

LTE system signaling procedure

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Objectives

- Upon completion of this course, you will be able to :
 - Know the LTE/SAE system architecture and functions
 - Know main elementary procedures of S1/X2/Uu interfaces
 - Know the procedure of service setup, service release, intra-eUTRAN handover



References

- 3GPP TS 36.300
- 3GPP TS 23.401
- 3GPP TS 36.413
- 3GPP TS 36.331
- 3GPP TS 36.423





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1. Overview
2. Elementary Procedures
3. Service signaling flow



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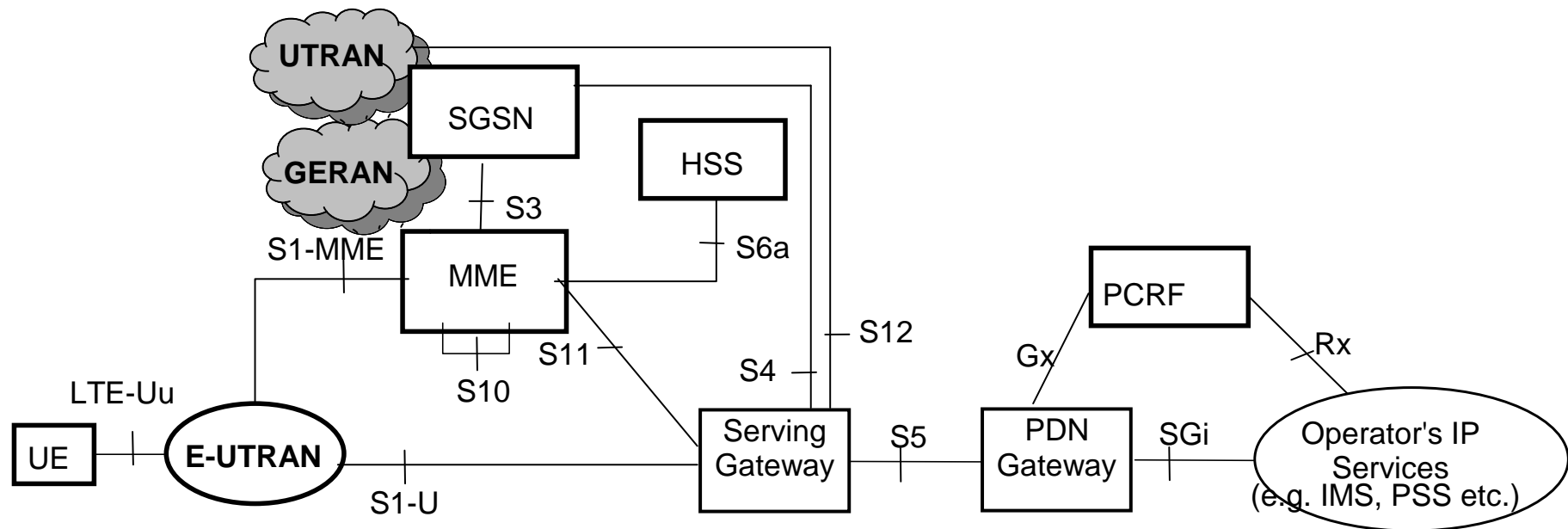
1. Overview

2. Elementary Procedures

3. Service signaling flow

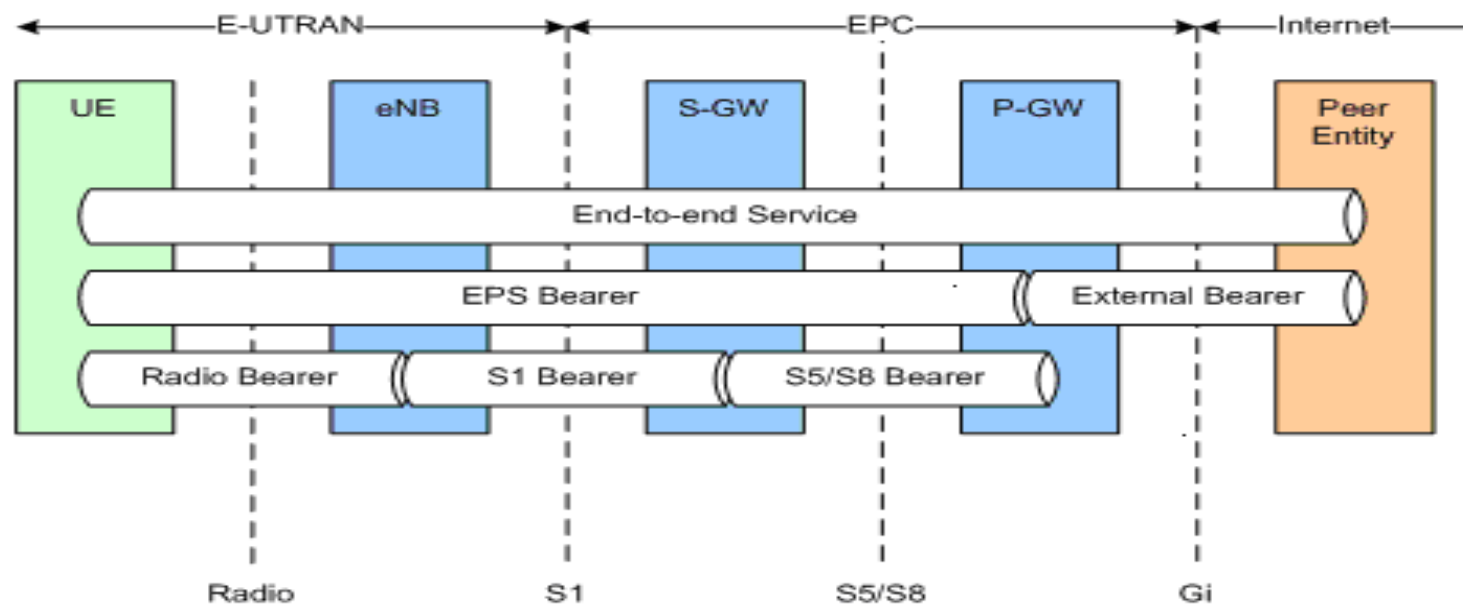
System Architecture Overview

- Main functions of the Serving GW is:
 - the local Mobility Anchor point for handover (inter-eNodeB/inter-3GPP)
 - Packet routing and forwarding
- Main functions of the PDN GW is:
 - UE IP address allocation
 - UL and DL service level charging

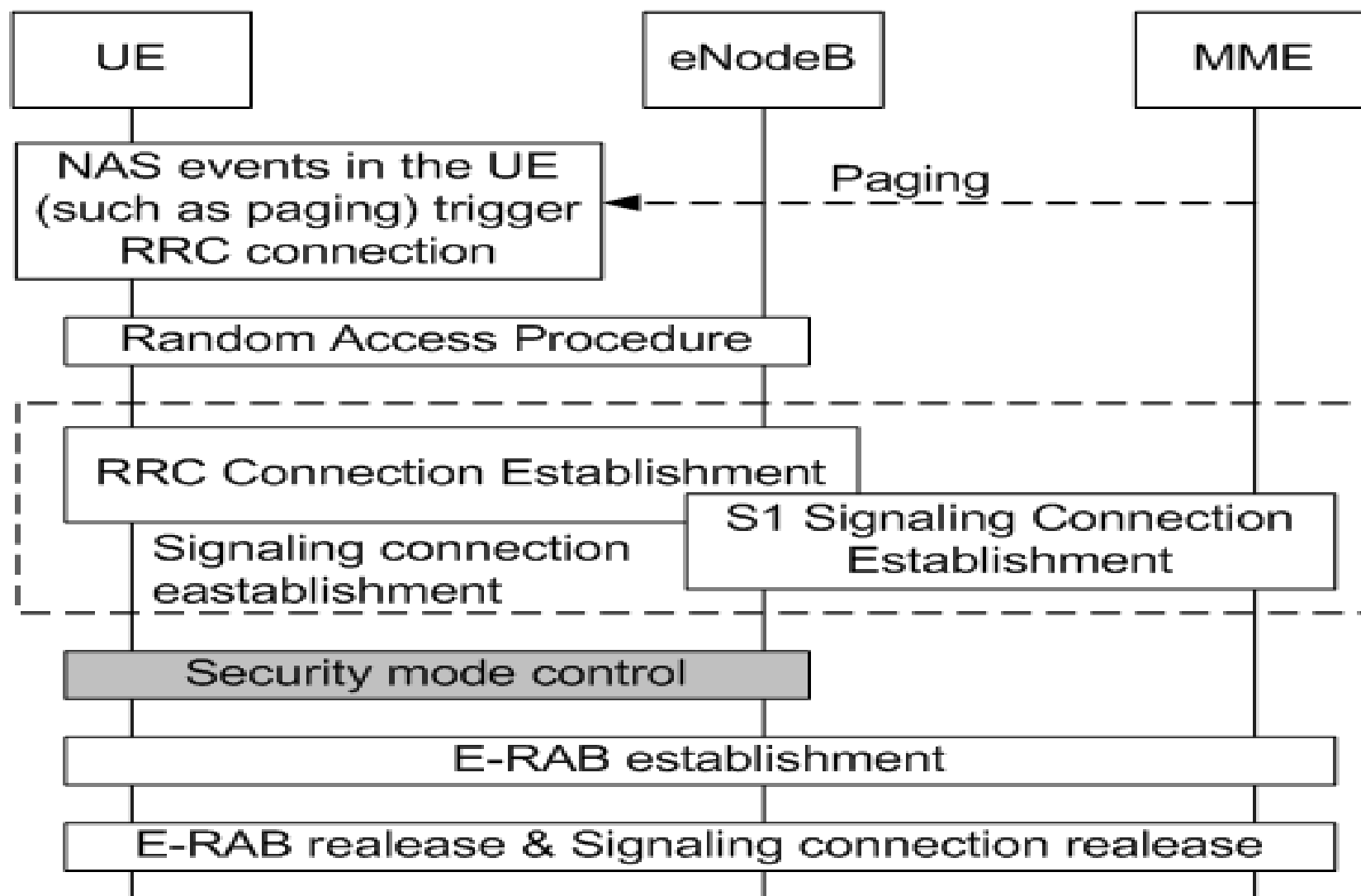


Bearer service architecture

- A radio bearer transports the packets of an EPS bearer between a UE and an eNB. There is a one-to-one mapping between an EPS bearer and a radio bearer.
- An S1 bearer transports the packets of an EPS bearer between an eNodeB and a Serving GW
- An eNB stores a one-to-one mapping between a radio bearer and an S1 to create the binding between a radio bearer and an S1 bearer in both the uplink and downlink.



Service request procedure



Bearer level QoS

- Basically, bearers can be classified into two categories
 - GBR bearers
 - Non-GBR bearers
- Each bearer has an associated QoS Class Identifier (QCI), and an Allocation and Retention Priority (ARP)
 - QoS Class Identifier (QCI)
 - QCI is characterized by priority, packet delay budget and acceptable packet loss rate
 - QCI is used to control bearer level packet forwarding treatment
 - The set of standardized QCIs is listed in the table of next page
 - The ARP of a bearer is used for call admission control
 - A GBR bearer is additionally associated with the following bearer level QoS parameters:
 - Guaranteed Bit Rate (GBR)
 - Maximum Bit Rate (MBR)

Bearer level QoS(Cont.)

- The set of standardized QCI

QCI	Resource type	Priority	Packet delay budget (ms)	Packet error loss rate	Example services
1	GBR	2	100	10^{-2}	Conversational voice
2	GBR	4	150	10^{-3}	Conversational video (live streaming)
3	GBR	5	300	10^{-6}	Non-conversational video (buffered streaming)
4	GBR	3	50	10^{-3}	Real time gaming
5	Non-GBR	1	100	10^{-6}	IMS signalling
6	Non-GBR	7	100	10^{-3}	Voice, video (live streaming), interactive gaming
7	Non-GBR	6	300	10^{-6}	Video (buffered streaming)
8	Non-GBR	8	300	10^{-6}	TCP-based (e.g. WWW, e-mail) chat, FTP, p2p file sharing, progressive video, etc.
9	Non-GBR	9	300	10^{-6}	

Application protocol identities

- EPS bearer identity
 - An EPS bearer identity uniquely identifies an EPS bearer for one UE accessing via E-UTRAN
 - The EPS Bearer Identity is allocated by the MME
 - There is one to one mapping between EPS RB and EPS Bearer, and the mapping between EPS RB Identity and EPS Bearer Identity is made by E-UTRAN
- eNB UE S1AP ID
 - A eNB UE S1AP ID shall be allocated so as to uniquely identify the UE over the S1 interface within an eNB
- MME UE S1AP ID
 - A MME UE S1AP ID shall be allocated so as to uniquely identify the UE over the S1 interface within the MME
- Old eNB UE X2AP ID
 - An Old eNB UE X2AP ID shall be allocated so as to uniquely identify the UE over the X2 interface within a source eNB
- New eNB UE X2AP ID
 - An New eNB UE X2AP ID shall be allocated so as to uniquely identify the UE over the X2 interface within a target eNB
- C-RNTI: The C-RNTI provides a unique UE identification at the cell level identifying RRC Connection and used for scheduling



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2. Elementary Procedures

2.1 Elementary Procures of Uu

2.2 Elementary Procedures of S1

2.3 Elementary Procures of X2

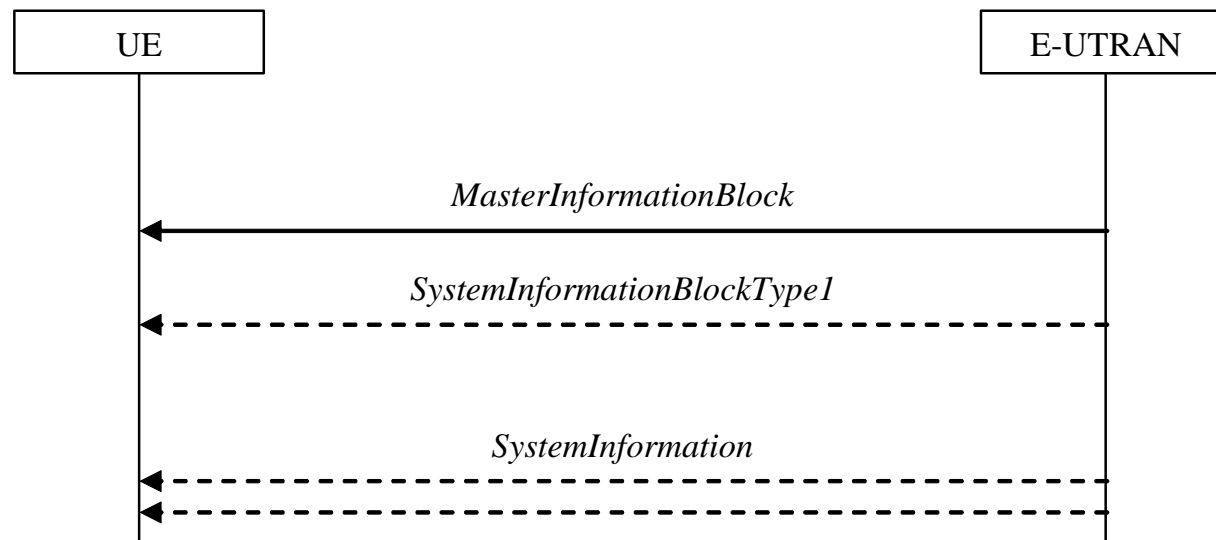
UE states

- RRC_IDLE
 - A UE specific DRX may be configured by upper layers
 - UE controlled mobility
 - The UE:
 - Monitors a Paging channel to detect incoming calls;
 - Performs neighbouring cell measurements and cell (re-)selection;
 - Acquires system information.
- RRC_CONNECTED
 - Transfer of unicast data to/from UE.
 - At lower layers, the UE may be configured with a UE specific DRX.
 - Network controlled mobility
 - The UE:
 - Monitors control channels associated with the shared data channel to determine if data is scheduled for it;
 - Provides channel quality and feedback information;
 - Performs neighbouring cell measurements and measurement reporting;
 - Acquires system information

Signalling radio bearers

- "Signalling Radio Bearers" (SRBs) are defined as Radio Bearers (RB) that are used only for the transmission of RRC and NAS messages. the following three SRBs are defined:
 - SRB0 is for RRC messages using the CCCH logical channel;
 - SRB1 is for RRC messages as well as for NAS messages prior to the establishment of SRB2, all using DCCH logical channel;
 - SRB2 is for NAS messages, using DCCH logical channel. SRB2 has a lower-priority than SRB1 and is always configured by E-UTRAN after security activation

System information



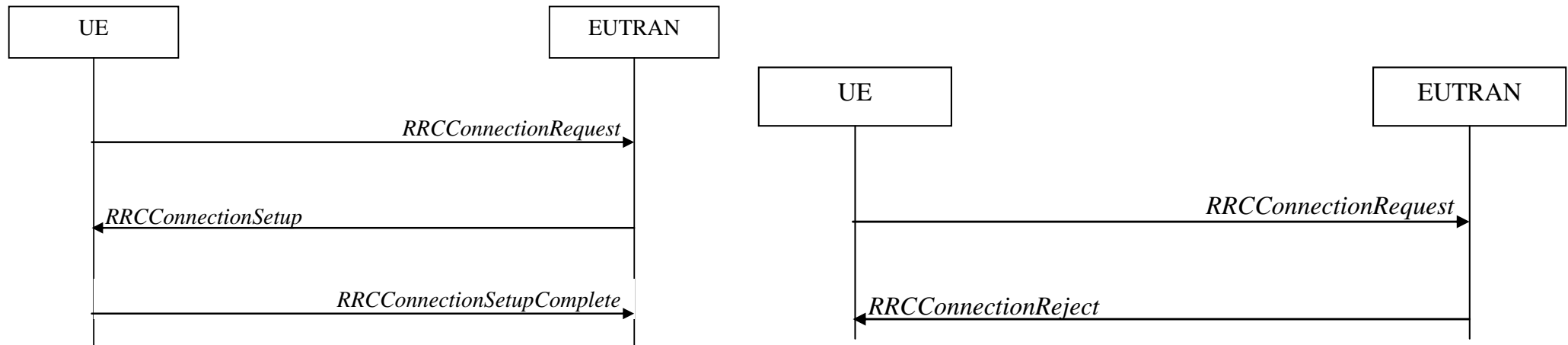
- System information is divided into the *MasterInformationBlock* (MIB) and a number of *SystemInformationBlocks* (SIBs).
- The MIB includes a limited number of most essential and most frequently transmitted parameters that are needed to acquire other information from the cell, and is transmitted on BCH
- *SystemInformationBlockType1* and all SI messages are transmitted on DL-SCH

Paging



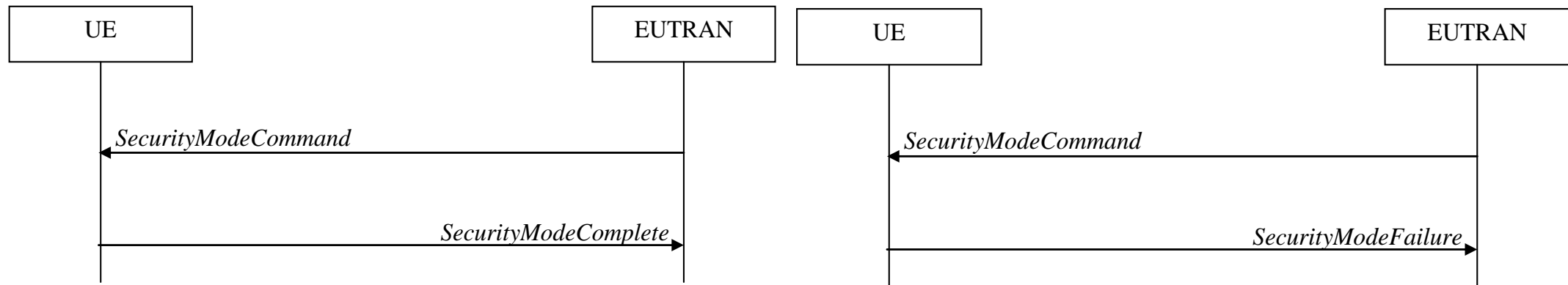
- Purpose:
 - To transmit paging information to a UE in RRC_IDLE and/ or to inform UEs in RRC_IDLE and UEs in RRC_CONNECTED about a system information change or about an ETWS (Earthquake and Tsunami Warning System) primary notification
- Main IE:
 - ue-Identity
 - cn-Domain
 - pagingCause
 - systemInfoModification
 - ETWS notification

RRC connection establishment



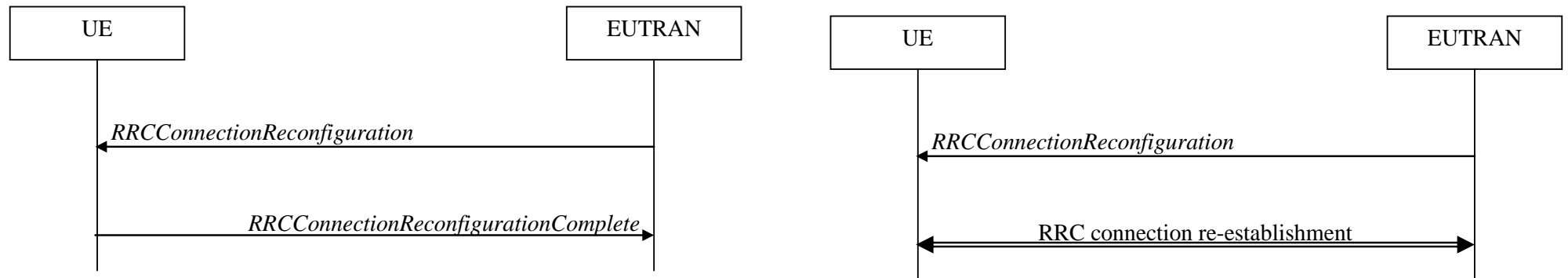
- Purpose:
 - ❑ RRC connection establishment involves SRB1 establishment. The procedure is also used to transfer the initial NAS dedicated information/ message from the UE to E-UTRAN
- Main IE:
 - ❑ establishmentCause
 - ❑ radioResourceConfiguration for Only SRB1
 - ❑ selectedPLMN-Identity
 - ❑ registeredMME
 - ❑ nas-DedicatedInformation

Initial security activation



- Purpose:
 - To activate AS security upon RRC connection establishment
 - When only SRB1 is established and prior to establishment of SRB2 and/ or DRBs.
- Main IE:
 - integrity protection and ciphering

RRC connection reconfiguration



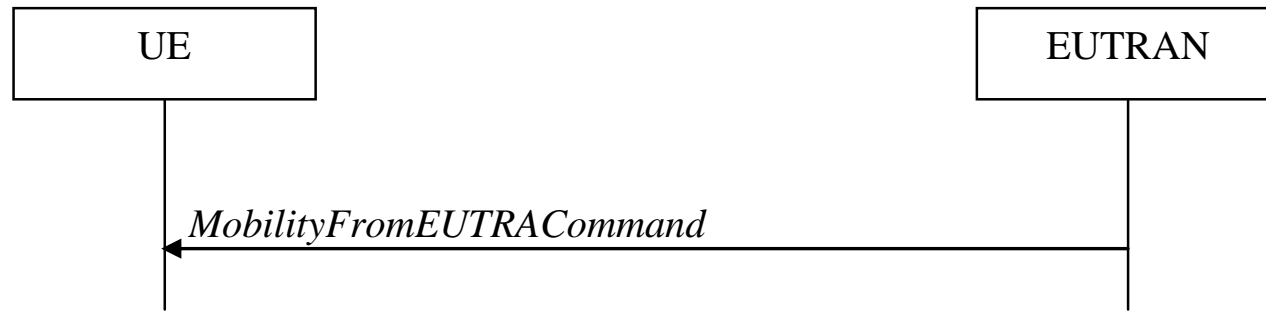
- Purpose:
 - To modify an RRC connection, e.g. to establish/ modify/ release RBs, to perform handover, to setup/ modify/ release measurements
- Main IE:
 - measurementConfiguration
 - mobilityControlInformation
 - nas-DedicatedInformation
 - radioResourceConfiguration (for SRB2 and possibly DRBs)
 - securityConfiguration
 - ue-RelatedInformation

RRC connection release



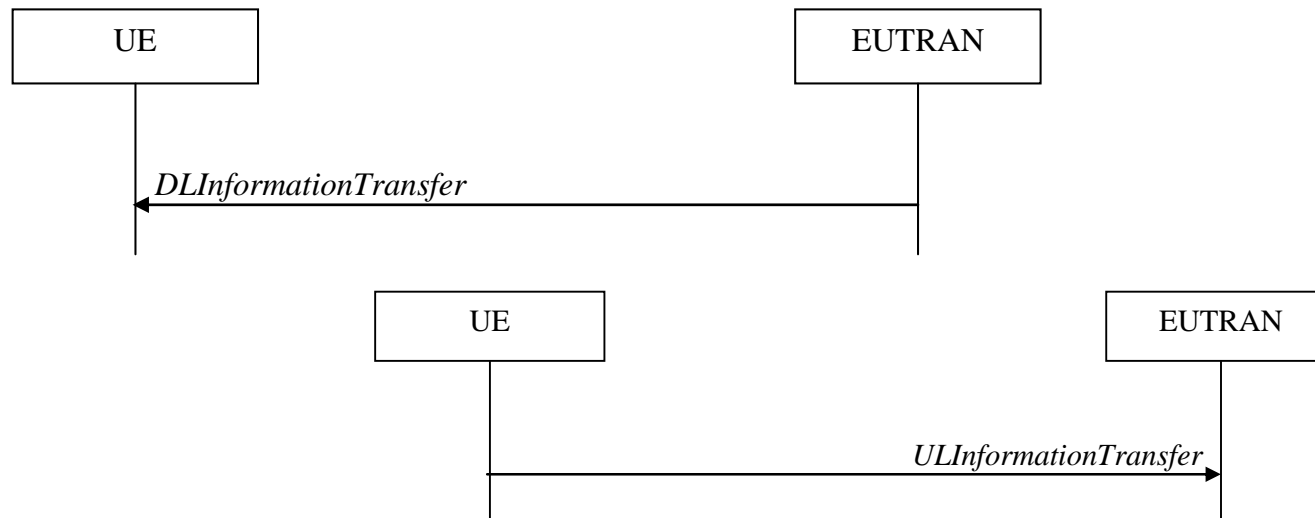
- Purpose:
 - To release the RRC connection, which includes the release of the established radio bearers as well as all radio resources.

Mobility from E-UTRA



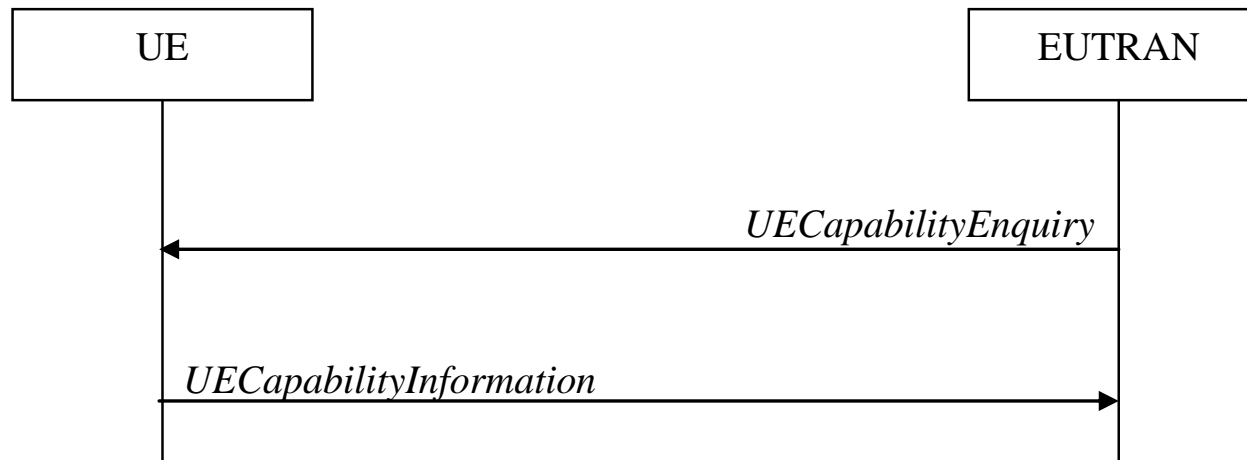
- Purpose:
 - To move a UE in RRC_CONNECTED to a cell using another Radio Access Technology (RAT), e.g. GERAN, UTRA or CDMA2000 systems
 - The mobility from E-UTRA procedure covers both:
 - handover, i.e. the *MobilityFromEUTRACommand* message includes radio resources that have been allocated for the UE in the target cell
 - cell change order, i.e. the *MobilityFromEUTRACommand* message may include information facilitating access of and/ or connection establishment in the target cell, e.g. system information. Cell change order is applicable only to GERAN.

DL/UL information transfer



- Purpose:
 - To transfer NAS or non-3GPP dedicated information from E-UTRAN/UE to a UE/E-UTRAN in RRC_CONNECTED

UE capability transfer



- Purpose:
 - To transfer UE radio access capability information from the UE to E-UTRAN



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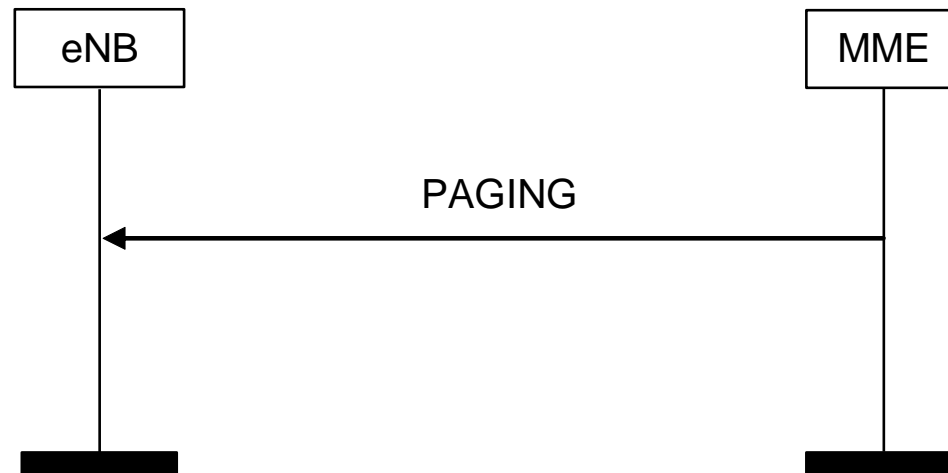
2. Elementary Procedures

2.1 Elementary Procedures of Uu

2.2 Elementary Procedures of S1

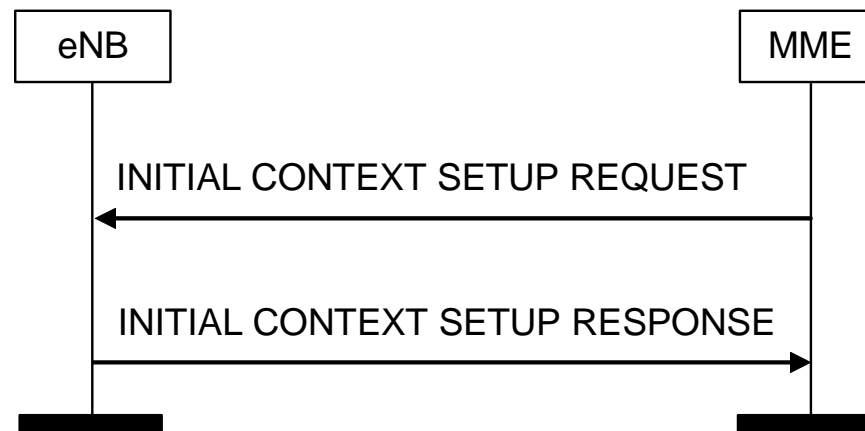
2.3 Elementary Procedures of X2

Paging



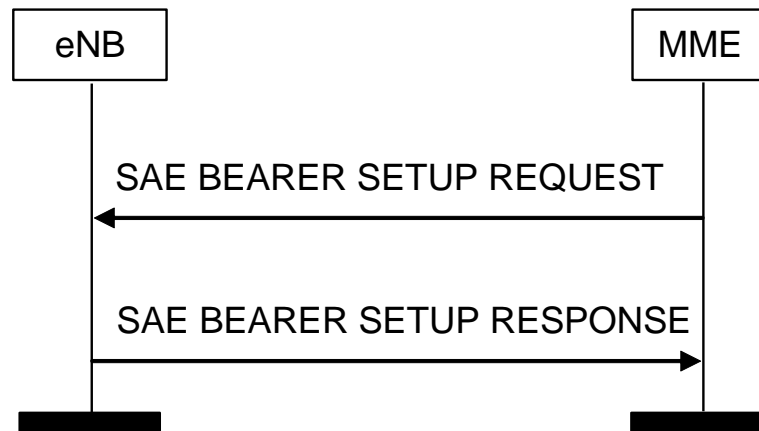
- Purpose:
 - The purpose of the Paging procedure is to enable the MME to page a UE in the specific eNB
- Main information:
 - UE Paging ID
 - Paging DRX
 - Paging Cause
 - List of TAIs

Context Management procedures



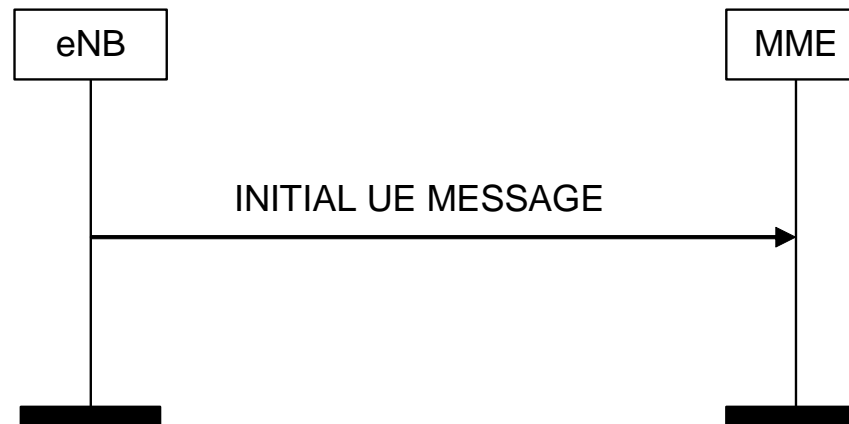
- Purpose:
 - To establish the necessary overall initial UE Context including SAE Bearer context, Security context, Handover Restriction List, UE capability information, NAS-PDU etc
 - Other message in this category includes: UE Context Release Request /release/modify
- Main information:
 - SAE Bearer Level QoS parameters
 - Transport Layer Address
 - NAS-PDU
 - Security
 - Handover Restriction List
 - UE Radio Capability
 - Subscriber Profile ID for RAT/Frequency priority

SAE Bearer Management procedures



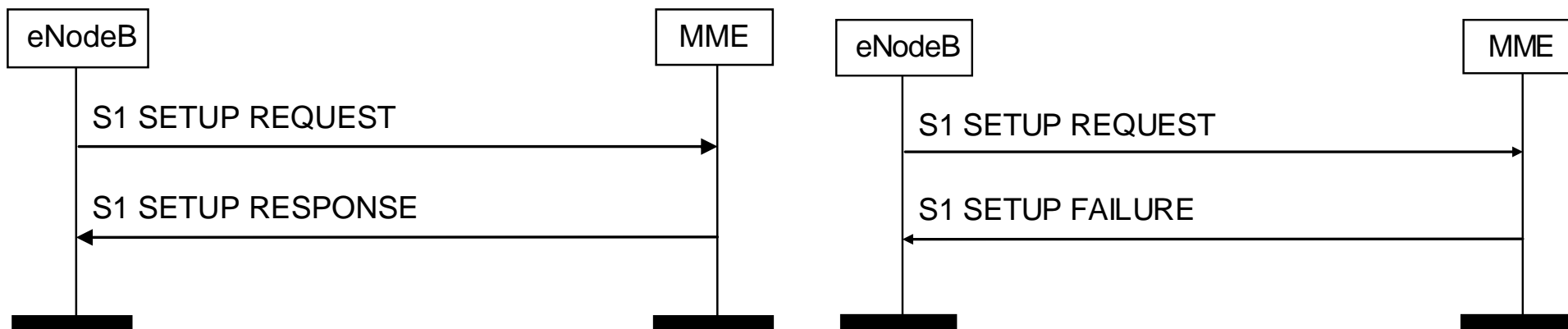
- Purpose:
 - To assign resources on Uu and S1 for one or several SAE bearers and to setup corresponding SAE Radio Bearers for a given UE
 - Other message in this category includes: SAE bearer modify and SAE bearer release
- Main information :
 - SAE Bearer Level QoS parameters
 - Transport Layer Address
 - NAS-PDU
 - SAE Bearer Setup List
 - SAE Bearer Failed to Setup List

NAS transport



- Purpose:
 - The purpose of the NAS Transport procedure is to carry UE – MME signalling over the S1 Interface.
 - The NAS messages are not interpreted by the eNB
 - Besides INITIAL UE MESSAGE, **DOWNLINK NAS TRANSPORT** and **UPLINK NAS TRANSPORT** messages are used for NAS Transport procedure also
- Main IE:
 - NAS-PDU
 - TAI
 - E-UTRAN CGI
 - S-TMSI (optional)
 - Handover Restriction List in DOWNLINK NAS TRANSPORT (optional)

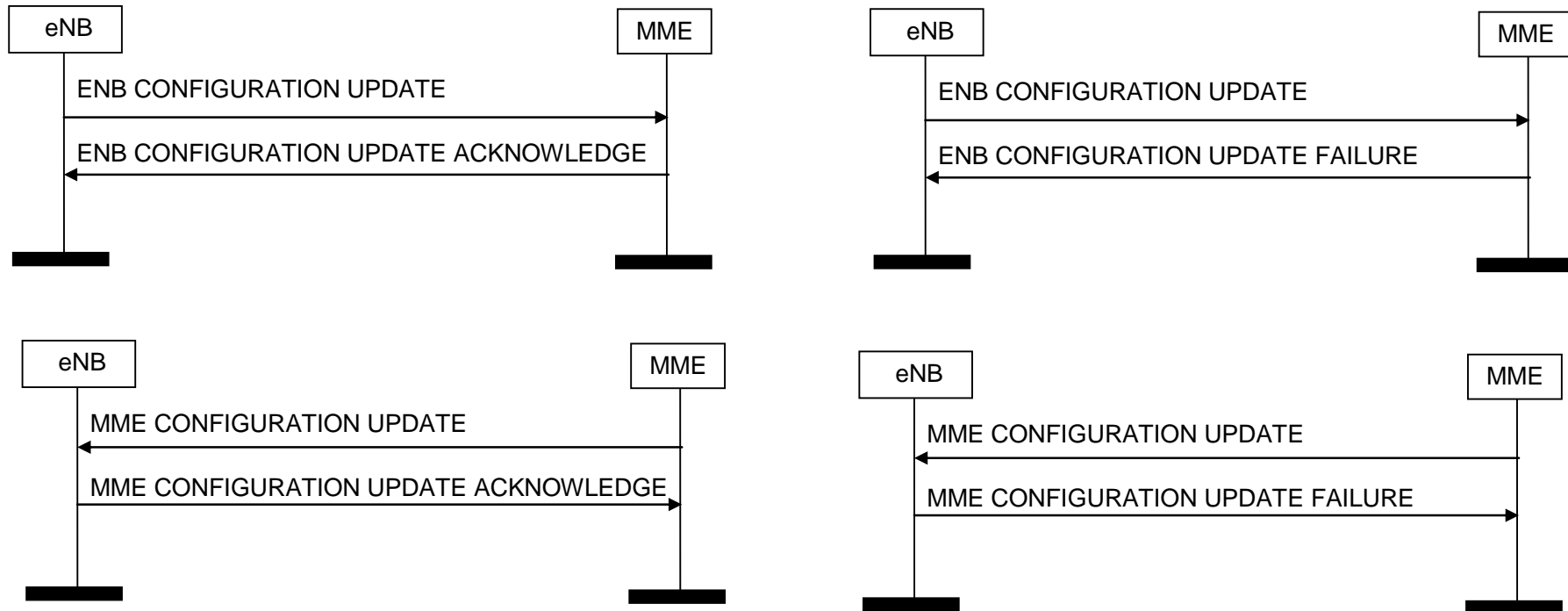
S1 Setup



- Purpose:
 - The purpose of the S1 Setup procedure is to exchange application level data needed for the eNodeB and MME to interoperate correctly on the S1 interface.
 - This procedure shall be the first S1AP procedure triggered after the TNL association has become operational
- Main IE:

▫ Global eNB ID	MME Name
▫ eNB Name	Served PLMNs
▫ Supported TAs of the eNodeB	Served GUMMEIs

MME/eNodeB Configuration Update



- Purpose:

- The purpose of the MME/ eNB Configuration Update procedure is to update application level configuration data needed for the eNB and MME to interoperate correctly on the S1 interface.
- This procedure doesn't affect existing UE-related contexts



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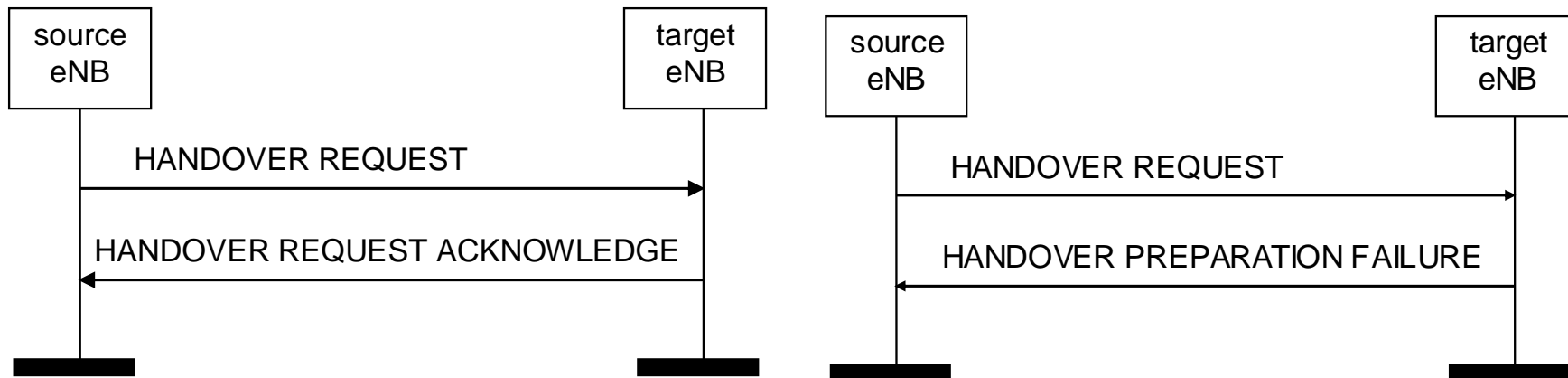
2. Elementary Procedures

2.1 Elementary Procedures of Uu

2.2 Elementary Procedures of S1

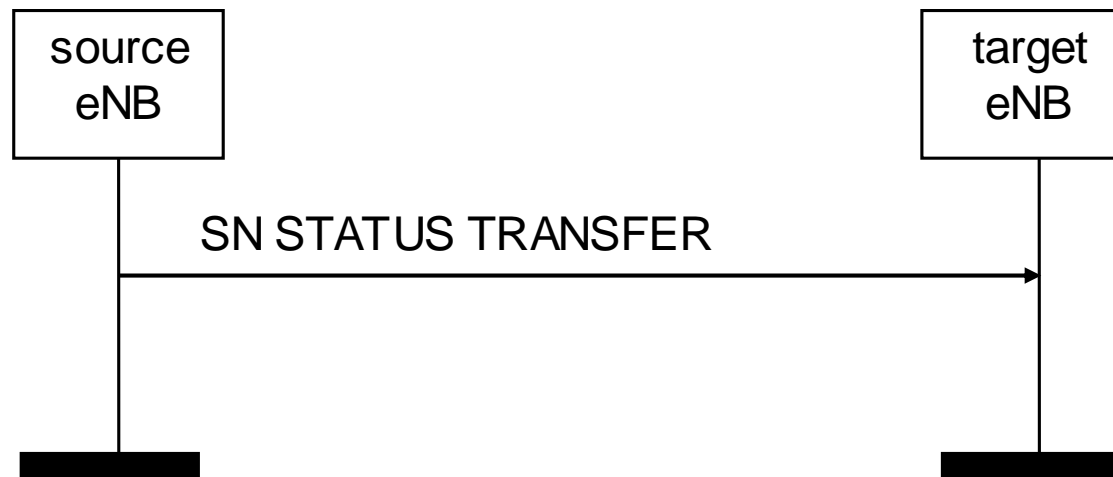
2.3 Elementary Procedures of X2

Handover Preparation



- Purpose:
 - To establish necessary resources in an eNB for an incoming handover
- Main IE:
 - Cause
 - Target Cell ID and GUMMEI
 - SAE Bearer Info

SN Status Transfer



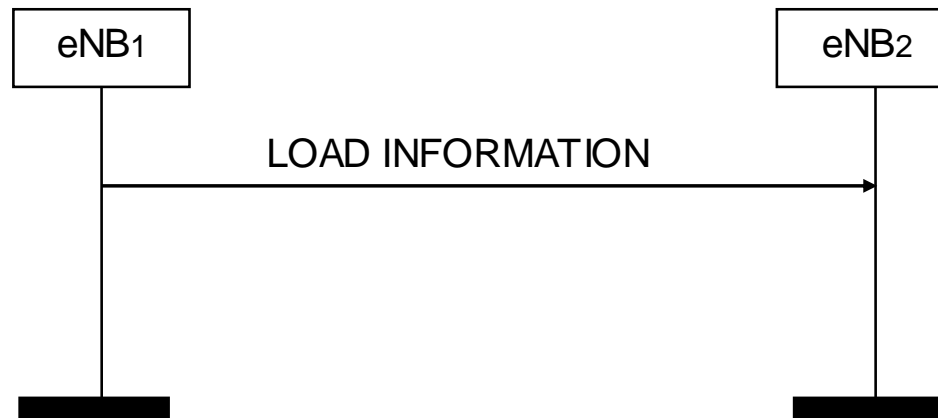
- Purpose:
 - To transfer the uplink PDCP-SN and HFN receiver status and the downlink PDCP-SN and HFN transmitter status from the source to the target eNB during an X2 handover for each respective SAE bearer for which PDCP SN and HFN status preservation applies
- Main IE:
 - SAE Bearers Subject To Status Transfer List

UE Context Release



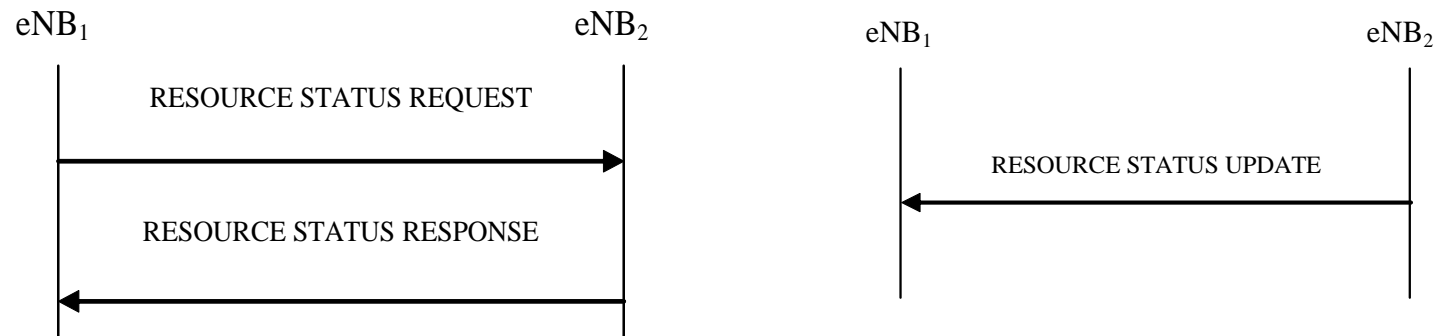
- Purpose:
 - To signal to the source eNB that control plane resources for the handed over UE context can be released
 - Upon reception of the UE CONTEXT RELEASE message, the source eNB can release radio and control plane related resources associated to the UE context

Load Indication



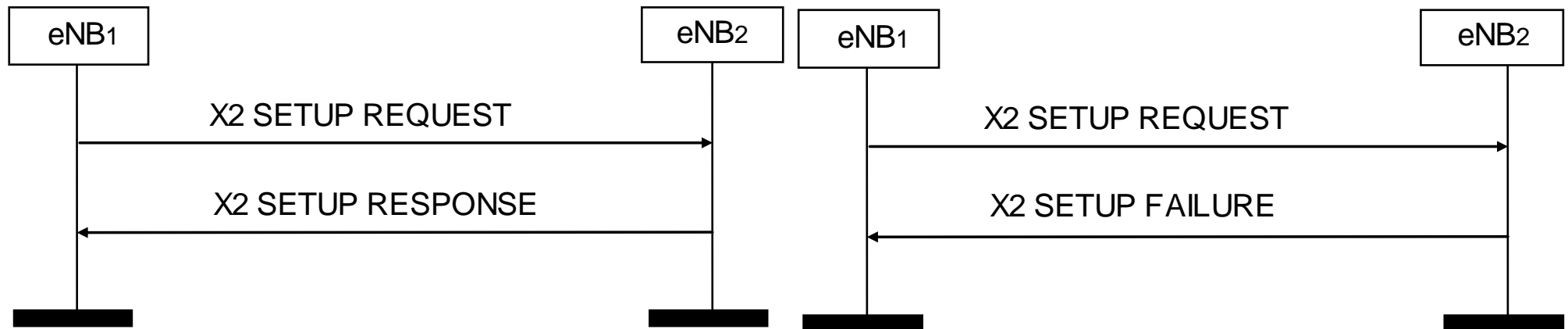
- Purpose:
 - To transfer load and interference co-ordination information between intra-frequency neighboring eNBs
- Main IE:
 - UL Interference Overload Indication
 - UL High Interference Indication
 - Relative Narrowband Tx Power (RNTP)

Resource Status Reporting Initiation /Reporting



- Purpose:
 - To request the reporting of load measurements to another eNB
 - And to report the result of measurements requested by eNB₁ using the Resource Status Reporting Initiation

X2 Setup



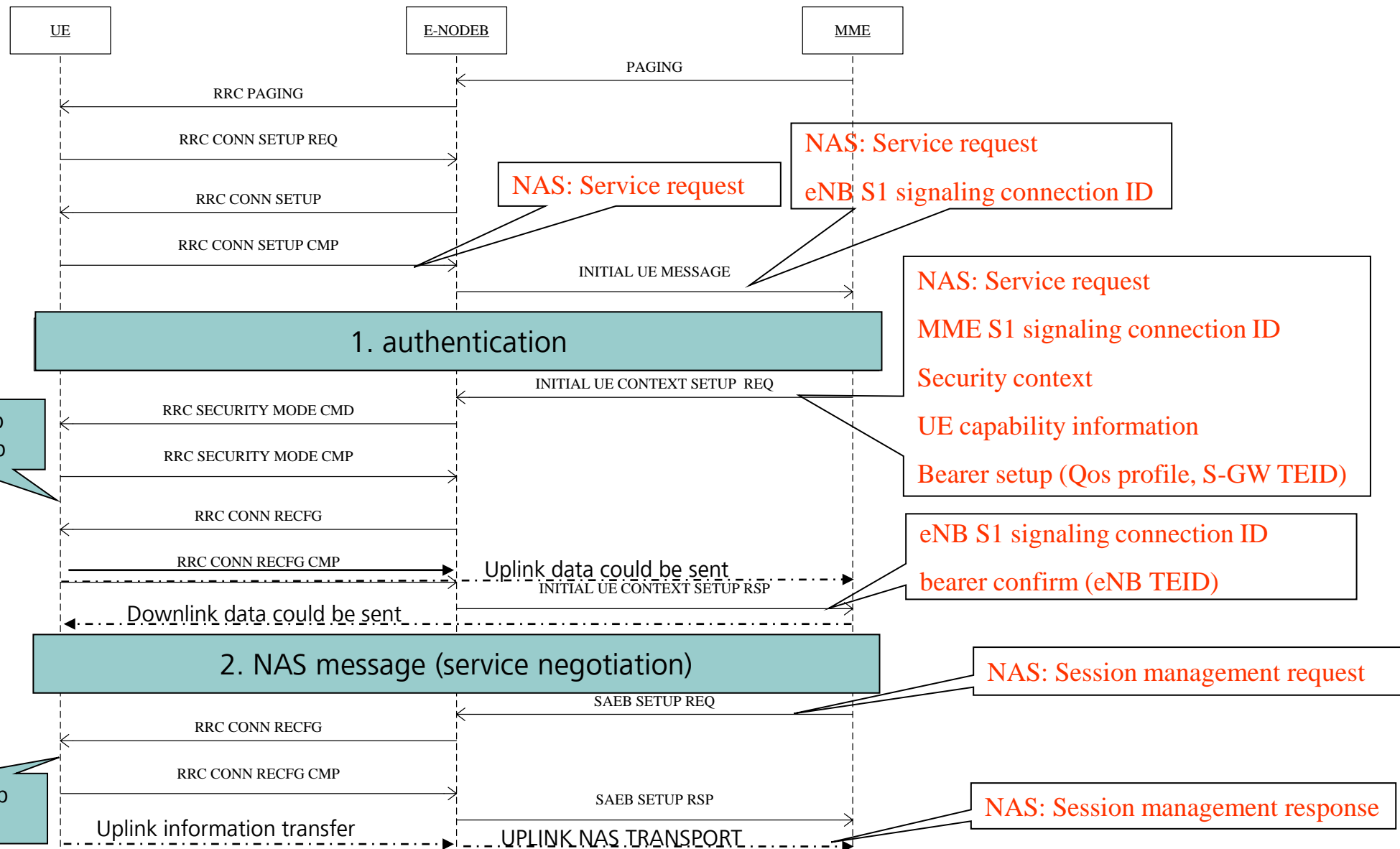
- Purpose:
 - To exchange application level data needed for two eNBs to interoperate correctly over the X2 interface
- Main IE:
 - Served Cell Information
 - PhyCID and Cell ID (CGI)
 - TAC
 - Broadcast PLMNs
 - UL EARFCN/DL EARFCN and Cell Transmission Bandwidth



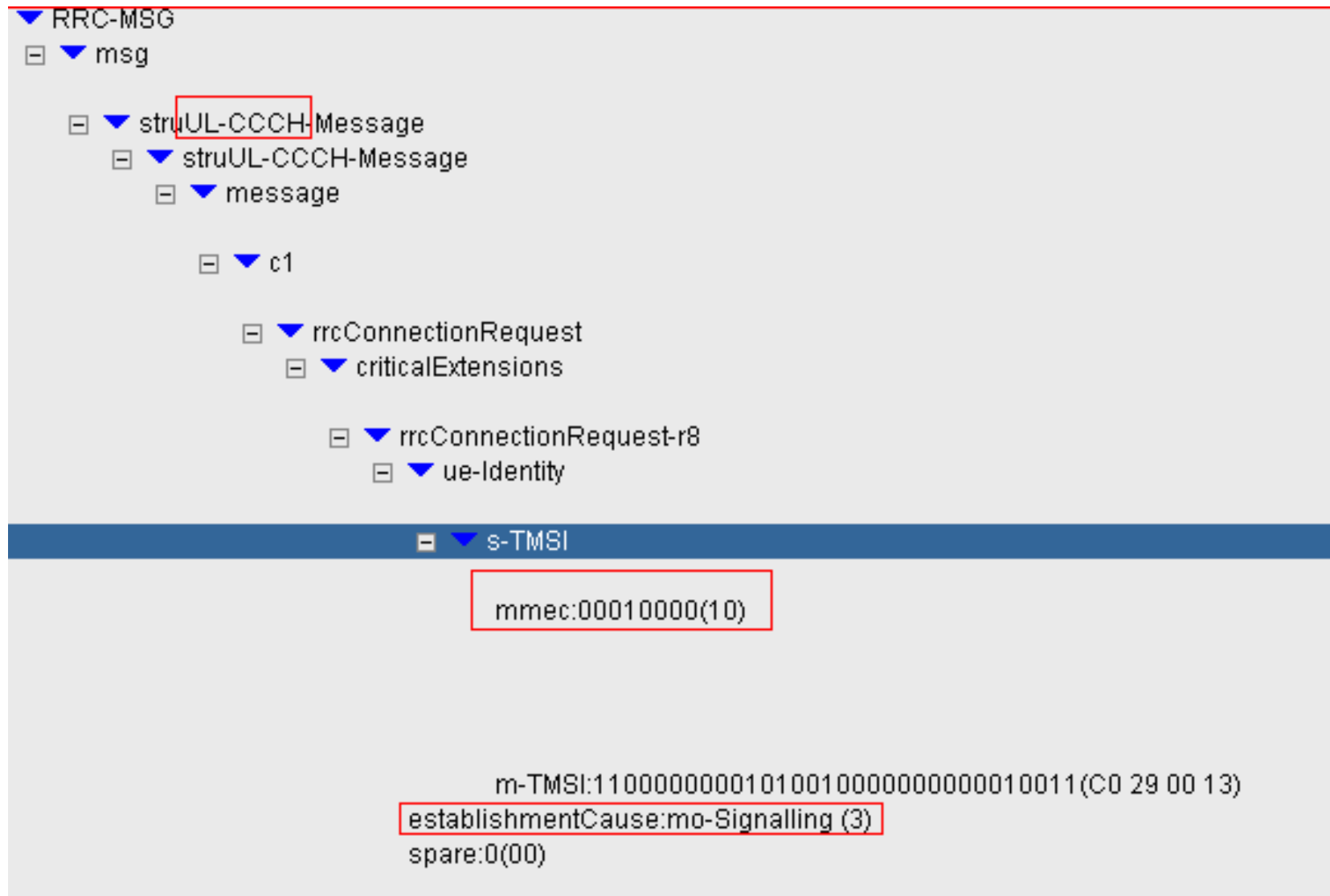
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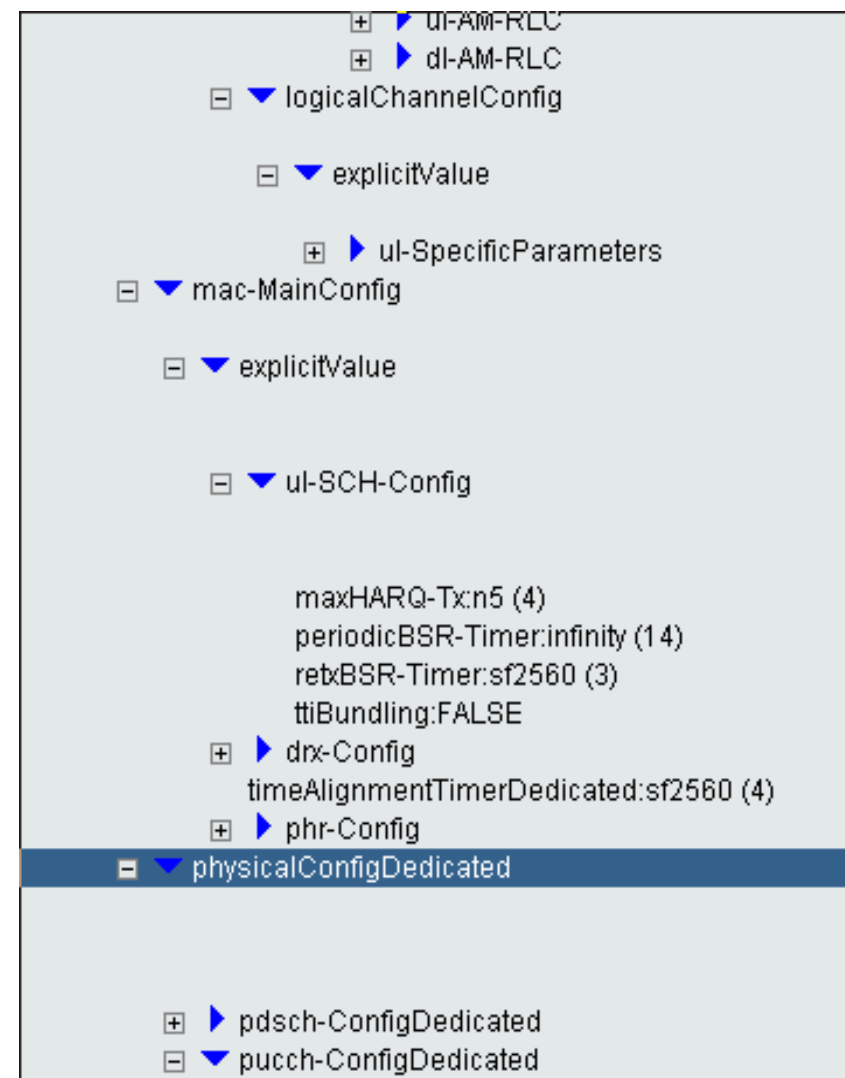
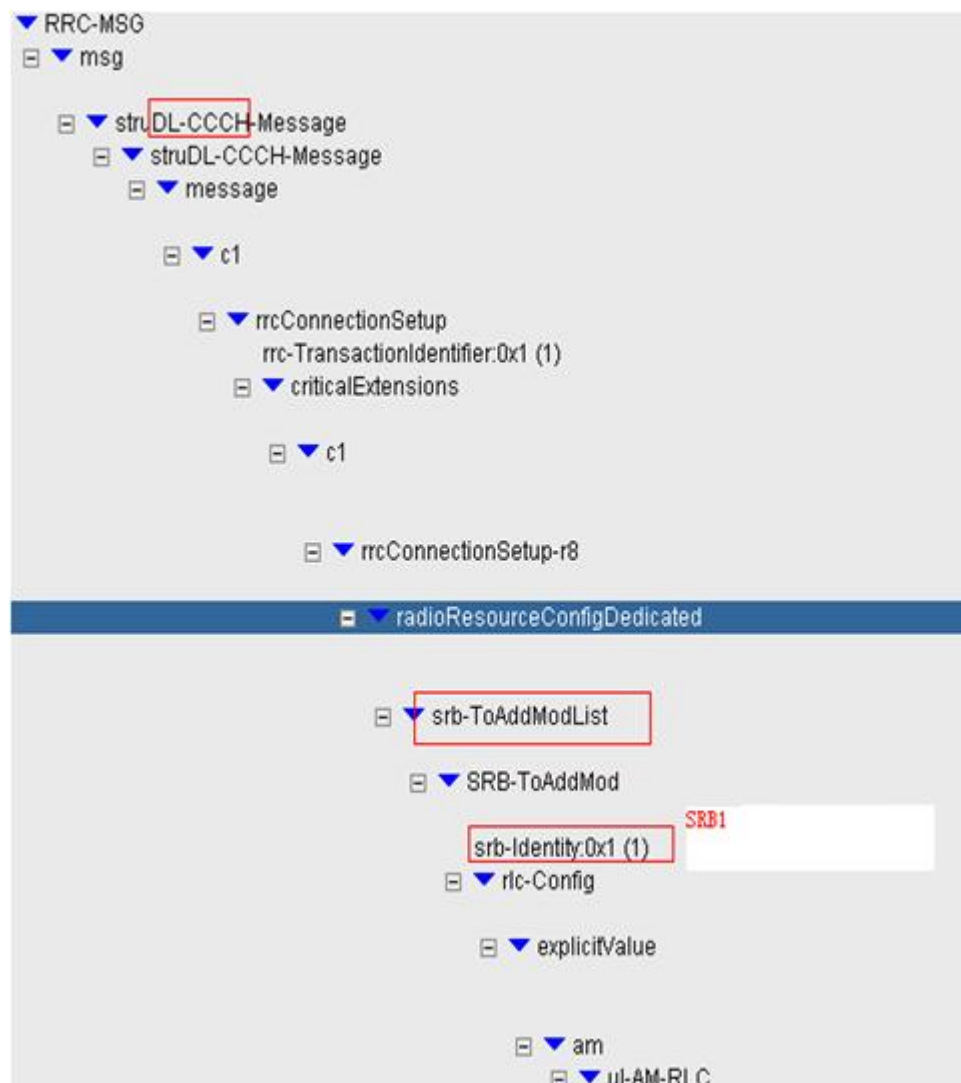
Service request procedure



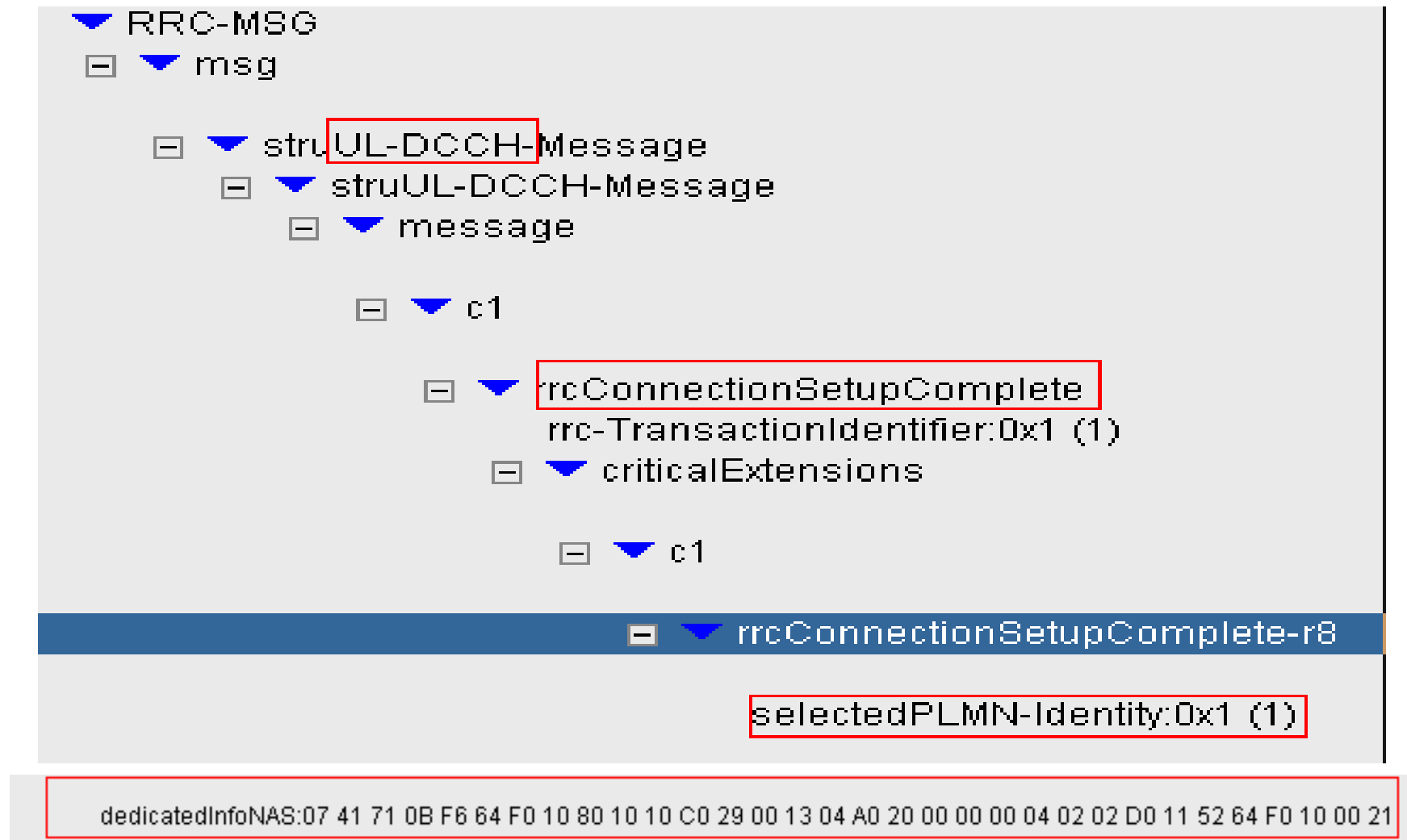
RRC CONN SETUP REQ



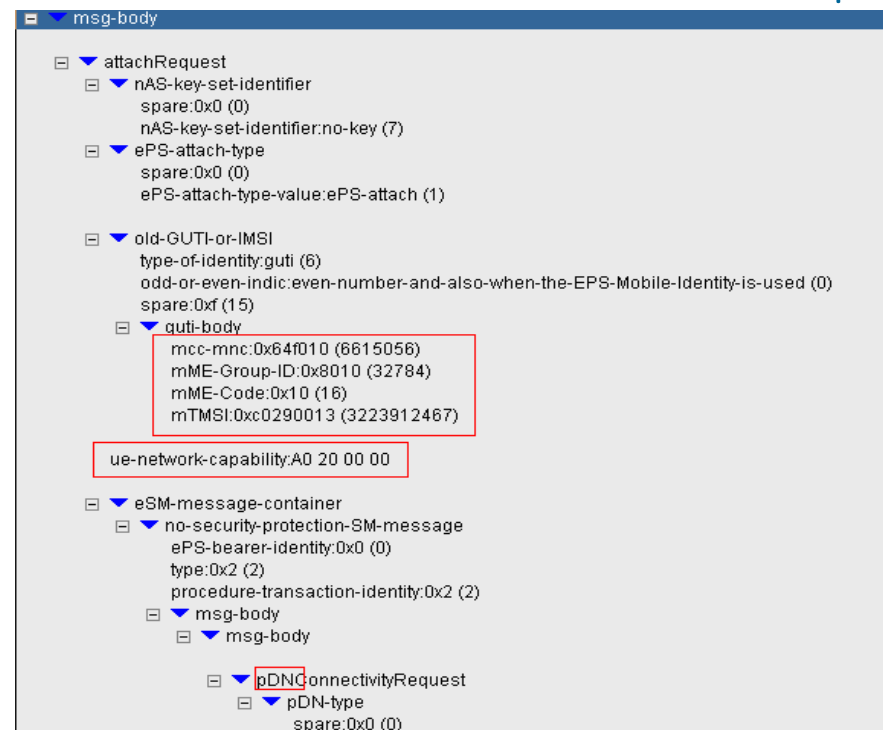
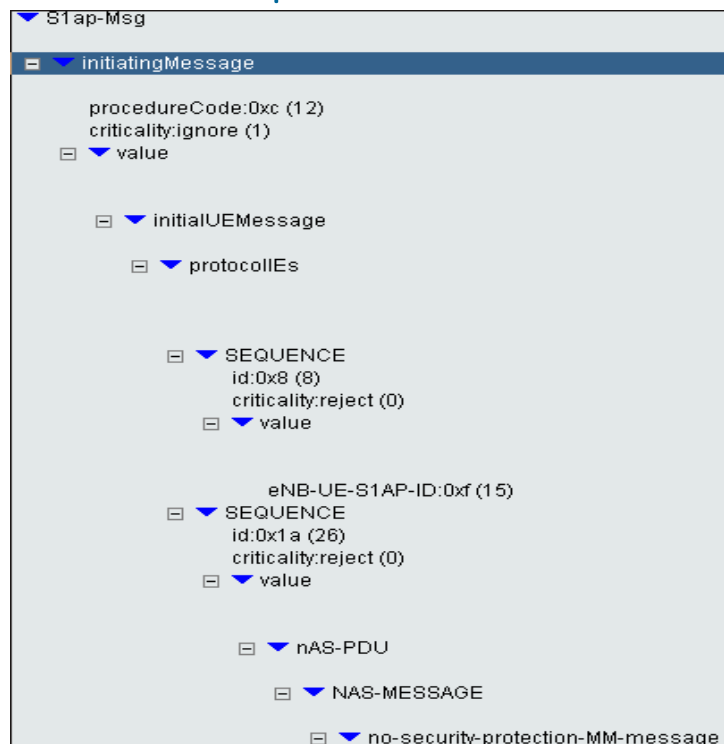
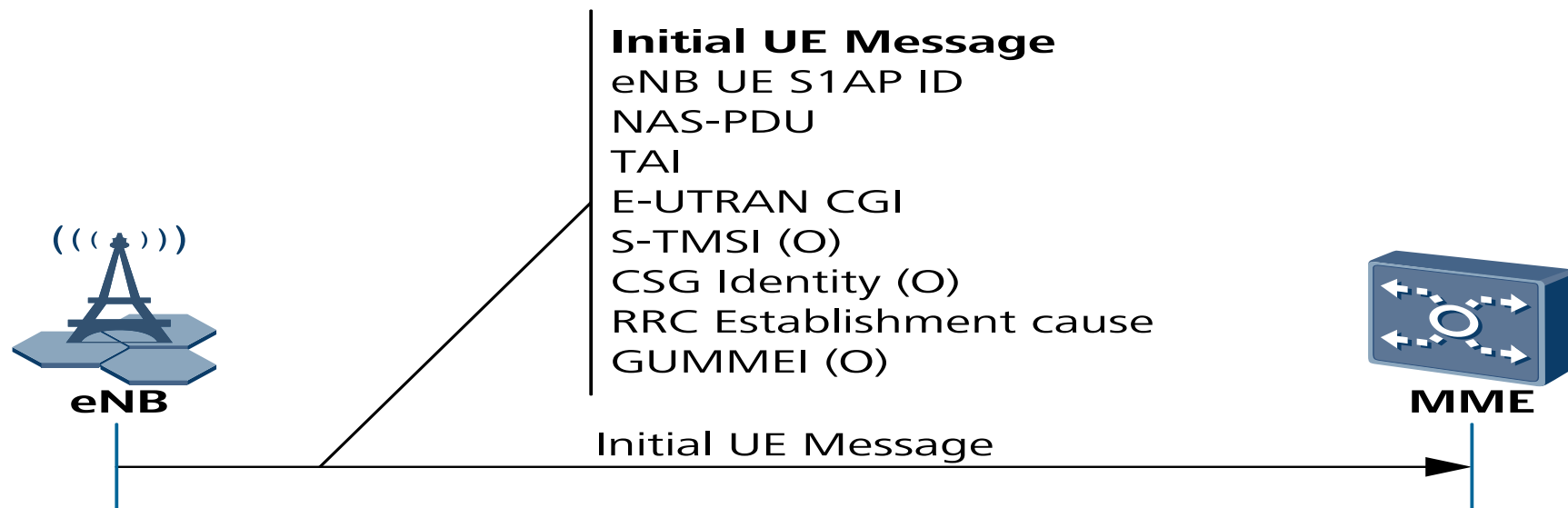
RRC CONN SETUP



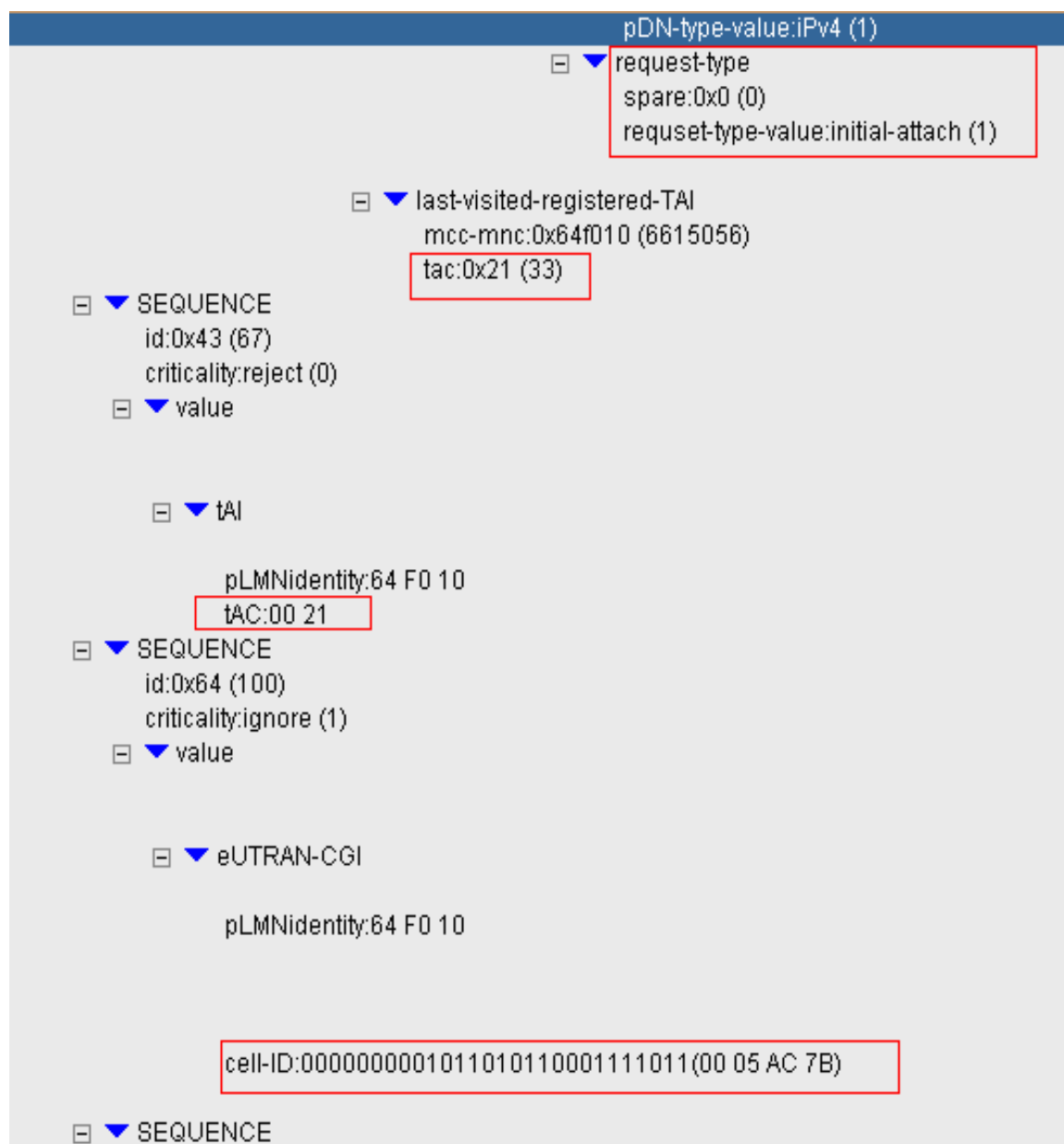
RRC CONN SETUP CMP



Direct transfer message of S1 interface



Direct transfer message of S1interface



Direct transfer (Authentication & ciphering)

Uu interface trace

C:\Documents and Settings\y00142117\桌面接入\AM21_Uu_2010-11-13-14-53-52.tmf

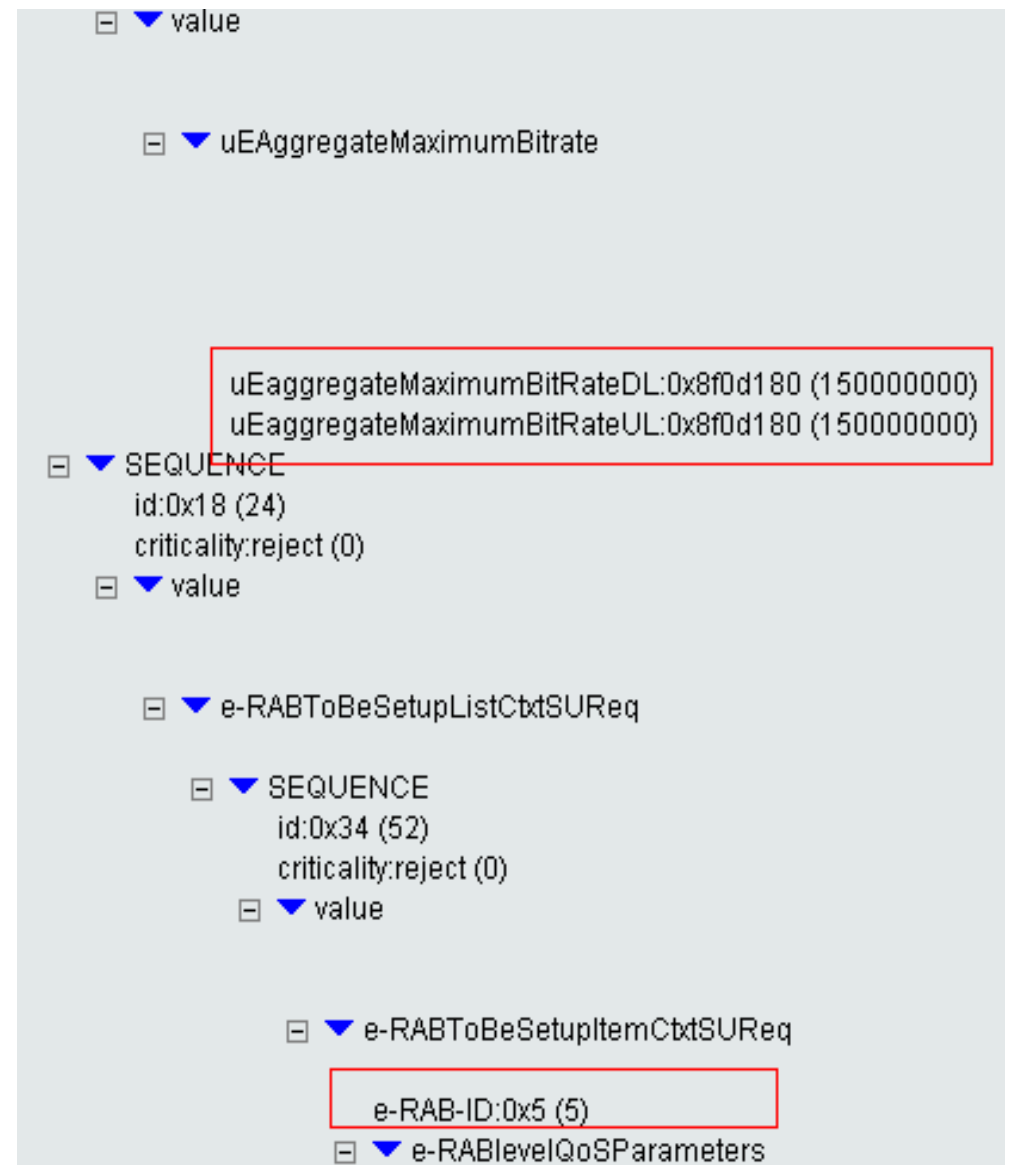
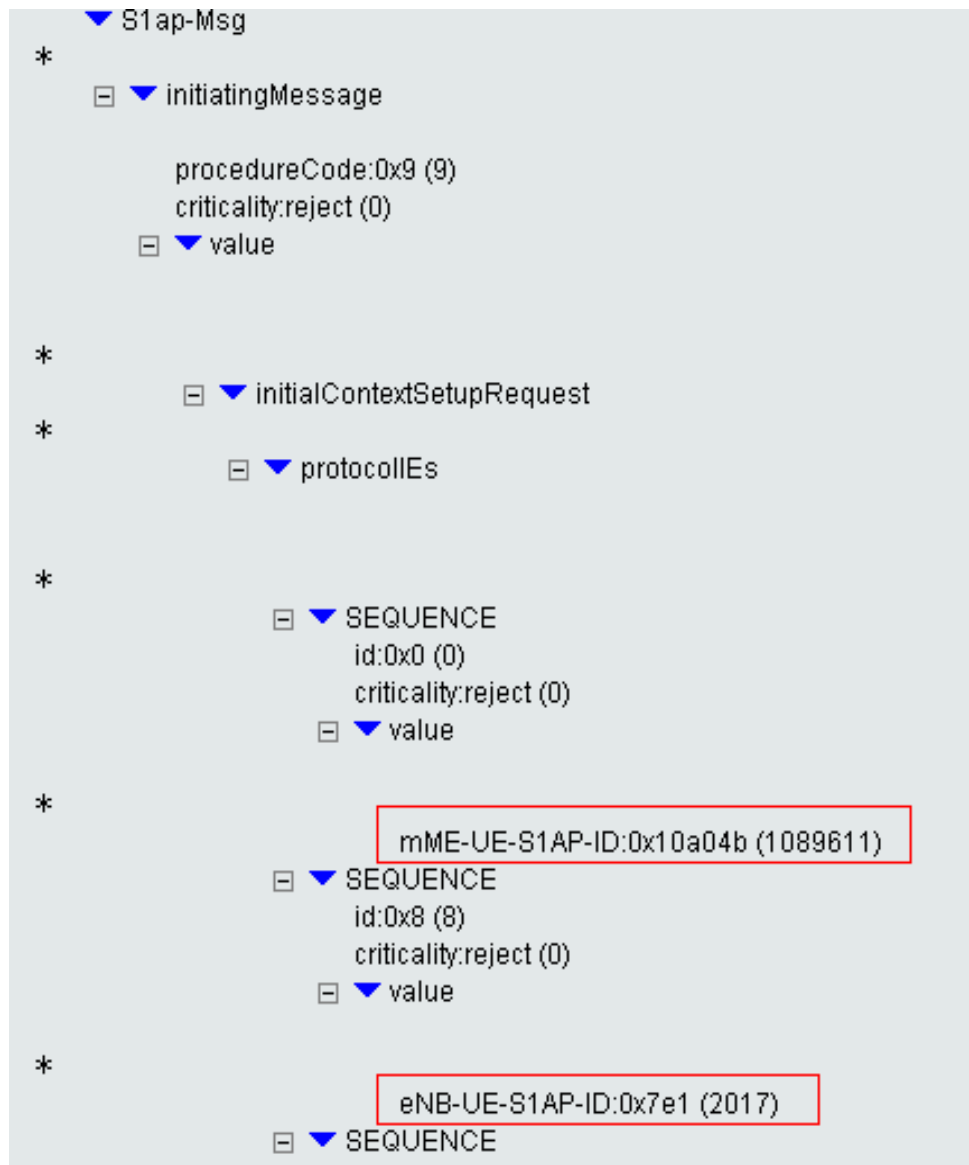
No. ▲	Time ▲	Standard Interface Message Type ▲	Message direction ▲	Local CELLID ▲	F
1	2010-06-05 21:42:35(508943)	RRC_CONN_REQ	RECEIVE	1	1
2	2010-06-05 21:42:35(513483)	RRC_CONN_SETUP	SEND	1	1
3	2010-06-05 21:42:35(530254)	RRC_CONN_SETUP_CMP	RECEIVE	1	1
4	2010-06-05 21:42:35(542255)	RRC_DL_INFO_TRANSF	SEND	1	1
5	2010-06-05 21:42:35(555249)	RRC_UL_INFO_TRANSF	RECEIVE	1	1
6	2010-06-05 21:42:35(558117)	RRC_DL_INFO_TRANSF	SEND	1	1
7	2010-06-05 21:42:35(570223)	RRC_UL_INFO_TRANSF	RECEIVE	1	1
8	2010-06-05 21:42:35(596559)	RRC_SECUR_MODE_CMD	SEND	1	1
9	2010-06-05 21:42:35(610316)	RRC_SECUR_MODE_CMP	RECEIVE	1	1
10	2010-06-05 21:42:35(610996)	RRC_UE_CAP_ENQUIRY	SEND	1	1
11	2010-06-05 21:42:35(625204)	RRC_UE_CAP_INFO	RECEIVE	1	1
12	2010-06-05 21:42:35(630563)	RRC_CONN_RECFG	SEND	1	1
13	2010-06-05 21:42:35(650405)	RRC_CONN_RECFG_CMP	RECEIVE	1	1
14	2010-06-05 21:42:35(653643)	RRC_CONN_RECFG	SEND	1	1
15	2010-06-05 21:42:35(654304)	RRC_UL_INFO_TRANSF	RECEIVE	1	1

S1 interface trace

C:\Documents and Settings\y00142117\桌面接入\AM21_S1_2010-11-13-14-54-41.tmf

No. ▲	Time ▲	Standard Interface Message Type ▲	Message direction ▲	S1 ID ▲
1	2010-06-05 21:42:35(531408)	S1AP_INITIAL_UE_MSG	SEND	0
2	2010-06-05 21:42:35(541436)	S1AP_DL_NAS_TRANS	RECEIVE	0
3	2010-06-05 21:42:35(555771)	S1AP_UL_NAS_TRANS	SEND	0
4	2010-06-05 21:42:35(557390)	S1AP_DL_NAS_TRANS	RECEIVE	0
5	2010-06-05 21:42:35(570751)	S1AP_UL_NAS_TRANS	SEND	0
6	2010-06-05 21:42:35(593533)	S1AP_INITIAL_CONTEXT_SETUP_REQ	RECEIVE	0
7	2010-06-05 21:42:35(625894)	S1AP_UE_CAPABILITY_INFO_IND	SEND	0
8	2010-06-05 21:42:35(651442)	S1AP_INITIAL_CONTEXT_SETUP_RSP	SEND	0
9	2010-06-05 21:42:35(654807)	S1AP_UL_NAS_TRANS	SEND	0

S1 Initial Context Setup Request



S1 Initial Context Setup Request

SEQUENCE
id:0x34 (52)
criticality:reject (0)
▼ value

▣ ▼ e-RABToBeSetupItemCtxtSUReq

e-RAB-ID:0x5 (5)

▣ ▼ e-RABLevelQoSParameters

qCI:0x9 (9)

▣ ▼ allocationRetentionPriority

priorityLevel:0x6 (6)
pre-emptionCapability:may-trigger-pre-emption (1)
pre-emptionVulnerability:pre-emptable (1)

transportLayerAddress:10001010001000000000000100110010(8A 20 01 32)
gTP-TEID:03 00 9C 1F

▣ ▼ NAS-PDU

▣ ▼ NAS-MESSAGE

▣ ▼ security-protected-and-ciphered-NAS-message
message-authentication-code:22 27 3D D1
sequence-number:0x1 (1)

▣ ▼ security-protected-and-ciphered-NAS-message
message-authentication-code:22 27 3D D1
sequence-number:0x1 (1)

▣ ▼ SEQUENCE
id:0x6b (107)
criticality:reject (0)
▣ ▼ value

⊕ ▶ uESecurityCapabilities

▣ ▼ SEQUENCE
id:0x49 (73)
criticality:reject (0)
▣ ▼ value

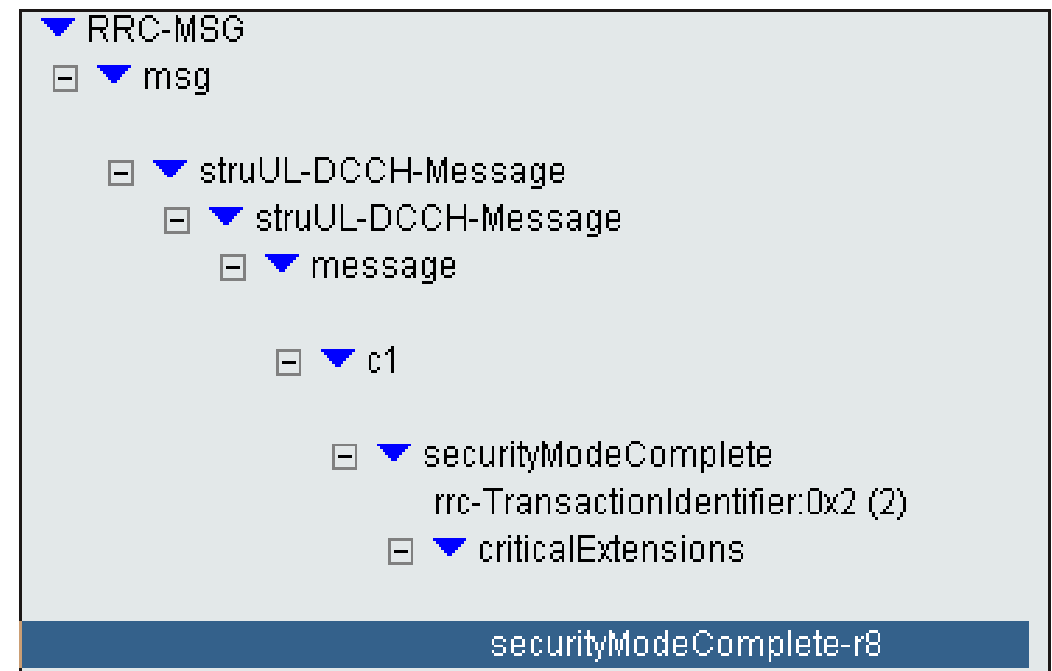
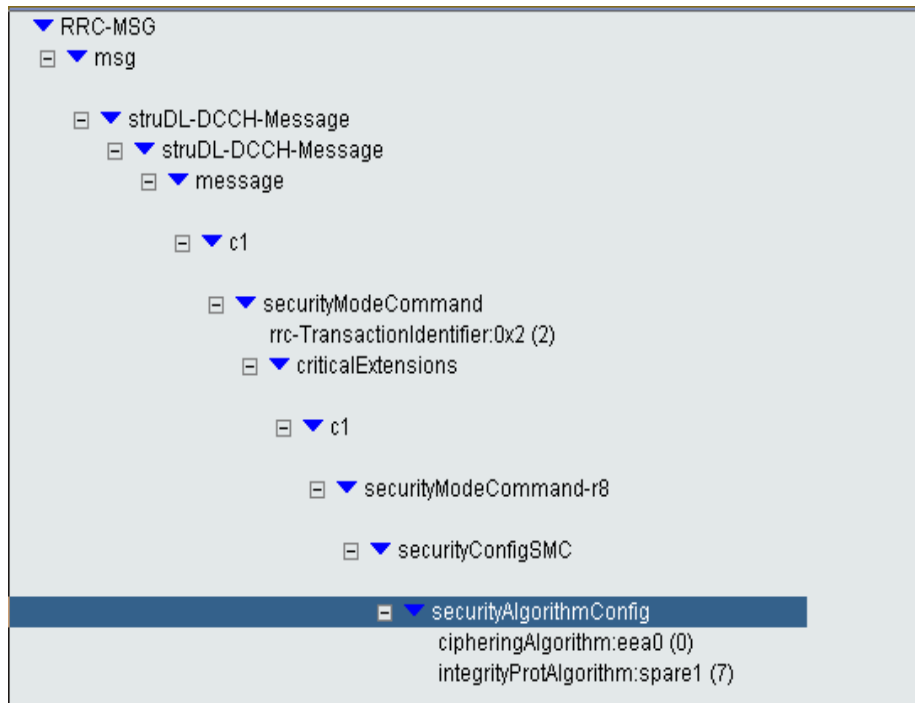
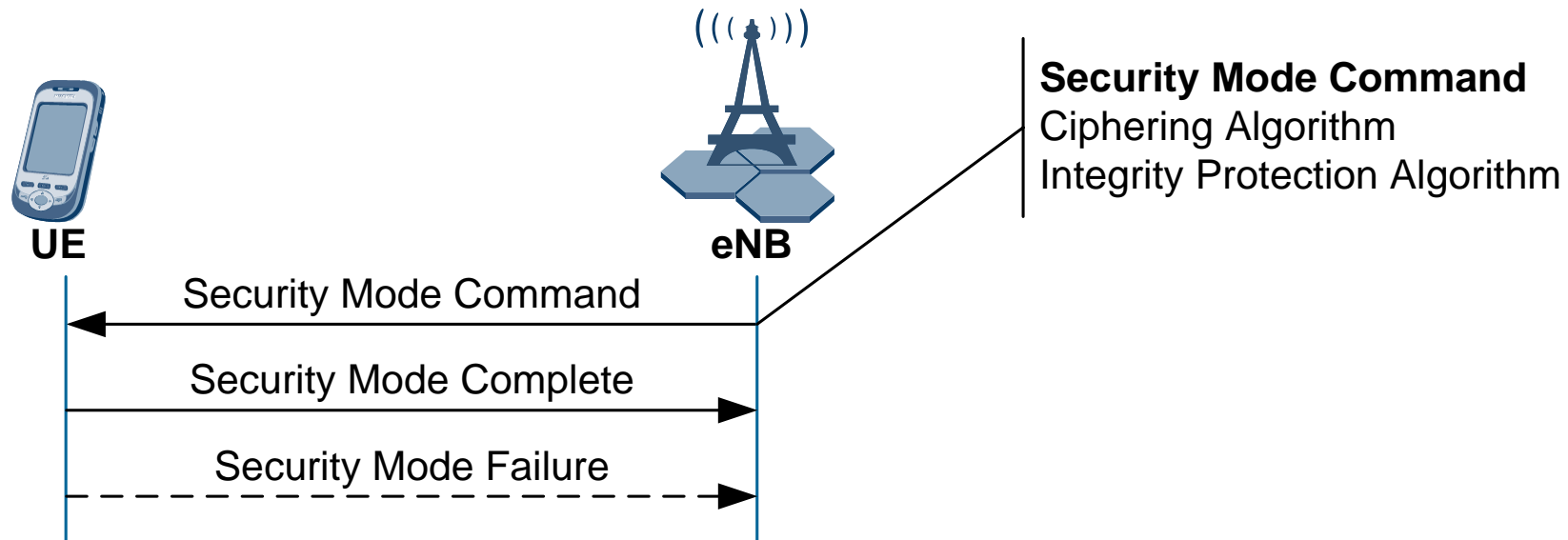
securityKey:11110110101000001111000111111000111010111111000

▣ ▼ SEQUENCE
id:0x29 (41)
criticality:ignore (1)
▣ ▼ value

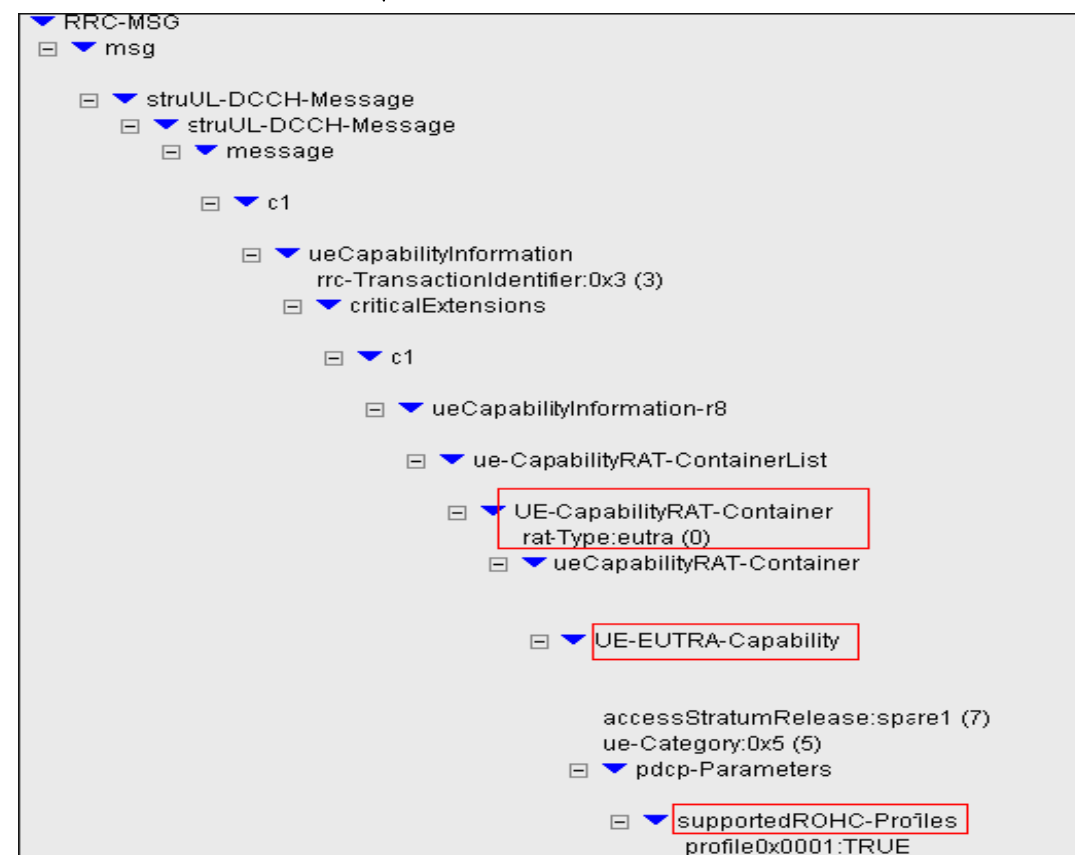
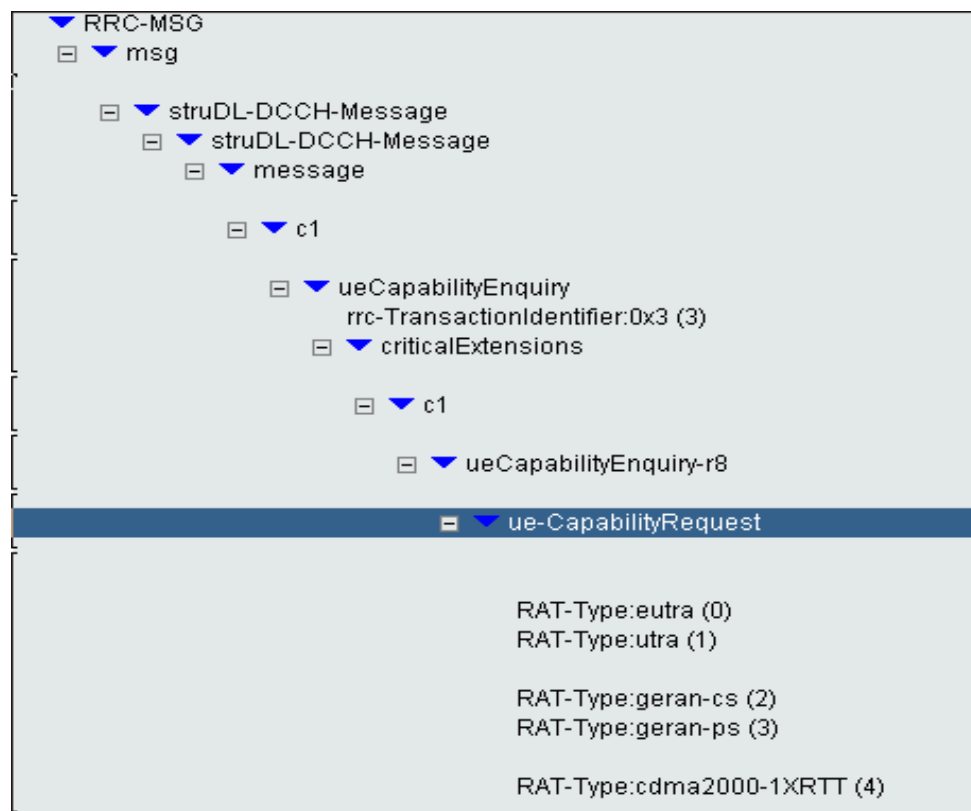
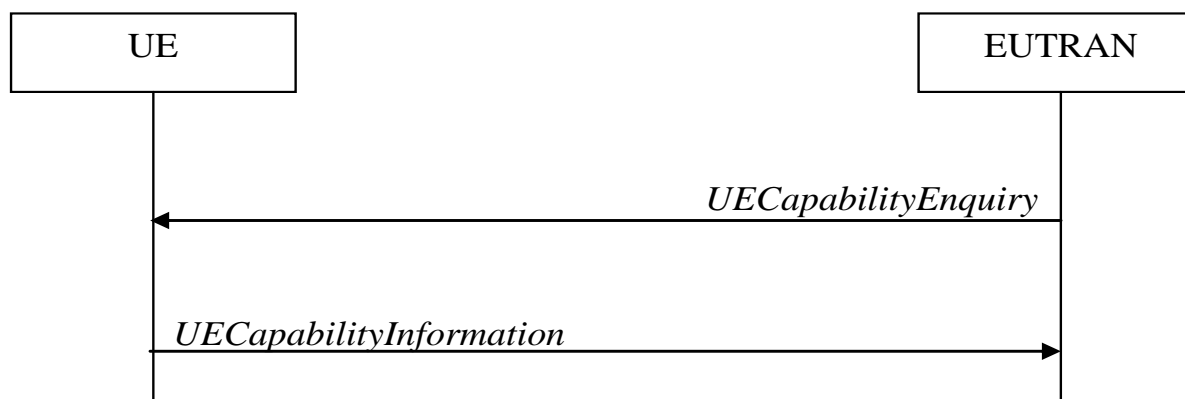
▣ ▼ handoverRestrictionList

servingPLMN:42 F0 60

RRC Security Mode Command

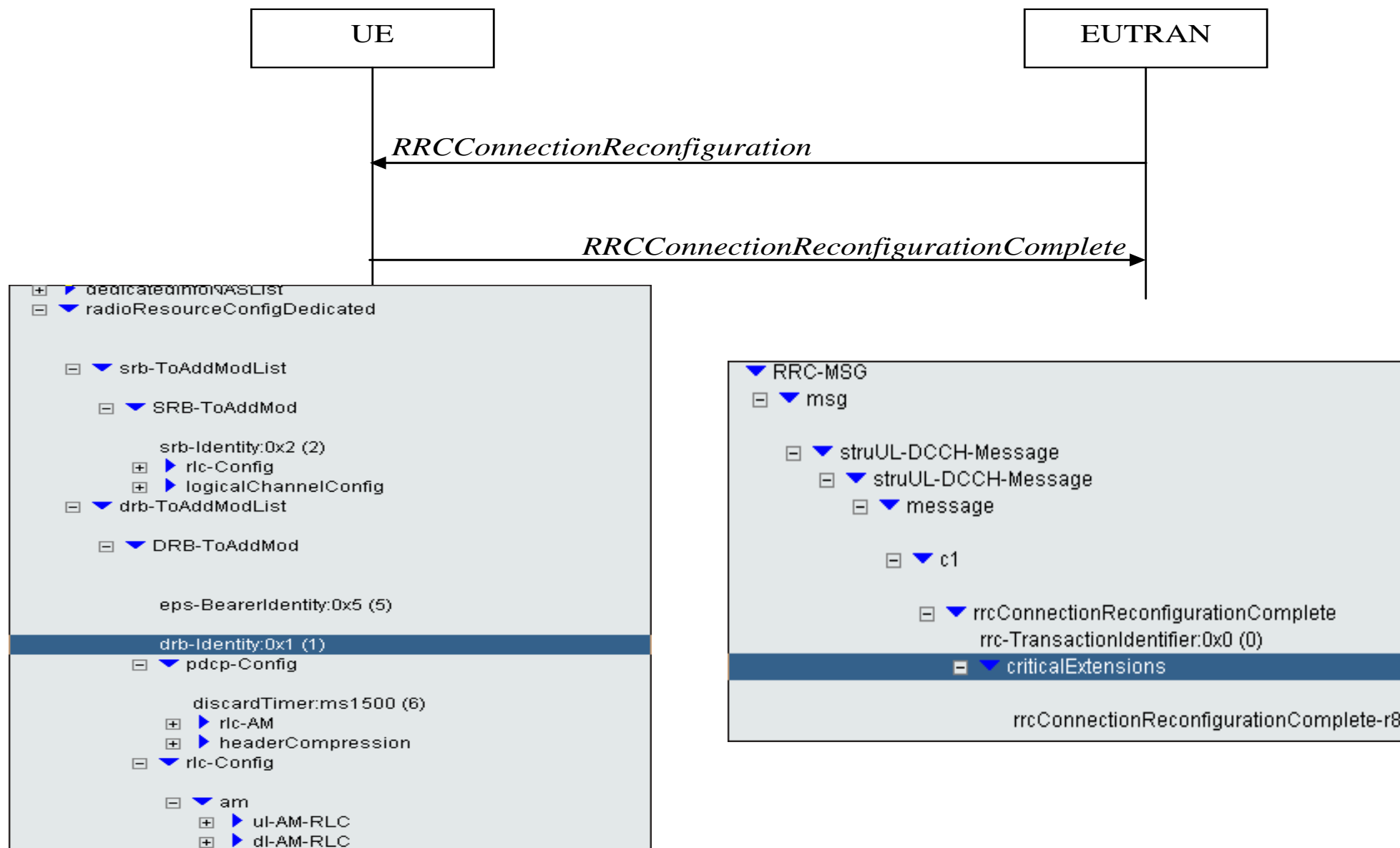


UE capability report

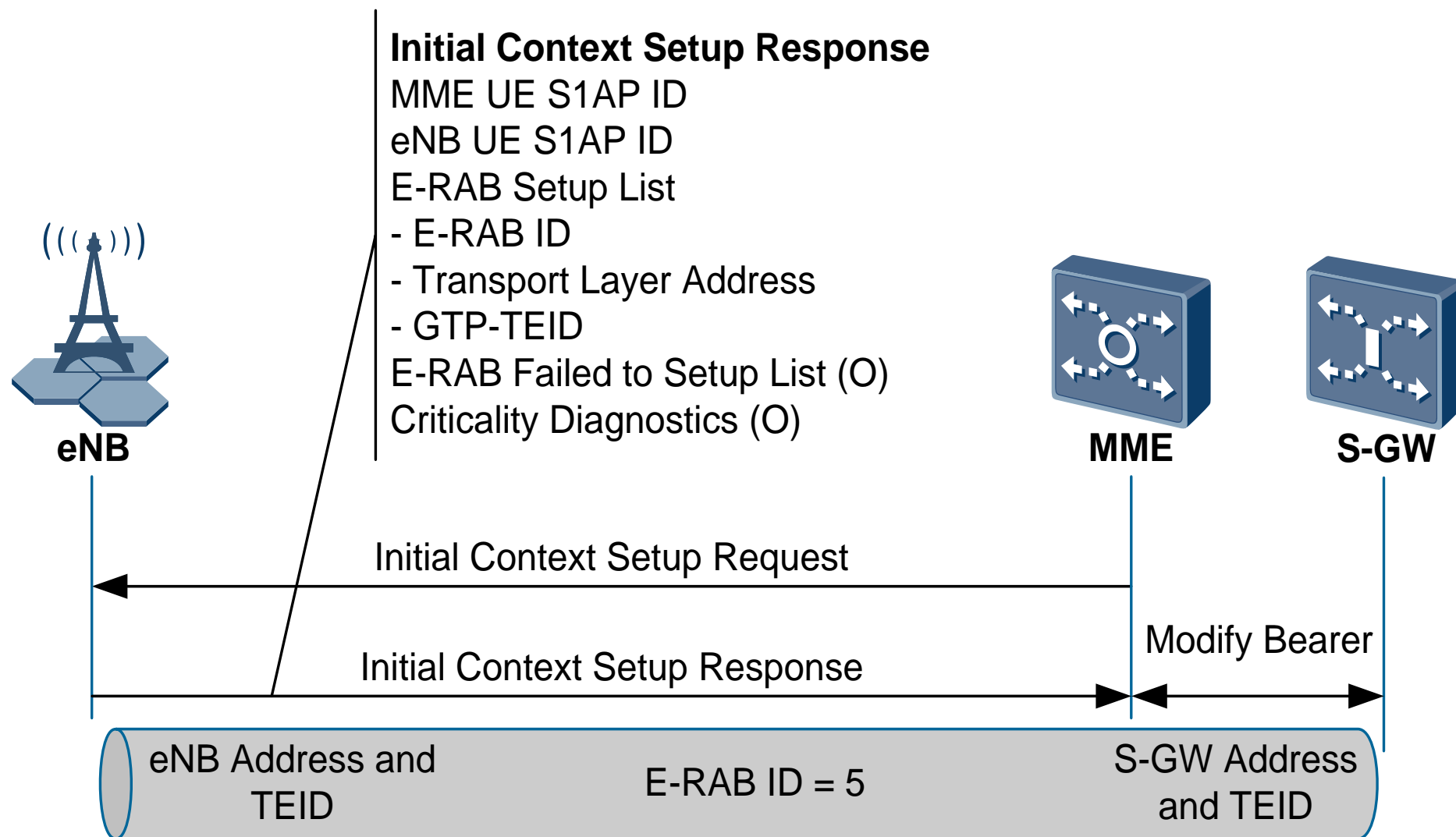


RRC connection reconfiguration

Used to establish SRB2 and default DRB1.



INITI UE CONTEXT SETUP RSP



INITI UE CONTEXT SETUP RSP

▼ S1ap-Msg

- ▼ successfulOutcome
 - procedureCode:0x9 (9)
 - criticality:reject (0)
 - ▼ value
- ▼ initialContextSetupResponse
 - ▼ protocolIEs
- ▼ SEQUENCE
 - id:0x0 (0)
 - criticality:ignore (1)
 - ▼ value
- ▼ SEQUENCE
 - id:0x8 (8)
 - criticality:ignore (1)
 - ▼ value
- ▼ SEQUENCE
 - id:0x33 (51)
 - criticality:ignore (1)

mME-UE-S1AP-ID:0x10a04b (1089611)

eNB-UE-S1AP-ID:0x7e1 (2017)

eNB-UE-S1AP-ID:0x7e1 (2017)

- ▼ SEQUENCE
 - id:0x33 (51)
 - criticality:ignore (1)
 - ▼ value
- ▼ e-RABSetupListCtxtSRes
 - ▼ SEQUENCE
 - id:0x32 (50)
 - criticality:ignore (1)
 - ▼ value
- ▼ e-RABSetupItemCtxtSRes
 - e-RAB-ID:0x5 (5)

transportLayerAddress:01011010001000000010100000010111(5A 20 28 17)
gTP-TEID:00 00 04 0B

Service request procedure

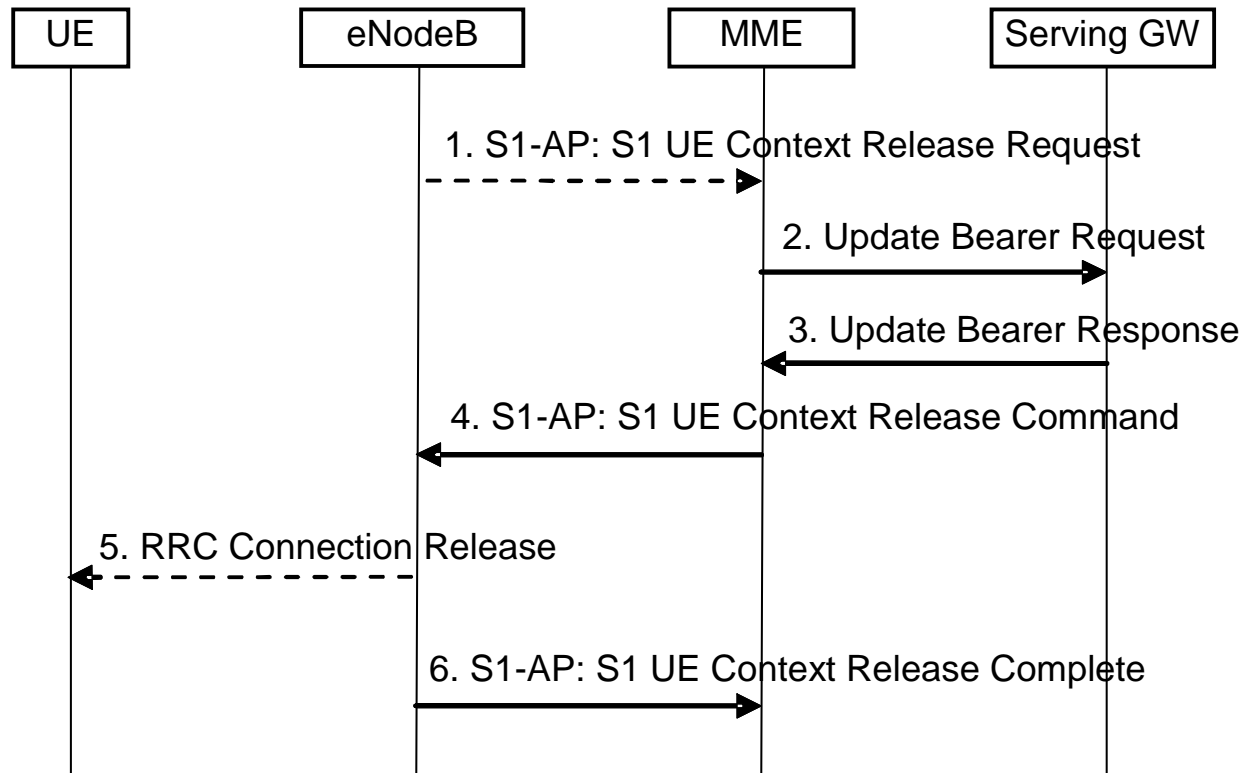
Uu interface trace

C:\Documents and Settings\y00142117\桌面\接入\AM21_Uu_2010-11-13-14-53-52.tmf					
No. ▲	Time ▲	Standard Interface Message Type ▲	Message direction ▲	Local CELLID ▲	F
1	2010-06-05 21:42:35(508943)	RRC_CONN_REQ	RECEIVE	1	1
2	2010-06-05 21:42:35(513483)	RRC_CONN_SETUP	SEND	1	1
3	2010-06-05 21:42:35(530254)	RRC_CONN_SETUP_CMP	RECEIVE	1	1
4	2010-06-05 21:42:35(542255)	RRC_DL_INFO_TRANSF	SEND	1	1
5	2010-06-05 21:42:35(555249)	RRC_UL_INFO_TRANSF	RECEIVE	1	1
6	2010-06-05 21:42:35(558117)	RRC_DL_INFO_TRANSF	SEND	1	1
7	2010-06-05 21:42:35(570223)	RRC_UL_INFO_TRANSF	RECEIVE	1	1
8	2010-06-05 21:42:35(596559)	RRC_SECUR_MODE_CMD	SEND	1	1
9	2010-06-05 21:42:35(610316)	RRC_SECUR_MODE_CMP	RECEIVE	1	1
10	2010-06-05 21:42:35(610996)	RRC_UE_CAP_ENQUIRY	SEND	1	1
11	2010-06-05 21:42:35(625204)	RRC_UE_CAP_INFO	RECEIVE	1	1
12	2010-06-05 21:42:35(630563)	RRC_CONN_RECFG	SEND	1	1
13	2010-06-05 21:42:35(650405)	RRC_CONN_RECFG_CMP	RECEIVE	1	1
14	2010-06-05 21:42:35(653643)	RRC_CONN_RECFG	SEND	1	1
15	2010-06-05 21:42:35(654304)	RRC_UL_INFO_TRANSF	RECEIVE	1	1

S1 interface trace

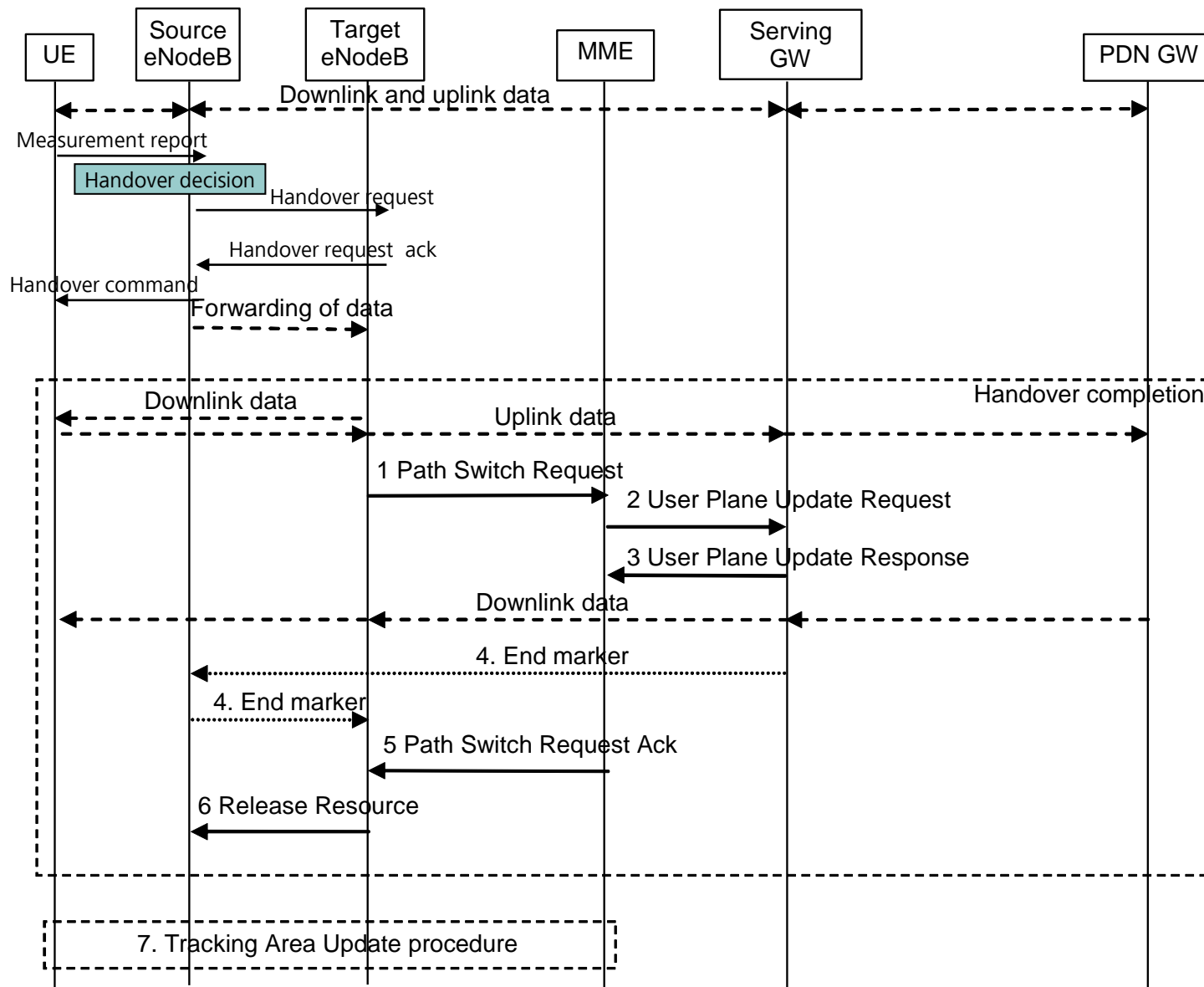
C:\Documents and Settings\y00142117\桌面\接入\AM21_S1_2010-11-13-14-54-41.tmf				
No. ▲	Time ▲	Standard Interface Message Type ▲	Message direction ▲	S1 ID ▲
1	2010-06-05 21:42:35(531408)	S1AP_INITIAL_UE_MSG	SEND	0
2	2010-06-05 21:42:35(541436)	S1AP_DL_NAS_TRANS	RECEIVE	0
3	2010-06-05 21:42:35(555771)	S1AP_UL_NAS_TRANS	SEND	0
4	2010-06-05 21:42:35(557390)	S1AP_DL_NAS_TRANS	RECEIVE	0
5	2010-06-05 21:42:35(570751)	S1AP_UL_NAS_TRANS	SEND	0
6	2010-06-05 21:42:35(593533)	S1AP_INITIAL_CONTEXT_SETUP_REQ	RECEIVE	0
7	2010-06-05 21:42:35(625894)	S1AP_UE_CAPABILITY_INFO_IND	SEND	0
8	2010-06-05 21:42:35(651442)	S1AP_INITIAL_CONTEXT_SETUP_RSP	SEND	0
9	2010-06-05 21:42:35(654807)	S1AP_UL_NAS_TRANS	SEND	0

S1 release procedure



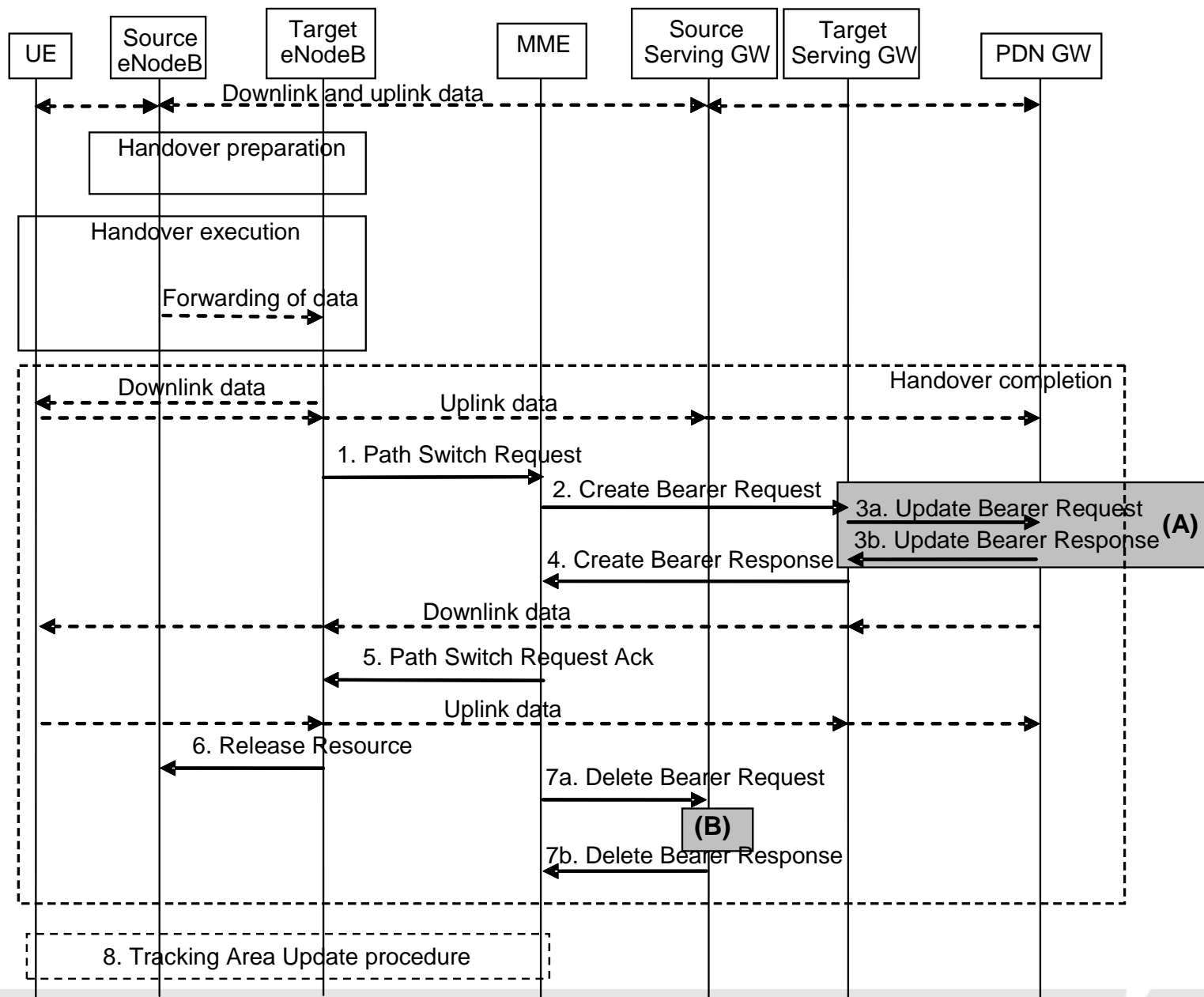
- Purpose:
 - To release the logical S1-AP signalling connection (over S1-MME) and all S1 bearers (in S1-U) for a UE. The procedure will move the UE from ECM-CONNECTED to ECM-IDLE in both the UE and MME, and all UE related context information is deleted in the eNodeB

Intra EUTRAN X2-based handover without Serving GW relocation

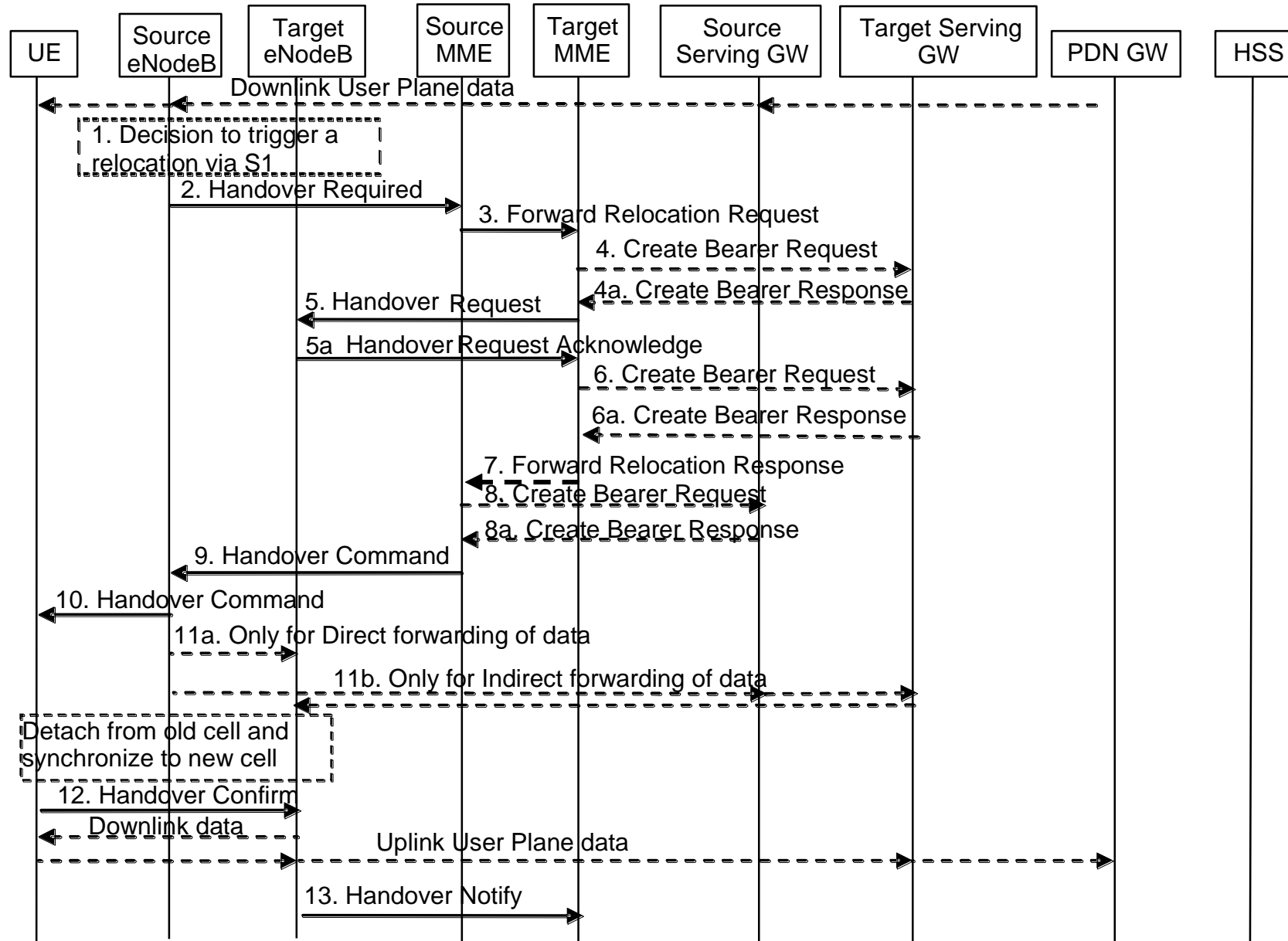


- See notes for details

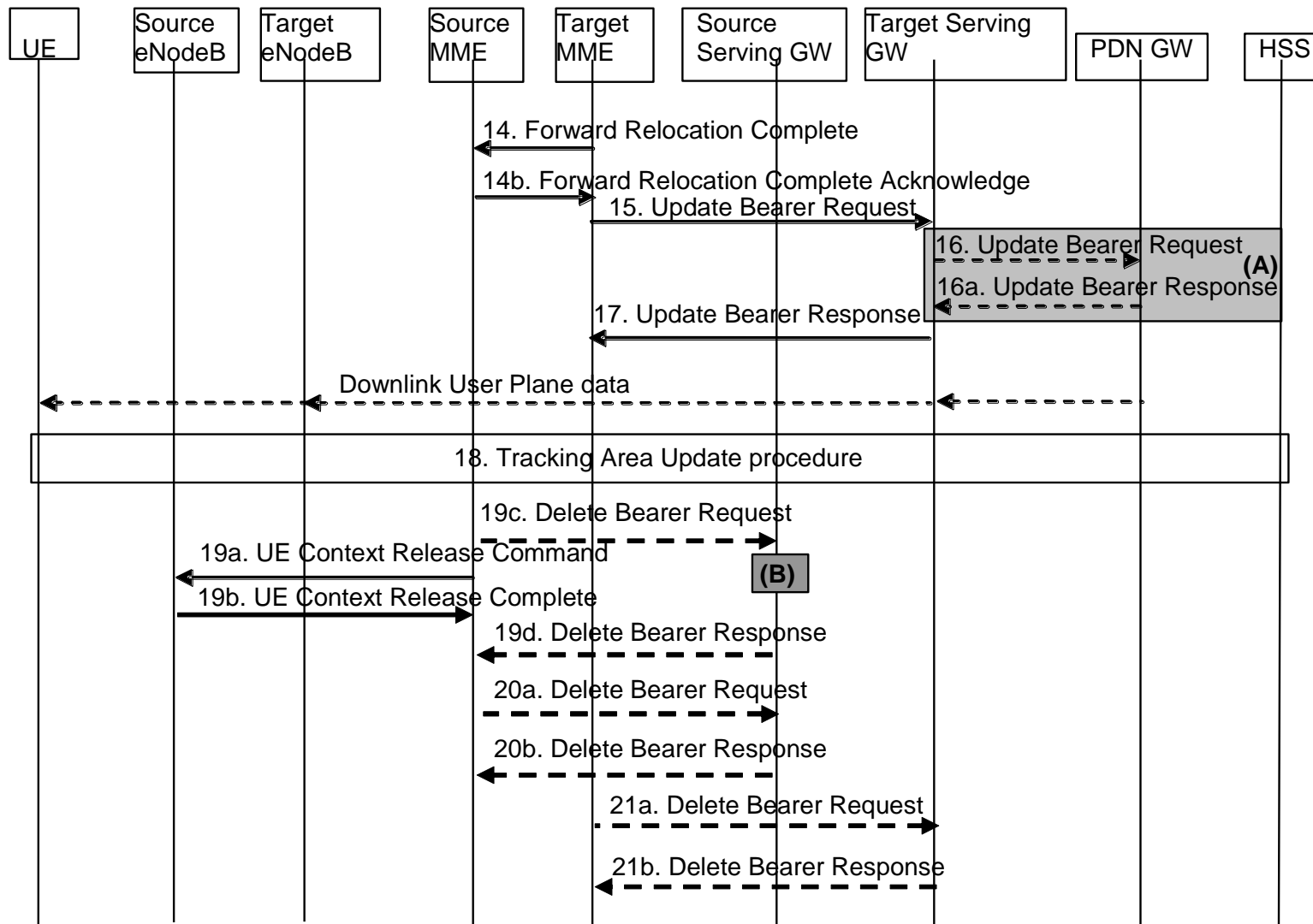
Intra EUTRAN X2-based handover with Serving GW relocation



Intra EUTRAN S1-based handover



Intra EUTRAN S1-based handover



Thank you

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