3GPP TSG-RAN WG2 Meeting #100 **R2-1714208**
Reno, US, 27th Nov – 1st Dec 2017

Agenda Item: **10.4.1.3.1**

Source: **Ericsson**

Title: **OFFLINE#22 LTE re-establishment and resume while using NR PDCP (Ericsson)**

Document for: **Discussion, Decision**

1 Introduction

The issue of LTE re-establishment in case NR PDCP was configured for some bearers (either in EN-DC or standalone LTE) was discussed, and the outcome was:

R2-1713388 LTE re-establishment when using NR PDCP (TP to 36.331 and 38.331) Ericsson discussion Rel-15 NR_newRAT-Core

- Lenovo think this reduces the chances to successfully re-establishment. Ericsson think in this case it would result in extra reconfiguration when the cell does support NR PDCP.
- IDC think the common case is reestablishment to a cell that does support NR PDCP.
- Intel wonder why reject is needed and full configuration is not used.
- HTC think that full configuration is not possible in the re-establishment , it can only be done in the first reconfiguration.
- OPPO think this proposal has some benefit when the cell supports EN-DC.

=> Offline discussion to progress the SRB1 issue to ensure that the mechasism works when the UE attempts to re-establish on an eNB that supports EN-DC, and when the UE attempts to re-establish on a a legacy eNB that has the context but can not understand the full context. (Offline discussion #22, Ericsson)

Agreements

1 For re-establishement in LTE, UE releases the lower layer SCG configuration (i.e. nr-secondaryCellGroupConfig) at RRC re-establishment while the DRB configuration (incl. the NR PDCP configuration received in radioBearerConfig) is kept.

The issue of NR PDCP version preservation during LTE suspend/resume was also discussed:

R2-1713399 Discussion and TP on preserving NR PDCP version Ericsson discussion Rel-15 NR_newRAT-Core

- OPPO think this should be discussed together with re-establishment. Samsung have the same view.
- Ericsson think this case is different as an additional reconfiguration is not always needed but if we change to LTE PDCP then an extra reconfiguration step will be needed
- Intel think this case has the same issue with legacy eNBs as the re-establishment.
- LG think this requires that all cells in the resume area will have to support NE-DC and NR PDCP.

=> Can be discussed within the scope of offline discussion #22

The purpose of this offline is:

- discuss the different ways of performing re-establishment in cases where NR PDCP was used for SRB1, and to agree on a solution that works for both re-establishment in EN-DC capable as well legacy eNBs.
- discuss the different ways of performing the resume operation in cases where NR PDCP was used for SRB1 and/or any other radio bearers

2 Problem description

2.1 LTE re-establishment procedure

The purpose of the LTE re-establishment procedure is to re-establish the RRC connection upon detecting radio link failure, handover failure, mobility from E-UTRA failure, integrity check failure on SRBs or RRC connection reconfiguration failure. Re-establishment involves the resumption of SRB1, the re-activation of security and the configuration of only the PCell (i.e. CA or DC operations are not re-established)

When the target eNB get a re-establishment request, it identifies the source eNB/cell from the *ReestabUE-Identity* included in the request, and can send an *RLF Indication* X2 message to the source eNB. The source eNB may respond with a Handover Request message that includes the UE context (RRC context and S1 context). If the target eNB is able to understand the UE context, re-establishment succeeds and the target sends an *RRCConnectionReestablishment* message to the UE. If the target does not receive the UE context or it doesn't understand the context, it may reject the re-establishment and the UE has to go to RRC_IDLE to re-connect. If the target doesn't understand the RRC context but can understand the S1 context, it doesn't necessarily should reject the re-establishment and can use still respond with *RRCConnectionReestablishment* and later use full reconfiguration to reconfigure the bearers based on the S1 context.

In case of re-establishment success, SRB1 operation resumes while the operation of other radio bearers (SRB2 and DRBs) remains suspended. If AS security has not been activated, the UE does not initiate the procedure but instead moves to RRC_IDLE directly.

E-UTRAN applies the re-establishment procedure as follows:

- When AS security has been activated:
  - to reconfigure SRB1 and to resume data transfer only for this RB;
  - to re-activate AS security without changing algorithms.

After this, the UE sends the *RRCConnectionReestablishmentComplete* message, and the target eNB responds by sending an *RRCConnectionReconfiguration* message to reconfigure SRB2 and the DRBs.

The RRC connection re-establishment procedure flow is shown in Figures 1 (success case) and Figure 2 (failure case). SRB0 is used for sending the *RRCConnectionReestablishmentRequest*, *RRCConnectionReestablishment* and *RRCConnectionReestablishementReject* messages, while *RRCConnectionReestablishmentComplete* uses SRB1.

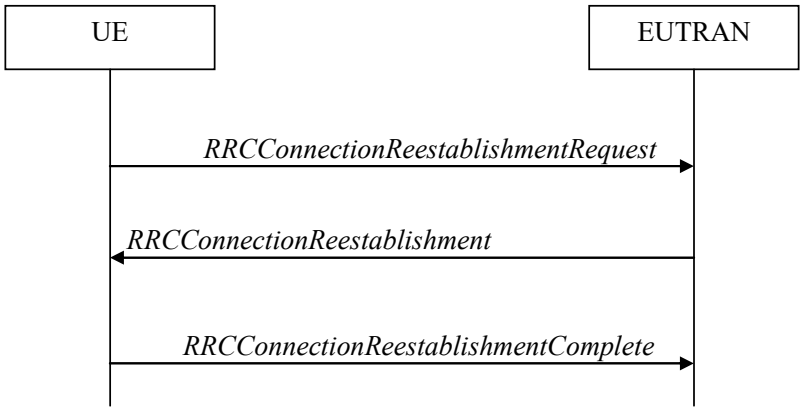

Figure 1: RRC connection re-establishment, successful

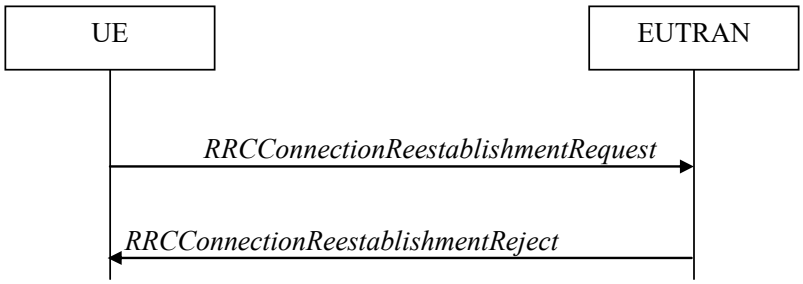

Figure 2: RRC connection re-establishment, failure

2.2 LTE Suspend/Resume procedure

The RRC suspend/resume functionality has been introduced in LTE rel-13. A suspended UE can be considered to be in an intermediate state between IDLE and CONNECTED, where the UE AS context is kept both at the UE and RAN, and the UE can be seen as if it is in connected mode but suspended from the CN point of view and in IDLE mode from the RAN point of view. The advantage of operating in this mode is reduced signaling and faster transition to CONNECTED mode as compared to legacy IDLE-CONNECTED mode transitions, while maintaining the UE power saving advantages of IDLE mode.

When a decision is made by the network to move the UE to suspended state, the eNB sends the UE an *RRCConnectionRelease* message with the release cause value of *rrc-suspend* and it is also provided with a *Resume ID.* The UE stores the ID and UE AS context (including the current RRC configuration, the current security context, the PDCP state including ROHC state, C-RNTI used in the source PCell, the cellIdentity and the physical cell identity of the source PCell;); re-establishes all RLC entities (both for SRBs and DRBs); and suspends all DRBs and SRBs expect SRB0.

When the UE later on wants to resume the connection (in response to an UL data to be sent or a paging request for DL data), it sends an *RRCConnectionResumeRequest* message with the saved *Resume ID.* If the resume operation is performed in an eNB other than the eNB that was serving the UE when the UE was suspended, the new eNB can perform a context fetch by using the *Retrieve UE Context* X2 procedure from the old eNB (as the Resume ID includes information about the old eNB/cell). Upon getting the context (if resuming on a new eNB) or if the resumption was in the same eNB, the target eNB responds with an *RRCConnectionResume* message, and both the UE and eNB restore the saved UE context, and data transmission/reception from/to the UE can be resumed.

The RRC connection resume procedure flow is shown in Figures 3 (success case), Figure 4 (fallback to RRC connection establishment) and Figure 5 (network reject or release) show the resume procedure in LTE. SRB0 is used for sending the *RRCConnectionResumeRequest*, *RRCConnectionSetup* and *RRCConnectionReestablishementReject*, while *RRCConnectionResume and RRCConnectionResume Complete* messages use SRB1.

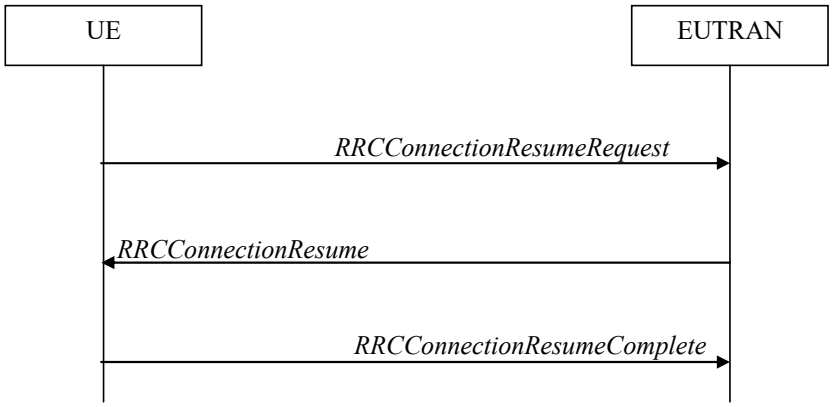

Figure 3: RRC connection resume, successful

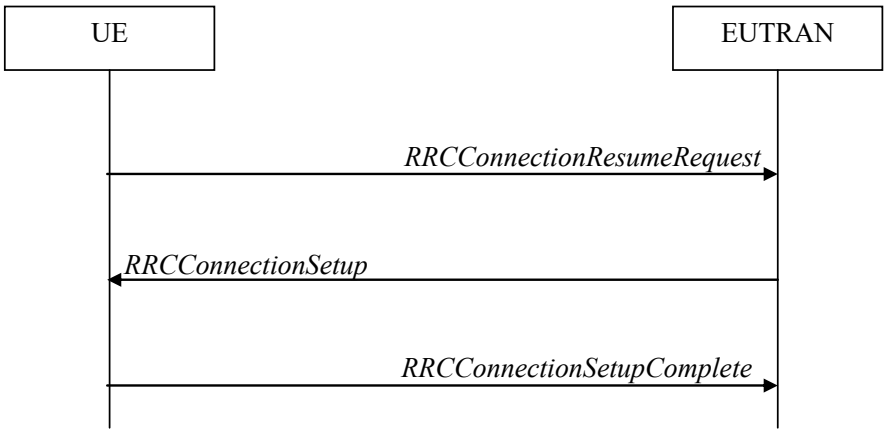

Figure 4: RRC connection resume fallback to RRC connection establishment, successful

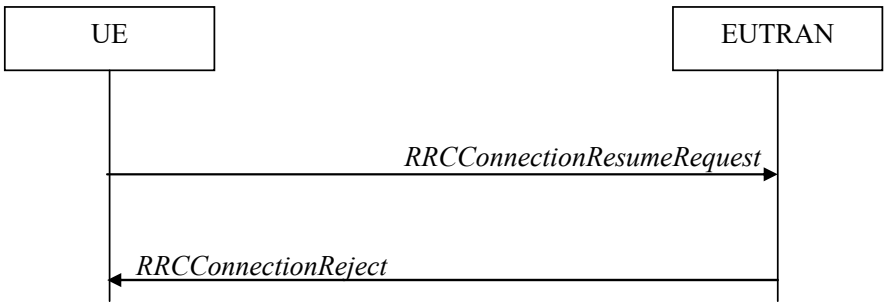

Figure 5: RRC connection resume, network reject or release

The main difference between resume and re-establishment are (from procedural perspective):

- SRB1 is used for the *RRCConnectionResume* message, while SRB0 is used for the *RRCConnectionReestablishment* message
- The *RRCConnectionResume* message, unlike the *RRCConnectionReestablishement* message, can contain the SRB2/DRB configuration, and thus *RRCConnectionReconfiguration* is not needed after resume (while it is necessary in the re-establishment case to reconfigure SRB2/DRBs)

2.3 Re-establishment in case NR PDCP was used

If the source eNB is EN-DC capable, it is possible that SRB1 (and other RBs) was configured with NR PDCP (even if the UE was not in EN-DC). This may cause problems if the target eNB is a legacy eNB. The table below illustrates the problem.

Table 1: Different cases of PDCP version usage for SRB1 and support of NR PDCP at the source and target eNBs

		Source eNB = legacy Target eNB = legacy	Source eNB = legacy Target eNB = NR capable	Source eNB = NR capable Target eNB = legacy	Source eNB = NR capable Target eNB = NR capable
SRB1 uses LTE PDCP		A	B	C	D
SRB1 uses		Not applicable	Not applicable	E	F

NR PDCP					

For cases A to D, there will be no issue because LTE PDCP is used for SRB1, and both source and target eNBs understand that. Case F is also OK because both source and target are EN-DC capable.

In Case E, if the UE resumes with re-establishing SRB1 with NR PDCP, then RRC communication with the the target will not be possible (even the *RRCConnectionReestablishmentComplete* message can't be received at the target eNB). The target eNB's behaviour is also not clear upon getting a UE context that it (partially) doesn't understand.

2.4 Resume in case NR PDCP was used

The different cases of table 1 are still relevant in the resume case. But there are two major differences to consider:

- SRB1 is used for the Resume message, so if both the UE and the target eNB use the same PDCP version, even the Resume message may not be understood by the UE.
- No RRCConnectionReconfiguration after resume is required (i.e. Resume message contains radio resource configuration)

3 Possible solutions

3.1 Re-establishment

During the online discussion and offline discussion with some companies afterwards, several ways of solving the problem were identified:

Solution 1: UE always falls back to using LTE PDCP on re-establishment

- If target eNB doesn't support EN-DC, and it doesn't understand the RRC Context, it will use the S1 context to do full reconfiguration of the bearers
- If target eNB supports EN-DC, the target will first setup SRB1 with LTE PDCP, and can use the *RRCConnectionReconfiguration* message to revert the PDCP of SRB1 back to NR.

Solution 2: target eNB supporting EN-DC includes a flag in *RRCConnectionReestablishment* that indicates that it can support EN-DC

- If UE gets such an indication, it uses the same PDCP version that it was using before failure
- If UE doesn't get such an indication, UE falls back to using LTE PDCP

Solution 3: UE re-establishes using the same PDCP version that it was using before failure

- If target eNB doesn't support EN-DC, and it doesn't understand the RRC context, it will reject the re-establishment; or
- If source eNB knows that the target eNB doesn't support EN-DC, it will not forward the UE context to the target (i.e. it will not respond with Handover Request upon getting RLF indication), forcing the target eNB to reject the re-establishment.

Solution 4: UE determines which PDCP is used for re-establishment procedure using "nr-Indication" in SIB.

Solution4a: UE determines which PDCP is used for re-establishment procedure using one new indication (eNB support NR PDCP) in SIB2/3.

Solution 5: The SRB1 is reverted to LTE PDCP upon initiation of re-establishment

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