Inter-RAT handover (E-UTRAN to UTRAN)

Computer Networks module - LTE assignment

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Spring term 2018

Assessment Feedback					
Aspect (& weighting)	Excellent	Very Good	Satisfactory	Needs some more work	Needs much more work
Content					
Critical Analysis					
Structure					
Referencing					
Presentation + Discussion					
Specific aspects of the assignment that the marker likes:		Specific aspects of the assignment that need more work:			
Tutor's Signature:		Date:		Grade	

1 Introduction

The intra-RAT handover from E-UTRAN to UTRAN is composed of two phases: the preparation phase and the execution phase. Both the phases involve either LTE nodes and UMTS node. In particular, the LTE nodes involved are the eNodeB, E-UTRAN, and the MME, the S-GW and the P-GW. The first cited node belongs to the E-UTRAN while the others belong to the core network. The UMTS nodes are instead the RNC, the SGSN,

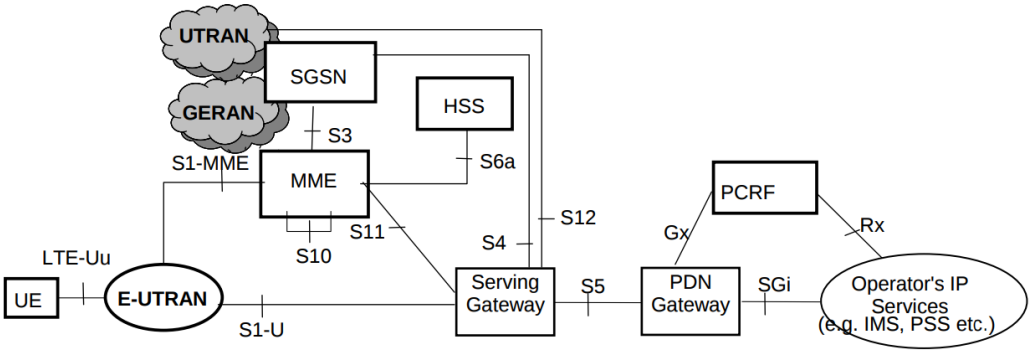


Figure 1: Architecture referece model (non-roaming architecture for 3GPP accesses)

2 Preparation phase

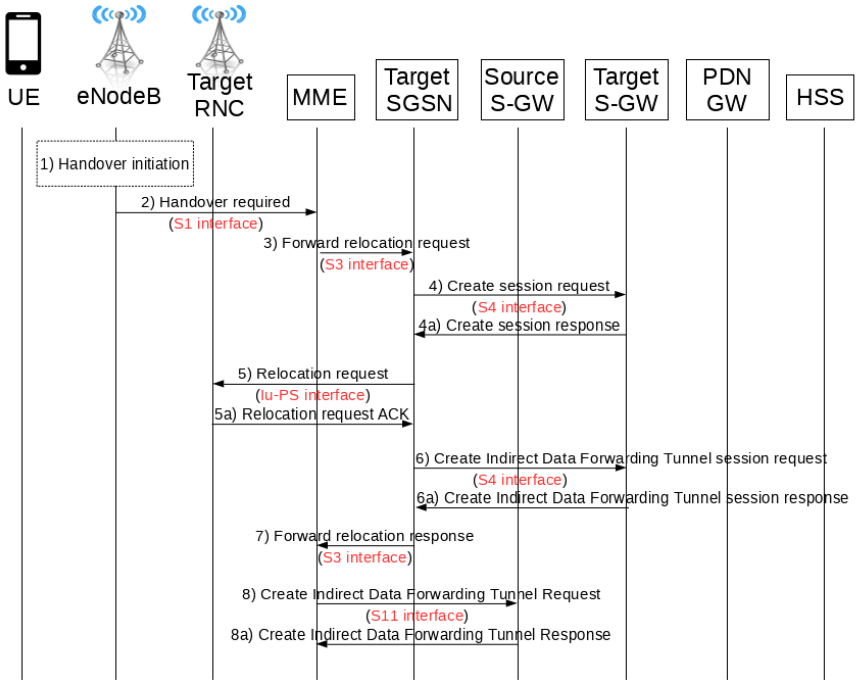


Figure 2: the flow of the messages and the nodes involved in the handover preparation phase

Step 1

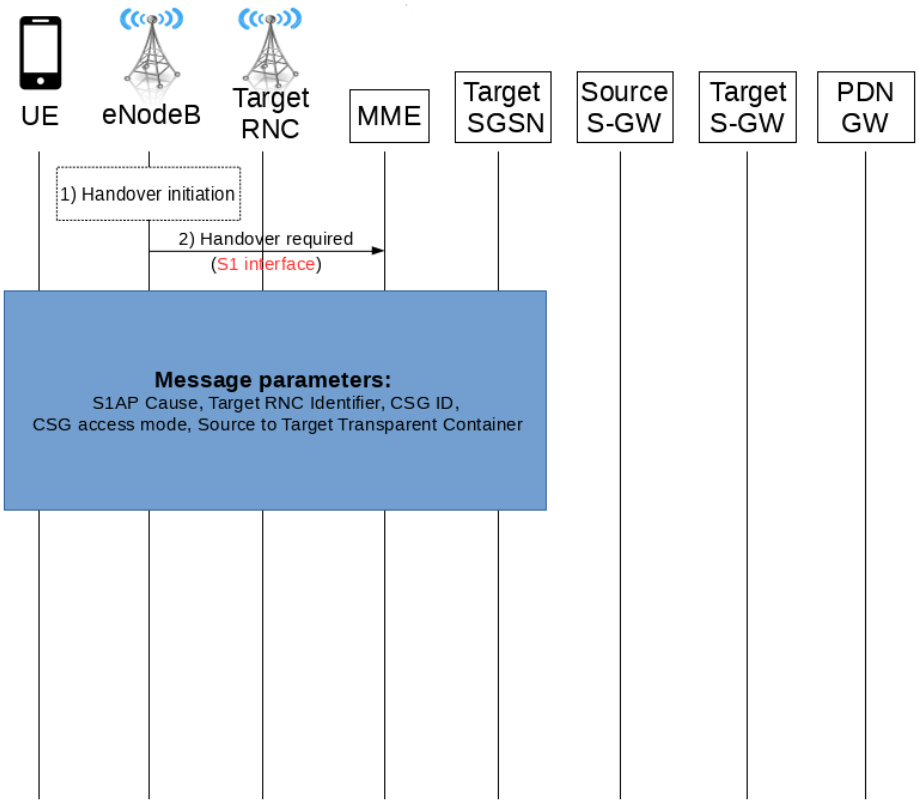
The source eNodeB decides to initiate an Inter-RAT handover to thetarget access network.

Note that at this point both uplink and downlink user data is transmitted through:

- Bearer(s) between UE and source eNodeB
- GTP[1] tunnel(s) between source eNodeB, Serving GW and PDN GW.

[1]GPRS Tunneling protocol (GTP) is a IP/UDP based protocol used to encapsulate user data when passing through core network (GTP-U) or to carry bearer specific signalling traffic between various core network nodes (GTP-C).

Step 2

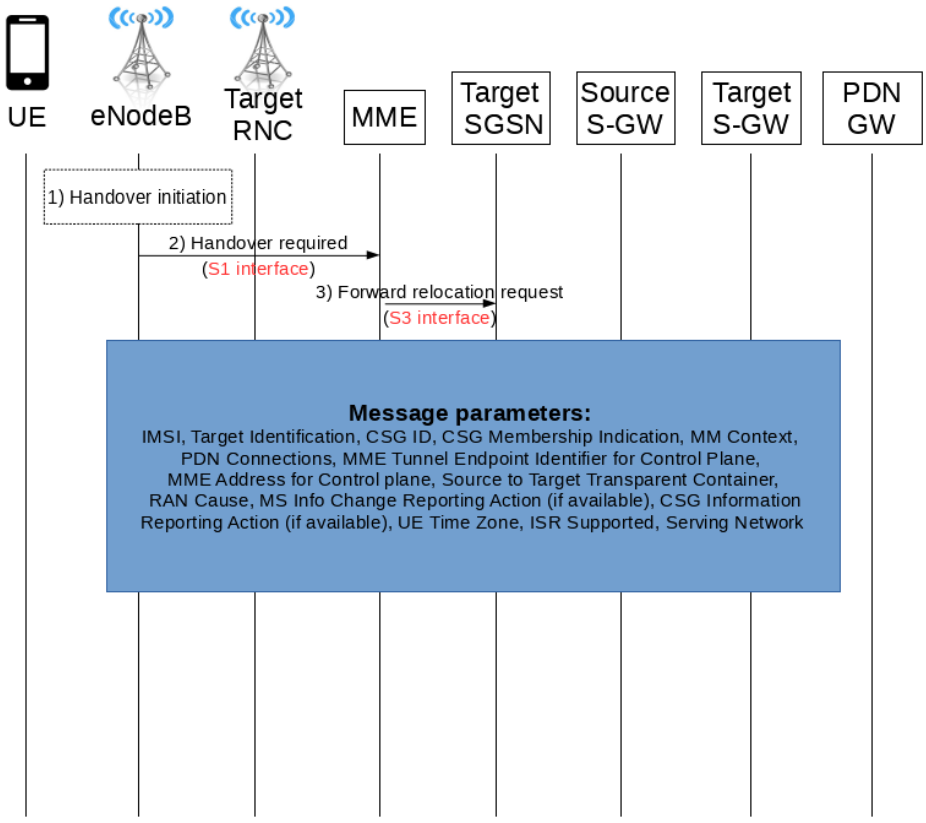


The source eNodeB sends a *Handover Required* message to the source MME, requesting the CN to establish resources in the target RNC, target SGSN and the Serving GW. The message is sent through the S1 interface and it contains the following parameters:

- S1AP Cause: it specifies the reason of the message
- Target RNC Identifier: it identifies the target RNC
- CSG access mode: included only if the target cell is a hybrid cell
- CSG ID: included only if the target cell is a CSG[2] or hybrid cell, it identifies the cell
- Source to Target Transparent Container: it carries RRC parameters and Radio Bearer information

[2]CSG = closed subscriber group of a home eNodeB

Step 3



The source MME determines from the "Target RNC Identifier" field that the type of handover is intra-RAT Handover to UTRAN Iu mode and, if the CSG ID is included in the message, it checks the UE's CSG subscribtion. If the UE isn't subscribed to the CSG, then the MME rejects the handover, unless the UE has emergency bearer services ongoing (in this case the handover to the target RNC is performed independent of the restrictions). If the handover isn't rejected then the MME selects the target SGSN and sends to it a *Forward Relocation Request* message through the S3 interface. Some of the parameters included in this message are:

- user IMSI
- ISR Supported: it indicates if the source MME and the source S-GW are able to activate ISR[3]

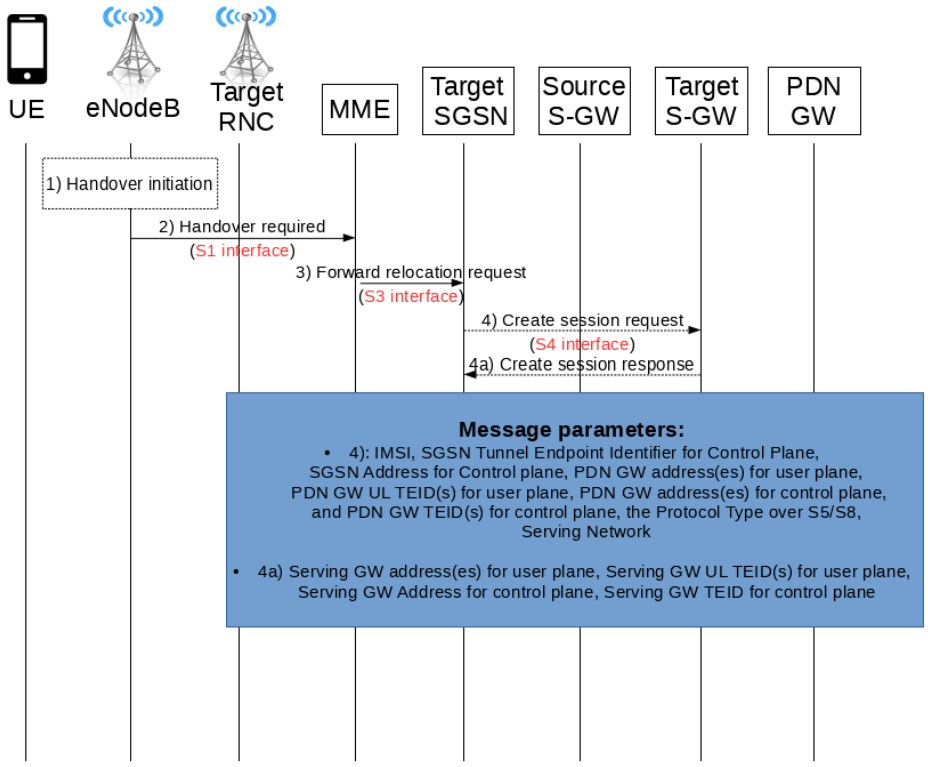
[3]ISR = "idle mode signalling reduction". When this mode is active the network can simultaneously register the UE in a routing area that is served by an SGSN and in one or more tracking areas that are served by an MME.

- PDN connections: it indicates the active PDN connections
- RAN cause: it's the S1AP cause received from the eNodeB
- CSG ID: included only if the target cell is a CSG cell or a hybrid cell
- CSG Membership Indication: it indicates if the UE is a CSG member. It's included only if the target cell is a hybrid cell or if it is a CSG cell and there is at least one emergency bearer service
- MM context: it includes information on the EPS Bearer[4] contexts
- Source to Target Transparent Container

If none of the UE's EPS Bearers is supported by the target SGSN, the source MME rejects the handover attempt and sends a Handover Preparation Failure message to the Source eNodeB.

[4]EPS Bearers = Bearers between the UE and the P-GW

Step 4



The target SGSN determines if the S-GW has to be relocated. If so, it selects the target S-GW and sends to it a *Create Session Request message* per each PDN connection.

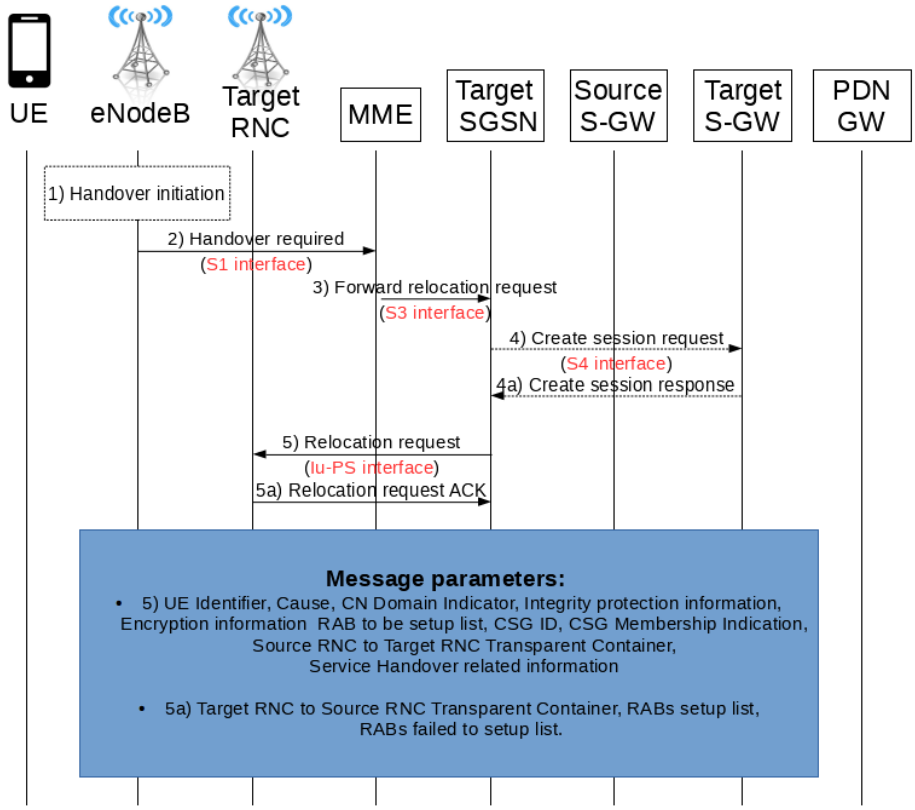
After that, the target SGSN establishes the EPS Bearer contexts indicated by the message received from the MME and deactivates the Bearer contexts which can't be estabilished.

Step 4a

The target S-GW allocates its local resources and returns a *Create Session Response* to the target SGSN.

Step 5

The target SGSN requests the target RNC to establish the radio network resources (radio access beares - RABs) by sending the *Relocation Request*



message through the Iu-PS interface. Some of the parameters included in this message are:

- Encryption information: it is sent in order to allow data transfer to continue in the new UTRAN target cell without requiring a new Authentication and Key Agreement (AKA) procedure
- RAB to be setup list: for each RAB to be set up it contains information such as the RAB ID and other RAB parameters
- CSG ID and CSG Membership Indication: included only when provided by the the source MME in the *Forward Relocation Request* message
- Source RNC to Target RNC Transparent Container: it includes the information received from the source eNodeB included in the Source to Target Transparent Container field of the *Handover required* message

If the target cell is a CSG cell, the target RNC verifies the CSG ID provided by the target SGSN and rejects the handover if it does not match the CSG

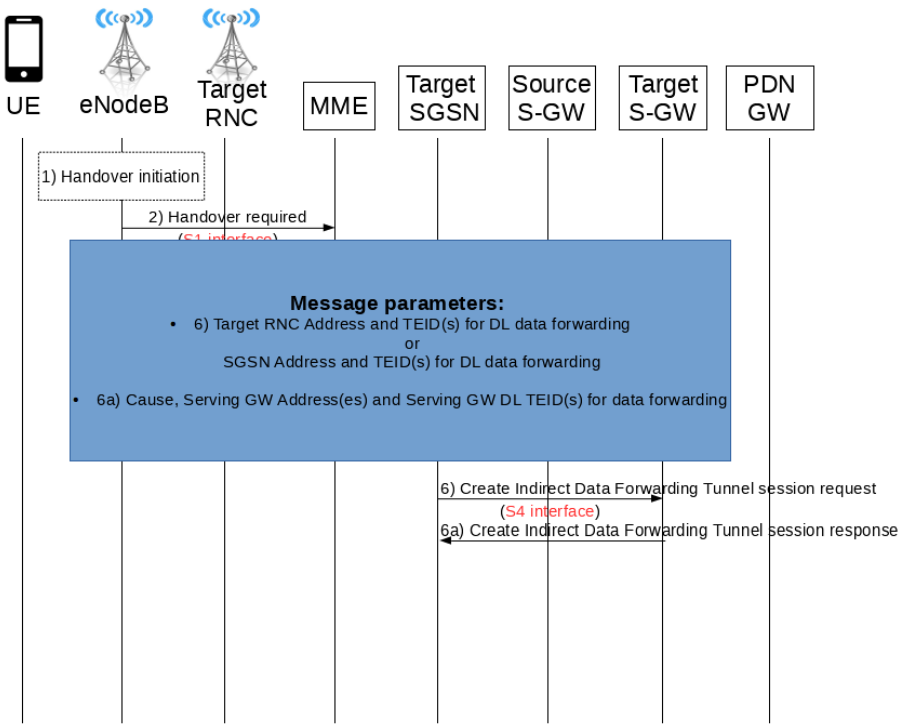
ID for the target cell. If the CSG Membership Indication is "non member", the target RNC only accepts emergency bearers.

Step 5a

For each accepted bearer, the target RNC allocates radio and Iu user plane resources. After that, the target RNC sends back to the SGSN the *Relocation Request Acknowledge* messages, which contains a list of the setup bearers and a list of the failed to setup bearers, which will be deactivated by the SGSN.

After sending the ACK the RNC is prepared to receive downlink GTP PDUs[5] from the S-GW (or from the target SGSN if Direct Tunnel is not used) for the accepted bearers.

Step 6



If Indirect Forwarding and relocation of S-GW apply then the target SGSN sends a *Create Indirect Data Forwarding Tunnel Request* message to the

[5]Packets received by a protocol layer are called Service Data Unit (SDU) while packets output of a layer are called Protocol Data Unit (PDU).

target S-GW through the S4 interface. If GTP Direct Tunnel is used then message includes the Target RNC Address, while if Direct Tunnel isn't used the message includes the SGSN address. In both cases the message also include the TEIDs[6] for downlink user data forwarding.

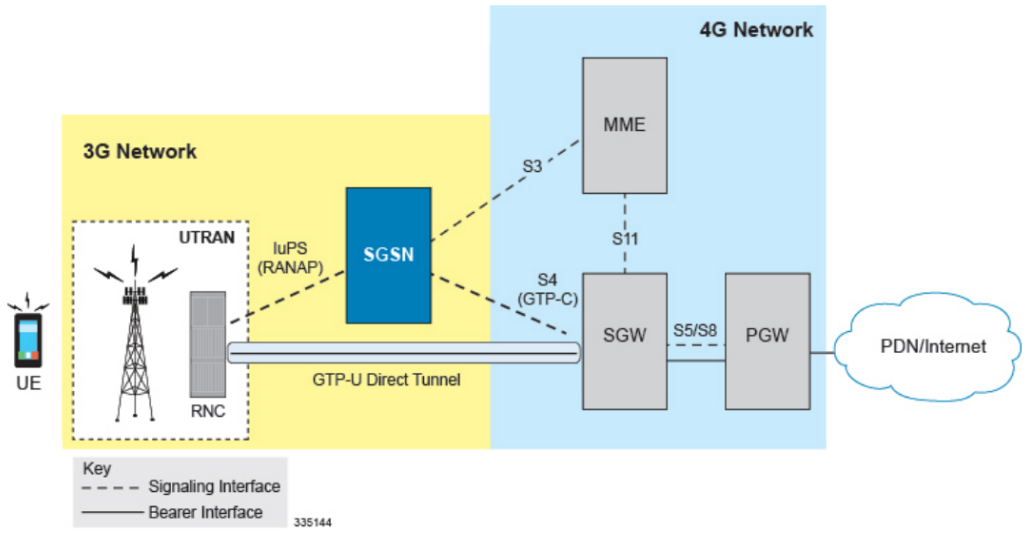


Figure 3: Direct tunnelling in a LTE network [1]

Step 6a

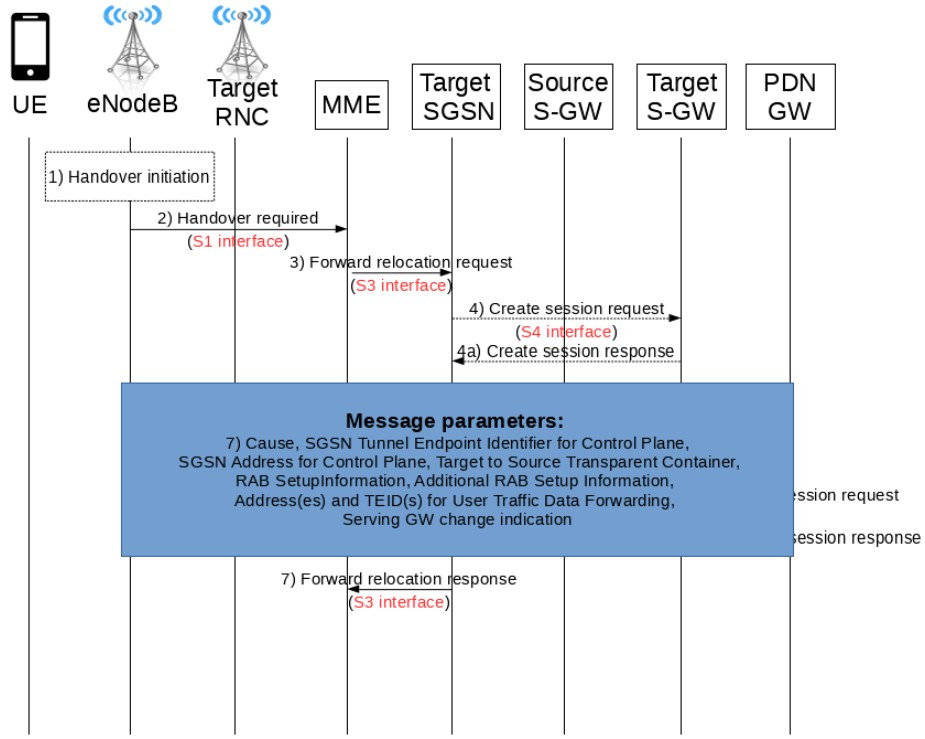
The S-GW responds to the SGSN with a *Create Indirect Data Forwarding Tunnel Response* message, specifying as parameter the S-GW Address(es) and the S-GW DL TEID(s) for data forwarding.

Step 7

The target SGSN sends the *Forward Relocation Response* message to the source MME through the S3 interface. Some of the parameters contained in the message are:

- S-GW change indication: indicates if a new S-GW has been selected

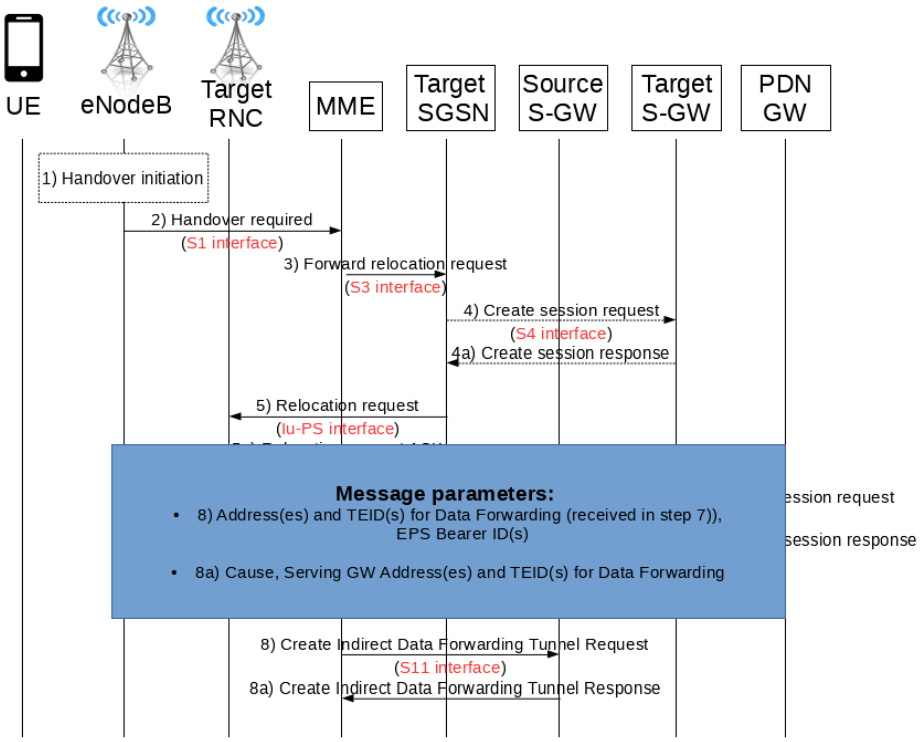
[6]TEID = Tunnel Endpoint identifier. Each GTP tunnel is associated with two TEID: one for the downlink and one for the uplink



- Target to Source Transparent Container: it contains the value of the Target RNC to Source RNC Transparent Container received from the target RNC
- Address(es) and TEID(s) for User Traffic Data Forwarding: they define the destination tunnelling endpoint for forwarded data
- Address(es) and TEID(s) for User Traffic Data Forwarding. If 'Indirect Forwarding' and relocation of Serving GW apply then this parameter

Step 8

If "Indirect Forwarding" applies, the Source MME sends the message *Create Indirect Data Forwarding Tunnel Request* to the S-GW used for indirect forwarding. The parameters contained in the message are the list of "Address(es) and TEID(s) for Data Forwarding" received in step 7 and the EPS Bearer ID(s).



Step 8a

The S-GW replies sending message *Create Indirect Data Forwarding Tunnel Response*, which contains the S-GW Address(es) and the TEID(s) for data forwarding. Note that the Indirect Forwarding may be performed via a Serving GW which is different from the Serving GW used as the anchor point for the UE. If the S-GW doesn't support data forwarding, the message contains only an appropriate cause.

3 Execution phase

Step 1

The source MME completes the preparation phase by sending to the source eNodeB the *Handover command* message through the interface S1. The message contains the following parameters:

- Target to Source Transparent Container
- E-RABs to Release List
- Bearers Subject to Data Forwarding List: if "Direct Forwarding" applies it is the list of "Address(es) and TEID(s) for user traffic data forwarding" received from the target SGSN during step 7 of the preparation phase, otherwise if "Indirect Forwarding" applies it contains the parameters received in step 8a from the S-GW
- E-RABs to Release List

Step 2

The source eNodeB initiates data forwarding for bearers specified in the "Bearers Subject to Data Forwarding List" of the message received from the MME.

After that, the eNodeB sends the E-UTRAN command *HO* to the UE for telling it to handover to the target access network. This message includes a transparent container which contains the radio parameters that the RNC has set-up during the preparation phase.

After the reception of the HO command the UE has to associate its bearer IDs to the respective RABs according to the relation with the NSAPIs[7] and has to suspend the uplink transmission of user data.

Step 3

Void

[7] NSAPI = Network Service Access Point Identifier, it is used to identify PDP contexts in the SGSN. A PDP context is a data structure which contains subscriber's session information such as its IMSI and its IP address

Step 4

The UE executes the handover to the target UTRAN according to the prameters contained in the message received in step 2. At this point it can resume the user data transfer only for those NSAPIs which have been associated to a RAB, namely the NSAPIs for which there are radio resources allocated in the target RNC.

Step 5

After the RNC-ID and the S-RNTI[8] are exchanged with the UE, the target RNC sends the *Relocation Complete* message to the target SGSN, indicating therefore the completion of the relocation from the source E-UTRAN to the target RNC. After receiving this message, the SGSN is ready for receiving data from the target RNC.

[8]S-RNTI = Serving RNC Radio Network Temporary Identifier, in UMTS the S-RNTI is the UE identifier which is allocated by the RNC and it's unique within that RNC

References

[1] Cisco. (2017). *P-GW Administration Guide, StarOS Release 20 - Direct Tunnel for 4G (LTE) Networks [Cisco ASR 5000 Series]*. [online] Available at: https://www.cisco.com/c/en/us/td/docs/wireless/asr_5000/20/P-GW/b_20_PGW_Admin/b_20_PGW_Admin_chapter_011111.html [Accessed 5 May 2018].