**3GPP TSG RAN WG1 #100bis-e R1-20xxxxx**

**e-Meeting, 20th – 30th April, 2020**

**Agenda item:** 7.2.11

**Source:** Moderator (NTT DOCOMO, INC.)

**Title:** Summary on email discussion [100b-e-NR-UEFeatures-Remaining] MR-DC/CA enhancement

**Document for:** Discussion and Decision

1. Introduction

This contribution summarizes the following email discussion in AI 7.2.11 regarding Rel-16 NR UE features.

[100b-e-NR-UEFeatures-Remaining] Email discussion/approval of remaining issues (especially the one identified as low priority items in FL’s summaries) starting no earlier than 4/30 till next meeting – Hiroki (DCM)/Ralf (ATT)

Companies are encouraged to check further updates for UE features list based on R1-2003073 shown below and provide feedback if any. Please note that the target of this email discussion is to reflect agreeable updates rather than solving any controversial discussion point. If there is any controversial discussion point, it should be discussed in the next RAN1 meeting.

1. MR-DC/CA enhancement

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **( 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 18. MR-DC/CA enhancement | 18-1 | Basic UL power sharing for DC | Semi-static power sharing mode1 between MCG and SCG cells of same FR for NR dual connectivity. | [intra-FR DC if such FG is introduced by RAN2] | Yes | N/A |  | Per BC | N/A | N/A | N/A | Absence means intra-FR DC is not supported. | Optional with capability signalling |
| 18-1a | Semi-static UL power sharing mode 2 for DC | Semi-static power sharing mode 2 between MCG and SCG cells of same FR for NR dual connectivity. | 18-1  TBD | Yes | N/A |  | Per BC | N/A | N/A | N/A | Semi-static power sharing mode 2 between MCG and SCG cells of same FR is applicable only for synchronous NR dual connectivity | Optional with capability signalling |
| 18-1b | Dynamic UL power sharing for DC | Dynamic power sharing between MCG and SCG cells of same FR for NR dual connectivity.   1. T\_offset | 18-1  TBD | Yes | N/A |  | Per BC | N/A | N/A | N/A | 1) {short, long} | Optional with capability signalling |
| 18-4 | SCell dormancy within active time | Support for SCell dormancy indication sent within the active time on PCell with DCI format 0\_1/1\_1 | 6-5, 6-6  TBD | Yes | N/A |  | FFS [Per UE or Per BC] | No | [Yes or N/A] | N/A |  | Optional with capability signalling |
| 18-4a | SCell dormancy outside active time | Support for SCell dormancy indication sent outside the active time on PCell with DCI format 2\_6 | 6-5, 6-6  [19-1]  TBD | Yes | N/A |  | FFS [Per UE or Per BC] | No | [Yes or N/A] | N/A |  | Optional with capability signalling |
| [18-4b] | [Support of SCell dormancy indication without data scheduling within active time] | [Support of SCell dormancy indication without data scheduling within active time] | TBD | Yes | N/A |  | FFS [Per UE or Per BC] | No | [Yes or N/A] | N/A |  | Optional with capability signaling |
| 18-5 | DL cross-carrier scheduling with different SCS | 1. The UE supports DL cross carrier scheduling for the different numerologies with carrier indicator field (CIF) in DL carrier aggregation where numerologies for the scheduling cell and scheduled cell are different  {Scheduling cell of lower SCS and scheduled cell of higher SCS, Scheduling cell of higher SCS and scheduled cell of lower SCS, both}  [2. Processing up to X unicast DCI scheduling for DL per scheduled CC ]  X is based on pair of (scheduling CC SCS, scheduled CC SCS):  X=[4] for (15,120), (15,60), (30,120),  X=[2] for (15,30), (30,60), (60,120 kHz),  X applies per span in a slot of scheduling CC | 6-5, 6-9/6-9a  TBD | Yes | N/A |  | FFS[Per UE or Per band and per BC or Per FS] | N/A | [Yes or N/A] | N/A | crossCarrierScheduling-OtherSCS    Note: This applies also to the case where there is a single span in the slot for the scheduling CC.  In case UE supports 3-5b, the limits apply for each span for FDD scheduling cell and TDD scheduling cell. | Optional with capability signalling |
| 18-5a | Default QCL assumption for cross-carrier scheduling | Indicates whether the UE can be configured with enabledDefaultBeamForCCS for default QCL assumption for cross-carrier scheduling. | 6-5, 6-10  TBD | Yes | N/A |  | FFS[Per UE or Per band and per BC or Per band] | N/A | [Yes or N/A] | N/A |  | Optional with capability signalling |
| 18-5b | UL cross-carrier scheduling with different SCS | 1. The UE supports UL cross carrier scheduling for the different numerologies with carrier indicator field (CIF) in UL carrier aggregation where numerologies for the scheduling cell and scheduled cell are different  {Scheduling cell of lower SCS and scheduled cell of higher SCS, Scheduling cell of higher SCS and scheduled cell of lower SCS, both}  [2. Processing up to X unicast DCI scheduling for UL per scheduled CC ]  X is based on pair of (scheduling CC SCS, scheduled CC SCS):  X=[4] for (15,120), (15,60), (30,120),  X=[2] for (15,30), (30,60), (60,120 kHz),  X applies per span in a slot of scheduling CC | 6-6, 6-9/6-9a  TBD | Yes | N/A |  | FFS[Per UE or Per band and per BC or Per FS] | N/A | [Yes or N/A] | N/A | crossCarrierScheduling-OtherSCS    Note: This applies also to the case where there is a single span in the slot for the scheduling CC.  In case UE supports 3-5b, the limits apply for each span for FDD scheduling cell and TDD scheduling cell. | Optional with capability signalling |
| [18-5c] | [DL cross-carrier scheduling with different SCS and PDSCH processing capability 2] | [DL cross-carrier scheduling with different SCS and PDSCH processing capability 2] | 18-5a  TBD | Yes | N/A |  | FFS[Per UE or Per band and per BC or Per FS] | N/A | [Yes or N/A] | N/A |  | [Optional with capability signaling] |
| [18-5d] | [UL cross-carrier scheduling with different SCS and PDSCH processing capability 2] | [UL cross-carrier scheduling with different SCS and PDSCH processing capability 2] | 18-5b  TBD | Yes | N/A |  | FFS[Per UE or Per band and per BC or Per FS] | N/A | [Yes or N/A] | N/A |  | [Optional with capability signaling] |
| 18-6 | Cross-carrier A-CSI RS triggering with different SCS | Cross-carrier A-CSI RS triggering with different SCS | 2-33  6-5  TBD | Yes | N/A |  | FFS[Per UE or Per band and per BC or Per FS or Per BC] | N/A | [Yes or N/A] | N/A | 1) {PDCCH cell of lower SCS and A-CSI RS cell of higher SCS, PDCCH cell of higher SCS and A-CSI-RS of lower SCS, both} . | Optional with capability signalling |
| 18-6a | Default QCL assumption for cross-carrier A-CSI-RS triggering | Indicates whether the UE can be configured with enabledDefaultBeamForCCS for default QCL assumption for cross-carrier A-CSI-RS triggering. | 6-5  TBD | Yes | N/A |  | FFS[Per UE or Per band and per BC or Per band or Per BC] | N/A | [Yes or N/A] | N/A |  | Optional with capability signalling |
| 18-7 | CA with non-aligned frame boundaries | CA with non-aligned frame boundaries for inter-band CA | 6-5, 6-6  TBD | Yes | N/A |  | Per BC | N/A | N/A | N/A | Defines whether the UE supports carrier aggregation operation where the frame boundaries of the Pcell and the Scell are not aligned, while the slot boundaries are. | Optional with capability signalling |
| 18-8 | HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group | HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group | 6-7, 6-8  TBD | Yes | N/A |  | Per UE | No | No | N/A | Support HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group.  Rel-15 had this per cell group | [TBD] |
| 18-2 | Single UL TX operation for TDD PCell in EN-DC | TDM restriction to LTE TDD PCell in EN-DC for single UL-Transmission associated functionality when tdm-patternConfig-r16 is configured  1) TDD UL/DL configuration#2, #4, #5 configured as DL-reference UL/DL configuration  2) PRACH transmission in non- designated UL subframes given by the DL-reference configuration (only for type 1 UE)  3) LTE UL transmissions scheduled/triggered by a DCI in any UL subframe of the TDM pattern (only for type 1 UE) | EN-DC  TBD | Yes | N/A |  | Per band combination | Applicable to TDD-TDD EN-DC only | Applicable to FR1 only |  | Extension of the R15 capability tdm-Pattern to TDD PCell  This FG is for synchronous EN-DC | Optional with capability signalling |
| 18-2a | Enhanced single UL TX operation for FDD Pcell EN-DC | TDM restriction to LTE FDD Pcell in EN-DC for single UL-Transmission associated functionality when tdm-patternConfig-r16 is configured  1) DL-reference UL/DL configuration defined for LTE-FDD-SCell in LTE-TDD-FDD CA with LTE-TDD-PCell  2) PRACH transmission in non- designated UL subframes given by the DL-reference configuration (only for type 1 UE)  3) LTE UL transmissions scheduled/triggered by a DCI in any UL subframe of the TDM pattern (only for type 1 UE) | 6-13  TBD | Yes | N/A |  | Per band combination | Applicable to in FDD-LTE -NR EN-DC | Applicable to FR1 only |  | Enhancement to the R15 capability tdm-Pattern  This FG is for synchronous EN-DC | Optional with capability signalling |
| 18-2b | Support of HARQ-offset for SUO case1 in EN-DC with LTE TDD PCell for type 1 UE | Support of HARQ-offset for SUO case1 in EN-DC with LTE TDD PCell for type 1 UE | 18-2  TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A | This FG is for synchronous EN-DC | Optional with capability signaling |
| 18-3 | Dual Tx transmission for EN-DC with FDD PCell(TDM pattern for dual Tx UE) | TDM restriction to LTE FDD PCell in EN-DC for dual UL Tx operation when tdm-patternConfig-r16 is configured  1) DL-reference UL/DL configuration defined for LTE-FDD-SCell in LTE-TDD-FDD CA with LTE-TDD-PCell  2) PRACH transmission in non- designated UL subframes given by the DL-reference configuration (only for type 1 UE)  3) LTE UL transmissions scheduled/triggered by a DCI in any UL subframe of the TDM pattern (only for type 1 UE) | EN-DC  TBD | Yes | N/A |  | Per band combination | Applicable to EN-DC with LTE FDD PCell only | Applicable to FR1 only |  | Extension of the R15 capability tdm-Pattern to a dual Tx UE  This FG is for synchronous EN-DC | Optional with capability signalling |
| 18-3a | Semi-statically configured LTE UL transmissions in all UL subframes not limited to tdm-pattern | UE configured with tdm-patternConfig-r16 can be semi-statically configured with LTE UL transmissions in all UL subframes not limited to the reference tdm-pattern (only for type 1 UE) | 18-2, 18-2a, 18-3  TBD | Yes | N/A |  | [Per band combination] | Applicable to EN-DC only | Applicable to FR1 only |  | This FG is for synchronous EN-DC | Optional with capability signaling |

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| Company | Comment |
| Huawei, HiSi | **For CA aspect**  We think the following can be discussed hopefully with progress within email discussion:   * Prerequisite feature groups   + 18-4/4a: 6-5/6-6   + 18-5/5a/6/6a: 6-5   + 18-5b: 6-6   + 18-7: 6-5, 6-6   + 18-8: 6-7/6-8 * Type   + 18-4/4a/5/5a/5b/6/6a: per BC   We think the following may be contraversl or need input from other WG, so we will leave those for the next meeting (however we provide our preference in case of any progress):   * Need of [18-4b]🡺 our preference is not needed * Need of components 2 for both 18-5/5b🡺 can be kept with different values from R15   **For EN-DC,**   * 18-3, “(for type 1 UE)” should be added as a postfix to component 3 according to the agreement below   Agreements:  For a UE configured with DL-reference DL/UL configuration in Rel-16 (including single Tx with LTE TDD PCell or LTE FDD PCell, and dual Tx cases):   * For type 2 UE (i.e., UE without dynamic power sharing capability), any LTE UL transmissions should take place only in UL subframes designated for HARQ-ACK feedback. * For type 1 UE (i.e., UE with dynamic power sharing capability),   + Confirm that any LTE UL transmissions scheduled/triggered by DCI can take place in UL subframes not designated for HARQ-ACK feedback.   + FFS UE is not expected to transmit semi-statically configured LTE UL transmissions in the UL subframes other than those designated as UL in the DL-reference configuration if such transmission collide with NR UL transmissions. * 18-3, the context of 18-3a should be copied into 18-3 as component 4, otherwise, 18-3 should be added as one of prerequisite of 18-3a, according to the agreement below,   Agreements:  For a UE configured with DL-reference DL/UL configuration in Rel-16 (including single Tx with LTE TDD PCell or LTE FDD PCell, and dual Tx cases):   * For type 2 UE (i.e., UE without dynamic power sharing capability), any LTE UL transmissions should take place only in UL subframes designated for HARQ-ACK feedback. * For type 1 UE (i.e., UE with dynamic power sharing capability),   + Confirm that any LTE UL transmissions scheduled/triggered by DCI can take place in UL subframes not designated for HARQ-ACK feedback.   + FFS UE is not expected to transmit semi-statically configured LTE UL transmissions in the UL subframes other than those designated as UL in the DL-reference configuration if such transmission collide with NR UL transmissions.   Agreements  For the FFS part in the agreement above,   * semi-statically configured LTE UL transmissions are allowed in all UL subframes.   + Note: In case of collision, LTE transmission is prioritized   + Note: this configuration is subject to UE capability * 18-3, 2Tx in “Extension of the R15 capability tdm-Pattern to a 2Tx UE” should be replaced with “dual-tx” in order to avoid misunderstanding as UL-MIMO UE. * 18-2/2a, “if UE indicates that it does not support simultaneous UL transmissions as defined in TS 38.101-3 [4] using singleUL-Transmission” in component 4 should be deleted, if this component will be updated at this phase. |
| ZTE | **For [18-4b]**  Technically speaking, “SCell dormancy indication with data scheduling” and “SCell dormancy indication without data scheduling” are the same. It seems no need have a separate UE feature for [18-4b].  **For 18-2, 18-2a and 18-3**  The component 2) and component 3) are not clear and wording is not aligned with 18-3a. We proposed the following update for component 2) and component 3) of 18-2, 18-2a and 18-3:  2) PRACH transmission in all UL subframes not limited to the reference tdm-pattern (only for type1 UE)  3) LTE UL transmissions scheduled/triggered by a DCI in all UL subframes not limited to the reference tdm-pattern (only for type1 UE)  **For 18-3a**  Based on the following agreements, 18-3 should also be 18-3a’s prerequisite.  Agreements:  For a UE configured with DL-reference DL/UL configuration in Rel-16 (including single Tx with LTE TDD PCell or LTE FDD PCell, and dual Tx cases):   * For type 2 UE (i.e., UE without dynamic power sharing capability), any LTE UL transmissions should take place only in UL subframes designated for HARQ-ACK feedback. * For type 1 UE (i.e., UE with dynamic power sharing capability),   + Confirm that any LTE UL transmissions scheduled/triggered by DCI can take place in UL subframes not designated for HARQ-ACK feedback.   + FFS UE is not expected to transmit semi-statically configured LTE UL transmissions in the UL subframes other than those designated as UL in the DL-reference configuration if such transmission collide with NR UL transmissions.   Agreements  For the FFS part in the agreement above,   * semi-statically configured LTE UL transmissions are allowed in all UL subframes.   + Note: In case of collision, LTE transmission is prioritized   + Note: this configuration is subject to UE capability |
| MTK | **For [18-4b]:**  We support to keep it. “SCell dormancy indication with data scheduling (Case 1)” and “SCell dormancy indication without data scheduling (Case 2)” may impose different HARQ ACK timeline for UE processing. According to current RAN1 discussion, Case 2 HARQ ACK timeline may follow the SPS timeline (still under discussion) which is more stringent than Case 1.  **For 18-4/4a:**  Type to be per BC or per UE.  **For 5/5a/5b/6/6a:**  Type to be per BC.  **For components 2 of both 18-5/5b:**  It should be deleted since RAN1 never achieved consensus to set this X values for basic features. We are open to introduce components 2 of both 18-5/5b as separate featrues, say as 18-5e and 18-5f.  **For [18-5c] and [18-5d]:**  These are cross-carrier counterpart for the same-carrier features:  FG 5-5a -- UE PDSCH processing capability #2  FG 5-5b -- UE PDSCH processing capability #2 with scheduling limitation for 30kHz-SCS  FG 5-5c -- UE PUSCH processing capability #2  Since 5-5a/b/c are all applicable to FR1 only, we think [18-5c] and [18-5d] should also be applicable to FR1 only. |
| Apple | **FG 18-5**   * Component 1: We would also prefer to separate the FR1/FR2. For example, even of UE supports lower SCS cell schedules higher SCS scell, UE may only support FR1 schedules FR2, not the cross carrier scheduling within FR1 or FR2   **FG 18-5/18-6b**   * Component 2: We request to remove component 2 as basic component   + First of all, we have not discussed the PDCCH monitoring type, there are at least 4 different PDCCH monitoring type (1) FG 3-5, (2) FG 3-5a (3) FG 3-5b (4) New Rel-16 span based   + We also need to discuss if it is preferred to seprate DL unicast DCI and UL unicast DCI which is not the case in Rel-15 * We need to discuss the PDCCH monitoring capability related to CCS. PDCCH monitoring is mainly enhanced for URLLC purpose, however, we are discussing CCS which has different issue, i.e. scheduling opportunity mismatch, to solve. |
| Moderator (NTT DOCOMO) | It seems that proposed updates are agreeable.  In addition, following further updates according to feedbacks would also be fine.   * additional prerequisite FGs for FG18-3a/4/4a/5a/7/8 suggested by Huawei/HiSi and ZTE * clarification on “only for type 1 UE” for FG18-2/2a/3 component 2/3 * replacing “2Tx” by “dual Tx”   Other discussion points mentioned by companies are already marked as yellow and hence should be discussed in the next meeting. |
| Qualcomm | Prerequisite feature group for FG18-1:   * No need to describe [intra-FR DC if such FG is introduced by RAN2] on “prerequisite feature groups”, at least for now. This part can be up to RAN2 based on the RAN1’s message in the LS.   Component [4] of FG18-2/2a:   * Delete [4) if UE indicates that it does not support simultaneous UL transmissions as defined in TS 38.101-3 [4] using singleUL-Transmission, NR (SCG) UL transmission is dropped when an overlapping LTE (MCG) UL transmission is present (for type 1 UE).”]   + The UE behavior is already captured in the RAN1 spec and there is no need to duplicate it here   + The component [4] is actually not fully aligned with the description of the RAN1 spec; having this component is nothing more than a risk for future maintenance.   Clarification on applicable scenario of FG18-2/2a/2b/3/3a:   * Necessary to clarify all these FGs are for “synchronous EN-DC”. This was raised in the RAN1#100-e meeting but not yet discussed due to the lack of time. We believe this is to be clarified in the next update.   Type for FG18-3:   * The FG should be per band combination.   For FG 18-4/4a/4b related to SCell dormancy:   * We support to have ‘Per band combination’ type * We support to keep FG 18-4b. In the meanwhile, clarify that given FG 18-4b, FG 18-4 only covers the Case 1 SCell dormancy which both includes SCell dormancy indication and schedules data.   For FG 18-5/5a/5b/5c/5d related to cross-carrier scheduling:   * Type: Per band and per BC * Keep FG 18-5c and 5d. Discuss whether additional features are needed to at least cover counterparts of Rel-15 capability 2 functions. * It was concluded in RAN1# 100bis-e that the capability 2 for CCS with same SCS should be discussed in other agendas. However, by checking all Rel-16 related UE feature discussions, we do not see this fit better in any other agenda than MR-DC/CA enhancement. Therefore, we propose to discuss that the following two FGs in this session   + [FG18-5e for DL cross-carrier scheduling with same SCS and PDSCH processing capability 2]   + [FG18-5f for UL cross-carrier scheduling with same SCS and PUSCH processing capability 2] * Besides, it would be necessary to add additional FGs to account for   + For DL cross-carrier scheduling with differernt SCS, only the scheduling or scheduled carrier support processing capability 2   + For UL cross-carrier scheduling with different SCS, only the scheduling or scheduled carrier support processing capability 2 * For the combination of CCS and capability 2, more discussions are needed to cover different cases. Without a corresponding feature, our understanding is that UE does not need to support it. * Remove componenent 2 from FG 18-5 and FG 18-5b. PDCCH processing and cross-carrier scheduling are two major and complicated features. It is hard to bundle these two together.   For FG 18-6/6a related to cross-carrier ACSI-RS:   * Type: Per band and per BC |
| Moderator (NTT DOCOMO) | Following further updates are made according to above comments.   * For FG18-2/2a/2b/3/3a, “This FG is for synchronous EN-DC” is described in note column * Component 4 in FG18-2/2a is removed |
| Ericsson | 18-1   * OK to have pre-requisite text related to intra-FR DC in square brackets for now.   18-2 and 18-2a   * Keep the component 4. Text should be modified as “dropping NR transmission when LTE and NR transmissions collide for Type 1 UE”. Note this component should be included because NR-side UE behaviour is different when UE is configured with tdmPatternConfig-r16 depending on whether UE indicates 18-2/2a or 18-3. * For 18-2a, unclear why 6-13 should be pre-requisite.   18-3a   * Pre-requisite should be clarified as 18-2/18-2a/18-3 since support of one of them is enough as pre-requisite. * This should be per-UE.   18-4 and 18-4a   * 6-6 (UL CA) should not be a pre-requisite. Only having 6-5 (DL CA) is enough. * This should be per-UE with FR1/FR2 differentiation.   18-4b   * Separate feature group 18-4b should not be introduced.   18-5   * Component 2 should be included. * OK for FR1/FR2 differentiation.   18-5a   * Pre-requisite should be 6-10/18-5 as it should apply to CCS with same and different numerology cases. * This should be per-UE.   18-5b   * Component 2 should be included. * OK for FR1/FR2 differentiation.   18-5c/5d   * Need further discussion on whether to introduce these FGs. So these should remain in square brackets. |
| Nokia | General comment on multiple pre-requisites that likely applies across all the discussions. It is not clear when the pre-requisite list means that AT LEAST ONE of the listed FGs must be supported, and when the list means that ALL of the listed FGs must be supported. In some occasions it seems x-x,y-y means x-x and y-y both, and x-x/y-y means that (at least) one of x-x or y-y, but this is not consistent.  18-4/4a, no need for 6-6 (UL CA) as a pre-requisite for this. FG, 6-5 (DL CA) alone suffices here. 6-6 has 6-5 as a pre-requisite, so it is not possible to support 6-6 without 6-5, so no need to try and say “at least one of 6-5 or 6-6, when 6-6 cannot exist without 6-5 anyway”. Having 6-6 as a pre-requisite would imply that the UE shall support UL CA in order to be able to support SCell dormancy.  18-7, no need for 6-6 (UL CA) as a pre-requisite for this. FG, 6-5 (DL CA) alone suffices here. 6-6 has 6-5 as a pre-requisite already, so it is not possible to support 6-6 without 6-5, so no need to try and say “at least one of 6-5 or 6-6, when 6-6 cannot exist without 6-5 anyway”. Having 6-6 as a pre-requisite would imply that the UE shall support UL CA in order to be able to support CA with non-aligned frame boundaries.  18-8, no need for 6-8 (PUCCH groups with different SCS) as a pre-requisite for this. FG, 6-7 (two PUCCH groups with the same SCS) alone suffices here. 6-8 has 6-7 as a pre-requisite already, so it is not possible to support 6-8 without 6-7. Having 6-8 as a pre-requisite would imply that the UE shall support PUCCH groups with different numerologies to be able to support 18-8. |