**3GPP TSG-RAN WG1 Meeting #104-e R1-210xxxx**

**e-Meeting, Jan 25th – Feb 5th, 2021**

**Agenda Item: 5**

**Source: Moderator (ZTE)**

**Title: Summary on the physical layer aspects of small data transmission**

**Document for: Discussion**

# Introduction

This document contains the summary of issues related to the Rel-17 physical layer aspects of small data transmission for the following email discussion.

* [104-e-AI5-LS-03] Email discussion regarding LS in R1-2100025 including a potential reply LS till 2/3

The issues were triggered by the following LS from RAN2 [1]

|  |
| --- |
| **Actions:**  **To RAN1 group.**  **ACTION:** RAN2 respectfully requests RAN1 to take the above into account and provide input for:   * Configuration of the coreset and search space for monitoring the PDCCH addressed to the C-RNTI after successful completion of the RACH procedure during RA-SDT. * Configuration of association between the type 1 CG resource(s) for CG-SDT and SSB(s)   For CG resource(s), the following agreement have been achieved in RAN2:   * The configuration of configured grant resource for UE uplink small data transfer is contained in the RRCRelease message. Configuration is only type 1 CG with no contention resolution procedure for CG. * The configuration of configured grant resource can include one type 1 CG configuration. * The configuration of configured grant resource for UE small data transmission is valid only in the same serving cell. * The UE can use configured grant based small data transfer if at least the following criteria is fulfilled (1) user data is smaller than the data volume threshold; (2) configured grant resource is configured and valid; (3) UE has valid TA. FFS for the candidate beam criteria. * From RAN2 point of view: An association between CG resources and SSBs is required for CG-based SDT. FFS up to RAN1 how the association is configured or provided to the UE. Send an LS to RAN1 to start the discussion on how the association can be made. Mention that one option RAN2 considered was explicit configuration with RRC Release message * A SS-RSRP threshold is configured for SSB selection. UE selects one of the SSB with SS-RSRP above the threshold and selects the associated CG resource for UL data transmission. * When UE is in RRC\_INACTIVE, it should be possible to send multiple UL and DL packets as part of the same SDT mechanism and without transitioning to RRC\_CONNECTED on dedicated grant. |

The moderator suggests to have a three-stage discussion in this meeting:

* Phase 1 (1.25~1.27): first round discussion, collecting companies’ initial views
* Phase 2 (1.27~2.1): second round discussion, trying to reach some consensus
* Phase 3 (2.1~2.3): LS drafting based on the consensus

# Configuration of the CORESET and search space for monitoring the PDCCH addressed to the C-RNTI after successful completion of the RACH procedure during RA-SDT

Both UE-specific and common CORESET/Searchspace are mentioned in the submitted TDocs. Some companies think UE-specific configuration can provide more flexibility, while some other companies are concerned about the necessity and specification efforts. Regarding the common CORESET/Searchspace, some companies proposed to use type-1 CSS and CORESET 0 as baseline, since those configurations are available during the random access, while some other companies believe it is beneficial to configure a new common CORESET and/or CSS to avoid the potential overloading.

## SearchSpace

### First round

The following options can be found in the TDocs submitted to this meeting.

Option 1: Common SearchSpace

Option 1.1: reuse the type-1 PDCCH CSS configured by *ra-SearchSpace*

Option 1.2: reuse the type-3 PDCCH CSS

Option 1.3: a new CSS configured from system information or RRC release

Option 2: UE-specific SearchSpace

Option 2.1: configured from RRC Release message

Option 2.2: configured from Msg4/MsgB

**Discussion point 2.1**

Any preference on the listed options, and is there any other option not listed here?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | Option 2 is preferred.  It’s pretty clear that the option 2 can have the full flexibility compared to option 1, and in this case, the signaling overhead is not an issue. For CG-SDT, RAN2 already considers to have SS/CORESET configuration in RRC release messages. Besides, if gNB wishes, it can configure the same SS/CORESET for different UEs, or even same for the CSS. |
| Apple | Option 2 is preferred.  Re-use common search space could increase the PDCCH blocking rate, thus the legacy UE performance would be impacted. |
| CATT | We support Option 1.3. New PDCCH CSS is used for scheduling small data transmission after successful completion of the RACH procedure during RA-SDT in order to reduce type1 PDCCH blocking rate random access of normal UE. CCE mapping position of each PDCCH candidate in the new PDCCH SS is determined according to the hash function with C-RNTI for randomization similar with CCE index determination of USS in order to reduce the PDCCH scheduling blockage rate between small data UEs  Compared with option 2, new special CSS method by broadcasting message can reduce resource and signaling overhead of the separate PDCCH SS by dedicated signaling message. |
| Intel | We support both Option 1.1 and option 2.1. It is clear that USS can be more flexible in terms of scheduling and reducing blocking among different UEs in RA-SDT procedure. Meanwhile, we also need to consider some default configuration for search space, in case when USS is not configured. In this case, our view is that Type 1 CSS should be natural way as it is already provided for RAR monitoring and can be straightforwardly extended for scheduling DL/UL data packet.  As for configuration from RRC release message or Msg4/MsgB, it can be similar to CG-SDT, where CG resource is configured via RRC release message. Note that it is more appropriate for RAN2 to make decision for this, rather than RAN1. |
| LG | We support Option 1.1, 1.2 and 2.1. gNB can determine which option is applied to SDT by configuration. |
| Huawei, HiSi | Option 1.3 is preferred. Option 2.1 is also acceptable if USS configured in RRC Release message is used only in serving cell.  For Option 1.1 and 1.2, reusing the type-1/type-3 PDCCH CSS may increase the PDCCH blocking and impact the legacy UE.  The sub-bullets of Option 2 require more RAN2 work first. For example, for Option 2.1, if UE moves to the neighbor cell, the dedicated configuration needs to be contained in the UE context and interchanged in the Xn-AP. For Option 2.2, RAN2 should first decide which RRC signaling is used in Msg4/MsgB of RA-SDT. If no proper RRC signaling can be used, the Option 2.2 is not feasible. |
| Nokia, NSB | Our proposal was Option 1.1, but if there are concerns on the loading, we can consider Option 1.2 and 1.3. Using USS has an issue when the UE is moving to a neighbor cell and is a decision that RAN1 should avoid if a CSS solution is feasible. |
| Qualcomm | Depending on the tradeoff of signaling overhead, scheduling flexibility and system loading, we think the following options can be further considered:   * Option 1.1 * Option 1.3 * Option 2.1 |
| Ericsson | In our view, Type-1 can be at least used as default search space set (option 1.1) which is already available for Msg2/Msg4/MsgB PDCCH monitoring in RACH based SDT.  Furthermore, for flexibility, and to reuse some other search space already defined in RRC connected state, an optional search space ID configuration in the RRC release message may be needed or it’s up to RAN2 to decide whether a new search space and CORESET can be defined in RRC release message. |
| InterDigital | We support Option 1.1 and 2.1. In general we agree with Intel’s views. If USS is available then the UE should prioritize it. The USS can be signaled in the RRC release message along with the CG configuration. If UE is not configured with an USS, the UE can use the default type 1 CSS. |
| vivo | We think both option 1 and option 2 can be adopted. For option 1, at least option 1.1 with Type-1 search space sets should be supported for RA-SDT, since PDCCH monitoring behavior for DCI format 0\_0/1\_0 with C-RNTI in the Type-1 CSS is already supported in Rel-15/16.  On the other hand, to provide more capacity and flexibility, and reduce latency, option 2 with UE-specific Search space sets can be supported. |
| Lenovo, Motorola Mobility | Option2 is preferred, since it is more flexible.  As a compromise, the UE specific SS could be optionally configured, and if not configured, one sub-option from option1 could be used for the scheduling. |

### Second round

To be updated

## CORESET

### First round

The following options can be found in the TDocs submitted to this meeting.

Option 1: common CORESET

Option 1.1: CORESET 0

Option 1.2: CORESET other than CORESET 0

Option 2: UE-specific CORESET configuration

Option 2.1: configured from RRC Release message

Option 2.2: configured from Msg4/MsgB

**Discussion point 2.2**

Any preference on the listed options, and is there any other option not listed here?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | Option 2 is preferred.  Same reason as in previous comment. |
| Apple | Option 1 is related to common CORESET, option 2 is CORESET configuration, both options seem not on the same level.  Option 1 is preferred.  The usage of CORESET is common for group of users, but it can be configured per UE. |
| CATT | We support Option 1.and CORESET for RA-SDT is flexibly configured by gNB. |
| Intel | We support both Option 1.1 and Option 2.1. As we mentioned above, both need to be supported: one for default configuration and another for flexibility. |
| LG | We support Option 1.1, 1.2 and 2.1. gNB can determine which option is applied to SDT by configuration. |
| Huawei, HiSi | Option 1 is preferred.  Whether to use Option 1.1 and Option 1.2 can be configured by the network in the system information. |
| Nokia, NSB | Option 1 is preferred |
| Qualcomm | Depending on the tradeoff of signaling overhead, scheduling flexibility and system loading, we think the following options can be further considered:   * Option 1.1 * Option 1.2 * Option 2.1 |
| Ericsson | Use the CORESET associated to the existing search space used for SDT.  It’s up to RAN2 to decide whether a new CORESET can be defined in RRC release message if a new search space is configured in RRC release message. |
| InterDigital | We support Option 1.1 and 2.1 for similar reasons as previous proposal. |
| vivo | We think both option 1 and option 2 can be supported. For option 2, option 2.1 is preferred. |
| Lenovo, Motorola Mobility | Same comment as for point 2.1. |

### Second round

To be updated

# Configuration of association between the type 1 CG resource(s) for CG-SDT and SSB(s)

It was mentioned in the LS that “From RAN2 point of view: An association between CG resources and SSBs is required for CG-based SDT. FFS up to RAN1 how the association is configured or provided to the UE. Send an LS to RAN1 to start the discussion on how the association can be made. Mention that one option RAN2 considered was explicit configuration with RRC Release message”.

## Configuration of SSBs and CG resources

### First round

The following options can be found in the TDocs submitted to this meeting. If we go with option 1, then the association between SSBs and CG occasions for the CG configuration is needed. For the other two options, the association can be avoided. While option 2 may not be as flexible as option 1, and option 3 needs to additionally configure SRS resources for the inactive UEs.

* Option 1: one or multiple SSBs can be configured per CG configuration
* Option 2: single SSB per CG configuration
* Option 3: SSB is associated with SRS resource by SRS-SpatialRelationInfo

**Discussion point 3.1**

Any preference on the listed options, and is there any other option not listed here?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | Option 1 is preferred.  As far as we discussed with RAN2, the intention is also allow UE to select one SSB and use the associated PUSCH resource for the SDT, thus gNB can understand the preferred DL beam by UE, which facilitate the follow up transmission. Thus option 2 will require each SSB configuring with one CG configuration, and option 3 seems only focusing on the beam management which has no connection with SDT transmission, e.g., will the UE requires further SRI indication before/during SDT?  For option 1, we can build up the SSB-PUSCH (CG-SDT) association, as we did for SSB-RO in RACH procedure. |
| Apple | Option 1 is preferred.  We are not so clear the Option 2, does it mean only one SSB is configured in the cell or SSB to CG configuration is one to one mapping? The former interpretation doesn’t need to define the association. But according RAN2 agreement, SS-RSRP threshold is used for SSB selection, which means multi-SSBs are assumed. If the second interpretation is the intention, the difference between option 1 and option 2 is just one or multiple to one mapping and one to one mapping between SSB and CG configuration. Option1 is include the option 2. |
| CATT | We support Option 1. Considering the mobility of SDT UE in the inactive mode, multiple SSBs should be configured per CG configuration and this is straightforward method on the association between SSB and CGO. |
| Intel | We support Option 2. Further, in term of configuration, we think SSB can be associated with SRS resource with SRS-SpatialRelationInfo and a reference to ssb-index. For multiple SSBs associated with CG-PUSCH resource, it is not clear to us how gNB can identify the Tx beam used for CG-PUSCH if multiple SSBs are associated. Our understanding is that one SSB is associated with one CG-PUSCH resource and multiple CG-PUSCH resources can be configured in a cell. Based on selected SSB-RSRP threshold, UE can select one corresponding CG-PUSCH for transmission. |
| LG | We support Option 3. The existing configuration can be reused for CG-SDT possibly with modification. |
| Huawei, HiSi | Prefer Option 1 but with some comments, e.g..  *One CG configuration is associated to one or multiple SSBs, and multiple CG configurations can be associated with different SSBs. The association is configured per UE, e.g. in RRC release messages.*  Option 3 seems to associate the UE’s Tx beam with SSB, which in our opinion is not the main motivation of the LS. Besides, UE power saving is one of the main motivations of SDT WI. Introducing SRS and beam management in RRC\_INACTIVE not only adds more specification impact, but also causes much power consumption. |
| Nokia, NSB | Option 1 |
| Qualcomm | Option 1 is preferred. |
| Ericsson | Before doing down-selection, we may need to understand following RAN2 agreements which seem telling that a UE will select a good enough SSB among a set of SSBs first and then select a corresponding CG PUSCH resource for CG based SDT.   1. From RAN2 point of view: An association between CG resources and SSBs is required for CG-based SDT. FFS up to RAN1 how the association is configured or provided to the UE. Send an LS to RAN1 to start the discussion on how the association can be made. Mention that one option RAN2 considered was explicit configuration with RRC Release message 2. A SS-RSRP threshold is configured for SSB selection. UE selects one of the SSB with SS-RSRP above the threshold and selects the associated CG resource for UL data transmission.   If multiple SSBs are supposed for UE to down select based on the SS-RSRP and an RSRP threshold, reusing mapping rules similar to SSB to RO mapping rules is enough in our view.  If only single SSB is assumed and both gNB and UE already knows this SSB beam assumed for SDT, there’s no need to discuss the mapping. |
| InterDigital | Option 1 |
| vivo | Option 1 is preferred.  Besides, it should be clarified that whether one or multiple CG configurations are used for SDT. |
| Lenovo, Motorola Mobility | Option 1 is preferred |

### Second round

To be updated

## Details of association between SSB and CG resources

### First round

If option 1 in section 3.1 is adopted, the following issues need to be further discussed

1) Mapping period

* + Option 1.1: reuse that of SSB-RO mapping (including mapping cycle, association period, association pattern period)
  + Option 1.2: reuse that of SSB-MsgA PO mapping
  + Option 1.3: the association period is explicit indicated in RRC configuration
  + Option 1.4: the association is explicitly provided in RRC Release message

**Discussion point 3.2.1**

Any preference on the listed options, and is there any other option not listed here?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | Similar to SSB-RO association, I think the SSB-(CG-SDT)PUSCH association period could be determined. |
| Apple | Option 1.2 is preferred.  Some parameters of the PO configuration could be used for CG configuration, such as PO periodicity, the time offset from PRACH slot, number of slot containing the PO, number of the POs in each slot, etc |
| CATT | We support option 1.1 and similar method with SSB-RO association can be used for SSB-CGO association. |
| Intel | We suggest to defer the discussion before we conclude on Discussion point 3.1 |
| LG | If Option 1 in section 3.1 is adopted, we prefer Option 1.4. But, we can also defer the discussion before we conclude on Discussion point 3.1 |
| Huawei, HiSi | None of them. We don’t see the need to specify “mapping period” in the main bullet.  Unlike RO/PO in RACH, where each SSB has corresponding CG PUSCH occasions, for SDT it is not necessary for the network to configure the same amount of CG PUSCH occasions associated to each SSB. The network knows UE specific information, therefore can configure more resource associated to certain SSB(s), not to all SSB(s), so as to decrease the PUSCH detection associated to other SSB(s).  In line with the discussion in 3.1.1 where the association can be configured per CG configuration, e.g. by explicitly provided in each *ConfiguredGrantConfig* in UE-specific signaling, the main bullet should be removed or modified as:   1. ~~Mapping period~~ Association between SSB and CG resources   And we support 1.4 with modification as   * + Option 1.4-modified: the association is explicitly provided in each *ConfiguredGrantConfig* in UE-specific signaling, e.g. RRC Release message |
| Nokia, NSB | Option 1.3 (sort of), but similar to Huawei’s comment, there is no period in the association. There should be an association from an SSB to a CG configuration, there is no need for any period in the association. Due to this, there is no need to define any timing similar to SSB-RO or SSB-MsgA, just a linkage from SSB to CG-PUSCH configuration. |
| Qualcomm | In terms of resource allocation for PUSCH/DMRS (and indexing/ordering of CGO), we prefer a solution based on Option 1.2, which can reduce the signaling overhead of CGO specification.  In terms of the signaling/indication of association period, we share a similar view as Huawei and Nokia, which provides more flexibility to accommodate different traffic patterns for UEs performing CG-SDT. |
| Ericsson | Option 1.1 and/or 1.2 assuming multiple SSBs are to be mapped to the CG PUSCH resources.  Note that we assume option 1.2 is actually option 1.1 except that multiple DMRS resources can be configured per PUSCH occasion, given that SSB to MsgA PO mapping is determined indirectly via SSB to RO mapping and RO to PO mapping. |
| InterDigital | We support Option 1.3 or Option 1.4 and, similarly to Huawei and Nokia, we think the SSB association should be defined to a CG configuration without the association period. |
| vivo | We prefer option 1.2, i.e. SSB is mapped to a CG occasion and the associated DMRS resource (port/sequence/scrambling ID) in a manner similar to 2-step RA mapping rule. |
| Lenovo, Motorola Mobility | Option 1.4 is preferred |

2) Mapping ratio

* + Option 2.1: One SSB map to one CG occasion
  + Option 2.2: N SSB map to one CG occasion with different DMRS resources
  + Option 2.3: One SSB map to M CG occasion, M>=1
  + Option 2.4: the association is explicitly provided in RRC Release message

**Discussion point 3.2.2**

Any preference on the listed options, and is there any other option not listed here?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | The mapping ratio could be explicitly indicated. |
| Apple | We are fine with Option 2.2 and Option 2.4. |
| CATT | We prefer to Option 2.4 because gNB can flexibly configure the association mapping ratio by dedicated signalling based on the number of SSBs and CGO. |
| Intel | We suggest to defer the discussion before we conclude on Discussion point 3.1 |
| LG | If Option 1 in section 3.1 is adopted, we prefer Option 2.4 e.g. with mapping one SSB to one or more PUSCH occasions or mapping multiple SSB to multiple PUSCH occasions. |
| Huawei, HiSi | Proposal modifications to the main bullet as not clear we need to specify mapping ratio, and propose one more option 2.5 in line with the flexibility that UE specific RRC can provide for certain SSBs,  2) Mapping ~~ratio~~ rules:   * + Option 2.5: N (N>=1) SSB map to all CG occasions in one CG configuration. |
| Nokia, NSB | In our view the mapping is not to a CG-PUSCH occasion (please see the RAN2 LS and RAN2 meeting notes, and even the heading 3.2 of this document), but to a CG-PUSCH configuration, which contains the DMRS resource configuration and CG occasion configuration.  Option 2.3 (sort of), one SSB maps to M CG configurations, where M≥1 |
| Qualcomm | Option 2.4 is preferred. |
| Ericsson | Option 2.2 is a bit preferred if only single PO is allowed per CG period and if only single CG configuration is configured, since it can save some time frequency resources.  If multiple POs can be configured per CG period, option 2.1 may also be fine.  Note that we assume here “CG occasion” term in the options means a timing frequency resource used for one CG PUSCH transmission in one CG period. |
| InterDigital | We agree with Nokia that the SSB mapping should be to a CG configuration rather than to a CG occasion. |
| vivo | We think that an SSB should be associated with a CG occasion with a given DMRS resource. We prefer an updated option 2.2 that N SSB map to one CG occasion with different DMRS resources, where one SSB is mapped to a DMRS resource on the CG occasion. |
| Lenovo, Motorola Mobility | Option 2.4 is preferred |

3) In case of K repetition:

* + Option 3.1: K CG resources in a CG period are considered as one CG occasion for the mapping
  + Option 3.2: K CG resources in a CG period are considered as K CG occasion for the mapping
  + Option 3.3: Repetition is not supported for CG-SDT

**Discussion point 3.2.3**

Any preference on the listed options, and is there any other option not listed here?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | K repetitions can be considered as K CG PUSCH occasions. |
| Apple | Option 3.3 is preferred.  CG-based solution needs to reserve dedicated resources for each UE, the reserved resources could not be shared among UEs. if repetition is supported, the overhead is the concern. |
| CATT | We prefer Option 3.1 and CG repetition should be considered for CG-SDT in order to increase the reliability of CG transmission |
| Intel | Our view is that this is considered as single CG resource and CG occasion even when repetition is configured. |
| LG | If Option 1 in section 3.1 is adopted, we prefer to exclude Option 3.3. |
| Huawei, HiSi | If option 2.5 in 3.2.2 can be proceeded then there is no need to discuss this, i.e. the same handling w/ or w/o repetitions. |
| Nokia, NSB | k is a property of the CG-PUSCH configuration and when a CG-PUSCH configuration is selected, the k-value of that configuration is to be used. No need to discuss this point separately. |
| Qualcomm | The answer to 3.2.3 depends at least on the solution to 3.2.1.  If Option 1.2 (or 1.1) is considered for 3.2.1, Option 3.2 would be an appropriate solution to 3.2.3.  If Option 2.4 is adopted for 3.2.1, we share a similar view as Nokia regarding the configuration of K for CGO. |
| Ericsson | Option 3.1, note that we assume option 3.1 means only one SSB is mapped to K repetitions from one transmission, i.e. K repetitions are only mapped once. |
| InterDigital | Repetitions should be supported for CG-SDT. |
| vivo | We think the repetitions case should be dependent on the discussion point 3.2.2. We prefer option 3.1 for K repetitions. |

4) Validation

(Samsung) Proposal: the valid PO is the PO in UL part in a slot, or at least Ngap symbols after the end of the DL part in a slot or after the end of the SSB in a slot.

(QC) Before CG-SDT, UE needs to validate the PUSCH occasion(s) and the TA. The PUSCH validation procedures specified in Section 8.1A of TS 38.213 can be re-used for the validation of CG-SDT resources.

**Discussion point 3.2.4**

Do you agree with the above proposals?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | This is needed for gNB to flexibly configure the resources with less complexity. |
| Apple | UE needs to check whether the UL slot is valid before SDT transmission, the validation rule defined for PO can be the starting point. |
| CATT | First of all, we should focus on RAN2 requirement on configuration of association between CGO and SSB in RAN2 LS. |
| Intel | We are fine to consider the validation for CG-PUSCH similar to PO validation in 2-step RACH. |
| LG | We also think that RAN1 should focus on RAN2 requirement on configuration of association between CGO and SSB in RAN2 LS. We suggest to postpone this discussion to next meetings. |
| Huawei, HiSi | UE needs to check the validation of TA and PUSCH occasions. At least the PUSCH occasions whose part or all symbols are within DL symbols/slots should be dropped. |
| Nokia, NSB | 1. Validation rule defined for PUSCH transmission should be used as the starting point. 2. There is no TA validation procedure in section 8.1A of TS38.213, just PUSCH validation. A TA validation procedure is needed. |
| Qualcomm | We think both TA validation and PUSCH occasion (CGO) validation need to be done before CG-SDT. If TA validation fails, UE needs to skips the CG-SDT occasion, regardless the PUSCH validation is successful or not.  As a baseline, the PUSCH validation procedures for msgA of 2-step RACH can be re-used.  When PUSCH repetition is supported for CG-SDT, additional validation rules can be considered when necessary, with a goal to minimize the spec impact and reduce UE’s power consumption. |
| Ericsson | PO validation can follow the validation rules in legacy for configured grant configured PUSCH transmissions.  According to the WI, the UE is only allowed to transmit in the CG-SDT resource with a valid TA. But the details can be discussed in RAN2. |
| InterDigital | We agree with the proposals, and with Nokia’s comment that a TA validation procedure is needed. TA validation details can be left to RAN2. |
| vivo | We think the validation for CG-SDT resource is needed. The PUSCH validation procedures for msgA of 2-step RACH can be re-used.  TA validation should be discussed in RAN2. |

### Second round

To be updated

# Other physical layer issues related to small data transmission

There are some other physical layer issues of small data transmission mentioned by different companies. As these issues may not be directly related to RAN2’s LS, the moderator think they could be discussed with lower priority.

## Other issues related to PDCCH addressed by C-RNTI (Huawei)

For the DCI formats and aggregation levels (ALs) of PDCCH candidates for subsequent scheduling, only the Format 0\_0/1\_0 and the existing ALs {4, 8, 16} in CSS should be supported from the complexity and power saving point of view. The additional fields in 0\_1/1\_1, e.g. for multi-layer transmission and beam management, are not required for SDT. Format 2\_x/3\_x are also unnecessary during SDT procedure.

In R15/R16, the UE may assume that the DMRS antenna port associated with PDCCH receptions in the CORESET configured by *pdcch-ConfigSIB1* (CORESET#0) and the corresponding SSB are quasi co-located [2]. Here, for monitoring the PDCCH in subsequent RA-SDT, the UE should also assume the QCL of DMRS antenna port between the PDCCH receptions and corresponding SSB, regardless whether the common CORESET is CORESET#0 or not.

***Proposal 2****: Support only the DCI Format 0\_0/1\_0 and ALs= {4, 8, 16} of PDCCH candidates for subsequent scheduling after initial RA-SDT.*

***Proposal 3****: UE assumes that the DMRS antenna port associated with PDCCH receptions addressed to C-RNTI and the corresponding SSB are quasi co-located.*

**Discussion point 4.1**

Do you agree with the above two proposals?

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSi | Agree.  The SDT work item is mainly for UE power saving and network signaling reduction. The Proposal 2 aims at decreasing the UE blind detection to save the UE power. The Proposal 3 aims at increasing the DL performance of PDCCH, which improves the success rate of blind detection, also benefit to UE power saving. |
| Nokia, NSB | Proposal 2: OK to use x\_0 only, and the ALs that are associated to these formats and the chosen SS should be kept unchanged.  Proposal 3: The same QCL rule as in Rel-15 should be kept |
| Qualcomm | The proposals above look good to us in principle. |
| vivo | In principle, we agree with the proposal. In addition, this QCL assumption can be applied for the case of CORESET #0 or other CORESET for SDT as discussion point 2.2. |

## BWP for SDT

(ZTE) In RAN2, whether the BWP associated with CG-SDT resources is configurable or not is being discussed. This aspect can be left to RAN2. RAN1 may further study the **BWP switching** if RAN2 agree that the multiple BWPs for CG-SDT resources is configurable.

(Apple) Proposal 1: For RA-SDT, the **initial BWP** is applied for UL and DL data transmission, USS set is configured for SDT transmission.

(QC) From RAN1 perspective, UE shall monitor PDCCH addressed to C-RNTI in **initial DL BWP or active DL BWP** after successful completion of the RACH procedure during RA-SDT.

**Discussion point 4.2**

Which BWP shall be applied for RA-SDT and CG-SDT respectively?

|  |  |
| --- | --- |
| Company | Comment |
| Apple | To avoid retuning from one BWP to another to receive the SDT related info and system information, the initial BWP is suitable for SDT transmission and reception. |
| Huawei, HiSi | For the RA-SDT, this should be discussed following section 2.2.  For the CG-SDT, both the initial UL/DL BWP and UE-specific UL/DL BWP for RRC INACTIVE can be used, up to network configuration. |
| Nokia, NSB | Agree with Qualcomm |
| vivo | Both initial BWP or non-initial BWP can be used. For SDT, initial BWP should be at least supported.  Also, whether the same or different BWPs for RACH procedure and subsequent transmission during SDT are used need to be determined. If different BWPs are used, the switching behavior during subsequent transmission should discussed, e.g. to avoid retuning. |

## TA validity within and across SSBs (Nokia)

The TA timer by itself is not a condition enough to validate if the UE still has a valid TA, since the configured timer duration does not reflect the UE’s mobility conditions and therefore the UE can become time misaligned before the TA timer expires. Also, the UE may be still time aligned when the TA timer expires. Therefore, in NB-IOT’s PUR, the TA validation procedure was extended to also include the observation of the variantion of the serving cell RSRP. Below we revisit this procedure as defined in TS 38.331 in clause 5.3.3.19

A UE before proceeding with its PUR transmission, has to ensure that the current measured serving cell RSRP as neither increased above the *increaseThresh* nor has decreased below the *decreaseThresh*, when compared to previous serving cell RSRP when the UE knows that the TA was valid. However, the same serving cell RSRP based TA validation procedure is not necessarilly sufficient in NR, mainly due to the characteristics associated with the NR’s beam-based operation.

**Observation: TA validation based on serving cell RSRP variation is not robust in a NR system due to the multi-beam scenarios.**

**Proposal: RAN1 to study additional TA validation mechanisms that can make TA validation robust in multi-beam scenarios.**

**Discussion point 4.3**

Should RAN1 study additional TA validation mechanism in multi-beam scenario? If so, what are the candidate solutions?

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSi | To be handled in RAN2. |
| Nokia, NSB | Prefer discussing this in RAN1, but if the decision is to defer this to RAN2, that should be said in the response LS |
| Qualcomm | Agree with the comments of Nokia.  Specifically, SSB-based measurement is a main reference for TA validation, which belongs to PHY procedures of UE. |
| vivo | This issue should be discussed in RAN2. |

## UL Tx spatial filter (Huawei)

***Proposal:*** *For promoting SDT performance, the rules of setting transmit spatial filter for CG-SDT can be also considered as in existing RACH procedure, if the UE is equipped with multiple Tx antennas.*

* *UE uses the same spatial filter as in the last PUSCH in RRC\_CONNECTED within a timer and without the changing of best SSB regarding RSRP.*
* *UE uses the same spatial filter as in the last PUSCH in the previous RA procedure within a timer and without the changing of best SSB regarding RSRP.*

**Discussion point 4.4**

Do you agree with the above proposal?

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSi | Agree.  The SDT work item is mainly for UE power saving and network signaling reduction. The two rules extended from existing specification can promote SDT performance, which help to reduce UE Tx power and decrease the network implementation complexity. |
| Nokia, NSB | Do not agree. The best SSB should be used |
| InterDigital | Agree with Nokia. |

## UE-specific configurations for SDT (vivo)

**Proposal:**  **For RACH-SDT, following UE-specific configurations for SDT need to be further discussed.**

* + CORESET and TCI state info
  + UE-specific search space
  + UE-specific TDRA
  + UE-specific PUCCH resource/timing
  + the num of DL/UL HARQ process
  + initial BWP and non-initial BWP
  + RLM/BFD/BFR configuration
  + Power control related parameters
  + SR resource
  + SPS/CG for subsequent data transmission for subsequent transmission

**Discussion point 4.5**

Do you think any of the above UE-specific configurations should be provided for RA-SDT?

|  |  |
| --- | --- |
| Company | Comment |
| LG | Some of them could be provided by RA-SDT based on RAN1/RAN2 discussion. |
| Nokia, NSB | FFS after the basic decisions are taken. |
| Qualcomm | Since R17 SDT WI did not allocate any RAN1 TU, it is preferred to re-use the solutions available in R16 2-step RACH as much as possible. |
| vivo | For UE-specific configuration for RA-SDT, the key questions are when and what to indicate the UE-specific configuration.  These UE-specific configurations/parameters should be further discussed if UE-specific search space or CORESET would be used for SDT. |
| Lenovo, Motorola Mobility | FFS |

# Summary

To be updated

Any other issues or comments?

|  |  |
| --- | --- |
| Company | Comment |
|  |  |
|  |  |
|  |  |

# References

1. R1-2100025 LS on physical layer aspects of small data transmission ZTE
2. R1-2100080 Discussion on the physical layer aspects of small data transmission ZTE, Sanechips
3. R1-2100317 Discussion on physical layer aspects of small data transmission CATT
4. R1-2100501 On physical layer aspects of small data transmission Nokia, Nokia Shanghai Bell
5. R1-2100627 Discussion on LS on small data transmission Intel Corporation
6. R1-2100910 Discussion on physical layer aspects of small data transmission LG Electronics
7. R1-2101159 Discussion on RAN1 impacts for small data transmisison vivo
8. R1-2101165 Discussion on physical layer aspects of small data transmission Samsung
9. R1-2101267 RA and CG based small data transmission Huawei, HiSilicon
10. R1-2101338 Discussion on physical layer aspects of small data transmission Apple
11. R1-2101405 Physical layer aspects of small data transmission InterDigital, Inc.
12. R1-2101430 Reply to RAN2 LS on SDT resource configuration Qualcomm Incorporated
13. R1-2101518 [DRAFT] LS reply on physical layer aspects of small data transmission Ericsson

# Appendix

List of proposals in the submitted contributions.

|  |  |
| --- | --- |
| TDoc | Proposals |
| R1-2100080  ZTE | ***Proposal 1:***  ***A new field specifically defined for CORESET/Seachspace configuration can be added in the PDCCH-ConfigCommon for RA-SDT C-RNTI DCI.***  ***Proposal 2:***  ***For CG-SDT, down-select from the following alternatives for the configuration of SSBs for the CG-SDT***   * ***Alt. 1: only one SSB is configured per CG configuration for the first transmission, which is explicitly indicated in RRC release message.***    + ***FFS autonomous beam switching mechanism or fall back method in case of beam failure for the subsequent data transmission.*** * ***Alt. 2: multiple SSBs are configured per CG configuration, and the mapping between SSBs and CG occasions should be defined.***   + ***FFS whether a subset of SSB indexes can be configured per CG configuration, to be indicated in RRC release message***   ***Proposal 3:***   * ***If multiple SSBs are configured per CG configuration, at least support one-to-one mapping between SSBs and CG occasions, and the configured CG repetition number (number of occasions in one CG period) is limited to 1;*** * ***FFS if the repetition is configurable, and further study the following possibilities***   + ***one SSB mapping to one CG occasion, the configured CG repetition number can be lager than one, while the actual repetition number is still limited to 1;***   + ***one SSB mapping to K CG occasions, where K is the configured repetition number as well as the actual repetition number.***   ***Proposal 4:***  ***If multiple SSBs are configured per CG configuration, it is preferable to explicitly configure the association period between SSB and CG occasions.*** |
| R1-2100317  CATT | **Proposal 1: Separate PDCCH search space from existing CSS is supported for scheduling small data transmission after successful completion of the RACH procedure during RA-SDT.**  **Proposal 2: Parameters related to separate PDCCH SS can be configured to small data UEs by the broadcast signaling. CCE mapping position of each PDCCH candidate in the separate PDCCH SS is determined according to the hash function with C-RNTI for randomization parameter.**  **Proposal 3: After successful completion of the RACH procedure during RA-SDT, UE should monitor separate PDCCH for small data transmission. UE should stop monitoring separate PDCCH search space after UE receives RRC release signaling or high layer signaling of configuration on USS (UE specific search space)/Type3-CSS(Common search space).**  **Proposal 4: Mapping ratio between SS/PBCH blocks and TOs of one Type1 CG configuration can be configured by RRC signaling within the association period.**  **Proposal 5: When PUSCH repetition is applied for Type1 CG configuration during CG-SDT, SS/PBCH blocks should be associated with one TO bundle including K TOs corresponding to the K repetitions.** |
| R1-2100501  Nokia | **Proposal 1:** The UE monitors the C-RNTI for small data transmission after the successful completion of the RA-SDT procedure in CSS type1 applying the CORESET configuration associated to that CSS.  **Observation 1:** The UE in RRC\_INACTIVE needs to support beam correspondence for the CG-PUSCH resource to SSB relation to be useful.  **Proposal 2:** From RAN1 perspective the CG-PUSCH resource to SSB relation can be provided explicitely in the RRC configuration. It should be possible to associate one CG-PUSCH configuration to several (or to all) SSBs.  **Observation 2:** TA validation based on serving cell RSRP variation is not robust in a NR system due to the multi-beam scenarios.  **Proposal 3:** RAN1 to study additional TA validation mechanisms that can make TA validation robust in multi-beam scenarios.  **Proposal 4:** Provide RAN2 with an LS response corresponding to the proposals and observations above. |
| R1-2100627  Intel | **Proposal 1**   * *If configured with dedicated configuration of CORESET and SS set for PDCCH monitoring during RA-SDT procedure and if the configuration is valid for RA-SDT, UE shall monitor the PDCCH addressed to C-RNTI according to the configured CORESET and SS set, and the CORESET and SS set used for detecting DCI format with CRC scrambled with RA-RNTI.* * *If UE is not configured with dedicated configuration for CORESET and SS set for RA-SDT, UE shall monitor PDCCH addressed to C-RNTI according to the CORESET and SS set used for detecting DCI format with CRC scrambled with RA-RNTI.*   **Proposal 2**  *CG-PUSCH resource is associated with an SRS resource with SRS-SpatialRelationInfo containing the ID of a reference “ssb-Index”* |
| R1-2100910  LGE | ***Proposal 1: Type3-PDCCH CSS set or USS set can be supported for monitoring the PDCCH addressed to the C-RNTI after successful completion of the RACH procedure during RA-SDT.***  ***Proposal 2: Dedicated configuration of CSS Type 3 PDCCH or USS should be provided before or when UE goes to RRC\_INACTIVE.***  ***Proposal 3: At least CORESET0 can be used for monitoring the PDCCH addressed to the C-RNTI after successful completion of the RACH procedure during RA-SDT.***  ***Proposal 4: If needed, other CORESET than CORESET0 can be also considered for monitoring the PDCCH addressed to the C-RNTI after successful completion of the RACH procedure during RA-SDT.***  ***Proposal 5: RAN1 needs to further discuss details about CORESET/SS for RA-SDT.***  ***Observation 1: For CG in RRC\_CONNECTED, SRS resources are mapped to spatial information e.g. SSB(s).***  ***Observation 2: Since RAN2 agreed that the configuration of configured grant resource for UE uplink small data transfer is contained in the RRCRelease message, IE SRS-SpatialRelationInfo indicated by SRS-ResourceIndicator in IE rrc-ConfiguredUplinkGrant (i.e. SRS-resourceId) can be also provided to UE for association between the type 1 CG resource(s) for CG-SDT and SSB(s).***  ***Proposal 6: Some of SRS configuration for CG-SDT (e.g. IE SRS-SpatialRelationInfo in SRS-Config) can be provided to a UE for association between the type 1 CG resource(s) for CG-SDT and SSB(s).***  ***Proposal 7: Respond to RAN2 based on the above observations and the proposals.*** |
| R1-2101159  vivo | **Observation 1: PDCCH monitoring with CRC scrambled by C-RNTI in CSS for subsequent transmission of RA-SDT can be supported in NR.**  **Proposal 1:**  **If USS is supported for PDCCH monitoring with CRC scrambled by C-RNTI for RA-SDT/CG-SDT, low power consumption for PDCCH monitoring in USS needs to be considered.**  **Proposal 2:**  **For RACH-SDT, following UE-specific configurations for SDT need to be further discussed.**   * + **CORESET** **and TCI state info**   + **UE-specific search space**   + **UE-specific TDRA**   + **UE-specific PUCCH resource/timing**   + **the num of DL/UL HARQ process**   + **initial BWP and non-initial BWP**   + **RLM/BFD/BFR configuration**   + **Power control related parameters**   + **SR resource**   + **SPS/CG for subsequent data transmission for subsequent transmission**   **Proposal 3:**  **NR-U CG (or MsgA PO) resource allocation method is reused for NR SDT.**  **Proposal 4:** **For NR SDT, the association between SSB and SDT CG resource is 1:1 mapping.**  **Proposal 5:**  **For NR SDT, SSB is mapped to a CG occasion and the associated DMRS resource (port/sequence/scrambling ID) in a manner similar to 2-step RA mapping rule.** |
| R1-2101165  Samsung | ***Proposal 1: the CORESET and search space used for RA-SDT is configured in msg4.***  ***Proposal 2: Configure the number of PUSCH transmission occasion (PO) in one SDT-PUSCH period by new parameter or re-interpret the number of repetitions configured.***  ***Proposal 3: the valid PO is the PO in UL part in a slot, or at least Ngap symbols after the end of the DL part in a slot or after the end of the SSB in a slot.***  ***Proposal 4: the mapping ratio (number of SSB per PO) is configured by gNB and no larger than 1;***  ***Proposal 5: the SSB-PO association starts from the*** *timeReferenceSFN* ***indicated by gNB.*** |
| R1-2101267  Huawei | ***Observation 1:*** *Both the subsequent UL and DL transmissions will be scheduled by PDCCH addressed to the C-RNTI. The number of subsequent transmissions for one UE can be large.*  ***Observation 2:*** *The UE-specific CORESET/SearchSpace may require more specification impacts.*  ***Proposal 1:*** *As a baseline, the UE uses common CORESET (e.g. CORESET#0) and a new common SearchSpace configured in system information for monitoring C-RNTI after contention resolution of initial RA-SDT. FFS if the bandwidth of UE-specific CORESET is not larger than initial BWP and UE is in serving cell, UE can also use the UE-specific CORESET/SearchSpace.*  ***Proposal 2****: Support only the DCI Format 0\_0/1\_0 and ALs= {4, 8, 16} of PDCCH candidates for subsequent scheduling after initial RA-SDT.*  ***Proposal 3****: UE assumes that the DMRS antenna port associated with PDCCH receptions addressed to C-RNTI and the corresponding SSB are quasi co-located.*  ***Proposal 4:*** *Support one CG configuration associated to one or multiple SSBs. Multiple CG configurations can be configured to associate with different SSBs. The configuration can be based on UE report and/or request.*  ***Proposal 5:*** *The association can be updated by DCI or high layer signaling after one CG-SDT.*  ***Proposal 6:*** *For promoting SDT performance, the rules of setting transmit spatial filter for CG-SDT can be also considered as in existing RACH procedure, if the UE is equipped with multiple Tx antennas.*   * *UE uses the same spatial filter as in the last PUSCH in RRC\_CONNECTED within a timer and without the changing of best SSB regarding RSRP.* * *UE uses the same spatial filter as in the last PUSCH in the previous RA procedure within a timer and without the changing of best SSB regarding RSRP.* |
| R1-2101338  Apple | **Proposal 1:** **For RA-SDT, the initial BWP is applied for UL and DL data transmission, USS set is configured for SDT transmission.**  **Proposal 2: The mechanism of MsgA PUSCH association with SSB is re-used for association between the type 1 CG resource(s) for CG-SDT and SSB(s).** |
| R1-2101405  InterDigital | ***Proposal 1: For PDCCH monitoring addressed to C-RNTI after successful completion of the RA, reply to RAN2 that:***  ***- UE can monitor dedicated search spaces if available; UE monitors common search space otherwise.***  ***- it is up to RAN2 how the UE keeps coreset and search space configurations upon transitioning into INACTIVE state.***  ***Proposal 2: CG-SDT can be configured with one-to-many mapping to SSBs.*** |
| R1-2101430  Qualcomm | From RAN1 perspective, UE shall monitor PDCCH addressed to C-RNTI in initial DL BWP or active DL BWP after successful completion of the RACH procedure during RA-SDT. The active DL BWP (if different from initial DL BWP), CORESET and search space configurations for the UE can be included in the *RRCResume* or *RRCReconfiguration* message.  From RAN1 perspective, gNB can explicitly indicate the SSB index(es) as well as the CG resources (i.e. PUSCH/DMRS occasions) associated with the SSB index(es) in the *RRCRelease* message. Each CG resource includes a PUSCH occasion and associated DMRS resource. Similar to higher layer parameter of *configuredGrantConfig* including *rrc-ConfiguredUplinkGrant*, the PUSCH occasion can be defined by a time and frequency resource and the DMRS can be defined by *antennaPort*, *cg-DMRS-Configuration* and *dmrs-SeqInitialization*. Before CG-SDT, UE needs to validate the PUSCH occasion(s) and the TA. The PUSCH validation procedures specified in Section 8.1A of TS 38.213 can be re-used for the validation of CG-SDT resources. |
| R1-2101518  Ericsson | **Response to topic 1:**  Type1-PDCCH CSS can be at least used as a default CSS for C-RNTI monitoring in SDT. It’s up to RAN2 to decide whether an optional search space or an optional search space ID of a search space defined for RRC connected state should be indicated in the RRC release message.  **Response to topic 2:** RAN1 would like to reuse mechanism of SSB to RO mapping to support the SSB to CG PUSCH mapping for UEs in RRC inactive state doing small data transmission if multiple SSBs are expected for CG-based SDT. In this case, RAN1 needs input from RAN2 on   * The possibility of configuring multiple PUSCH resources per PUSCH occasion in one CG period, * CG period candidate values, * The number of CG configurations. |