3GPP TSG-RAN WG2 Meeting #112 Electronic R2-20xxxxx

Online, 2 – 13 November 2020

**Agenda item: 8.2.3**

**Source: CATT**

**Title: [AT112-e][231][eDCCA] Progressing conditional reconfiguration for SN initiated inter-SN CPC (CATT)**

**WID/SID: LTE\_NR\_DC\_enh2-Core - Release 17**

**Document for: Discussion and Decision**

# 1 Introduction

This is the report for the following email discussion:

[AT112-e][231][eDCCA] Progressing conditional reconfiguration for SN initiated inter-SN CPC (CATT)

Scope: Discuss the option 1 and option 3 details from P4 of email discussion [Post111-e][920][1] to better understand the technical details between the alternatives (e.g. signalling flows, signalling load, etc.)

Intended outcome: Discussion summary in R2-2010734 (by email rapporteur).

Deadlines phase 1: Monday 9th November, UTC 1200. Phase 1 is to gather information for detail of option 1 and option 3 and technical points for comparison.

Deadline phase 2: email discussion report: 2nd week Thu, UTC 1000

Note that the focus of this email discussion is primarily on proposal 4 of email discussion [1]. The two options listed in Proposal 4 is analysed taken in to account the signalling flow, signalling details in order to understand the options. Also pros and cons of each option are discussed with an intention to select the most appropriate option for SN initiated Inter-SN CPC.

# 2 Discussion

For SN initiated Inter-SN CPC, the SN should provide the CPAC trigger condition. Same as in Rel-16 CPC, the trigger condition in this case can be defined by a measurement identity, given by a measurement configuration provided by the SN.

For SN initiated inter-SN conditional PSCell change, [1] discussed different options for generating the conditional configuration message. The following options were selected for further discussion.

**Option 1: The MN generates CPC. The source SN sets the execution condition and communicates it to the MN. The MN generates the conditional reconfiguration message including the execution condition(s) provided by the source SN and RRCReconfiguration provided by the candidate PSCell(s).**

**Option 3: The source SN generates CPC. The source SN sets the execution condition. The source SN communicates with target SN and receives RRCReconfiguration provided by the candidate PSCell(s). The source SN generates the conditional reconfiguration message and provides it to the MN (possibly in a transparent container) for transmission to the UE.**

**2.1 Discussion of Option 1**

***Option 1: The MN generates CPC. The source SN sets the execution condition and communicates it to the MN. The MN generates the conditional reconfiguration message including the execution condition(s) provided by the source SN and RRCReconfiguration provided by the candidate PSCell(s).***

Figure 1 is an illustration of signaling flow for SN initiated Inter-SN CPC based on Option 1. The figure follows the steps used in a conventional SN initiated SN change procedure as shown in Figure 10.5.1-2 of TS37.340. Note that Figure 1 shows the signaling flow up to the signaling of the conditional configuration for SN initiated Inter-SN CPC to the UE. Signaling upon the execution of CPC is not shown in the figure as the main focus of this discussion is on the generation of conditional reconfiguration for SN initiated Inter-SN CPC.

In this solution, the MN generates a CPC configuration, i.e., the IE *ConditionalReconfiguration* as an MN configuration based on reconfiguration per target candidate (denoted RRCReconfiguration\*\* in Figure 1) and the execution condition per candidate cell. Reconfiguration\*\* per target candidate is provided by each target candidate cell in response to a conditional SN Addition Request. The execution condition per candidate cell is provided by the S-SN in the conditional SN Change Required.



**Figure 1: Configuration of SN-initiated CPC based on option 1.**

**Steps 1:** Based on RRC measurement report received from the UE, source SN decides to initiate the CPC procedure. Source SN determines the set of target SNs for the CPC procedure, and the candidate target PSCells for each target SN. For each candidate target PSCell, source SN determines the CPC execution condition. In the SN Change Required message, source SN provides information relevant to CPC configuration to the MN. In addition to the content of conventional SN Change Required message, CPC execution condition for each candidate target PSCell is included in the SN Change Required message.

**Steps 2:** MN initiates the SN Addition procedure with the set of target SNs indicated in SN Change Required. As a base line, the content of SN addition Request is similar to the conventional SN Addition Request message.

**Step 3:**  The target SN generates RRCReconfiguration\*\* for each candidate PSCell and provides it to the MN in SN addition request acknowledgement message. FFS on inclusion of multiple candidate cell configurations.

**Step 4:**  The MN generates an RRCReconfiguration to be provided to the UE including CPC configuration (as an MN configuration), mapping the execution condition configuration to an RRCReconfiguration\*\* provided by the target SN for candidate PSCell.

**Step 5:** the UE provides RRCReconfigurationComplete message to the MN upon reception of RRCReconfiguration message.

**Question 1: Companies are requested to comment whether Figure 1 is a reasonable representation of signalling flow for SN initiated Inter-SN CPC according to Option 1. For SN initiated CPC based on Option 1;**

**A: CPC configuration is generated by the MN.**

**B: SN provides the execution conditions to the MN.**

**C: the message applied upon CPC execution is in MN format.**

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| --- | --- | --- |
| **Company** | **Agree/not agree** | **Comments** |
| Qualcomm | Agree |  |
| Lenovo and Motorola Mobility | Agree | The figure looks fine in general. |
| Sharp | Agree |  |

**2.2 Discussion of Option 3**

***Option 3: The source SN generates CPC. The source SN sets the execution condition. The source SN communicates with target SN and receives RRCReconfiguration provided by the candidate PSCell(s). The source SN generates the conditional reconfiguration message and provides it to the MN (possibly in a transparent container) for transmission to the UE.***

Option 3 requires communication between the source SN and the target SN. There are two methods for enabling communication between the source SN and the target SN [3].

 the communication between S-SN and T-SN is performed directly

 the communication between S-SN and T-SNs occurs via MN

As discussed in [3], there is no direct communication between the source SN and the target SN is supported today. Enabling direct communication between the source SN and the target SN has a significant specification impact, eg. Xn. Therefore [3] argues that a direct communication between the source SN and the target SN should be avoided.

**Question 2: should direct communication be avoided between the source SN and the target SN?**

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| **Company** | **Yes/no** | **Comments** |
| Qualcomm | Yes | In our view, direct communication between source SN and target SN has significant specification impact and more signaling overhead than Option 1. |
| Lenovo and Motorola Mobility | Yes | Agree with the view in [3] that direct communication between SNs has significant spec impact while the gain is questionable, e.g. for both option 1 and option 3 with direct SN communication, 4 steps of message exchanges are needed to transmit the conditional configuration to UE.   * For option 1: S-SN -> MN, MN-> T-SN, T-SN->MN, MN->UE * For option 3 with direct SN communication: S-SN->T-SN, T-SN ->S-SN, S-SN->MN, MN->UE |
| Sharp | Yes | We see much spec impact to introduce direct communication between S-SN and T-SN. |

Figure 2 shows an illustration of signaling flow for SN initiated Inter-SN CPC based on Option 3. It is assumed that there is no direct communication between the Source SN and target SN. In option 3), the source SN generates CPC. The source SN sets the execution condition. The source SN communicates with target SN and receives RRCReconfiguration provided by the candidate PSCell(s). The source SN generates the conditional reconfiguration message and provides it to the MN (possibly in a transparent container) for transmission to the UE. Some assumptions are made regarding the inter-node messages (step 4) in Figure 2 which need to be finally agreed and discussed in RAN3. The source SN sends an S-Node Change Required message. The MN initiates an SN addition procedure to a target candidate SN. The target SN generates RRCReconfigurtaion\*\* for the candidate cell. The target SN sends S-Node Addition Request Ack message including CG-Config and the target generated RRCReconfigurtaion\*\*. In Step 4, the MN sends the CG-Config, including the target generated RRCReconfigurtaion\*\* to the source SN. Note that S-Node Change confirm message is modified to include CG-Config including the target generated RRCReconfigurtaion\*\* (highlighted in red) in the illustration in Figure 2. This should be discussed and agreed in RAN3. The source SN generates an RRCReconfiguration\* including CPC configuration, RRCReconfiguration\*\* generated by the target SN. Steps as in Rel-16 CPC can be used for the delivery of the source SN generated RRCReconfiguration\* message to the UE. In the illustration in Figure 2, SN initiated SN modification procedure is used to signal the source SN generated RRCReconfigurtaion\* message to the UE via the MN (using SRB1).



**Figure 2: Configuration of SN-initiated CPC based on option 3.**

**Steps 1:** Based on RRC measurement report received from the UE, source SN decides to initiate the CPC procedure. Source SN determines the set of target SNs for the CPC procedure, and the candidate target PSCells for each target SN. For each candidate target PSCell, source SN determines the CPC execution condition but the execution condition is not provided to the MN. In the SN Change Required message, source SN provides information relevant to CPC configuration to the MN in a similar way as in conventional SN change required message.

**Steps 2:** MN initiates the SN Addition procedure with the set of target SNs indicated in SN Change Required. As a base line, the content of SN addition Request is similar to the conventional SN Addition Request message.

**Step 3:** the target SN generates RRCReconfiguration\*\* for each candidate PSCell and provides it to the MN in SN addition request acknowledgement message. FFS on inclusion of multiple candidate cell configurations.

**Step 4:** The MN provides the CG-Config, including the target SN generated RRCReconfiguration\*\* received from the target SN in step 3 to the source SN in S-Node Change Confirm message. This message and the content should be discussed in RAN3.

**Step 5-8:** The source SN generates an RRCReconfiguration\* including CPC configuration, RRCReconfiguration\*\* generated by the target SN and execution condition. Steps as in Rel-16 CPC can be used for the delivery of the source SN generated RRCReconfiguration\* message to the UE under the assumption that MN is not involved with the configuration of CPC.

**Question 3: Companies are requested to comment whether Figure 2 is a reasonable representation of signalling flow for SN initiated Inter-SN CPC according to Option 3. For SN initiated CPC based on Option 3;**

**A: CPC configuration is generated by the source SN.**

**B: SN does not provide the execution conditions to other NW nodes.**

**C: the message applied upon CPC execution is in source SN format.**

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| **Company** | **Agree/not agree** | **Comments** |
| Qualcomm | Agree |  |
| Lenovo and Motorola Mobility | Agree | It looks fine in general. |
| Sharp | Agree |  |

**2.3 Comparison of option 1 and option 3**

In this section we discuss the main technical points for the operation of SN-Initiated Inter-SN CPC.

**MN involvement**

MN involvement of the procedure affects the generation and structure of the final CPC configuration message for Inter-SN CPC.

As discussed in [2,6], the UE needs to be provided with the MN generated sk-Counter in order to derive a new secondary KgNB for the operation of SN terminated DRBs and SRB3. Sk-Counter is provided to the UE as in an MN configuration in the conventional SN addition/change procedures. In option 1, MN generates the final conditional configuration, hence it can also provide the sk-Counter in MN configuration following the legacy signalling approach for sk-Counter.

It is questionable how sk-Counter can be provided to the UE in Option 3. Note that provisioning of sk-Counter was not an issue for Rel-16 CPC as security keys do not need to be refreshed for Intra-SN CPC. But for inter-SN CPC, sk-Counter should be provided to the UE.

It is clear how option 1 allows a key refresh upon an SN change triggered by CPC, as Sk counter is an MN/MCG configuration. However it is not clear how to provide sk-Counter for key refresh in Option 3.

**Question 4: Companies are requested comment on how to provide sk-Counter for key refresh in Option 1 and Option 3.**

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| **Company** | **Option 1** | **Option 3** | **Comments** |
| Qualcomm | sk-Counter can be added as part of MCG configuration included in the final conditional configuration message generated by MN | Not possible to provide sk-Counter | For **Option 1**, it seems clear that sk-Counter can be added as part of MN configuration included in the final conditional configuration message generated by MN.  Under the assumption in **Option 3** that source SN generates the final conditional configuration message and that MN is not involved in CPC configuration, any part of MCG configuration, e.g., sk-Counter, cannot be added. If MN involvement in CPC configuration is allowed, then it is possible to add sk-Counter as part of MCG configuration, for each target PSCell. |
| Lenovo and Motorola Mobility | Take legacy approach for sk-Counter as the baseline |  |  |
| Sharp | MN can provide the sk-Counter to UE in the CPC configuration when generate the final CPC configuration | New scheme is needed for this | For option 3, it may need to enhance step2~3 to include the sk-Counter in the CPC configuration. |

In conventional SN initiated SN change, the Radio bearer configuration could be changed due to that target SN may not be able to admit some of the SN terminated DRBs. As discussed in [2, 4], DRBs which could not be admitted by the target SN is desirable to be configured as MN terminated DRBs. It would be preferable to perform this change at execution time.

Considering final conditional configuration is performed by the MN, it is clear how the bearer configuration (reflecting the change of SN terminated bearer to MN terminated bearer) be signalled in Option 1. However it is not clear how the CPC configuration affecting MN bearer configuration can be signalled in Option 3.

**Question 5: Companies are requested comment on how the bearer configuration (reflecting the change of SN terminated bearer to MN terminated bearer) be signalled in Option 1 and Option 3.**

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| **Company** | **Option 1** | **Option 3** | **Comments** |
| Qualcomm | MN can change the MN bearer configuration when it adds the MCG configuration to the final conditional configuration | Not possible to change MN bearer configuration | Similar to response to Question 4.  For **Option 1**, it seems clear that MN can change the MN bearer configuration when it adds the MCG configuration to the final conditional configuration to be sent to the UE. In general, a separate MN bearer configuration may need to be provided for each target PSCell configuration.  For **Option 3**, it is not possible since MN is not involved in CPC configuration. If MN involvement in CPC configuration is allowed, then it is possible to add MN bearer configuration as part of MCG configuration, for each target PSCell. |
| Lenovo and Motorola Mobility | MN modifies the radio bearer configuration if needed when generating the conditional configuration |  |  |
| Sharp | MN can include the bearer configuration in the CPC configuration when generate the final CPC configuration | New scheme is needed for this | For option 3, agree with QC that MN should be involved in the CPC configuration generation steps, e.g. step2~4, so that the MN bearer configuration can be included in the CPC configuration. |

[6] discusses another aspect of MN involvement at CPC, requirement on capability coordination to facilitate Inter SN CPC. Upon change of SN, the MN and Target SN interact may share some of the UE capabilities and that the nodes interact for this (capability coordination) purpose. E.g. the band combination and/ or feature set combination used by MN/ for MCG may need to be adjusted to facilitate configuration of the SCG configuration included in the condRRCConfig. This means that, the MN configuration may need modification to ensure that, together with the SCG configuration applied at execution time, it respects the UE capabilities. It would again be preferable to avoid that MN configuration should be restricted prior to conditional reconfiguration execution. I.e. if application of the MN configuration cannot be delayed until execution, MN has to restrict its configuration such that in conjunction with every conditional CPC candidate, UE capabilities are respected. This would result in performance loss. Hence, it should be possible to delay application of MN generated fields until CPC execution.

With Option 1, it is clear how to provide MN configuration, affecting capability coordination which could be applied at the CPC execution, to the UE. However it is not clear how this can be enable in Option 3.

**Question 6: Companies are requested comment on how to provide MN configuration (affecting capability coordination which could be applied at the CPC execution) to the UE in Option 1 and Option 3.**

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| **Company** | **Option 1** | **Option 3** | **Comments** |
| Qualcomm | Possible following the usual SN Addition procedure | Not possible | In **Option 1** it is possible following the usual SN Addition procedure. |
| Lenovo and Motorola Mobility | Take legacy procedure for SN addition as the baseline |  |  |
| Sharp | Similar to current SN addition procedure | Not clear yet |  |

**Signalling load for inter-node messages**

Limitation in support of multiple candidate cell configurations in single inter-Node message was discussed in [2,5]. Currently, only one PSCell configuration can be provided in a single inter-Node message (RAN3 scope). If multiple candidate PSCell configurations are to be provided in a single inter-node message, RAN3 should be consulted.

The above issue of multiple candidate PSCell configurations occures if target SN requires providing multiple candidate PSCell in the same target SN. The issue of how to provide multiple candidate PSCell configurations by the target SN is seen in both Option 1 (step 3 in Figure 1) and Option 2 (step 3 in Figure 2).

The number of inter-node messages required for Option 3 is more than that of Option 1 as can be seen in Figure 1 and Figure 2, however the content of the messages are different in option 1 and option 3.

Considering that the target candidate PSCell is chosen by target SN, the MN or Source SN can’t perform the mapping of the execution condition and the candidate target SCG configuration until the MN or source SN received the candidate target SCG configuration in option 1 and option 3 respectively. In order to facilitate mapping of the execution condition and the target SCG configuration, Option 1 requires the provision of a list of execution conditions and candidate PSCells to the MN in step 1 of Figure 1. In option 3, provision of execution condition to the MN or target SN is not required. However, the candidate target SCG configuration should be forwarded to Source SN by the MN (step 4/5) in Figure 2.

**Question 6: Considering the number of inter-node messages and signalling content in each message, companies are requested to comment on/compare the overhead of inter-node messages in option 1 and option 3.**

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| --- | --- | --- | --- |
| **Company** | **Inter-node signaling in Option 1 (High/low)** | **Inter-node signaling in Option 3 (High/low)** | **Comments** |
| Qualcomm | Potentially lower than Option 3 |  | The higher signaling overhead in Option 3 compared to Option 1 is because of the following reasons:  - Step 2 (Option 3) in which target PSCell SCG configurations are forwarded from MN to source SN;  - Step 5 (Option 3) in which source SN forwards the generated conditional configuration to MN.  The overhead here should be higher than the overhead in transmitting the list of execution conditions in Step 1 in Option 1 (Fig 1).  However, the main concerns or disadvantages with Option 3 are the limitations discussed in responses to Questions 3, 4, and 5 above. |
| Lenovo and Motorola Mobility | Low | High | We are not sure about “In option 3, provision of execution condition to the MN or target SN is not required” in above statement, since the execution condition will be carried in the RRCReconfiguration in step 5 option 3.  In our view, step 4 and step 5 in option 3 produce extra overhead compared to option 1. |
| Sharp |  |  | From figures for option 1 and 3, seems signaling overhead for option 3 is higher than that of option 1.  For option 3, at least there more steps are needed to forward target cell CPC configuration to S-SN (step 4) and to forward CPC configuration from S-SN to MN (step 5). |

**RAN3 involvement and Specification impact**

The procedure in Option 1 reuses conventional SN change procedure. Even though, additional message content may need to be included in inter-node messages in Option 1 (step 1), option 1 does not require introducing new inter-node messages.

Option 3 uses Rel-16 Intra-SN CPC based signalling. Rel-16 intra-SN CPC only supported scenario where MN is not involved in the CPC configuration. As discussed in section 2.3, the MN involvement is required for Inter-SN CPC in order to provide sk-Counter, affected MN radio bearer configuration, etc. this would require additional modification to the Rel-16 CPC procedure in RAN2. Required modification on inert-node message to support Option 3 should be discussed in RAN3. Especially the message involved in step 4 in Figure 2 needs further discussion in RAN3.

**Question 6: Considering the above discussion points (inter-node message content, enabling MN involvement in CPC configuration), companies are requested to comment on/compare the specification impact (in RAN2 and RAN3) for introduction of Option 1 and Option 3.**

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| **Company** | **Specification impact of Option 1 (High/low)** | **Specification impact of Option 3 (High/low)** | **Comments** |
| Qualcomm | Potentially lower than Option 3 |  | The **specification impact of Option 1**, as per our understanding:  1. Including execution condition per candidate target PSCell in SN Change Required from source SN to MN in Step 1 of the call-flow in Figure 1. Likely RAN2 impact.  2. In Step 3, in case multiple target PSCell configurations are provided in SN Addition Request Acknowledge, the list of target PSCell IDs at the top level of the message so that MN attaches execution conditions to the appropriate target PSCells. Alternative option is to provide this list in the CG-Config container. Likely RAN3 or RAN2 impact depending upon which of the above options is adopted.  The **specification impact of Option 3**, as per our understanding:  1. Including target PSCell SCG configuration in SN Change Confirm in Step 4 of the call-flow in Figure 2. Likely RAN3 impact.  2. In Steps 3 and 4, in case multiple target PSCell configurations are provided in SN Addition Request Acknowledge, the list of target PSCell IDs at the top level of the messages so that source SN attaches execution condition to the appropriate target PSCells. Alternative option is to provide this list in the CG-Config container. Likely RAN3 or RAN2 impact depending upon which of the above options is adopted. |
| Lenovo and Motorola Mobility | Low | High | Apparently, option 3 requires quite some modification to X2/Xn messages as pointed out by rapporteur. |
| Sharp | Low | High | We expect more spec impact based on the observation in the previous questions 3~5. |

**Any other point to be considered for comparison of Option 1 and Option 3**

**2.4 Decision on option 1 or option 3 [Phase 2]**

# 5 Conclusion

[TBC]

# 6 Reference

[1] R2-2009360 Summary of [Post111-e][920][eDCCA] Conditional PSCell Change and Addition (CATT) CATT discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[2] R2-2010088 Progressing conditional configuration for R17 Samsung Telecommunications discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[3] R2-2010626 Further consideration for Conditional PSCell addition and change NTT DOCOMO INC. discussion Rel-17 LTE\_NR\_DC\_enh2-Core Late

[4] R2-2010130 Configuration of Conditional PSCell addition/change Qualcomm Incorporated discussion Rel-17

[5] R2-2010529 Regarding inter MN-SN signaling design for Conditional PSCell Addition Intel Corporation discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[6] R2-2010003 Conditional PSCell Change / Addition Ericsson discussion LTE\_NR\_DC\_enh2-Core

[7] R2-2009771 On Rel-17 Conditional PSCell Addition and Change (CPAC) Nokia, Nokia Shanghai Bell discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[8] R2-2010125 Discussion on support of conditional PSCell change/addition Huawei, HiSilicon discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[9] R2-2010373 Discussions about CPAC procedures CMCC discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[10]R2-2009379 Discussion on conditional PSCell addition/change ZTE Corporation, Sanechips discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[11] R2-2009596 Discussion on conditional PSCell change and addition OPPO discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[12] R2-2009868 Issues on inter-SN CPC Lenovo, Motorola Mobility discussion Rel-17

[13] R2-2009592 Discussion on inter-SN conditional PSCell change (SN initiated) China Unicom discussion LTE\_NR\_DC\_enh2-Core

[14] R2-2009358 Discussion on Further CPAC Enhancements CATT discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[15] R2-2009816 Framework of Inter-SN Conditional PSCell change NEC discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[16] R2-2009815 Conditional PSCell addition procedure NEC discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[17] R2-2009088 Conditional PSCell change / addition vivo discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[18] R2-2009158 CPC configuration number restriction Spreadtrum Communications discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[19] R2-2009260 Coexistence of CHO and CPC InterDigital discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[20] R2-2009285 CPAC failure handling discussio Futurewei discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[21] R2-2009475 Discussion on conditional PSCell change and addition Apple discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[22] R2-2010248 Discussion on SN initiated CPC and CPAC Execution ETRI discussion Rel-17 LTE\_NR\_DC\_enh2-Core

[23] R2-2010282 Considerations of CPAC in Rel-17 LG Electronics discussion Rel-17 R2-2007985