**NETMANIAS**
www.netmanias.com

**NMC** CONSULTING GROUP
www.nmcgroups.com

# EMM Procedure 7. Cell Reselection without TAU

This document will provide the procedure for cell reselection without Tracking Area Update (TAU), as defined as EMM Case 7 in our technical document, "Eleven EMM Cases in an EMM Scenario". This procedure is performed when a UE, staying in EMM-Registered, ECM-Idle and RRC-Idle after network attach, moves to another TA registered at the network (MME), and reselects a cell. Moving to a TA already registered at the network (MME) does not require a TAU procedure after the reselection procedure. First, this document will explain what system information is needed in cell reselection, and on what criteria cells are reselected. Then, it will describe the cell reselection procedure, with main focus on the criteria for cell reselection triggering and cell ranking. Here in this document, we will only discuss intra-frequency cell reselection (i.e. cell reselection within the same frequency) in a single LTE-only network that operates with a single LTE carrier frequency.

**April 23, 2014**

**(Initial Released: May 9, 2013)**

**www.netmanias.com**

**NMC Consulting Group (tech@netmanias.com)**

## Netmanias LTE Technical Documents

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

## Abbreviations

| | |
|---|---|
| CDMA | Code Division Multiple Access |
| DRX | Discontinuous Reception |
| ECM | EPS Connection Management |
| EMM | EPS Mobility Management |
| eNB | Evolved Node B |
| EPC | Evolved Packet Core |
| EPS | Evolved Packet System |
| E-UTRA | Evolved Universal Terrestrial Radio Access |
| E-UTRAN | Evolved Universal Terrestrial Radio Access Network |
| GERAN | GSM/EDGE Radio Access Network |
| LTE | Long Term Evolution |
| MBSFN | Multimedia Broadcast multicast service Single Frequency Network |
| MIB | Master Information Block |
| MME | Mobility Management Entity |
| PCI | Physical Cell ID |
| PLMN | Public Land Mobile Network |
| RAT | Radio Access Technology |
| RRC | Radio Resource Control |
| RSRP | Reference Signal Received Power |
| RSRQ | Reference Signal Received Quality |
| SFN | System Frame Number |
| SI | System Information |
| SIB | System Information Block |
| TA | Tracking Area |
| TAC | Tracking Area Code |
| TAI | Tracking Area Identity |
| TAU | Tracking Area Update |
| UE | User Equipment |
| UMTS | Universal Mobile Telecommunication System |
| UTRA | Universal Terrestrial Radio Access |
| VPLMN | Visited Public Land Mobile Network |

## I. Introduction

Through the three companion documents previously presented [1][2][3], we have looked into the "EMM Case 6. Handover without TAU" procedure for inter-cell handover within a Tracking Area (TA).[1] This document provides a description of how UE, in Idle state, moves and reselects a cell.

While handover controls the mobility of UE in Connected (**EMM-Registered, ECM-Connected** and **RRC-Connected**) state, cell reselection controls the same while in Idle (**EMM-Registered, ECM-Idle** and **RRC-Idle**) state. During a handover, it is the network (MME or source eNB) that decides which cell to handover to. During cell reselection, however, it is UE that decides which cell to camp on[2].

A cell reselection procedure can be one of the two types as seen below and in Figure 1. In Figure 1, the UE is camping on Cell 5 that belongs to the TA list of {TA1, TA2} previously assigned by the MME at the time of network attach, and is staying in Idle state.

- **Cell Reselection without TAU** (**7**: EMM Case 7): UE moves to a TA that IS registered at MME (i.e. listed in the TAI list of the UE), for example TA2 in Figure 1. Cell reselection is performed but no Track Area Update (TAU) is required.
- **Cell Reselection with TAU** (**9**: EMM Case 9): UE moves to a TA that is NOT registered at MME (i.e. not listed in the TAI list), for example TA3 in Figure 1. After cell reselection, a TAU procedure is performed.
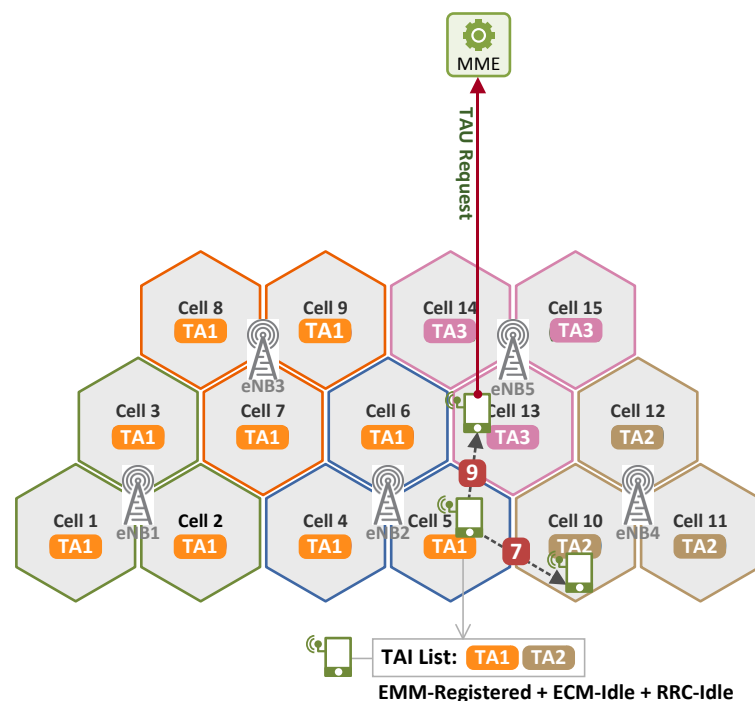


**Figure 1. Two Cell Reselection Types**

UE may reselect a cell i) that uses the same LTE frequency as its current serving cell that it is camping on (intra-

---

[1]  See the previous document [4] for a complete EMM scenario.
[2]  After cell reselection, UE monitors the system and paging information at the newly selected cell. See 3GPP TS 36.304 [5] for details.

frequency), ii) that does not use the same frequency (inter-frequency), or iii) that uses other Radio Access Technology (RAT[3]) (inter-RAT). In the example cases of cell reselection shown in Figure 1, we only discuss **intra-frequency cell reselection** in a single LTE network environment that uses only a single LTE frequency.

This document describes cell reselection case 🔴7 only, and the other case (🔴9) will be covered in our next document "EMM Procedure 8 & 9. Handover & Cell Reselection with TAU" [6]. In Chapter II below, we will review the preliminary information required to understand the cell reselection procedure. In Chapter III, a detailed description of the cell reselection without TA procedure will be given.

According to one of our LTE documents [7], while UE stays in Idle state (**EMM-Registered, ECM-Idle, RRC-Idle**) after attach:

- UE IP address is kept valid, and an EPS bearer remains active in the EPC.
- EPC (MME) knows the presence of UE, but E-UTRAN (eNB) does not.
- UE is known to MME at TA level (i.e. MME knows in which TA UE is located).
- UE performs a TAU procedure when it moves to a TA that is not registered at MME (i.e. one that is not in the TAI list), and informs MME of its new location (TA).
- UE cannot send it generates.
- If there is data destined to UE, MME initiates paging in the entire TA allocated the UE.
- UE wakes up periodically and checks if there is any **Paging** message for it.

While camping on a cell, UE in Idle state:

- Receives the system information that eNB broadcasts.
- Receives Paging signal, and responds to **Paging** messages.
- Measures the signal strength of the serving cell periodically.
- Measures the signal strength of neighbor cells and reselects a cell when cell reselection is triggered.
- Initiates a TAU procedure if the reselected cell does not belong to the UE's registered TA list.

---

[3]  Radio access technologies used in UTRAN, GERAN, CDMA2000, etc.

## II. Cell Reselection: Required System Information and Criteria

Before we learn the detailed cell reselection procedure in Chapter III, we will provide a brief overview of a cell reselection procedure in Section 2.1 first. Then, we will look into what system information is required for the procedure and the criteria for the cell reselection in Sections 2.2 and 2.3, respectively.

### 2.1 Overview of Cell Reselection Procedure

It is UE who is in control of cell reselection. UE obtains information needed for cell reselection (e.g. threshold values used to decide whether to measure the signal strength of neighbor cells or not, parameters used for calculating rank of the serving cell and neighbor cells, etc.) from the system information broadcasted by eNB. In case of intra-frequency cell reselection, required information is delivered through System Information Block (SIB) 3 and SIB 4, which will be discussed further in Section 2.2.

■ **Cell Reselection Triggering**

**Serving Cell Measurement**: UE, in Idle state, wakes up at the end of every DRX cycle to measure the signal of its serving cell ($Q_{rxlevmeas}$) and calculate the received signal level (**Srxlev**) of the serving cell to decide whether it should stay or move to another cell. Here, the UE's transmission and reception conditions are reflected in the calculation, for example by applying minimum received signal level $Q_{rxlevmin}$, allowed maximum TX power level $P_{EMAX}$, etc., (see Section 2.2 for details).

**Cell Reselection Triggering**: If the received signal level of the serving cell (**Srxlev**) is greater than the specified threshold value (**s-IntraSearch**), the UE stays in the current serving cell. If not, it triggers a cell reselection procedure. The threshold value that works as triggering criterion is delivered through SIB 3, and defined as **s-IntraSearch** in Release 8 and as **s-IntraSearchP** and **s-IntraSearchQ** in Release 9.

UE in Idle state wakes up at the end of every DRX cycle to measure the received signal level of its serving cell (**Srxlev**) when it has stayed in the same location for a while. Let's assume a UE that has camped on the same serving cell for a while because the received signal level of the cell has remained lower than the set threshold (**s-IntraSearch**). If it leaves the serving cell, the received signal level of the cell decreases gradually. Finally when the received signal level becomes lower than the threshold (**s-IntraSearch**), a cell reselection procedure is triggered. Then the UE begins to measure the signal strength of the neighbor cells (i.e. non-serving cells).

■ **Cell Reselection Criteria**

**Cell-Ranking Criterion**: The UE ranks each cell (**R$_s$**, **R$_n$**) based on the measured signal strength of the serving cell ($Q_{meas,s}$) and neighbor cells ($Q_{meas,n}$). Parameters required for cell ranking are delivered through SIBs 3 and 4 (see Section 2.2). The serving cell is ranked using the hysteresis (**q-Hyst**) value stored in SIB 3 while the neighbor cells are ranked based on the offset (**q-OffsetCell**) value specified for each cell in SIB 4.

**Cell Reselection**: Once the serving cell and neighbor cells (non-serving cells) are ranked, the UE checks whether the cell reselection criterion is satisfied (**R$_n$ > R$_s$**) or not. If there are neighbor cell(s) that satisfy the criterion, the UE selects the best satisfying cell, and then camps there. Cell reselection is performed only when the criterion is satisfied for a certain period of time (**t-ReselectionEUTRA**).

Mobile operators can prevent too frequent cell reselection and make sure reselection is performed in accordance with the cell status by controlling the UE's dwelling time on the serving cell, based on the

hysteresis and cell-specific offset values. In addition, they can control the **q-Hyst** and **t-ReselectionEUTRA** values by applying appropriate scaling factor (**q-hystSF**, **t-ReselectionEUTRA-SF**) depending on the traveling speed of the UE.

## 2.2 System Information

System Information (SI) refers to the information broadcasted by eNB and consists of MIB (Master Information Block) and SIBs (System Information Blocks; SIBs 1 ~ 16) [4]. MIB, SIB 1 and SIB 2 are mandatory, but the rest SIBs are optional. All SI is delivered to UE through an RRC message like **MIB**, **SIB 1**, or **SI** message[4]. An **SI** message consists of a group of SIBs (SIBs 2 ~ 16), excluding MIB and SIB 1.

UE performs a cell reselection procedure based on the SI broadcasted by eNB. MIB, SIB 1 and SIB 2 are applied to all the UEs, either in Connected state (**EMM-Registered, ECM-Connected, RRC-Connected**) or in Idle state (**EMM-Registered, ECM-Idle, RRC-Idle**). Conversely, SIBs 3 ~ 8 are only used in cell reselection by those in Idle state. Table 1 describes different types of SI and their parameters (see our One-Shot Gallery for more information about for a selected list of SIB information[5]).

**Table 1. Cell Reselection-related System Information**

| Type | | Description | Parameters |
|---|---|---|---|
| Mandatory | MIB | • Mandatory for UE to access a cell | DL bandwidth, SFN, HARQ channel (PHICH) info |
| | SIB 1 | • Provides information relating to granting/restricting cell access<br>• Defines scheduling of other SIBs | Access restriction info, Cell selection info, Scheduling info for other SIBs |
| | SIB 2 | • radio resource configuration information common for all UEs | Common and shared channel info (RACH, BCCH, PCCH, PRACH, PDSCH, PUSCH, PUCCH, Sounding RS, UL Power Control), Sub-frame for MBSFN |
| Cell reselection-related SIBs | SIB 3 | • Information commonly used in all types of cell reselection (intra-frequency, inter-frequency and/or inter-RAT)<br>• Intra-frequency cell reselection information other than neighbor cell related | q-Hyst, s-NonIntraSearch, threshServingLow, cellReselectionPriority q-RxLevMin, p-Max, s-IntraSearch, t-ReselectionEUTRA, q-QualMin |
| | SIB 4 | • Information on neighbor cells related only to intra-frequency cell reselection | intraFreqNeighCellList (*physCellId, q-OffsetCell*), intraFreqBlackCellList (*physCellId Range*), CSG-PCI Range |
| | SIB 5 | • Information on other E-UTRA frequencies and neighbor cells related only to inter-frequency cell reselection | Supported E-UTRA frequency list (E-UTRA frequency, Neighbor cell list, Black cell list, Reselection threshold) |
| | SIB 6 | • Information for Inter-RAT (UTRA) cell reselection | UTRA frequency |
| | SIB 7 | • Information for Inter-RAT (GERAN) cell reselection | GERAN frequency |
| | SIB 8 | • Information for Inter-RAT (CDMA2000) cell reselection | CDMA 2000 frequency |

---

[4]  In the physical layer, MIBs and SIBs are broadcasted through Physical Broadcast Channel (PBCH) and Physical Downlink Shared Channel (PDSCH), respectively.

[5]  Netmanias One-Shot Gallery, "System Information Broadcasted by eNB", http://www.netmanias.com/en/?m=view&id=oneshot&no=5954

Let's assume two mobile operators (A and B) who operate the network as follows:

- A: – has a LTE-only nationwide network
  - LTE frequency: only one channel of 10 MHz in 1.8 GHz band (**lteFA**1)

- B: – has nationwide 3G (UMTS) AND LTE networks
  - 3G frequency: six channels of 5 MHz in 2.1 GHz band (**3gFA 1/2/3/4/5/6**)
  - LTE frequency: one channel of 10 MHz in 1.8 GHz band, and another channel of 10 MHz in 850 MHz band (**lteFA1, lteFA2**)

In case of Operator A, its eNB needs information relating to intra-frequency for cell reselection (eNB broadcasts SIBs 3 and 4, but not SIBs 5, 6, 7 and 8. On the other hand, Operator B's eNB needs information relating to all three types of reselection: intra-frequency, inter-frequency, and inter-RAT (3G UTRA) (eNB broadcasts SIBs 3, 4, 5 and 6).

The SI broadcasted by eNB is commonly applied to all the UEs, but each UE may receive different type of SI depending on its capacity (e.g. Release 9 UE or Release 11 UE).

Figure 1 displays a UE camping on Cell 5 at eNB 2 along with its neighbor eNBs. Figure 2 however shows eNB 2 only, along with its mandatory and cell reselection-related SI.
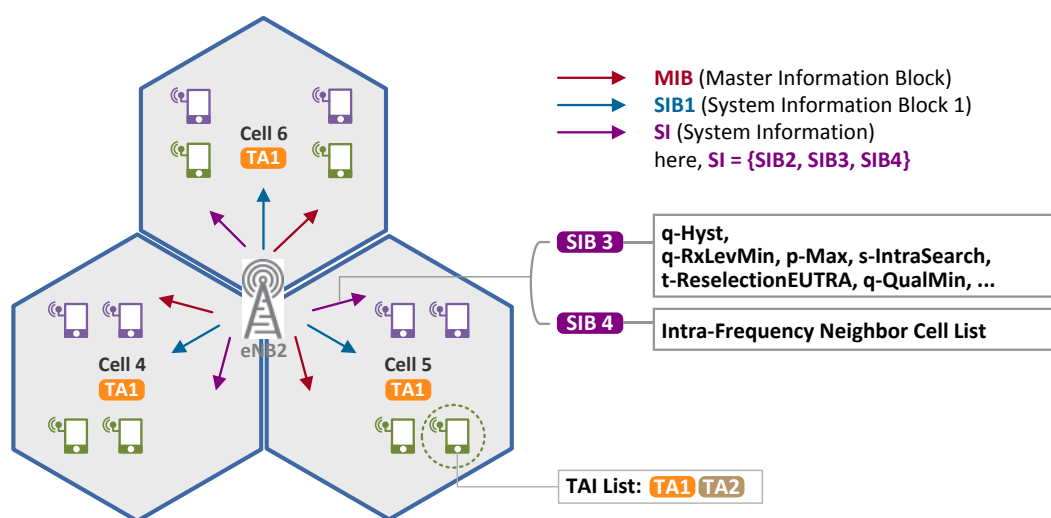


**Figure 2. Cell Reselection-related SIBs Broadcasted by eNB2**

The network used in Figure 1 is an LTE-only network that uses a single frequency (lteFA1) with home PLMN only. This document is about the intra-frequency cell reselection procedure. The SI related to intra-frequency cell reselection is broadcasted through SIBs 3 and 4. Table 2 below lists the parameters used in the two SIBs, but not those related to other frequency, RAT or VPLMN.[6]

---

[6] For a complete list of SIB 3 and SIB 4 parameters that include inter-frequency, inter-RAT, and VPLMN, see "*SystemInformationBlockType3*" and "*SystemInformationBlockType4*" in 3GPP TS 36.331, 6.3.1 System information blocks [8].

**Table 2. Cell Reselection Parameters (SIBs 3 and 4)**

| | Parameters | Description |
|---|---|---|
| SIB 3 | cellReselectionInfoCommon | Cell reselection information common for all cells |
| |   *q-Hyst* | · hysteresis value for ranking criteria |
| |   speedStateReselectionPars | · Reselection parameters depending on UE's speed |
| |     mobilityStateParameters | ·   Parameters to determine the mobility state of UE |
| |     *q-hystSF* | ·   Scaling factor for $Q_{hyst}$ that varies depending on UE's speed |
| |       *Sf-Medium* | ·   If medium or high mobility state is detected, sf-Medium or sf-High value is added to $Q_{hyst}$ value |
| |       *Sf-High* | |
| | intraFreqCellReselectionInfo | Cell reselection information to be sued for intra-frequency cells |
| |   *q-RxLevMin* | · Minimum Rx level required for UE to continue to camp on the cell [dBm] |
| |   *p-Max* | · Maximum TX power level allowed for UE [dBm]<br>· Used to limit the Tx power of UE, and used in computing $P_{Compenation}$ (see Section 2.3) |
| |   *s-IntraSearch* | · Srxlev threshold value that triggers intra-frequency measurement [dB]<br>· If Srxlev is lower than *s-IntraSearch*, UE begins to measure neighbor cells within the same frequency. |
| |   *allowedMeasBandwidth* | · DL Bandwidth to be measured by UE |
| |   *presenceAntennaPort1* | · Indicates whether neighbor cells use Antenna Port 1 or not |
| |   *neighCellConfig* | · Information relating to MBSFN of neighbor cells |
| |   *t-ReselectionEUTRA* | · Cell reselection timer value. A cell reselection criterion has to be satisfied for longer than this value in order for reselection to be performed. |
| |   *t-ReselectionEUTRA-SF* | · Scaling factor for t-ReselectionEUTRA that varies depending on UE's speed. |
| | lateNonCriticalExtension | Intra-frequency cell reselection information added in Release 9 |
| |   *s-IntraSearchP* | · Srxlev threshold value that triggers intra-frequency measurement [dB] |
| |   *s-IntraSearchQ* | · Squal threshold value that triggers intra-frequency measurement [dB] |
| |   *q-QualMin* | · Minimum quality level required for UE to continue to camp on the cell [dB] |
| SIB 4 | intraFreqNeighCellList[7] | List of intra-frequency neighbor cells that have cell specific q-Offset values |
| |   *physCellId* | · PCI of a neighbor cell |
| |   *q-OffsetCell* | · Offset between the current cell on which the UE is camping and neighbor cell |
| | intraFreqBlackCellList | List of neighbor cells that are not subject to reselection |
| |   *physCellId Range* | · PCI range |

---

[7]  In LTE, the signal strength of the cells that operate with the same frequency can be measured even without the list of neighbor cells. If cell-specific offset values are allocated, they are broadcasted through the intra-frequency neighbor cell list included in SIB 4.

## 2.3 Cell Reselection Criteria

Though not within the scope of this document, below we will review briefly the criteria used in cell reselection after UE is turned on. One of the following criteria is applied (i.e. criterion (1-1) for Release 8 UE and (1-2) for Release 9 or later UE). Table 3 provides a description of parameters used in the criteria.

■ **Cell Selection Criteria**

- Release 8:     Srxlev > 0                                                    (1-1)
- Release 9:     Srxlev > 0    and    Squal > 0                       (1-2)

$$\text{where, Srxlev} = Q_{rxlevmeas} - Q_{rxlevmin} - P_{Compensation} \text{ [dB]}$$

$$\text{Squal} = Q_{qualmeas} - Q_{qualmin} \text{ [dB]}$$

**Table 3. Cell Selection Criteria Parameters (TS 36.304 [5])**

| Parameters | Description |
|---|---|
| Srxlev | ・ Cell selection RX level value [dB] |
| $Q_{rxlevmeas}$ | ・ Cell RX level value measured by UE (RSRP) [dBm] |
| $Q_{rxlevmin}$ | ・ Minimum required RX level in the cell [dBm]<br>・ Defined by q-RxLevMin value delivered by SIB 1 |
| $P_{Compensation}$ | ・ Max ($P_{EMAX} - P_{PowerClass}$ , 0) [dB] |
| $P_{EMAX}$ | ・ Maximum TX power level allowed for UE on the uplink in the cell [dBm]<br>・ Defined by p-Max value delivered through SIB 1 |
| $P_{PowerClass}$ | ・ Maximum output power of UE according to the UE power class[8] [dBm] |
| Squal | ・ Cell selection quality value [dB] |
| $Q_{qualmeas}$ | ・ Cell quality value measured by UE (RSRQ) [dB] |
| $Q_{qualmin}$ | ・ Minimum required quality level in the cell [dB]<br>・ Defined by q-QualMin value delivered through SIB 1 |

During the initial cell selection, a cell must have the cell RX level (Srxlev) greater than the sum of $Q_{rxlevmin}$ and $P_{Compensation}$ to be a serving cell. The Srxlev must be greater than $Q_{rxlevmin}$ because, in order for UE to correctly receive messages from its serving cell, the measured signal strength must be at least greater than $Q_{rxlevmin}$. UE's Tx power ($P_{PowerClass}$) lower than the value allowed in the cell ($P_{EMAX}$) will result in greater $P_{Compensation}$ value, making it hard to select the cell. When selecting a cell, UE's transmission and reception conditions are considered.

In case of Release 9, in addition to Srxlev, Squal is added as a cell selection criterion. **$Q_{rxlevmeas}$** is the cell's Reference Signal Received Power (RSRP) while **$Q_{qualmeas}$** is the cell's Reference Signal Received Quality (RSRQ). Compared to RSRP which only indicates the strength of received signal, RSRQ provides more accurate information for radio link quality because it indicates the signal to interference and noise ratio (SINR).

■ **Cell Reselection Triggering**

UE camping on the serving cell may continue to camp on there without having to measure other cells if the serving cell's RX level fulfills the criterion (2-1) for Release 8 UE or (2-2) for Release 9 or later UE.

---

[8]   See 3GPP TS 36.101 [9].

- Release 8:    $Srxlev > S_{intraSearch}$            (2-1)
- Release 9:    $Srxlev > S_{intraSearchP}$   and   $Squal > S_{intraSearchQ}$     (2-2)

$$where,\ Srxlev = Q_{rxlevmeas} - Q_{rxlevmin} - P_{Compensation}\ [dB]$$
$$Squal = Q_{qualmeas} - Q_{qualmin}\ [dB]$$

In the above inequalities, values of $S_{intraSearch}$, $S_{intraSearchP}$ and $S_{intraSearchP}$ are given by SIB 3 (see Table 2). If the serving cell does not fulfill either of the foregoing criteria ((2-1) or (2-2)), i.e. if it fulfills the criterion (3-1) in case of Release 8 UE or (3-2) in case of Release 9 or later UE below, the UE begins measuring the neighbor cells for reselection.

## Cell Reselection Triggering (Neighbor Cell Measurement Triggering)

- Release 8:    $Srxlev \leq S_{intraSearch}$            (3-1)
- Release 9:    $Srxlev \leq S_{intraSearchP}$   or   $Squal \leq S_{intraSearchQ}$     (3-2)

## ■ Cell Reselection Criteria

### Cell Ranking Criterion

If the measured Srxlev of the serving cell fulfills the foregoing criterion ((3-1) or (3-2)), the UE begins to measure the neighbor cell's RSRP. Then based on the resulting measurements, it ranks all the cells by applying the criteria (4-1) and (4-2) below [5]. Table 4 shows the parameters used in cell ranking.

- Serving Cell Rank:            $\mathbf{R_s = Q_{meas,s} + Q_{hyst}}$      (4-1)
- Neighbor Cell (non-serving cell) Rank:   $\mathbf{R_n = Q_{meas,n} - Qoffset}$     (4-2)

**Table 4. Cell Reselection Criteria Parameters (TS 36.304 [5])**

| Parameters | Description |
|---|---|
| $Q_{meas,s}$ | ・RSRP measurement for the serving cell |
| $Q_{meas,n}$ | ・RSRP measurement for the neighbor cell |
| $Q_{hyst}$ | ・hysteresis value for the serving cell |
| Qoffset | ・Offset between the serving cell and the neighbor cell (Qoffset = $Qoffset_{s,n}$) <br> ・Defined by q-OffsetCell value delivered by SIB 4 |

### Cell Reselection

If there are multiple neighbor cells that fulfill the criterion (5) below, the UE selects the best cell and camps on it.

$$\mathbf{R_n > R_s} \hspace{6cm} (5)$$

As seen in the foregoing criteria (4-1) and (4-2), $\mathbf{R_s}$ and $\mathbf{R_n}$ are calculated using different criteria. The greater $\mathbf{Q_{hyst}}$ and **Qoffset** values are, the longer the UE can stay in the serving cell.

## III. Procedure for Cell Reselection without TAU

Figure 3 illustrates the EMM Case 7. **Cell Reselection without TAU** (**7**) procedure. In Figure 1, the UE selected Cell 5 that fulfills the criterion (1-1) or (1-2), and was allocated a TA list of {TA1, TA2} by the MME after its initial attach to the network through Cell 5. Then later while being served in Cell 5, the UE transited to Idle state, and now is camping on Cell 5.

Figure 3 shows how UE camping on Cell 5 performs an intra-frequency cell reselection procedure as it switches to eNB 4, and camps on Cell 10. Here, the UE's mobility state is "Normal", and hence scaling factors are not considered. Neighbor cells to be measured are Cells 4, 6, 10 and 13, but Figure 3 displays Cells 10 and 13 only for the sake of convenience. Chapter III will explain the procedure for intra-frequency cell reselection that is successfully performed as seen in Figure 1, and thus satisfies the following conditions:

- Camping on the serving cell: The UE is camping on Cell 5.
- **Cell Reselection Triggering**: As UE moves away from the serving cell, cell reselection is triggered.
    1. Serving cell measurement: The serving cell is measured to decide whether to measure neighbor cells or not.
    2. Neighbor cells measurement: Neighbor cells (Cells 4, 6, 10 and 13) are measured for cell reselection.
- **Cell Reselection Criteria**
    1. Cell ranking: Cells are ranked based on the measurement results for the serving cell and neighbor cells.
    2. Cell reselection: Cells that satisfy the criteria are identified, and the best satisfying cell (Cell 10) is selected.
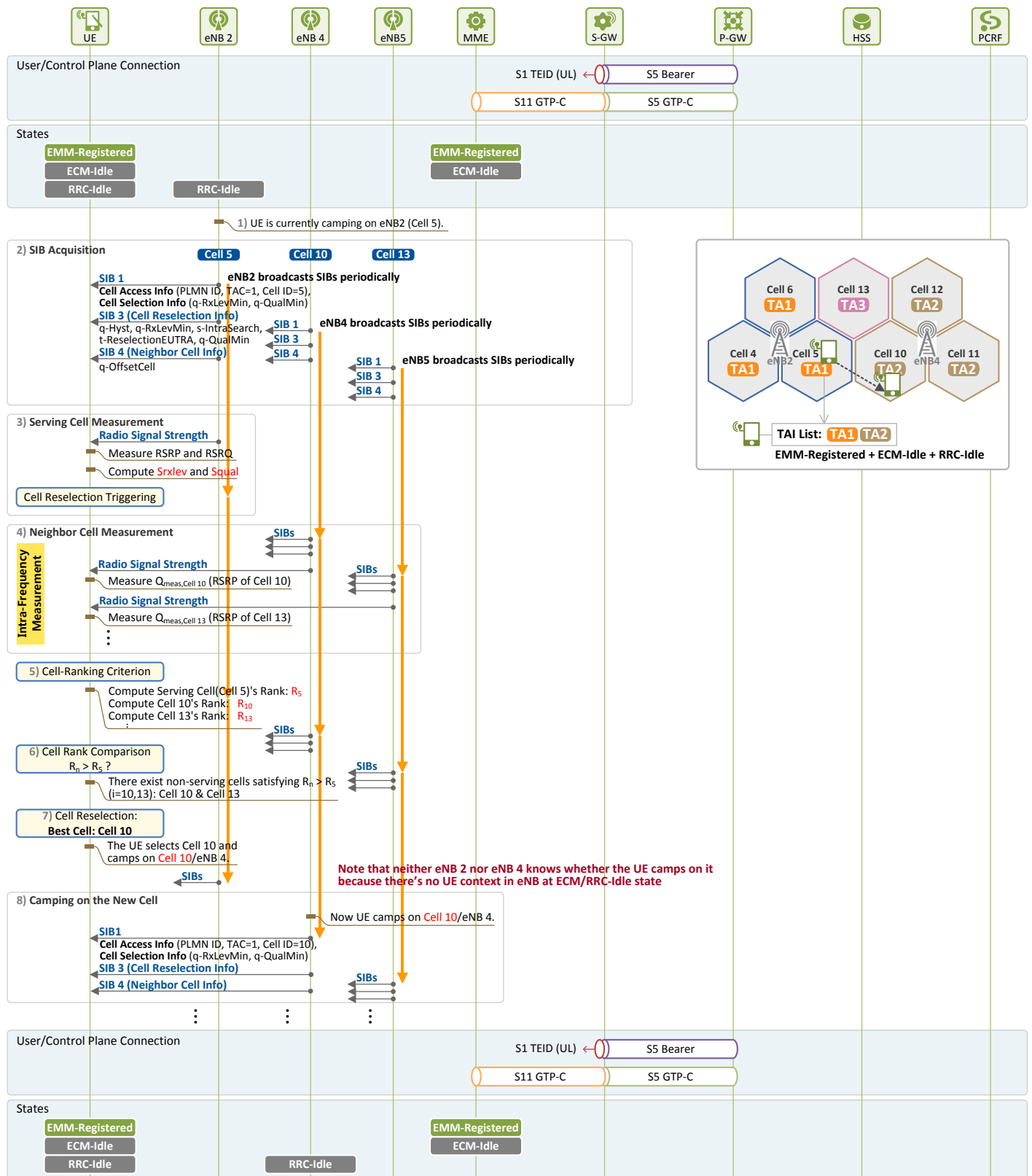- Camping on the new cell: The UE camps on Cell 10.

**Figure 3. Intra-frequency Cell Reselection Procedure (UE Moving to a registered TA)**

1) **[UE] UE Camping on the Serving Cell**

The UE is camping on its serving cell (i.e. Cell 5 in eNB 2) while staying Idle.

2) **[UE] Obtaining SI from the Serving Cell**

The UE obtains SI required for cell reselection from the serving cell. If each neighbor cell has different offset values with the serving cell, the serving cell then provides the UE with the list of neighbor cells through SIB 4. Then the UE acquires the following parameters through SIBs 3 and 4:

- Parameters required for deciding on cell reselection triggering: *q-RxLevMin*, *p-Max*, *s-IntraSearchP*, *s-IntraSearchQ*, *t-ReselectionEUTRA*, *q-QualMin* (SIB 3)
- Parameters required for ranking the serving cell: *q-Hyst* (SIB 3)
- Parameters required for ranking the neighbor cells: *q-OffsetCell* (SIB 4)

3) **[UE] Measuring the Signal Strength of the Serving Cell**

At the end of the every DTX cycle, the UE wakes up and measure the signal of the serving cell (RSRP and RSRQ) to get $Q_{rxlevmeas}$ and $Q_{qualmeas}$. Then, based on them, it computes the cell reselection received level (**Srxlev**) and cell reselection quality level (**Squal**). The UE, by applying the criterion (3-1) or (3-2), whichever is applicable depending on its release, checks whether it should reselect a new cell or it may continue to camp on the current serving cell. For example, if **Srxlev** and **Squal** does not satisfy the criterion, the UE continues to camp on the current cell. If either of them does, then it performs Step **4)**.

4) **[UE] Measuring Neighbor Cells**

The UE measures RSRP of the neighbor cells that are in the same frequency as the serving cell ($Q_{meas,n}$, n=4,6,10,13).

5) **[UE] Cell-Ranking Criterion**

Once the RSRPs are measured, the UE ranks the serving cell (Cell 5) and neighbor cells (Cells 4, 6, 10 and 13). The rank of the serving cell, Rank $R_5$, can be computed by applying the criterion (4-1), and those of neighbor cells, $R_4$/$R_6$/$R_{10}$/$R_{12}$, can be determined by applying the criterion (4-2).

6) **[UE] Cell Rank Comparison**

Now, the UE compares Rank $R_5$ and Rank $R_n$ (n=4,6,10,13), and checks if the criterion (5) is satisfied. If no cell satisfies it, then the UE continues to camp on Cell 5. In the figure, the criterion (5) was satisfied by Cells 10 and 13.

7) **[UE] Selecting a New Cell**

The UE compares the two satisfying cells, $R_{10}$ and $R_{13}$, and selects $R_{10}$, the best satisfying cell, as its new serving cell.

8) **[UE] Camping on the New Cell**

The UE now camps on Cell 10. After receiving SIB 1 broadcasted by Cell 10, it learns that TAI at Cell 10 is in the TAI list. Since the new serving cell belongs to the UE's registered TA list, no TAU is performed. Thereafter, the UE wakes at the end of every DRX cycle, to monitor the system and paging information of Cell 10, and measure the signal of Cell 10 (RSRP, RSRQ).

## IV. EPS Entity Information: Before/After Cell Reselection without TAU

This chapter will describe how information elements in the EPS entities are different before and after the cell reselection procedure. Since the UE stays in Idle state (**EMM-Registered, ECM-Idle, RRC-Idle**) before and after the procedure, MME also stays in Idle state (**EMM-Registered, ECM-Idle**). The UE moves from Cell 5 to Cell 10, and hence no TAU procedure was performed. Thus, after cell reselection, the information elements in the EPS entities remain unchanged, and will be the same as those stored after S1 release [10], as seen in Figure 4.

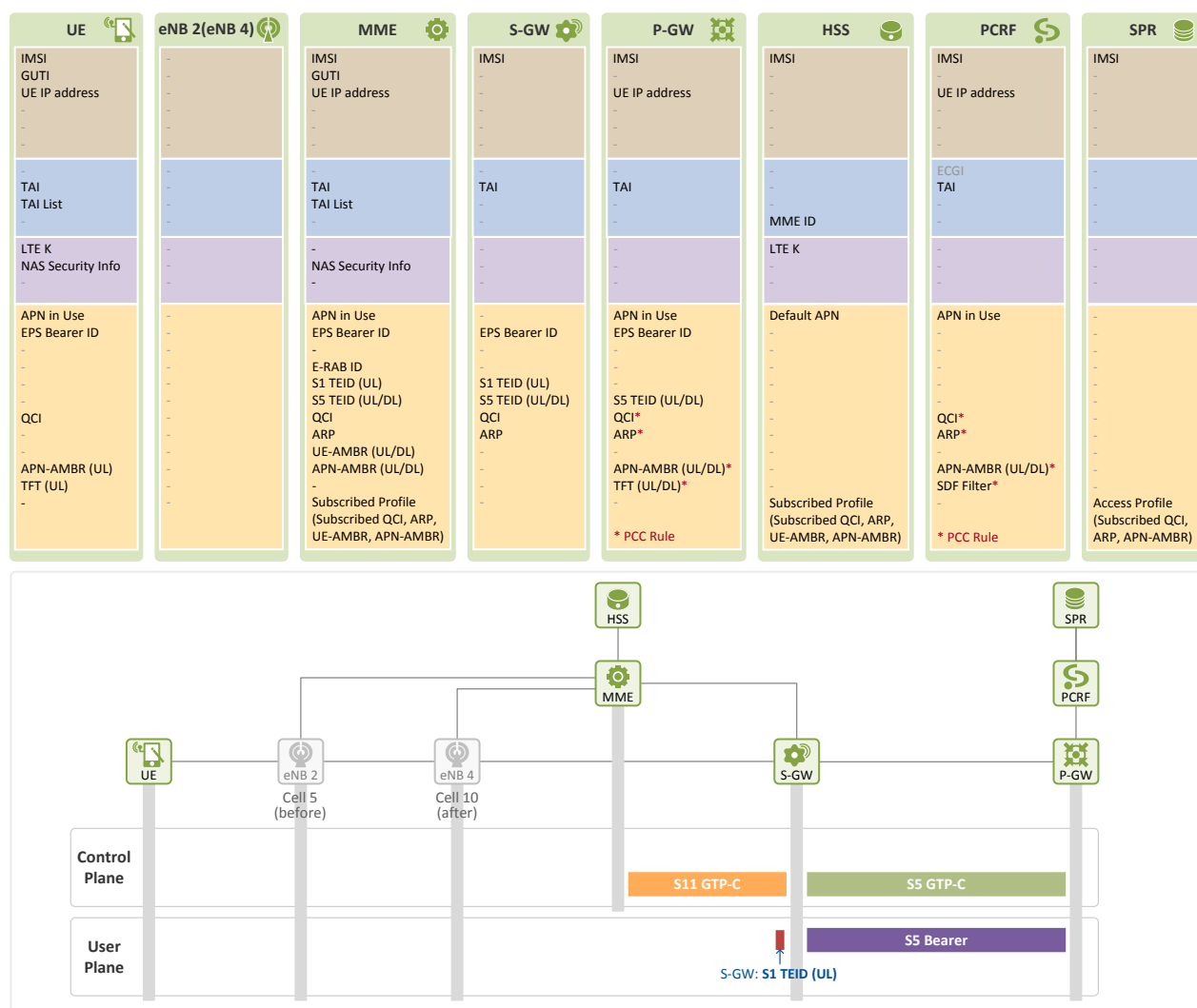| UE | eNB 2(eNB 4) | MME | S-GW | P-GW | HSS | PCRF | SPR |
|---|---|---|---|---|---|---|---|
| IMSI | - | IMSI | IMSI | IMSI | IMSI | IMSI | IMSI |
| GUTI | - | GUTI | - | - | - | - | - |
| UE IP address | - | UE IP address | - | UE IP address | - | UE IP address | - |
| - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - |
| TAI | - | TAI | TAI | TAI | - | ECGI | - |
| TAI List | - | TAI List | - | - | - | TAI | - |
| - | - | - | - | - | MME ID | - | - |
| LTE K | - | - | - | - | LTE K | - | - |
| NAS Security Info | - | NAS Security Info | - | - | - | - | - |
| - | - | - | - | - | - | - | - |
| APN in Use | - | APN in Use | - | APN in Use | Default APN | APN in Use | - |
| EPS Bearer ID | - | EPS Bearer ID | EPS Bearer ID | EPS Bearer ID | - | - | - |
| - | - | - | - | - | - | - | - |
| - | - | E-RAB ID | - | - | - | - | - |
| - | - | S1 TEID (UL) | S1 TEID (UL) | - | - | - | - |
| - | - | S5 TEID (UL/DL) | S5 TEID (UL/DL) | S5 TEID (UL/DL) | - | - | - |
| QCI | - | QCI | QCI | QCI* | - | QCI* | - |
| - | - | ARP | ARP | ARP* | - | ARP* | - |
| - | - | UE-AMBR (UL/DL) | - | - | - | - | - |
| APN-AMBR (UL) | - | APN-AMBR (UL/DL) | - | APN-AMBR (UL/DL)* | - | APN-AMBR (UL/DL)* | - |
| TFT (UL) | - | - | - | TFT (UL/DL)* | - | SDF Filter* | - |
| - | - | Subscribed Profile (Subscribed QCI, ARP, UE-AMBR, APN-AMBR) | - | * PCC Rule | Subscribed Profile (Subscribed QCI, ARP, UE-AMBR, APN-AMBR) | * PCC Rule | Access Profile (Subscribed QCI, ARP, APN-AMBR) |



**Figure 4. Information in EPS entity before/after Cell Reselection without TAU**

## V. Closing

We have learned how a UE in Idle state moves to TA where the UE is registered, and reselects a new cell without TAU. This document covers only the intra-frequency cell reselection procedure where cell reselection is performed within the same frequency. Most LTE operators might have more than one LTE carrier frequency in their commercial networks, and they usually operate their LTE network along with their 2G/3G networks. So, not only intra-frequency cell reselection that we discussed here, but also inter-frequency and inter-RAT cell reselections are considered in actual cell reselection. In the next document, we will discuss the procedure for cell reselection with TAU required when UE moves to TA where the UE is not registered.

## References

[1] Netmanias Technical Document, "LTE EMM Procedure 6. Handover without TAU – Part 1. Overview of Handover", March 2014, http://www.netmanias.com/en/?m=view&id=techdocs&no=6224

[2] Netmanias Technical Document, "LTE EMM Procedure 6. Handover without TAU – Part 2. X2 Handover", March 2014, http://www.netmanias.com/en/?m=view&id=techdocs&no=6257

[3] Netmanias Technical Document, "LTE EMM Procedure 6. Handover without TAU – Part 3. S1 Handover", March 2014, http://www.netmanias.com/en/?m=view&id=techdocs&no=6286

[4] Netmanias Technical Document, "Eleven EMM Cases in an EMM Scenario", October 2013, http://www.netmanias.com/en/?m=view&id=techdocs&no=6002

[5] 3GPP TS 36.304, "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) Procedures in Idle Mode"

[6] Netmanias Technical Document, "LTE EMM Procedure 8 & 9. Handover and Cell Reselection with TAU", 2014, TBD

[7] Netmanias Technical Document, "LTE EMM and ECM States", September 2013, http://www.netmanias.com/en/?m=view&id=techdocs&no=5909

[8] 3GPP TS 36.331, "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol Specification"

[9] 3GPP TS 36.101, "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) Radio Transmission and Reception"

[10] Netmanias Technical Document, "LTE EMM Procedure 3. S1 Release", January 2014, http://www.netmanias.com/en/?m=view&id=techdocs&no=6110

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

## Netmanias Research and Consulting Scope

| | | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Services** | eMBMS/Mobile IPTV | | | | | | | | | | | | | | ■ | ■ |
| | CDN/Mobile CDN | | | | | | | | | | | | | | ■ | ■ |
| | Transparent Caching | | | | | | | | | | | | | ■ | ■ | ■ |
| | BSS/OSS | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | Cable TPS | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | Voice/Video Quality | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | IMS | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | Policy Control/PCRF | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | IPTV/TPS | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| **Mobile Network** | LTE | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ |
| | Mobile WiMAX | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | Carrier WiFi | | | | | | | | | | | | | ■ | ■ | ■ |
| | LTE Backaul | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ |
| **Wireline Network** | Data Center Migration | | | | | | | | | | | | ■ | ■ | ■ | ■ |
| | Carrier Ethernet | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | FTTH | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | Data Center | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | Metro Ethernet | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | MPLS | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | IP Routing | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |

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