

## EMM Procedure 3. S1 Release

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This document, as the third of the EMM Procedure series, will explain procedures for releasing S1 connection when a UE becomes inactive, and thus not connected to any eNB, as in EMM Case 3 defined in our technical document, "Eleven EMM Cases in an EMM Scenario". We will learn how S1 signaling connection is released in control plane, and the downlink S1 bearer connection is released in user plane during the procedures. We will also describe how information elements in EPS entities are different before and after S1 release.

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## Abbreviations

AMBR	Aggregated Maximum Bit Rate
APN	Access Point Name
ARP	Allocation Retention Priority
AS	Access Stratum
C-RNTI	Cell Radio Network Temporary Identifier
CSG	Closed Subscriber Group
DL	Downlink
DRB	Data Radio Bearer
ECGI	E-UTRAN Cell Global Identifier
ECM	EPS Connection Management
EMM	EPS Mobility Management
eNB	Evolved Node B
EPS	Evolved Packet System
E-RAB	E-UTRAN Radio Access Bearer
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
GTP	GPRS Tunneling Protocol
GUTI	Globally Unique Temporary Identifier
HSS	Home Subscriber Server
IMSI	International Mobile Subscriber Identity
LTE	Long Term Evolution
MME	Mobility Management Entity
NAS	Non Access Stratum
O&M	Operation and Maintenance
PCC	Policy and Charging Control
PCRF	Policy and Charging Rule Function
P-GW	Packet Data Network Gateway
QCI	QoS Class Identifier
RRC	Radio Resource Control
S1AP	S1 Application Protocol
SDF	Service Data Flow
S-GW	Serving Gateway
SPR	Subscriber Profile Repository
TAI	Tracking Area Identity
TEID	Tunnel End Point Identifier
TFT	Traffic Flow Template
UE	User Equipment
UL	Uplink

## I. Introduction

This document will describe procedures for releasing S1 connection when a UE becomes inactive, as in EMM Case 3 defined in our technical document, “Eleven EMM Cases in an EMM Scenario”[1]. While inactive, the UE - registered at the network, but not in use of any service – does not use any radio resources allocated by eNB. So, among the allocated resources, the network releases those associated with radio access, and deletes their related information (e.g. IDs, QoS parameters, etc.).

From a network’s perspective, S1 release means releasing the S1 signaling and RRC connections in control plane, and the downlink S1 bearer and DRB (Data Radio Bearer) in user plane, that are associated with a UE. However, from a UE’s perspective, it means losing its RRC connection and DRB in control and user planes, respectively. Once S1 connection is released, the ECM connection between UE and MME is lost, and all contexts associated with the UE are deleted at eNB. Then, the user transits from **ECM-Connected** to **ECM-Idle** state at the UE and MME, but remains in **EMM-Registered** state even after the transit.

This document explains the procedures for S1 release due to user inactivity in an LTE network. Chapter II provides a description of how S1 release is performed, and Chapter III summarizes what information elements are changed after the S1 release procedure.

## II. S1 Release due to User Inactivity

S1 release may be triggered by either eNB or MME. eNB-triggered release can be caused by:

- user inactivity
- repeated RRC signaling integrity check failure
- release due to UE generated signaling connection release
- unspecified failure
- O&M intervention

MME-triggered release can be caused by:

- authentication failure
- detach
- disallowed CSG cell

In addition, S1 release can be triggered by the two for other reasons, such as control processing overload, not enough user plane processing resources available, etc.

Figure 1 shows the connections established in user and control planes, and the UE and MME states in the planes, before and after S1 release. Before the release, an EPS bearer and signaling connection are established to support traffic transmission between a user and the network (UE through P-GW). The EPS bearer consists of a DRB, S1 bearer and S5 bearer, while the signaling connection consists of an ECM (RRC + S1 signaling connections), S11 and S5 connections. The UE and MME are in **EMM-Registered** and **ECM-Connected** state, while the UE and eNB are in **RRC-Connected** state.

However, after S1 release, the DRB and downlink S1 bearer are released in the user plane, and the ECM connection (RRC + S1 signaling connections) is lost in the control plane, releasing E-UTRAN resources. It should be noted that at this time only the resources for the downlink S1 bearer are released, and those for the uplink are kept in the network.

The S1 release is different from the one in detach events described in our previous document. In the event of detach, all the resources allocated to a UE by the network are released, and thus the UE transits to **EMM-Deregistered** state. However, in the event of S1 release, only those allocated by the radio access network (E-UTRAN or eNB) are released, and ones allocated by EPC are kept unreleased. So, the UE remains in **EMM-Registered** state, transiting to **ECM-Idle** state. Then later when there is uplink/downlink user traffic, ECM connection and DRB/S1 bearer (downlink) setup is performed, switching the UE state into **ECM-Connected**, and delivers the traffic.

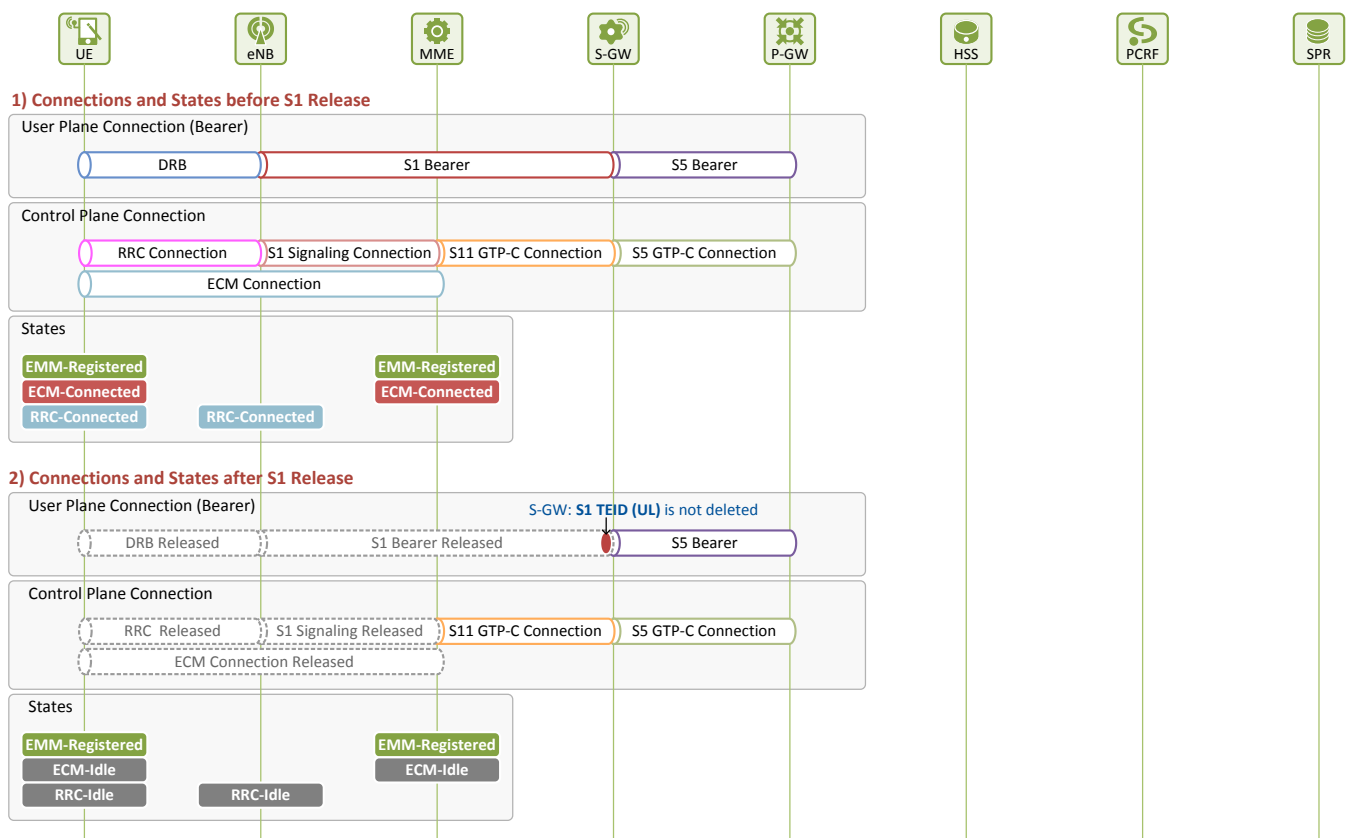


Figure 1. Connections and States before/after S1 Release

Figure 2 displays the procedures for S1 release triggered by eNB upon detection of user inactivity (Note: Procedures will still be the same even when S1 release is triggered by a cause other than user inactivity). In case S1 release is triggered by MME, Step 1) in Figure 2 will be skipped.

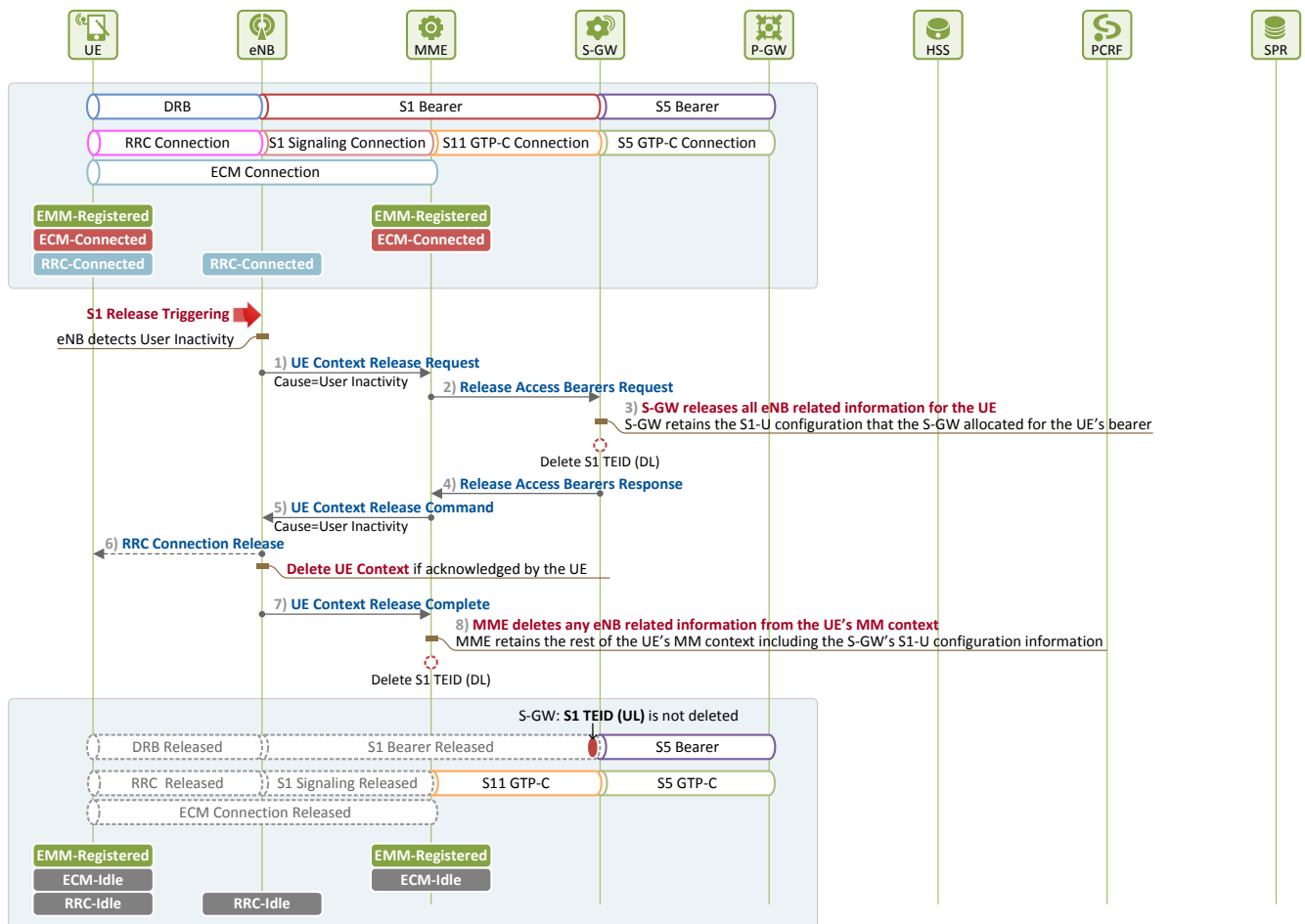


Figure 2. Procedures for S1 Release (eNB-initiated)

### 1) [eNB → MME] Requesting UE Context Release

The eNB, upon detecting user inactivity, sends the MME a **UE Context Release Request** message, along with the cause for release, to release the UE context.

### 2) [MME → S-GW] Requesting S1 Bearer Release

The MME requests the S-GW for release of resources associated with the eNB, a downlink endpoint of the S1 bearer, by sending the S-GW a **Release Access Bearers Request** message. This way, it informs the S-GW that no downlink traffic can be delivered to the UE.

### 3) [S-GW] Downlink S1 Bearer Release

The S-GW releases all the downlink S1 bearer resources associated with the UE (eNB related resources, including downlink S1 TEID allocated by eNB, etc.), but keeps the uplink S1 bearer resources (S-GW related resources, including uplink S1 TEID allocated by itself, etc.) unreleased. So, when uplink packets arrive, the eNB can obtain the uplink S1 TEID from the MME, and deliver the packets through the S1 bearer without delay.

### 4) [MME ← S-GW] Responding to S1 Bearer Release Request

The S-GW acknowledges that the downlink S1 bearer resources have been released by sending the MME a **Release Access Bearers Response** message. After that, if downlink packets destined to the UE arrive, the S-GW buffers them, and delivers them only after the downlink S1 bearer is re-established.

The detailed procedures will be explored in the subsequent document, “EMM Procedure 4. Service Request”.

**5) [eNB ← MME] UE Context Release Command**

The MME sends the eNB a **UE Context Release Command** message to release the UE context stored at the eNB.

**6) [UE ← eNB] RRC Connection Release**

The eNB, upon receiving the command from the MME, deletes all the UE contexts it had. If RRC connection has not been released yet, the eNB sends the UE a **RRC Connection Release** message to release it. By doing so, the eNB releases all the radio resources and bearers allocated to the UE, and deletes the UE contexts.

**7) [eNB → MME] UE Context Release Complete**

The eNB sends the MME a **UE Context Release Complete** message as a response to the request sent in Step 5). The MME then confirms all the UE contexts have been deleted.

**8) [MME] S1 Release**

The MME deletes all the eNB related information, except for uplink S1 bearer information, in the UE contexts. But it keeps other information not related to the eNB.

### III. EPS Entity Information: Before/After S1 Release

This chapter explores how information elements in the EPS entities are changed before and after S1 release. All the information elements are categorized into UE ID, UE Location, Security, and EPS Session/Bearer information.

#### 3.1 Before S1 Release

Before S1 release, the UE has been connected to the network, using services in **EMM-Registered**, **ECM-Connected** and **RRC-Connected** state. Therefore, all the EPS entities have the same information they initially had after initial attach in EMM Case 1 (see [2] for more information). Figure 3 lists the information elements stored in each EPS entity before S1 release is performed.

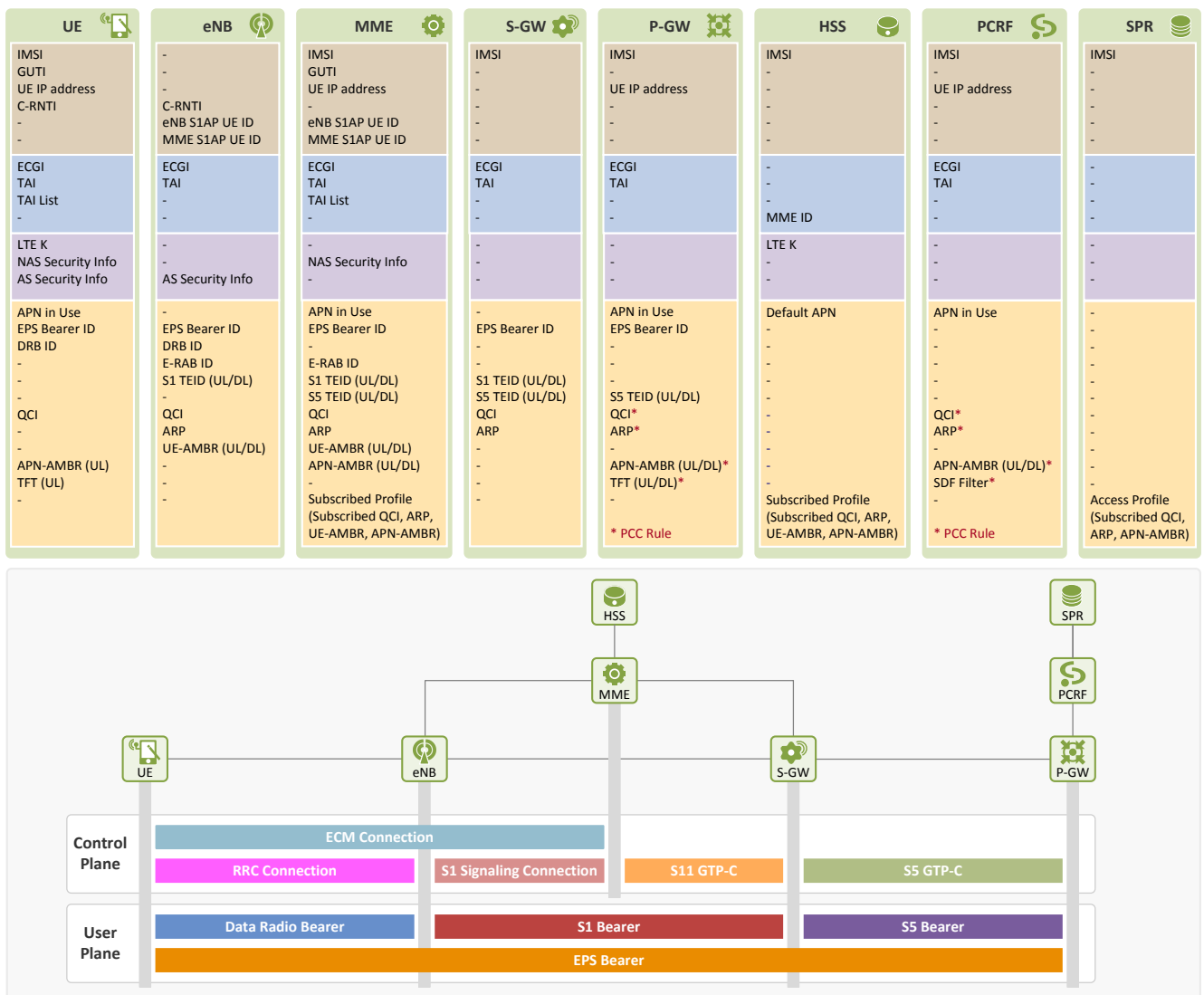


Figure 3. Information in EPS entities before S1 release



## 3.2 After S1 Release

After S1 release, the UE is still registered at the network, but stays in **EMM-Registered**, **ECM-Idle** and **RRC-Idle** state without using any service. Because the UE has no connection to any eNB, all the information required for the UE to connect the eNB (E-UTRAN), and to transmit traffic is released. In the control plane, the ECM connection (RRC + S1 signaling connections) is released while the DRB and downlink S1 bearer are released in the user plane. Figure 4 lists the information elements each EPS entity has, and the connections that remain active after S1 release. The elements deleted after S1 release are shown in gray.

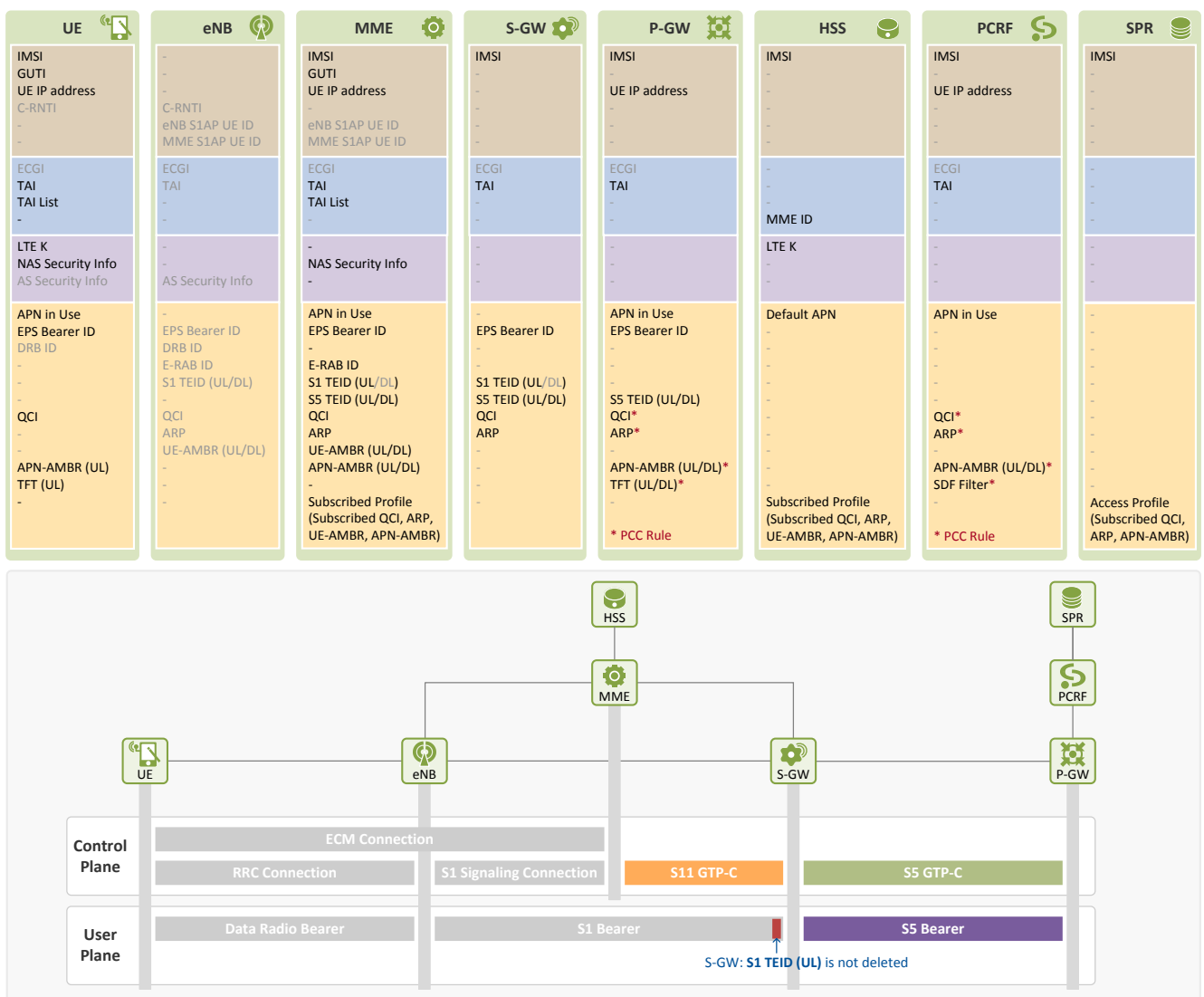


Figure 4. Information in EPS entities after S1 release

### Information deleted at UE:

- **C-RNTI**: identifies UEs in a cell that UE has connected to
- **ECGI**: information on the cell that UE is connected to
- **DRB ID**: ID for EPS bearer over radio link (DRB). Allocated to UE by eNB.
- **AS Security Info**: AS security context between UE and eNB (to be used for integrity protection/ciphering of RRC messages, and for ciphering of user packets)

### Information deleted at eNB:

- All information

### Information deleted at MME:

- **S1AP UE ID**: UE IDs information used in S1 signaling connection (eNB S1AP UE ID and MME S1AP UE ID)
- **ECGI**: information on the cell that UE is connected to
- **S1 TEID (DL)**: TEID information to be used in downlink S1 bearer

### Information deleted at S-GW:

- **ECGI**: information on the cell that UE is connected to
- **S1 TEID (DL)**: TEID information to be used in downlink S1 bearer

## IV. Closing

We have so far discussed the S1 Release (“EMM Case 3” in [1]) procedure that is performed when a UE stays inactive for a certain period of time after using services through the LTE network it accessed. We have learned the UE remains in **EMM-Registered** state, but transits to **ECM-Idle**, after the release procedure. In the subsequent document, we will look into the Service Request procedure (“EMM Case 4: Service Request” in [1]). This procedure is required to re-establish S1 connection to serve a UE, which has stayed in **ECM-Idle** state after S1 release, again when there is new UL/DL traffic from/to it.

## References

- [1] Netmanias Technical Document, “Eleven EMM Cases in an EMM Scenario”, October 2013, <http://www.netmanias.com/en/?m=view&id=techdocs&no=6002>
- [2] Netmanias Technical Document, “LTE EMM Procedure 1. Initial Attach – Part 2. Call Flow of Initial Attach”, January 2014, <http://www.netmanias.com/en/?m=view&id=techdocs&no=6102>
- [3] NMC Consulting Group Confidential Internal Report, “E2E LTE Network Design”, August 2010

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