**3GPP TSG-RAN WG4 Meeting # 100-e R4-2115337**

**Electronic Meeting, 16th – 27th August 2021**

**Agenda item:** 9.10.2.2

**Source:** Moderator (vivo)

**Title:** WF on further RRM enhancement for NR and MR-DC – HO with PSCell

**Document for:** Information

# Introduction

This WF captures agreements during GTW session and email discussion, and open issues in email summary with thread [100-e][221] NR\_RRM\_enh2\_2 for HO with PSCell.

# Topic #1: HO with PSCell

## Sub-topic 2-1 Scenarios for RRM requirement of HO with PSCell

Agreements in the 1st round email discussion

* RAN4 specifies RRM requirement for HO with PSCell for the following scenarios as in the WID RP-202874:
  + from NR SA to EN-DC
  + from EN-DC to EN-DC
  + from NE-DC to NE-DC
  + from NR-DC to NR-DC
* In Rel-17, RAN4 define RRM requirements for NR-DC and NE-DC mode
  + FR1+FR2 NR-DC
  + FR1+LTE NE-DC

Agreements in the 2st round email discussion

* The baseline RRM requirements for FR1+FR1 NR-DC is not in the scope of Rel-17 FeRRM WI. It is up to RAN plenary decision whether and in which release the baseline RRM requirements for FR1+FR1 NR-DC are specified.

## Sub-topic 2-2 Delay requirement design of HO with PSCell

Agreements during GTW session

* In HO with PSCell for NR-DC to NR-DC
  + Parallel processing shall be the baseline for delay requirements
  + Sequential processing shall be assumed for the following cases
    - Case 1: If SMTC of target unknown PSCell is configured in targetcellSMTC-SCG-r16 but not configured in reconfigurationWithSync.
    - Sequential processing is used for cell search and [timing sync]. FFS if additional margin shall be added.

Agreements in the 1st round email discussion

* RACH processing for PCell and PSCell are performed in parallel independently.
* For UE which is already configured with DC, the UE’s behavior is the same whether the configured PSCell is same as the original one or not.

Agreements in the 2nd round email discussion

* In HO with PSCell for EN-DC to EN-DC
  + Parallel processing shall be the baseline for delay requirements
* In HO with PSCell for NE-DC to NE-DC
  + Parallel processing shall be the baseline for delay requirements
* RRM requirements for HO with PSCell are defined for both parallel processing and sequential processing cases.

Open issues

**Issue 2-2-1a-1: Condition of parallel processing without considering RACH for NR SA to EN-DC**

* Proposals
  + Option 1 (Xiaomi, Huawei, vivo, Intel, OPPO)
    - Parallel processing shall be the baseline for delay requirements
    - Sequential processing shall be assumed for the following cases
      * If SMTC of target unknown PSCell is configured in RRCConnectionReconfiguration in targetRAT-MessageContainer
      * FFS if target PCell is known. (Intel)
  + Option 2 (Qualcomm, vivo, CATT, Ericsson, ZTE, CMCC)
    - Parallel processing shall be the baseline for delay requirements
    - Sequential processing shall be assumed for the following cases
      * FFS since the reference timing is not yet determined in RAN2
  + Option 3
    - Parallel processing shall be the baseline for delay requirements
  + Option 4 (Apple)
    - Sequential processing shall be the baseline for delay requirements

**Issue 2-2-2a: How the requirements for parallel processing and sequential processing are defined without considering Tprocessing and RA procedures**

* Proposals
  + Option 1: (Xiaomi, Apple, Huawei, vivo, Intel, OPPO, CATT, ZTE, CMCC)
    - Different requirements for parallel processing cases and sequential processing cases
  + Option 2: (Qualcomm)
    - Unified requirements to cover both parallel processing cases and sequential processing cases

**Issue 2-2-2b: Timeline for delay requirements without considering Tprocessing and RA procedures**

*The remaining parallel processing cases and sequential processing cases are discussed under Issue 2-2-1a.*

*This issue is dependent on Issue 2-2-2a.*

*Option 1 is for requirements regarding option 1 in Issue 2-2-2a if different requirements are defined for parallel processing cases and sequential processing cases*

*Option 2 is for requirements regarding option 2 in Issue 2-2-2a if unified requirements are defined for parallel processing cases and sequential processing cases*

* Proposals
  + Option 1 (Xiaomi, Apple, Huawei, vivo, Intel, CATT)
    - For parallel processing cases, PCell HO and PSCell addition are performed in parallel independently
    - For sequential processing cases,
      * Option A: Sequential processing of cell search and timing sync for PCell handover and PSCell addition. (Huawei, vivo
      * Option B: Tsearch can be extended for sequential processing cell search, e.g. Tsrch= Tsearch\_MCG+Tsearch\_SCGand the time for SSB post-processing may also be extended e.g. Tm=2xTmargin
        + Adopt the same time for loop processing as legacy T∆ i.e. the fine time tracking and acquiring full timing information of the target cell shall be assumed running independently for each CG
      * Option C: Sequential processing of cell search, timing sync and SSB processing time for PCell handover and PSCell addition. (Apple, vivo (FFS))
      * Option D: FFS (CATT, CMCC, OPPO)
  + Option 2 (Qualcomm)
    - For both parallel processing cases and sequential processing cases
    - Option A:
      * Tsearch can be extended for sequential processing cell search, e.g. Tsrch= Tsearch\_MCG+Tsearch\_SCGand the time for SSB post-processing may also be extended e.g. Tm=2xTmargin
        + Adopt the same time for loop processing as legacy T∆ i.e. the fine time tracking and acquiring full timing information of the target cell shall be assumed running independently for each CG
    - Option B:
      * Other options are not precluded

**Issue 2-2-3a: Timeline of Tprocessing (UE SW processing and RF warm-up(if needed) time) for HO with PSCell**

* Proposals
  + Option 1: (Huawei, Qualcomm, vivo, Intel, CATT, Ericsson, ZTE)
    - For both parallel processing cases and sequential processing cases, UE SW processing and RF warm-up for PCell handover and PSCell addition/change are performed in parallel.
  + Option 2: (Apple, OPPO)
    - For parallel processing cases, UE SW processing and RF warm-up for PCell handover and PSCell addition/change are performed in parallel.
    - For sequential processing cases, UE SW processing and RF warm-up for PCell handover and PSCell addition/change are performed in sequential.
  + Option 3: (vivo)
    - For parallel processing cases, UE SW processing and RF warm-up for PCell handover and PSCell addition/change are performed in parallel.
    - For sequential processing cases, FFS.

**Issue 2-2-3b: If UE SW processing and RF warm-up for PCell HO and PSCell addition/change are performed in parallel**

* Proposals
  + Option 1: (Apple, Huawei, Intel, OPPO, CATT, Ericsson, ZTE)
    - Tprocessing for HO with PSCell = max(Tprocessing for PCell HO, Tprocessing for PSCell addition/change)
  + Option 2:
    - Tprocessing for HO with PSCell = max(Tprocessing for PCell HO, Tprocessing for PSCell addition/change) + 10ms
  + Option 3:
    - No need to define Tprocessing for HO with PSCell since HO with PSCell can refer to current legacy PCell HO and PSCell addition requirement directly.
  + Option 4: (Qualcomm)
    - Tprocessing = 30ms for NR-SA to EN-DC
    - Tprocessing = 20ms for NR-DC to NR-DC without FR mode switch on PSCell
    - Tprocessing = 40ms for all other cases
  + Option 5: (vivo)
    - Tprocessing for HO with PSCell = max(Tprocessing for PCell HO, Tprocessing for PSCell addition/change) for EN-DC to EN-DC, NR-DC to NR-DC and NE-DC to NE DC
    - Tprocessing for HO with PSCell = max(Tprocessing for PCell HO, Tprocessing for PSCell addition/change) + 10ms for NR-SA to EN-DC

**Issue 2-2-3c: If UE SW processing and RF warm-up for PCell HO and PSCell addition/change are performed in sequential**

*It further depends on conclusion of Issue 2-2-3a whether this is needed or not.*

* Proposals
  + Option 1: (Apple, Intel, OPPO, CATT, ZTE)
    - Tprocessing for HO with PSCell = sum(Tprocessing for PCell HO, Tprocessing for PSCell addition/change)
  + Option 2: (vivo)
    - FFS

**Issue 2-2-3d: Tprocessing for PCell HO**

* Proposals
  + Option 1: (Apple, Huawei, Qualcomm, vivo, Intel, OPPO, Ericsson, ZTE)
    - 20ms, when source and target cells are in the same FR
    - 40ms, when source and target cells are in different FRs
  + Option 2:
    - Other options are not precluded

**Issue 2-2-3e: Tprocessing for PSCell addition/change**

* Proposals
  + Option 1: (Apple, Huawei, Qualcomm, vivo, Intel, OPPO, Ericsson, ZTE)
    - For PSCell change for NR-DC and EN-DC
      * 20ms, when source and target cells are in the same FR
      * 40ms, when source and target cells are in different FRs
    - For PSCell addition for NR-DC and EN-DC
      * 20ms, when NR PSCell is in FR1
      * 40ms, when NR PSCell is in FR2
  + Option 2:
    - Other options are not precluded

**Issue 2-2-5: Ending point of the delay requirement for HO with PSCell**

* Proposals:
  + Option 1 (Apple, Xiaomi, CMCC, CATT, OPPO):
    - the later timing between “timing when UE shall be capable to transmit PRACH preamble towards target PCell” and “the timing when UE shall be capable to transmit PRACH preamble towards target PSCell”.
  + Option 2 (vivo, CMCC, Intel, Huawei, MTK, Ericsson, Qualcomm, CATT, Apple):
    - Defining delay requirements for HO and PSCell addition/change separately with the ending points defined as PCell PRACH and PSCell PRACH, respectively.
  + Option 3 (Nokia):
    - No need to discuss and define the ending point of HO with PSCell.

**Issue 2-2-8: Delay requirements design**

* Proposals
  + Option 1 (CATT):
    - The delay requirement will be defined as Delay = TRRC processing + max(Tinterrupt , Tconfig\_PSCell – TRRC\_delay).
      * TRRC processing is RRC processing time defined as in introduction.
      * Tinterrupt is interruption time defined in requirements of handover in every scenarios.
      * Tconfig\_PSCell is delay requirement for PSCell addition.
      * TRRC\_delay is RRC processing time defined for PSCell addition.
  + Option 2 (Xiaomi):
    - the overall delay requirement for HO with PSCell is defined as TRRC\_delay + max(Tinterrupt, TSync\_PSCell), where,
      * Tinterrupt is the interruption time for HO, which is defined in section 6.1 TS38.133;
      * TSync\_PSCell is the preparation time for synchronizing to target PSCell, which is defined in section 8.8 or 8.9 TS38.133.
  + Option 3 (CMCC):
    - Delay for HO with PSCell is maximum (PSCell addition delay, HO delay)
      * PSCell addition delay= TRRC\_delay + Tprocessing + Tsearch + T∆ + TPSCell\_ DU + 2 ms
      * HO delay = TRRC\_delay +Tinterrupt = TRRC\_delay +Tsearch + TIU + Tprocessing + T∆ + Tmargin ms
  + Option 4 (Intel):
    - The delay requirements for HO with PSCell can be described as:
      * THO\_PSCell= maximum (THO\_delay, Tconfig\_PSCell)
      * THO\_delay = TRRC\_delay + Tsearch + Tprocessing +TIU + T∆ + Tmargin ms
      * Tconfig\_PSCell = TRRC\_delay + Tsearch + Tprocessing + TPSCell\_ DU + T∆ + 2 ms
        + TRRC\_delay is the RRC procedure delay as specified in TS 38.331.
        + Tsearch is the time required to search the target cell.
        + Tprocessing is the SW processing time needed by UE, including RF warm up period.
        + T∆ is time for fine time tracking and acquiring full timing information of the target cell.
        + TIU and TPSCell\_ DU are the interruption uncertainty in acquiring the first available PRACH occasion in the PCell and PSCell.
  + Option 5 (Nokia):
    - HO with PSCell RRM requirements can refer to existing handover requirements and PSCell addition requirements directly
    - Agree the TP provided in R4-2114213
  + Option 6 (Qualcomm):
    - Requirement definition assumes UE run independent loop processings and RACHs towards PCell and PSCell respectively.
    - RAN4 to specify the delay requirement for HO with PSCell based on the assumption that some of procedures should be able to be performed in parallel.
    - If any component during the procedure has a dependency bw/ PCell and PSCell, define a common term to capture the most applicable requirement.
    - RRC processing, UE processing(to prep the RF) are proceudures common to both PCell and PSCell
    - Introduce a common term of search time budgeted for the joint PCell HO with PSCell, which is twice of the legacy search time Tsearch reserved for HO i.e. Tsrch= Tsearch\_MCG+Tsearch\_SCG.
    - Also introduce a common margin time Tm which is twice of the time of legacy Tmargin i.e. Tm=2xTmargin.
    - Adopt the same time for loop processing as legacy T∆.
  + Option 7 (Huawei):
    - **For NR SA to EN-DC, the delay of HO and PSCell addition:**
    - THO = TRRC\_delay +Tsearch\_PCell + TIU + TProcessing
    - TPSCell= TRRC\_delay + Tprocessing + Tsearch\_PSCell + T∆ + TPSCell\_ DU + TPCell\_DU+ Tmargin ms
    - Where TRRC\_delay = 50 ms, TPCell\_DU is the delay uncertainty due to PCell RACH preamble transmission defined in TS 38.213.
    - **For EN-DC to EN-DC, the delay of HO and PSCell addition:**
    - THO = TRRC\_delay +Tsearch\_PCell + TIU + TProcessing
    - TPSCell= TRRC\_delay + Tprocessing + Tsearch\_PSCell + T∆ + TPSCell\_ DU + TPCell\_DU+ Tmargin ms
    - Where TRRC\_delay = 20 ms, TPCell\_DU is the delay uncertainty due to PCell RACH preamble transmission defined in TS 38.213.
    - **For NE-DC to NE-DC, the delay of HO and PSCell addition:**
    - THO = TRRC\_delay + Tsearch\_PCell + Tprocessing + TIU + TPSCell\_DU + T∆ + Tmargin
    - TPSCell= TRRC\_delay + Tprocessing + Tactivation\_time + TE-UTRAN-PSCell\_ DU
    - Where TRRC\_delay = 16 ms, TPSCell\_DU is the delay uncertainty due to PSCell RACH preamble transmission defined in TS 38.213.
    - **For NR-DC to NR-DC (FR1+FR2 NR-DC), the delay of HO and PSCell addition:**
    - THO = TRRC\_delay + Tsearch\_PCell + Tprocessing + TIU + T∆ + Tmargin
    - TPSCell= TRRC\_delay + Tprocessing + Tsearch\_DU+ Tsearch\_PSCell + T∆ + TPSCell\_ DU + Tmargin ms
    - Where TRRC\_delay = 16 ms. Tsearch\_DU is delay uncertainty due to time tracking of PCell if targetCellSMTC-SCG is configured; Tsearch\_DU = 0 otherwise.
    - It should be noted Tprocessing depends on the conclusion of related issues.

## Sub-topic 2-3 Interruption requirement design of HO with PSCell

Open issues

**Issue 2-3-2a: Interruption requirements, similar as Tinterrupt for in legacy handover requirements, for HO with PSCell**

* Proposals
  + Option 1a
    - No new interruption requirement for HO with PSCell is needed. Interruption in legacy handover delay requirement can still be applied for the PCell HO.
  + Option 1b: (Xiaomi, Apple, Huawei, Qualcomm, vivo, Intel, OPPO, CATT, Ericsson)
    - Interruption in legacy handover delay requirement can be applied for PCell. No interruption is defined for PSCell.
  + Option 2
    - Other options are not precluded.

**Issue 2-3-2b: Interruption requirements on PCell/PSCell due to PSCell/PCell RF retuning**

* Proposals
  + Option 1 (Qualcomm, vivo, Intel, Ericsson)
    - No interruption requirement should be defined during HO with PSCell
  + Option 2 (Xiaomi, Apple, OPPO)
    - Interruption in legacy handover delay requirement can be applied for Pcell. No interruption is defined on PSCell.
      * If sequential processing is used for HO with PSCell, UE may have an interruption on new PCell due to the PSCell addition.
      * If parallel processing is used for HO with PSCell, no need to define interruption requirement.
  + Option 3 (Intel)
    - FFS.

## Sub-topic 2-4 Generic RACH assumption for HO with PSCell

Agreements during GTW session

* Continue discussion on RACH occasion on NR-U CC for HO with PSCell in RAN4 #101e
  + Prioritize EN-DC to EN-DC scenario
  + Companies are encouraged to provide inputs on the candidate requirements
  + FFS whether to introduce requirements

**Issue 2-4-1: 2 step and 4 step RACH for HO with PSCell**

* Proposals
  + Option 1a (ZTE, Nokia, vivo, CATT, Ericsson):
    - Include both 2-step RA and 4-step RA into the new requirements made for handover with PSCell. No need to mention 2-step or 4-step in HO with PSCell requirements.
  + Option 1b (ZTE, CATT, vivo):
    - RAN4 shall define delay requirements for HO with PSCell for both 2-step and 4-step RA. Impact on delay requirements depends on timeline with respect to parallel processing of RA.
  + Option 2 (Apple, Xiaomi, Qualcomm, OPPO, Intel, MTK):
    - For requirement of HO with PSCell, RAN4 starts the discussion with 4 step RACH first and FFS on 2 step RACH.
  + Option 3 (Qualcomm):
    - Define the ending points as Pcell PRACH and PSCell PRACH respectively by assuming 4-step RACH

**Issue 2-4-2: RACH occasion collision between Pcell and PSCell**

* Proposals
  + Option 1 (Apple, Ericsson, Huawei, vivo, CATT, Qualcomm):
    - for FR1+FR1 EN-DC, an additional uncertainty delay due to PSCell RACH collision with PCell UL channels may be introduced if the PSCell RACH cannot be transmitted based on the criteria in TS38.213 section 7.6.1;
    - for FR1+FR1 NE-DC, an additional uncertainty delay due to PCell RACH collision with PSCell RACH may be introduced if the PCell RACH cannot be transmitted based on the criteria in TS38.213 section 7.6.2;
    - otherwise, if target PCell and target PSCell are on the different FRs for EN-DC or NR-DC, no need to consider RO collision issue.
    - FFS how to capture the extra uncertain delay in spec.

**Issue 2-4-4: CSI-RS based CFRA**

* Proposals
  + Option 1 (Apple):
    - If CSI-RS based CFRA is used for RACH on PSCell, the additional CSI-RS measurement and the CSI-RS to RO association period shall be considered.
    - The baseline requirement of PSCell addition and handover when CSI-RS based CFRA is used could be discussed in TEI16.
  + Option 2 (vivo, Apple):
    - FFS
  + Option 3 (Qualcomm, Nokia, Huawei, Qualcomm, Ericsson):
    - Follow the same assumption as legacy HO requirements and do not need to discuss CSI-RS based CFRA
  + Option 4 (MTK):
    - Should not consider the Rel-16 feature

# References

[1] R4-2115396 Email discussion summary: [100-e][221] NR\_RRM\_enh2\_2, moderator(vivo)

[2] R4-2108045 WF on further RRM enhancement for NR and MR-DC – HO with PSCell, vivo, RAN4 #99-e

[3] R4-2105787 WF on further RRM enhancement for NR and MR-DC – Handover with PSCell, Apple, RAN4#98bis-e

[4] R4-2103673 WF on further RRM enhancement for NR and MR-DC – Handover with PSCell, Apple, RAN4#98-e