Mobility in LTE

- Radio Network Design for Roll-Outs (RNDR) RL60/45

❑ Connected Mode Mobility

❑ Idle Mode Mobility

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RNDR Training
Scope: Radio Planning Process

Link Budget
- **Coverage thresholds calculation**
- Dimensioning is out of the scope of this training

Planning Tool
- **Detailed coverage/throughput simulations (plots)**
- Site database
- PCI, neighbour plann… definition (optional)

Acceptance Testing
- Cluster acceptance
- …m coverage / …t targets

LTE Mobility Topics

Planning Parameters
- Site specific **radio planning parameters**
- Areas: PCI, PRACH, UL DM RS

Plan Creation
- **Based on radio/HW inputs (parameters)**
- (Transport parameters out of scope)
- Tools/methods used in network plan creation

Mobility Management
- Mobility types
- **Mobility thresholds (parameters)**
- Layering Strategies

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Connected Mode Mobility

- **Overview**
  - Mobility supported in different releases
  - Mobility triggers
  - Mobility Thresholds
- **Connected Mode Mobility types**
  - Intra and Inter-frequency Handovers
  - S1 Handover
  - IRAT Handover to WCDMA
  - eNACC to GSM
  - RRC Connection Release with Redirect
  - CS Fallback
- **RL40, RL50/35 RL60/45 Improvements/additions**

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Connected Mode Mobility Overview

- Procedures supported:
  - **Handover:** Transfer of an ongoing call/data session from a cell to another without call interruption. Handovers in LTE are:
    - Network controlled
    - UE assisted
    - Hard handovers: Only a connection exist to one cell at a time
  - **Redirection:** Similar to handover, but requires connection release prior to the transfer the ongoing call
  - **Cell change:** procedure dedicated for call transfer from LTE to GSM; it requires connection release

Licensing:

- All IRAT HO, inter-frequency HO, CSFB to UTRAN/GERAN via redirect and S1 handovers are optional features:
  - When enabled they are activated for the whole eNodeB
  - If deactivated the eNB does not configure UE to measure other technologies/ frequencies so handover is not triggered

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Mobility supported in different Releases

FDD RL10	RL20	RL30	RL40	RL50	RL60
Intra eNB Handover	Inter Frequency HO (intra eNB and via X2)	IRAT Handover: LTE to WCDMA	SRVCC towards WCDMA and GSM	TDD-FDD handover	RAN Information Management (RIM) GSM
Inter eNB HO via X2 interface	S1 based HO	eNACC from LTE to GSM	CS Fallback Enhancements	Inter-eNB Inter-Freq Load Balancing	Inter RAT Handover from WCDMA
RRC connection Release with Redirect	CSFB to UTRAN or GSM via Redirect		High Speed Users	RSRQ based redirection	eCS Fallback to CDMA/1xRTT
			Load Ballancing	RSRQ based Cell Reselection	Inter RAT Handover to eHRPD

TDD RL15TD	RL25TD	RL35TD	RL45TD
Intra eNodeB Handover	IRAT Handover: LTE to WCDMA	RSRQ based Cell Reselection	SRVCC to WCDMA /GSM
Inter eNodeB Handover via X2	eNACC from LTE to GSM	RSRQ based redirection	RAN Information Management (RIM) Support
Inter frequency handover (intra eNodeB and via X2)	CSFB to UTRAN or GSM via Redirect	TDD-FDD handover	Inter RAT Handover from UTRAN
RRC connection Release with Redirect			Inter RAT Handover to eHRPD
Inter eNodeB Handover via S1			

Mobility Triggers (1/3)

Mobility is handled via events triggering. 3GPP defines following events:

Event A4 is supported since RL50 (IF load balancing)

Event A1	Serving becomes better than threshold
Event A2	Serving becomes worse than threshold
Event A3	Neighbour becomes offset better than serving
Event A4	Neighbour becomes better than threshold
Event A5	Serving becomes worse than threshold1 and neighbour becomes better than threshold2
Event B1	Inter RAT neighbour becomes better than threshold
Event B2	Serving becomes worse than threshold1 and inter RAT neighbour becomes better than threshold2

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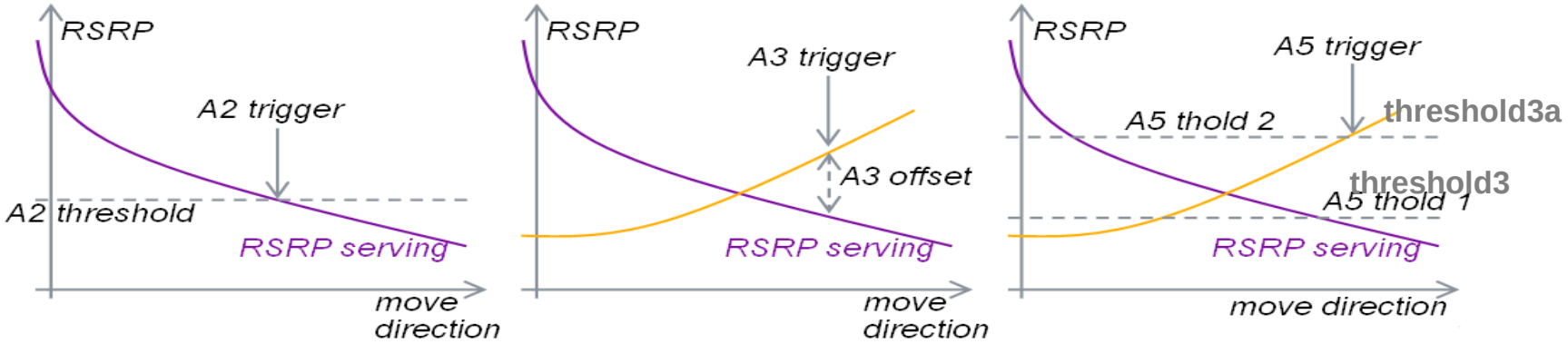
Mobility Triggers (2/3)

- **Event A2/A1**: RSRP of serving cell is down/up-crossing certain RSRP threshold (threshold2a/ threshold1)
- **Event A3 (better cell HO)**: RSRP of neighbour cell is a predefined offset better than RSRP of serving (for intra and inter frequency HOs)
- **Event A5 (coverage HO)**: RSRP of serving cell is down-crossing certain threshold, while RSRP of neighbour cell is up-crossing an other threshold (for intra and inter frequency HOs)



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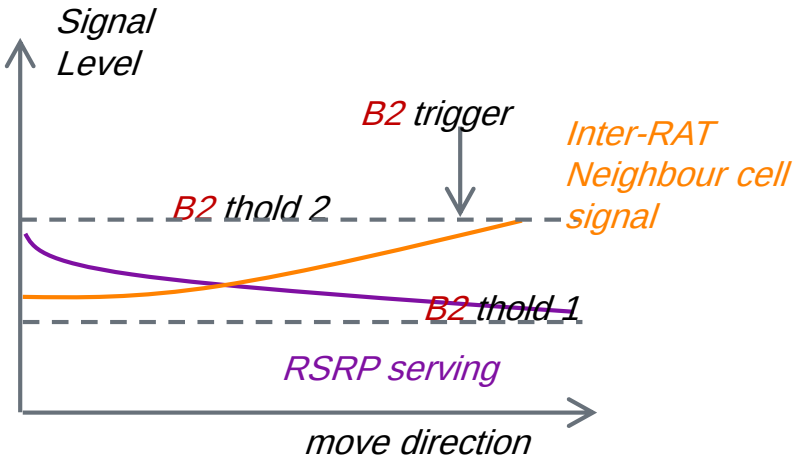
Mobility Triggers (3/3)

Inter-RAT measurements (GERAN or UMTS supported from RL30)

- **Event B2:** Serving cells RSRP down-crossing threshold1, while neighbour cell RSSI or CPICH RSCP or CPICH Ec/No up-crossing threshold2
- Triggers for Inter-RAT reports are:
  - **RSSI** in case of GERAN
  - **CPICH RSCP** or **CPICH Ec/N0** in case of UMTS



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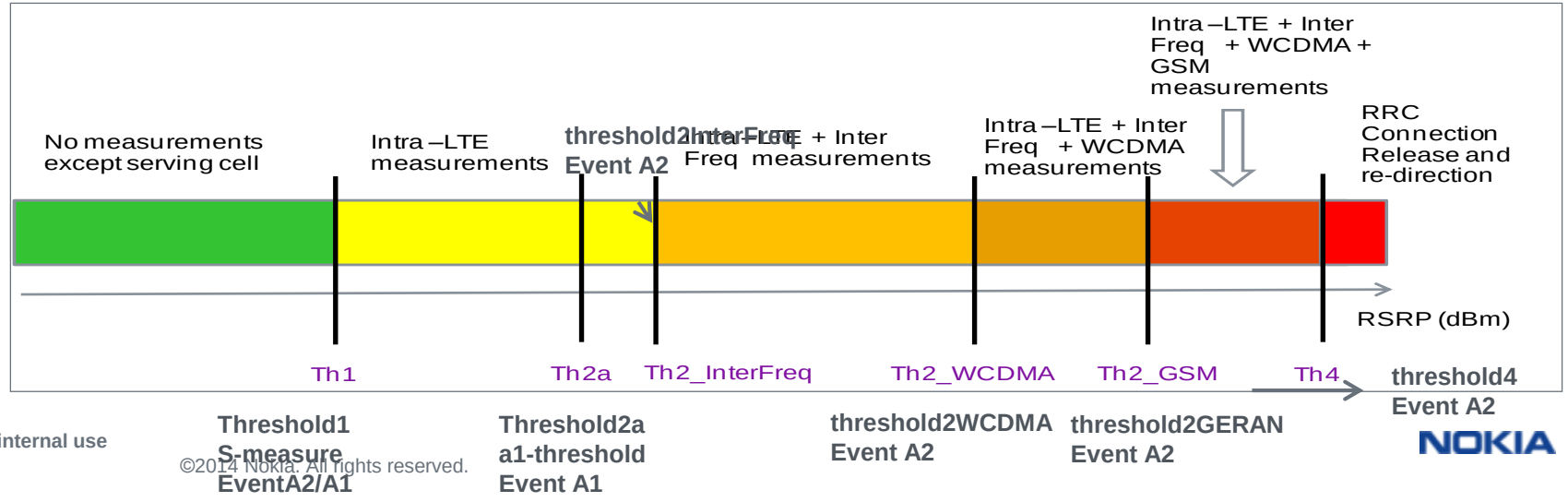
Handover Thresholds
Measurement Activations

- **Threshold 1 (Th1):** UE does not perform measurements of neighbour cells when the serving cell RSRP is above Threshold1 (Th1)
- **Thresholds 2 (Th2_interfreq/Th2_WCDMA/Th2_GSM):**UE starts performing measurement gaps when one of the Th2 events is reported to the eNodeB in a measurement report. **Event A2**
- **Threshold2a (Th2a):** Measurement gaps are cancelled if serving cell RSRP rises above Th2a. **Event A1**
- **Threshold 4 (Th4):**RRC Connection Release with redirection is triggered if no suitable intra or inter frequency/IRAT cells are found. **Event A2**



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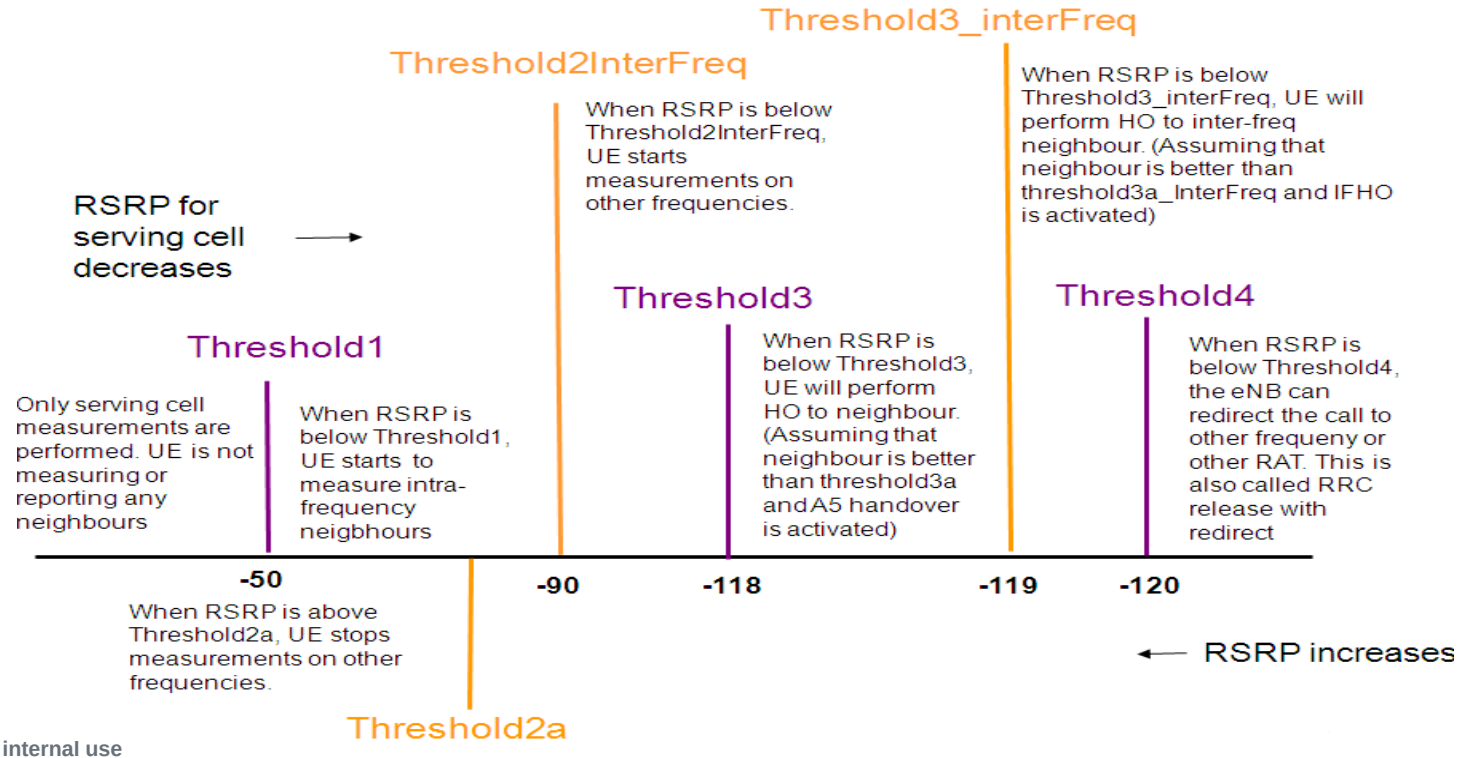
Intra- and Inter-frequency Handover Thresholds
Serving cell (not including neighbour cell thresholds)

- Example values:



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Mobility thresholds comments
RRC_connected mode

- LTE thresholds are relative to -140 dBm. This means if for example threshold3 is set to 21, the RSRP value is (-140+21=) -119dBm

- The following restrictions need to be fulfilled:
  - Threshold4 < Threshold3 < Threshold2_xxxx <= Threshold2a < Threshold1
  - Threshold3 < Threshold3a
  - Threshold3InterFreq < Threshold3aInterFreq

- The higher the threshold the better the RSRP signal

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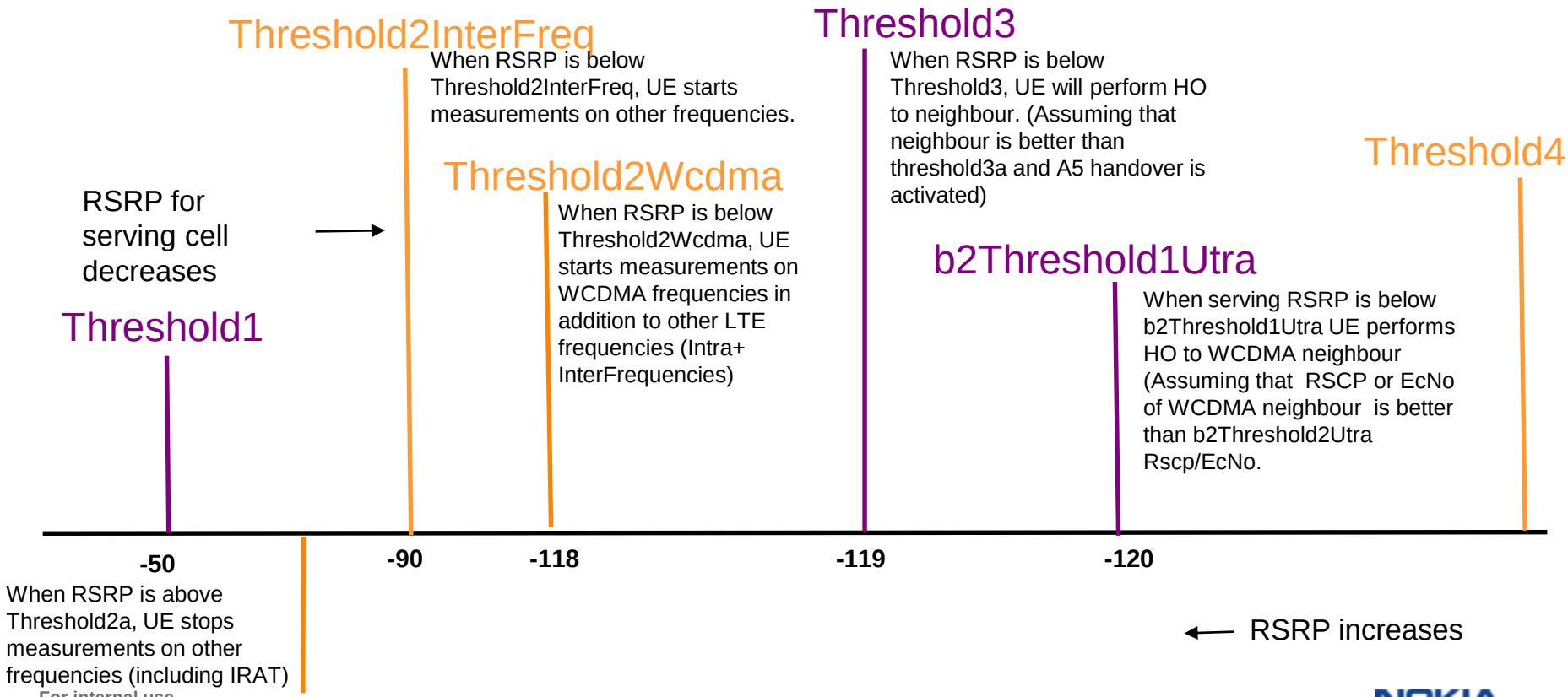
IRAT (WCDMA) handover thresholds

Serving cell



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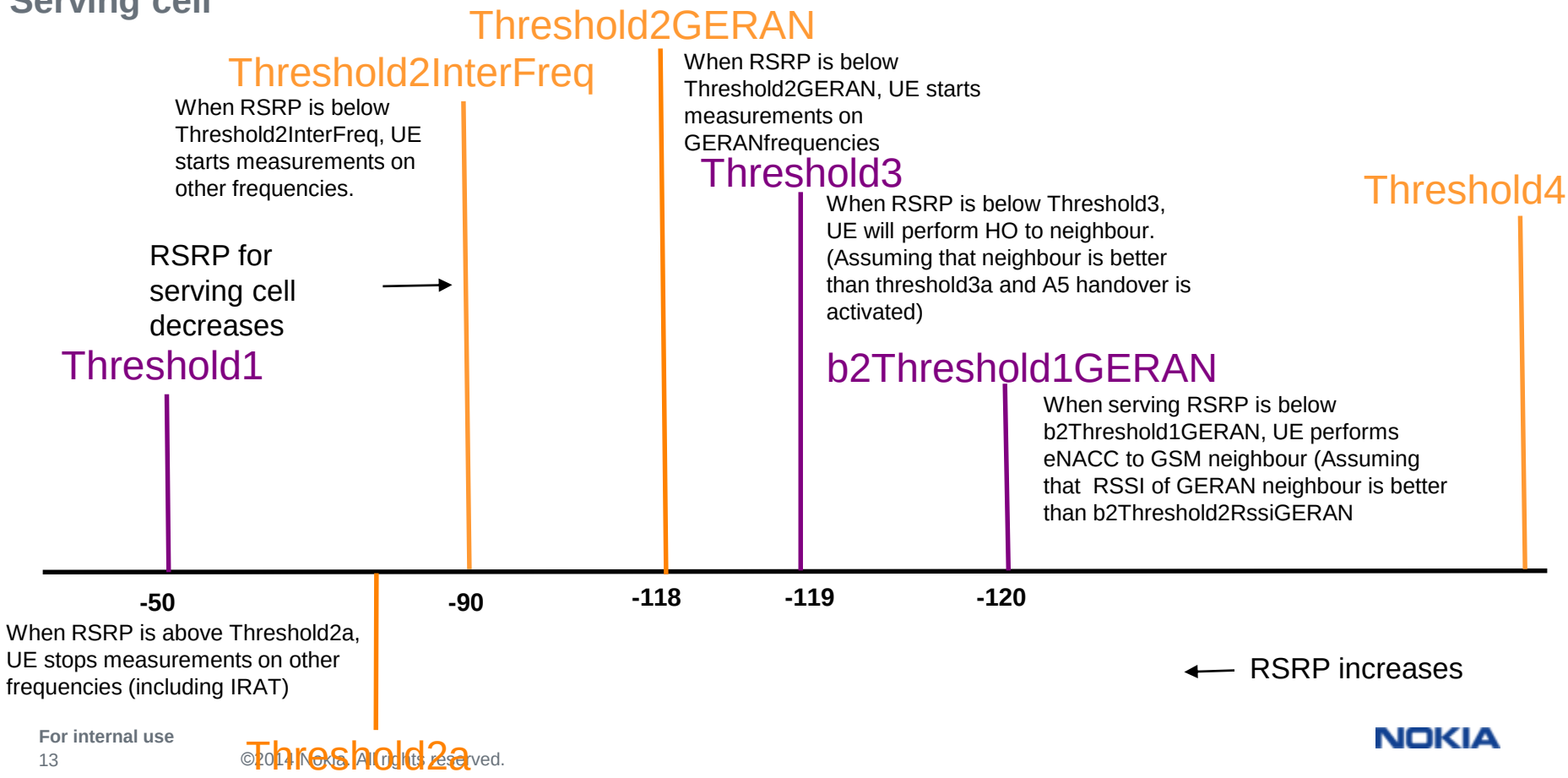
IRAT (eNACC) handover thresholds

Serving cell



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Intra and inter frequency handovers

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Handovers

Two main types of handovers in LTE:

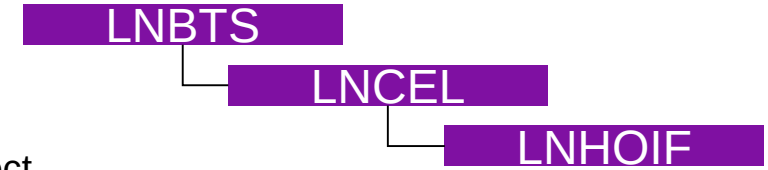
Better Cell Handover or **A3** Handover

- It aims to keep the UE always on best cell (measured by RSRP/RSRQ), e.g. HO to another cell happens when neighbour cell becomes more than 4 dB better than serving cell

Coverage Handover, or **A5** Handover

- When serving cell RSRP gets below a certain threshold (e.g.-95 dBm RSRP) AND neighbour cell RSRP gets better than an absolute threshold (e.g. -92 dBm RSRP)

- They can be intra and inter frequency (different parameters) and intra or inter eNodeB



- They can be enabled/disabled on cell level:

  Inter-frequency HO parameters are defined in LNIFHO object whereas Intra-frequency HO parameters are defined in LNCEL object

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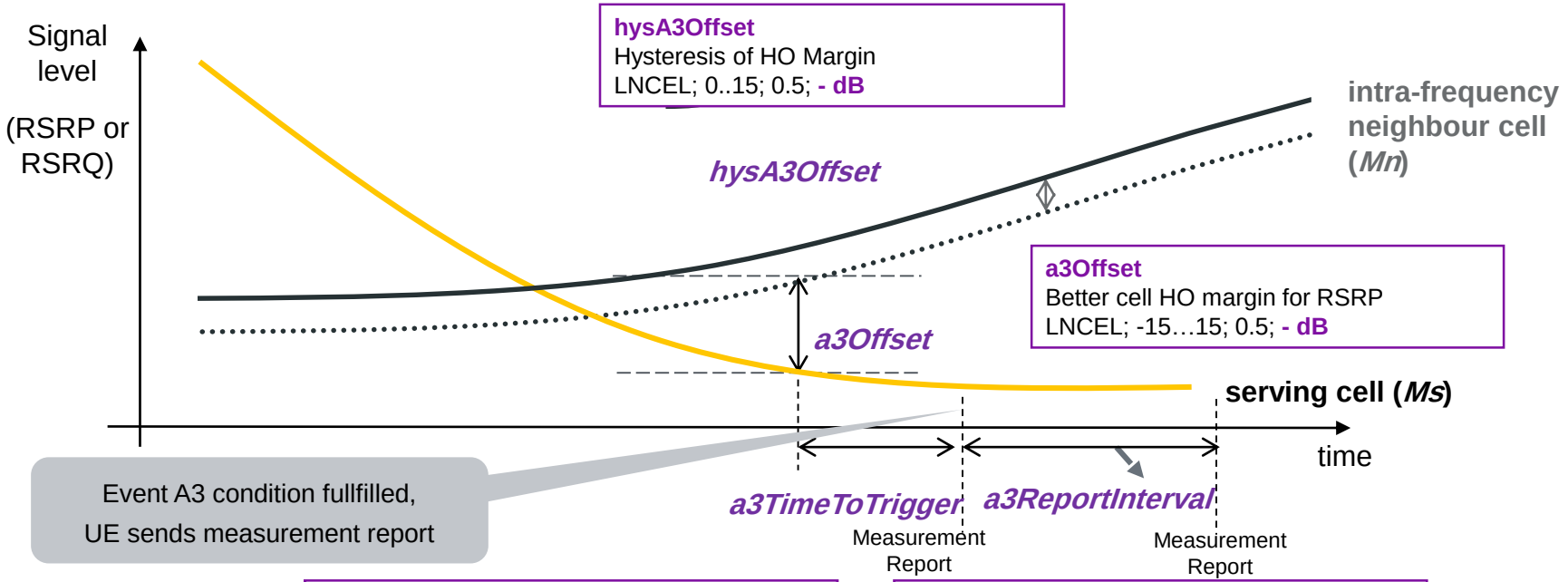
A3 event based Handover Intra-Frequency

- Intra-frequency better coverage based (A3) handover event evaluation
  Mn – **hysA3Offset** > Ms + **a3Offset**

Parameters involved:

Better cell HO parameters



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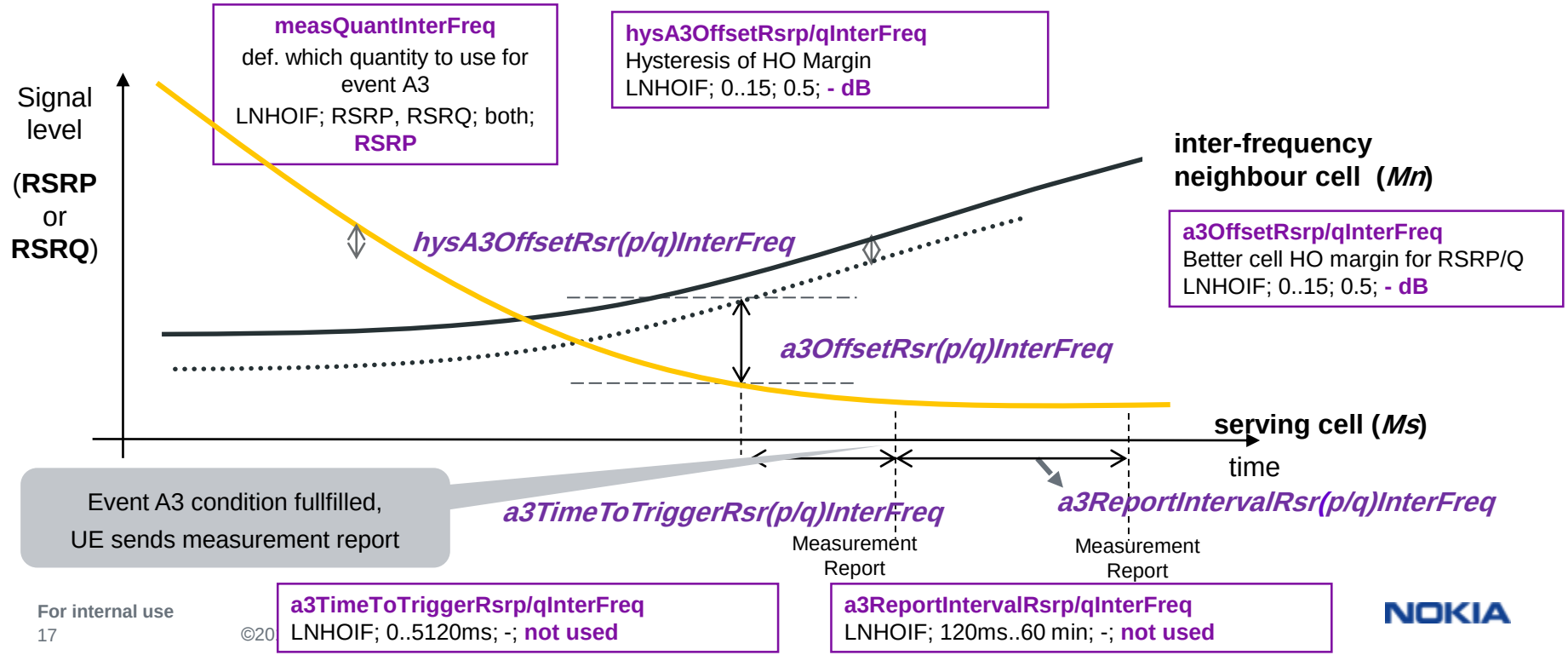
A3 event based Handover Inter-Frequency

- Inter-frequency better coverage/quality based (A3) handover event evaluation
  Mn – hysA3OffsetRsr(p/q)InterFreq > Ms + a3OffsetRsr(p/q)InterFreq



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A5 event based Handover - Intra-Frequency

- Intra-frequency coverage based (A5) handover event evaluation

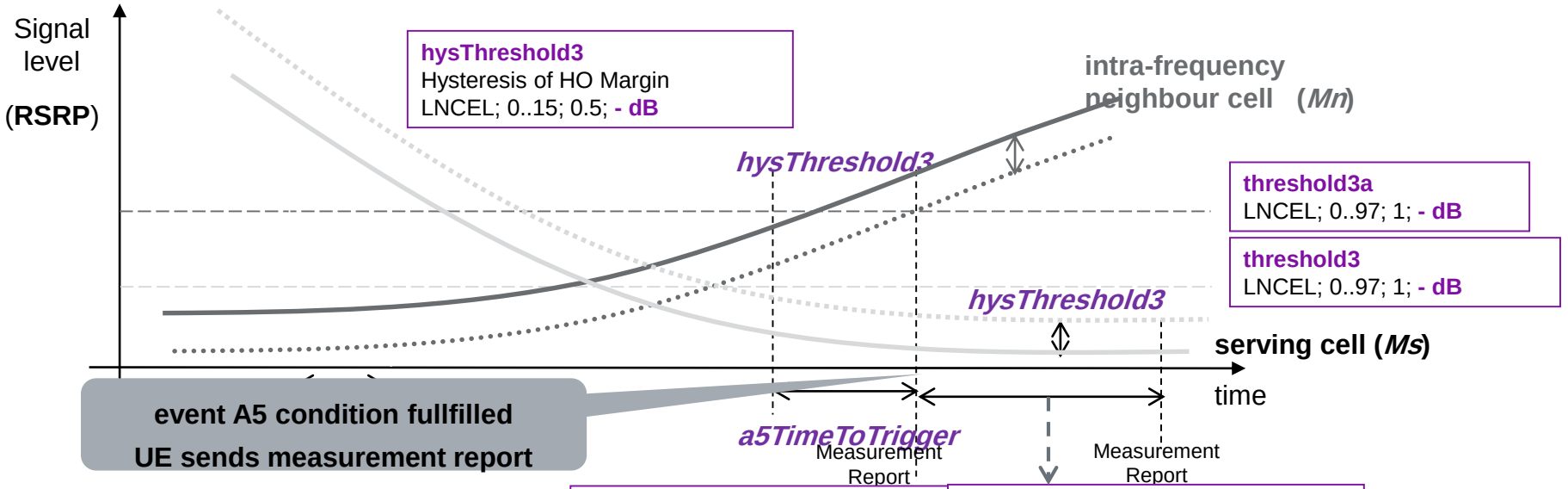
  Ms + **hysThreshold3** < **threshold3**

  and

  Mn – **hysThreshold3** > **threshold3a**

Parameters involved:

Coverage HO parameters



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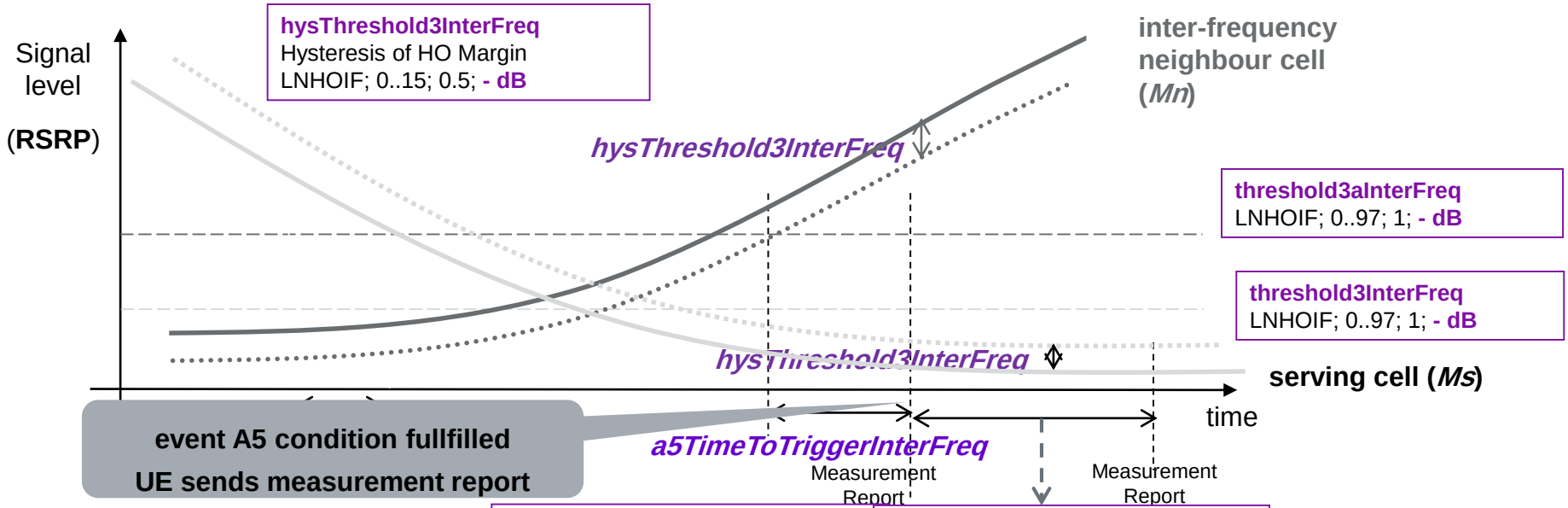
A5 event based Handover Inter-Frequency

- Inter-frequency coverage based (A5) handover event evaluation
  Ms + **hysThreshold3InterFreq** < **threshold3InterFreq**
  and
  Mn – **hysThreshold3InterFreq** > ***threshold3aInterFreq***



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S1 handover

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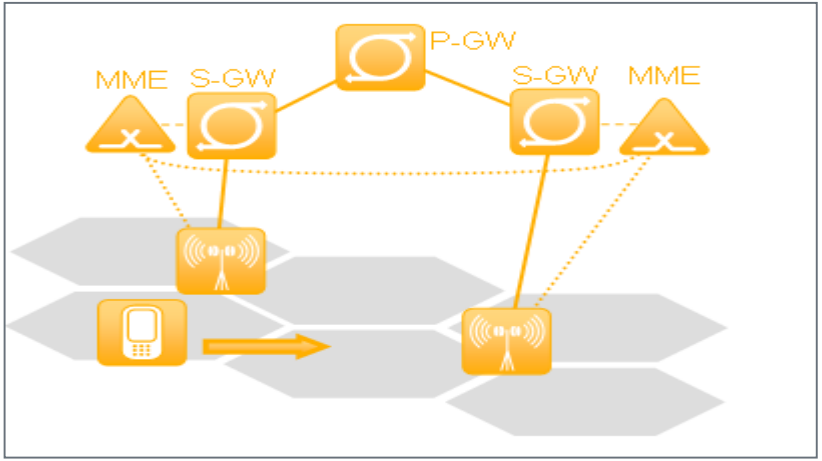
RL15TD RL20

Intra LTE Handover via S1

Extended mobility option to X2 handover

- Applicable for **intra** and **inter** frequency HO and only for inter-eNB HO
- DL Data forwarding via S1
- Handover in case of
  - no X2 interface between eNodeBs, e.g. not operative, not existing or because blacklisted usage
  - eNodeBs connected to different CN elements



- For the UE there is no difference whether the HO is executed via X2 or S1 interface
- HO reasons ‘better cell HO’ (A3) and ‘coverage HO’ (A5) are supported
- MME and/or SGW can be changed during HO (i.e. if source and target eNodeB belong to different MME/S-GW)

Feature ID(s): LTE54

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IRAT HO to WCDMA

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Inter RAT Handover to WCDMA

RL25TD RL30

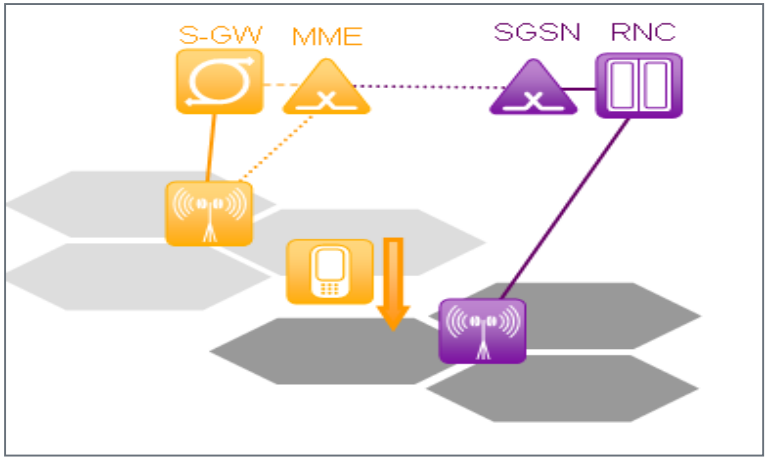
- IRAT hard handover from LTE to WCDMA PS domain through S1 interface
- Phases:

1. **Handover initiation**:
   - eNB starts a HO to WCDMA following a received measurement report with event B2
   - Max. 8 cells reported (strongest first) that create the TCL (target cell list)

2. **Handover preparation:**
   - Resource allocation on target side (E-RAB parameters mapped into PDP context)

3. **Handover execution:**
   - UE moves into WCDMA cell after receiving 'MobilityfromEUTRACommand' message

4. **Handover completion:**
   - Release of S1 connection and internal resources after successful HO (no timers expired)



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Inter-RAT Handover to WCDMA
Event B2

- Handover from LTE to WCDMA is triggered by poor LTE radio coverage and sufficient WCDMA cell radio signal quality
- Radio conditions for serving and neigbour cells are defined with **event B2**

Entering conditions

1. Ms + Hys < Thresh1
and
2. Mn + Ofn – Hys > Thresh2

Leaving conditions

1. Ms - Hys > Thresh1
or
2. Mn + Ofn + Hys < Thresh2

reportConfigInterRAT

Ms -> RSRP of serving cell
Mn -> RSCP/EcN0 of neigbour cell
Thresh1 -> **b2threshold1Utra** -> refers to signal level of serving cell
Thresh2 -> **b2threshold2UtraRSCP/EcN0** -> refers to signal level of neighbour cell
Hys -> **hysB2ThresholdUtra** -> hysteresis to prevent ping-pong effect between entering and leaving conditions; parameter **common** for both serving and neigbour cell

Ofn -> **OffsetFreqUtra** -> refers to neighbour cell only

measObjectUTRA

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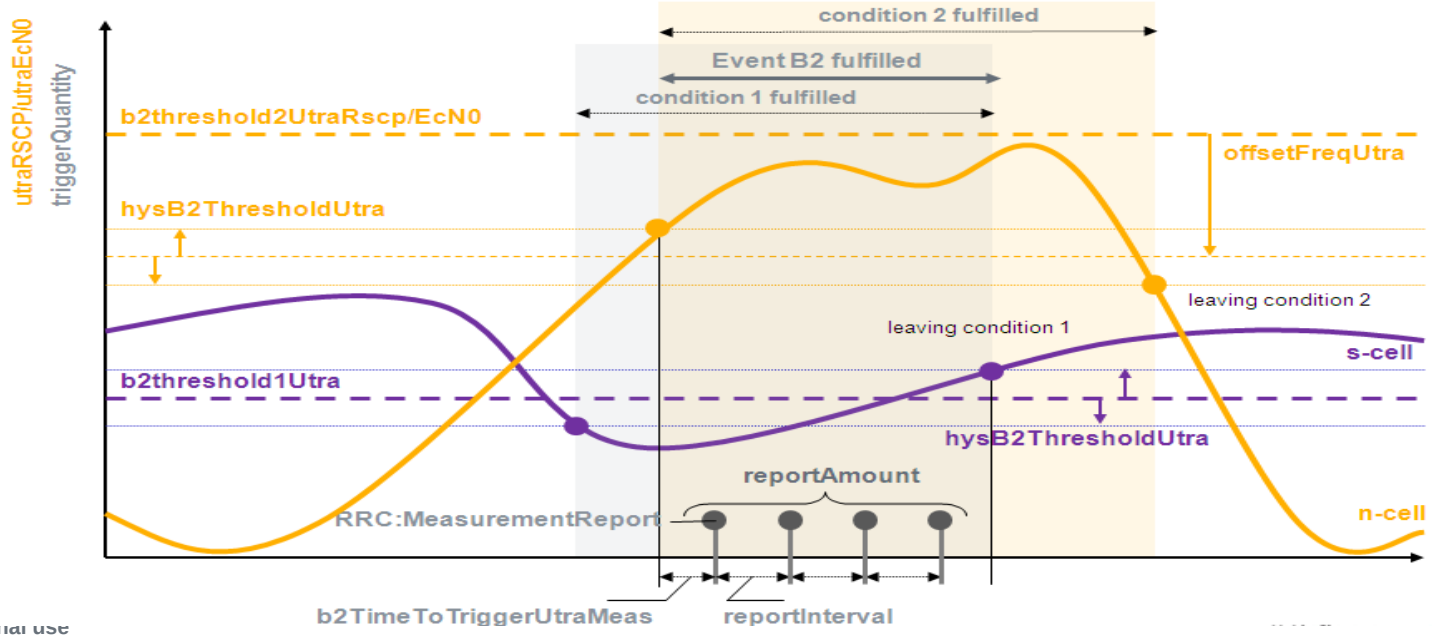
Inter-RAT Handover to WCDMA
Event B2

IRAT_eNACC_Parameters

- Entering condition:
- **RSRP,s < b2threshold1Utra – hysB2thresholdUtra AND**
- **utraRSCP/EcNo,n > b2theshold2UtraRscp/EcNo- offsetFreqUtra + hysB2ThresholdUtra**



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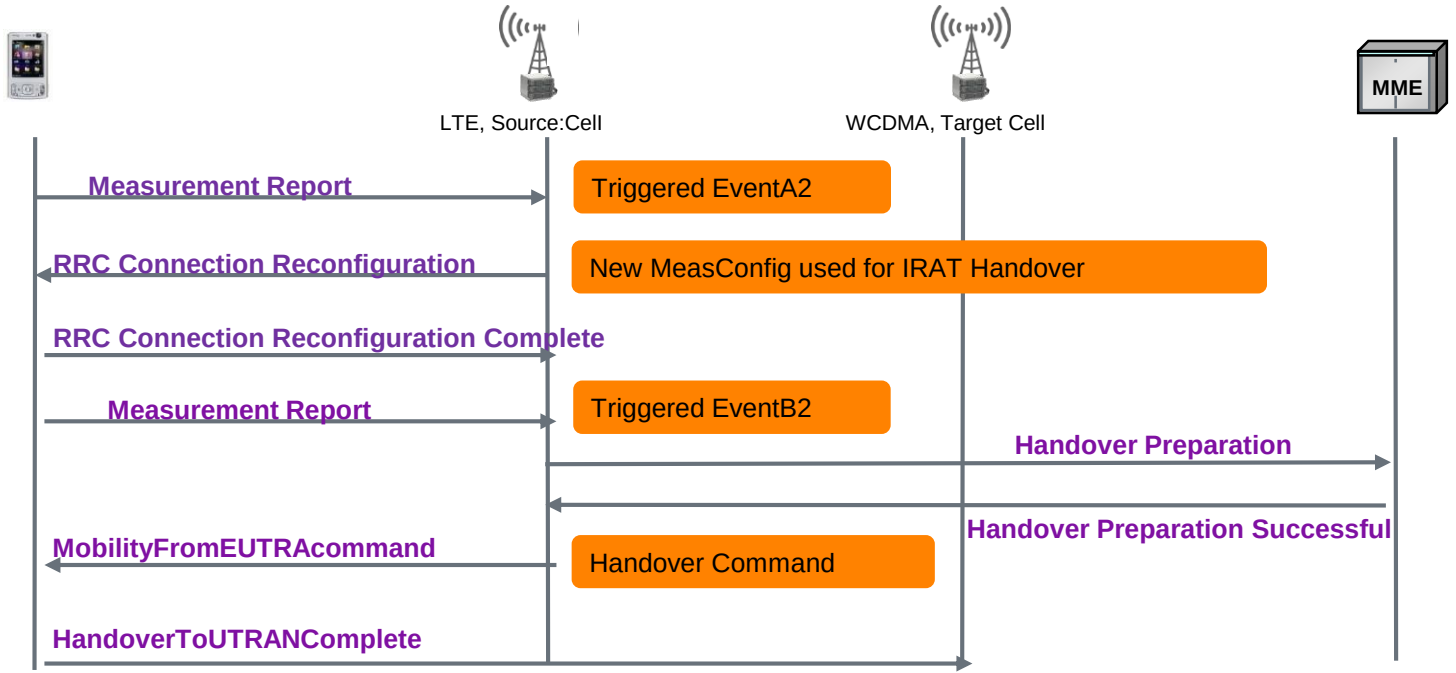
Inter-RAT Handover to WCDMA Flow



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eNACC to GSM

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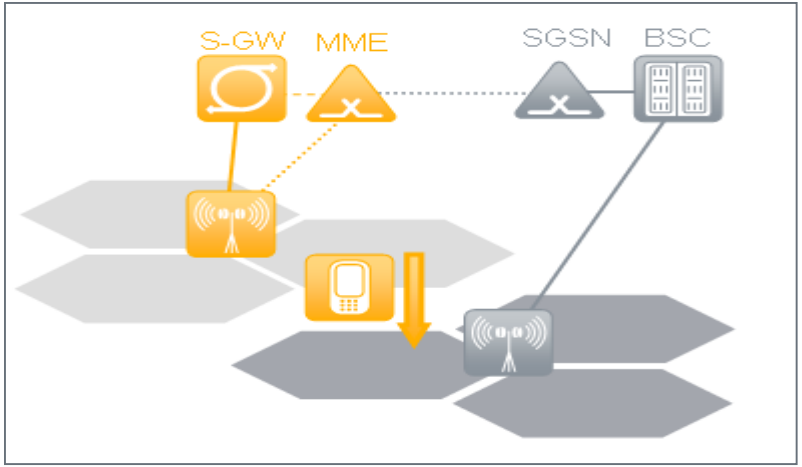
eNACC to GSM
Network Assisted Cell Change to GSM

- Similar feature to HO to WCDMA:
  - IRAT Measurements triggered via event A2/A1 (activated/deactivated)
  - Triggered by event B2 (although using different parameter values)

- Difference: it is **not a handover procedure**
  - UE goes first into GSM RRC Idle mode and starts the RRC Connection Setup procedure in GSM

- Network Assisted: GSM system information of 2G target cell is sent to UE (giving a gain of ~1s in the process but with significant service interruption)

- Maximum number of GSM cells to be reported is hardcoded to 8



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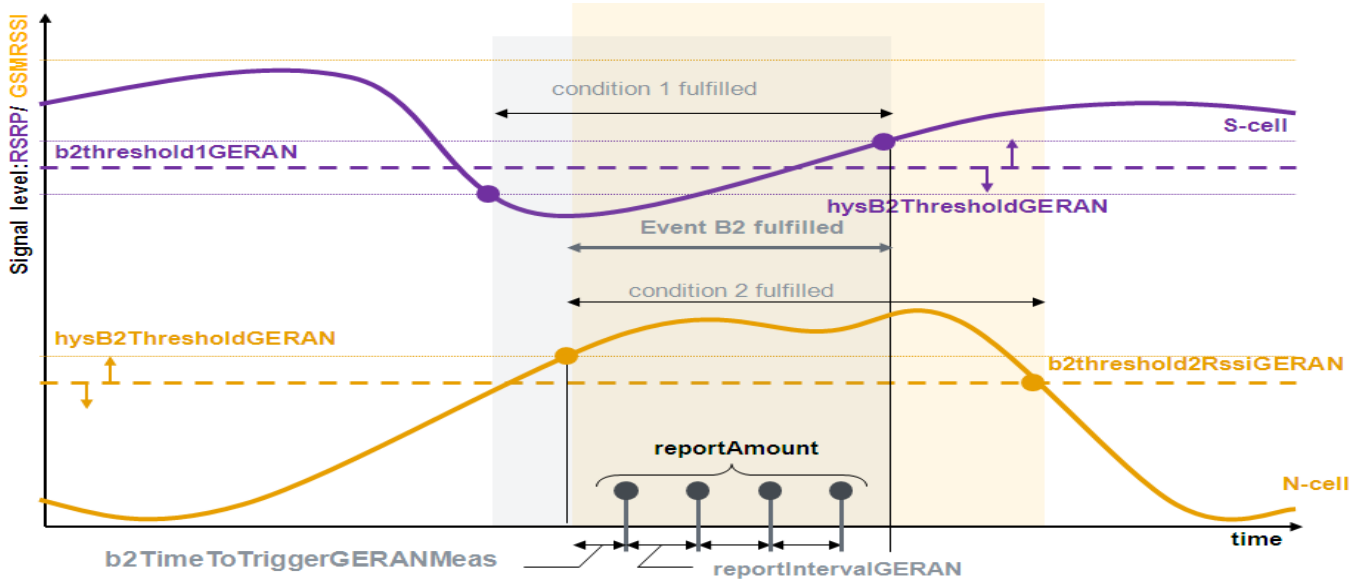
eNACC to GSM
Event B2

Entering conditions

1. Ms + Hys < Thresh1
and
2. Mn– Hys > Thresh2

Entering Condition:

- **RSRP,s < b2threshold1GERAN – hysB2ThresholdGERAN AND**
- **RxLev,n > b2theshold2RssiGERAN+ hysB2ThresholdGERAN**



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RRC Connection Release with Redirect

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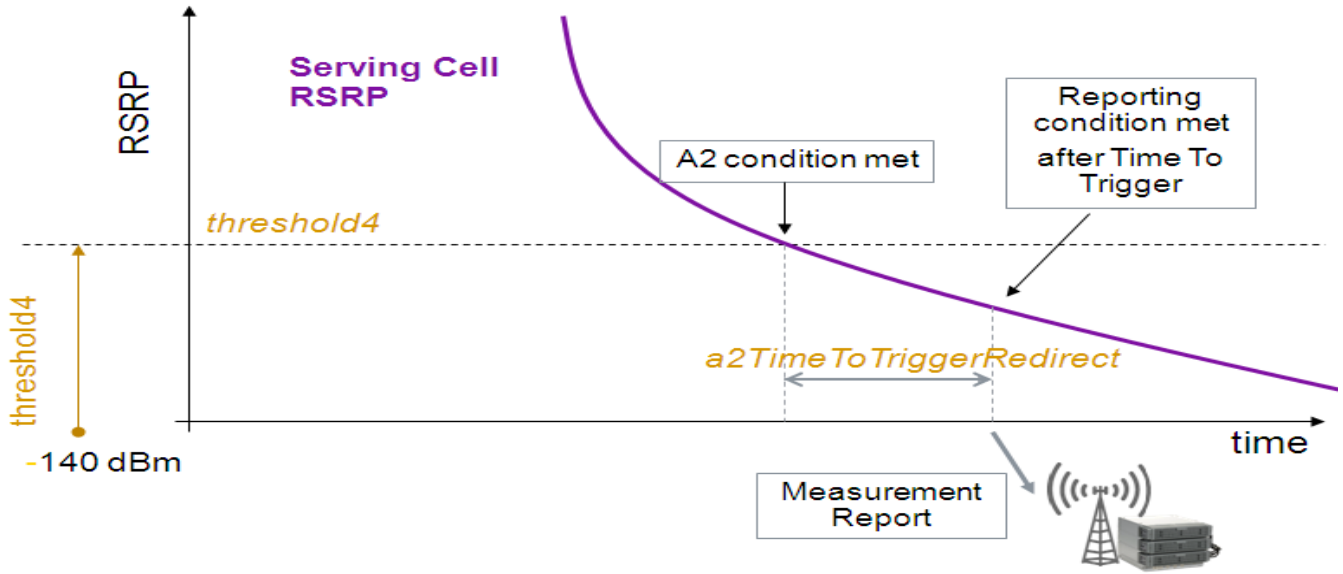
RRC Connection Release with Redirect
Event A2

- When serving RSRP falls below ***threshold4*** for a time ***a2TimeToTriggerRedirect*** the RRC connection is released and UE redirects to the E-UTRA or inter-RAT carrier frequency with **highest priority** (if several redirection objects defined) regardless of the signal strength of the target carrier
- **UE capabilities are considered** when performing redirect



RRC Connection Release with Redirect

- It is possible to define different redirection (REDR) objects and different priorities between those objects
- eNB selects the target frequency for redirect based on the priorities configured for frequency layers
- If the highest priority layer is not supported by UE according to capabilities reported earlier, then the next highest priority layer is selected.
- Redirection is ‘blind’: UE does not measure on the target frequency for redirection before the connection is released - there is improvement in RL40 via measurement of the target cells.
  - If there is no coverage in the target frequency the connection drops

- Note: **Priority 1 is highest!** (unlike for the cell reselection priority parameters where 7 is highest)

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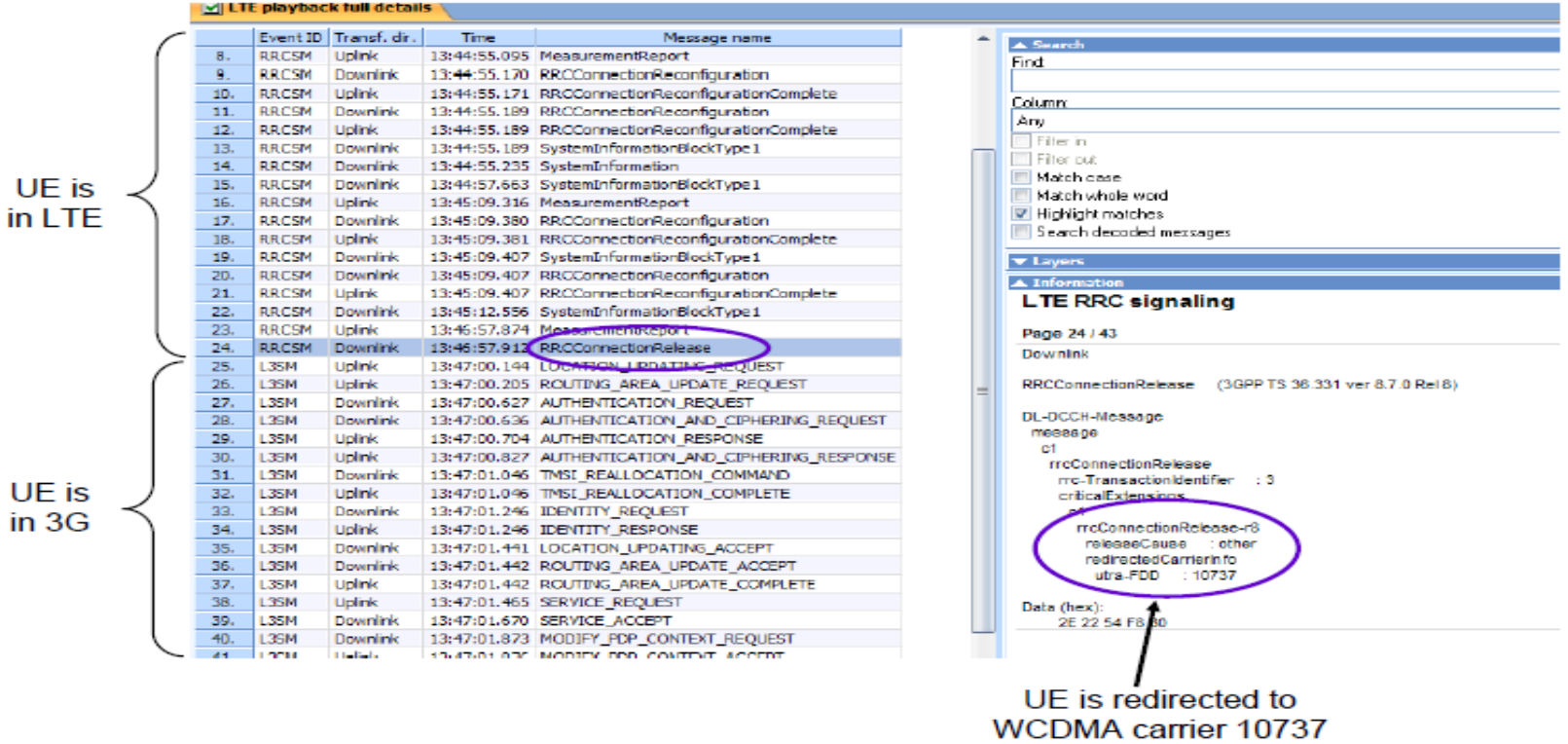
RRC Connection Release with Redirect Signalling



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RRC Connection Release with Redirect Performance (LTE -> 3G)

- Test results (FTP DL session and streaming session) show that user impact of Redirect is minimal and end user will not notice the RRC release with redirect

Effects:

- FTP: couple seconds gap in the transmission is noticed while connection is redirected to 3G
- Streaming (YouTube): redirection is not noticeable. No gaps in sound/picture

CSFB - Circuit Switched Fallback

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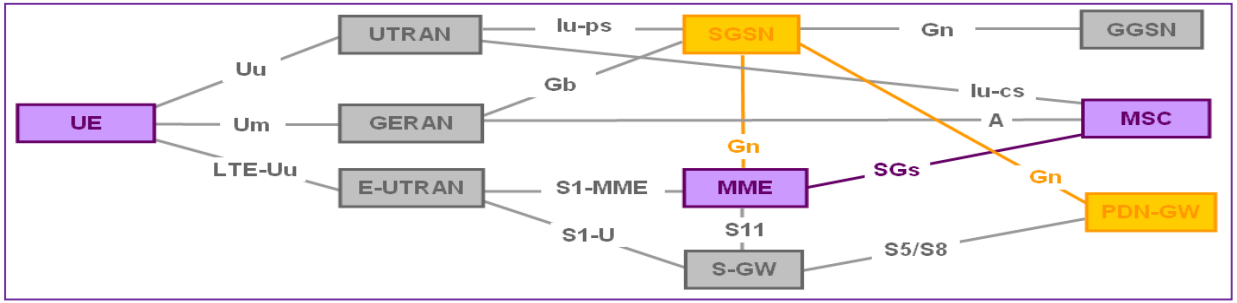
CSFB to UTRAN or GSM via redirect

RL20

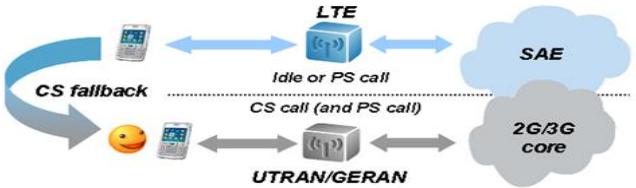
- Required when there is **no Conversational Voice support on LTE side**
- **Redirection** from LTE to UTRAN or to GSM during the call setup. MOC and MTC setup supported
  - EPC must support CS inter-working for mobility management and paging



- **Redirection by RRC connection release** message with a *RedirectedCarrierInfo* IE that enforces the UE to search for any cell first at the highest priority UTRA carrier or within BCCH carrier set for GSM
- After termination of the CS call, UEs supporting CS fallback may stay in current RAT of camp back into the LTE carrier

CSFB: Circuit Switched Fallback
IE: Information Element

MOC: Mobile Originated Calls
MTC: Mobile Terminated Calls



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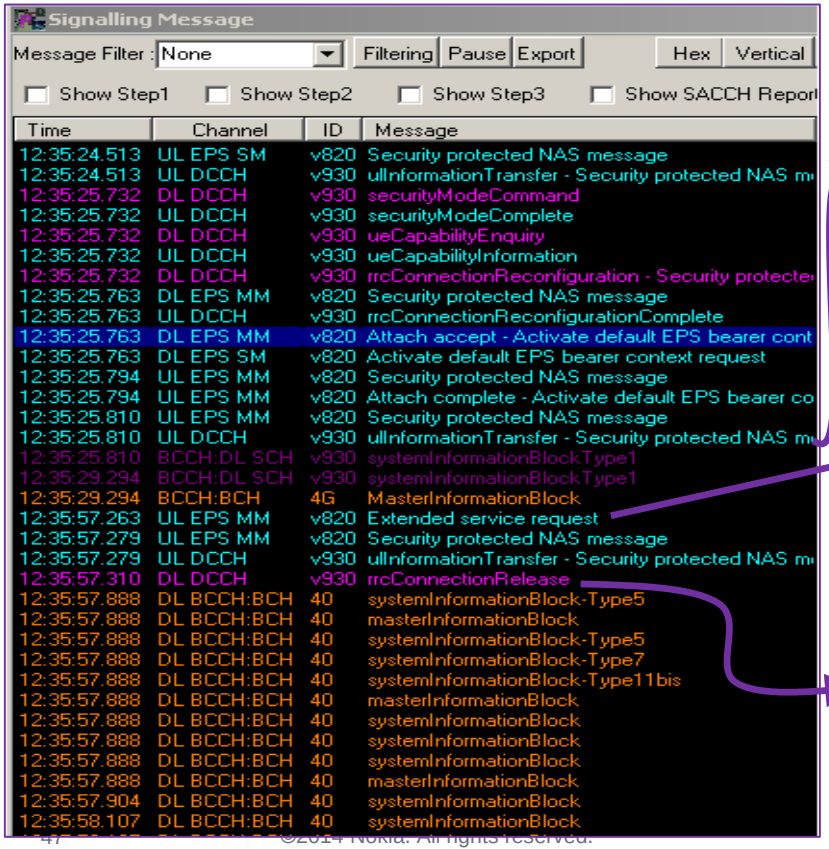
CS Fallback Signalling Example
MOC in ECM_Connected

Further examples (ECM_IDLE, MTC) in: https://sharenet-ims.inside.nokiasiemensnetworks.com/Overview/D437659035




```
ATTACH_ACCEPT:
 SecurityHeaderType: 0
 EPSAttachResult: 2 (combined EPS/IMSI attach)
 T3412Value:
   Unit: 2 (value is incremented in multiples of decihours)
   TimerValue: 9
```

UE needs to be IMSI attached

```
EXTENDED_SERVICE_REQUEST:
 SecurityHeaderType: 0
 ServiceType: 0 (mobile originating CS fallback or 1xCS fallback)
 NASKeySetIdentifier:
   TSC: 0 (native security context)
   NASKeySetId: 0
 MTMSI:    Identity:
   IdentityDigit:
     01: 240
     02: 96
     03: 177
     04: 192
   IdentityType: 4 (TMSI/P-TMSI/M-TMSI)
```

UE starts Initial Access procedure and sends *Extended Service Request* message with *Service Type* set to "mobile originating CS fallback"

```
value DL-DCCH-Message ::=
 message c1 : rrcConnectionRelease :
     rrc-TransactionIdentifier 3,
     criticalExtensions c1 : rrcConnectionRelease-r8 :
         releaseCause other,
         redirectedCarrierInfo utra-FDD : 10713
```

eNB sends "RRCConnectRelease" message with redirect information of WCDMA Frequency to be used for redirection

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RL40 & RL50/35 Improvements/additions

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List of RL40 Features/Improvement

- Voice Call Handling
  - LTE 872 & 873 SRVCC to WCDMA/SRVCC to GSM (RL40 only).
  - LTE 736 CS Fallback to UTRAN (RL40/RL35TD).
- Measurement and System Info Support
  - LTE 1073 Measurement based redirect to UTRAN (RL40 only).
  - LTE 984 GSM Redirect with System Information (RL40/RL35TD).
- Load Ballancing
  - RAN 2717 Smart LTE Layering (Offlload 3G->LTE)
  - LTE1387- Intra-eNB Inter-frequency Load balancing (RL40 only).
- General LTE Support
  - LTE 48 Support of high speed users (RL40 only).

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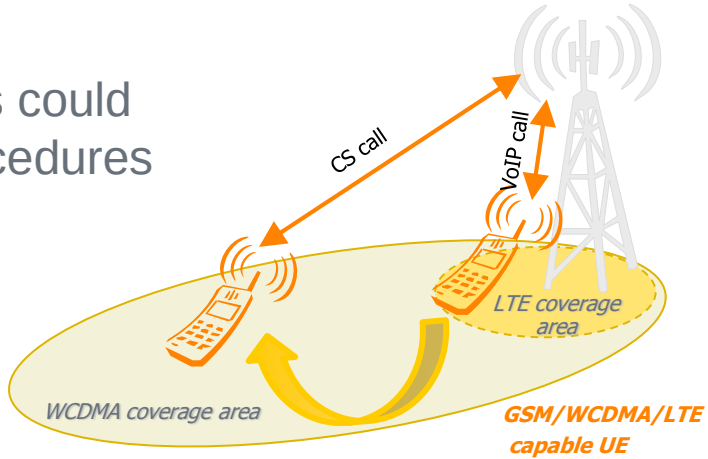
LTE872/873 – SRVCC to WCDMA/SRVCC to GSM

- Features supplement voice over LTE solutions based on IMS
- Thanks to SRVCC functionality **LTE voice calls** could be handed over to 2G or 3G network where these calls are served by the **CS domain** of the target RAT
- Handling of other bearers depends on among others target RAT capability
  - In case of SRVCC to WCDMA these bearers could be handed over via typical PS handover procedures



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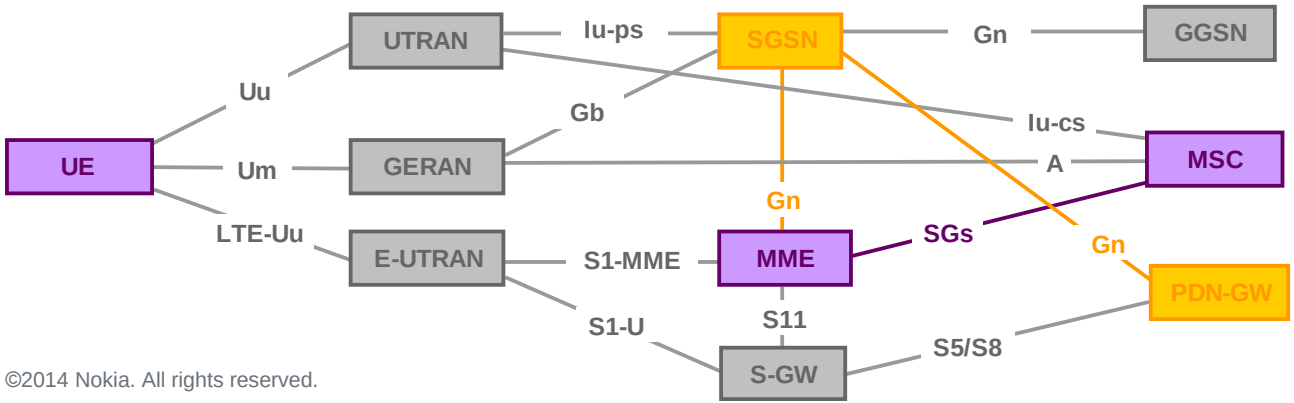
LTE 736 CS Fallback to UTRAN

- **An enhanced way of realizing the CS fallback so that EPS-attached UEs can be provided with CS voice service with even better user experience**
  - This feature introduces service-based handover of multimode and PS-HO-capable UE from E-UTRAN to UTRAN whenever CS voice call is to be established
    - E-UTRAN coverage must be overlapped by UTRAN coverage
  - having terminated CS call, the UE may either stay in current RAT or go back to E-UTRAN using existing mechanisms
- **EPC must support CS inter-working for mobility management and paging**
  - **SGs interface between MME and MSC server is needed**
  - interworking between SGSN and MME and PDN-GW is realized via pre-Rel.8 Gn interface or via S3/S4 interfaces
- **CS domain must support CS Fallback, i.e. MSC must support SGs interface to MME**



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LTE 1073 Measurement based redirect to UTRAN

- **LTE1073 Measurement based redirect to UTRAN** provides the means to send an UE to WCDMA by UE Context Release with Redirect after the UE has performed Measurements on WCDMA

- LTE1073 is an enhancement to LTE56

- Measurement concepts and configuration for handover to WCDMA are reused; measurement report for event B2 is a trigger for redirection procedure to frequency layer of reported by event B2 target WCDMA cell.

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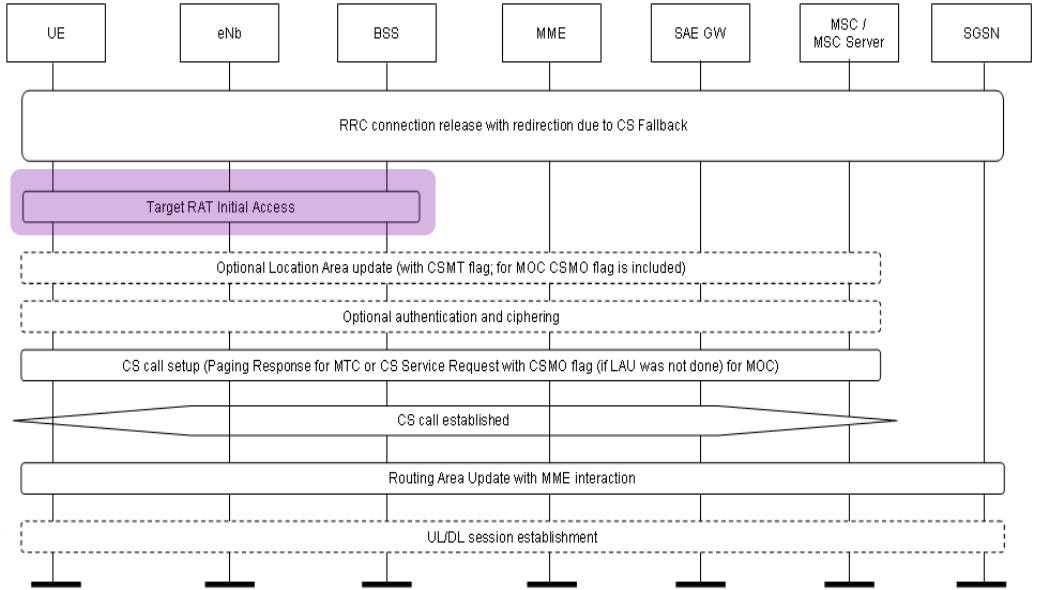
LTE 984 GSM Redirect with System Information

- UE being redirected from LTE to GSM needs to start connection setup from scratch
  - before starting the random access procedure in the new cell, the UE needs to acquire basic System Information
  - acquisition of system information constitutes significant portion of the connect. setup time
    - this applies to both CS voice call setup and PS connection setup
- **GSM Redirect with System Information** introduces the possibility to provide UE with necessary GSM System Information upon redirecting it from LTE
  - **this allows UE to avoid reading of System Information Broadcasts when accessing the target cell and hence to shorten the connection setup times for both CS voice call (for CS Fallback) and PS connection (redirection due to radio conditions)**



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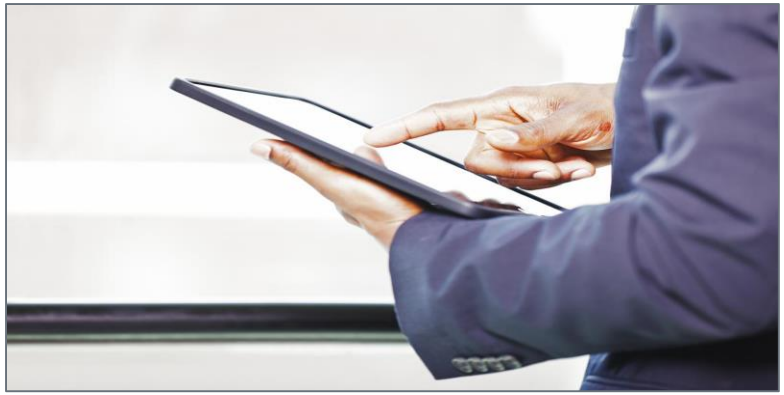
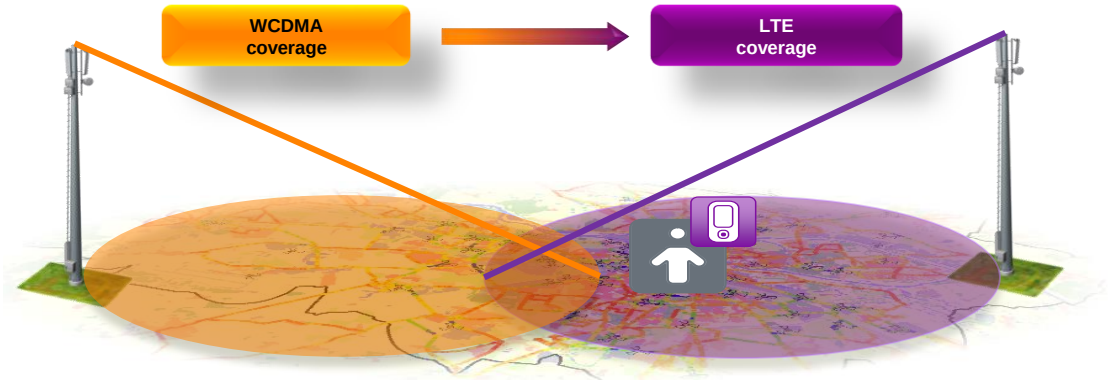
RAN 2717 Smart LTE Layering

- Feature designed to support redirection from WCDMA to LTE
- Possibility to redirect active UEs (in UTRAN Connected Mode) from WCDMA to LTE
- Possibility to offload WCDMA network
  - Smart LTE Layering introduces mechanism for network load balancing
- Better user experience after redirection from WCDMA to LTE in case of high load and lack of cell resources
  - instead of waiting for resources in WCDMA, redirection to LTE improves user experience





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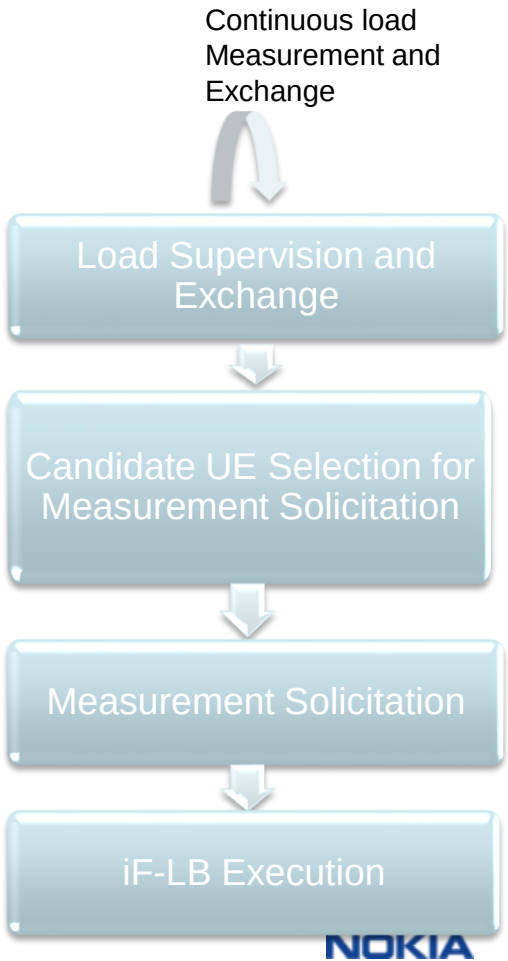
LTE1387- Intra-eNB Inter-frequency Load balancing

- To move **incoming load** from a **highly-loaded cell to low-loaded cells** using **different frequency bands** within the **same eNB**
- Load Supervision and Exchange
  - **DL GBR and DL nGBR** cell load is periodically measured and exchanged between cells of the same eNB
  - Cell Load Balancing Status is evaluated periodically
- Candidate UE Selection for measurement solicitation
  - **UEs which switch from Idle to Connected states** are considered candidates for measurement solicitation
    - Triggered HOs **eventually** reduces load for the highly-loaded cells, since already connected UEs will not be offloaded
  - Special treatment for **QCI1 bearers**
    - Depending on *iFLBBearCheckTimer*, UE which establishes QCI1 bearers may be removed from candidate UEs
- Measurement Solicitation
  - For each candidate UE, **if serving eNB is highly loaded, A4 measurements** of different frequency neighbor cells is activated
  - RSRP and RSRQ measurements from received A4 reports are **post-processed** to select best target cell for UE offloading
- iF-LB Execution
  - Normal handover procedure to offload candidates UEs to selected target cells.



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LTE 48 Support of high speed users

Enables LTE usages in high speed environment

- The Flexi Multiradio BTS is able to handle UE speed of up to 350 km/h in open space and 300 km/h in tunnels.
- Basic LTE call handling and interworking
- For 3GPP defined conditions

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Feature ID(s): LTE48

List of RL50/RL35TD/RL50FZ Mobility Features/Improvement

- LTE1060 TDD-FDD handover.
- LTE1170 Inter-eNB Inter-Frequency Load Balancing.
- LTE1407 RSRQ based redirection (RL50 only).
- LTE1442 Open Access Home eNB Mobility (RL50 only).
- LTE507 Inter RAT Neighbor Relation Optimization.

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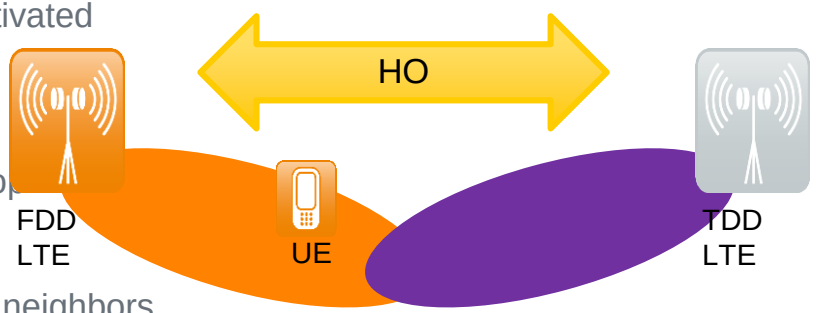
LTE1060 TDD-FDD Handover - Introduction

RL50/RL35TD/RL50FZ

- LTE1060 TDD-FDD Handover introduced in RL50 (RL35TD) provides support for inter-eNB inter-frequency handover from LTE TDD to LTE FDD and vice versa
- TDD-FDD Handover is extension of LTE55 Inter-frequency Handover (introduced in RL20/RL05TD)
  - LTE55 is prerequisite for the TDD-FDD Handover. Both features are activated with the same flag (actIfHo)
  - The mechanisms (evaluation of measurements reports, handover preparation, execution, completion and data forwarding) introduced by LTE 55 are re-used in TDD-FDD Handover .
    - Additionally to the original Inter-frequency Handover feature LTE1060 TDD-FDD Handover cooperates with Inter eNB IF Load Balancing (LTE1170) if it is activated



- Both S1 (LTE54) and X2 (LTE53) handovers are supported
  - events A1 and A2 are used to control the start and stop of inter-frequency measurements of the target cells,
  - events A3 (better cell handover) or A5 (coverage handover) are used to report suitable inter-frequency neighbors
  - In case if Inter eNB Inter-frequency Load Balancing is activated event A4 is used to report suitable inter-frequency neighbors for load balancing.

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LTE1170 - Inter-eNB Inter-Frequency Load Balancing

RL50/RL35TD/RL50FZ

- LTE1170 extends RL40 functionality in providing means to move incoming load from a high-loaded cell to low-loaded cells which use different frequency than the high-loaded serving cell
  - UEs entering Connected state can be offloaded if target cell is measured to be at good radio condition
  - Offloading of UEs can be done towards intra-eNB or inter-eNB neighbor cells
  - Target cell for offloading must have available capacity to serve offloaded UEs
  - Load information is exchanged only between cells of the same eNB
  - Load information from cells belonging to other eNBs are implicitly determined from HO preparation decision in Load blind HO
  - The feature balances load only between inter-frequency cells
  - DL GBR, DL non-GBR and PDCCH load are evaluated to trigger offloading of UEs
- LTE55 Inter-frequency handover must be activated in order for LTE1170 to work

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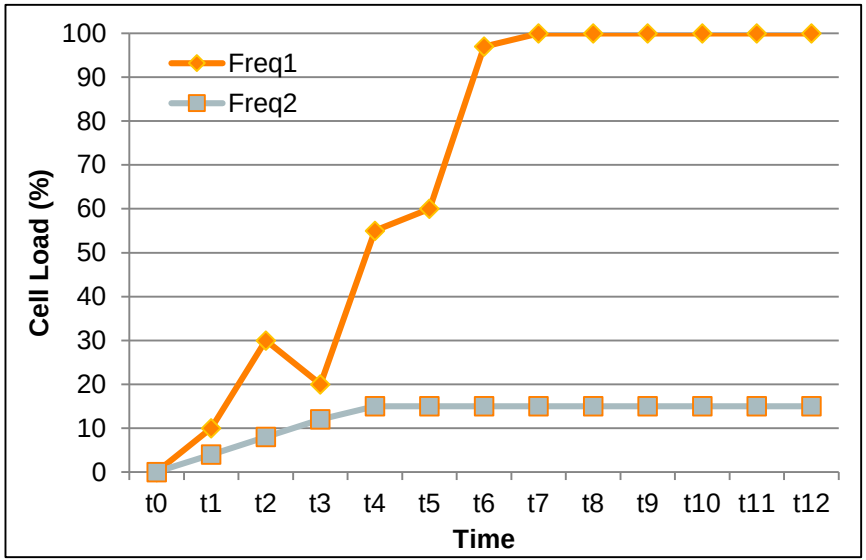
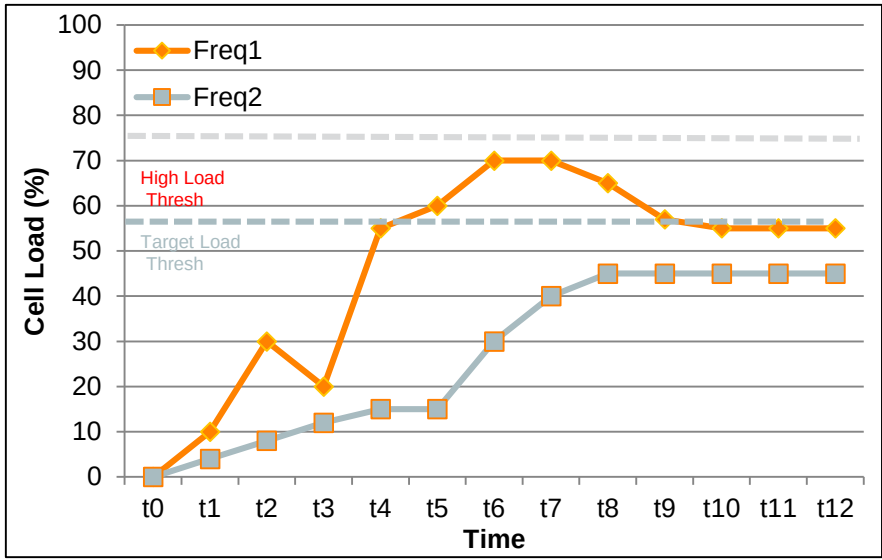
LTE1170 - Inter-eNB Inter-Frequency Load Balancing

RL50/RL35TD/RL50FZ

- LTE1170 is aimed to improve the utilization of resources between inter-frequency cells
  - Does not aim to equally distribute between cells but to have cell load below a configurable threshold



With LTE1170



Imbalanced utilization of resources in an eNB resulting in some UEs not scheduled in Freq1

Resources are better utilized, resulting in more scheduled UEs

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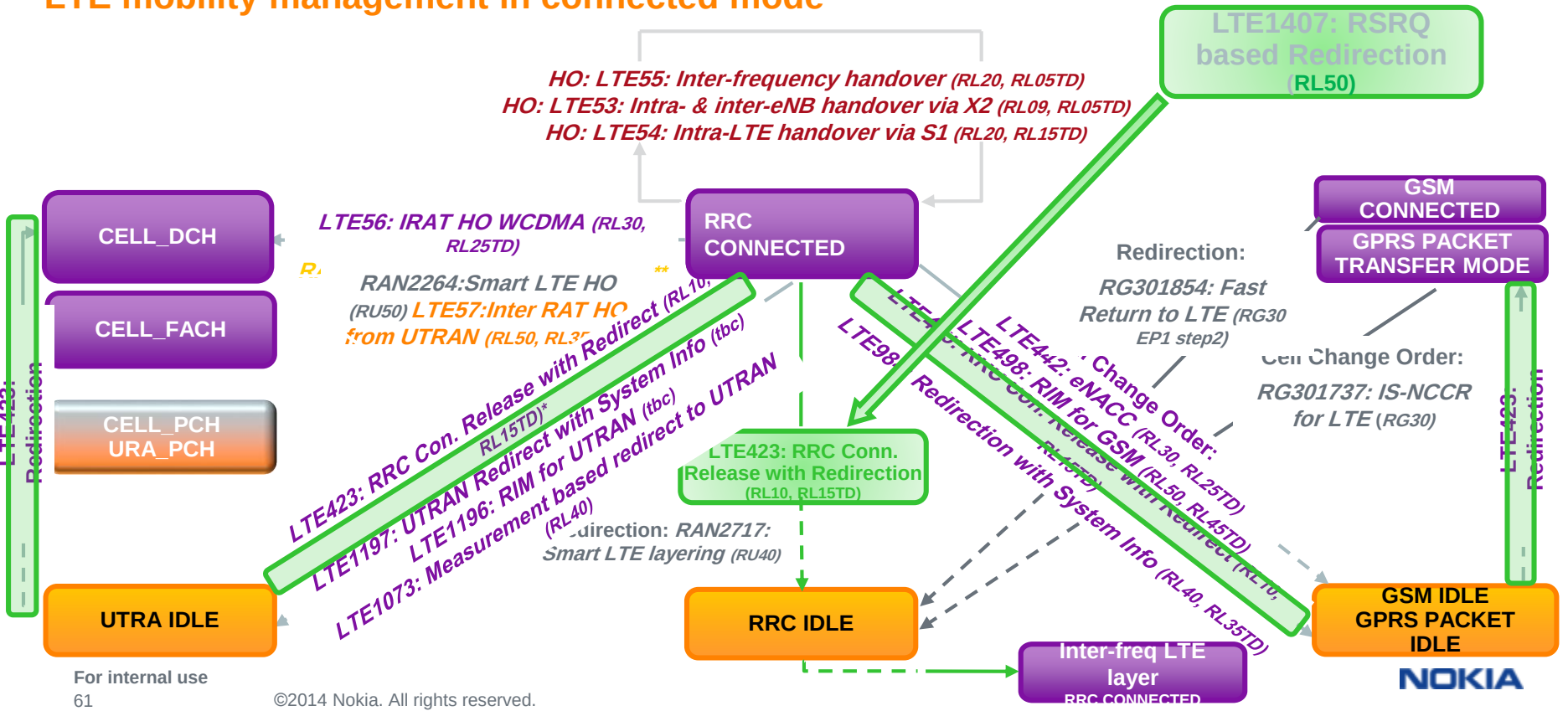
LTE1407 – RSRQ based redirection - overview

RL50

LTE mobility management in connected mode



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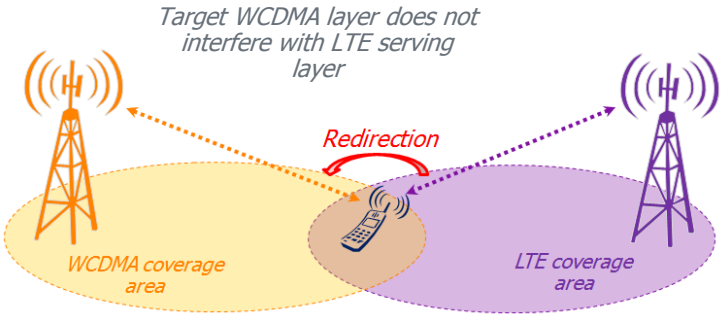
LTE1407 – RSRQ based redirection - overview

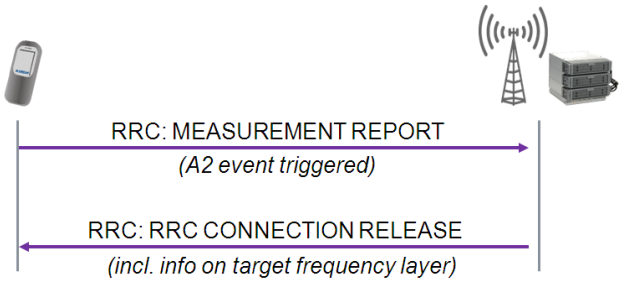
RL50

Redirection – “last ditch from drops”

Redirection – a procedure of RRC connection release with redirecting of a UE to other frequency/RAT layer

- Redirection is a mechanisms to force a UE to:
  - switch from RRC-CONNECTED to RRC-IDLE mode and
  - reselect to inter-frequency/inter-RAT neighbor cell for PS session continuation and/or CS call setup (CS Fallback*)
- Redirection is triggered by the radio conditions
  - RSRP or RSRQ$_{\text{from RL50 onwards}}$
  - in case of CS Fallback*, redirection is triggered by mobile originating or terminating CS call
- Target RAT/frequency layer is indicated to a UE by an eNB within *RRC:rrcConnectionRelease* message
- At first glance, redirection could be regarded as the last-ditch from loosing of signaling connection between an eNB and a UE in case of either poor coverage or extensive interference





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** RRC connection release with redirection mechanism is one of the means of realization of the CS Fallback functionality*

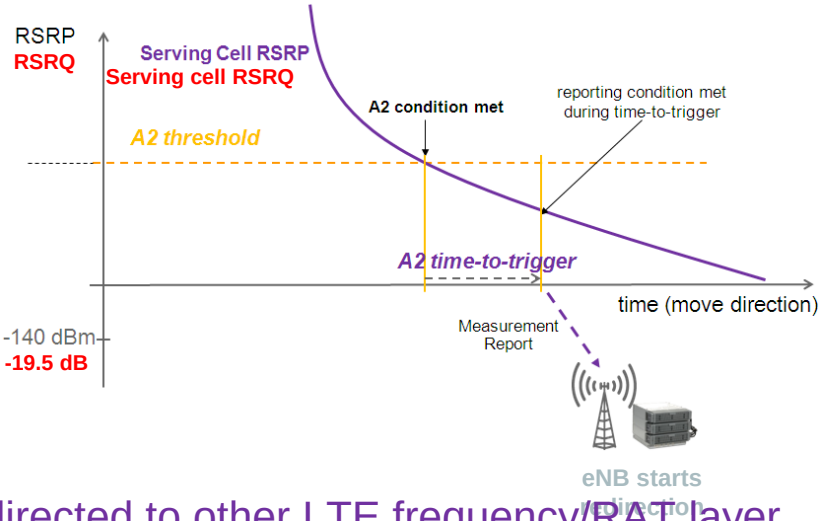
LTE1407 – RSRQ based redirection - overview

RL50

RSRQ based redirection (LTE1407) – enhancement of RSRP based redirection (LTE423)

LTE423 redirection is triggered by RSRP criterion only, LTE1407 brings additional RSRQ trigger event

- LTE423: RRC Connection Release with Redirect was introduced in RL10/RL15TD
  - redirection is triggered by RSRP based Event-A2
- LTE1407: RSRQ Based Redirection
  - redirection is triggered by either RSRP based Event-A2 or RSRQ base Event-A2
- Active LTE423 is a prerequisite for LTE1407 activation
- Redirection target selection and procedure flow is the same for both RSRP and RSRQ triggered cases
- Having both RSRP and RSRQ criterion, UE can be redirected to other LTE frequency/RAT layer to avoid performance degradation not only due to poor coverage but also due to extensive interference
  - RSRQ based redirection should be regarded as the remedy for interference caused performance degradation
  - Feature in



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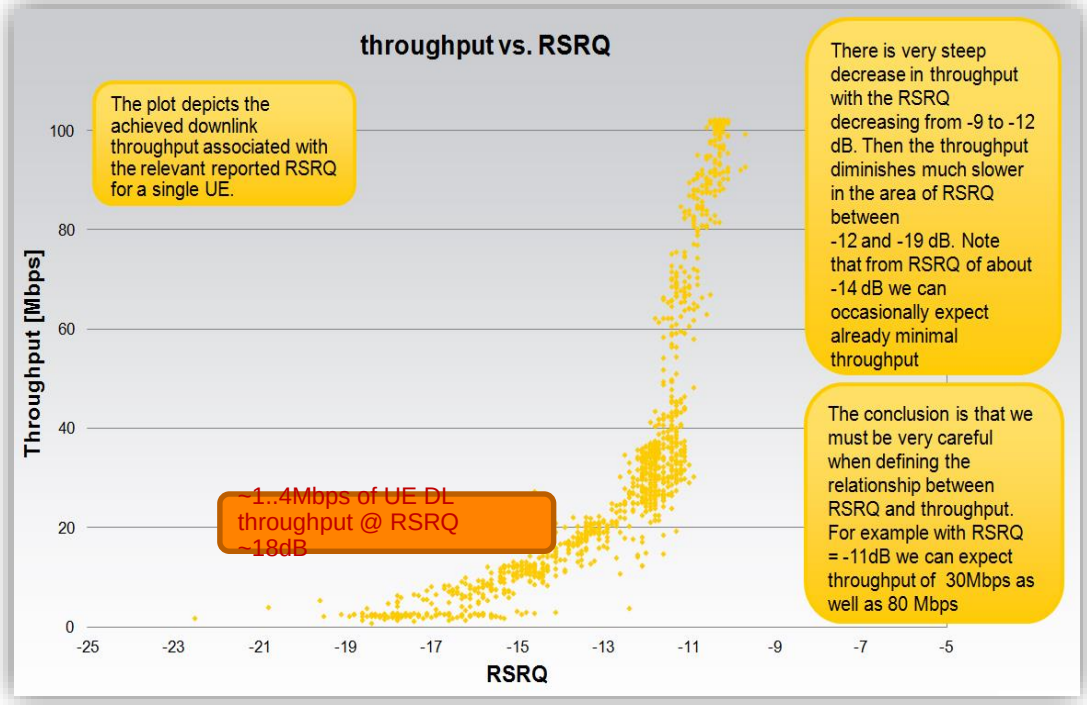
RSRQ Redirection targets definition

Targets for RSRQ based redirection should be carefully planned so that the network performance and user experience are not compromised

- Targets should be planned so that UE is not redirected to the layer which is in mutual interference relation with the serving layer.
  - redirection towards interfering layer could result in further increasing of interference level towards serving layer leading to more and more RSRQ based redirections
  - redirecting UE to interfered layer could result in ping-pong effect – entering poor quality layer UE may start redirection/HO back towards initial serving layer
- Activation of RSRQ based redirection may require re-planning of redirection targets previously configured for RSRP based redirection
- Targets should be planned so that UE is redirected to the layer providing better user experience (throughput, connection retainability, delay,…) than serving cell @ RSRQ around RSRQ redirection threshold
  - note that @ RSRQ of ~18dB, UE may still experience throughput of 1-4Mbps (@ MAC layer)

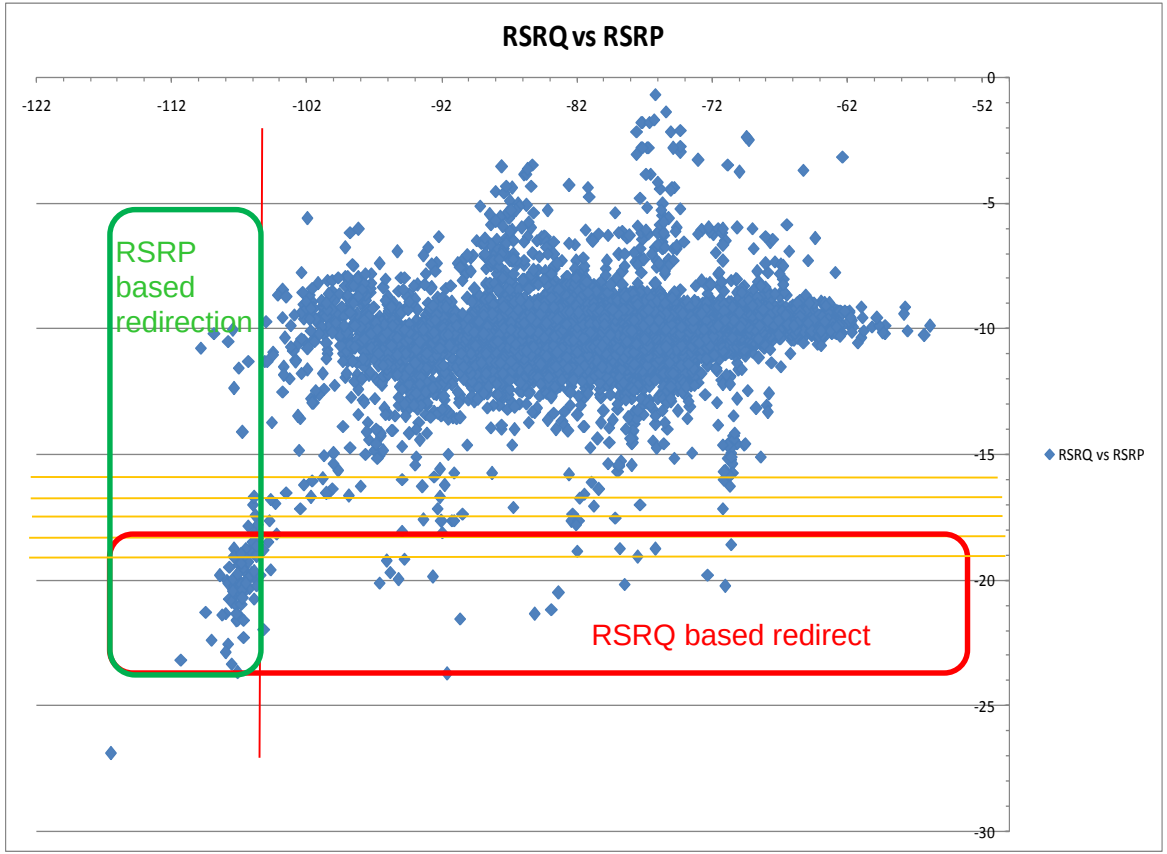


This plot depicts single UE DL throughput @ MAC layer measured in test network; no conclusions on the average cell throughput for multi-UE scenario shall be drawn from this.

RSRQ vs. RSRP Redirection

RSRQ – radio channel quality indicator used as criterion for triggering redirection before cell edge is reached

- Starting value of RSRQ threshold should be set close to the value of -19dB so that redirection is not too sensitive – otherwise redirection may become the only effective mobility management mechanism – RSRQ will trigger redirection well before any HO (or even trigger HO measurement) conditions are met
  - further tuning of this threshold should be carefully done based on drive test results so finally assumed strategy is achieved
- If narrowband RSRQ measurement phenomenon applies, it may be considered to set RSRQ threshold to higher values so that the effect of overestimated RSRQ is compensated
  - when making RSRQ based redirection more sensitive, the risk of making other mobility mechanisms (e.g. inter-frequency better cell HO) unworkable must be kept in mind



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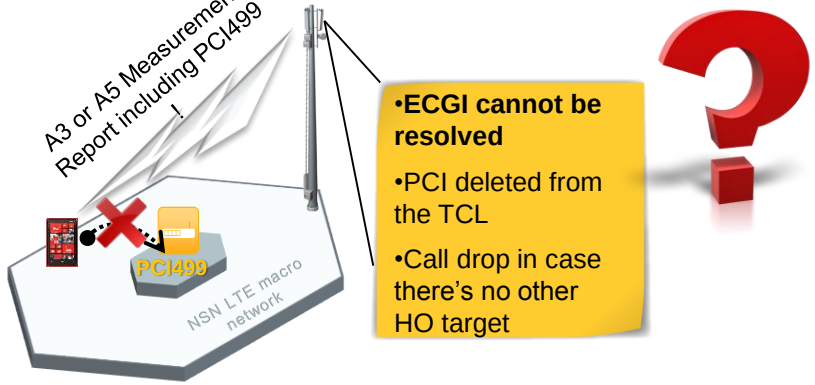
LTE1442 - Open Access Home eNB Mobility (RL50 only).

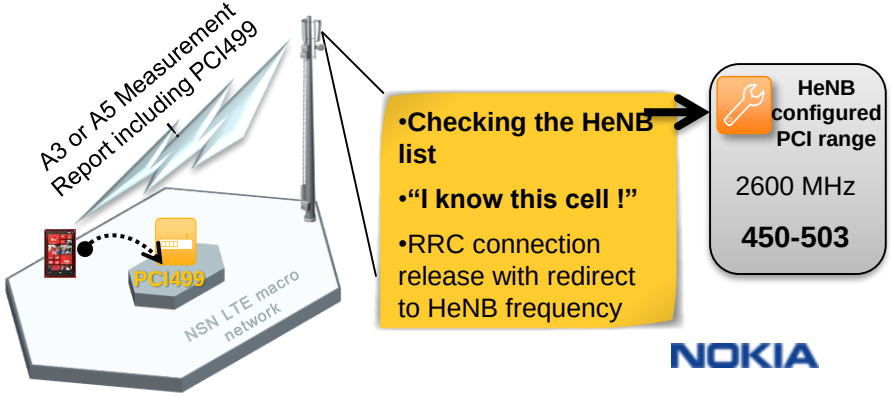
LTE1442
Not activated

1. eNB **does not check** for **HeNB-PCIs** within the measurement report
2. eNB cannot resolve the PCI reported by the UE
3. ***Mobility to HeNB not possible***



LTE1442
Activated

1. eNB **checks** for **HeNB PCI configured** by operator within each intra LTE measurement report received from UE
2. eNB applies **dedicated handling** of handover procedure



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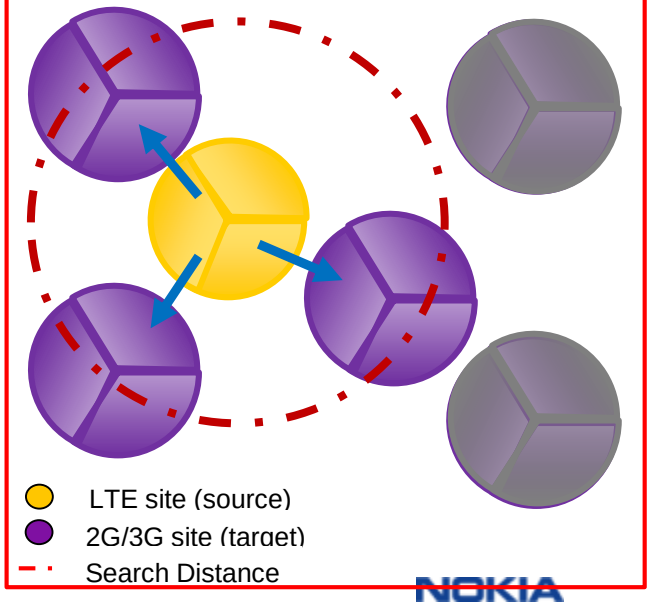
LTE507 InterRAT Neighbor Relation Optimization (NetAct feature)

There was lack of mechanism for InterRAT neighbor optimization

- **Up to RL40/25TD neighbor relations (NBRs) are made manually or provided by following features (without automatic optimization)**
  - ***LTE783 ANR InterRAT UTRAN / LTE784 ANR InterRAT GERAN*:***
    - Both features create (and also delete) NBR respectively
    - NBRs are determined with help of NetAct Optimizer, Configurator and Operator user
    - Features are based on planning information (Geo-location, antenna direction) from NetAct Configurator
    - An uni-directional neighbor relationship is created – from LTE towards GERAN or/and WCDMA
  - ***LTE510 Synchronization of InterRAT neighbors***
    - The feature is an enhancement of ***LTE783 ANR InterRAT UTRAN/LTE784 ANR InterRAT GERAN***
    - Automatically keeps inter-RAT neighbor relations up-to-date in case of inter-RAT cell is added or deleted
    - It runs *LTE783* or *LTE784* when NBR to new cell must be added or deleted
- **Established NBRs are optimized by manual intervention only**

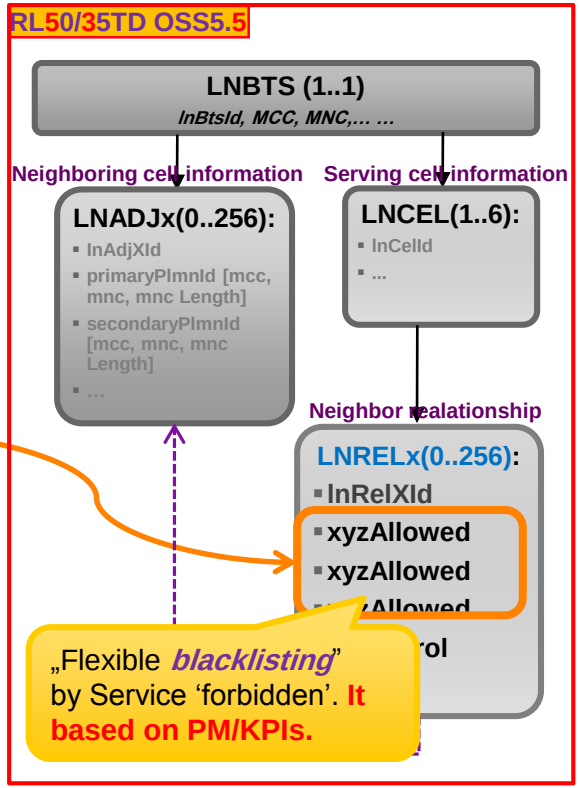
- **Feature *LTE783 or LTE784* for NBR candidates considers sites inside Search Distance and excludes sites outside the Search Distance**
- **Search Distance is considered based on geo-location data of each site**



* LTE784 for LTE TDD is available from RL35TD

LTE507 InterRAT Neighbor Relation Optimization (NetAct feature)

- **The goal of the feature is to keep only stable and reliable neighbor relations active for given mobility procedure** (e.g. Inter RAT PS HO, CSFB to UTRAN, SRVCC to GERAN, etc.)
- **This feature manages and optimizes the existing interRAT neighbor relations between:**
  - LTE and **WCDMA/TD-SCDMA** and/or
  - LTE and **GERAN** for a defined set of mobility procedures
- **NetAct Optimizer user or automatic scheduler is able to use PM counters and KPIs to identify and blacklist various bad performing mobility procedures (e.g.blacklist Inter RAT PS HO with Success ratio < 90%)**
  - The generation of PM data is separated from LTE507 functionality (must be provided to NetAct by a user)
  - NetAct supports reading of PM data and generates required KPIs
  - Mobility to GERAN is not supported by Flexi Zone Micro. LNADJG and LNRELG are not avialable in RL50FZ
- Blacklisting is done **in** neighbor relation object LNRELx (means LNRELG/LNRELW/LNRELT*) on **mobility procedure** level
- NBR optimization is an uni-directional – from LTE towards 2G or/and 3G



LNRELx.xyzAllowed means particular mobility procedure per RAT per NR

*LNRELT (and LNADJT, LNHOT) refers to TD-SCDMA, provided in RL35TD due to *LTE898 Inter RAT HO to TD-SCDMA* and *LTE736 CS fallback to TD-SCDM*

RL60/45 Additions

- LTE1531: Inter-frequency load balancing extension
- LTE1198: RSRQ triggered mobility
- LTE498: RAN Information Management for GSM
- LTE57: Inter RAT handover from UTRAN
- LTE874: CSFB to CDMA/1xRTT for dual RX Ues
- LTE1441: Enhanced CS Fallback to CDMA/1xRTT (e1xCSFB)
- LTE60: Inter RAT handover to eHRPD/3GPP2

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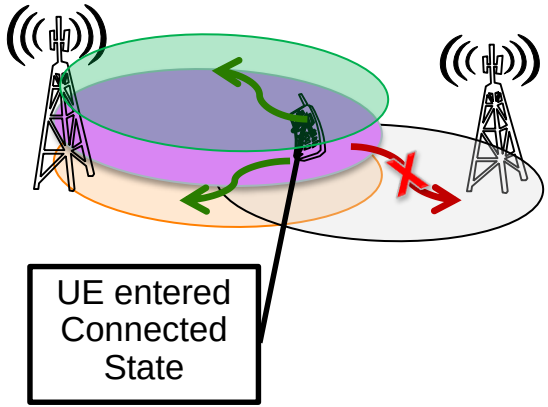
LTE1531: Inter-frequency load balancing extension

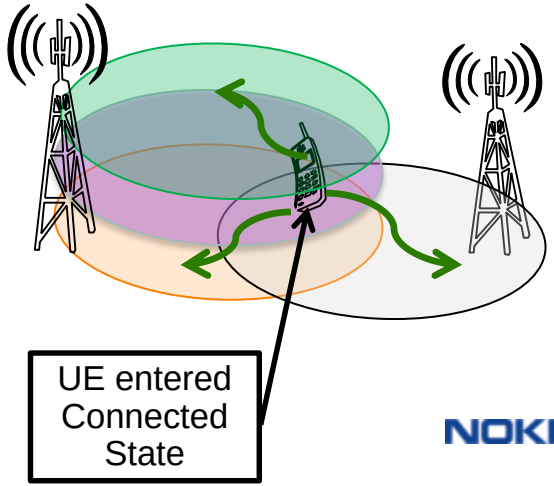
RL40 LTE1387 Intra-eNode B Inter Frequency Load Balancing

- UE can be offloaded to cell of the same eNB
- UEs that are entering RRC Connected state from RRC Idle state are considered as candidates for Load Balancing
- UE cannot be offloaded to cell of another eNB



RL50 LTE1170 Inter-eNode B Inter Frequency Load Balancing

- UE can be offloaded to cell of the same or different eNB,
- UEs that are entering RRC Connected state from RRC Idle state are considered as candidates for Load Balancing



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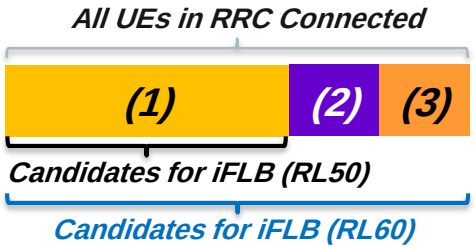
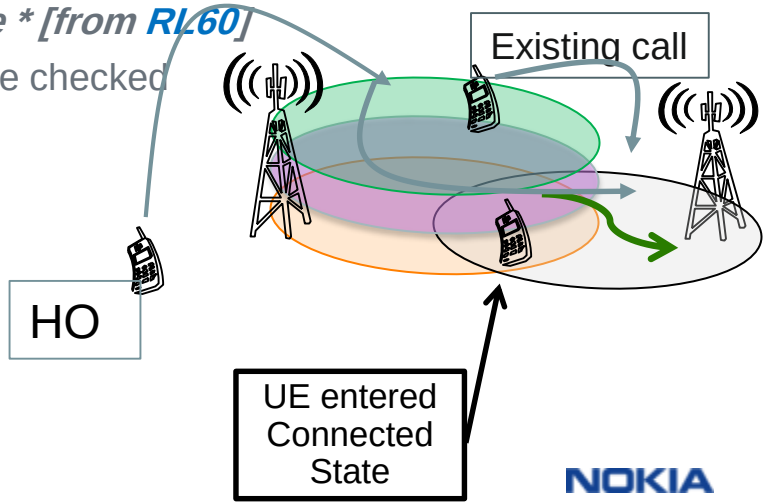
LTE1531: Inter-frequency load balancing extension RL60

- UE can be offloaded to cell of the same or different eNB
- Feature works on top of existing LTE1170 feature and shares the activation flag (*LNBTS:actInterFreqLB*)
- Main enhancement is increased number of Candidates for Inter Frequency Load Balancing (**iFLB**):
  - ***(1)*** UEs that enter RRC Connected state from RRC Idle state
  - ***(2) UEs entering the cell via Handover [from RL60]***
  - ***(3) UEs that are already in RRC Connected state * [from RL60]***
    - UEs that are already in RRC Connected state are checked periodically (more frequent LB triggers)





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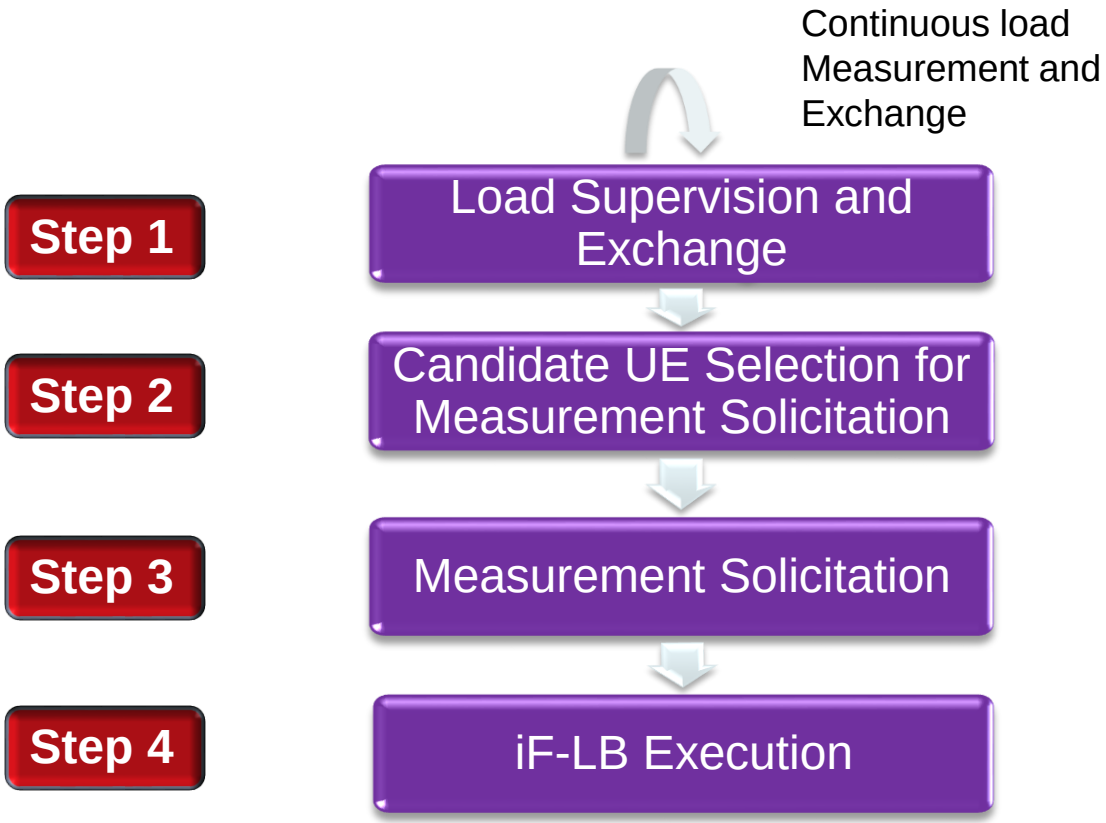
LTE1531: Inter-frequency load balancing extension RL60



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LTE1198: RSRQ triggered mobility

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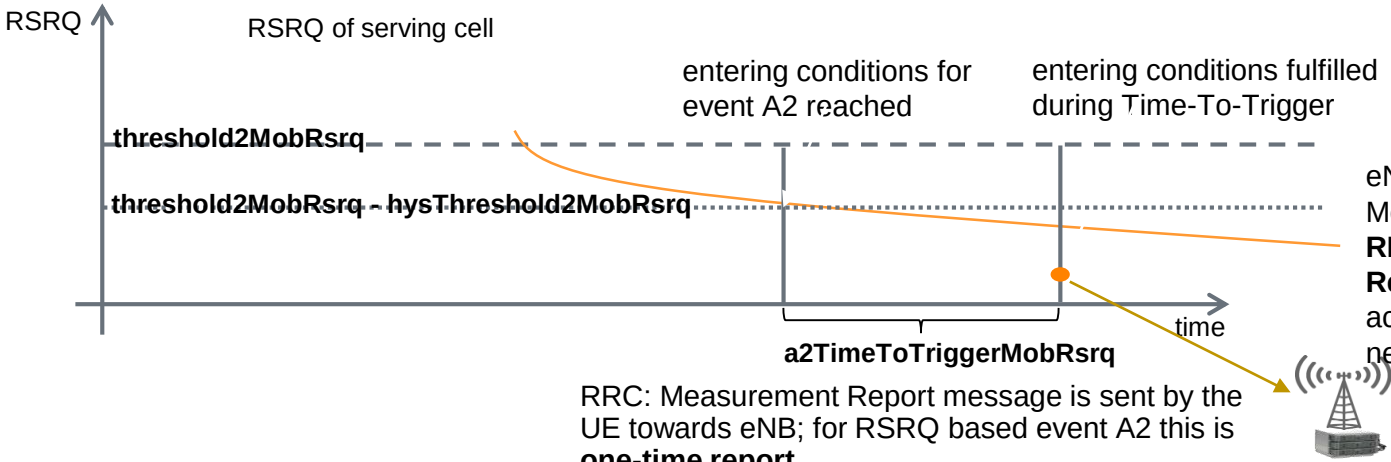
LTE1198: RSRQ triggered mobility
Event A2 for RSRQ

Entering conditions for event A2
RSRQ < **threshold2MobRsrq - hysThreshold2MobRsrq**



eNB receiving such RRC: Measurement Report triggers **RRC Connection Reconfiguration** procedure to activate measurements of neighbor layers,

RRC: Measurement Report message is sent by the UE towards eNB; for RSRQ based event A2 this is **one-time report**

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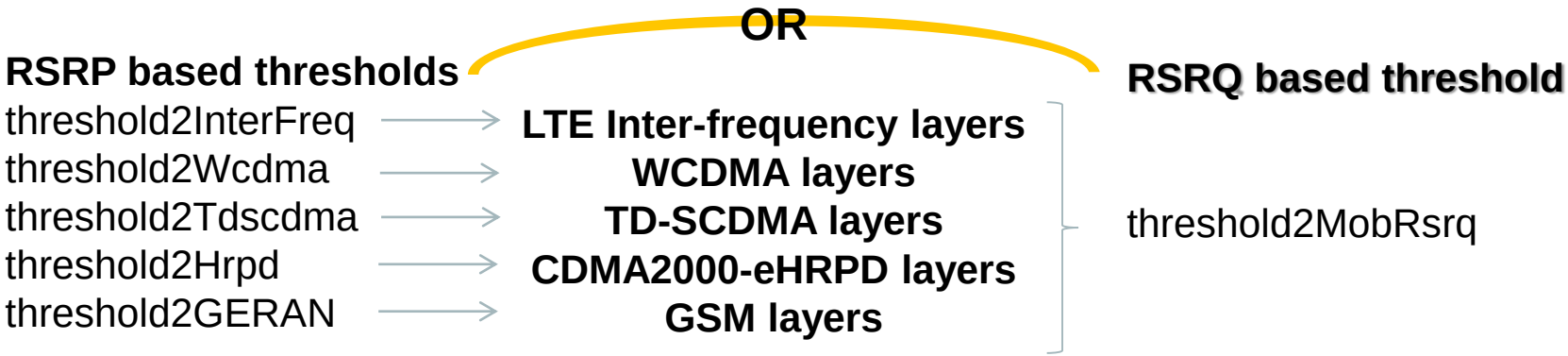
LTE1198: RSRQ triggered mobility

Measurement activation of particular layers can be triggered either by **dedicated RSRP thresholds** or can be triggered by one common **RSRQ based threshold**



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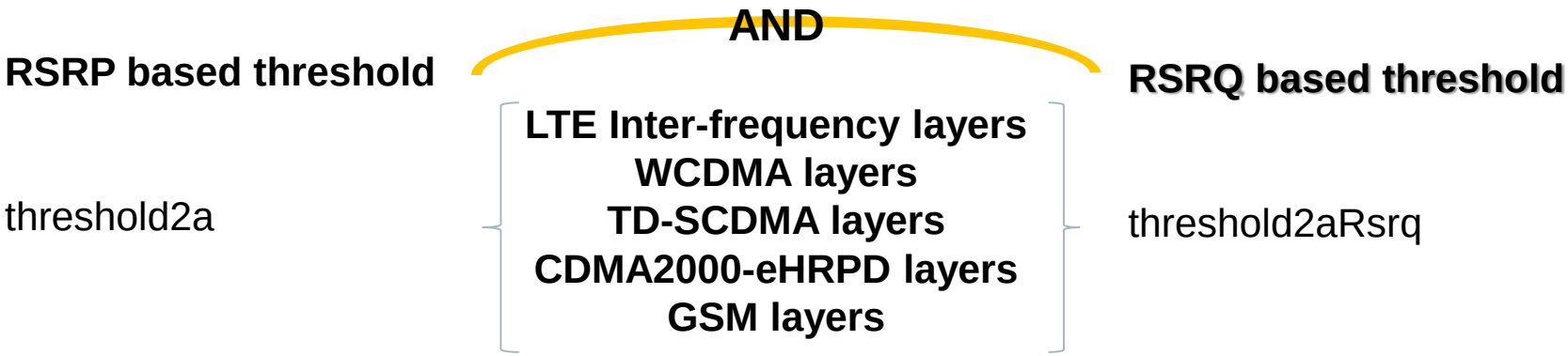
LTE1198: RSRQ triggered mobility

Measurement deactivation, of measured LTE inter-frequency/inter-RAT layers, is triggered if **both** **RSRP** level and **RSRQ** quality of serving cell are above particular **RSRP** and **RSRQ** thresholds



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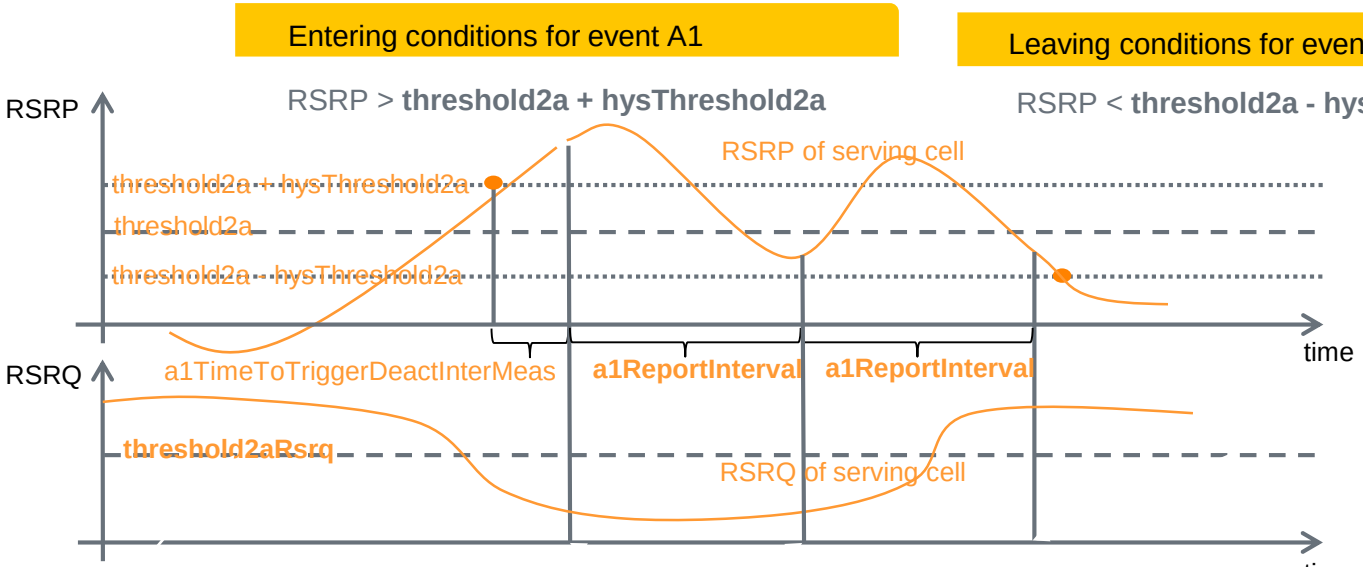
LTE1198: RSRQ triggered mobility

RRC: MeasurementReport triggered by event A1 for active LTE1198



RSRQ, even above **threshold2aRsrq,** never triggers event A1 based Measurement Report;

RRC: Measurement Report sent with actual RSRP and RSRQ of serving cell
RSRQ **< threshold2aRsrq**, so measurements still active

RRC: Measurement Report sent with current RSRP and RSRQ of serving cell

RSRQ **> threshold2aRsrq** at third Measurement Report, so eNB commands the UE to deactivate inter-frequency/ inter-RAT measurements

RRC Connection Reconfiguration procedure used for these purposes

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LTE1198: RSRQ triggered mobility

Object	Parameter	Description
LNCEL	rsrqMobilityParams	RSRQ mobility parameters
LNCEL	rsrqMobilityParams	A1 report interval for serving becomes better than RSRP
LNCEL	a2TimeToTriggerMobRsrq	Time to trigger A2-RSRQ to start mobility measurement
LNCEL	hysThreshold2MobRsrq	Related hysteresis of threshold Th2 for RSRQ mobility
LNCEL	threshold2MobRsrq	Threshold Th2 for RSRQ mobility
LNCEL	threshold2aRsrq	Threshold Th2a for RSRQ mobility
LNCEL	rsrqRedirectParams	RSRQ redirection parameters
LNCEL	a2TimeToTriggerRedirectRsrq	Time to trigger for A2 by RSRQ to start redirect
LNCEL	hysThreshold4Rsrq	Related hysteresis of threshold Th4 for RSRQ
LNCEL	threshold4Rsrq	Threshold Th4 for RSRQ

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LTE498: RAN Information Management for GSM

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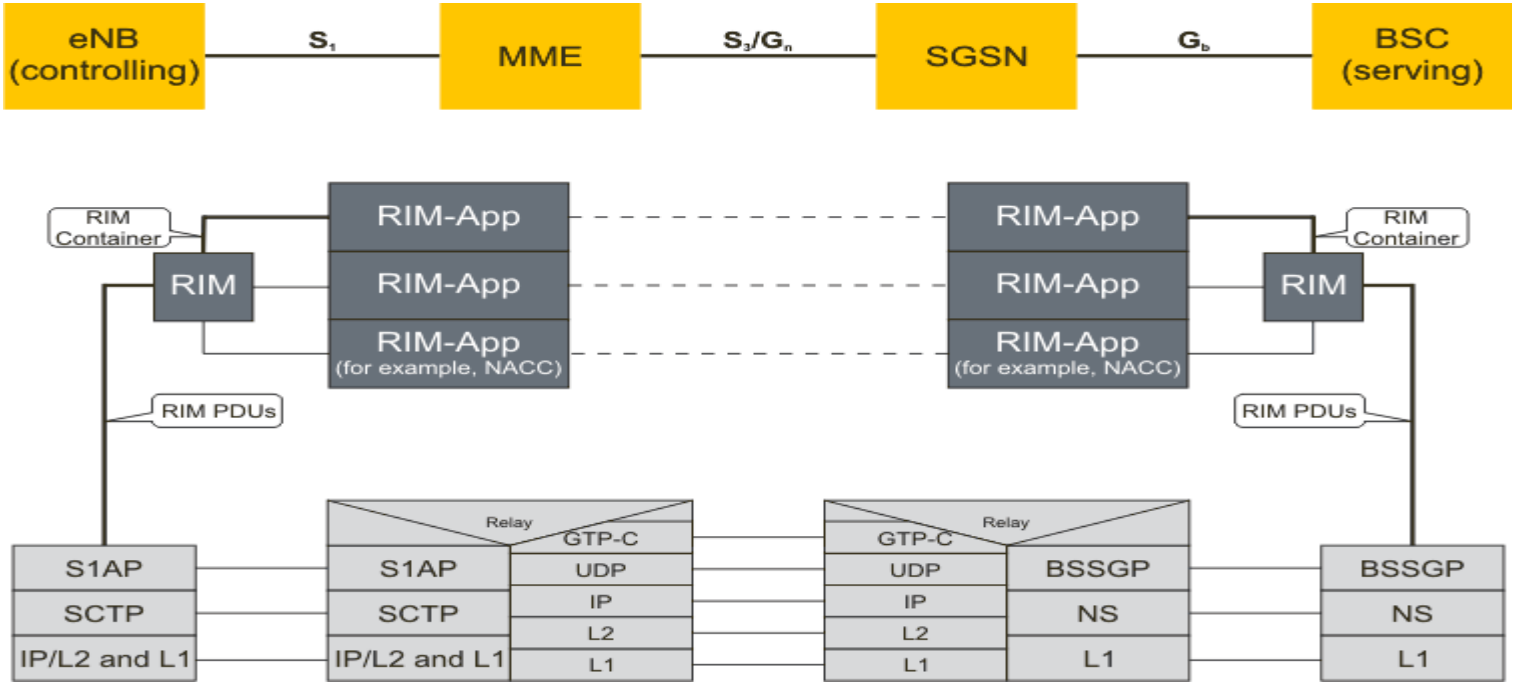
LTE498 RIM for GSM
RIM protocol structure between E-UTRAN and GERAN



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LTE57: Inter RAT handover from UTRAN

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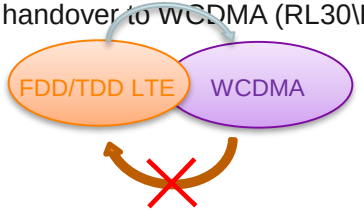
LTE57: Inter RAT handover from UTRAN

Without the feature LTE57:

Assuming that LTE56 or LTE898 are activated only handovers towards 3G initiated on LTE side can be supported by Flexi Multiradio BTS

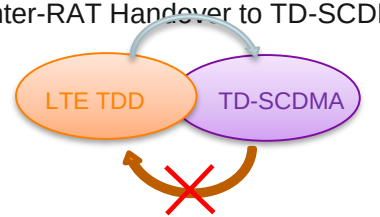
•LTE FDD/TDD -> WCDMA

LTE56 inter-RAT handover to WCDMA (RL30\RL25TD)



• LTE TDD -> TD-SCDMA

LTE898 TDD Inter-RAT Handover to TD-SCDMA (RL35TD)

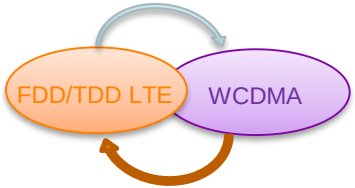


With the feature LTE57

Handovers to LTE initiated by 3G side are handled by Flexi Multiradio BTS

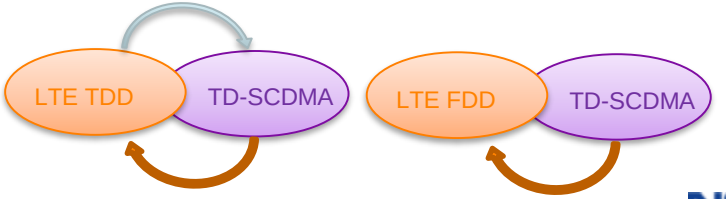
•WCDMA -> LTE FDD/TDD

LTE57 Handover from UTRAN (RL60\RL45TD)



•TD-SCDMA -> LTE FDD/TDD

LTE57 Handover from UTRAN (RL60\RL45TD)



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Mobility Parameter Settings

Examples from real cases

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Example of Mobility Parameter Settings
Compilation of real cases (1/2)

- Examples show that mobility related parameters are particularly project dependant even cell/area dependant and it is not possible to establish a ‘common’ value
- In order to trigger the A5 handover (coverage) it is necessary that:
  (threshold3a – threshold3) + 2*hysThreshold3 < a3offset +hystA3Offset

Item	Parameter Name	GMC RL20	RL20 Project1	RL20 Project2	RL20 Project3	GMC RL30	RL30 Project1	RL30 Project2
Intra LTE Handover (EventA3)	EnableBetterCellHo	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
	Threshold1	90	90	90	90	90	90	90
	a3Offset	6	4	4	6	6	6	3
	a3ReportInterval	1 (240ms)	4 (1024ms)	4 (1024ms)	1 (240ms)	1 (240ms)	1 (240ms)	240
	a3TimeToTrigger	8 (320ms)	12 (1024ms)	12 (1024ms)	8 (320ms)	8 (320ms)	8 (320ms)	320
	hysA3Offset	0	4	4	0	0	0	0
	cellIndOffServ	n/a	n/a	n/a	n/a	0	0	0
Intra LTE Handover (EventA5)	EnableCovCellHo		TRUE	TRUE	TRUE		TRUE	TRUE
	Threshold3	30	45	45	30	30	30	44
	Threshold3a	31	46	46	31	31	31	45
	a5ReportInterval	1(240ms)	1(240ms)	1(240ms)	1(240ms)	1(240ms)	1(240ms)	240
	a5TimeToTrigger	8(320ms)	11 (640ms)	11 (640ms)	8(320ms)	8(320ms)	8(320ms)	320
	hysThreshold3	0	4	4	0	0	0	0

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Idle mode mobility

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Contents

- **Idle Mode Mobility**
  - Cell Selection
  - LTE intra-frequency Reselection
  - LTE inter-frequency Reselection
  - Inter RAT Re-selection
- **RL50/35/50FZ Improvements/additions**
  - LTE1036 RSRQ based Cell Reselection.
  - LTE487 Idle Mode Mobility Load Balancing
- **RL60/45 Improvements/addition**
  - LTE1677: Idle mode mobility balancing extensions

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Cell Selection

- Procedure that allows the UE to camp on a cell
- UE searches for a suitable cell (belonging to the selected PLMN, not barred, belonging to a TA not forbidden and that satisfies the **S-criteria):**
  - The UE selects a cell if **Srxlev > 0**

VPLMN: Visited PLMN

LNCEL: qRxLevMinOffset
Typically 0 (only used when camping in VPLMN)

Srxlev = Qrxlevmeas – (Qrxlevmin + Qrxlevminoffset) – P compensation

Max(LNCEL:pMaxOwnCell - P_max from UE (*) , 0)

Measured value

LNCEL:qRxLevMin
Typically -130dBm

(*) P_max from UE : UE class specific max. UL Tx power; 23 dBm

pMaxOwnCell (SIB1)
Used to calculate P_compensation
LNCEL; -30..33dBm; 1dBm; -

- SIB1 is used to transmit cell selection parameters

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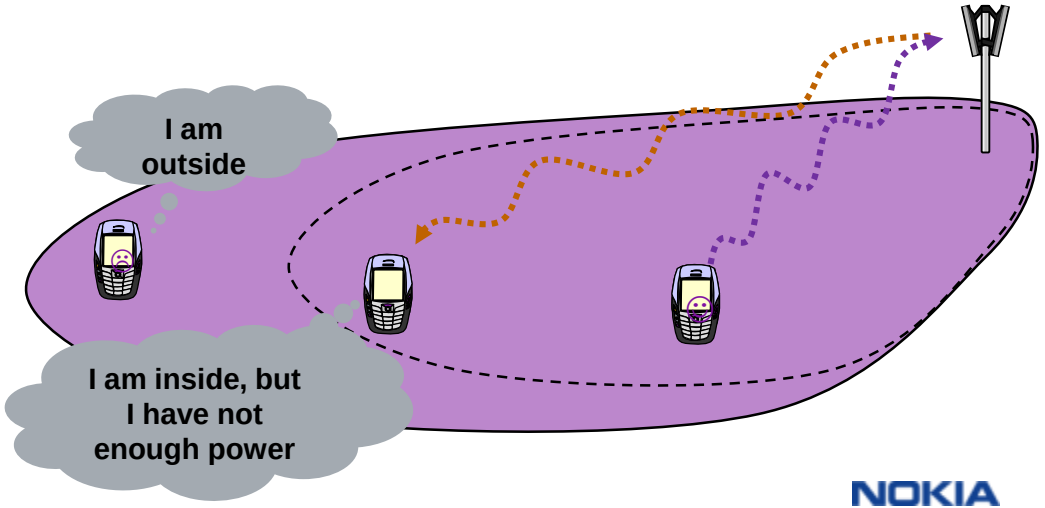
S – Criterion Cell Selection

P_compensation = max(pMaxOwnCell – P_max from UE, 0)

- P_compensation provides a contribution only if the UE has **less TX power capabilities than allowed in the radio cell**
  - If P_compensation > 0 the S-criteria is more difficult to achieve as Qrxlevmeas needs to be higher
- P_compensation avoids UEs camping on cells for which they have insufficient power to access (towards cell edge)
- qrxLevMin defines the cell size

- qrxLevMin can be set up differently for intra frequency, inter frequency and IRAT:

Cell selection Parameters



E.g. pMaxOwnCell: 33 dBm in GMC files

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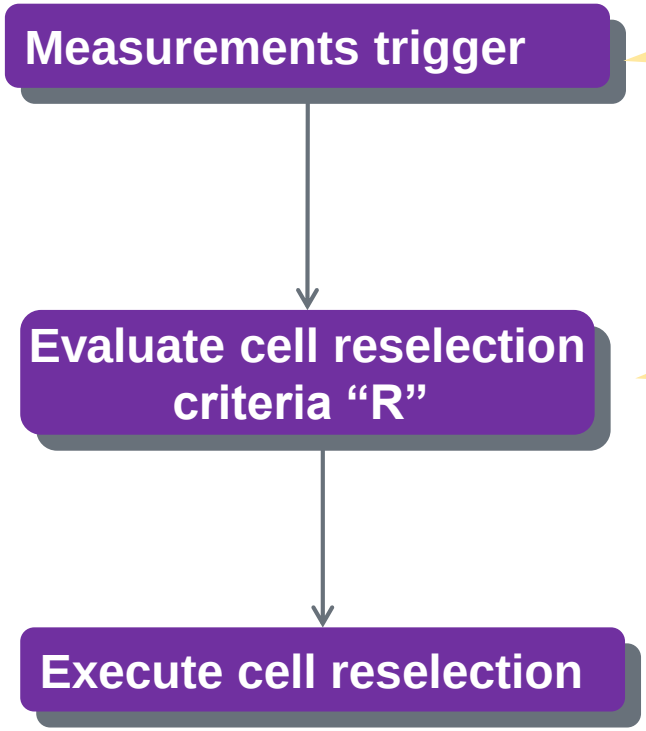
Cell Reselection Process Overview



UE measures neighbour cells only when the RSRP signal level is below some threshold

Measurements **trigger is based primarily on absolute priorities** of serving and non serving frequency layers (inter freq and inter RAT)

Different **reselection cases depending on the priorities** of the neighbour frequency layers (inter-frequency and inter-RAT)

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Intra frequency cell reselection

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Intra frequency cell reselection
Triggering Measurements

- When a UE is camped on a cell it looks for better candidate cells for reselection according to **sIntrasearch** parameter:
- If **Srxlev > sIntraSearch** : UE doesn't measure the neighbour cells
- If **Srxlev <= sIntraSearch** : UE starts to measure neighbour cells on the same frequency
- **Example:**
  - LNCEL: sIntraSearch is 62 dB
  - LNCEL: qrxlevmin is -130 dBm
  - LNCEL: qRxLevMinOffset is 0
  - pCompensation is 0

Srxlev = Qrxlevmeas – (Qrxlevmin + Qrxlevminoffset) - pcompensation

-130 dBm 0 dB 0 dB

- Qrxlevmeas< - 68 dBm
- UE will start to measure intra-frequency neighbours when RSRP is worse than - 68 dBm

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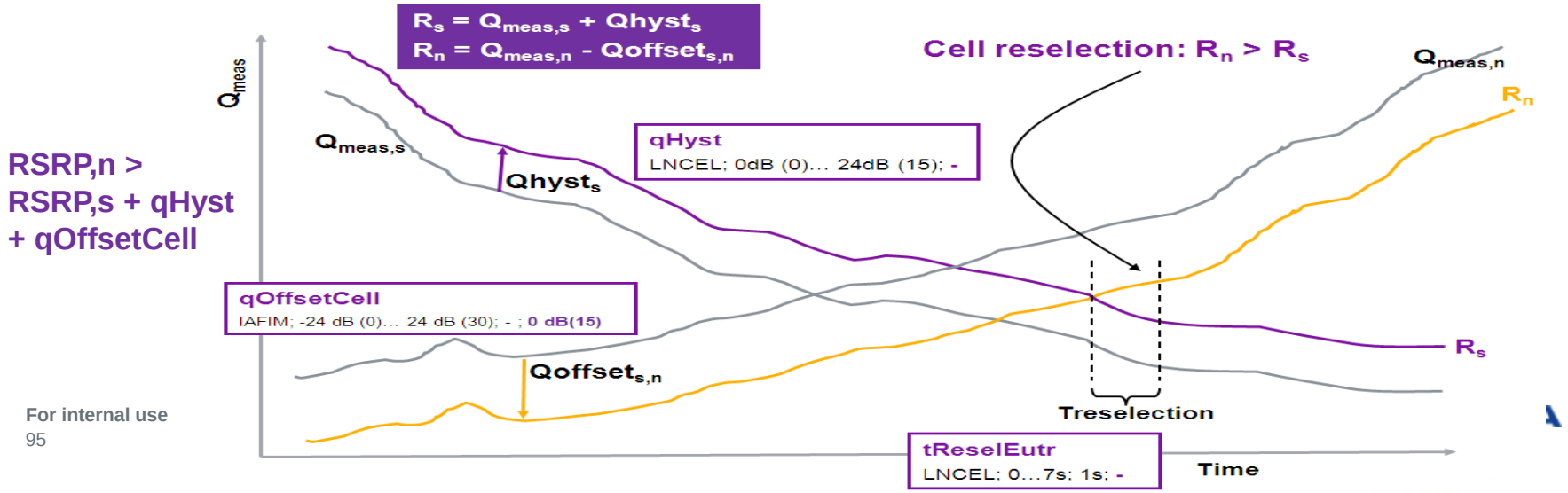
Intra frequency cell reselection: R-Criterion (Ranking Criterion)

- Once the measurements for neighbour cells have been triggered the UE will rank the measured cells according to the R-Criterion
  - $Rank_{serving\ cell}$ = Measured $RSRP_{serving\ cell}$ + LNCEL:qHyst
  - $Rank_{neighbour\ cell}$ = Measured $RSRP_{neighbour\ cell}$ – IAFIM:qOffsetCell

- Re-selection if :
  - $Rank_{neighbour\ cell}$ **>** $Rank_{serving\ cell}$ for *tReselEutr* and
  - More than 1 second has elapsed since the UE camped on the current serving cell



Intra Frequency cell Reselection Parameter Summary (1/2)

MOC	Parameter Name	Description	Range and step	Default value	GMC Value
LNCEL	sIntrasearch	Defines the threshold (in dB) for intra-frequency measurements	0...62 dB, step 2 dB	-	62
LNCEL	qrxlevMin	Minimum required RX RSRP in the cell	-140...-44 dBm, step 2 dBm	-	-130 dBm
LNCEL	qRxLevMinOffset	Affects the minimum required RX level in the cell	2...16 dB, step 2 dB	-	-
LNCEL	pMaxOwnCell	Used to calculate Pcompensation	-30...33 dBm, step 1 dBm	-	33
LNCEL	qHyst	Provides the hysteresis value in dB for ranking criteria in the cell reselection procedure.	0dB (0), 1dB (1), 2dB (2), 3dB (3), 4dB (4), 5dB (5), 6dB (6), 8dB (7), 10dB (8), 12dB (9), 14dB (10), 16dB (11), 18dB (12), 20dB (13), 22dB (14), 24dB (15)	-	1dB
LNCEL	tReselEutr	Cell reselection timer value	0...7 s, step 1 s	-	1

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Inter frequency cell reselection

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Inter frequency cell reselection
Triggering Measurements

- Measurement trigger depends on the **absolute priorities** of the serving and non-serving layers
  - The priority of the serving layer is defined in the parameter LNCEL:cellReSelPrio
  - For each neighbouring frequency/layer, it is necessary to define the corresponding priority: IRFIM:eutCelResPrio (**7 is highest priority, 0 is lowest**)
  - For equal priority frequency layers it is possible to define an offset with IRFIM:qOffFrq

- If **IRFIM:eutCelResPrio > LNCEL:cellReSelPrio** then measurements of the neighbour cell are mandatory

- If **IRFIM:eutCelResPrio <= LNCEL:cellReSelPrio** then measurements are performed when RSRP of serving cell is below sNonIntrsearch threshold:

  Srxlev <= sNonIntrsearch

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Inter frequency cell reselection
Triggering Measurements

- UE starts inter-frequency measurements when **Srxlev <= sNonIntrSearch**
- sNonIntrsearch is a valid threshold for inter-frequency and inter-RAT measurements
- **Example:**
  - LNCEL: sNonIntrSearch is 12 dB
  - LNCEL: qRxLevMin is -130 dBm
  - LNCEL: qRxLevMinOffset is 0
  - pCompensation is 0

Srxlev = Qrxlevmeas – (Qrxlevmin + Qrxlevminoffset) - pcompensation

-130 dBm 0 dB 0 dB

- Qrxlevmeas <=-118 dBm
- UE will start to measure inter-frequency neighbours when RSRP is worse than -118 dBm

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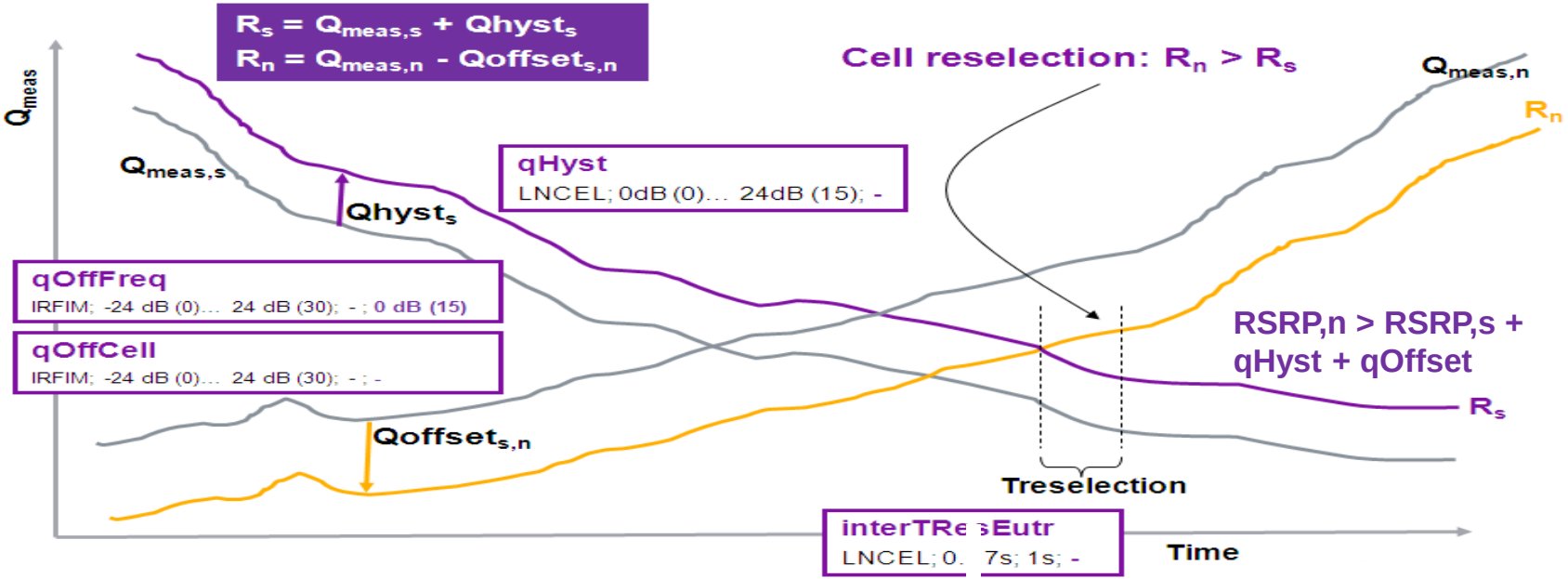
Inter Frequency Reselection: R-criteria: Equal priority between layers

- Similar to intra frequency



- A frequency-specific offset for equal priority E-UTRAN frequencies can be considered:

Qoffset = qOffCell,n + qOffFreq

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Inter Frequency Reselection: R-criteria: Reselect to lower priority layers

- If the neighbour cell layer has **lower priority**, the reselection will happen if:

$$Srxlev_{neighbour} > IRFIM:interFrqThrL \;\&\&\; Srxlev_{serving} < LNCEL:threshSrvLow$$

Where:
$Srxlev_n = QrxlevMeas_n$ – IRFIM:qRxLevMinInterF – P_compensation
$Srxlev_s = QrxlevMeas_s$ – LNCEL:qRxLevMin + LNCEL: qRxLevMinOffset – P_compensation

$$Qrxlevmeas_s < qRxLevMin + thresholdSrvLow - qRxLevMinOffset + P\_compensation$$

AND

$$Qrxlevmeas_n > qRxLevMinInterF + interFrqThrL + P\_compensation$$

- The criterias above have to be fullfilled during a time interval IRFIM:interTResEut
- And the UE must have been camped in the current cell more than 1 sec.

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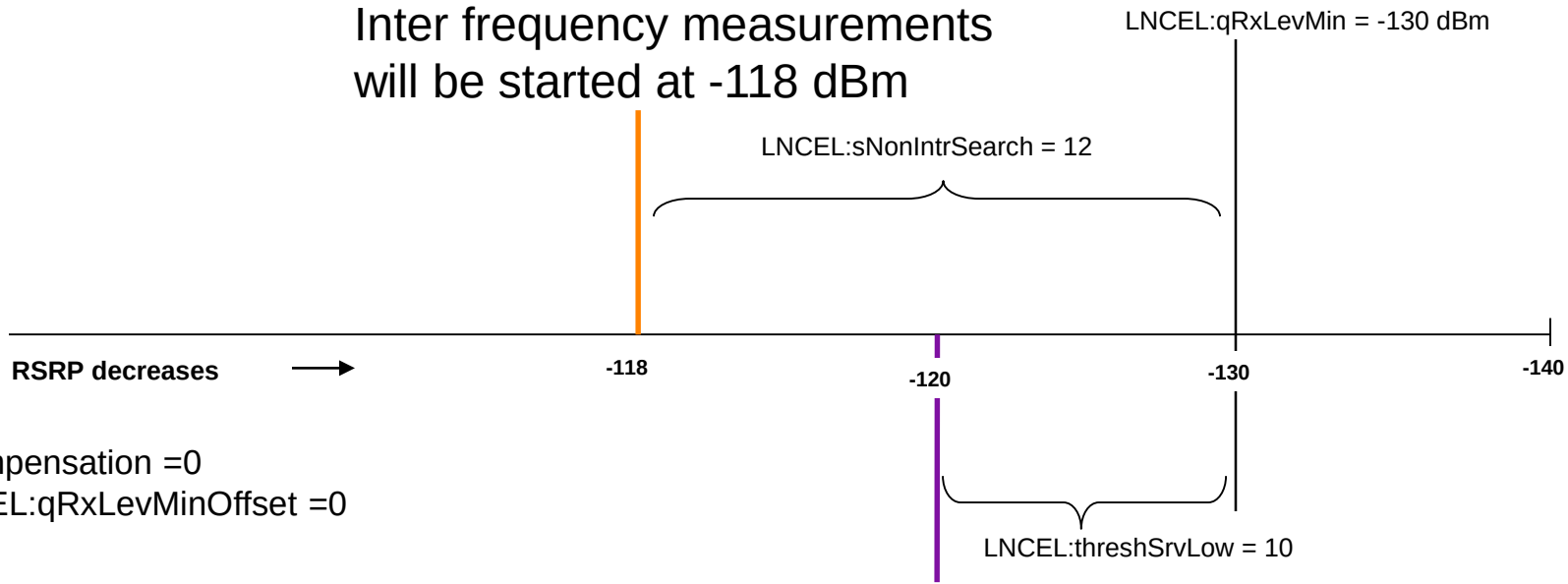
Inter frequency cell reselection

Example of reselection to lower priority



Pcompensation =0
LNCEL:qRxLevMinOffset =0

If suitable neighbour (*) cell is found, reselection will be performed when RSRP decreases under -120 dBm

(*) suitable neighbour-> $RSRP_n$ > qRxLevMinInterF +interFreqThrL

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Inter Frequency Reselection
R-criteria: Reselection to higher priority layers

- If the neighbouring cell layer has **higher priority** than the serving layer, reselection will happen if:

$$Srxlev_{neighbour} > IRFIM:interFrqThrH$$

Where:

$Srxlev_{neighbour} = Qrxlevmeas – IRFIM:qRxLevMinInterF – P\_compensation$

$$Qrxlevmeas_{neighbour} > qRxLevMinInterF + interFrqThrH$$

(Assuming P_compensation = 0)

- The criteria above must be satisfied for a time period equal to IRFIM: interTResEut
- And the UE must have been camped in the current cell more than 1 sec.

interFrqThrH > interFrqThrL > threshSrvLow

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Inter Frequency cell Reselection - Parameter Summary (1/3)

MOC	Parameter Name	Description	Range and step	Default value	GMC Value
LNCEL	sNonIntrsearch	Defines the threshold (in dB) for inter-frequency and inter-RAT measurements	0...62 dB, step 2 dB	-	2
LNCEL	qrxLevMin	Minimum required RX RSRP in the serving cell	-140...-44 dBm, step 2 dBm	-	-130 dBm
LNCEL	qRxLevMinOffset	Affects the minimum required RX level in the serving cell	2...16 dB, step 2 dB	-	-
LNCEL	pMaxOwnCell	Used to calculate P_compensation	-30...33 dBm, step 1 dBm	-	33 dBm
LNCEL	cellReSelPrio	Absolute priority of the serving layer. 0 means the lowest priority.	0...7, step 1	-	1
LNCEL	threshSrvLow	Threshold for the serving frequency used in reselection evaluation towards lower priority EUTRAN frequency or RAT	0...62 dB, step 2 dB	-	2
LNCEL	qrxlevminintraF	Minimum required RX RSRP level for the intra-frequency neighbouring E-UTRA cells. (Qrxlevmin in 36.304)	-140...-44 dBm, step 2 dBm	-	-130 dBm
IRFIM	qRxLevMinInterF	Minimum required Rx RSRP level for the neighbouring EUTRA cells on this carrier frequency	-140...-44 dBm, step 2 dBm	-	-68 dBm
IRFIM	dlCarFrqEut	eUTRAN frequency	0...65535, step 1	-	-
IRFIM	eutCelResPrio	Absolute priority of the EUTRA carrier frequency	0...7, step 1	-	5

Inter RAT cell reselection

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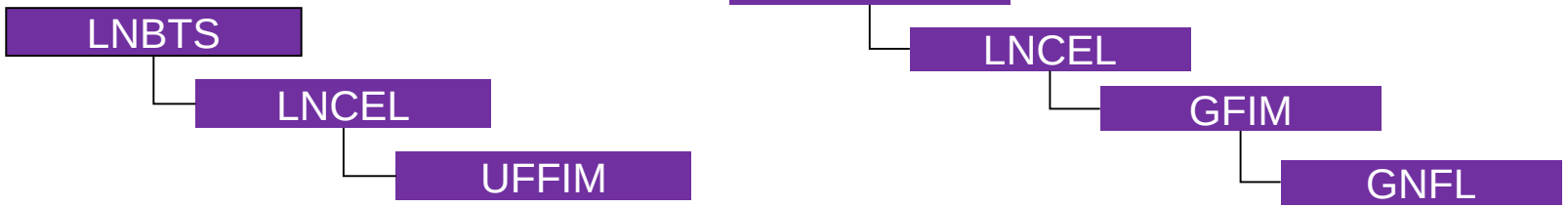
Inter-RAT cell reselection

- Inter RAT cell reselection is idle mode mobility from LTE to another radio access technology (RAT), e.g. WCDMA or GSM
- UFFIM is the managed object class for idle mode parameters LTE to WCDMA:
  - UFFIM parameters are broadcasted in the SIB6
- GFIM/GNFL are the managed object classes for idle mode parameters LTE to GSM:
  - GFIM/GNFL parameters are broadcasted in the SIB7



UFFIM: UTRA Frequency Idle Mode Parameters
GFIM: GERAN Frequency Idle Mode Parameters
GNFL: GERAN Neighbours Frequency List

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Inter RAT cell re-selection
Measurements Triger

- IRAT cell reselection procedure and related parameters are similar to those for inter frequency cell reselection

- Similar to the inter frequency case, there is the priority concept (7 is highest priority, 0 is lowest):
  - The priority of serving cell is defined with **LNCEL:cellReSelPrio**
  - The priority of the neighbouring cell is defined:
    - **For WCDMA: UFFIM: uCelResPrio**
    - **For GSM: GFIM: gCelResPrio**

- If **UFFIM: uCelResPrio/GFIM: gCelResPrio > LNCEL:cellReSelPrio** then measurements of the neighbour WCDMA/GSM cell are mandatory

- If **UFFIM: uCelResPrio/GFIM: gCelResPrio <LNCEL:cellReSelPrio** then measurements are performed when RSRP of serving cell is below Snonintrasearch threshold (same as per inter-frequency):

- **Srxlev <= SNonIntrsearch**

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Inter RAT cell reselection
R-criteria

- Reselection to a **higher priority RAT** will happen if:

WCDMA: $Srxlev_{neighbour}$ > UFFIM:utraFrqThrH
GSM: $Srxlev_{neighbour}$ > GFIM:gerFrqThrH

- Reselection to a **lower priority RAT** will happen if:

Towards WCDMA:
$Srxlev_{ngbr(WCDMA)}$ > UFFIM:utraFrqThrL
&&
$Srxlev_{serv(LTE)}$ < LNCEL:threshSrvLow

Towards GSM:
$Srxlev_{ngbr(GSM)}$ > GFIM:gerFrqThrL
&&
$Srxlev_{serv(LTE)}$ < LNCEL:threshSrvLow

- The criterias above have to be fullfilled during a time interval **UFFIM:tResUtra** for WCDMA and **GFIM:tResGer** for GSM
- And the UE must have been camped in the current cell more than 1 sec.

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Inter RAT cell reselection
R-criteria

- $Srxlev_{neighbour}$ is referred to the candidate cell:

- **GSM:** $Srxlev_{neighbour}$ = QrxlevMeas – Qrxlevmin – P_compensation
  Where:
  QrxlevMeas = **RSSI**
  Qrxlevmin = GNFL:qRxLevMinGer

- **UMTS:** Srxlev = QrxlevMeas – Qrxlevmin – P_compensation
  Where:
  QrxlevMeas = **CPICH RSCP**
  Qrxlevmin = UFFIM:qRxLevMinUtra
  Additionally Squal > 0 required for UMTS FDD
  Squal = QrxlevMeas – Qqualmin
  Qrxlevmeas = CPICH Ec/No
  Qqualmin = UFFIM:qQualMinUtra

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LTE → 3G cell reselection, signalling example

UE is in LTE

UE is in 3G

LTE playback full details | LTE playback full details

	Event ID	Transf. dir.	Time	Message name
73.	RRCSM	Downlink	11:49:09.343	MasterInformationBlock
74.	RRCSM	Downlink	11:49:09.343	SystemInformationBlockType1
75.	RRCSM	Downlink	11:49:10.035	SystemInformationBlockType1
76.	RRCSM	Downlink	11:49:13.734	MasterInformationBlock
77.	RRCSM	Downlink	11:49:13.886	SystemInformationBlockType1
78.	RRCSM	Downlink	11:49:15.203	SystemInformationBlockType1
79.	RRCSM	Downlink	11:49:15.823	MasterInformationBlock
80.	RRCSM	Downlink	11:49:15.823	SystemInformationBlockType1
81.	RRCSM	Downlink	11:49:19.883	MasterInformationBlock
82.	RRCSM	Downlink	11:49:19.921	SystemInformationBlockType1
83.	RRCSM	Downlink	11:49:20.282	SystemInformationBlockType1
84.	RRCSM	Downlink	11:49:23.959	MasterInformationBlock
85.	RRCSM	Downlink	11:49:24.098	SystemInformationBlockType1
86.	RRCSM	Downlink	11:49:24.098	SystemInformationBlockType1
87.	RRCSM	Downlink	11:49:25.887	SystemInformationBlockType1
88.	RRCSM	Downlink	11:49:26.682	SystemInformationBlockType1
89.	RRCSM	Downlink	11:49:28.573	MasterInformationBlock
90.	RRCSM	Downlink	11:49:28.573	SystemInformationBlockType1
91.	RRCSM	Downlink	11:49:30.375	SystemInformationBlockType1
92.	L3SM	Uplink	11:49:37.302	LOCATION_UPDATING_REQUEST
93.	L3SM	Uplink	11:49:37.302	ROUTING_AREA_UPDATE_REQUEST
94.	L3SM	Downlink	11:49:37.719	AUTHENTICATION_REQUEST
95.	L3SM	Downlink	11:49:37.719	AUTHENTICATION_AND_CIPHERING_REQUEST
96.	L3SM	Uplink	11:49:37.920	AUTHENTICATION_RESPONSE
97.	L3SM	Uplink	11:49:38.025	AUTHENTICATION_AND_CIPHERING_RESPONSE
98.	L3SM	Downlink	11:49:38.025	TMSI_REALLOCATION_COMMAND
99.	L3SM	Uplink	11:49:38.025	TMSI_REALLOCATION_COMPLETE
100.	L3SM	Downlink	11:49:38.339	IDENTITY_REQUEST
101.	L3SM	Uplink	11:49:38.339	IDENTITY_RESPONSE
102.	L3SM	Downlink	11:49:38.433	LOCATION_UPDATING_ACCEPT
103.	L3SM	Downlink	11:49:38.777	ROUTING_AREA_UPDATE_ACCEPT
104.	L3SM	Uplink	11:49:38.777	ROUTING_AREA_UPDATE_COMPLETE
105.	L3SM	Uplink	12:03:13.987	SERVICE_REQUEST
106.	L3SM	Downlink	12:03:14.631	MODIFY_PDP_CONTEXT_REQUEST
107.	L3SM	Uplink	12:03:14.631	MODIFY_PDP_CONTEXT_ACCEPT

Search
Find:
Column:
Any
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Filter out
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Layers

Information

LTE RRC signaling

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Downlink

SystemInformationBlockType1 (3GPP TS 36.331 ver 8.7.0

```
BCCH-DL-SCH-Message
 message
  c1
   systemInformationBlockType1
    cellAccessRelatedInfo
     plmn-IdentityList
      plmn-IdentityList value 1
       plmn-Identity
        mcc
         mcc value    : 2, 3, 8
        mnc
         mnc value    : 2, 0
       cellReservedForOperatorUse    : notReserved
     trackingAreaCode
      Bin    : 17 70  (= 6000)
     cellIdentity
      Bin    : 27 1C 21 E (= 41009694)
```


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RL50/35/FZ Improvements/additions

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List of RL50/RL35TD/RL50FZ Idle Mode Mobility Features/Improvement

- LTE1036 RSRQ based Cell Reselection.
- LTE487 Idle Mode Mobility Load Balancing

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LTE1036 RSRQ based reselection - Introduction

Cell selection and cell reselection in Rel.8

- For evaluation of conditions used for cell selection and cell reselection processes UE terminals Rel.8 use only RSRP (Reference Signal Received Power) based measurements of LTE cells
- After UE camps on a cell in cell selection process it is typical that it moves across the network from one cell to another.
- For UEs in IDLE mode (without any transmission) this mobility issue is solved via cell reselection mechanism.

Cell selection and cell reselection are fundamental functionalities in LTE and implemented in NSN product since the first LTE release - RL10/RL15TD/RL50FZ

- LTE39 System information broadcast
- LTE762 Idle mode mobility from LTE to WCDMA, GSM or other LTE bands

  …and later on in RL20/RL35TD/RL50FZ
- LTE870 Idle mode mobility from LTE to CDMA/eHRPD

  …and in RL30/RL35TD/RL50FZ
- LTE807 Idle mode mobility from LTE to CDMA/1xRTT

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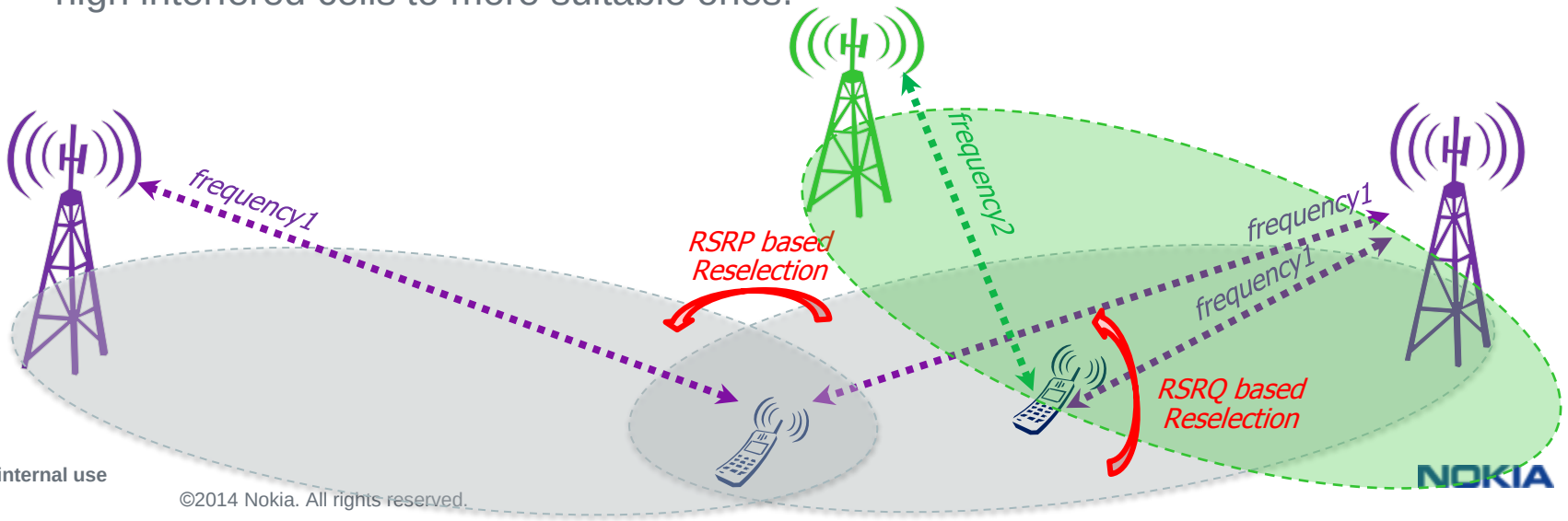
LTE1036 RSRQ based reselection

- **Cell selection and cell reselection in Rel.9**
  - Cell reselection triggered by weak signal power (RSRP based for LTE) prevents UEs in IDLE mode from losing network connectivity at the cell edge due to coverage loss.
  - Cell reselection triggered by weak signal quality (RSRQ based for LTE) prevents UEs in IDLE mode from losing connectivity at any place within the cell where high interferences appear and in this context RSRQ based reselection provides offloading of UEs from the high interfered cells to more suitable ones.



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LTE1036 RSRQ based reselection

- **Cell selection and cell reselection in Rel.9**
  - According 3GPP, UE terminals Rel.9 are obligated to make besides RSRP (Reference Signal Received Power) also RSRQ (Reference Signal Received Quality) based measurements and use them for cell selection and cell reselection procedures.
  - All Rel.9 and higher compliant UE terminals shall support RSRQ measurements in IDLE mode
  - RSRQ, as relevant to LTE technology, is applicable for measurements of LTE serving cell as well as neighbor intra-frequency and inter-frequency LTE cells.
  - In Rel.9 the scope of SI (System Information) messages broadcasted by eNB is extended by information applicable for RSRQ measurements.
  - Also criteria for cell selection and cell reselection were modified in Rel.9.
  - **In RL50 LTE1036 RSRQ based cell reselection is introduced to be inline with Rel.9 cell selection and cell reselection requirements.**
    - The feature introduces new handling not only for cell reselection (as feature name indicates) but affects also cell selection process.

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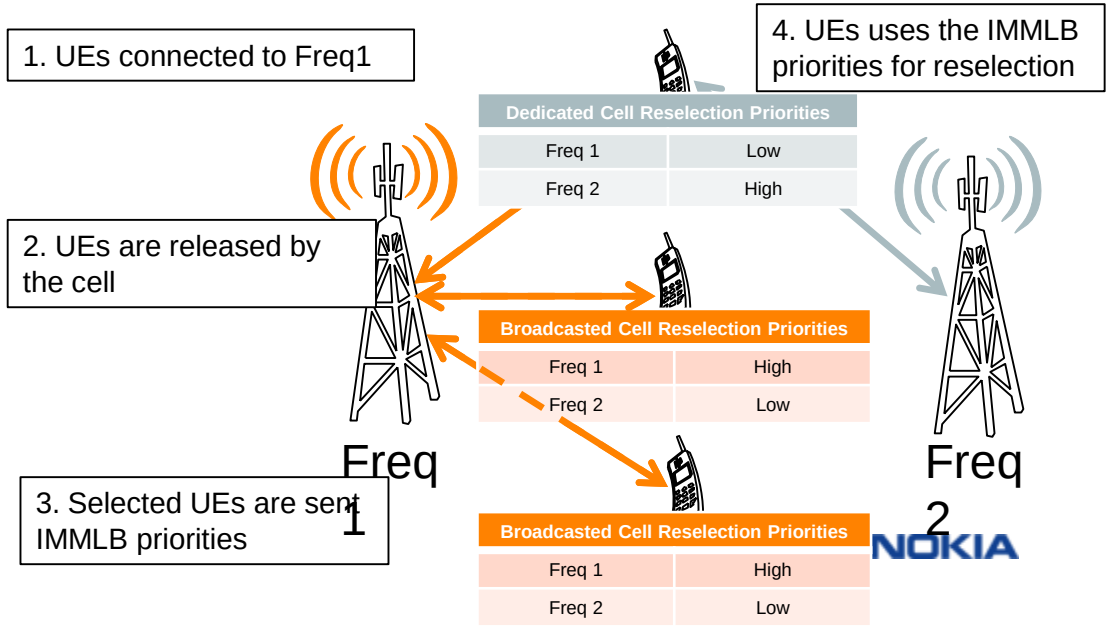
LTE 487 Idle Mode Mobility Load Balancing - Example

- The LTE487 idle mode mobility load balancing (IMMLB) feature allows for statistical distribution of UEs towards different frequency layers and RATs
  - A configurable percentage of UEs switching from connected to idle state are provided configurable dedicated IMMLB cell reselection priorities for different frequency layers and RATs via RRC Release message
  - The provision of dedicated priorities is a means to steer UEs toward frequency layer or RAT with the highest priority subject to cell reselection thresholds
  - There is no load trigger to start IMMLB, i.e. each UE release would initiate UE and target selection procedures

Percentage of UEs	33%

Broadcasted Cell Reselection Priorities	
Freq 1	High
Freq 2	Low

Dedicated Cell Reselection Priorities	
Freq 1	Low
Freq 2	High



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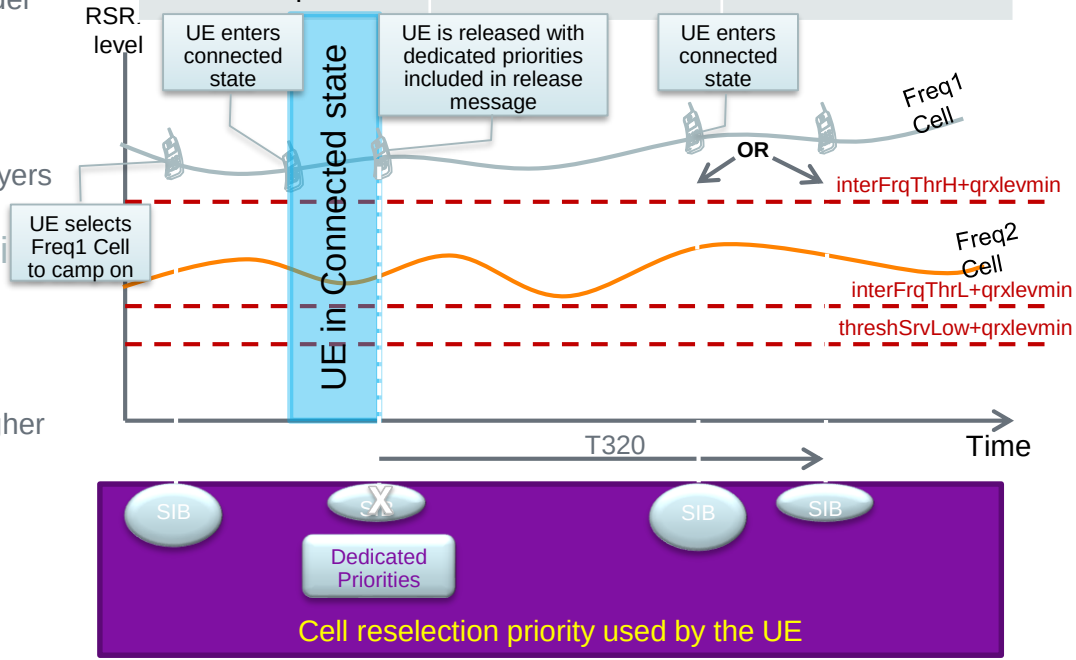
LTE 487 Idle Mode Mobility Load Balancing - Example

- **IMMLB mechanism (3/3)**
- It should be noted that receiving dedicated cell reselection priorities when UE is released does not guarantee the reselection of the UE towards the higher priority layer
  - The neighbor cells should meet cell reselection thresholds (according to the priority used for the neighbor cell) in order for the UE to reselect to the neighbor cells
  - In the example, UE cannot reselect to the higher priority Freq2 cell since measured RSRP is below the *"interFrqThrH+qrxlevmin"*
  - Cell reselection thresholds should be aligned between layers in order to avoid reselection ping-pongs
- IMMLB only takes effect if there is a difference in cell reselection prioritization order between SIB priorities and dedicated priorities from RRC connection release message
  - For example, equal/lower priority cells in SIB become higher priority cells via dedicated priorities sent when UE is released

Cell reselection priorities configured in Freq1 Cell		
	SIB Cell Reselection Priorities	Dedicated Cell Reselection Priorities
Freq 1	7	5
Freq 2	5	7



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Additions RL60/45 – idle mode load balancing extensions

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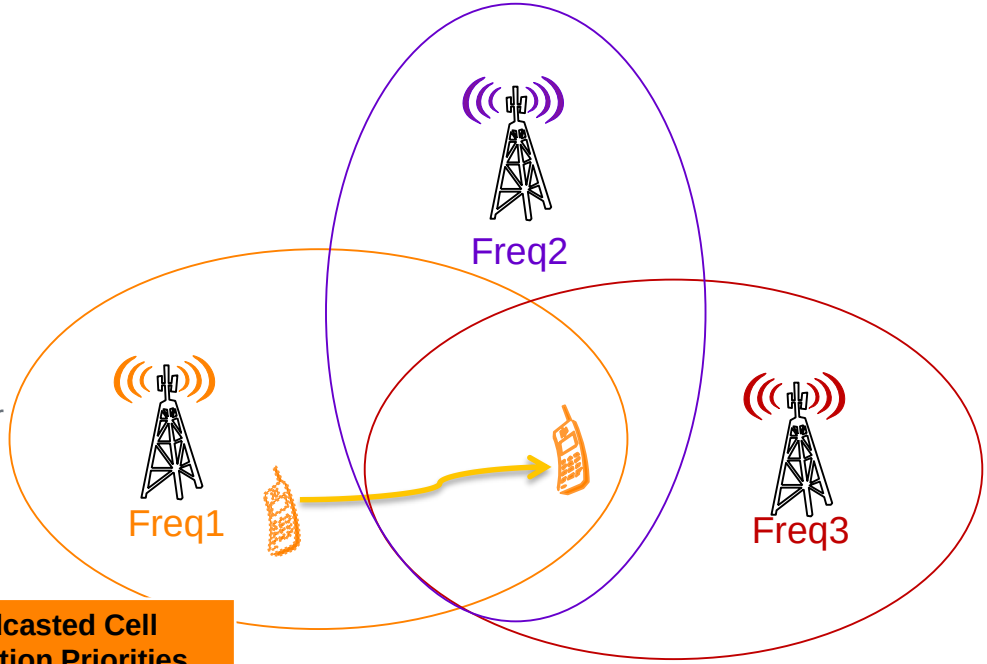
LTE1677: Idle mode mobility balancing extensions

Cell Reselection

Selection of Cell in RRC idle is done according to:

- Certain defined thresholds (based on **RSRP, RSRQ**)
- Priorities (Broadcasted and **Dedicated**)

- Broadcasted Cell Reselection Priorities ***are contained in SIBs*** and can be read by the UE
- Dedicated Cell Reselection Priorities are used by Load Balancing (LB) features
  - Dedicated Cell Reselection Priorities **are sent** only for UEs that are candidates for LB
  - They are sent in **Idle Mode Mobility Control Info (IMMCI)** that is a part of **RRC Connection Release Message**



Broadcasted Cell Reselection Priorities	
Freq 1	High
Freq 2	Medium
Freq 3	Low

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LTE1677: Idle mode mobility balancing extensions

With LTE1677 (from RL60)

The LTE1677 idle mode mobility load balancing extension allows for **statistical distribution** of UEs towards **different frequency layers and RATs**

- A configurable **percentage of UEs** switching from **connected to idle state** are provided dedicated **IMMLB cell reselection priorities** that were calculated with usage of configurable **IMMLB weights and priorities configured for SIB broadcast**
- Different sets of Dedicated Cell Reselection Priorities among UEs evaluated under **the same object**: MOPR-x/MODPR/LNCEL are possible

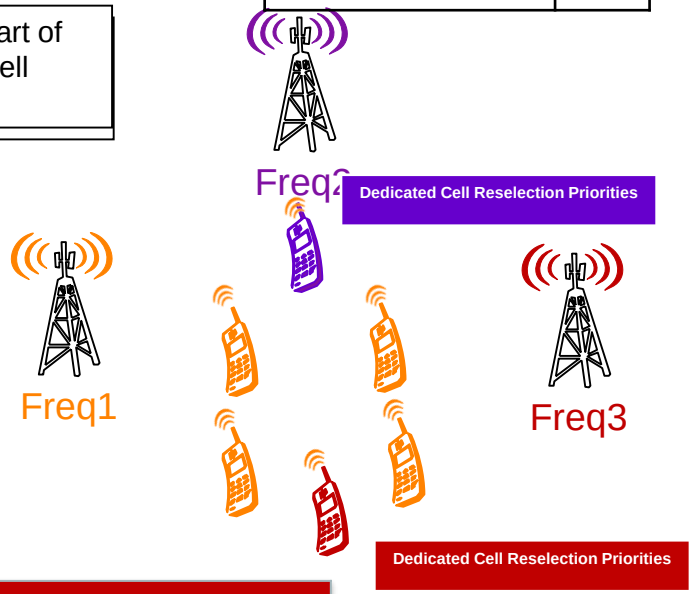
According to different priorities part of UEs can be camped in different cell (Freq 2 and Freq 3).

Broadcasted Cell Reselection Priorities	
Freq 1	High
Freq 2	Medium
Freq 3	Low

Dedicated Cell Reselection Priorities *	
Freq 2	High
Freq 3	Medium
Freq 1	Low

Dedicated Cell Reselection Priorities *	
Freq 3	High
Freq 1	Medium
Freq 2	Low

Percentage of UEs	33%



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General Inter-RAT cell Reselection Parameter Summary (1/3)

MOC	Parameter Name	Description	Range and step	Default value	GMC Value
LNCEL	sNonIntrsearch	Defines the threshold (in dB) for inter-frequency and inter-RAT measurements	0...62 dB, step 2 dB	-	2
LNCEL	qrxLevMin	Minimum required RX RSRP in the serving cell	-140...-44 dBm, step 2 dBm	-	-130 dBm
LNCEL	qRxLevMinOffset	Affects the minimum required RX level in the serving cell	2...16 dB, step 2 dB	-	
LNCEL	pMaxOwnCell	Used to calculate P_compensation	-30...33 dBm, step 1 dBm	-	33 dBm
LNCEL	cellReSelPrio	Absolute priority of the serving layer. 0 means the lowest priority.	0...7, step 1	-	1
LNCEL	threshSrvLow	Threshold for the serving frequency used in reselection evaluation towards lower priority EUTRAN frequency or RAT	0...62 dB, step 2 dB	-	2
UFFIM	tResUtra	UTRA cell reselection timer	0...7, step 1	-	-
UFFIM	utrFddCarFrqL	List of UTRA FDD carrier frequencies		-	-
UFFIM	dlCarFrqUtra	DL Utra frequency	0...16383, step 1	-	-

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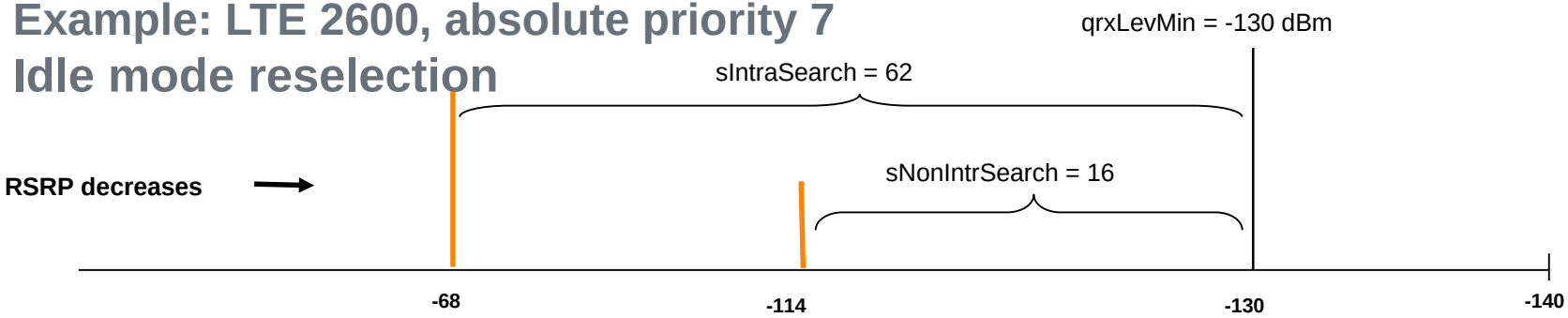
Example: LTE 2600, absolute priority 7
Idle mode reselection



When RSRP < -68 dBm UE starts to measure intra-freq neighbours

LNCEL:Qhyst = 3dB
IAFIM: qOffestCell = 0dB

Reselection to other LTE2600 cell will happen:

1. **When neighbour is 3dB better than serving**
2. **For a time LNCEL:tReselEutr = 1s**
3. **AND more than 1 s has elapsed since the UE camped in the currrent cell**

Rn > Rs + qoff + hys

When RSRP < -114 dBm UE starts to measure on LTE1800 and WCDMA

LNCEL:threshSrvLow = 10
IRFIM:interFrqThrL = 20
IRFIM:qRxLevMinInterF= -130dBm

Reselection to LTE1800 cell will happen:

1. **When serving is below -120dBm AND LTE1800 neighbour's RSRP is better than -110 dBm**
2. **For a time IRFIM:intertResEutr = 1s**
3. **AND more than 1 s has elapsed since the UE camped in the current cell**

Srxlev, n > qRxLevMinInter/Utra + interFrqThrhL
Srxlev, s < qRxLevMin + threshSrvLow

LNCEL:threshSrvLow = 10
UFFIM:utraFrqThrL = 10
UFFIM:qRxLevMinUtra= -119 dBm

If no suitable LTE1800 cell found, then reselection to WCDMA will happen

1. **When serving cell is below -120 dBm and neighbouring WCDMA cell RSCP > -109 dBm**
2. **For a time UFFIM:tResUtra = 1s**
3. **AND more than 1 s has elapsed since the UE camped in the current cell**

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