NETMANIAS
www.netmanias.com

NMC CONSULTING GROUP
www.nmcgroups.com

LTE Identification III: EPS Session/Bearer Identifiers

Table of Contents

As the third document for LTE Identification, this document (Part III, LTE Identification III) covers EPS Session/Bearer ID groups related to user traffic delivery. Session/Bearer IDs such as Packet Data Network (PDN) ID (Access Point Name (APN)), EPS bearer ID, E-RAB ID, Data Radio Bearer (DRB) ID, Tunnel Endpoint Identifier (TEID) and Linked EPS Bearer Identity (LBI) are described, followed by a summary of the characteristics of these IDs. Finally, all the LTE IDs covered in the three LTE Identification documents are listed.

August 26, 2013
(Initial Released: February 9, 2011)

www.netmanias.com

NMC Consulting Group (tech@netmanias.com)

About NMC Consulting Group
NMC Consulting Group is an advanced and professional network consulting company, specializing in IP network areas (e.g., FTTH, Metro Ethernet and IP/MPLS), service areas (e.g., IPTV, IMS and CDN), and wireless network areas (e.g., Mobile WiMAX, LTE and Wi-Fi) since 2002.

Netmanias LTE Technical Documents

Visit http://www.netmanias.com to view and download more technical documents.

Index	Topic	Document Title	Document presented here
1	Network Architecture	LTE Network Architecture: Basic	
2	**Identification**	LTE Identification I: UE and ME Identifiers	
3		LTE Identification II: NE and Location Identifiers	
4		**LTE Identification III: EPS Session/Bearer Identifiers**	**O**
5	Security	LTE Security I: LTE Security Concept and LTE Authentication	
6		LTE Security II: NAS and AS Security	
7	QoS	LTE QoS: SDF and EPS Bearer QoS	
8	EMM	LTE EMM and ECM States	
9		Eleven EMM Cases in an EMM Scenario	
10		LTE EMM Procedure 1. Initial Attach - Part 1. Cases of Initial Attach	
11		LTE EMM Procedure 1. Initial Attach - Part 2. Call Flow of Initial Attach	
12		LTE EMM Procedure 2. Detach	
13		LTE EMM Procedure 3. S1 Release	
14		LTE EMM Procedure 4. Service Request	
15		LTE EMM Procedure 5. Periodic TAU	
16		LTE EMM Procedure 6. Handover without TAU - Part 1. Overview of LTE Handover	
17		LTE EMM Procedure 6. Handover without TAU - Part 2. X2 Handover	
18		LTE EMM Procedure 6. Handover without TAU - Part 3. S1 Handover	
19		LTE EMM Procedure 7. Cell Reselection without TAU	
20		LTE EMM Procedure 8 & 9. Handover and Cell Reselection with TAU	
21		LTE EMM Procedure 10 & 11. Move to Another City and Attach	
22	PCC	LTE Policy and Charging Control (PCC)	
23	Charging	LTE Charging I: Offline	
24		LTE Charging II: Online (TBD)	
25	IP Address Allocation	LTE: IP Address Allocation Schemes I: Basic	
26		LTE: IP Address Allocation Schemes II: A Case for Two Cities	

Abbreviations

APN	Access Point Name
C-RNTI	Cell Radio Network Temporary Identifier
CSG	Closed Subscriber Group
DNS	Domain Name Server
DRB	Data Radio Bearer
ECGI	E-UTRAN Cell Global Identifier
ECI	E-UTRAN Cell Identifier
eNB	Evolved Node B
EPC	Evolved Packet Core
E-RAB	E-UTRAN Radio Access Bearer
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
FQDN	Fully Qualified Domain Name
GUMMEI	Globally Unique MME Identifier
GUTI	Globally Unique Temporary Identifier
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
LBI	Linked EPS Bearer Identity
MME	Mobility Management Entity
MMEC	MME Code
MMEGI	MME Group Identifier
MMEI	MME Identifier
M-TMSI	MME Temporary Mobile Subscriber Identity
OCS	Online Charging System
OFCS	Offline Charging System
PCRF	Policy and Charging Rule Function
PDN	Packet Data Network
P-GW	PDN Gateway
PLMN	Public Land Mobile Network
S1AP	S1 Application Protocol
S-GW	Serving Gateway
SPR	Subscriber Profile Repository
S-TMSI	SAE Temporary Mobile Subscriber Identity
TAC	Tracking Area Code
TAI	Tracking Area Identity
TEID	Tunnel Endpoint IDentifier
TIN	Temporary Identity used in Next update
X2AP	X2 Application Protocol

I. Introduction

We have learned about the LTE ID groups such as UE and ME IDs, and Network Equipment (NE) and UE location identifier (location) IDs in LTE Identification 1 [1] and LTE Identification II [2], respectively. This document, as the third document of the LTE Identification series, describes EPS Session/Bearer IDs related to user traffic delivery. E2E sessions that include application entities are out of the scope of this document, and hence only EPS sessions that provide users with PDN connectivity will be covered herein. In Table 1, EPS Session/Bearer IDs to be discussed herein are shown in the last row with a gray background.

Table 1. Classification of LTE Identification [1]

Classification	LTE Identification	Related Document
UE ID	IMSI, GUTI, S-TMSI, IP address (PDN address), C-RNTI, UE S1AP ID, UE X2AP ID	LTE Identification I
ME ID	IMEI	
NE ID	GUMMEI, MMEI, Global eNB ID, eNB ID, ECGI, ECI, P-GW ID	LTE Identification II
Location ID	TAI, TAC	
Session/Bearer ID	PDN ID (APN), EPS Bearer ID, E-RAB ID, DRB ID, LBI, TEID	LTE Identification III

The LTE IDs that we have learned in [1] and [2] are used to identify a different UE, ME and NE in an LTE network, whereas EPS Session/Bearer IDs are used in a UE[1]. This means, since more than one EPS session and bearer can be established in a UE concurrently, IDs are needed to identify them.

II. EPS Session and EPS Bearer: Overview

Before we discuss IDs relating EPS sessions and EPS bearers, an overview of what the EPS sessions and EPS bearers are and what they are like and a description of the relationship among the IDs will be given.

Figure 1 shows the EPS sessions and EPS bearers of a user, with their IDs shown underneath.

[1] A PDN ID (APN) is used to identify a PDN in an operator's network as well as in a UE. It is classified as a session ID in LTE Identification documents and will be discussed along with other session IDs in this document.

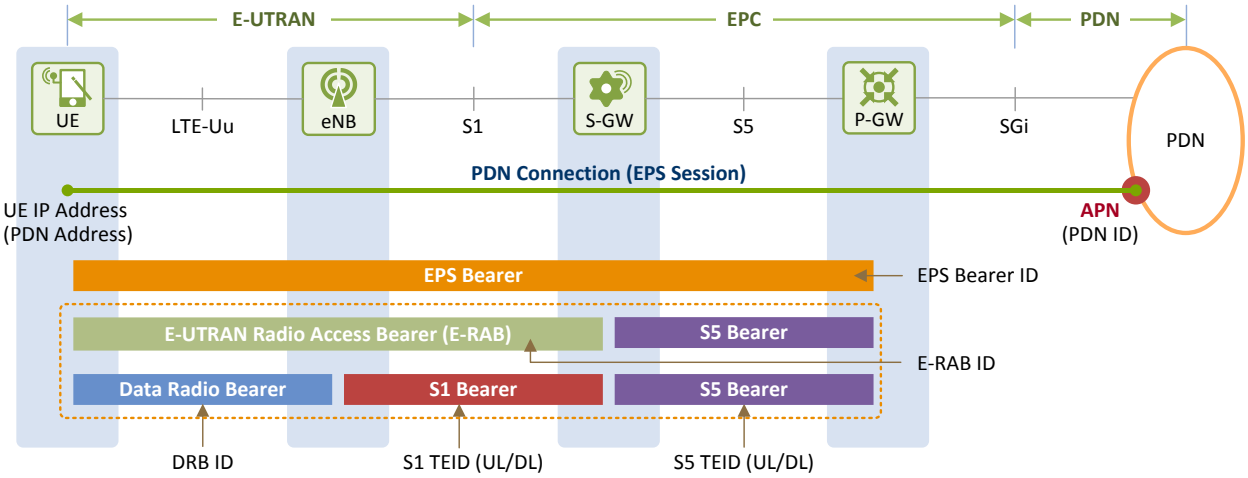


Figure 1. Overview of Session/Bearer IDs

2.1 EPS Session

IP connection between a UE and a PDN is called PDN connection or EPS session. Each PDN connection (or EPS session) is represented by an IP address of the UE and a PDN ID (in other words, Access Point Name (APN)). It has more than one EPS bearer to deliver user traffic (IP packets), and applies the service quality (QoS) policy obtained from a PCRF to the EPS bearers. The minimum fundamental bearer that an EPS session has for a PDN is called a default EPS bearer.

Having an EPS session established means i) a PDN through which a user is to use services has been selected (by the user's input or based on the subscription information provisioned by an HSS), ii) an IP address to be used in the PDN has been assigned to the user, iii) policy rules to be applied to the user IP packets (QoS and charging rules) have been selected, and iv) a default EPS bearer for delivering IP packets over the LTE network has been established. Through this EPS session established, IP packets can be exchanged between the user and the PDN according to the rules set by the operator.
Management and operation of sessions, including PCRF, will be explained in other document, and a PDN ID (APN) will be discussed as an ID relating to the EPS session in this document.

2.2 EPS Bearer

An EPS session is in charge of delivering and handling flows of the IP packets that are labeled with UE IP addresses and travel between a UE and a PDN (UE – P-GW – PDN). On the other hand, an EPS bearer is a pipe through which IP packets are delivered over the LTE network, i.e., between a UE and a P-GW (UE – eNB – S-GW - P-GW). A UE can have multiple EPS bearers concurrently. So, different EPS bearers are identified by their EPS bearer ID, which is allocated by an MME.
As seen in Figure 1, an EPS bearer actually is a concatenation of the following three bearers (DRB, S1 bearer and S5 bearer):

- [UE] - [eNB]: Data Radio Bearer (DRB)
  EPS bearer established over LTE-Uu interface. User traffic (IP packet) is delivered through a DRB. Different DRBs are identified by their DRB ID, which is allocated by an eNB.

- [eNB] - [S-GW]: S1 bearer
  EPS bearer established over S1-U interface. User traffic is delivered through a GTP tunnel. Different S1 bearers are identified by their tunnel endpoint identifier (TEID), which is allocated by the endpoints (eNB and S-GW) of the GTP tunnel.

- [S-GW] - [P-GW]: S5 bearer
  EPS bearer established over S5 interface. User traffic is delivered through a GTP tunnel. Different S5 bearers are identified by their tunnel endpoint identifier (TEID), which is allocated by the endpoints (S-GW and P-GW) of the GTP tunnel.

E-RAB is a bearer that has two endpoints of a UE and an S-GW, and consists of a DRB and an S1 bearer. Technically, E-RAB is a concatenation of a DRB and an S1 bearer, and connects from a UE to an S-GW (UE – eNB – S-GW). Different E-RABs are identified by their E-RAB ID, which is allocated by an MME. DRB IDs and E-RAB IDs are mapped with EPS bearer IDs on 1:1 basis.

2.3 Types of EPS Bearers

Before we go ahead and describe EPS bearer-related IDs, we will look at different types of EPS bearers and how they work. Figure 2 shows two different types of EPS bearers: default and dedicated. Each PDN must have one default EPS bearer, but may have none to many dedicated EPS bearers.

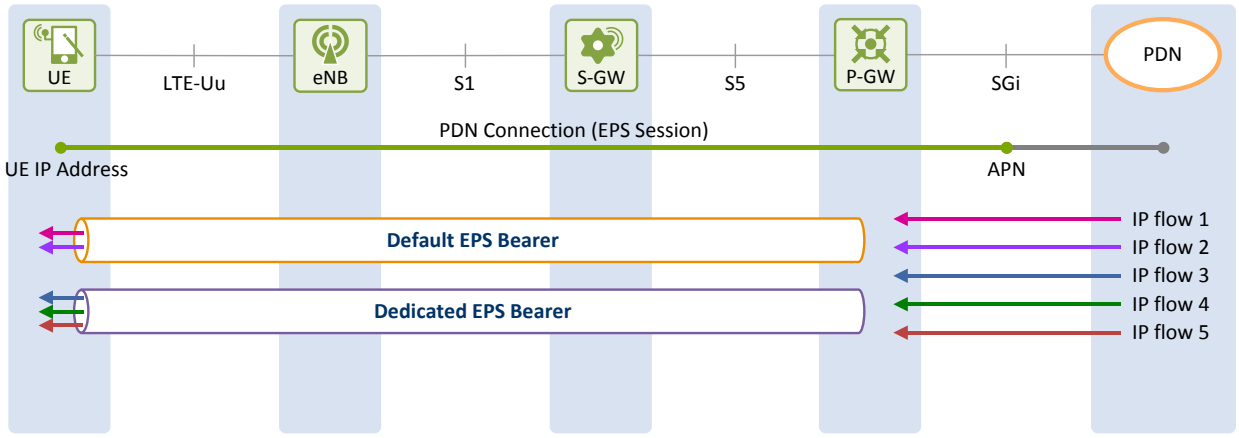


Figure 2. EPS Bearer Types

The LTE network is an all-IP network, and provides its users with always-on IP connectivity. This means, once a UE connects to a PDN using the IP address assigned at its initial attach to the network, the IP connection remains connected after a default EPS bearer is established over the LTE network and until the UE detaches from the LTE network (i.e., the PDN connection is terminated). Even when there is no user traffic to send, the default EPS bearer always stays activated and ready for possible incoming user traffic.

Additional EPS bearer can be established if the default EPS bearer itself is not sufficient enough to obtain QoS (see LTE QoS document). The additional EPS bearer established is called a dedicated EPS bearer and multiple dedicated bearers can be created if required by the user or the network. When there is no user traffic, these dedicated EPS bearers can be removed, whereas the default one is never removed and keeps the user staying

connected to the network unless the user detaches from the network. Dedicated EPS bearers are linked to a default EPS bearer. The linked bearers are represented by a Linked EPS Bearer Identity (LBI), indicating they are all associated with the same default EPS bearer.

IP traffic from or to a UE is delivered through an EPS bearer appropriately depending on QoS class over the LTE network. Uplink IP traffic is mapped from a UE up to the EPS bearer while downlink IP traffic is mapped from a P-GW down to the EPS bearer.

As discussed in Sections 2.2 and 2.3, IDs relating to EPS bearers, such as EPS bearer ID, E-RAB ID, DRB, TEID, and LBI are described in this document. The following Chapter III will further explain about these EPS session/bearer IDs.

III. Identifiers for EPS Session/Bearer (Session/Bearer IDs)

3.1 ID to identify PDN: PDN ID (APN)

PDNs are identified by PDN IDs (or Access Point Names (APNs)). An APN, as can be easily inferred, refers to an access point to a PDN where a user wishes to connect for services/applications. In Figure 3, APNs and their format are illustrated. An APN is a combination of a network ID and an operator ID. The network ID is used when identifying PDNs such as Internet or Corporate VPNs or identifying services like IMS that the PDN provides.

An APN is provisioned to an HSS as subscription information at the time of a user's subscription (as in case 1 of Figure 3)[2]. Upon a UE's initial attach, a default APN is downloaded from the HSS to an MME. The MME selects a PDN to connect the UE based on the APN first, and then a P-GW through which the UE is connected to the PDN . In Figure 3, the MME selected PDN 1 based on APN 1, and then P-GW 1 for connection to PDN 1.

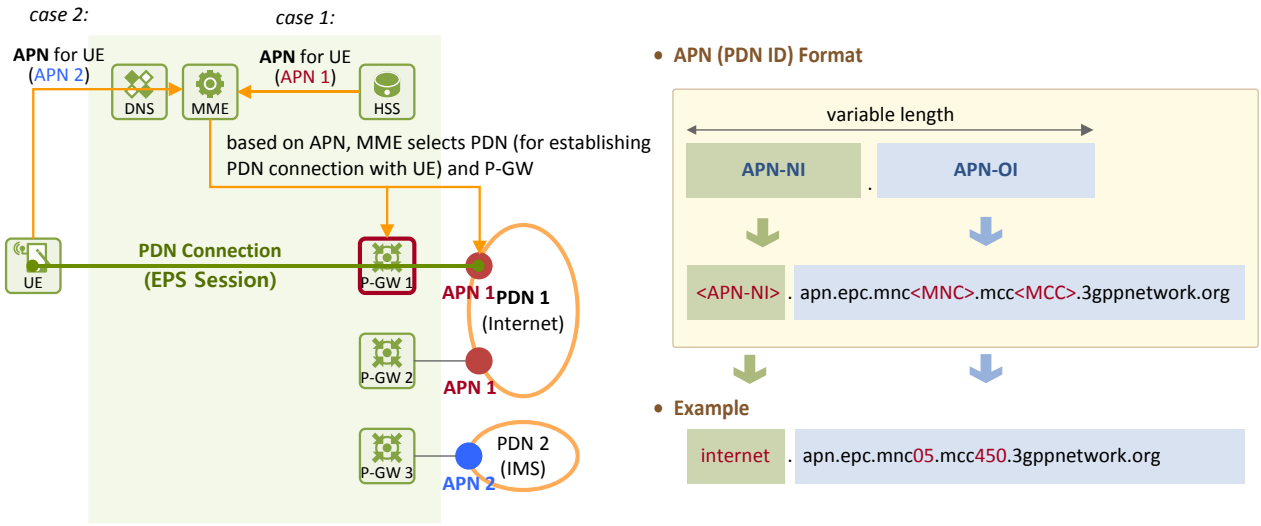


Figure 3. APN ID and format

[2] An APN can also be provided by a UE (as in case 2 of Figure 3).

3.2 ID to indicate user traffic delivery routes over the EPS network: EPS Bearer IDs

An EPS bearer is virtual connection set between a UE and a P-GW to deliver user traffic over the LTE network. Different bearers in the EPS bearer are identified by 4-bit EPS bearer IDs. Table 2 show EPS bearer ID values and their allocation ranges. A UE can have up to 11 EPS bearers and their ID values can range from 5 to 15.

Table 2. EPS Bearer ID value assignment range

EPS Bearer ID Value	Assigned/Not assigned
0	Not Assigned
1 ~ 4	Reserved
5 ~ 15	Available values

Figure 4 is an illustration of EPS bearer related IDs and their respective allocators. IDs for EPS bearers, default or dedicated, are allocated by an MME. When a UE initially attaches an LTE network, the MME obtains QoS profile needed to establish a default EPS bearer from an HSS, and sets up the bearer based on the received QoS. The setup procedure of the default EPS bearer is initiated when an EPS bearer ID is allocated by the MME.

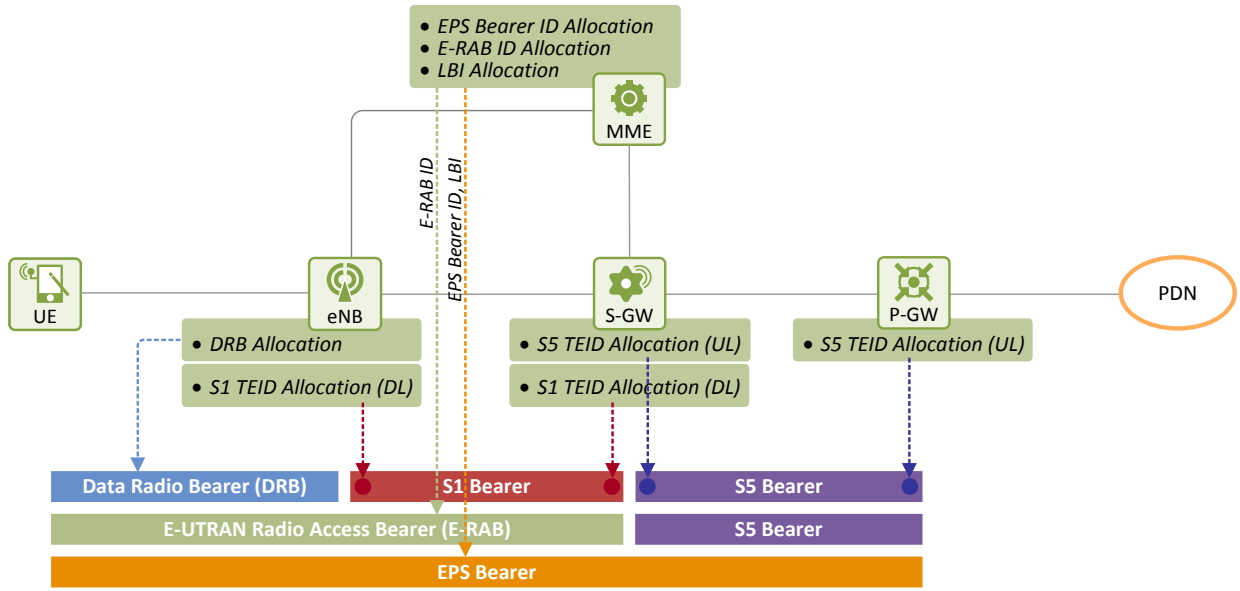


Figure 4. Bearer IDs allocators

The two endpoints of an EPS bearer are a UE and a P-GW. They both perform traffic flow filtering - the UE filters uplink user traffic while the P-GW does downlink traffic - to decide through which bearer the traffic is to be sent (See LTE QoS document for more information about traffic flow filtering). Figure 2 shows an example of downlink user traffic that consists of five IP flows, 1 through 5. When the IP flows arrive at the P-GW through the PDN, the P-GW performs traffic flow filtering to decide to which EPS bearer each IP flow is to be delivered, and delivers accordingly. Downlink EPS bearer traffic is delivered through S5 bearer, S1 bearer and DRB, and finally arrives at the UE, which forwards the traffic, in IP flows, to upper layers. To make this happen, each entity must map the bearer IDs in each bearer as seen in Table 3. Figure 5 is an illustration of such mapping process.

Table 3. Mapping among EPS bearer IDs

노드 entity	상향 (uplink)	하향 (downlink)
UE	*UL IP flows* → DRB ID	
eNB	DRB ID → S1 베어러 ID (UL S1 TEID)	S1 Bearer ID (DL S1 TEID) → DRB ID
S-GW	S1 Bearer ID (UL S1 TEID) → S5 베어러 ID (UL S5 TEID)	S5 Bearer ID (DL S5 TEID) → S1 Bearer ID (DL S1 TEID)
P-GW		*DL IP flows* → S5 Bearer ID (DL S5 TEID)

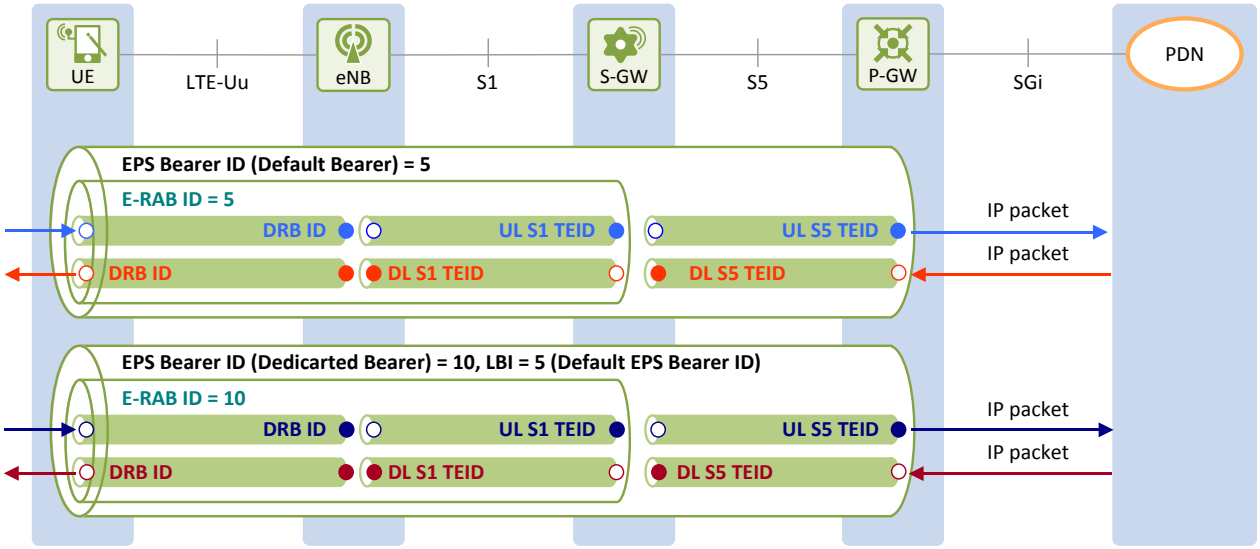


Figure 5. Mapping among EPS bearer IDs

3.3 ID to identify EPS bearers between UE and EPC: E-RAB ID

As can be seen in Figures 1, 4 and 5, E-RAB is an EPS bearer set between a UE and an S-GW, and identified by a 4-bit E-RAB ID. The E-RAB ID is assigned by an MME, generally with the same value as the EPS bearer ID, upon establishment of the EPS bearer, and is mapped with the EPS bearer IDs on 1:1 basis. When, during the setup procedure of the EPS bearer, the MME requests the eNB for e-RAB setup, the eNB creates DRB with the UE and S1 bearer with the S-GW.

The default EPS bearer keeps the UE connected to the network. When there is no user traffic and thus the UE state changes to idle, E-RAB is deactivated and only the S5 bearer stays on. However, as soon as new user traffic arrives, E-RAB is re-established, allowing the traffic to be delivered between the UE and the P-GW.

3.4 ID to identify EPS bearers over radio link: DRB ID

As can be seen in Figures 1, 4 and 5, DRB, an EPS bearer, is set over the radio link between a UE and an eNB, and identified by a 4-bit DRB ID. The DRB ID is assigned by an eNB upon establishment of the EPS bearer, and

is mapped with EPS bearer IDs on 1:1 basis. When, during the setup procedure of the EPS bearer, the MME requests the eNB for E-RAB setup, the eNB creates DRB for communication with the UE by assigning a DRB ID and selecting logical channel configuration parameters based on the required QoS.

3.5 ID to identify the endpoints of a GTP tunnel: TEID

S1 and S5 bearers, both EPS bearers, are established between an eNB and an S-GW, and between an S-GW and a P-GW, respectively, in forms of GTP tunnels. GTP tunnels are identified by Tunnel Endpoint Identifiers (TEID), in 32-bit integer, of two endpoints in uplink and downlink. Figure 4 shows TEID allocators in S1 and S5 GTP tunnels. While EPS bearers are being set up, for S5 bearer, the S-GW allocates DL S5 TEID and the P-GW allocates UL S5 TEID. However, for S1 bearer, the S-GW assigns UL S1 TEID and the eNB assigns DL S1 TEID (See [3] for more information on how user traffic flows through GTP tunnels).

3.6 ID to connect a default EPS bearer and dedicated EPS bearers: LBI

As seen in Figure 2, one EPS session can have more than one EPS bearer. The default EPS bear is activated/de-activated when the EPS session is created/terminated. On the other hand, the dedicated EPS bearers can be created or removed at any time once the EPS session is created. Since both of the bearers (the default and the dedicated EPS bearers) belong to the same PDN for the same user, an ID to indicate the two are intended for the same PDN is needed. For such purpose, an ID called LBI is used, and the default EPS bearer ID is used as the LBI.

When a default EPS bearer is created, the MME allocates a bearer ID, which also is assigned as a LBI. Later, when dedicated EPS bearers are established, the MME assigns LBIs along with bearer IDs to identify the default EPS bearer.

IV. Summary

We have seen EPS session/bearer-related IDs among the LTE IDs classified in Table 1. Table 4 classifies and lists them in terms of their ranges (within which they are uniquely identified), allocators, and attribute types. Finally Table 5 summarizes all the LTE IDs covered in LTE Identification documents (LTE Identification I, II and III), along with their respective purposes and formats.

Table 4. LTE Identification: EPS Session/Bearer

ID group	LTE identifier	Range (uniquely identified within)	Allocator	Type of value
Session/Bearer ID	PDN ID (APN)	Global	Operator	Fixed
	EPS Bearer ID	UE	MME	Temporary
	E-RAB ID	UE	MME	Temporary
	DRB ID	UE	eNB	Temporary
	TEID	S5 TEID: S-GW, P-GW S1 TEID: eNB, S-GW	S5 TEID: S-GW, P-GW S1 TEID: eNB, S-GW	Temporary
	LBI	UE	MME	Temporary

Table 5. LTE IDs

Identifier	Full Name	Description	Format
IMSI	International Mobile Subscriber Identity	•Uniquely identifies a mobile subscriber •Network (MME) checks the PLMN of the subscriber	PLMN ID + MSIN = MCC + MNC + MSIN (up to 15 digits)
PLMN ID	Public Land Mobile Network Identifier	Uniquely identifies a PLMN	MCC + MNC (up to 6 digits)
MCC	Mobile Country Code	Code assigned by ITU	3 digits
MNC	Mobile Network Code	Code assigned by National Authority	2 or 3 digits
MSIN	Mobile Subscriber Identification Number	Number assigned by an operator	up to 10 digits
GUTI	Globally Unique Temporary UE Identity	ID used instead of IMSI when an MME identifies a UE for security reason	GUMMEI + M-TMSI (up to 80 bits)
TIN	Temporary Identity used in Next Update	Indicates which temporary ID will be used in the next update	TIN = GUTI
S-TMSI	SAE Temporary Mobile Subscriber Identity	Shorter version of ID that identifies a UE locally within an MME group of an operator.	MMEC + M-TMSI (40 bits)
M-TMSI	MME Mobile Subscriber Identity	Identifies a UE uniquely within a MME of an operator	32 bits
GUMMEI	Globally Unique MME Identity	•Identifies an MME uniquely in global •GUTI contains GUMMEI	PLMN ID+ MMEI (up to 48 bits)
MMEI	MME Identifier	Identifies an MME uniquely within an operator	MMEGI + MMEC (24 bits)
MMEGI	MME Group Identifier	Identifies an MME group uniquely within an operator	16 bits
MMEC	MME Code	Identifies an MME uniquely within an MME group of an operator	8 bits
IP Address (PDN Address)	IP Address (Packet Data Network Address)	Identifies a UE uniquely when the UE uses IP services	Network ID + Host ID (32 bits)
C-RNTI	Cell- Radio Network Temporary Identifier	Identifies a UE uniquely in a cell (on PDCCH (Physical Downlink Control Channel))	0x0001 ~ 0xFFF3 (16 bits)
eNB UE S1AP ID	eNB UE S1 Application Protocol ID	Uniquely identifies a UE on S1- MME Interface in an eNB	32-bit Integer (0 .. 2^{32} - 1)
MME UE S1AP ID	MME UE S1 Application Protocol ID	Uniquely identifies a UE on S1- MME Interface in an MME	32-bit Integer (0 .. 2^{32} - 1)
Old eNB UE X2AP ID	Old eNB UE X2 Application Protocol ID	Uniquely identifies a UE on X2 Interface in source eNB	32-bit Integer (0 .. 2^{32} - 1)
New eNB UE X2AP ID	New eNB UE X2 Application Protocol ID	Uniquely identifies a UE on X2 Interface in target eNB	32-bit Integer (0 .. 2^{32} - 1)
IMEI	International Mobile Equipment Identity	Identifies an ME (Mobile Equipment) uniquely	IMEI: TAC + SNR + CD (15 digits)
IMEI/SV	International Mobile Equipment Identity/Software Version	Identifies an ME (Mobile Equipment) uniquely	IMEI/SV = TAC + SNR + SVN (16 digits)
TAC	Type Allocation Code	Identifies a reporting body, manufacturer's name and model ID of an ME	RBID + ME Type ID (8 digits)
Global eNB ID	Global eNodeB Identifier	Identifies an eNB uniquely in global	PLMN I D+ eNB ID(up to 44 bits)

eNB ID	eNodeB Identifier	Identifies an eNB uniquely within a PLMN	20 bits
ECGI	E-UTRAN Cell Global Identifier	•Identifies a cell uniquely in global •EPC can locate a UE based of ECGI	PLMN I D+ ECI (up to 52 bits)
ECI	E-UTRAN Cell Identifier	Identifies a cell uniquely within a PLMN	eNB ID + Cell ID (28 Bits)
P-GW ID	PDN GW Identity	•Identifies a specific PDN GW (P-GW) •HSS assigns a P-GW for PDN (IP network) connection of each UE	IP address (4 bytes) or FQDN (variable length)
TAI	Tracking Area Identity	Identifies, uniquely in global, the Tracking Area where an eNB belongs to (at cell level)	PLMN ID + TAC (up to 32 bits)
TAC	Tracking Area Code	Identifies, uniquely in within a PLMN, the Tracking Area where an eNB belongs to (at cell level)	16 bits
TAI List	Tracking Area Identity List	A UE can travel within the cells included in TAI list without location update (TA update)	{TAI1, TAI2, …} (variable length)
PDN ID (APN)	Packet Data Network Identity	•Identifies a PDN (IP network) that a user wants to communicate with •Is used to determine the P-GW and point of interconnection with a PDN •Corresponds to a DNS name of a P-GW	•APN-NI + APN-OI (variable length, up to 100 octets) •<APN-NI>.apn.epc.mnc<MNC>.mcc<MCC>.3gppnetwork.org
APN-NI	APN Network Identifier	Defines to which PDN the P-GW is connected	<APN-NI>
APN-OI	APN Operator Identifier	Defines in which operator backbone the P-GW is located	apn.epc.mnc<MNC>.mcc<MCC>.3gppnetwork.org
EPS Bearer ID	Evolved Packet System Bearer Identifier	Identifies an EPS bearer (default or dedicated) per a UE	4 bits
E-RAB ID	E-UTRAN Radio Access Bearer Identifier	Identifies an E-RAB per an UE	4 bits
DRB ID	Data Radio Bearer Identifier	Identifies a DRB per an UE	4 bits
TEID	Tunnel End Point identifier	Identifies the endpoints of a GTP tunnel when the tunnel is established	32 bits
LBI	Linked EPS Bearer ID	Identifies the default bearer associated with a dedicated EPS bearer	4 bits

V. Closing

Through the LTE Identification technical document (three companion documents), we have covered the LTE IDs listed in Table 1, and provided a brief description of the IDs and their functions to help understand how and for what purposes they are used. Based on what we have learned from the LTE Network Architecture and LTE Identification documents, we will discuss further into some of the major topics in the LTE technologies.

References

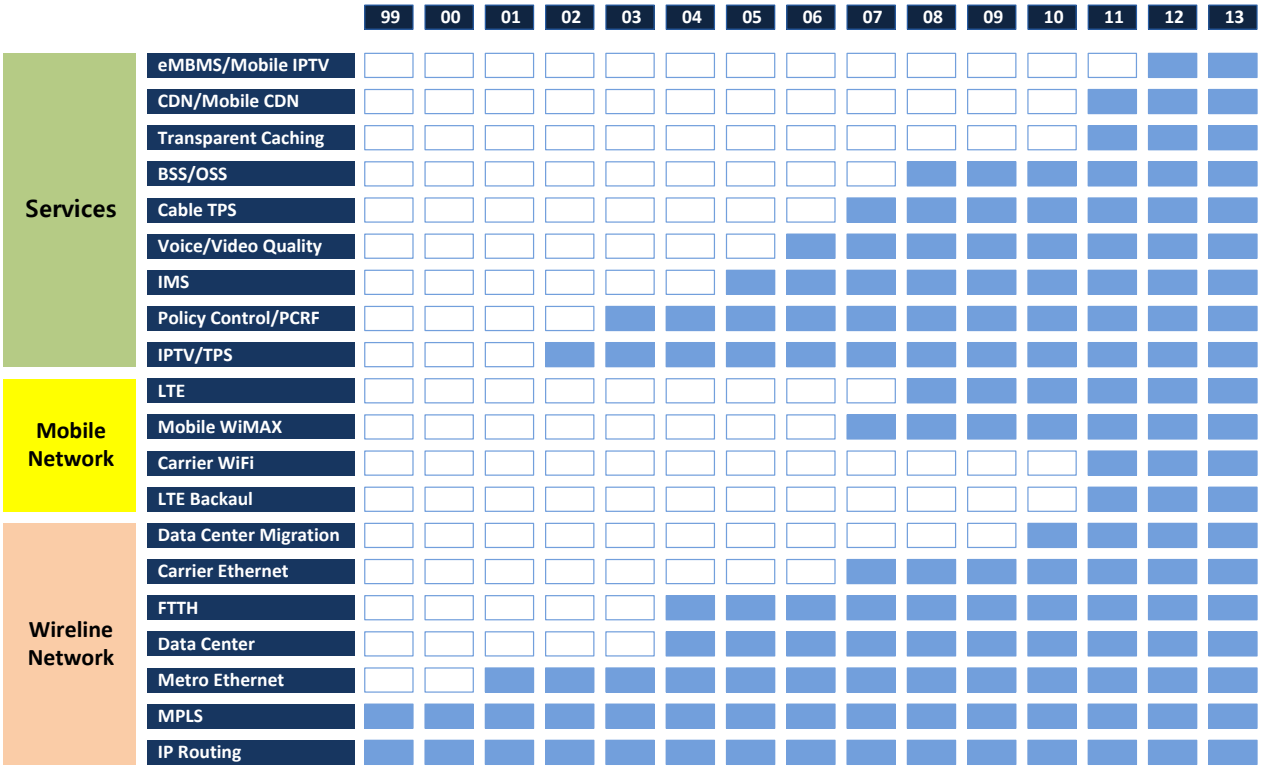
[1] Netmanias Technical Document, "LTE Identification I: UE and ME Identifiers", August 2013, http://www.netmanias.com/en/?m=view&id=techdocs&no=5905

[2] Netmanias Technical Document, "LTE Identification II: NE and Location Identifiers", August 2013, http://www.netmanias.com/en/?m=view&id=techdocs&no=5906

[3] Netmanias Technology Document, "LTE Network Architecture: Basic", July 2013, http://www.netmanias.com/en/?m=view&id=techdocs&no=5904

[4] NMC Consulting Group Confidential Internal Report, "E2E LTE Network Design", August 2010.

Netmanias Research and Consulting Scope



Visit http://www.netmanias.com to view and download more technical documents.