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# LTE Identification II: NE and Location Identifiers

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The LTE Identification technical document consists of three companion documents (LTE Identification I, II and III). As the second document for LTE Identification, this document (Part II, LTE Identification II) describes Network Equipment identifiers (NE IDs) and Location Identifiers groups. Some NE such as MME, eNB and P-GW are included in NE IDs group, and NE IDs such as GUMMEI, MMEI, Global eNB ID, eNB ID, ECGI, ECI and P-GW ID are explained first. Then location IDs that identify location of UEs, such as TAC and TAI, are discussed. Finally, features of these IDs are briefly summarized.

**August 26, 2013**

**(Initial Released: February 9, 2011)**

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## 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 |
| X2AP | X2 Application Protocol |

## I. Introduction

In the previous document, "Part I, LTE Identification I" [1], identifications of UE and ME have been described. This document (Part II, LTE Identification II), as the second document for LTE Identification, explains Network Equipment (NE) and location IDs. Some of the NE to be identified and covered in this document includes eNB, MME and P-GW, which are all EPS entities. Also, a cell - the area covered by an antenna installed in an eNB[1] - is discussed with these NE as well. Location IDs include IDs that identify the location of a UE. UEs are registered at TA level in the network. So, TA related IDs are described in this document as location IDs.

In Chapter II and Chapter III, NE IDs and Location IDs are described respectively based on the classification in [1]. In Chapter IV, the overall features of these IDs are briefly summarized.

The scopes and types of the IDs to be dealt with in this document are shown again in Figure 1 and Table 1 previously presented in [1]. The IDs enclosed in dotted boxes (ECGI, TAI) are delivered from the eNB to the PCRF (Policy and Charging Rule Function) in case the policy of an operator requires the eNB to report the location of the UEs that belong to the eNB.

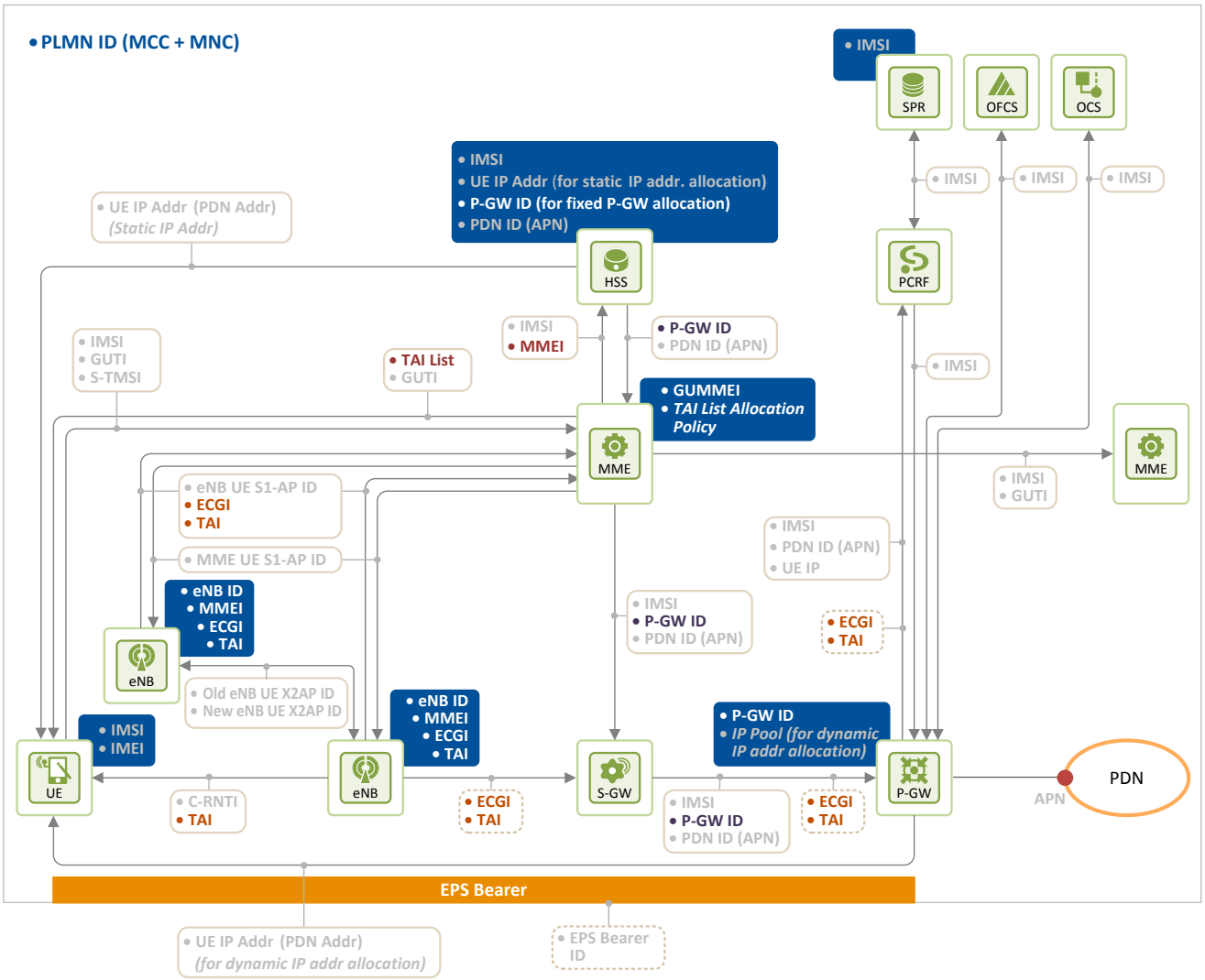



**Figure 1. LTE Identification [1]**

[1] Antennas may be remotely located away from eNBs (e.g. RRH).

**Table 1. Classification of LTE Identification [1]**

| ID group | LTE ID | Related Document |
|---|---|---|
| UE ID | I IMSI, GUTI, S-TMSI, IP address (PDN address), C-RNTI, eNB UE S1AP ID, MME UE S1AP ID, Old UE X2AP ID, New 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, TEID, LBI | LTE Identification III |

## II. Identifiers for Network Equipment (NE IDs)

This chapter describes IDs related to LTE network equipment (NE). IDs that belong to the NE ID group are GUMMEI and MMEI for MMEs, Global eNB ID and eNB ID for eNBs, ECGI and ECI for cells, and P-GW ID for P-GWs. LTE NE IDs are classified into two groups - one with PLMN ID or one without PLMN ID - depending on whether they are uniquely identified within a PLMN only or globally.

### 2.1 IDs to Identify MME: GUMMEI, MMEI, MMEGI and MMEC

An MME is located between E-UTRAN and EPC. It is the key control equipment that allows, on behalf of an HSS, a UE to attach to an LTE network by exchanging control signals with the HSS which has subscription information of the UE. It also supports bearer management and UE's mobility by exchanging control signals with an S-GW (or S/P-GW) on EPC side and with an eNB on E-UTRAN side. As such, to UEs, MMEs serve as brain for the LTE network. In general, LTE operators group multiple MMEs into a group and operate them as MME groups. An MME ID for identifying an MME is allocated by the operator when the MME is installed.

An MMEI (MME Identifier) is used when identifying an MME in the network of an operator (e.g. when a network operating personnel at "A" LTE operator needs to identify an MME in "A" LTE network). However, a GUMMEI (Globally Unique MME Identifier), combination of a PLMN ID and an MMEI, is used when identifying an MME outside of the network of the operator (e.g. when "C" is operating the networks of "A" and "B" LTE operators, and "C" needs to identify an MME in "A" LTE network). In case of an MME group formed by the operator, an MMEI consist of an MMEGI that represents an MME group, and an MMEC that represents a particular MME in the MME group. Figure 2 shows the MME-related IDs and their format.

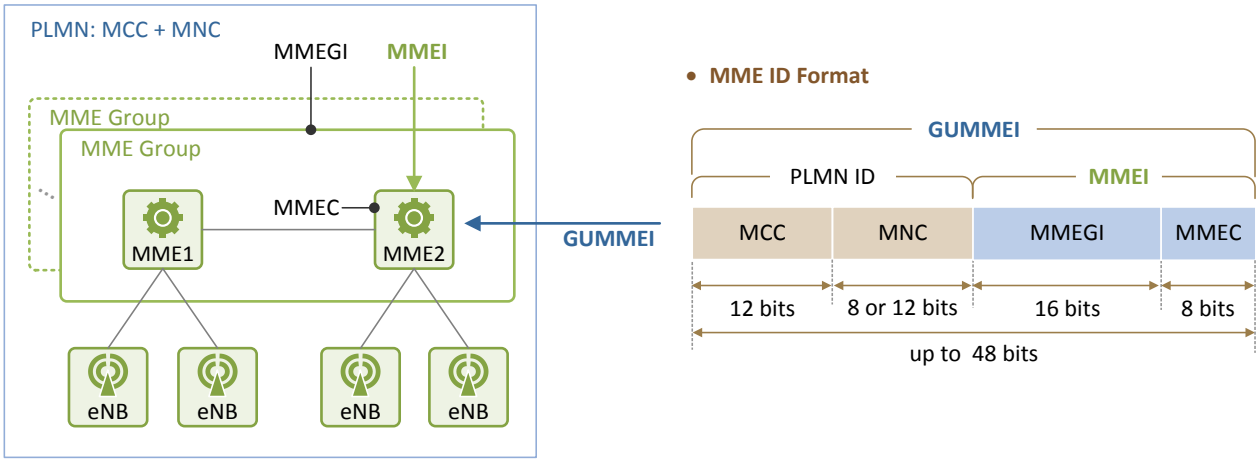



**Figure 2. IDs to identify MME and format**

## 2.2 IDs to identify eNB: eNB ID and Global eNB ID

An eNB ID is used for identifying an eNB within an operator's network only, whereas a Global eNB ID, combination of a PLMN ID and an eNB ID, is used for identifying one outside the network. Figure 3 shows eNB/cell-related IDs and their format. To identify a cell belonging to an eNB, an ID created by adding a cell ID to the combination of an eNB ID and a Global eNB ID is used.

eNB IDs and cell IDs are allocated by the network operator when an eNB is installed. Once installed, the eNB begins a procedure for setting up an S1 link between an MME and itself. When it requests the MME for S1 link setup, it reports its Global eNB ID and supported TAs (See Chapter III for more information about TAs) and a CSG (Closed Subscriber Group) ID if CSGs are supported. A CSG is a cell open to only a certain group of subscribers, and is made up of a single cell or a collection of cells. The MME sends served GUMMEIs to the eNB as a response to the S1 link setup request, providing MME pool information.

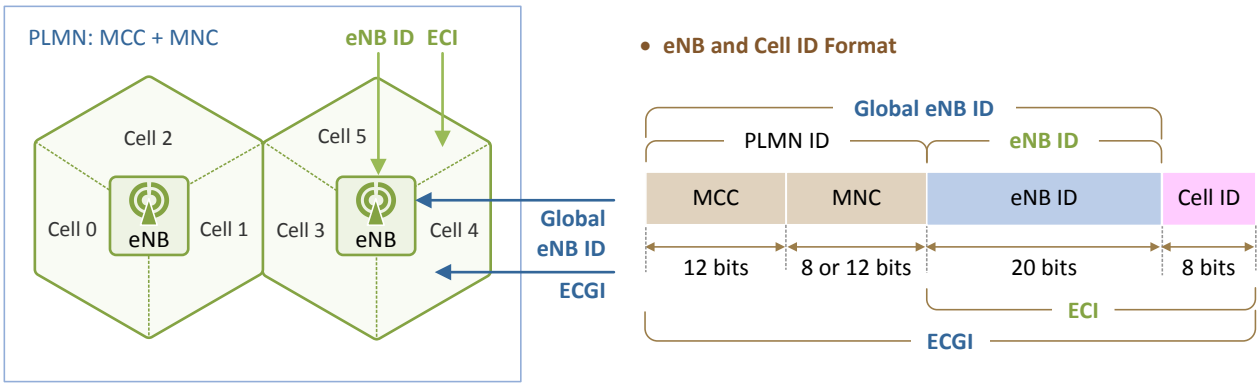



**Figure 3. IDs to identify eNB and cell**

## 2.3 ID to Identify P-GW: P-GW ID

When a UE attempts to attach an LTE network, the LTE network provides the UE with PDN connection (See LTE Identification III for more information about PDN connection). To set up PDN connection between the UE and

a PDN, the MME has to know the PDN to connect the UE and the P-GW to attach the UE through. The default PDN for the UE has already been provisioned in the HSS as a subscribed profile. So, the MME can simply use this information downloaded from the HSS. For the P-GW, there are two ways of allocating – fixed allocation in which the network operator provisions a P-GW ID as a subscribed profile in the HSS, and dynamic allocation in which the MME selects a P-GW according to the P-GW selection policy set by the operator. In case of fixed allocation, the HSS informs the MME of the P-GW ID, so that the MME can request the P-GW for PDN connection.

P-GW IDs are used to identify P-GWs, and can be in either IP address or FQDN (Fully Qualified Domain name) forms. Figure 4 illustrates the P-GW ID assigned according to the fixed allocation policy and its format. For example, there can be a UE whose default PDNs are allocated as PDN 1 (Internet) for Internet services and PDN2 for voice services. When the UE initially accesses an LTE network, the MME requests the HSS for subscription information of the UE. The HSS then informs the MME that (i) the default PDNs of the UE are PDN 1 (Internet) and PDN 2 (IMS), and that (ii) the P-GW connecting PDN 1 is P-GW 1 and the one for PDN 2 is P-GW 3. The MME then establishes PDN connection between the UE and the Internet through P-GW 1, and one between the UE and IMS through P-GW 3.

For P-GW ID assigned according to the dynamic allocation policy, the MME obtains a P-GW IP address list through DNS query, selects one from the list, and requests the P-GW to establish PDN connection (See “LTE Identification III: Session/Bearer ID” for more information about PDN connection and EPS bearers.). If a P-GW list is provided by DNS, the MME selects one from the list in accordance with the P-GW selection policy.

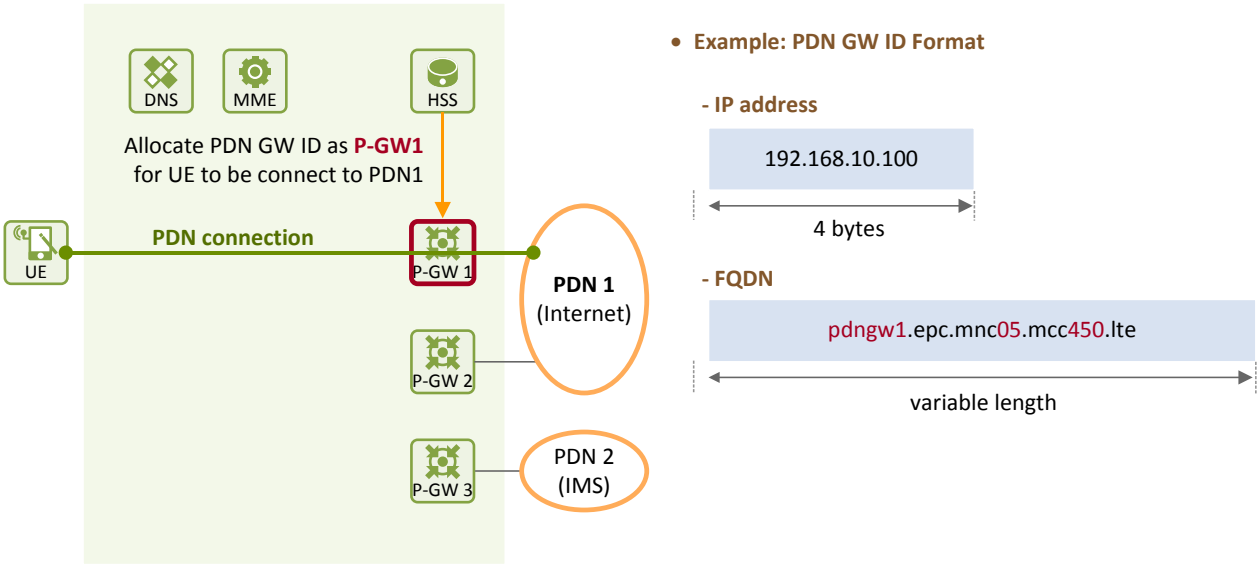



**Figure 4. ID to identify P-GW**

## III. Identifiers for UE Location (Location IDs)

An MME is in charge of managing a UE's mobility, and thus has to have updated information on the UE's location. Location of a UE is known by the LTE network at cell level if the UE is in active state and is using services, or at TA level if it is in idle state and thus not using services. Since cell IDs, one of the UE location IDs, have already been explained in Chapter II, only TA IDs will be covered in Chapter III.

### 3.1 IDs to identify the location of a UE: TAC and TAI

A UE is registered to a network at TA level. An MME also locates a UE in idle state at TA level as well. IDs identifying TAs are TAC (Tracking Area Code) and TAI (Tracking Area Identifier). The TAC is used to identify a TA in the network of an operator, whereas the TAI, combination of a PLMN ID and a TAC, is used to uniquely identify a TA globally. Figure 5 shows different types of TA IDs and their formats.

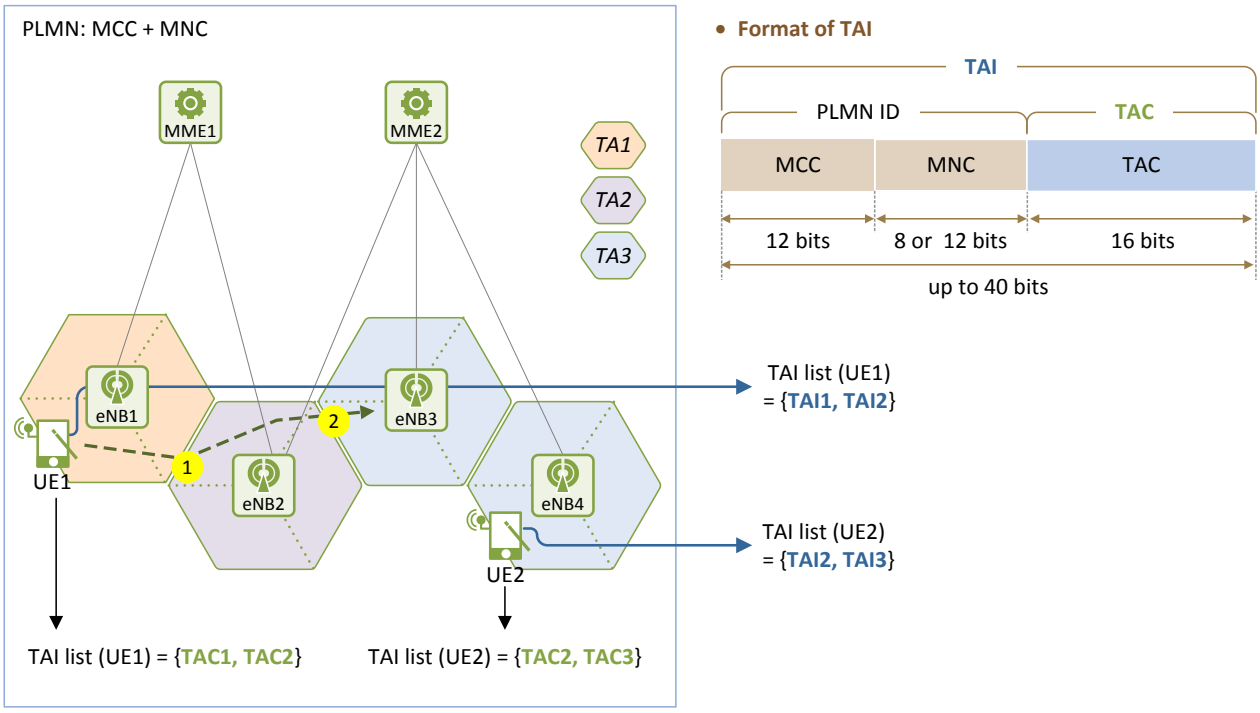



**Figure 5. Example of IMEI applied**

When a UE initially attaches to an LTE network, the UE is registered to the network by an MME. The MME allocates a TAI list to the UE at its initial attach, and keeps track of its location thereafter. For this, the UE informs the MME of its new location and requests for TA update whenever it leaves its registered TA[2]. This way, the MME knows in which TA the UE is currently located, and keeps the TAI list of the UE updated. The UE does not have to request TA update if travelling to a TA listed in the TAI list. However, if the current TA renewal period is expired, the UE has to inform the MME of its current TA, even while staying in TAs listed in the list, and let the MME know that it is able to receive data.

When data destined to the UE is arrived at the LTE network, the MME needs to know the location of the UE to

[2] The UE requests for TA update by sending TAU (Tracking Area Update) Request message to the MME.

forward the data properly. If the UE is in active state, the MME knows in which cell the UE is, and hence can simply forward the data. However, if the UE is in idle state, the MME does not know which cell the UE is located in. So, it searches the TA last reported for the UE. In other words, the MME sends a **Paging** message to all the eNBs belonging to the TA announcing there is data for the UE. A UE in idle state wakes up at certain periods to check for any **Paging** message. If it finds it has been paged (by checking the S-TMSI in the **Paging** message), it responds to the message to receive the data. The larger TA means the higher chance of finding the UE easily. But, at the same time, the larger TA also means more eNBs to page, and hence the greater signaling overhead. How a TAI list is allocated is one of the optimization issues.

An eNB learns which MME and TA it belongs to through the provisioning information when it is installed. Each cell in the eNB broadcasts its cell IDs (ECI, ECGI) and TA information (TAC, TAI) as its system information. A UE attempting to access a new cell figures out whether the new cell is in a different TA from the current one, and hence its TA has to be changed, or the new cell is within its current TA, by listening to the broadcasted system information.

Figure 5 illustrates how a UE with an allocated TA list behaves. In the figure, eNB1 is in TA1, eNB2 is in TA2, and eNB3 and eNB4 are in TA3 (A TA can be made up of cells or eNBs. But only those made up of eNBs will be used here). UE1 is registered to MME1 and is assigned a TAI list of {TAI1, TAI2} while UE2 is registered to MME 2 and is assigned a TAI list of {TAI2, TAI3}. After UE1 accessed to eNB1 turns idle, as it travels along the dotted line (eNB1 → eNB2 → eNB3), UE1's behavior can be described as follows (TAs are checked at cell level. However, UE1's behavior when switching between cells in an eNB is not discussed here):

- While in eNB1: UE1's current TA is TA1.
- While traveling from eNB1 to eNB2 (① in Figure 5): UE1 learns its new TA is TA2 by listening to the system information broadcasted by the new cell it is trying to access. It checks the TAI list for TA2 and realizes it does not have to request for TA update because TA2 is listed.
- While traveling from eNB2 to eNB3 (② in Figure 5): UE1 learns its new TA is TA3 by listening to the system information broadcasted by the new cell it is trying to access. It checks the TAI list for TA3 and realizes it has to send **TAU Request** message to the MME to have its location updated because TA3 is not listed.

## IV. Closing

We have learned about the LTE ID groups classified in Table 1 - UE IDs and ME IDs in the previous document [1] and NE IDs and Location IDs in this document. Table 2 summarizes these IDs in terms of their range (within which IDs are uniquely identified), allocators and type of value. Other IDs not covered yet (i.e. Session/Bearer IDs) will be described in LTE Identification III that follows.

**Table 2. LTE Identification: NE and Location**

| ID group | LTE Identifier | Range (uniquely identified within) | Allocator | Type of value |
|---|---|---|---|---|
| NE ID | GUMMEI | Global | Operator | Fixed |
| | MMEI | Operator Network | Operator | Fixed |
| | Global eNB ID | Global | Operator | Fixed |
| | eNB ID | Operator Network | Operator | Fixed |
| | ECGI | Global | Operator | Fixed |
| | ECI | Operator Network | Operator | Fixed |
| | P-GW ID | Global | Operator | Fixed |
| Location ID | TAI | Global | Operator | Fixed |
| | TAC | Operator Network | Operator | Fixed |

## References

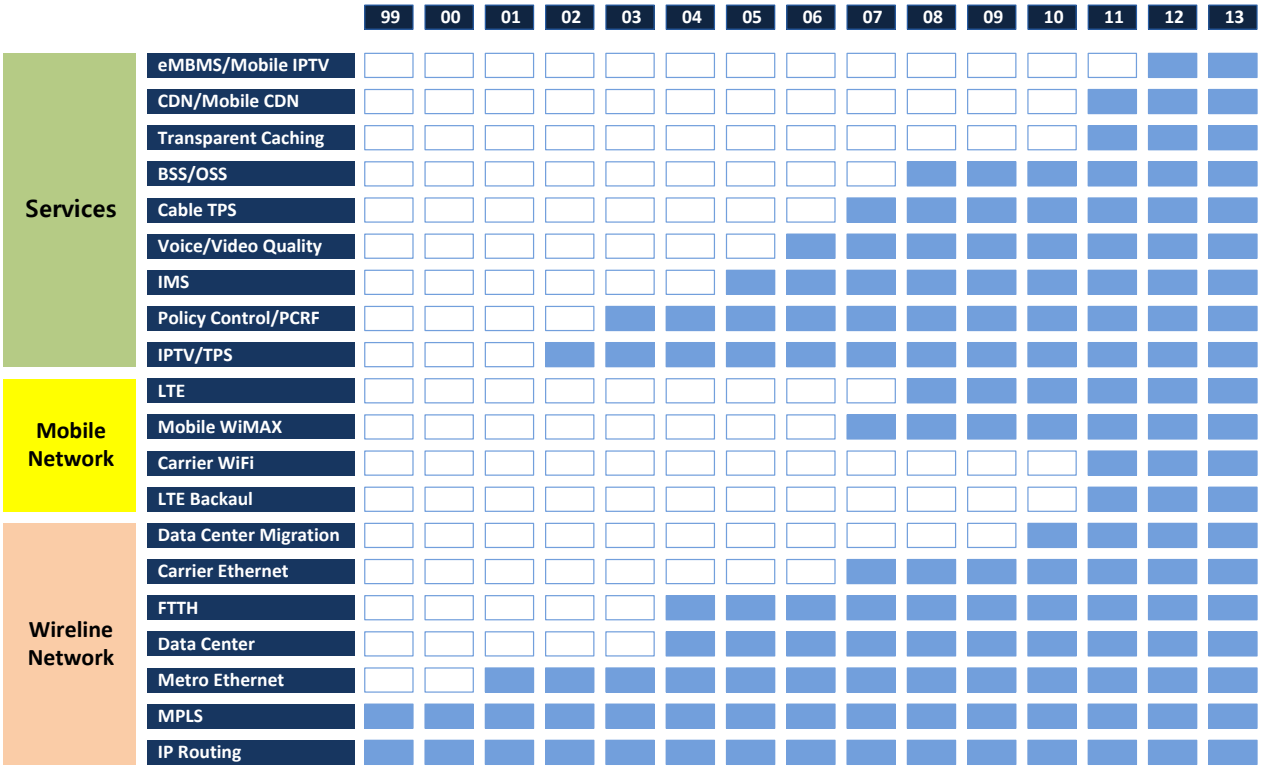

[1] Netmanias Technical Document, “LTE Identification I: UE and ME Identifiers”, August 2013, http://www.netmanias.com/en/?m=view&id=techdocs&no=5905

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

[3] 3GPP TS 23.003, “Numbering, addressing and identification”.

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

## Netmanias Research and Consulting Scope

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