3GPP TSG-RAN WG2 #115-e Tdoc R2-21xxxxx

Electronic meeting, November 1th – November 12th 2021

Agenda Item: 8.13.2.1

Source: Ericsson

Title: [Post115-e][899][SON/MDT] Handover related SON aspects (Ericsson)

Document for: Discussion, Decision

# 1 Introduction

This document captures the outcome of this email discussion:

* [Post115-e][899][SON/MDT] Handover related SON aspects (Ericsson)

Scope:

Technical discussion rather than voting yes/no on FFS issues figured out so far and the timers of CHO context.

How to capture all the related agreements we got so far.

Intended outcome: Report

Deadline: until next meeting

Companies inputs to this email discussion are appreciated by the 18th October 2021 (EOB).

# 2 Discussion

## 2.1 CHO

### 2.1.1 “Time D” definition

RAN2 has agreed to include in the RLF-Report, associated to CHO, the following timer:

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| C | Time elapsed between the first CHO execution and the corresponding latest CHO configuration received for the selected target cell, i.e. timeSinceCHOReconfig. | Time of received CHO configuration | Time of CHO execution | Agreed in RAN2#112 |
| D | Time elapsed between CHO execution until the first HOF/RLF | Time of executing the first CHO | Time of first HOF/RLF | Agreed in RAN2#113 |

Related to timer D, it was debated in RAN2#115 how to capture it in the specification, and the following FFS was captured:

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| **From RAN2#115-e:**  FFS in the next meeting:  Proposal 1 RAN2 to select one of the following two options to represent Time D:  a. Option 1: The “Time D” is equal to the timeConnFailure, which is supposed to start at CHO execution and stop when the HOF/RLF occurs.  b. Option 2: The timeConnFailure is supposed to start at reception of the CHO configuration and stop when the HOF/RLF occurs. The “Time D” is equal to the difference between timeConnFailure and “Time C” |

Before discussing which option to select, Rapporteur would like to recap the definition of too early/too late HO according to the specification and the usage of timeConnFailure.

According to TS 38.300, the definition of the “too late/too early HO” and the associated detection mechansims are defined as follows:

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| **From TS 38.300:**  **Too Late/Too Early HO definitions:**  - Intra-system Too Late Handover: an RLF occurs after the UE has stayed for a long period of time in the cell; the UE attempts to re-establish the radio link connection in a different cell.  - Intra-system Too Early Handover: an RLF occurs shortly after a successful handover from a source cell to a target cell or a handover failure occurs during the handover procedure; the UE attempts to re-establish the radio link connection in the source cell.  **Too Late/Too Early HO detection mechanism:**  - Intra-system Too Late Handover: there is no recent handover for the UE prior to the connection failure e.g. the UE reported timer is absent or larger than the configured threshold (e.g. Tstore\_UE\_cntxt).  - Intra-system Too Early Handover: there is a recent handover for the UE prior to the connection failure e.g. the UE reported timer is smaller than the configured threshold (e.g. Tstore\_UE\_cntxt), and the first re-establishment attempt cell/the successful re-connect cell is the cell that served the UE at the last handover initialisation. |

The above detection mechanism described in the stage-2 specification implies that there are two scenarios when the timeConnFailure (included by the UE in the RLF report) is useful in classifying a HO:

1. When there is an RLF in the target cell due to “too late HO” triggered by the target cell
2. When there is an RLF in the target cell due to “too early HO” triggered by the source cell

So far, in case of RLF in the target, RAN2 understanding has been that the timeConnFailure (reported by the UE as part of the RLF-Report) is used by the network to evaluate whether an HO was a too late HO or a too early HO, as described above.

Companies are asked to confirm this assumption:

* **Q1: Given the above specified definitions of “Too Late/Early HO”, in case of RLF in the target do you agree that the timeConnFailure (included in the RLF-Report) is used by the network to evaluate whether an HO was a Too Late HO (triggered by the target cell) or a Too Early HO (triggered by the source cell)?**

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| **Company** | **Yes/No** | **Comments** |
| **Qualcomm** | NO (The current definition of too early or too late handover failure in TS 38.300 is provided in the context of legacy handover) | In CHO, a handover should be considered too late if UE has received the CHO configuration but is unable to execute due to improper configuration. Therefore, the evaluation mechanism for too late and too early needs to be modified considering CHO in TS 38.300. Furthermore, RAN3 has already agreed to extend the definition of early and late handover in R3-213180 as:  - Intra-system Too Late Handover: there is no recent handover for the UE prior to the connection failure e.g. the UE reported timer is absent or larger than the configured threshold (e.g. Tstore\_UE\_cntxt), or if CHO is configured but the CHO execution is not initiated for the UE prior to the connection failure, or if DAPS HO is configured but an RLF is detected in the source cell with successful DAPS HO.  - Intra-system Too Early Handover: there is a recent handover for the UE prior to the connection failure e.g. the UE reported timer is smaller than the configured threshold (e.g. Tstore\_UE\_cntxt), and the first re-establishment attempt cell/the cell UE attempts to re-connect is the cell that served the UE at the last handover initialisation or fall back to the source cell configuration in case of DAPS HO. |
| **Intel** | Yes or no | Not sure the intend of the question. Since CHO is a little different by nature compare to regular HO when the HO triggering (HO starts). In regular HO, HO starts at HO command sent to the UE by the network. In CHO, HO starts at HO execution when condition met. RLF report should evaluate the condition is execute too early or too late. But on the other hand, network resource is held starting from conditional HO reconfiguration in CHO, this time is also very important for network to evaluate how long the resource is held to particular UE. |
| **OPPO** | Yes | timeConnFailure should be used for evaluating the condition for too early or too late HO, regardless of CHO or legacy HO being applied/ |
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Companies are now asked to evaluate the impact on the Option 1 and Option 2 on the current legacy mechanism described above.

In particular, in the email discussion during RAN#115-e [1], it was discussed whether the two proposes options still allows the network to make proper use of the timeConnFailure to classify the RLF as we did in the legacy. The scenario considered was the one in Figure 1 below.



Figure 1: Comparison between Option 1 and Option 2 for the "Time D".

**Description of scenario in Figure 1:** The UE receives and ordinary HO command for HO from cell A to cell B. The UE moves in cell B and it receives a CHO configuration. However, before executing the CHO to cell C, the UE experiences an RLF, and as a consequence it logs the RLF-Report.

* Implications of Option 1 in the scenario in Figure 1: Option 1 assumes that the time D starts at CHO execution. Hence, when the UE experiences an RLF in cell B before the CHO execution, the timeConnFailure associated to the previous HO is still up and running. It will then represent the time elapsed since the HO command execution in cell A until the RLF in cell B. Once the RLF-Report is retrieved, the network can use this timeConnFailure as in legacy operations, i.e. to evaluate whether the HO from cell A to cell B was “too early” or if the cell B was “too late” with the HO.
* Implications of Option 2 in the scenario Figure 1: In Option 2, the timeConnFailure is started at reception of the CHO configuration. This implies that the previous timeConnFailure that was started at HO from cell A to cell B is overwritten. Hence, when the RLF occurs in cell B, the UE only includes the timeConnFailure started at CHO configuration. Once the RLF-Report is retrieved, the network may not know how to interpret the value of timeConnFailure and to properly use it for the “too early/too late” evaluation as it happens in legacy. For example, cell A, i.e. the previous PCell, does not know that the UE was configured with CHO at the time of RLF, hence it will think that the timeConnFailure represents the time since the HO from cell A to cell B, but in fact the UE had restarted the timeConnFailure and hence in reality it would represent the time since the CHO configuration reception.

Taking the above scenario into account and the legacy definitions of too Early/Late HO, as well as the usage of timConnFailure as per Q1, companies are now asked to describe their concerns on the Option 1 and 2.

* **Q2: In case Option 2 is adopted, which concerns do you have?**
  + **A:** The legacy usage of timeConnFailure as described in Q1 is affected, because the interpretation of timeConnFailure would become ambiguous, and hence erroneous HO failure classifications may occur, i.e. the previousPCell (which could be a legacy PCell) will think that the timeConnFailure represents the time since the HO from cell A to RLF in cell B, but in fact this is wrong because the UE restarted the timeConnFailure at reception of CHO configuration.
  + **B:** None. Please motivate your reply.
  + **C:** Other. Please motivate your reply.

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| **Company** | **A/B/C** | **Comments** |
| **Qualcomm** | B | Consider a scenario in legacy HO:  UE has received the configuration in cell A perform successful HO to cell B receives a new configuration for performing HO to cell C (just after successful completion of Handover). Once the new configuration is received the reference point is shifted to the time/event of reception of the new RRCReconfig.  We should follow the same/similar mechanism. Once the new configuration is received UE is expected to evaluate and perform the handover. If the UE is unable to perform the HO, then that implies the CHO configuration is inappropriate and needs to be optimized. |
| **Intel** | C | Option 2 provides the time when CHO configuration to the UE (similar to HO command in legacy) until RLF. This is the amount of time where the network reserves the resource to the UE. The network may not know when the UE condition met to trigger HO happens. I guess this is what E/// concerns as to compare to too early HO or too late HO configuration. |
| **OPPO** | A | We agree that overwriting the timeConnFailure is a critical problem that should be avoided. Also, the scenario given in the figure is not a corner case, which could happen in e.g., highway mobility sceanario. |
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* **Q3: In case Option 1 is adopted, which concerns do you have? Please motivate your reply.**

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| **Company** | **Comments** |
| **Qualcomm** | It breaks the framework and creates more confusion in the process of evaluation. It will make it unclear when the handover process should be considered too late. For example, if UE receives the configuration in cell B but didn’t execute the configuration for a long duration and RLF happens at cell B. Then, we will not optimize CHO configuration considering too early Handover. In my understanding, if a new configuration is received then we should optimize the configuration such that CHO is performed in a timely fashion. |
| **Intel** | Option 1 report the time where the CHO execution to RLF. Network will not have the time CHO is sent to the UE til CHO execution. This time is part of the total time network reserve the resource to the UE. It is as important for network to lean for adjusting measurement event configuration. |
| **OPPO** | Respond to Intel: RAN2 has agreed to include the time CHO is sent to the UE til CHO execution into the spec, as follows:  RAN2 #112e agreements:  The following time information is as part of the UE RLF report:  Time between the first CHO execution and the corresponding CHO command received at UE at least in the CHO failure case.  This might could address Intel’s concern. |
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Companies are now asked to express their preference on Option 1 or 2:

* **Q4: Which option do you prefer to represent the Time D?**
  + **Option 1:** The “Time D” is represented via the timeConnFailure, which is supposed to start at CHO execution and stop when the HOF/RLF occurs.
  + **Option 2**: The timeConnFailure is supposed to start at reception of the CHO configuration and stop when the HOF/RLF occurs. The “Time D” amounts to the difference between timeConnFailure and “Time C”.

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| **Company** | **Option 1/2** | **Comments** |
| **Qualcomm** | Option 2 | See above arguments. |
| **Intel** | Option 2 | We think that the resource reservation aspect is important for the network as well as the time from network sending CHO configuration to RLF is more align with legacy handover. |
| **OPPO** | Option 1 | As addressed in Q2 |
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### 2.1.2 CHO indicator in case of RLF in target cell after HO

Some contributions submitted to previous RAN2 meetings highlighted that a HO indicator can be used in case of RLF in a target cell after a CHO. This HO indicator would indicate whether the last HO was a CHO or an ordinary HO.  
The reasoning for this proposal would be that the CHO parameters for HO to this target cell might be different than the ordinary HO parameters for the same target cell. Hence the network may use this information to tune the CHO or the HO parameters accordingly, depending on whether the last HO was a CHO or ordinary HO.

Note that the network may not have other ways to retrieve this information implicitly from the RLF-Report, because at the time of RLF in target cell the UE does not have available anymore the CHO configuration previously provided by the source cell, e.g. the UE cannot include in the RLF-Report the information on the candidate cells (as instead it will happen for the HOF case).

* **Q5: Do you believe that it is beneficial to include in the RLF-Report an indicator indicating whether the last executed HO before the RLF in the target cell was a CHO HO?**

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| **Company** | **Yes/No** | **Comments** |
| **Qualcomm** | No | Don’t see a use case. |
| **Intel** | No | We don’t see a strong need for it. |
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### 2.1.3 Other issues on CHO

* **Q6: Is there any other issue/enhancement related to CHO that you would like to discuss?**

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| **Company** | **Issue** | **Comments** |
| **Qualcomm** | No |  |
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## 2.2 DAPS

The following agreements about DAPS were reached in the last RAN2#115-e meeting:

**Agreements on DAPS from RAN2#115-e:**

1 In case the RLF occurs in source cell after fallback, the timeConnSourceFailure is used to represent the time elapsed between the DAPS HO execution and the RLF in the source.

2 For the case of HOF while performing DAPS HO followed by a fallback to the source cell, following signalling is applied: The detailed handover failure related information are included in the RLF-Report and this RLF report can be fetched like any other RLF report.

The legacy timeConnFailure can be reused to represent in the RLF report the scenario of DAPS HOF or RLF in target cell (after DAPS HO).

3 For the case of RLF in source cell while performing DAPS HO (i.e. before fallback), the follow time information is included in the RLF-Report:

a. timeConnSourceFailure: The time elapsed since DAPS HO execution until RLF occurs in source cell while performing DAPS HO before the fallback

4 The RLF report is used to log the failure related measurement in these scenarios:

a. Failure at the source (RLF) while performing access to DAPS target cell and failing to access the target (HOF)

b. Failure at the target cell (HOF) and failing to perform fallback (RLF at source)

FFS in the next meeting:

Proposal 3 Include a DAPS HO indicator in the RLF-Report, in case the RLF occurs in the target cell after a DAPS HO

### 2.2.1 DAPS HO indicator in case of RLF in target cell after HO

Related to the FFS highlighted above, in the email discussion during RAN2#115-e [1] it was discussed the benefits of including the DAPS HO indicator in the RLF-Report. Supporting companies claimed that the network cannot know that the last performed HO was a DAPS HO or an ordinary HO, hence obtaining this information can be beneficial for the network to optimize HO parameters, especially if the configuration of DAPS HO parameters is different from the configuration of the ordinary HO parameters.

* **Q7:** **Do you believe that it is beneficial to include in the RLF-Report an indicator indicating that the last executed HO before the RLF in the target cell was a DAPS HO?**

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| **Company** | **Yes/No** | **Comments** |
| **Qualcomm** | No | We have introduced the timeConnSourceFailure report time since reception/execution of DAPS HO until RLF at the source. In scenarios, where have RLF happens at the source, this timer can be indicative of DAPS HO.  One scenario, I can think where I the network cannot determine the above scenario if the timeConnFailre is set as NULL, i.e. no RLF at the source. However, we can optimize this timeConnSourceFailure and set this timer value as 0 indicative that DAPS HO was configured prior to RLF at target after successful HO. |
| **Intel** | No | We don’t see a strong need for it. |
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### 2.2.2 Other issues on DAPS

* **Q8: Is there any other issue/enhancement related to DAPS that you would like to discuss?**

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| **Company** | **Issue** | **Comments** |
| **Qualcomm** | No |  |
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## 2.3 Successful HO Report (SHR)

The following agreements and FFS were captured in RAN2#115-e about SHR:

**From RAN2#115-e**

Agreements:

1: Define separate thresholds for T310/T312/T304, and the percentage values are 40%, 60%, 80%. The percentage is to indicate the ratio of the threshold value (unit: ms) over the signalled T310/T312/T304 value (unit: ms).

1a: For threshold for T312, the percentage value also includes 20%.

2: For the thresholds of T310/T312 in the source cell, the source cell configures the values. FFS source cell or target cell can configure the threshold for T304.

3: Introduce a UE capability indication for SHR.

4: The UE may discard the SHR, i.e. release the UE variable VarSuccHO-Report, 48 hours after the SHR is stored.

### 2.3.1 T304 configuration

Related to T304 configuration, in the email discussion [3], some companies indicated that T304 pertains to the target cell and it is provided to the UE by the target cell via the HO command. Hence, some companies are proposing that the threshold on T304 for the SHR configuration should be provided by the target cell.

* **Q9: Should the target cell configure the value of the T304 threshold to be provided in the SHR configuration?**

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| **Company** | **Yes/No** | **Comments** |
| **Qualcomm** | No strong opinion |  |
| **Intel** | Yes | Seem reasonable. |
| **OPPO** | No | T304 threshold for the SHR configuration is not necessarily related to the T304 absolute value set by the target cell. SHR is for source cell to optimize itself handover performance, so it is better for the source cell to set the T304 threshold. Source cell could choose any value between 0 and T304 value given by the target cell for setting the T304 threshold for triggering SHR. |
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### 2.3.2 RA-InformationCommon in SHR

In the email discussion [3], it was also discussed whether/when to include the RA information in the SHR. Since there was no clear consensus on how to proceed, Rapporteur proposes to further discuss this issue. In particular, some companies believe that the RA-InformationCommon should always be included in the SHR, whereas some others believe that it should be included only if the SHR is triggered due to certain conditions, e.g. T304 above the configured threshold.

* **Q10: Should the RA-InformationCommon be included in the SHR?**
  + **A:** Yes, always. Irrespective of the fulfilled triggering conditions.
  + **B:** Yes, but only in case the SHR is generated due to T304 above the threshold
  + **C:** No, never.
  + **D:** Others. Please explain the scenario in which RA-InformationCommon should be included

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| **Company** | **A/B/C/D** | **Comments** |
| **Qualcomm** | C | Already part of RA-report. No need to duplicate it. |
| **Intel** | C | Network should have this information |
| **OPPO** | B and D | It should be noted that SHR generation does not necessarily imply RACH problems. The SHR generation could be due to other reasons such as T312 exceeding configured value. Hence, we should restrict the cases when including the RACH information into the SHR report, for avoiding unnecessary signalling/storing overhead  Besides T304, another condition triggering including the RA-InformationCommon could be pre-configured dedicated RACH resource is not used and the UE is forced to use the CBRA for HO. Source gNB could use such information (e.g., ssb-index-r16) for more proper dedicated RACH resource configuration. |
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### 2.3.3 RLF-Report and SHR after the same HO

According to the Rapporteur, another relevant issue discussed in [3] is how to deal with scenarios in which the UE generates both an RLF report and HO success report associated to the same HO. This can happen for example, in case the UE successfully completes an HO to a target cell (upon which it generates an SHR), and slightly after an early RLF is detected in the target (upon which an RLF Report is generated).

The concern is that the RLF-Report and the SHR for the same target cell may be fetched separately by the network. For example, the RLF-Report may be feched by a Rel.16 gNB, but the SHR can only be fetched by a Rel.17 gNB. Hence the source gNB of this HO may receive the SHR and the RLF-Report separately (at different points in time) and it may not be able to correlate that this SHR and this RLF-Report are in fact associated to the same HO. Hence the source gNB may change the HO parameters twice (once after RLF-Report reception, and once again after SHR reception).

Companies are asked to provide their view on whether the above is an issue or not, and also to provide solutions (if any) to it.

* **Q11: Do you believe that fetching separately (at different points in time) the RLF-Report and the SHR associated to the same HO may cause issues at network side, e.g. the source gNB changing the HO parameters twice? Please motivate your answer and also provide your solution (if any) on how to fix this issue.**

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| **Company** | **Yes/No** | **Comments** |
| **Qualcomm** | No | I do not see any issue with this. The two reports have different optimization objectives. For example, even if the RLF happens after successful completion of the handover, then the lower layer parameters need to be optimized considering the CHO report. If CHO is extracted by the target cell and reported to the source, then the source can implement optimization of the lower layer. When the RLF report is received by another cell, it will be forwarded to the source to implement optimizations related to the selected target cell and others.  As the two reporting has different optimization objective, we don’t see any issue with the reports being fetched separately.  If the SHR is not fetched by the target cell and RLF happens at the target then UE should be allowed to throw out the SHR report to avoid wastage of UE memory. |
| **Intel** | No | I think this is related to network implementation issue. Network can resolve this base on the time stamp. |
| **OPPO** | No | Maybe only a implementation issue. Details could be further discussed in the next meeting. |
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### 2.3.4 SHR for early HO right after successful HO

Still in the email discussion [3], it was discussed whether to adopt the SHR in other scenarios. In particular, it was discussed the scenario in which a UE performs a successful HO upon which it generates an SHR. However, it can happen that after this successful HO the UE is handed-over to another cell or to the PCell, e.g. in case of ping-pong between source cell and target cell.

* **Q12: Should the SHR include information on whether the UE is handed-over to another cell early after the successful HO?**
  + **A:** Yes, but only in case there is an early HO back to the source cell after the successful HO (ping-pong effect)
  + **B:** Yes, whenever there is an early HO right after the successful HO
  + **C:** No, never.

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| **Company** | **A/B/C** | **Comments** |
| **Qualcomm** | C | It comes under the domain of RLF. SHR shouldn’t consider this. IF a handover fails early UE should discard SHR. |
| **Intel** | C | Agree with QC |
| **OPPO** | C | SHR report should be only generated at one single time moment (complete of the HO). It will bring more complexity to UE if more contents are allowed to be included in the SHR report afterwards. |
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### 2.3.5 UP measurements

Related to UP measurements, the following agreement and FFS was captured in RAN2#115e:

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| **From RAN2#115-e:**  1 UP measurements for Successful Handover Report will be introduced as RAN3 required. FFS the details |

Given the above FFS, Rapporteur proposes discussing which UP measurements should be considered relevant during an HO procedure.

In the following, it is a list of possible UP measurements and related definitions. Companies are invited to review the below list and include (if needed) additional UP measurements.

1. **User plane interruption at handover, as evaluated at MAC layer**

Definition: Time between the reception of the first packet from the target cell and the time of reception of last packet from the source cell, measured at the time of reception of the first packet from the target cell.

Usefulness: This measurement indicates the actual performance of the handover in terms of whether the UE experienced any DL UP delay or not as measured at lower layers.

1. **User plane interruption at handover, as evaluated at PDPC layer without considering duplicates**

Definition: Time from the last packet received from the source and the first non-duplicate packet received from the target, measured at the time of reception of the first non-duplicate packet from the target cell.

Usefulness: Unlike A), this measurement represents the time without new packets being forwarded to upper layers. Hence, it indicates the actual interruption perceived by upper layers in the UE.

1. **Number of duplicated packets received from source and the target cell during the DAPS HO**

Definition: The number of packets that were sent both from the source cell and the target cell while performing the handover

Usefulness: The source may not know if the same PDCP PDU has been received successfully by the UE from both source and target. For example, if the amount of successfully received duplicates from source and target is very high, the source may decide to trigger a DAPS HO a bit later or reduce duplicates’ generation, in order to reduce radio resource consumption and UE burden

1. **Others. Please describe possible UP measurements and provide description on the “definition” and “usefulness”.**

* **Q13: Which of the above UP measurements should the UE include in the SHR?**

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| **Company** | **A/B/C/D** | **Comments** |
| **Qualcomm** | **B** | In my understanding, only B matters. The network knows what is the first sequence number it has forwarded to both MN and SN and the last sequence number it has forwarded to both MN and SN. Therefore, to optimize the no of duplicated packets or reduce the user plane interruption (where the definition in B should be followed instead of A). |
| **Intel** | B | Base on RAN2 agreement: Mobility interruption time means the shortest time duration supported by the system during which a user terminal is not able to exchange user plane packets with any base station during transitions. Therefore, option B seems more suitable. |
| **OPPO** | A or B | We doubt the usefulness of C. The amount of successfully received duplicated packets is different for different data services being used during handover. Suppose A is doing internet surfing, and B is doing data downloading. In such cases, their amount of successfully received duplicated packets during the DAPS HO is totally different, but they all require demands of no-interruption data transmission service. It is difficult for the network to optimize the DAPS HO triggering with only data packet transmission information. |
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### 2.3.6 Other issues on SHR

* **Q14: Is there any other issue/enhancement related to SHR that you would like to discuss?**

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| **Company** | **Issue** | **Comments** |
| **Qualcomm** | No |  |
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# 3 Conclusion

To be updated later….

# 4 References

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