial relation switch for periodic SRS. * the MAC based active spatial relation switch for semi-persistent SRS. * the DCI based active spatial relation switch for aperiodic SRS.   Proposal 8: If the SRS-SpatialRelationInfo is configured as srs, the spatial relation switch is always in known condition.  Proposal 9: When network configures the periodic/semi-persistent SRS transmission and the SRS-SpatialRelationInfo with DL RS, both known and unknown requirement shall be defined.  Proposal 10: Only define the delay requirement of aperiodic SRS spatial relation switch in known condition. |
| R4-2001667 | Huawei, HiSilicon | Proposal 1: The MAC-CE based PUCCH spatial relation switching delay can be specified as below,   * If the spatial relation associated downlink RS is known and the fine timing of the downlink RS is acquired or the associated RS is SRS, upon receiving MAC-CE activation command indicating a value of pucch-SpatialRelationInfoId in slot n, UE shall be able to transmit a PUCCH with target spatial relation no later than in slot n+ THARQ +3 ms/ NR slot length. * If the spatial relation associated downlink RS is unknown, there is no requirement.   Downlink known condition refers to section 8.10(active TCI state switching delay).  Proposal 2: No requirements are defined for PUCCH spatial relation switching if UE is not provided PUCCH-SpatialRelationInfo.  Proposal 3: There is no need to define the PUSCH spatial relation switching requirement.  Proposal 4: Aperiodic SRS spatial relation switching delay is specified in RAN1 and no unknown case is considered.  Proposal 5: Periodic SRS spatial relation switching delay is specified as below,   * When the spatial relation associated RS is SSB/CSI-RS, if the associated DL RS is known and the fine timing of the downlink RS is acquired, the periodic SRS spatial relation switching delay is TRRC\_processing, otherwise no requirements are specified. * When the spatial relation associated RS is SRS, the spatial relation switching delay is TRRC\_processing.   Proposal 6: Semi-persisitent SRS spatial relation switching delay can be specified as below,   * If the spatial relation associated downlink RS is known and the fine timing of the downlink RS is acquired or the associated RS is SRS, upon receiving MAC-CE command indicating triggering a new semi-persistent SRS in slot n, UE shall be able to transmit semi-persistent SRS with target spatial relation no later than in slot n+ THARQ +3 ms/ NR slot length. * If the spatial relation associated downlink RS is unknown, there is no requirement.   Downlink known condition refers to section 8.10(active TCI state switching delay). |
| R4-2002060 | Qualcomm Incorporated | Proposal 1: RAN4 to define requirements for spatial relation switch for PUCCH, PUSCH and SRS.  Proposal 2: RAN4 to prioritize defining requirements for the case where the spatial relation is QCL’d to (or the QCL chain contains) SSB or CSI-RS.  Proposal 3: Re-use the known state definition for TCI state for known spatial relation.  Proposal 4: RAN4 to define requirements for PUCCH spatial relation switch via MAC-CE. The PDCCH TCI switch timeline to be used as baseline.  Proposal 5: For PUSCH spatial relation switch, no new requirements need to be defined. RAN4 to refer to RAN1 requirements.  Proposal 6: RAN4 to define requirements for RRC based switch for P SRS and MAC based activation for SP SRS. |
| R4-2002088 | Ericsson | Proposal 1: Introduce spatial relation switching delay requirement for RRC-based reconfiguration of the spatial relation for a single active SRS resource.  Proposal 2: Introduce the following spatial relation switching delay requirements for PUCCH:  RRC-based reconfiguration of a single spatial relation for PUCCH  MAC-based switching of spatial relation for PUCCH  Proposal 3: No spatial relation switching delay requirements are introduced for PUSCH, as delays would be secondary effects from switching of spatial relation for SRS resource or PUCCH.  Proposal 4: Use requirements for MAC-CE based TCI state switch delay (TS 38.133 clause 8.10.3) as starting point for delay requirements for MAC-CE-based switching to spatial relations with DL reference signal (SSB or CSI-RS). Address known/unknown condition. Address assumptions on whether DL reference signal needs to be part of tracked TCI state list for PDSCH. For MAC-CE based switching to spatial relation with UL reference signal (SRS), refer to RAN1 requirement.  Proposal 5: Use requirements for RRC-based TCI state switch delay (TS 38.133 clause 8.10.5) as starting point for delay requirements for RRC-based switching of single active spatial relation. Address known/unknown condition for the case of DL reference signal (SSB, CSI-RS). Address assumptions on whether DL reference signal needs to be part of tracked TCI state list for PDSCH. |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 2-1 : MAC CE based spatial relation info switch

*Sub-topic description: Requirements for MAC CE based spatial relation switch for DL-RS and SRS*

*Open issues and candidate options before e-meeting:*

**Issue 2-1-1: Applicability of MAC CE based spatial relation info switching delay**

* Proposals
  + Option 1 (Intel, Apple, QC, Samsung): PUCCH
  + Option 2 (MediaTek, Huawei, Ericsson): PUCCH, SP-SRS
* Recommended WF

**Issue 2-1-2: MAC CE based spatial relation info switching associated with DL-RS**

* Proposals

For known TCI state

* + Option 1 (Intel, Ericsson?): THARQ +3ms
  + Option 1A (Huawei): THARQ +3ms, if the fine timing of the downlink RS is acquired. Otherwise, no requirement.
  + Option 2 (Qualcomm, ~~Ericsson~~, DCM, Samsung, Apple, MTK): THARQ +3ms + time for time tracking if applicable

For unknown TCI state

* + Option 1 (Intel, Ericsson?): THARQ + 3ms + TL1-RSRP
  + Option 2 (Qualcomm, ~~Ericsson,~~ DCM, Apple, ~~MTK~~): THARQ + 3ms + TL1-RSRP + time for time tracking if applicable
  + Option 3 (Huawei, Samsung, MTK): No requirement
* Recommended WF

**Issue 2-1-3: MAC CE based spatial relation info switching associated with SRS**

* Proposals
  + Option 1 (Intel, Apple, DCM, MTK): THARQ +3ms
  + Option 2 (Qualcomm, Huawei, Samsung): Deprioritize
  + Option 3 (Ericsson, Samsung): Refer to RAN1 requirement
* Recommended WF
  + Define MAC CE based spatial relation info switching delay associated with SRS as THARQ +3ms

### Sub-topic 2-2: RRC based spatial relation info switch

*Sub-topic description: Requirements for RRC based spatial relation switch for DL-RS and SRS*

*Open issues and candidate options before e-meeting:*

**Issue 2-2-1: Applicability of RRC based spatial relation info switching delay**

* Proposals
  + Option 1 (Qualcomm, Huawei, MediaTek, Apple, Ericsson, Huawei, DCM): P-SRS
  + Option 2 (): PUCCH
  + Option 3 (Intel): PUCCH and P-SRS
* Recommended WF
  + RRC based spatial relation info switch requirements are defined for P-SRS

**Issue 2-2-2: RRC based spatial relation info switching associated with DL-RS**

* Proposals

For known TCI state

* + Option 1 (~~Ericsson~~, Apple, QC, MTK, DCM): Define delay based on RRC based TCI state switching requirements
  + Option 2 (Huawei, Ericsson): TRRCprocessing (timing is acquired)
  + Option 3 (Intel): No requirements

For unknown TCI state

* + Option 1 (~~Ericsson~~, MTK, DCM): Define delay based on RRC based TCI state switching requirements
  + Option 1a (Intel, Ericsson): TRRCprocessing + TL1-RSRP
  + Option 2 (Huawei, Apple, QC, MTK): No requirements
* Recommended WF

**Issue 2-2-3: RRC based spatial relation info switching associated with SRS**

* Proposals
  + Option 1 ( MTK, Ericsson): TRRCprocessing
  + Option 2 (Intel, Apple, Huawei, QC): No requirements
* Recommended WF

### Sub-topic 2-3: DCI based spatial relation info switch

*Sub-topic description: Requirements for DCI based spatial relation switch*

*Open issues and candidate options before e-meeting:*

**Issue 2-3-1: Applicability of DCI based spatial relation info switching delay**

* Proposals
  + Option 1 (MediaTek, DCM, Ericsson, QC, Apple): A-SRS
* Recommended WF
  + DCI based spatial relation info switch requirements are defined for A-SRS

**Issue 2-3-2: DCI based spatial relation info switching**

* Proposals

For known TCI state for DL RS /SRS

* + Option 1 (MediaTek, Huawei, Samsung, DCM, HW, Ericsson, QC, Apple): Refer to RAN1 requirement

For unknown TCI state for DL RS

* + Option 1 (MediaTek, Huawei, Samsung, DCM, HW, Ericsson, QC, Apple): No requirements
* Recommended WF
  + For DCI based spatial relation info switch: No requirements for unknown TCI state; refer to RAN1 requirement for known TCI state

### Sub-topic 2-4: General

*Sub-topic description: Requirements for DCI based spatial relation switch*

*Open issues and candidate options before e-meeting:*

**Issue 2-4-1: Spatial relation info switching for PUSCH**

* Proposals
  + Option 1 (Most companies): No requirements
* Recommended WF
  + No requirements are defined for spatial relation info switching for PUSCH

**Issue 2-4-2: When PUCCH-SpatialRelationInfo is not configured**

* Proposals
  + Option 1 (Huawei, Apple, QC, Intel, MTK, Ericsson): No requirements
* Recommended WF
  + No requirements are defined for spatial relation info switching for PUCCH when PUCCH-SpatialRelationInfo is not configured

**Issue 2-4-3: When configured spatial relation info is unknown**

* Proposals
  + Option 1 (Intel): UE transmits with previous TX beam/ arbitrary beam
* Recommended WF
  + The UE shall select arbitrary or previous TX beam for UL transmission if the TX beam for SRS associated with spatial relation info is not known or TCI state of DL-RS is unknown

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Sub topic 2-1:  Issue 2-1-1: MAC CE based SP-SRS activation is like a SP-SRS activation rather than a spatial relation change, so we may only focus on the MAC CE based spatial relation change for PUCCH. Support option 1.  Issue 2-1-2: for known case, we also think it’s necessary to consider fine time tracking for UE to switch to apply the target spatial relation for UL transmission, support option 2.  Issue 2-1-2: for unknown case, if the DL-RS is available for L1-RSRP for Rx beam refinement and the TCI of L1-RSRP RS is known to UE, we agree with option 2. Otherwise, we suggest to not define the requirement.  Issue 2-1-3: fine with Option 1.  Sub topic 2-2:  Issue 2-2-1: support option 1.  Issue 2-2-2: For known case, we think this requirement could be similar as RRC based TCI switching, but the condition of TOk shall be changed, here we may assume TOk is always as 1 for the worst case. For unknown case, we don’t understand the use case and motivation of network, so we prefer option 2.  Issue 2-2-3: fine with option 2.  Sub topic 2-3:  Issue 2-3-1: either no requirement or option 1 is fine to us, because DCI based A-SRS transmission is mostly like a SRS transmission triggering activity rather than a spatial relation change.  Issue 2-3-2: agree with the recommended WF.  Sub topic 2-4:  Issue 2-4-1: agree with the recommended WF.  Issue 2-4-2: agree with the recommended WF.  Issue 2-4-3: For SRS if the spatial relation info is unknown, we need to further consider more options before making the decision, e.g. using the last available spatial relation for SRS or the PL-RS TCI could be used for SRS transmission in this case.  For PUCCH, UE will keep using the last spatial relation before the delay of the PUCCH spatial relation change. |
| QC | Sub topic 2-1:  Issue 2-1-1:  We are fine with defining requirements only for PUCCH too and down prioritize SP\_SRS  Issue 2-1-2:  Issue 2-1-3:  Our preference here is to down-prioritize. If we do want to define these requirements, we need a new definition of known/unknown and need to consider UL beam sweeping.  Sub topic 2-2:  Issue 2-2-1:  Issue 2-2-2:  Can be similar to RRC based TCI state switching. Exact numbers may need more work. Agree to formulate the same way.  Issue 2-2-3:  Don’t define requirements.  Sub topic 2-3:  Issue 2-3-1:  Either no requirements or refer to RAN1  Issue 2-3-2:  No requirement or refer to RAN1  Sub topic 2-4:  Issue 2-4-1:  No requirements  Issue 2-4-2:  No requirements  Issue 2-4-3:  This should be an error case where UE behavior is undefined.  -- 02/27/2020  Issue 2-1-2:  Just to be clear RAN1 specification says the UE to switch to new beam at Tharq+3ms. The question here should be more when is the UE performance on the new beam guaranteed. So our position is a bit more subtle than just supporting Option 2. The beam switch needs to follow RAN1 specification on THarq + 3ms as indicated in option 1. However, the UE performance as in the case of TCI state switch we will need one more SSB. |
| Mediatek | **Issue 2-1-1:**  Option 2.  The spatial relation of SP SRS is also activated by MAC CE. There is no reason not to define SP SRS requirement.  **Issue 2-1-2:**  For known TCI state   * Option 2. We don’t see any difference with TCI state processing flow when spatial relation is QCLed with DL RS. UE still need fine timing tracking time.   For unknown TCI state   * Option 2. We don’t see any difference with TCI state processing flow when spatial relation is QCLed with DL RS, but we’re also fine with option 3.   **Issue 2-1-3:**   * Option 1. It should clarify that associated to SRS means the source QCL of spatial relation is SRS.   **Issue 2-2-1:**   * Option 1.   **Issue 2-2-2:**  For known TCI state,   * We don’t see any difference with TCI state processing flow when spatial relation is QCLed with DL RS. UE still need fine timing tracking time. It should be TRRC\_processing +TOk\*(Tfirst-SSB + TSSB-proc).   For unknown TCI state, we think firstly we should agree whether to define unknown requirement. If yes, we don’t see any difference with TCI state processing flow when spatial relation is QCLed with DL RS.  **Issue 2-2-3:**   * Option 1.   **Issue 2-3-1:**   * Option 1. Similar as DL PDSCH, we can define the requirement for A-SRS followed with RAN1 spec and only in known scenario.   **Issue 2-3-2:**   * Agree with the potential WF. For DCI based spatial relation info switch: No requirements for unknown TCI state; refer to RAN1 requirement for known TCI state.   **Issue 2-4-1:**   * Agree   **Issue 2-4-2:**   * Agree   **Issue 2-4-3:**  As discussed in our paper, we think UE should transmit with previous TX beam when UE doesn’t finish the active spatial relation switching because this is the only beam both UE and network know. |
| Intel | Sub-topic 2-1 : MAC CE based spatial relation info switch  Issue 2-1-2: Do we need to consider time for fine time tracking of Dl-RS for UL spatial relation info switch?  Sub-topic 2-2: RRC based spatial relation info switch  Issue 2-2-1: RRC based - applicable to both PUCCH and P-SRS  Issue 2-2-2: For RRC based switching, the delay is RRC processing time plus additional time for RX beam sweeping if applicable. The additional time for RX beam sweep is needed for unknow TCI state for DL-RS. Defining requirements would be useful only for unknown TCI state for DL-RS  Sub-topic 2-3: DCI based spatial relation info switch  Issue 2-3-1: For DCI activation of A-SRS, there is no spatial relation info switch, just configuration. RAN4 should not define requirements for this case  Sub-topic 2-4: General  Issue 2-4-1: Agree with recommended WF Issue 2-4-2: Agree with recommended WF  Issue 2-4-3: The issue is for configured spatial relation info, not spatial info switch. Should RAN4 define some UE behavior? |
| Ericsson | **Issue 2-1-1:** Support Option 2.  **Issue 2-1-2:** Use corresponding TCI requirements as starting point for discussions. Additional time tracking may be further discussed since the DL-RS in this context is only source for spatial transmission filter and not for timing.  **Issue 2-1-3:** Current RAN1 requirement in 38.213, clause 9.2.2, 2nd paragraph already specifies when actions shall have been taken by the UE in response to a MAC-CE that selects the new SR for PUCCH. When the reference is SRS, there is little more for the UE to do than to switch to the corresponding spatial transmission filter. We do not strongly oppose repeating the same requirement in the RAN4 specification but would like to see some justification.  **Issue 2-2-1:** OK with Option 1. This does however mean that we do not consider a case where a single active SR for PUCCH is reconfigured. For TCI state activation, we have such requirement for PDCCH.  **Issue 2-2-2:** Use corresponding TCI requirements as starting point for discussions. Additional time tracking may be further discussed since in this context DL-RS is only source for spatial transmission filter and not for timing.  **Issue 2-2-3:** OK with Option 1.  **Issue 2-3-1:** Support the WF proposed by moderator.  **Issue 2-3-2:** Support the WF proposed by moderator.  **Issue 2-4-1:** Support Option 1 (No requirements for SR switching for PUSCH)  **Issue 2-4-2:** Support Option 1 (No requirements when PUCCH-SpatialRelationInfo is not configured)  **Issue 2-4-3:** We think some more discussions may be needed. We agree with previous TX beam, but not necessarily with arbitrary TX beam. |
| Huawei, HiSilicon | **Sub-topic 2-1**  Issue 2-1-1: SP-SRS UL spatial relation changed when MAC CE activated a new SP-SRS. So option 2 makes sense.  Issue 2-1-2: Firstly we agree the DL fine timing shall be acquired before transmitting uplink. So to some extent option 1A in known case is like option2. The difference is we think the DL timing shall be in the active TCI list, it means that the DL timing is maintained already. If the DL timing is unknown, UE needs additional time for DL timing tracking, the UL transmission is not timely (at least shall wait for one SMTC and plus UE processing time). In other words, the known definition of uplink spatial relation shall add one condition: DL TCI state is in the active TCI state list. We suggest no requirements are specified for the case that DL timing is not maintained.  In unknown TCI state, UE shall perform DL RX beam identification and then DL timing tracking, more time will cost. So we suggest no requirements are specified for this case, i.e., option 3.  Issue 2-1-3: option 2.  Sub-topic 2-2  Issue 2-2-1: recommended WF is agreeable.  Issue 2-2-2: option 2. For known case, we think the precondition shall be that the DL timing is maintained. In other words, the known definition of uplink spatial relation shall add one condition: DL TCI state is in the active TCI state list.  Issue 2-2-3: we can compromise that deprioritize the case.  Sub-topic 2-3  Issue 2-3-1: Besides A-SRS, PUSCH transmission(s) can be dynamically scheduled by an UL grant in a DCI.  Issue 2-3-2: the recommended WF is agreeable.  Sub-topic 2-4  Issue 2-4-1, issue 2-4-2: the recommended WF is agreeable.  issue 2-4-3: it is up to UE implementation. No spec impact. |
| MTK | We think there are following common issues need to be further discussion.   1. Whether to add fine timing tracking in the procedure when spatial relation is QCLed to a DL RS   Some companies think the DL-RS is only use for the source of spatial relation filter, but we have already agreed that the uplink timing adjustment is based on DL timing. Obviously, when UL spatial relation is QCLed to one DL RS, the timing for uplink shall adjust based on that DL RS. In TCI state configuration, there are two QCL types. QCL Type 1 is related to timing, frequency. If QCL Type 1 of the new associated DL RS TCI state is changed, we need the fine timing tracking.   1. Whether to define the requirement when spatial relation is associated with a SRS   From our understanding, if we define the requirement, we still don’t need to discuss known and unknown for UL Tx beam sweeping. It shall believe that if the network configure a new SRS index, it means network has the confidence to indicate UE to switch to the new SRS direction. Then UE just follows this SRS. If this SRS don’t have the ‘beamManagement’ configuration, there is no requirement.  But we’re fine to deprioritize this scenario.   1. Whether to define the requirement for SP-SRS   We think the MAC-based SP-SRS activation is an implicitly spatial relation switch. The network can utilize the MAC-EC to active another SP-SRS to change the spatial relation. Thus, we suggest also to define these implicitly spatial relation switch.   1. Whether to define RRC-based PUCCH spatial relation switch   Since RAN1 spec. already captured this scenario, we slightly agree on defining the requirement for this scenario.   1. How to handle the Tx transmission when spatial relation switching hasn’t finish?   The scenario happens when the UL signal has spatial relation to an unknown TCI-state. Our proposal is UE should transmit with previous TX beam before UE acquires the required Rx beam direction and timing for reception because this previous TX beam is the only beam both UE and network know |
| NTT DOCOMO, INC. | Issue 2-1-1: First of all it should be clarified that whether source RS for spatial relation info of SP SRS is unknown or not. If there is no case that the source RS for spatial relation info of SP SRS is unknown, we support option 1 because existing RAN1 spec can be enough. Otherwise we support option 2. Although SP SRS Activation/Deactivation MAC CE only switches SP SRS resource, UE has to switch spatial filter if the spatial relation info for previous SRS resource and that of new SRS resource are different.  Issue 2-1-2: Support option 2 both known/unknown case.  Issue 2-1-3: Support option 1.  Issue 2-2-1: Support option 1.  Issue 2-2-2: Support option 1 both known/unknown case.  Issue 2-3-1: Support the recommended WF.  Issue 2-3-2: Support the recommended WF.  Issue 2-4-1: Support the recommended WF.  Issue 2-4-2: Support the recommended WF.  Issue 2-4-3: We would like to exclude arbitrary TX beam case because it may cause unexpected UL interference. |
| Samsung | General comment on UL spatial relation info switching:   1. The wording “UL channel QCL’ed to SRS/DL-RS” should be avoided to be used, which is not accurate wording. 2. UE to use same spatial filter as DL RS is conceptual, however from RAN4 perspective, the performance will finally be validated by certain UE TX performance, like UE’s transmission toward certain direction same as DL RS. Considering UE beam book design is UE implementation issue, the requirement defined here is hard to be converted to test case, especially considering the following testability issues:    1. Testability of UE’s choice on certain TX beam is not studied in either Rel-15/Rel-16 testability WI; The most comparable item could be beam correspondence in which the beam correspondence tolerance test is still based on self-to-self comparison between EIRP with SRS beam sweeping assisted and EIRP without. Here we can see the straightforward method to judge UE has choose “proper” TX beam.    2. Another issue is at least for Rel-15 UE, it is allowed for certain UE rely on SRS beam sweeping to achieve beam correspondence (bit-0 UE in TS38.101-2). For this kind of UE, beam sweeping is always needed for BC performance (and also EIRP spherical coverage performance). For this kind of UE, a command (RRC, MAC or DCI) for update its certain UL channel’s SR to a DL-RS is doable, but performance is further relaxed, which gives additional difficulty in testability.    3. Of course the above analysis is only based on RAN4’s final target is to define test requirement and test case in which UE’s behaviour or performance can be validated, rather than requirement not testable. 3. UE to use same spatial filter as another SRS: the testability issue could be smaller in this cases, however, the necessity of RAN4 requirement for validating UE’s behaviour of using the same spatial filter as another SRS is not significant, as mentioned below and also by some other companies.   Sub-topic 2-1: MAC CE based spatial relation info switch  Issue 2-1-1: Option 1 (Only focusing on PUCCH is preferable due to similar behaviour expected)  Issue 2-1-2: Know TCI state Option 2; Unknown TCI state Option 3;  Issue 2-1-3: Option 2 or 3 (We don’t observe the difficulty why UE has difficult to update spatial relation with SRS, since we don’t believe the difficulty comes from MAC CE decoding or applying TX filtering.)  Sub-topic 2-2: RRC based spatial relation info switch  Sub-topic 2-3: DCI based spatial relation info switch  Issue 2-3-1: No requirement, or refer to RAN1 spec  Issue 2-3-2: No requirement, or refer to RAN1 spec  Sub-topic 2-4: General  Issue 2-4-1: Agree with Moderator’s proposed WF;  Issue 2-4-2: Agree with Moderator’s proposed WF;  Issue 2-4-3: UE behaviour shall not be specified for the period until TCI state becomes known. Specifying UE behaviour to previous TX beam could be problematic if UE has better beam management than standard required, and we expect no issue if UE’s behaviour is not specified in this transition period under this network configuration. |

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic 2-1 : MAC CE based spatial relation info switch** | **Issue 2-1-1: Applicability of MAC CE based spatial relation info switching delay**  *Candidate options:*   * Option 1 (Intel, Apple, QC, Samsung, DCM): PUCCH * Option 2 (MediaTek, Huawei, Ericsson, DCM): PUCCH, SP-SRS   *Recommendations for 2nd round: For the sake of progress could the proponents of Option 1 agree to option 2?*  **Issue 2-1-2: MAC CE based spatial relation info switching associated with DL-RS**  *Candidate options:*  For known TCI state   * + Option 1 (Intel, Ericsson?): THARQ +3ms   + Option 1A (Huawei): THARQ +3ms, if the fine timing of the downlink RS is acquired. Otherwise, no requirement.   + Option 2 (Qualcomm, ~~Ericsson~~, DCM, Samsung, Apple, MTK): THARQ +3ms + time for time tracking if applicable   For unknown TCI state   * + Option 1 (Intel, Ericsson?): THARQ + 3ms + TL1-RSRP   + Option 2 (Qualcomm, ~~Ericsson,~~ DCM, Apple, ~~MTK~~): THARQ + 3ms + TL1-RSRP + time for time tracking if applicable   + Option 3 (Huawei, Samsung, MTK): No requirement   *Recommendations for 2nd round: Need to discuss further the necessity for fine timing for UL spatial relation switch.*  **Issue 2-1-3: MAC CE based spatial relation info switching associated with SRS**  *Candidate options:*   * Option 1 (Intel, Apple, DCM, MTK): THARQ +3ms * Option 2 (Qualcomm, Huawei, Samsung): Deprioritize * Option 3 (Ericsson, Samsung): Refer to RAN1 requirement   *Recommendations for 2nd round: Option 1 and option 3 are the same. Is there a point for RAN4 to define requirement that is same as RAN1? Can proponents of options 1,3 agree to de-prioritize/ no requirements?* |
| **Sub-topic 2-2: RRC based spatial relation info switch** | **Issue 2-2-1: Applicability of RRC based spatial relation info switching delay**  *Tentative agreements:* *RRC based spatial relation info switch requirements are defined for P-SRS*  The above tentative agreement is based on majority view  **Issue 2-2-2: RRC based spatial relation info switching associated with DL-RS**  *Candidate options:*  For known TCI state   * + Option 1 (~~Ericsson~~, Apple, QC, MTK, DCM): Define delay based on RRC based TCI state switching requirements   + Option 2a (Huawei): TRRCprocessing (timing is acquired)   + Option 2b (Ericsson): TRRCprocessing (timing is not required)   + Option 3 (Intel): No requirements   For unknown TCI state   * + Option 1 (~~Ericsson~~, MTK, DCM): Define delay based on RRC based TCI state switching requirements   + Option 1a (Intel, Ericsson): TRRCprocessing + TL1-RSRP   + Option 2 (Huawei, Apple, QC, MTK): No requirements   *Recommendations for 2nd round: Discuss need for fine timing for UL spatial relation switch.*  **Issue 2-2-3: RRC based spatial relation info switching associated with SRS**  *Candidate options:*   * + Option 1 (MTK, Ericsson): TRRCprocessing   + Option 2 (Intel, Apple, Huawei, QC): No requirements   *Recommendations for 2nd round: Can proponents of option 1 agree to deprioritize/ no requirements* |
| **Sub-topic 2-3: DCI based spatial relation info switch** | *Tentative agreements:* *DCI based spatial relation info switch requirements are defined for A-SRS. For DCI based spatial relation info switch no requirements for unknown TCI state; refer to RAN1 requirement for known TCI state* |
| **Sub-topic 2-4: General** | **Issue 2-4-1: Spatial relation info switching for PUSCH**  *Tentative agreements: No requirements are defined for spatial relation info switching for PUSCH.*  **Issue 2-4-2: When PUCCH-SpatialRelationInfo is not configured**  *Tentative agreements: No requirements are defined for spatial relation info switching for PUCCH when PUCCH-SpatialRelationInfo is not configured*  **Issue 2-4-3: When configured spatial relation info is unknown**  *Candidate options:*   * Option 1 (Intel): UE transmits with previous TX beam/ arbitrary beam * Option 1a (MTK, Apple, Ericsson, DCM): UE transmits using previous TX beam * Option 2 (HW): Up to UE implementation * Option 3 (Samsung): UE behaviour shall not be specified for the period until TCI state becomes known.   *Recommendations for 2nd round: Needs further discussion* |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 | Way forward on UL spatial relation info switching | MTK |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

### Sub-topic 2-1: MAC CE based spatial relation info switch

**Issue 2-1-1: Applicability of MAC CE based spatial relation info switching delay**

*Candidate options:*

* Option 1 (Intel, Apple, QC, Samsung, DCM): PUCCH
* Option 2 (MediaTek, Huawei, Ericsson, DCM): PUCCH, SP-SRS

*Recommendations for 2nd round: For the sake of progress could the proponents of Option 1 agree to option 2?*

**Issue 2-1-2: MAC CE based spatial relation info switching associated with DL-RS**

*Candidate options:*

For known TCI state

* + Option 1 (Intel, Ericsson?): THARQ +3ms
  + Option 1A (Huawei): THARQ +3ms, if the fine timing of the downlink RS is acquired. Otherwise, no requirement.
  + Option 2 (, ~~Ericsson~~, DCM, Samsung, Apple, MTK): THARQ +3ms + time for time tracking if applicable
  + Option 3(Qualcomm): UE to switch beams at THARQ + 3ms (RAN1 specification). Performance guaranteed (in terms of timing etc) after reception 1 SSB (similar to TCI state switching)

For unknown TCI state

* + Option 1 (Intel, Ericsson?): THARQ + 3ms + TL1-RSRP
  + Option 2 (Qualcomm, ~~Ericsson,~~ DCM, Apple, ~~MTK~~): THARQ + 3ms + TL1-RSRP + time for time tracking if applicable
  + Option 3 (Huawei, Samsung, MTK): No requirement

*Recommendations for 2nd round: Need to discuss further the necessity for fine timing for UL spatial relation switch.*

**Issue 2-1-3: MAC CE based spatial relation info switching associated with SRS**

*Candidate options:*

* Option 1 (Intel, Apple, DCM, MTK): THARQ +3ms
* Option 2 (Qualcomm, Huawei, Samsung): Deprioritize
* Option 3 (Ericsson, Samsung): Refer to RAN1 requirement

*Recommendations for 2nd round: Option 1 and option 3 are the same. Is there a point for RAN4 to define requirement that is same as RAN1? Can proponents of options 1,3 agree to de-prioritize/ no requirements?*

### Sub-topic 2-2: RRC based spatial relation info switch

**Issue 2-2-2: RRC based spatial relation info switching associated with DL-RS**

*Candidate options:*

For known TCI state

* + Option 1 (~~Ericsson~~, Apple, QC, MTK, DCM): Define delay based on RRC based TCI state switching requirements
  + Option 2a (Huawei): TRRCprocessing (timing is acquired)
  + Option 2b (Ericsson): TRRCprocessing (timing is not required)
  + Option 3 (Intel): No requirements

For unknown TCI state

* + Option 1 (~~Ericsson~~, MTK, DCM): Define delay based on RRC based TCI state switching requirements
  + Option 1a (Intel, Ericsson): TRRCprocessing + TL1-RSRP
  + Option 2 (Huawei, Apple, QC, MTK): No requirements

*Recommendations for 2nd round: Discuss need for fine timing for UL spatial relation switch.*

**Issue 2-2-3: RRC based spatial relation info switching associated with SRS**

*Candidate options:*

* + Option 1 (MTK, Ericsson): TRRCprocessing
  + Option 2 (Intel, Apple, Huawei, QC): No requirements

*Recommendations for 2nd round: Can proponents of option 1 agree to deprioritize/ no requirements*

### Sub-topic 2-4: General

**Issue 2-4-3: When configured spatial relation info is unknown**

*Candidate options:*

* Option 1 (Intel): UE transmits with previous TX beam/ arbitrary beam
* Option 1a (MTK, Apple, Ericsson, DCM): UE transmits using previous TX beam
* Option 2 (HW, QC): Up to UE implementation
* Option 3 (Samsung): UE behaviour shall not be specified for the period until TCI state becomes known.

*Recommendations for 2nd round: Needs further discussion*

## Companies views’ collection for 2nd round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | Sub-topic 2-1: MAC CE based spatial relation info switch  Issue 2-1-1:  We can start by defining requirement for PUCCH and leave SRS as FFSIssue 2-1-2:  Clarifying our position as was done at end of round 1  Just to be clear RAN1 specification says the UE to switch to new beam at Tharq+3ms. The question here should be more when is the UE performance on the new beam guaranteed. So our position is a bit more subtle than just supporting Option 2. The beam switch needs to follow RAN1 specification on THarq + 3ms as indicated in option 1. However, the UE performance as in the case of TCI state switch we will need one more SSB. Added option 3 above.  Issue 2-1-3:  Sub-topic 2-2: RRC based spatial relation info switch  Issue 2-2-2:  To HW/Ericsson, UL timing is dependent on UE having accurate DL timing. Can you explain the reasoning behind timing not required here?  Issue 2-2-3:  Sub-topic 2-4: General  Issue 2-4-3:  We think options 2 and 3 are similar. Can Samsung clarify that leaving it to UE implementation would suffice. We support not defining any requirements here and leaving it to UE implementation. Network shouldn’t really ever trigger a switch to a unknown state |
| Intel | Sub-topic 2-1: MAC CE based spatial relation info switch  Issue 2-1-1: Support option 2. The requirements will not be different for PUCCH and SP-SRS. So no additional work is needed to consider both  Issue 2-1-2: We still prefer option 1. Could companies clarify the necessity for DL fine timing for UL TX beam switch? If TX beam for one of the UL channels, say SRS in certain symbols changes, does the timing of full UL slot change  Issue 2-1-3: We are okay with de-prioritizing or not having requirements  Sub-topic 2-2: RRC based spatial relation info switch  Issue 2-2-2: Same as Issue 2-1-2 – need clarification and discussion as to why DL fine timing is needed for UL TX beam switch  Issue 2-2-3: We are fine with option 2 – to de-prioritize/ not define requirements  Sub-topic 2-4: General  Issue 2-4-3: We are fine with option 2 |
| Huawei, HiSilicon | Issue 2-1-1: Semi-persistent SRS is activated/deactivated by MAC CE. RAN1 has specified the applicable delay for SP-SRS in TS 38.214. RAN4 can refer RAN1’s requirements.  Issue 2-1-2:  For known TCI state: Support option1. The downlink timing can be unchanged when uplink spatial relation is switched.  For unknown TCI state support option 3. If the TCI state is unknown, UE shall perform DL RX beam identification and then DL timing tracking, more time will cost. This is more an expected configuration.  Issue 2-2-2: @ Qualcomm UL timing is dependent on UE having accurate DL timing, this is a fact. Herein we discuss the UL spatial relation switching. The DL timing can be unchanged (means the DL beam is not changed as well) when UE receives the indication of change the uplink spatial relation. So we doubt whether the DL fine timing acquirement time is needed.  For unknown TCI state we had the same view as issue 2-1-2.  Issue 2-2-3: option2.  Issue 2-4-3: option2. The spatial relation info is unknown is not a typical scenario. |
| Ericsson | **Issue 2-1-1:** We support Option 2.  **Issue 2-1-2:** For known TCI state: We support Option 1. The UL timing is depending on the DL timing, which in turn is associated with a TCI state. The spatial relation is only about the spatial transmission filter to use for uplink transmissions. Hence fine timing information should not be needed for the spatial relation. For unknown TCI state: We support Option 1. Beam sweeping may be needed when the spatial relation is depending on a DL RS that is yet to be detected.  **Issue 2-1-3:** We support Option 3. The time line is already clear in the RAN1 specification, and there is not much to do for the UE. This differs a bit from cases where DL RS is reference by which there are cases where the DL RS first needs to be detected by the UE.  **Issue 2-2-2:** For known TCI state, we support Option 2b. There is no need for fine timing for the spatial relation. UL timing is depending on DL timing for a configured TCI state. The spatial relation is just about which spatial transmission filter to use, and not about timing.  For unknown TCI state, we support Option 1a. Beam sweeping may be needed when the spatial relation is depending on a DL RS that is yet to be detected.  **Issue 2-2-3:** Option 1. But potentially we do not need an explicit requirement in the RAN4 specification for it. It should follow from RAN2 processing time for RRC reconfiguration.  **Issue 2-4-3:** Our preference is Option 1a. |
| NTT DOCOMO, INC. | Issue 2-1-1: Generally we supports Option 2, but agree with Huawei’s comment. The applicable delay for SP-SRS can be specified as refer to RAN1.  Issue 2-1-2: For known TCI state, according to current RAN4 spec, the fine timing is needed only if the target TCI state is not in the active TCI state list. Since this condition is not applicable for spatial relation info switching, we support Option 1.  Issue 2-1-3: Option 3 is fine. As mentioned in moderator’s recommendation, we think Option 1 and Option 3 are same.  Issue 2-2-2: We support Option 2b. Same stance as Issue 2-1-2.  Issue 2-2-3: We support Option 1  Issue 2-4-3: We support Option 1a. It’s difficult to manage NW if other option is employed due to the unexpected UE behaviour. |

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #3: Non-simultaneous UL carrier operation in FR2

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2002163 | Apple | **Observation 1: BWP switching framework is more efficient in terms of switching delay. However the feasible is subject to further study.**  **Observation 2: SCell activation framework should be feasible to enable NSU. The related activation/deactivation delay should be further investigated.**  **Observation 3: SCell configuration framework will result in long switching delay to make NSU less efficient in terms of switching delay. However, compared to Alt. 2, Alt. 3 can be more power efficient.**  As a result, it is proposed that  **Proposal: RRM related work should be kicked off to investigate**   * **the feasibility of extending BWP switching framework to NSU** * **the SCell activation framework based NSU switching delay and how to fit it into NSU time frame.** |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 3-1 : RRM plan

*Sub-topic description: Requirements for MAC CE based spatial relation switch for DL-RS and SRS*

*Open issues and candidate options before e-meeting:*

**Issue 3-1-1: RRM plan**

* Proposals
  + Option 1 (Apple):

RRM related work should be kicked off to investigate

* + - the feasibility of extending BWP switching framework to NSU
    - the SCell activation framework based NSU switching delay and how to fit it into NSU time frame.
* Recommended WF

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Mediatek | Sub topic 3-1:          Whether BWP switch framework can be used should involve RAN1 discussion. Based on Rel-15 BWP framework, BWP switch is always within one CC, rather than switch across CCs.                         It is unclear to us on the definition of NSU time frame. |
| Intel | Sub topic 3-1:  No agreement in RF session on whether this is supported. Hence we need to postpone the discussion |
| Ericsson | **Issue 3-1-1:** According to our understanding, extending the BWP switching framework or the SCell activation framework to NSU requires RAN1 and RAN2 specification changes. It thus should be handled in RAN1 and RAN2 first before we start related RRM work. To minimize RAN1/RAN2 impact our preference is to use RRC based reconfiguration of UL CC, which is similar to reconfiguration of any carrier and it does not need any new RRM requirements. |
| Huawei, HiSilicon | The benefits and feasibility of Non-simultaneous UL carrier operation are still under discussion in RF room, and also the switching mechanism. Hence the we should postpone the RRM discussion. |
| Nokia | Issue 3-1-1: RF session is still ongoing and have no agreement yet. RRM session should wait until RF session has decision. |
| Samsung | Similar to Ericsson, don’t prefer the mechanism with RAN1/2 impact such as extending BWP switching framework to NSU; however if PCell/PSCell is not involved, SCell activation framework should also have no impact on RAN1/2. |

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic# 3-1** | **Issue 3-1-1: RRM plan**  *Candidate options:*   * Option 1 (Intel, HW, Nokia): RRM requirements can be discussed after RF room has conclusion on the topic * Option 2 (MTK, Ericsson, Samsung): Don’t extend BWP switching framework or SCell activation as it impacts RAN1/2   *Tentative agreement: RRM requirements can be discussed after RF session has conclusion on the topic. RAN1/2 input could be considered based on RF session agreement* |

*Suggestion on WF/LS assignment*

|  |  |  |
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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |