EMM Procedure 2. Detach

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This document, as the second of the EMM Procedure series, will discuss detach procedures required for cases where a user detaches/is detached from the LTE network he attached to, as in EMM Case 2 in "Eleven EMM Cases in an EMM Scenario". Depending on where detach triggering is detected, we will categorize detach into three types: UE-initiated Detach, MME-initiated Detach and HSS-initiated Detach. Then we will describe detach procedures required in each type. Finally, we will look into what changes are made in the information EPS entities have after detach.

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Abbreviations

AMBR	Aggregated Maximum Bit Rate
APN	Access Point Name
AS	Access Stratum
ASME	Access Security Management Entity
C-RNTI	Cell Radio Network Temporary Identifier
CS	Circuit-Switched
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
GUTI	Globally Unique Temporary Identifier
HSS	Home Subscriber Server
IMSI	International Mobile Subscriber Identity
KSI	Key Set Identifier
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
RRC	Radio Resource Control
S-GW	Serving Gateway
SMS	Short Message Service
SPR	Subscriber Profile Repository
TAI	Tracking Area Identity
UE	User Equipment
UL	Uplink
USIM	Universal Subscriber Identity Module

I. Introduction

This document discusses detach procedures defined as EMM Case 2 in our previous document, "Eleven EMM Cases in an EMM Scenario"[1]. During this phase, a user is detached/detaches from the network he attached to. A user, initially attached to the network after going through the initial attach procedures as in EMM Case 1, uses LTE services in EMM-Registered state. After using the services, the user may be detached by the network or UE, while in ECM/RRC-Connected or ECM/RRC-Idle state. In any case, once detach procedures are completed, the user's EPS bearer(s) are released, and his state is cleared.

This document is about detach procedures in an LTE network, and is organized as follows: Chapter II identifies detach types depending on where the detach is triggered. Chapters III through V describe detach procedures required in each detach type. In Chapter VI, we will look into what kinds of information in each EPS entity are changed after the detach procedures in EMM Case 2.

II. Cases of Detach

A user uses LTE services after generating an EPS session and default EPS bearer through the initial attach procedures. In some cases, he may detach from the network once done using the services. In other cases, he may be detached by the network while still using services through the network, and becomes unable to stay connected to the network any more.

Once a user is detached from the network, all the network/radio resources allocated to the EPS session and bearer established for the user are released. This release will delete the user's MM context and EPS bearer that have been set to the EPS entities (UE and network nodes). At this time, the EMM state transits from Registered to De-Registered. If the user is properly detached, GUTI, a NAS-level user ID, and the security context that he used to access the network are kept valid in the UE and the MME, so that he can use the same in his next access to the network.

Detach can be triggered by UE or a network. Network-triggered detach is caused by either MME or HSS. Detach can be categorized as one of the following cases depending on where detach triggering is detected:

1) **Detach Case 1: UE-initiated Detach**

   UE can initiate detach:
   - if UE is turned off
   - if a USIM card is removed from UE
   - if UE is attempting to use a non-EPS service (e.g. CS fallback, SMS, etc.)

2) **Detach Case 2: MME-initiated Detach**

   MME-initiated detach can be further divided into explicit detach and implicit detach. In case of explicit detach, MME notifies UE of its intent to detach in advance by sending a Detach Request message, and informs the UE whether it has to attach the network again or not after detach. In case of implicit detach, however, the MME initiates detach procedures without notification (i.e. without sending a Detach Request message) because the UE is not capable of communicating with the MME. MME can initiate:

  i) Explicit Detach

- for an operator's O&M (Operation & Maintenance) purposes
- if re-authentication fails
- if it cannot provide the resources allocated to a user

  ii) Implicit Detach

- if it is not able to communicate with a user because of poor radio link quality (e.g. radio link failure)

3) Detach Case 3: HSS-initiated Detach

HSS can initiate detach:

- if the user profile provisioned in HSS is changed, and thus the one saved in MME also has to be changed
- if an operator is trying to restrict access by an illegal UE (e.g. a stolen device) to its network

The next three chapters (III, IV and V) describe different detach procedures required in the three detach cases mentioned above. In all three cases, it is assumed a user is in EMM-Registered, ECM-Connected and RRC-Connected state before detach, and services are provided through the default EPS bearer only. Figure 1 illustrates what connections are established, and in what state UE and MME are in user/control planes before and after detach. Before detach, a default EPS bearer and its related control connections are established, and the user is in EMM-Registered, ECM-Connected and RRC-Connected. Then, after detach, the default EPS bearer and all the signaling connections are released, and the user enters EMM-Deregistered, ECM-Idle and RRC-Idle state.
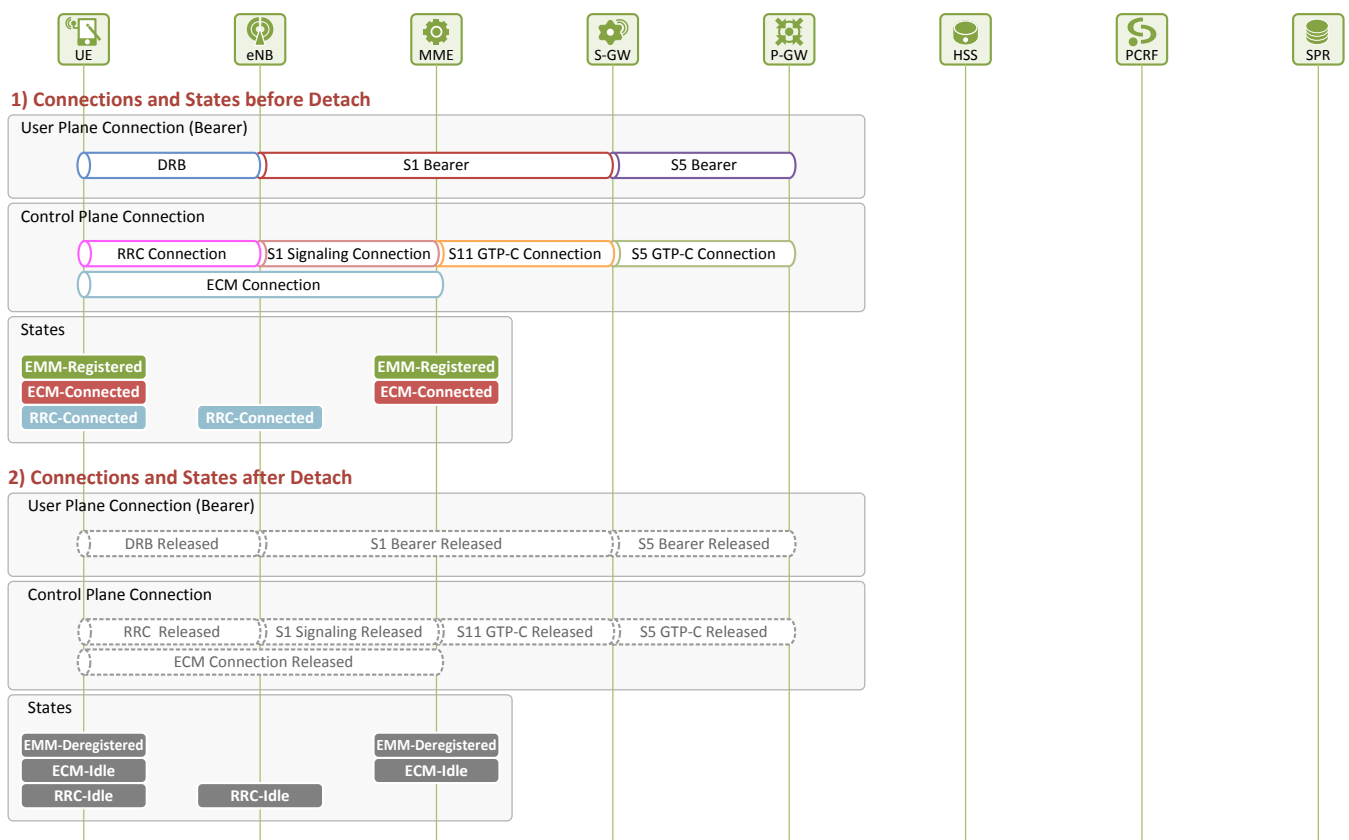
Figure 1. Connections and States before/after Detach

III. UE-initiated Detach

Figure 2 shows how user-initiated detach is performed. The detach procedure for this type of detach begins when detach triggering is detected at UE (see Chapter II), and thus the UE sends a **Detach Request** message. The procedure ends when the UE receives a **Detach Accept** message from MME, unless the UE is turned off by the user.
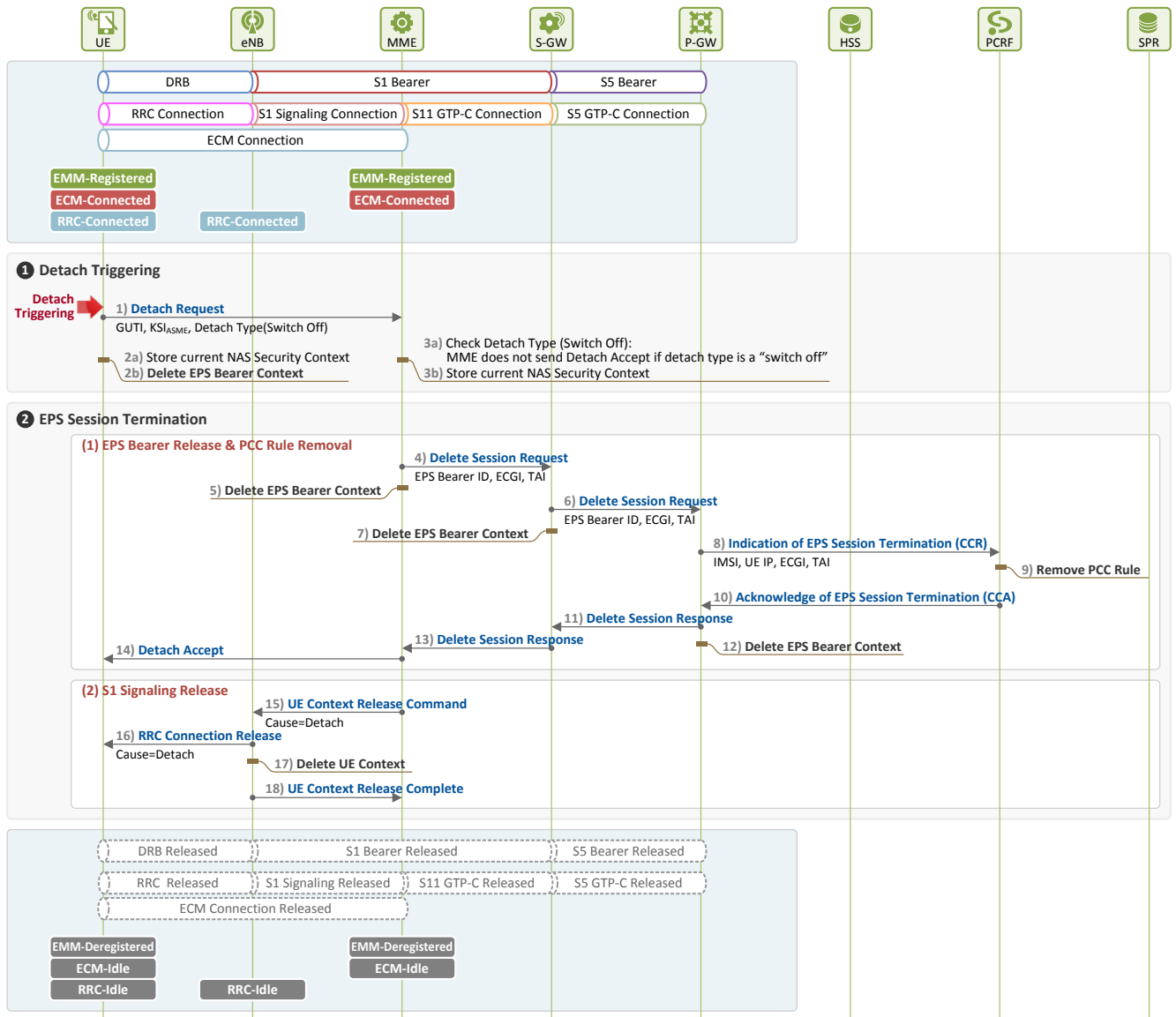
Figure 2. Procedure for UE-initiated Detach

❶ Detach Triggering by UE

When detach triggering is detected at UE, and thus the UE and MME become aware of it, the two entities will begin the following procedures:

1) **[UE → MME] Detach Request**

The UE requests the MME for detach by sending a **Detach Request** message to the MME. Interpretation of the **Detach Request** message parameters varies depending on which direction the message is delivered. If it is from UE to MME, the message parameters will be as follows:

> **Detach Request (GUTI, KSI_{ASME}, Detach Type(Switch Off))**
> - **GUTI**: User ID assigned by MME at the time of network attach
> - **KSI_{ASME}**: KSI value that is being used by UE
> - **Detach Type**: Indicates a detach type
>   - **Switch Off**: Indicates whether the case is normal detach (0) or switch off (1)
>   - **Type of Detach**: EPS detach

2) [UE] Handling Security and Bearer Contexts

After sending the **Detach Request** message, the UE stores its current NAS security context, GUTI and TA information, and then deletes its EPS bearer context.

3) [MME] Noticing Detach Intent and Handling Security Context

After receiving the **Detach Request** message from the UE, the MME becomes aware of the UE's intent to detach. It then stores the user's current NAS security context, and checks the type of the intended detach, i.e. whether it is a case of normal detach, or a turned off device. By doing this, the MME finds out whether it has to send a **Detach Accept** message or not.

❷ **EPS Session Termination**

Once the MME perceived UE-initiated detach and stored the user's current NAS security context, it requests for termination of the activated EPS session. This request triggers PCEF (P-GW)-initiated EPS termination, releasing all the network/radio resources allocated to the user, as to be described below.

(1) EPS Bearer Release and PCC Rule Removal

4) [MME → S-GW] Requesting EPS Session Release

The MME and the S-GW communicate with each other over S11 interface using GTP protocol (GTP-C). The MME begins procedures for deleting the user's EPS session and default EPS bearer by sending the S-GW a **Delete Session Request** message. At this time, the default EPS bearer ID and UE location information (ECGI, TAI) are delivered.

5) [MME] Deleting EPS Bearer Context

The MME deletes the user's EPS bearer context after sending the **Delete Session Request** message.

6) [S-GW → P-GW] Requesting EPS Session Release

The S-GW and the P-GW communicate with each other over S5 interface using GTP protocol (UP: GTP-U, CP: GTP-C). The S-GW forwards the **Delete Session Request** message received from the MME to the P-GW.

7) [S-GW] Deleting EPS Bearer Context

The S-GW deletes the user's EPS bearer context after sending the **Delete Session Request** message.

8) [P-GW → PCRF] Notifying of EPS Session Termination

The P-GW and the PCRF communicate with each other over Gx interface using Diameter protocol. The P-GW sends PCRF a **CCR (CC-Request)** message to notify the user has finished using services through the network. This way it has the EPS session termination procedures (PCEF-initiated EPS

Session Termination) initiated.

9) [PCRF] Deleting RCC Rule

The PCRF deletes the user's PCC rule once it receives the **CCR** message from the P-GW.

10) [P-GW ← PCRF] Acknowledging EPS Session Termination

The PCRF acknowledges the user's PCC rule has been deleted by sending a **CCA (CC-Answer)** message to the P-GW.

11) [S-GW ← P-GW] Responding to EPS Session Release Request

When the P-GW receives the **CCA** message from the PCRF, it sends the S-GW a **Delete Session Response** message as a response to the message sent in Step 6) above.

12) [P-GW] Deleting EPS Bearer Context

The P-GW deletes the user's EPS bearer context after sending the **Delete Session Response** message.

13) [MME ← S-GW] Responding to EPS Session Release Request

When the S-GW receives the **Delete Session Response** message from the P-GW, it sends the MME a **Delete Session Response** message as a response to the message sent in Step 4) above.

14) [UE ← MME] Acknowledging Detach

Upon receipt of the **Delete Session Response** message, the MME recognizes the user's resource release has been approved by the PCRF. So, it sends the UE a **Detach Accept** message as a response to the request sent in Step 1). A **Detach Accept** message is sent only when the UE's detach request was made due to a cause other than a switched off device (i.e. when Switch Off=0 in the **Detach Request**). If detach was requested because of a device's switch off, no **Detach Accept** message is sent by MME.

(2) S1 Signaling Connection Release

After sending the **Detach Accept** message to the UE, the MME and the eNB release any resources left for the user (S1 signaling connection, RRC connection and UE Context left in the eNB) as they do not serve the UE any more.

15) [eNB ← MME] Acknowledging S1 Signaling Connection Release

The MME sends a **UE Context Release Command** message to the eNB to release the S1 signaling connection.

16) [UE ← eNB] RRC Connection Release

The eNB sends an **RRC Connection Release** message to the UE to release any RRC connection left unleased.

17) [eNB] Deleting UE Context

The eNB deletes all the information related to the UE.

18) [eNB → MME] RRC Connection Release Complete

Finally, the eNB sends the MME a **UE Context Release Complete** message as a response to the request sent in Step 15).

IV. MME-initiated Detach

Figure 3 displays how MME-initiated explicit detach is performed. The detach procedure for this type of detach begins when detach triggering is detected at MME, and thus the MME sends a **Detach Request** message to the UE. The procedure ends when the resources previously allocated to the UE's EPS session are released.
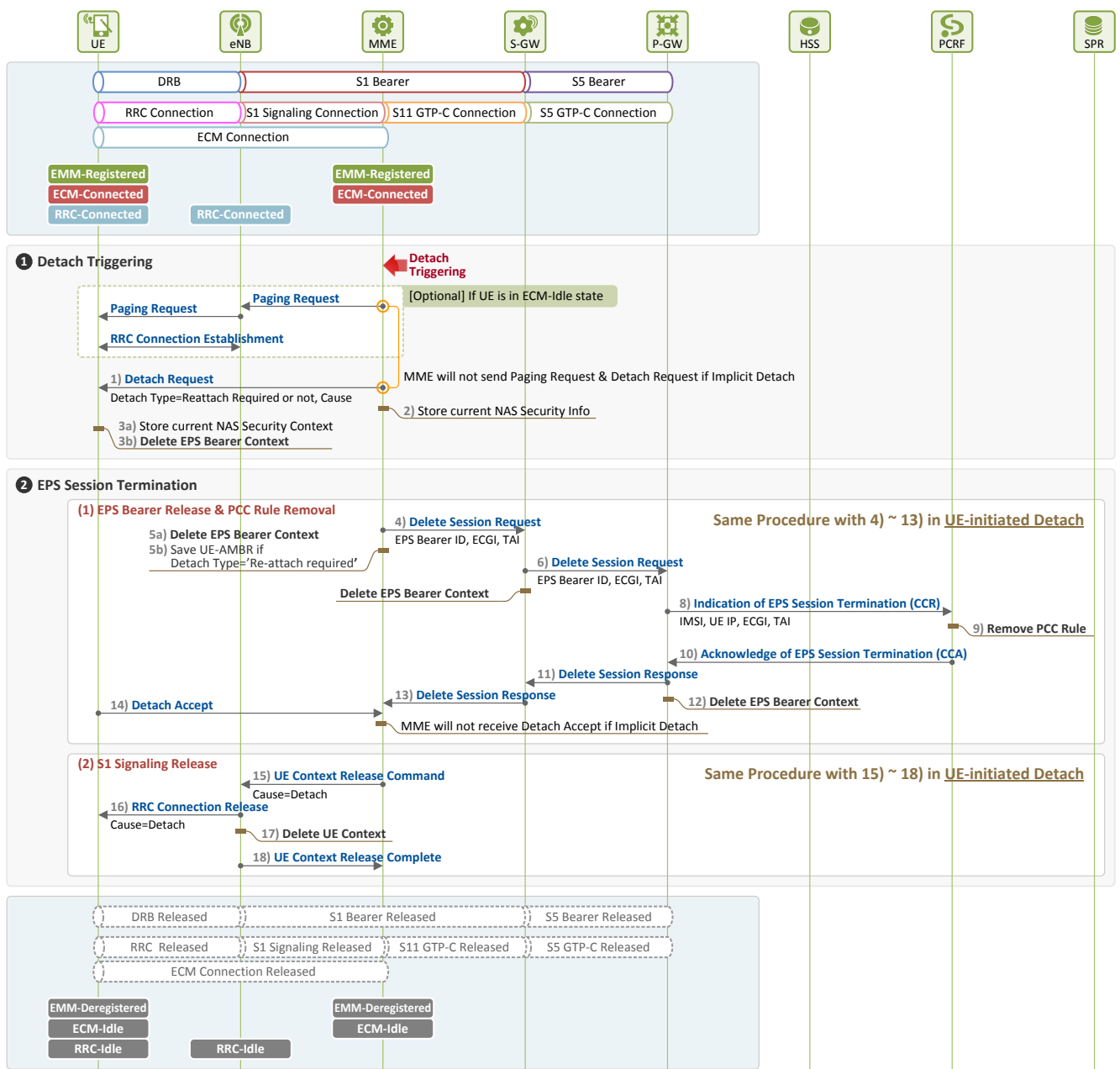
Figure 3. Procedure for MME-initiated Detach

❶ **Detach Triggering by MME**

Below is a description of the procedures to be performed after MME detects detach triggering, and before the EPS session termination procedure is carried out. If the user is in Idle state at this time, the MME performs paging to establish S1 signaling connection (Detailed paging procedures will be explored in our technical document "EMM Procedure 4. Service Request due to New Traffic", and hence will not be

discussed here).

1) **[UE ← MME] Detach Request**

As it is explicit detach, the MME sends a **Detach Request** message to request the UE for detach. Message parameters are as follows in case a detach request is sent by MME to UE:

> **Detach Request (Detach Type(Re-attach required or not), Cause)**
> - **Detach Type**: indicates whether UE is required to be re-attached or not after detach
>   ◦ 001: Re-attach required
>   ◦ 010: Re-attach not required
> - **Cause**: indicates why detach is caused

In case of implicit detach, however, MME does not send a **Detach Request** message to UE.

2) **[MME] Handling Security Context**

After sending the **Detach Request** message to the UE, the MME stores the current NAS security context in use before deleting the EPS session. Next time the UE re-attaches, the MME can use the stored context again and skip the authentication and NAS security setup procedures for the user.

3) **[UE] Noticing Detach Intent and Handling Security and Bearer Contexts**

After receiving the **Detach Request** message from the MME, the UE becomes aware of the MME's intent to detach. It checks the type of the intended detach to see whether or not re-attach is required after detach. Then it stores the current NAS security context and deletes the EPS bearer context.

❷ **EPS Session Termination**

Once the MME stored the NAS security context upon perceiving detach triggering, it requests the P-GW for termination of the user's EPS session. This request triggers PCEF (P-GW)-initiated EPS termination, releasing all the network/radio resources allocated to the user, as to be described below.

(1) EPS Bearer Release and PCC Rule Removal

Through Steps 4) ~ 13), the MME requests for termination of the user's EPS session, the PCRF deletes PCC rule upon the request, and S5 bearer resources are released, as in Steps 4) ~ 13) in Chapter III. In case of a detach type that requires re-attach, the MME can save the current UE-AMBR value in Step 5) so that the UE can establish an EPS bearer faster next time it re-attaches.

14) **[UE → MME] Acknowledging Detach**

After storing the NAS security context and deleting the EPS bearer context upon receipt of the **Detach Request** message from the MME in Step 1), the UE sends the a **Detach Accept** message as a response to the request in Step 1). In case of implicit detach, Steps 1), 14) and 16) are skipped.

(2) S1 Signaling Connection Release

In this phase, the MME releases any unreleased resources (S1 signaling connection, RRC connection and UE context left in the eNB) after receiving the **Detach Accept** message from the UE and the **Delete Session Response** message from the S-GW. Steps in this phase are the same as Steps 15) ~ 18) in Chapter III, except that in case the detach type is set as "re-attach required", UE re-attaches the network after RRC connection is released.

V. HSS-initiated Detach

Figure 4 provides an illustration of how HSS initiates detach after detecting detach triggering.
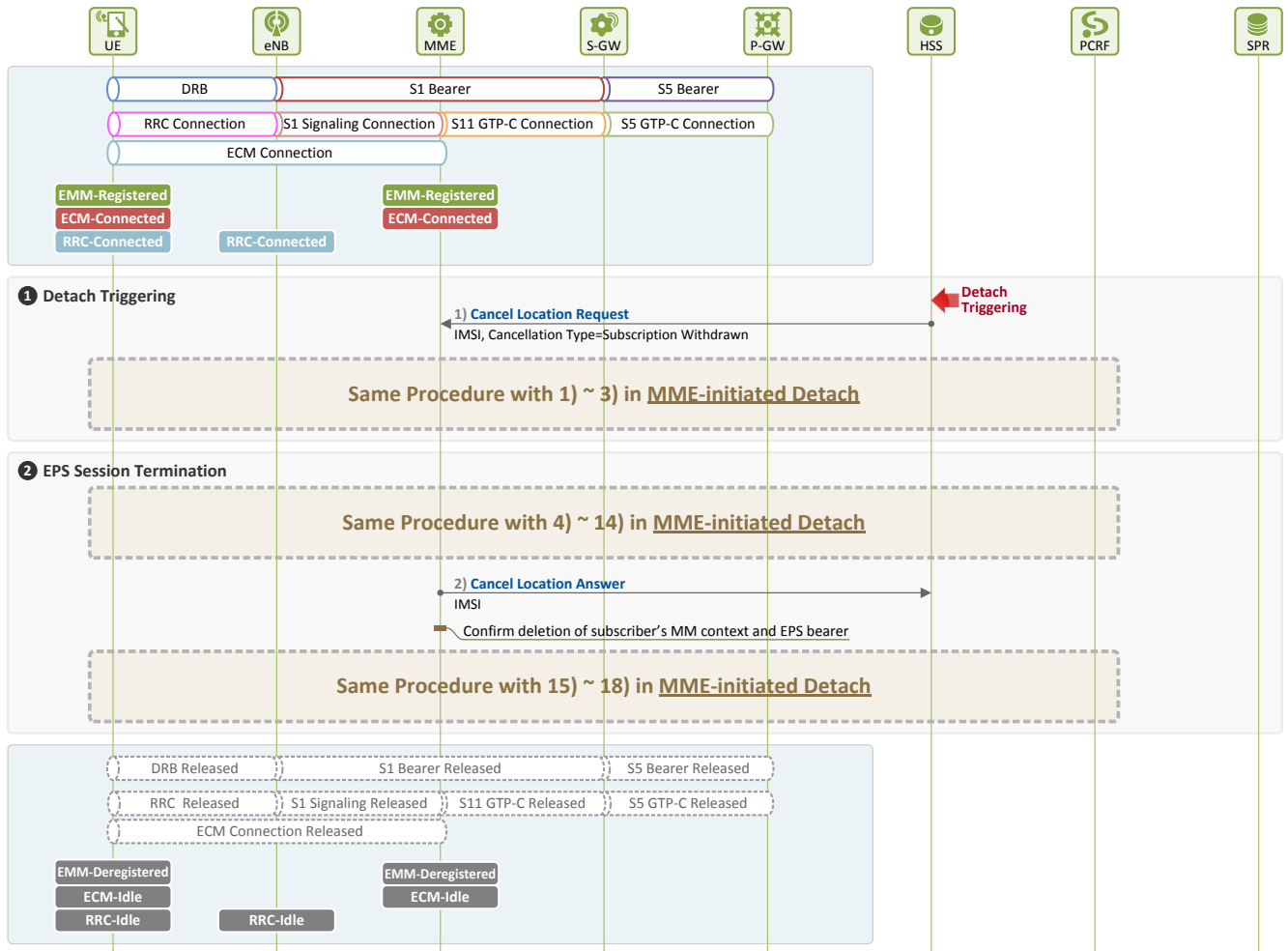

Figure 4. Procedure for HSS-initiated Detach

❶ **Detach Triggering by HSS**

When detach is triggered at HSS due to subscriber withdrawal, the HSS attempts to delete the user's MM context and EPS bearer immediately.

1) **[MME ← HSS] Detach Request**

The HSS and the MME communicate with each other over S6a interface using Diameter protocol. The HSS requests the MME for detach of the user by sending a **Cancel Location Request (CLR)** message with the following parameters:

> **Cancel Location Request (IMSI, Cancellation Type)**
> - **IMSI**: ID of the user to be detached (i.e. the user whose MM Context and EPS bearer are to be deleted)
> - **Cancellation Type**[1] **= Subscription Withdrawn**: indicates the reason for detach

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[1] Other cancellation types include MME Update Procedure and Initial Attach Procedure used during initial attach.

❷ **EPS Session Termination**

Upon receipt of the **Cancel Location Request (CLR)** message from the HSS, the MME releases all the resources previously allocated to the user. Steps for such procedure are the same as in MME-initiated detach (Figure 3) described in Chapter III, except that an additional action is required by the MME in Step 2). The MME needs to send the HSS a **Cancel Location Answer** message as a response to the request made in Step 1).

2) **[MME → HSS] Responding to Detach Request**

   After receiving the **Detach Accept** message from the UE, and the **Delete Session Response** message from the S-GW, the MME sends a **Cancel Location Answer** message to the HSS as a response to the **Cancel Location Request** message sent in Step 1).

VI. EPS Entity Information: Before/After Detach

This chapter explains how information in EPS entities is changed after "EMM Case 2: Detach" procedures are performed. All the information in each entity is categorized into UE ID, UE Location, Security and EPS Session/Bearer information (see [2] for more information).

6.1 Before Detach

According to the EMM Case 2 scenario, a user stays in ECM/RRC-Connected state before he detaches or is detached from the network. Therefore, before detach, all the EPS entities have the same information they initially had after initial attach in EMM Case 1 (see [2] for more information). Figure 5 lists the information stored in each EPS entity before detach is performed.
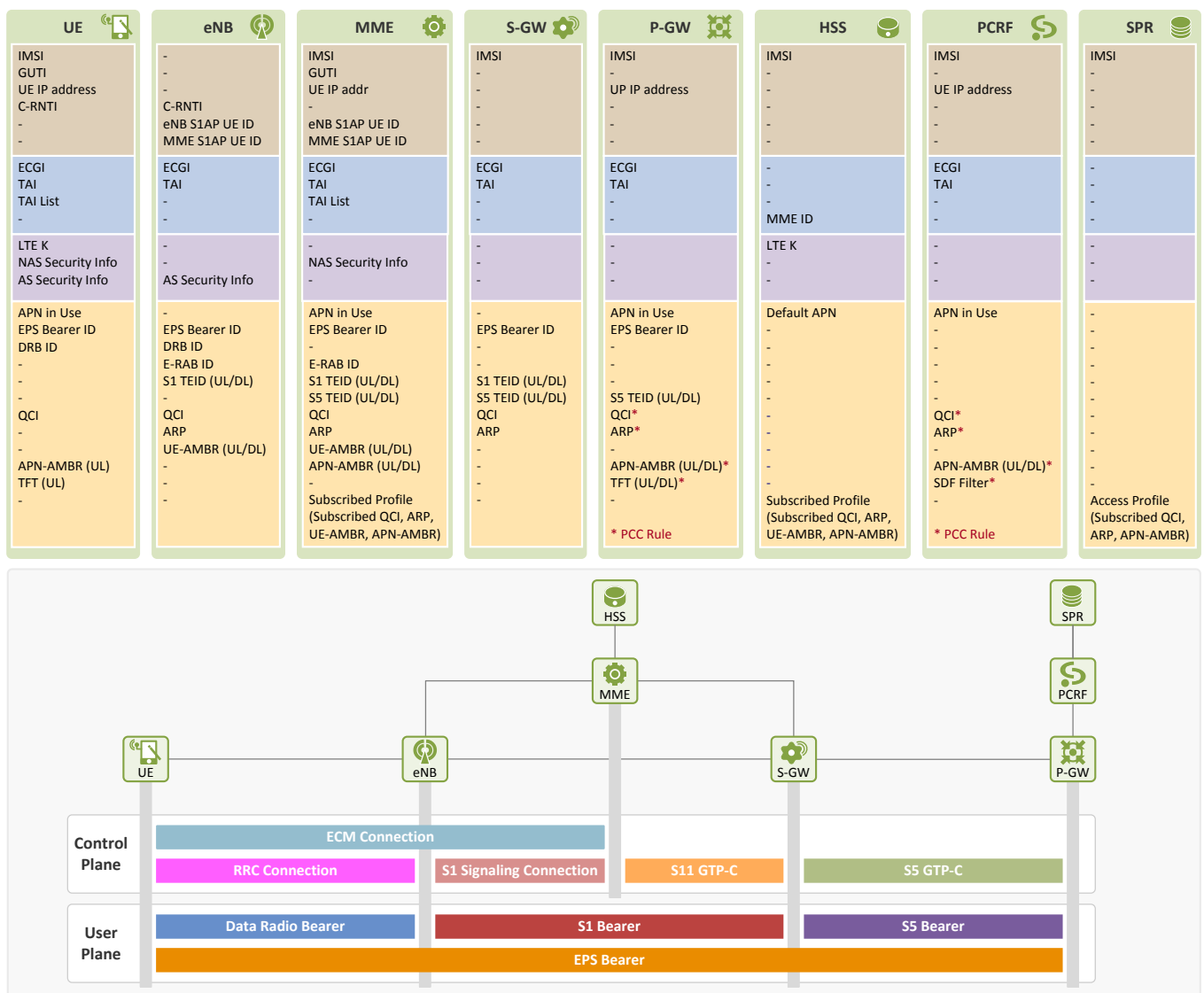

Figure 5. Information in EPS Entities before Detach

6.2 After Detach

After detach, information that can be used for the user's fast and secured attach next time is stored in UE and MME. All other contexts related to the user, such as NAS security context, GUTI and TAI information allocated

by MME, etc., are deleted. Figure 6 lists the information elements stored in each EPS entity after "EMM Case 2: Detach" procedures. Ones that are to be deleted after detach are shown in gray, provisioned ones that are to be kept are in black, and ones to be used in next attach are in blue.
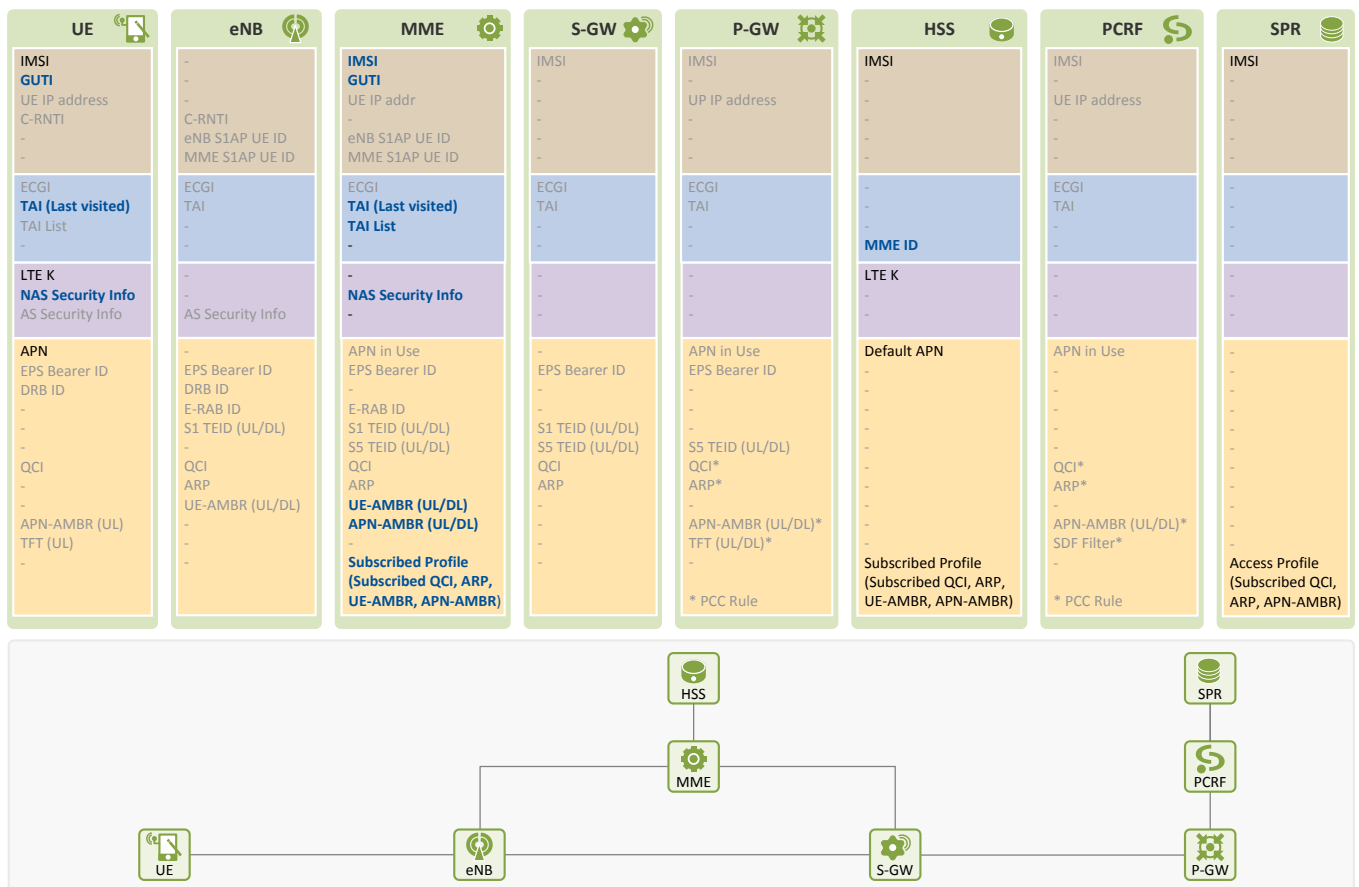

Figure 6. Information in EPS entities after Detach

Information elements kept for next attach are stored as follows:

At UE:

- **UE ID**: GUTI allocated by MME at the time of initial attach or TA updates
- **UE Location**: The last TA that UE visited before detach
- **Security**: NAS security context information that UE used before detach

At MME:

- **UE ID**: IMSI that UE provided at its initial attach, and GUTI allocated by MME at the time of UE's initial attach or TA updates
- **UE Location**: The last TA that UE visited before detach. The TAI list allocated to UE may be kept as well.
- **Security**: NAS security context information that UE used before detach
- **EPS Session/Bearer**: Subscribed profile received from HSS at the time of UE location registration. The UE-AMBR value determined by MME at the times of EPS bearer establishment, and the APN-AMBR value used in UE-AMBR may be kept as well.

At HSS:

- **UE Location:** The last MME UE was registered at before detach

VII. Closing

We have learned how a user, while connected to the LTE network, detaches/is detached from the LTE network ("EMM Case 2" in [1]). We categorized detach cases depending on the entity that detects detach triggering, and looked into the detach procedures in each case. We also checked, after detach, what kinds of information elements are stored at UE, MME and HSS for later use at next attach. The subsequent document will discuss how S1 resource is released when a user, after initial attach, stays inactive for a certain period of time ("EMM Case 3. S1 Release due to User Inactivity" in [1]).

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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