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QXDM/QCAT Log Analysis for LTE - Basic Functionality and Operational Scenarios

November 2014

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Agenda

- Working with QXDM
  - Introduction
  - Main Views
  - Log mask
  - Real time displays/plots
- LTE Log Analysis with QXDM
  - DL Data Transfer
  - UL Data Transfer
  - Intra-LTE Mobility
  - RLF

Working with QXDM – Introduction

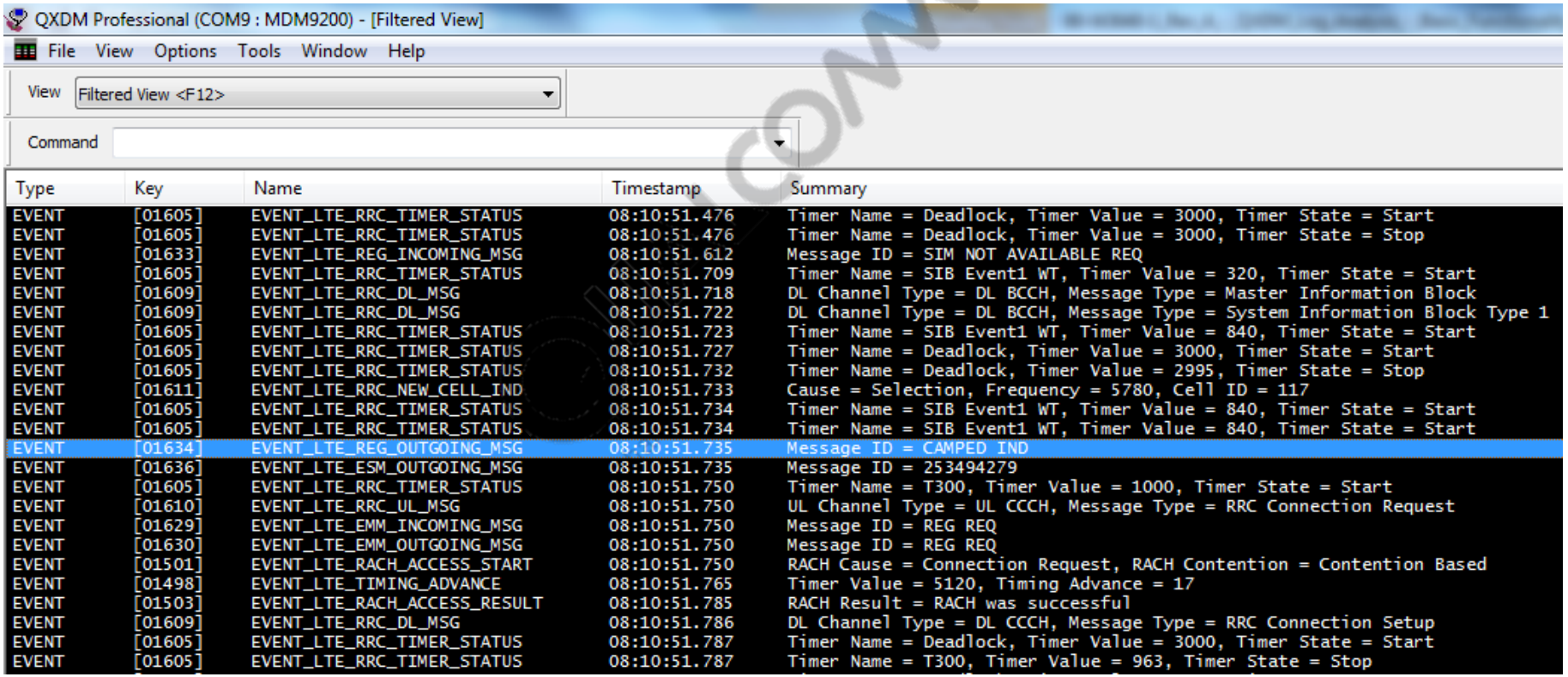
- QXDM is a Diagnostic Monitor tool used for:
  - *Diagnostic Protocol Packet logging*
  - *Real-time monitoring of progress*
  - Real-time displays/plots
  - Basic post-processing
- QCAT is the underlying parser for QXDM
- QCAT is used for:
  - *Post-processing*
  - Packet filtering
  - Acts as Friendly viewer for Log packets with tables, like 0xB173 (LTE PDSCH Stat Indication)

Various Views in QXDM

- Main Views - *Item View*, *Filtered View*

  - **Item View** – Main window. The Item View (F11) is a special item list view that shows all items generated during a QXDM session. Always save (and upload) logs from Item View. File->New Items (ALT + I) to restart logging, and using the File->Save Items (CTRL + I) to save the log session.
  - **Filtered View** – A Filtered View represents a subset of the contents of the current ISF and therefore the Item View. This subset is configured by item type and/or item key. Unlimited filtered views may be created by using the accelerator key F12 or selecting Filtered View from the View Bar.

QXDM Filtered View



Type	Key	Name	Timestamp	Summary
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	08:10:51.476	Timer Name = Deadlock, Timer Value = 3000, Timer State = Start
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	08:10:51.476	Timer Name = Deadlock, Timer Value = 3000, Timer State = Stop
EVENT	[01633]	EVENT_LTE_REG_INCOMING_MSG	08:10:51.612	Message ID = SIM NOT AVAILABLE REQ
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	08:10:51.709	Timer Name = SIB Event1 WT, Timer Value = 320, Timer State = Start
EVENT	[01609]	EVENT_LTE_RRC_DL_MSG	08:10:51.718	DL Channel Type = DL BCCH, Message Type = Master Information Block
EVENT	[01609]	EVENT_LTE_RRC_DL_MSG	08:10:51.722	DL Channel Type = DL BCCH, Message Type = System Information Block Type 1
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	08:10:51.723	Timer Name = SIB Event1 WT, Timer Value = 840, Timer State = Start
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	08:10:51.727	Timer Name = Deadlock, Timer Value = 3000, Timer State = Start
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	08:10:51.732	Timer Name = Deadlock, Timer Value = 2995, Timer State = Stop
EVENT	[01611]	EVENT_LTE_RRC_NEW_CELL_IND	08:10:51.733	Cause = Selection, Frequency = 5780, Cell ID = 117
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	08:10:51.734	Timer Name = SIB Event1 WT, Timer Value = 840, Timer State = Start
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	08:10:51.734	Timer Name = SIB Event1 WT, Timer Value = 840, Timer State = Start
EVENT	[01634]	EVENT_LTE_REG_OUTGOING_MSG	08:10:51.735	Message ID = CAMPED IND
EVENT	[01636]	EVENT_LTE_ESM_OUTGOING_MSG	08:10:51.735	Message ID = 253494279
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	08:10:51.750	Timer Name = T300, Timer Value = 1000, Timer State = Start
EVENT	[01610]	EVENT_LTE_RRC_UL_MSG	08:10:51.750	UL Channel Type = UL CCCH, Message Type = RRC Connection Request
EVENT	[01629]	EVENT_LTE_EMM_INCOMING_MSG	08:10:51.750	Message ID = REG REQ
EVENT	[01630]	EVENT_LTE_EMM_OUTGOING_MSG	08:10:51.750	Message ID = REG REQ
EVENT	[01501]	EVENT_LTE_RACH_ACCESS_START	08:10:51.750	RACH Cause = Connection Request, RACH Contention = Contention Based
EVENT	[01498]	EVENT_LTE_TIMING_ADVANCE	08:10:51.765	Timer Value = 5120, Timing Advance = 17
EVENT	[01503]	EVENT_LTE_RACH_ACCESS_RESULT	08:10:51.785	RACH Result = RACH was successful
EVENT	[01609]	EVENT_LTE_RRC_DL_MSG	08:10:51.786	DL Channel Type = DL CCCH, Message Type = RRC Connection Setup
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	08:10:51.787	Timer Name = Deadlock, Timer Value = 3000, Timer State = Start
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	08:10:51.787	Timer Name = T300, Timer Value = 963, Timer State = Stop

- Filtered View can be configured to display a subset of Items, e.g., specific Events (as shown)

QXDM Configuration/Log Mask

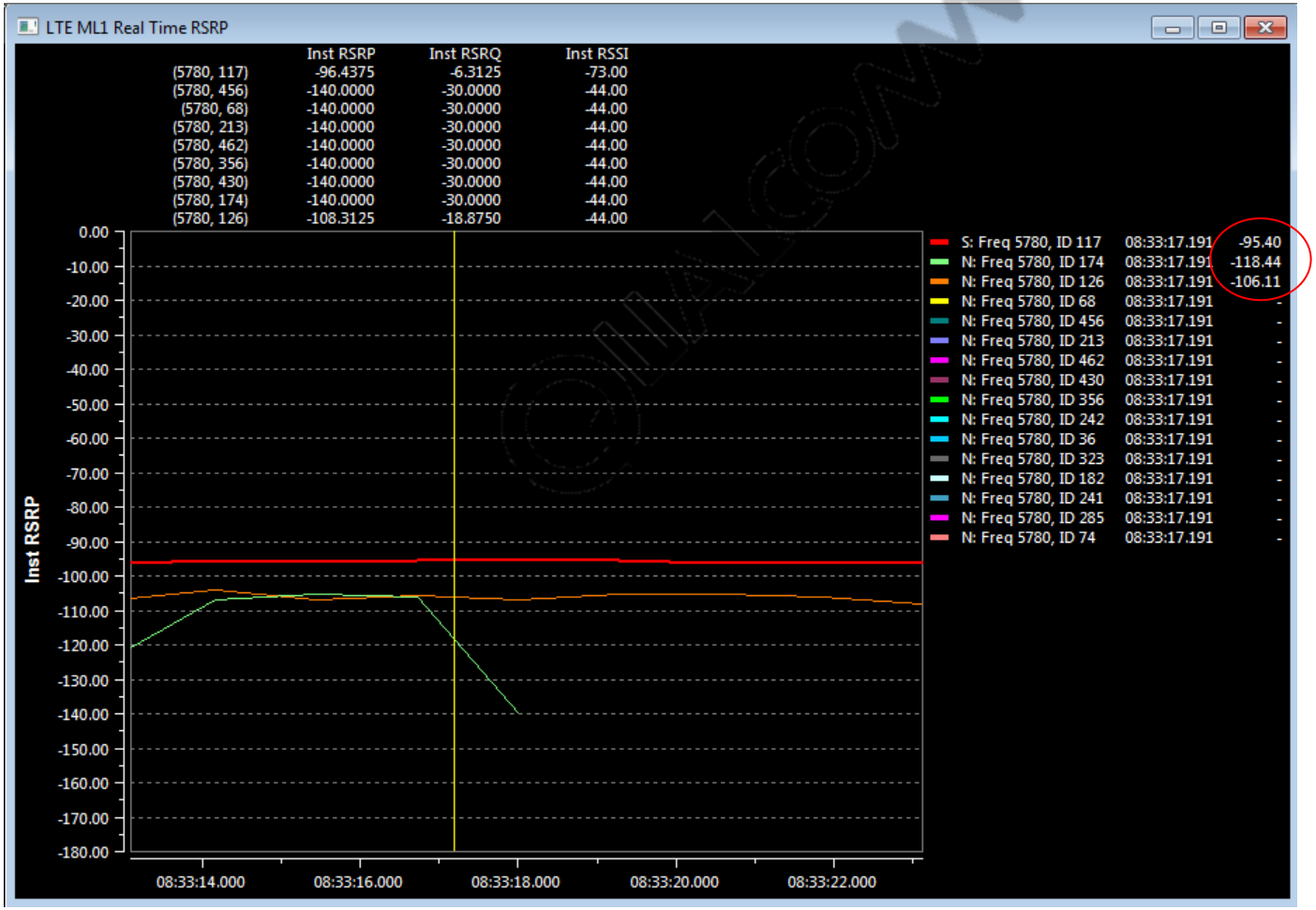
- A configuration defines what Log packets are logged and what windows/displays are configured by the user
- To load a new Configuration
  - File – Load Configuration
- To add packets to an existing log mask:
  - Options –>Log View Configuration–>Log Packets –>Edit Log Packet Selections –>Known Log Items –>LTE
  - Options – Log View Configuration–>Message Packets –>Known Messages (By Subsystem) –>LTE
  - Options – Log View Configuration –>Event Reports –>Known Events –>LTE
- To save a new log mask:
  - File – Save Configuration

QXDM Displays/Plots

- Plots – Helpful in real-time monitoring of Metrics
  - DL Throughput and BLER
  - UL Throughput and BLER
  - Real Time RSRP…
  - LTE RRC State Change Plot
  - IRAT Indicator Display

- NV Items – Do not change any NV Items and maintain the Factory default settings. However:
  - For Test purposes, a user may change the Mode Preference (NV Item 10), e.g., putting the device in LTE Only mode or WCDMA only, etc.
  - For LTE, Mode Preference (NV Item 10) is typically set to 4 (Determine Mode Automatically), 30 (LTE Only), 31 (GWL)

QXDM Plots – Real Time RF Metrics



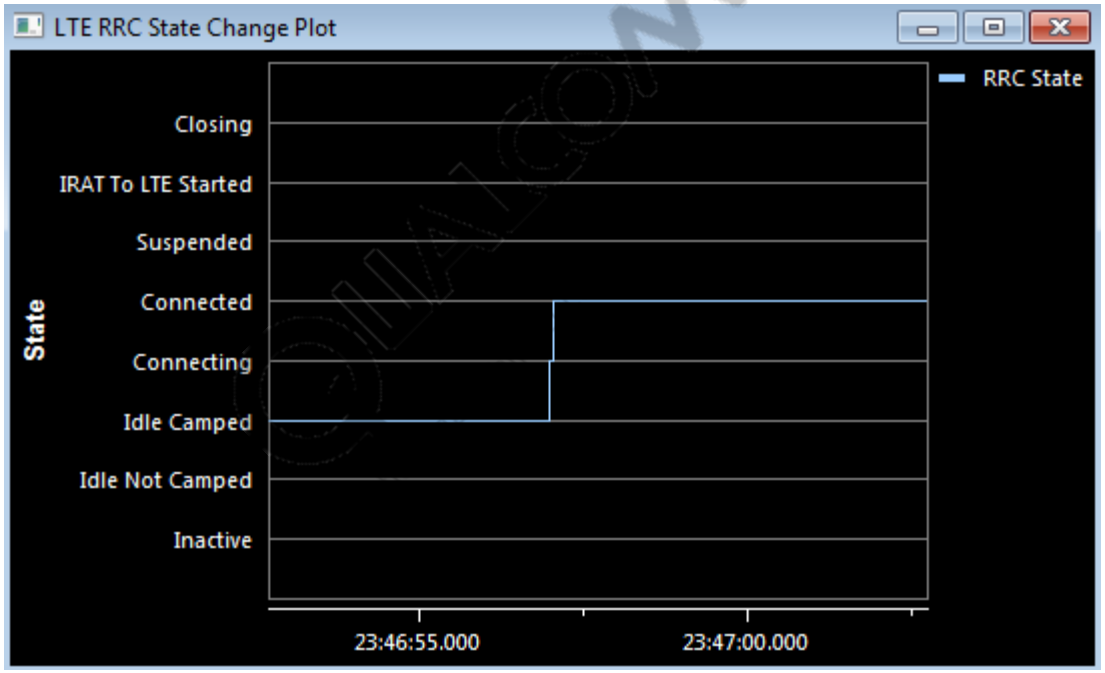
Note: Enable Cursor by right clicking on the display. Selecting Cursor causes a vertical line cursor to displayed or hidden on views that support this feature. Values for items over which the cursor is placed are displayed in the legend. The cursor can be dragged with the mouse to highlight points on the graph.

- **LTE ML1 Real Time RSRP Plot gives RSRP, RSRQ, and RSSI for Serving and Neighbor cells**

QXDM Plots – Serving Cell Measurements Display

- Serving Cell Measurement display provides real time RF Metrics (RSRP, RSRQ, RSSI, SINR) for the Serving Cells

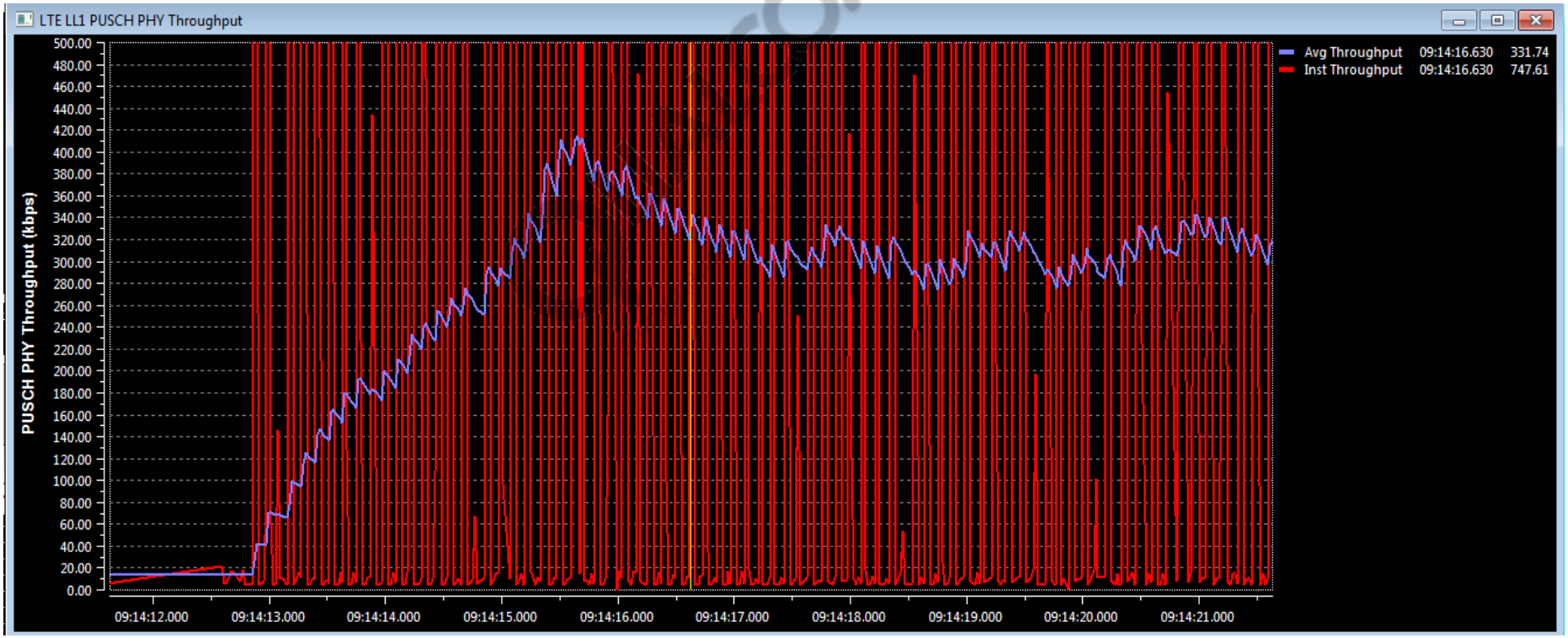
QXDM Plots – LTE RRC State Change Plot



- LTE RRC State Change Plot tells about the RRC state of the UE

QXDM Plots – DL Throughput and BLER

QXDM Plots – PUSCH PHY Throughput

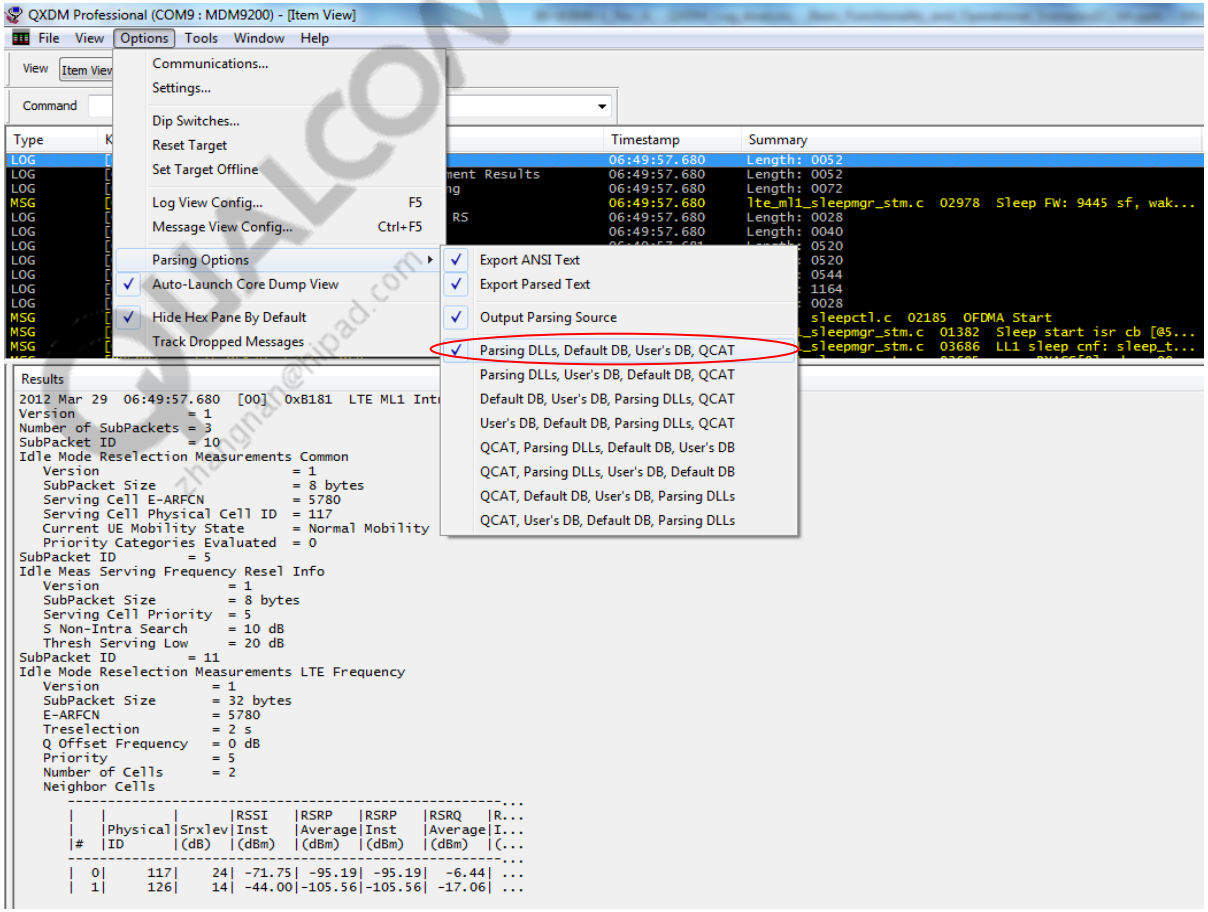


IRAT Indicator Display

- RAT Indicator display can be useful in IRAT Mobility scenarios

What if a Log Packet does not display properly in QXDM?

- If a Log packet doesn't display properly in QXDM, check the Parser options and ensure it is set as shown
- Alternately the user can open the specific QXDM Log in QCAT



LTE Log Analysis with QXDM: DL Data Transfer

DL Performance Troubleshooting Overview

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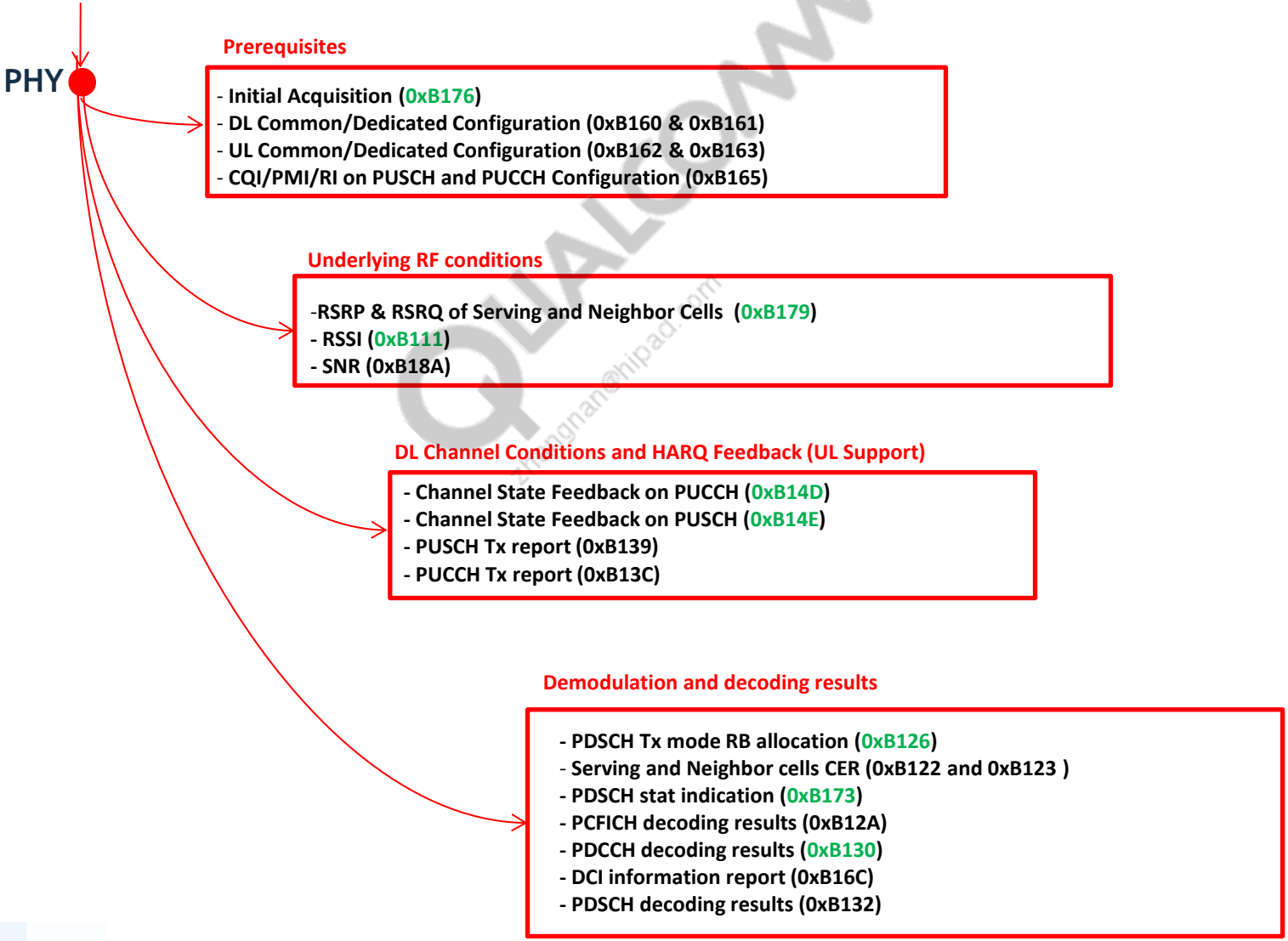
- DL performance: What could go wrong?
  - Underlying RF conditions may not be the most favorable (coverage)
  - Serving cell load could limit scheduling grants in time & frequency (capacity)
  - Load in surrounding neighbors may be too high (interference)
  - Frequent, unnecessary, serving cell changes (Pilot pollution or settings)
  - Link imbalance (different coverage for DL and UL)
  - Parameter Settings (optimization)
  - Backhaul limitation (dimensioning)
- These issues can be diagnosed and understood though log analysis
- Debugging process can be on a single layer or can be extended to multiple protocol layers on a case-by-case basis

Troubleshooting in PHY

Possible causes of low performance detected from PHY perspective:

- **Low RSRP, RSRQ, or SNR**
  - This points to coverage or inter-cell interference issues
- **Scheduling in Time domain**
  - Verify if DL grants occur in contiguous DL SFs
  - If there are gaps in scheduling and geometry is good, this points to:
    - Intra-cell load
    - Not enough data in eNB (backhaul limitation or traffic pattern)
    - Network and Terminal Equipment settings
- **Scheduling in Frequency domain**
  - RB allocation fluctuations could point to load, upper layer issue, or backhaul limitation
- **Scheduling: Space domain**
  - How frequently spatial multiplexing gain is possible (Tx Mode configuration)
- **MCS is lower than expected based on CQI**
  - Points to eNB scheduling issue
- **Discarded Retransmissions are frequently observed**
  - This points to an UL ACK issue or link imbalance or high eNB RSSI
- **Check if UE RSSI is reasonable and not close to sensitivity**
  - (RSSI < -90 dBm, or RSRP < -110 dBm)

DL PHY Relevant Log Information

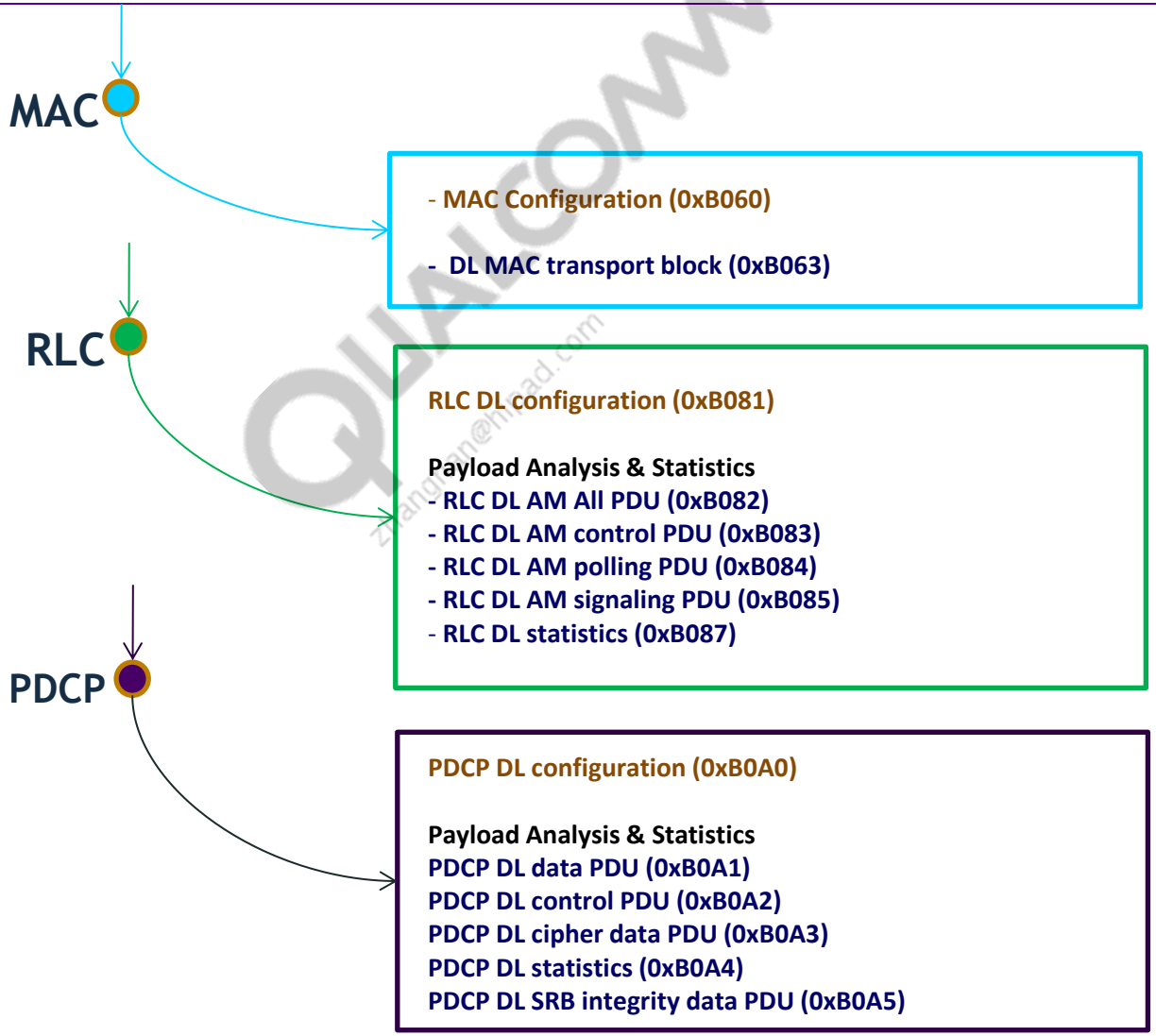


Troubleshooting in L2

Possible low throughput issues detected in L2 logs

- Scheduling duty cycle: How frequently a user is scheduled in MAC
- Differences between scheduled and actual throughput
  - MAC PDUs provide:
    - The scheduled TBS (Transport Block Size) and the effective number of information bytes delivered to physical layer.
    - Additional information about zero padding not available in other layers.
- RLC layer provides information about RLC retransmissions and possible stalls due to link imbalance

L2 Relevant Information



Connected Serving & Neighbor Measurements 0xB179

This ML1 packet contains:

1. Filtered serving and neighbor cell RSRPs
2. Filtered serving and neighbor cell RSRQs
3. List of detected cells from neighbor search

These filtered RSRPs are used to trigger measurement reports. RSRQs can be also used.

Note:

The frequency ML1 packet is logged depends on the setting of the filter coefficient

```
Version                      = 1
E-ARFCN                      = 5780
Serving Physical Cell ID     = 12
Sub-frame Number             = 9460
Serving Filtered RSRP        = -57.75 dBm
Serving Filtered RSRQ        = -7.13 dB
Number of Neighbor Cells     = 2
Number of Detected Cells     = 2
Neighbor Cells
   ------------------------------------
   |   |          |Filtered |Filtered |
   |   |Physical  |RSRP     |RSRQ     |
   |#  |Cell ID   |(dBm)    |(dB)     |
   ------------------------------------
   |  0|       5  |  -74.50 | 8168.13 |
   |  1|     104  | -112.25 | 8132.00 |

Detected Cells
   -------------
   |   |Physical |
   |#  |Cell ID  |
   -------------
   |  0|      96 |
   |  1|     189 |
```

0xB173 – LTE PDSCH Stat Indication

- Contains a wealth of information about the DL performance and throughout
- Relevant Columns for good throughput:
  - Subframe/SFN – all subframes should be scheduled
  - Num RBs – this should be 50 with no fluctuations
  - Num Layers/TBs – should be 2
  - NDI – this should toggle to indicate new data
  - CRC result – should be Pass. Fail indicates DL BLER
  - Discarded re-transmission – should be “none”
  - TB size – should be a high
  - MCS should be 27 - 28

PDSCH STAT Indication (FDD)

2011 Jan 14 23:13:19.562 [00] 0xB173 LTE PDSCH Stat Indication

Version = 3
Version3
Num Records = 18
Records

#	Subframe Num	Frame Num	Num RBs	Num Layers	Num Transport Blocks Present	Transport Blocks HARQ ID	RV	NDI	CRC Result	RNTI Type	TB Index	ReTx Present	TB Size (bytes)	DId Recombining	MCS
0	1	684	12	2	1	0	0	0	Pass	C	1	None	132	No	5
1	7	687	12	2	1	5	0	0	Fail	C	1	None	132	No	5
2	6	688	12	2	1	5	2	0	Fail	C	1	None	132	No	31
3	4	689	12	2	1	5	3	0	Fail	C	1	None	132	No	31
4	2	690	12	2	1	5	1	0	Fail	C	1	None	132	No	31
5	1	691	15	2	1	0	0	1	Fail	C	1	None	136	No	4
6	9	691	15	2	1	0	0	1	Pass	C	1	None	136	No	4
7	1	694	12	2	1	5	0	1	Fail	C	1	None	132	No	5
8	9	694	12	2	1	5	2	1	Pass	C	1	None	132	No	31
9	1	697	12	2	1	0	0	0	Fail	C	1	None	132	No	5
10	9	697	12	2	1	0	0	0	Pass	C	1	None	132	No	5
11	1	700	12	2	1	5	0	0	Fail	C	1	None	132	No	5
12	9	700	12	2	1	5	0	0	Pass	C	1	None	132	No	5
13	1	703	12	2	1	0	0	1	Fail	C	1	None	132	No	5
14	9	703	12	2	1	0	2	1	Fail	C	1	None	132	No	31
15	7	704	12	2	1	0	3	1	Fail	C	1	None	132	No	31
16	9	712	12	2	1	5	0	1	Fail						
17	7	713	12	2	1	5	2	1	Pass						

1 Tx and 3 retransmissions on HARQ 5. None of the attempts is successful.
Throughput degradation is expected.

Same HARQ 5 process used to transmit new data PDU. Observe that NDI has toggled.

There is no Spatial Multiplexing, but still there are two layers defined. Transmit Diversity is used, denoting weak RF coverage.

Diversity; low scheduling, low NumRBs, CRC failures, small TB size, low MCS

PDSCH STAT Indication (TDD)

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1980 Jan 6 00:20:57.830 [00] 0xB173 LTE PDSCH Stat Indication

Version = 4

Num Records = 25

Records

#	Subframe Num	Frame Num	Num RBs	Num Layers	Num Transport Blocks Present	HARQ ID	RV	NDI	CRC Result	RNTI Type	TB Index	Discarded reTx Present	Did Recombining	TB Size (bytes)	MCS	Num RBs
0	9	555	100	2	1	5	0	0	Fail	C	0	None	No	1767	8	100
1	0	556	100	2	1	3	0	0	Fail	C	0	None	No	1767	8	100
2	1	556	100	2	1	2	0	0	Pass	C	0	None	No	1146	7	100
3	4	556	100	2	1	0	0	1	Fail	C	0	None	No	1767	8	100
4	5	556	60	2	1	6	2	0	Pass	C	0	None	Yes	1767	29	60
5	9	556	100	2	1	1	2	1	Pass	C	0	None	Yes	1767	8	100
6	0	557	100	2	1	5	2	0	Pass	C	0	None	Yes	1767	8	100
7	1	557	100	2	1	4	0	0	Pass	C	0	None	No	1146	7	100
8	4	557	100	2	1	3	2	0	Pass	C	0	None	Yes	1767	8	100
9	5	557	100	2	1	0	2	1	Pass	C	0	None	Yes	1767	8	100
10	6	557	100	2	1	2	0	1	Pass	C	0	None	No	970	6	100
11	9	557	100	2	1	6	0	1	Pass	C	0	None	No	1530	7	100
12	0	558	100	2	1	1	0	0	Pass	C	0	None	No	1530	7	100
13	1	558	100	2	1	5	0	1	Pass	C	0	None	No	970	6	100
14	4	558	100	2	1	4	0	1	Pass	C	0	None	No	1530	7	100
15	5	558	53	2	1	3	0	1	Fail	C	0	None	No	810	7	53

There is no Spatial Multiplexing, but still there are two layers defined. Transmit Diversity is used, denoting weak RF coverage.

PDSCH STAT Indication (TDD)

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1980 Jan 6 00:20:58.174 [00] 0xB173 LTE PDSCH Stat Indication
Version = 4
Num Records = 25
Records

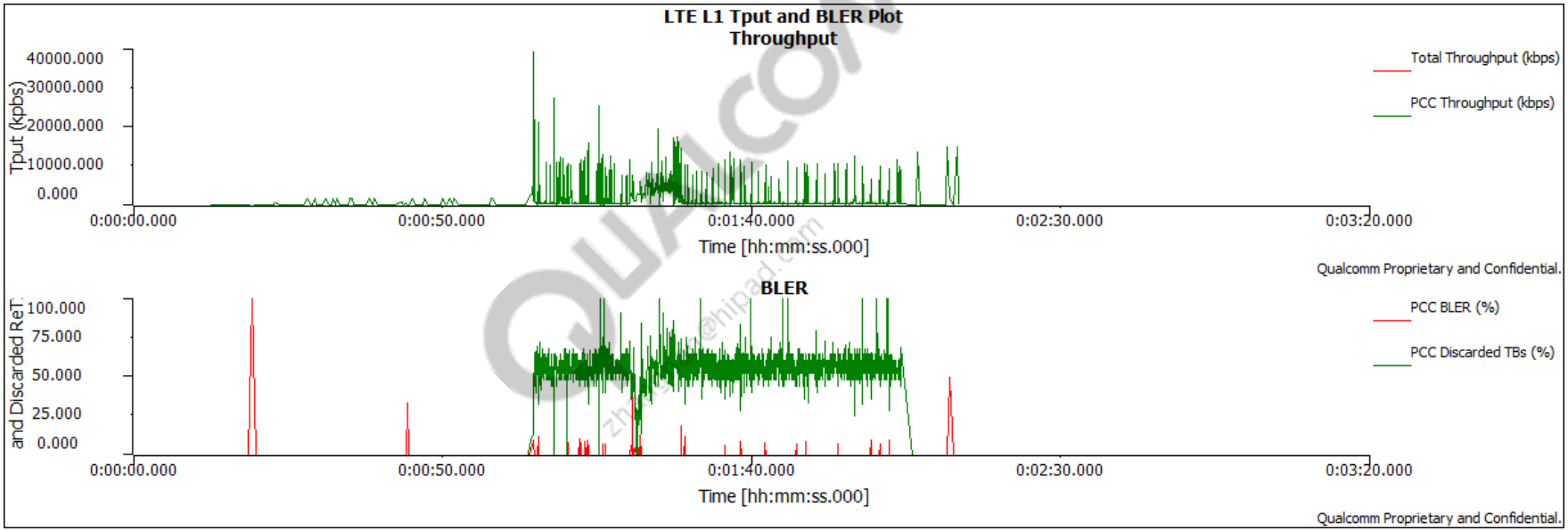
#	Subframe Num	Frame Num	Num RBs	Num Layers	Num Transport Blocks Present	HARQ ID	RV	NDI	CRC Result	RNTI Type	TB Index	Discarded reTx Present	Did Recombining	TB Size (bytes)	MCS	Num RBs
0	5	590	68	2	1	4	0	1	Pass	C	0	None	No	1194	8	68
1	6	590	100	2	1	2	0	1	Pass	C	0	None	No	1146	7	100
2	9	590	100	2	1	0	0	1	Pass	C	0	None	No	1767	8	100
3	0	591	100	2	1	5	0	0	Pass	C	0	None	No	1767	8	100
4	1	591	100	2	1	6	0	0	Pass	C	0	None	No	1146	7	100
5	4	591	100	2	1	1	0	0	Pass	C	0	None	No	1767	8	100
6	5	591	100	2	1	3	0	0	Pass	C	0	None	No	1767	8	100
7	6	591	100	2	1	4	0	0	Pass	C	0	None	No	1146	7	100
8	9	591	100	2	1	2	0	0	Pass	C	0	None	No	1767	8	100
9	0	592	50	2	1	0	2	1	Fail	C	0	Present	No	1767	29	50
10	1	592	100	2	1	5	0	1	Pass	C	0	None	No	1146	7	100
11	4	592	100	2	1	6	0	1	Pass	C	0	None	No	1767	8	100

- 1st DL transmission is successful; nevertheless eNB retransmits same PDU.
- Hint: eNB did not receive UL ACK. If the problem is observed consistently, it may be related to RF link imbalance.

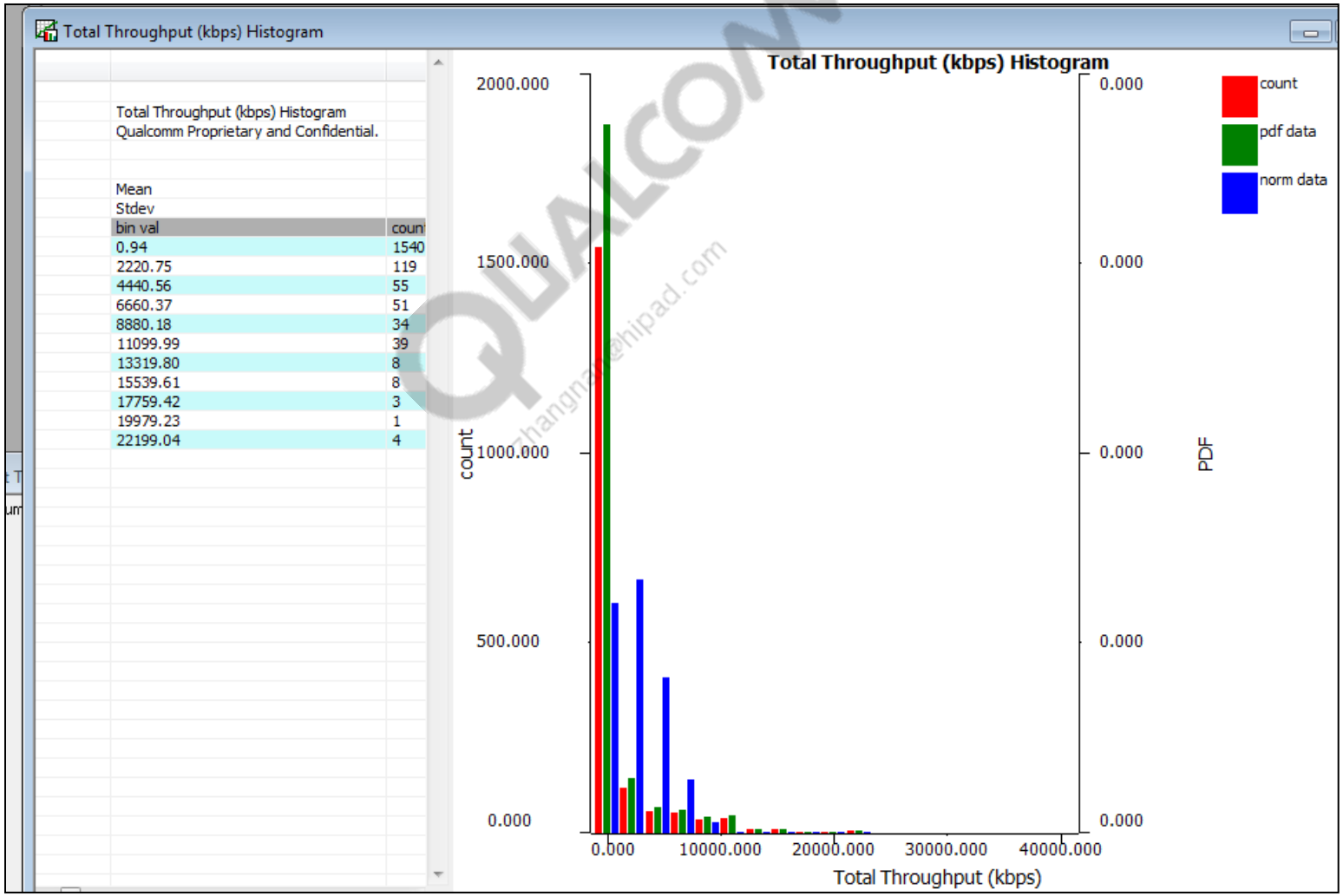
- There is no Spatial Multiplexing, but still there are two layers defined in the DL.
- Transmit Diversity is used, denoting weak DL RF coverage.

- Lower MCS values denotes weak coverage

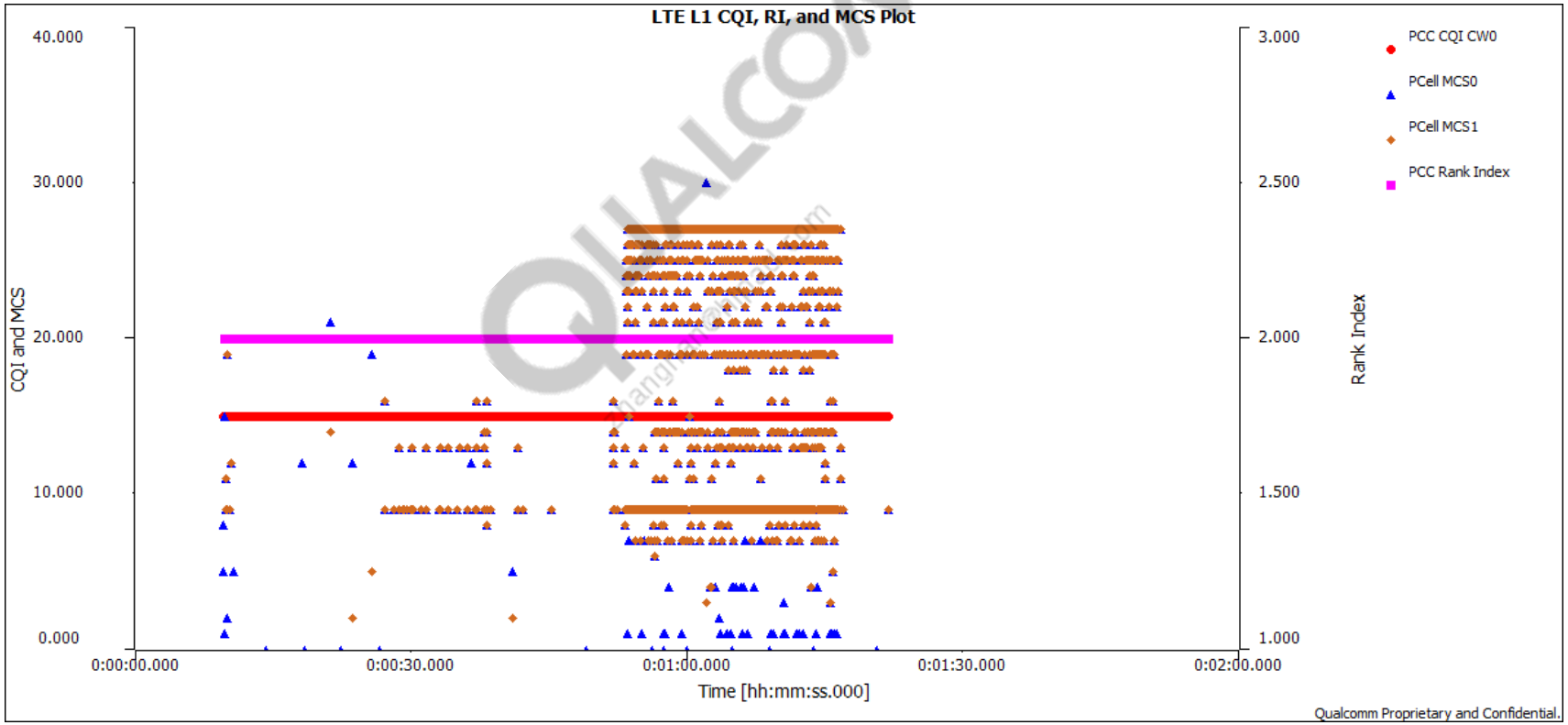
QCAT Views: Throughput and BLER



QCAT Views: Throughput Histograms

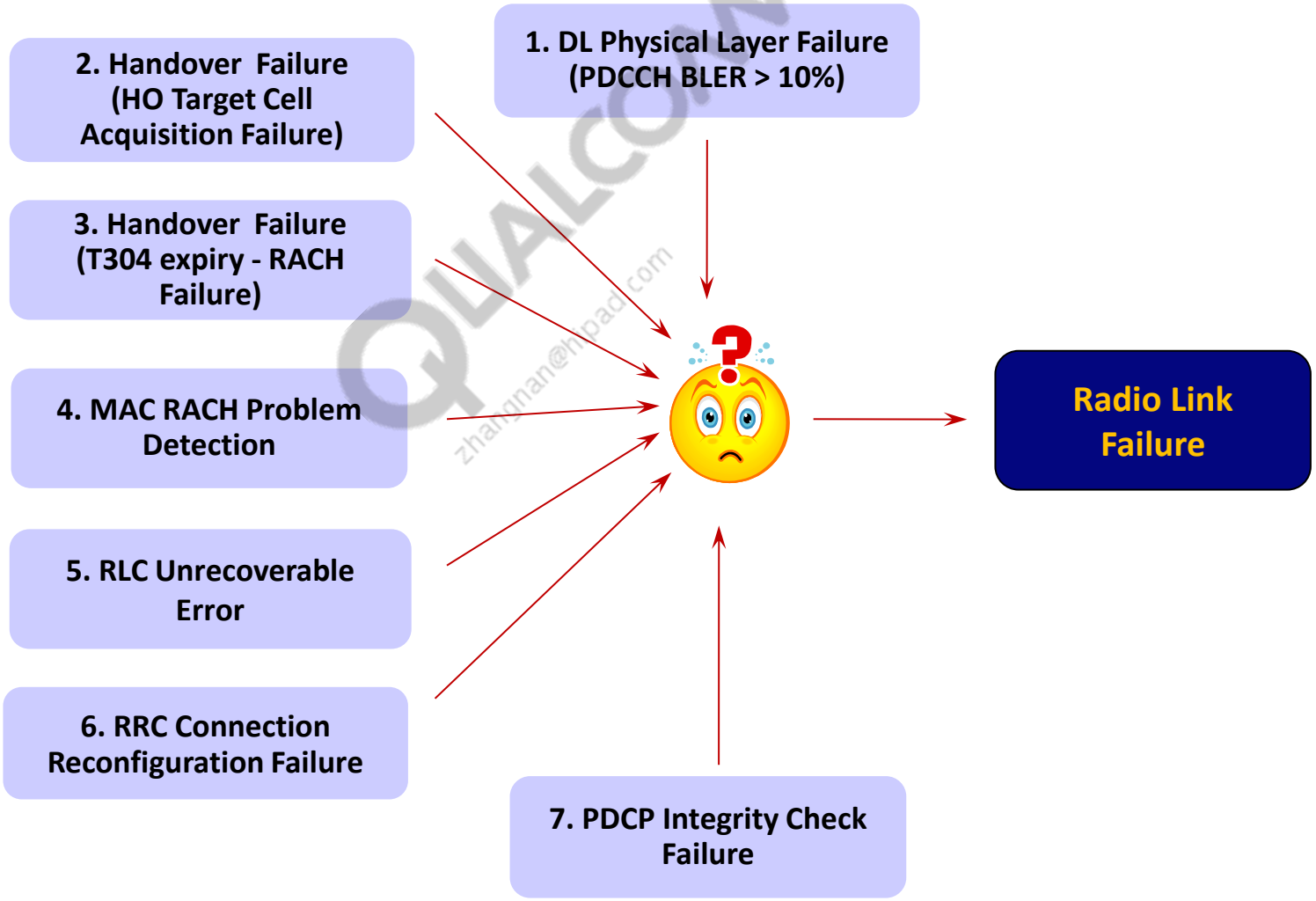


QCAT Views: MCS, CQI, and RI



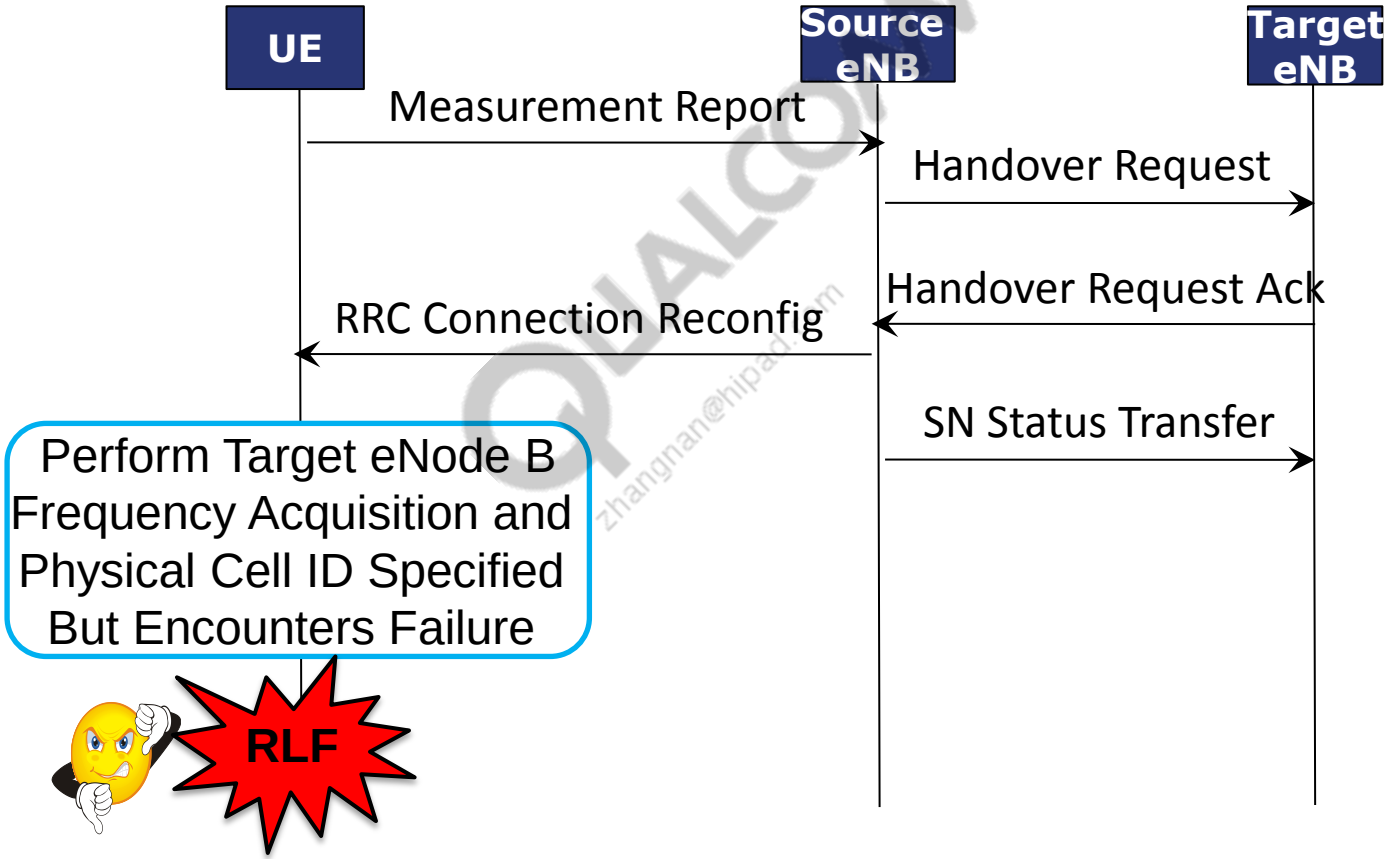
LTE Log Analysis with QXDM: Radio Link Failure Analysis

RLF Scenarios



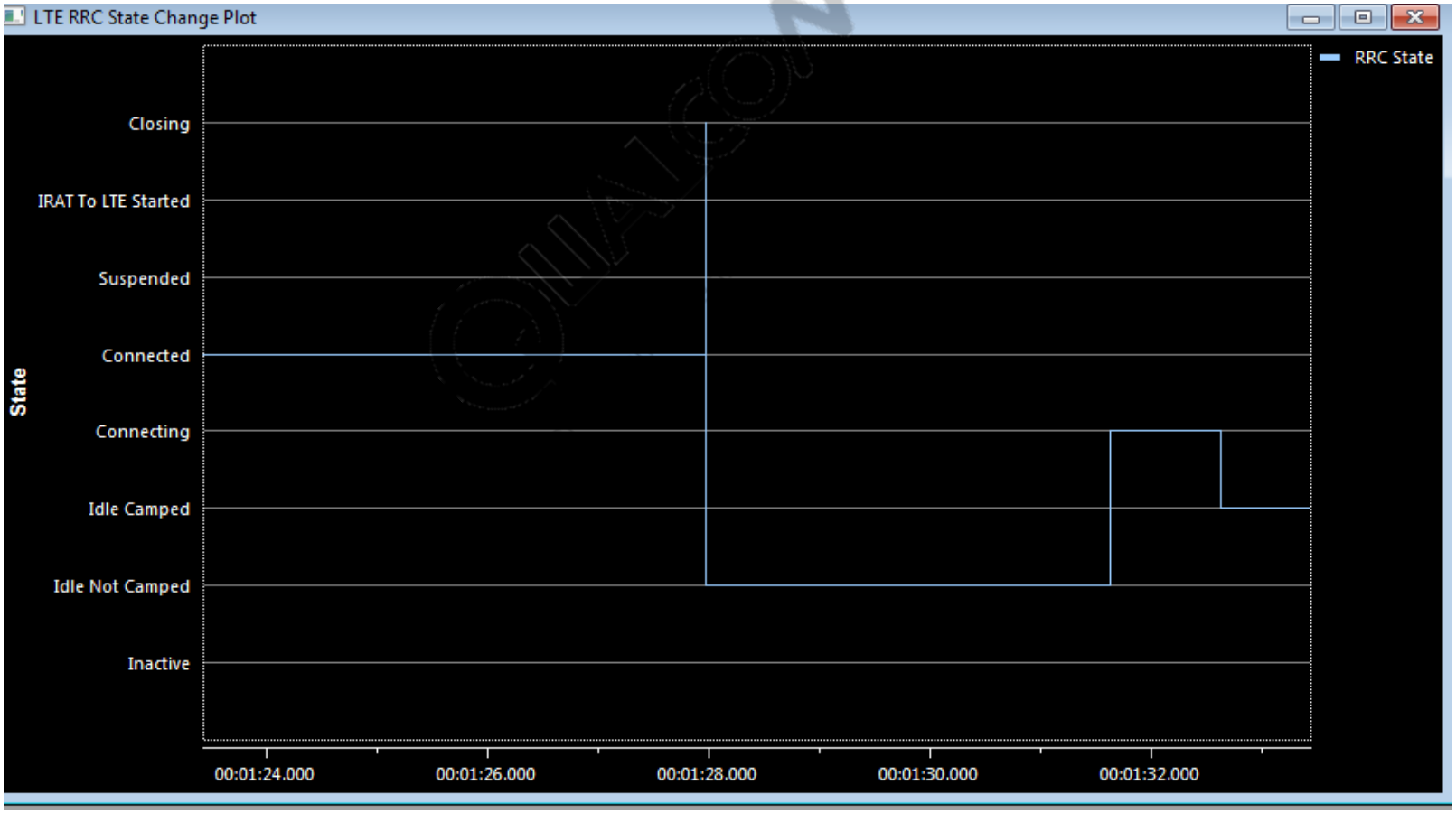
RLF: Handover Failure (Target Cell Acquisition Failure/SIB Read Failure & T304 Timer Expiry)

RLF: Handover Failure



RRC Connection Reconfiguration specifies target eNode B C-RNTI, Radio Resource info, Dedicated RACH Info, SecurityConfigHO, etc.

LTE RRC State Change Plot



RLF: Handoff Failure Analysis

- **EVENT_LTE_RRC_HO_FAILURE**

  This event is logged when UE fails to perform handover

- **EVENT_LTE_RRC_RADIO_LINK_FAILURE**

  `Counter = 1`

  This counter indicates how many times UE declared RLF since power up

EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	20:57:03.021	Timer Name = Deadlock, Timer Value = 3000, Timer State = Start
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	20:57:03.021	Timer Name = Deadlock, Timer Value = 2968, Timer State = Stop
EVENT	[01613]	EVENT_LTE_RRC_HO_FAILURE	20:57:03.021	Length: 0005
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	20:57:03.021	Timer Name = T304, Timer Value = 462, Timer State = Stop
EVENT	[01608]	EVENT_LTE_RRC_RADIO_LINK_FAILURE	20:57:03.021	Counter = 1
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	20:57:03.021	Timer Name = Deadlock, Timer Value = 3000, Timer State = Start
EVENT	[01718]	EVENT_LTE_MAC_RESET	20:57:03.021	Cause = RLF

Results

Counter = 1

RLF: Handoff Failure Analysis (4 of 4)

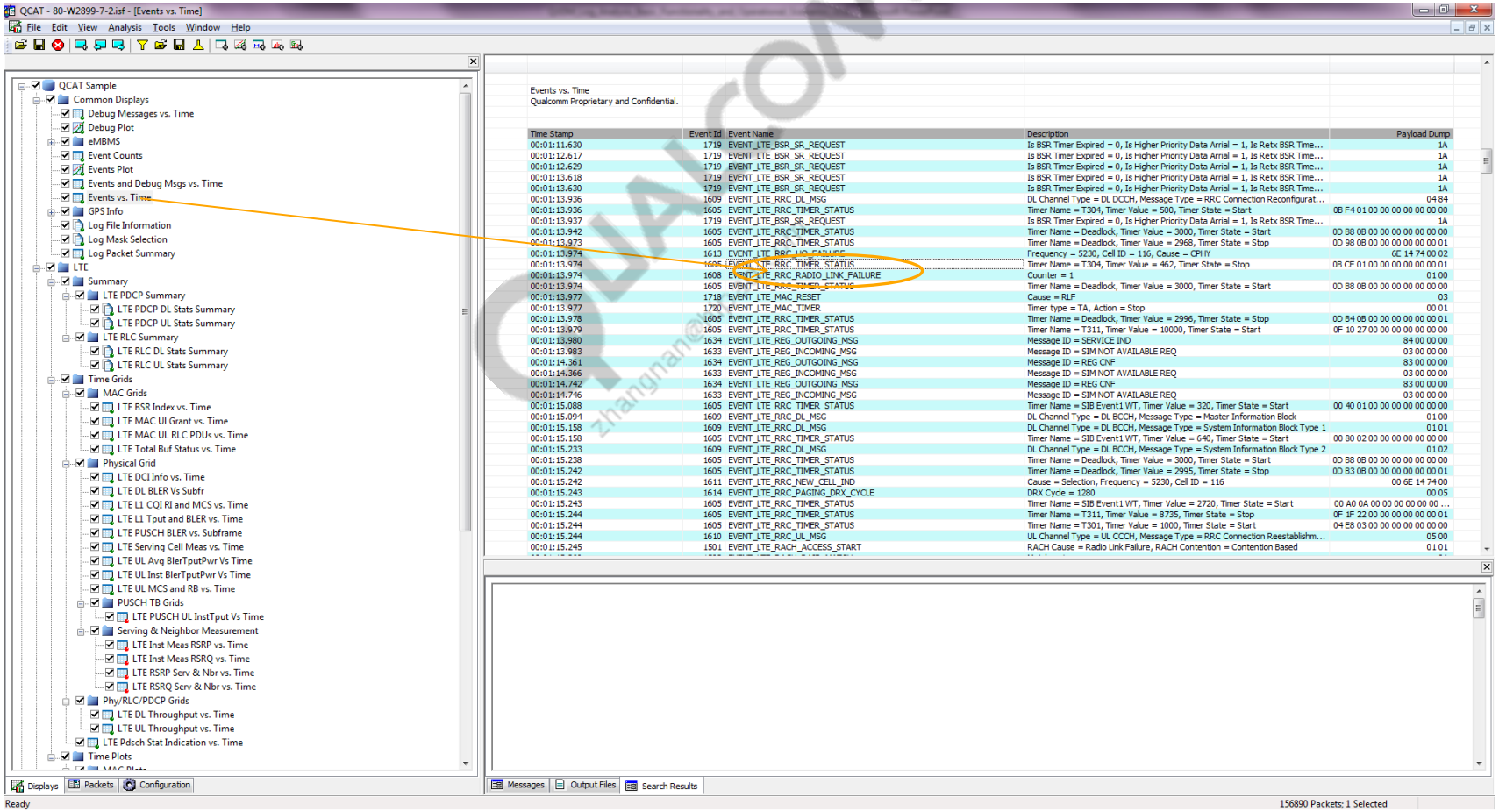
EVENT_LTE_RRC_SIB_READ_FAILURE:
This event indicates SIB Read Failure

EVENT	[01503]	EVENT_LTE_RACH_ACCESS_RESULT	00:01:15.285	Length: 0001
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	00:01:15.327	Timer Name = T301, Timer Value = 916, Timer State = Stop
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	00:01:15.333	Timer Name = Deadlock, Timer Value = 3000, Timer State = Start
LOG	[0xB0C0]	LTE RRC OTA Message	00:01:15.327	Length: 0021
LOG	[0xB0C0]	LTE RRC OTA Message	00:01:15.335	Length: 0015
LOG	[0xB0EE]	LTE NAS EMM State	00:01:15.338	Length: 0019
LOG	[0xB0C0]	LTE RRC OTA Message	00:01:15.580	Length: 0027
LOG	[0xB0C0]	LTE RRC OTA Message	00:01:15.583	Length: 0015
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	00:01:15.335	Timer Name = Deadlock, Timer Value = 2998, Timer State = Stop
EVENT	[01614]	EVENT_LTE_RRC_PAGING_DRX_CYCLE	00:01:15.336	DRX Cycle = 1280
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	00:01:15.581	Timer Name = Deadlock, Timer Value = 3000, Timer State = Start
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	00:01:15.583	Timer Name = Deadlock, Timer Value = 2998, Timer State = Stop
LOG	[0xB0EE]	LTE NAS EMM State	00:01:17.970	Length: 0019
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	00:01:17.963	Timer Name = SIB Event1 WT, Timer Value = 0, Timer State = Expire
EVENT	[01619]	EVENT_LTE_RRC_SIB_READ_FAILURE	00:01:17.963	Frequency = 5230, Cell ID = 116, Rxed SIBs Mask = 0x0007
EVENT	[01608]	EVENT_LTE_RRC_RADIO_LINK_FAI...	00:01:17.963	Counter = 2
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	00:01:17.963	Timer Name = Deadlock, Timer Value = 3000, Timer State = Start
EVENT	[01720]	EVENT_LTE_MAC_TIMER	00:01:17.967	Timer type = TA, Action = Stop
EVENT	[01605]	EVENT_LTE_RRC_TIMER_STATUS	00:01:17.968	Timer Name = Deadlock, Timer Value = 2995, Timer State = Stop

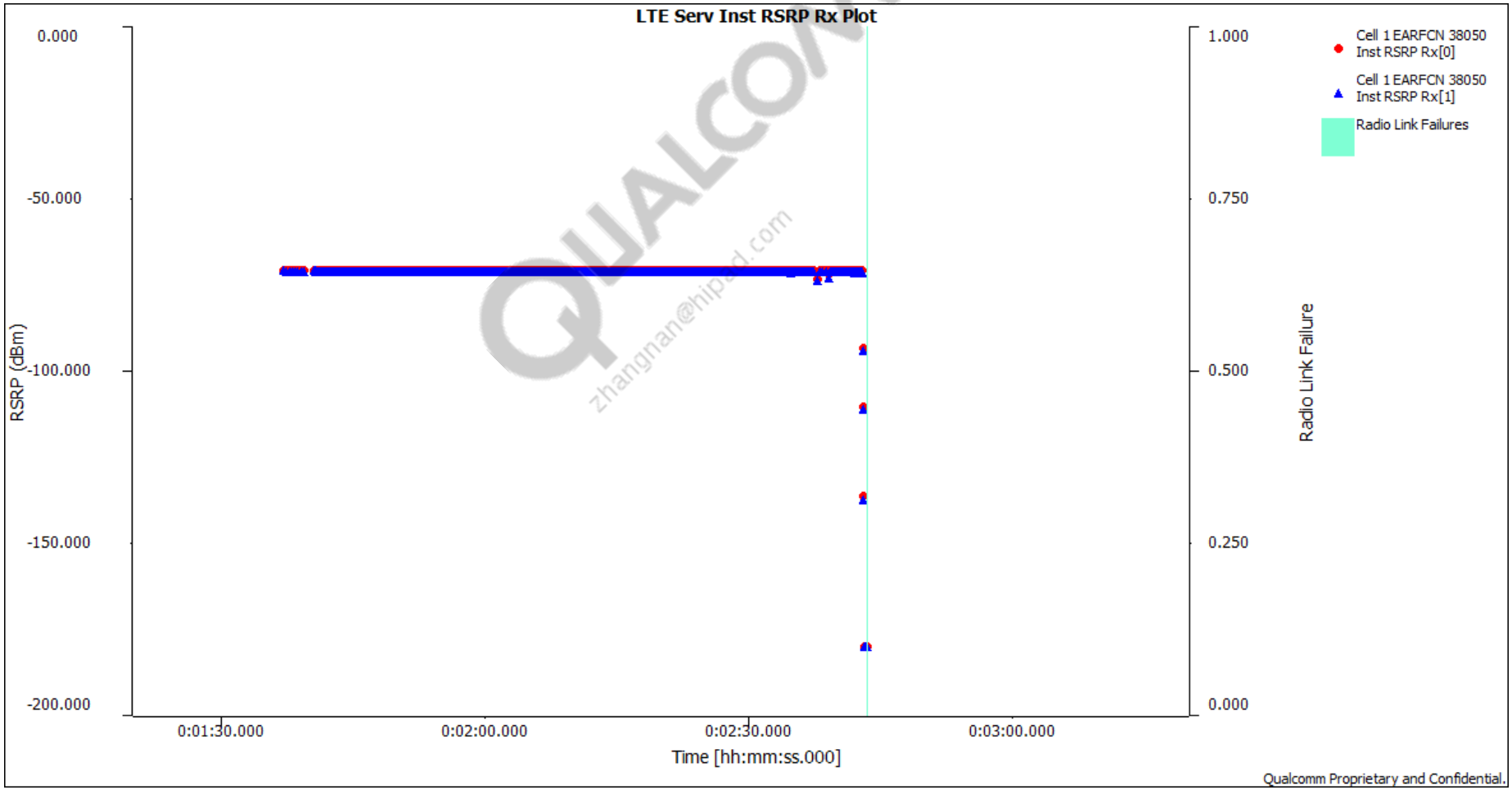
Results

Counter = 2

QCAT Views:
Events indicating Radio Link Failure

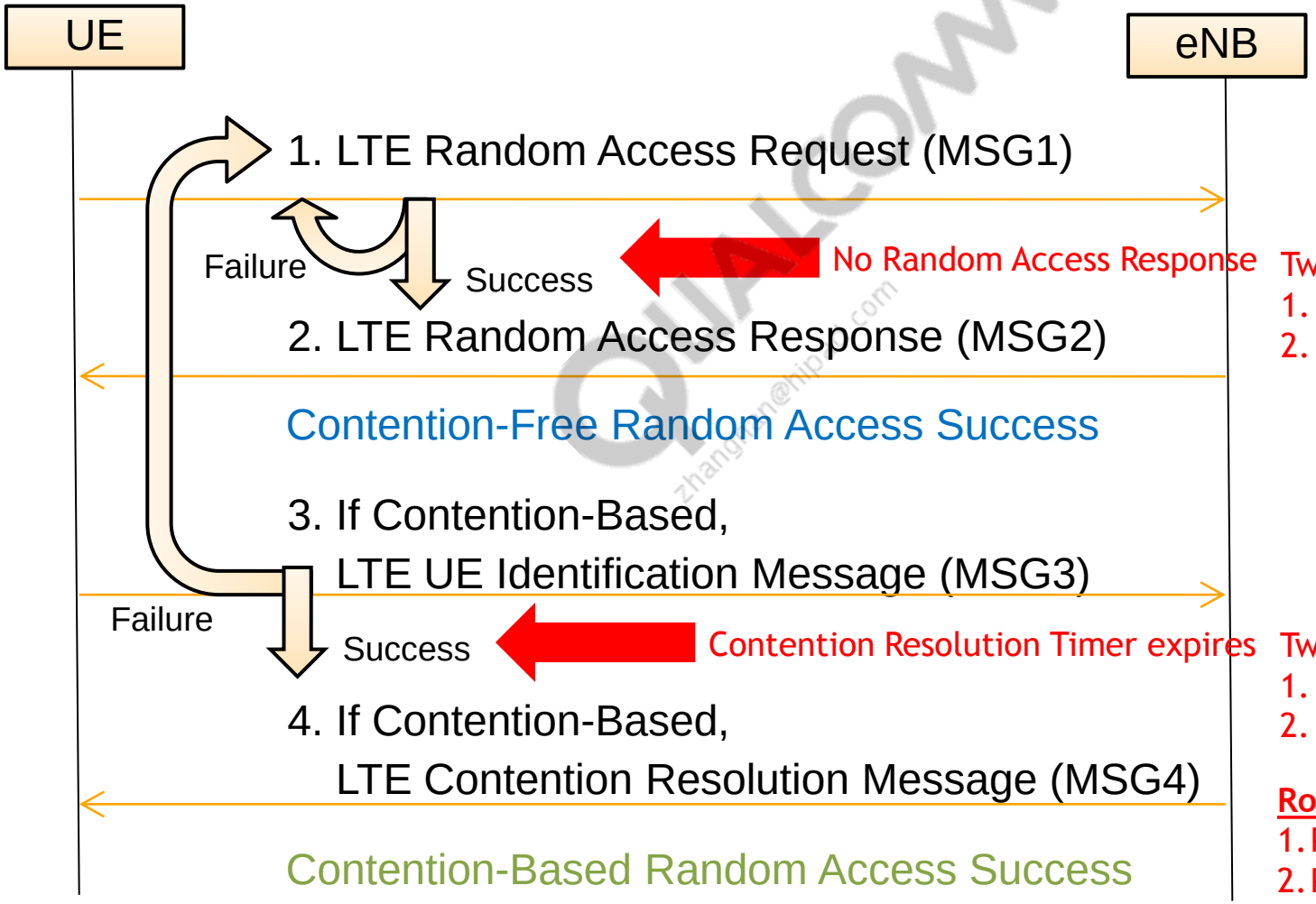


QCAT Views: RSRP Plot indicating Radio Link Failure



Case Study: UL Data Transfer

What could go wrong with LTE UL Random Access?



Two possibilities:
1. MSG1 cannot reach eNB
2. MSG2 cannot reach UE

Two possibilities:
1. MSG3 cannot reach eNB
2. MSG4 cannot reach UE

Root causes:
1. Poor RF / Link Imbalance
2. PRACH congestion
3. Suboptimal parameters
4. Equipment failure

Key UE Log Packets to Check in Random Access Analysis

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Parameters:

- MIBs, SIBs and RRC Connection Request: LTE RRC OTA Packet (0xB0C0)
- Serving Cell Info: LTE RRC Serving Cell Info Log Pkt (0xB0C2)

RF Conditions:

- DL RSRP, RSRQ and RSSI (Idle): LTE ML1 Idle Serving Cell Meas Response (0xB193)
- DL RSRP, RSRQ and RSSI (Connected): LTE ML1 Cell Measurement Results (0xB196)
- DL RSSI (Connected): LTE LL1 Rx Agc (0xB111)

Random Access Process:

- RACH Start: LTE MAC Rach Trigger (0xB061)
- Preamble Tx: LTE Random Access Request (MSG1) Report (0xB167)
- Timing Advance: LTE Random Access Response (MSG2) Report (0xB168)
- MSG3 Tx: LTE UE Identification Message (MSG3) Report (0xB169)
- Contention Result: LTE Contention Resolution Message (MSG4) Report (0xB16A)
- Overall RACH Result: LTE MAC Rach Attempt (0xB062)
- Random Access Problem Indicator: Event_LTE_Rach_Access_Result (0x1FFB)

PUSCH Transmission:

- RAR Grant: LTE DCI Information Report (0xB16C)
- MSG3 Tx Power, MCS, #RBs and HARQ details: LTE LL1 PUSCH Tx Report (0xB139) or LTE GM Tx Report (0xB16D)

PUSCH Scheduling

How the UE is Granted to Send UL Data

- PDCCH DCI Format 0 is used for UL scheduling
  - CRC is scrambled with UE's C-RNTI in order to address to the UE
- Look in the opened log for the **LTE DCI Information Report** (0xB16C) log packet containing UL grant assignment @ 22:40:09.850

Example: FDD

			UL Grant Info													
SFN	Sub-fn	UL Grant Present	RIV Width	RIV Value	Hopping Flag	MCS Index	NDI	TPC	Cyclic Shift DMRS	CQI Request	Start of Resource Block	Number of Resource Blocks	TBS Index	Modulation Type	Redundancy Version Index	HARQ ID
387	5	Yes	11	2	Disabled	3	1	1	0	0	2	1	3	QPSK	0	7
387	6	Yes	11	2	Disabled	3	1	1	0	0	2	1	3	QPSK	0	0
387	7	Yes	11	8	Disabled	3	1	1	0	0	8	1	3	QPSK	0	1
387	8	Yes	11	2	Disabled	3	1	1	0	0	2	1	3	QPSK	0	2
387	9	Yes	11	2	Disabled	3	1	1	0	0	2	1	3	QPSK	0	3
388	0	Yes	11	2	Disabled	3	1	1	0	0	2	1	3	QPSK	0	4
388	1	Yes	11	2	Disabled	3	1	1	0	0	2	1	3	QPSK	0	5
388	2	Yes	11	2	Disabled	3	1	1	0	0	2	1	3	QPSK	0	6

How the UE is Granted to Send UL Data

- PDCCH DCI Format 0 is used for UL scheduling
  - CRC is scrambled with UE's C-RNTI in order to address to the UE
- Look in the opened log for the **LTE DCI Information Report** (0xB16C) log packet containing UL grant assignment @ 01:01:42.470

Example: TDD

				UL Grant Info																	
#	SFN	Sub-fn	UL Grant Present	RIV Width	RIV Value	Hopping Flag	MCS Index	NDI	TPC	Cyclic Shift DMRS	Duplex Mode	K of DCI 0	UL Index/DAI	CQI Request	Start of Resource Block	Number of Resource Blocks	TBS Index	Modulation Type	Redundancy Version	HARQ ID	PI Or Pr
0	249	9	Yes	13	2699	Disabled	24	0	1	0	TDD	4	0	0	0	75	22	16 QAM	0	1	
1	250	4	Yes	13	400	Disabled	24	1	1	0	TDD	4	0	0	0	5	22	16 QAM	0	3	
2	250	6	Yes	13	200	Disabled	24	0	1	0	TDD	6	0	0	0	3	22	16 QAM	0	0	
3	251	4	No																		
4	251	9	Yes	13	300	Disabled	24	1	1	0	TDD	4	0	0	0	4	22	16 QAM	0	1	
5	252	4	Yes	13	200	Disabled	24	0	1	0	TDD	4	0	0	0	3	22	16 QAM	0	3	
6	252	5	No																		

PUSCH Transmission

Transmitting on PUSCH (1 of 2) (FDD)

- Look for the **LTE GM Tx Report** (0xB16D) log packet @ 00:00:18.640 and find the following:
  - Frequency Hopping
  - Modulation Order
  - Resource Block Start and Number of Resource Blocks
  - Transport Block Size
  - Redundancy Version and HARQ ID
- Do they correspond with the Uplink grant?

4 Subframes After DCI Format 0

```
Tx Report Records[2] {
   Chan Type                        = PUSCH
   Tx SFN                           = 276
   Tx Sub-fn                        = 4
   Transport Block Size             = 26
   CSF Present Flag                 = 1
   UL ACK/NAK Present Flag          = 0
   ACK/NAK Reporting Mode           = 0
   Total Tx Power                   = -4 dBm
   Beta PUSCH                       = 242
   Cyclic Shift DMRS                = 0
   Resource Block Start             = 8
   Redundancy Version               = 0
   ACK/NAK Length                   = 0
   Modulation Type                  = QPSK
   Number of Resource Blocks        = 4
   Retransmission Index             = 0
   HARQ ID                          = 4
   Freq Hopping Flag                = Disabled
   HARQ ACK Offset Index            = 9
   CQI Offset Index                 = 8
   RI Offset Index                  = 6
   PUSCH Hopping Payload            = 0
   SRS Present Flag                 = 1
   SRS UE/Cell Specific             = 0
   N_drms                           = 0
   Num Antenna                      = 1
}
```

Troubleshooting LTE UL PUSCH

Key UE Log Packets to Check in PUSCH Analysis

QUALCOMM CORPORATE ENGINEERING SERVICES

Parameters:

- RRC Messages: LTE RRC OTA Packet (0xB0C0)
- Serving Cell Info: LTE RRC Serving Cell Info Log Pkt (0xB0C2)

RF Conditions:

- DL RSRP, RSRQ and RSSI (Idle): LTE ML1 Idle Serving Cell Meas Response (0xB193)
- DL RSRP, RSRQ and RSSI (Connected): LTE ML1 Cell Measurement Results (0xB196)
- DL RSSI (Connected): LTE LL1 Rx Agc (0xB111)

PUSCH Tx:

- UL Grant: LTE DCI Information Report (0xB16C)
- PUSCH Tx: LTE LL1 PUSCH Tx Report (0xB139) or LTE GM Tx Report (0xB16D)

SRS Tx:

- PUSCH Tx: LTE LL1 SRS Tx Report (0xB140) or LTE GM Tx Report (0xB16D)

QCAT Time Plots: LTE UL Throughput

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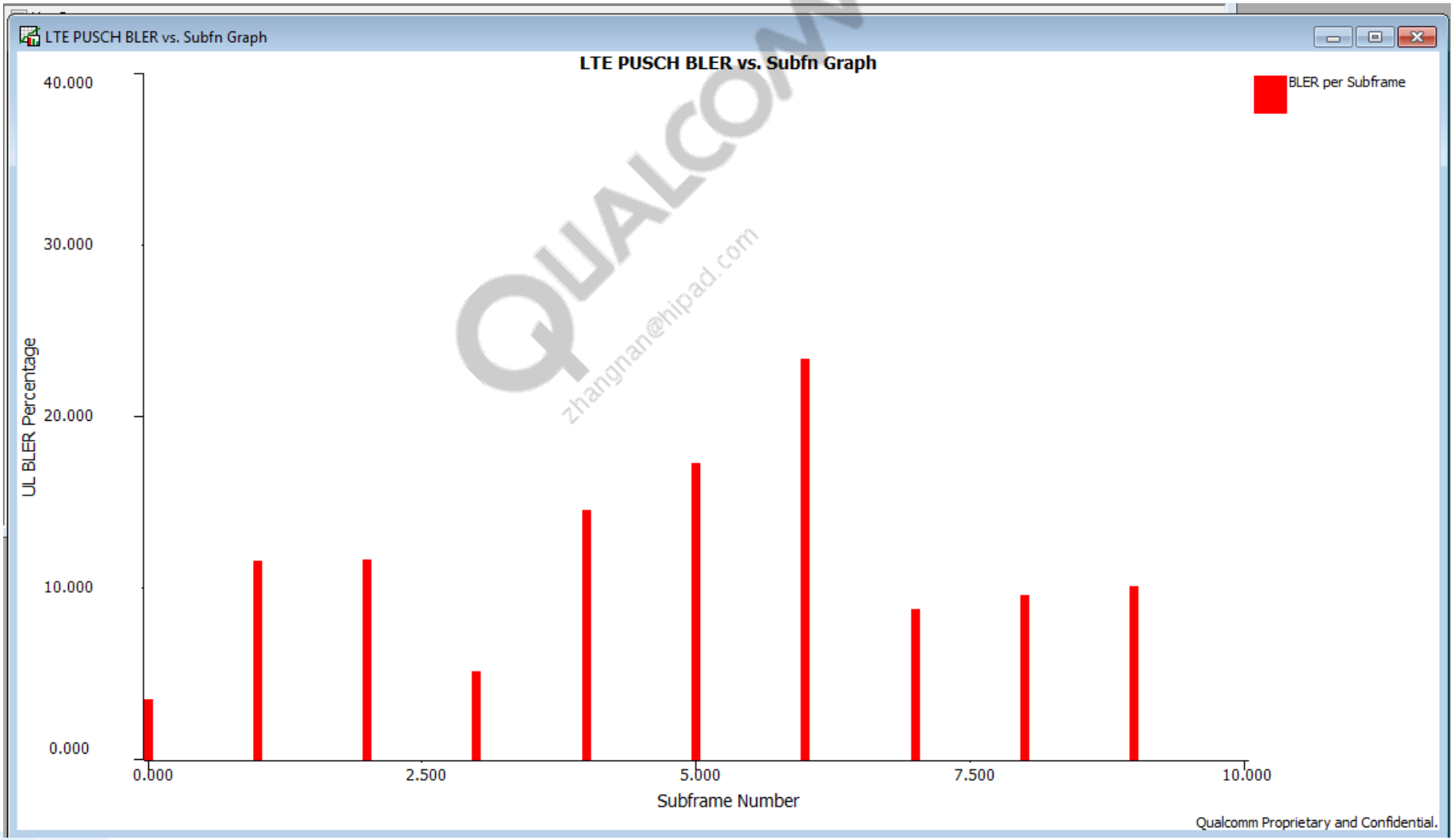
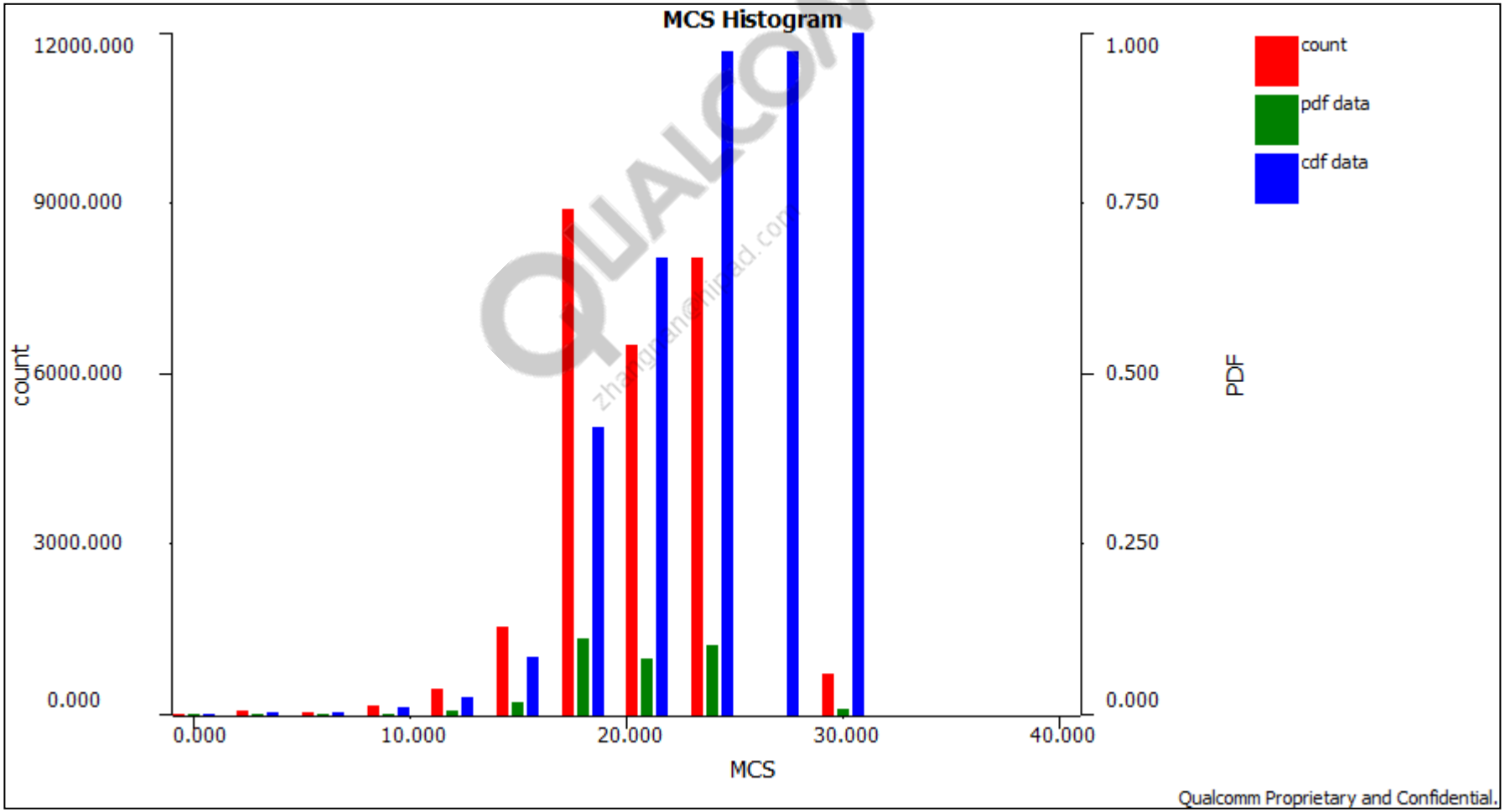
QCAT Time Plots: LTE BLER Plot



QCAT Time Plots: MCS Histogram



Case Study: Intra LTE Mobility

Handover Log Analysis – Summary 1 of 2

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Layer: PHY	Entity	Log Packet	Look for …
Management Layer 1 (ML1)	Connected Serving Cell instantaneous measurement results	0xB193	Instantaneous RSRP, RSRQ, RSSI, RS SINR
	Connected Neighbor Cell instantaneous measurement results	0xB195	Instantaneous RSRP, RSRQ, RSSI
	Connected Serving & neighbor Cells filtered measurement	0xB179	Filtered RSRP, filtered RSRQ

Handover Log Analysis – Summary 2 of 2

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Layer: RRC	Entity	Log Packet	Look for …
RRC OTA Messages	RRC Reconfiguration Message	0xB0C0	Key Handover Parameters, Handover command
	Measurement Report	0xB0C0	Reported measurement ID, Measurement results for serving and neighbor cells
	RRC Reconfiguration complete	0xB0C0	Handover complete
RRC Events	EVENT_LTE_RRC_STATE_CHANGE	0x1FFB	Cell Connected
	EVENT_LTE_RRC_NEW_CELL_IND	0x1FFB	Handover indication
	EVENT_LTE_RRC_RADIO_LINK_FAILURE	0x1FFB	Radio Link Failure indication
	EVENT_LTE_RRC_HO_FAILURE	0x1FFB	Handover failure indication

Intra Frequency Handover Procedure

Log Analysis – PHY Layer

Intra Frequency Handover Procedure

- **PHY Layer**
- **RRC Layer**

Serving Measurements 0xB193

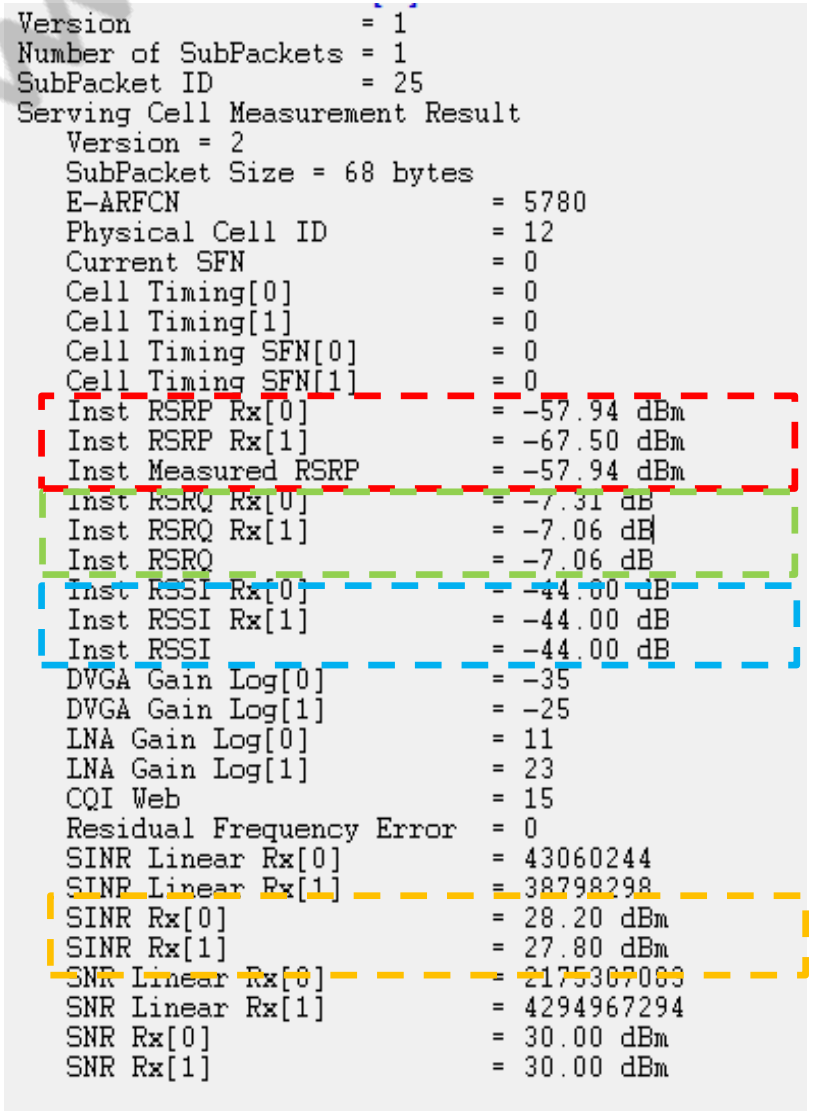
- This ML1 packet logs Instantaneous Serving Cell measurements:

1. Connected mode instantaneous serving RSRP measurements

- 2. Connected mode instantaneous RSRQ, RSSI, RS SINR

  where RSRQ = N_RB * (RSRP/RSSI)

- Note:
- This ML1 packet is logged every 40 ms



```
Version                 = 1
Number of SubPackets    = 1
SubPacket ID            = 25
Serving Cell Measurement Result
   Version = 2
   SubPacket Size = 68 bytes
   E-ARFCN                          = 5780
   Physical Cell ID                 = 12
   Current SFN                      = 0
   Cell Timing[0]                   = 0
   Cell Timing[1]                   = 0
   Cell Timing SFN[0]               = 0
   Cell Timing SFN[1]               = 0
   Inst RSRP Rx[0]                  = -57.94 dBm
   Inst RSRP Rx[1]                  = -67.50 dBm
   Inst Measured RSRP               = -57.94 dBm
   Inst RSRQ Rx[0]                  = -7.31 dB
   Inst RSRQ Rx[1]                  = -7.06 dB
   Inst RSRQ                        = -7.06 dB
   Inst RSSI Rx[0]                  = -44.00 dB
   Inst RSSI Rx[1]                  = -44.00 dB
   Inst RSSI                        = -44.00 dB
   DVGA Gain Log[0]                 = -35
   DVGA Gain Log[1]                 = -25
   LNA Gain Log[0]                  = 11
   LNA Gain Log[1]                  = 23
   CQI Web                          = 15
   Residual Frequency Error         = 0
   SINR Linear Rx[0]                = 43060244
   SINR Linear Rx[1]                = 38798298
   SINR Rx[0]                       = 28.20 dBm
   SINR Rx[1]                       = 27.80 dBm
   SNR Linear Rx[0]                 = 2175367063
   SNR Linear Rx[1]                 = 4294967294
   SNR Rx[0]                        = 30.00 dBm
   SNR Rx[1]                        = 30.00 dBm
```

Connected Neighbor Instantaneous Measurements 0xB195

- This ML1 packet logs Instantaneous Neighbor Cells measurements:
- 1. Connected mode instantaneous RSRP of neighbor cells
- 2. Connected mode instantaneous RSRQ, RSSI of neighbor cells
- Note:
- This ML1 packet is logged every 40 ms

Connected Neighbor Meas Response
Version = 1
SubPacket Size = 88 bytes
E-ARFCN = 5230
Num Cells = 2
Cnt Swrp = 0
Duplexing Mode = FDD
Neighbor Cells

#	Physical Cell ID	FTL Cumulative Freq Offset	Inst RSRP Rx[0] (dBm)	Inst RSRP Rx[1] (dBm)	Inst Measured RSRP (dBm)	Inst RSRQ Rx[0] (dBm)	Inst RSRQ Rx[1] (dBm)	Inst RSRQ (dBm)	Inst RSSI Rx[0] (dB)	Inst RSSI Rx[1] (dB)	Inst RSSI (dB)	DVGA Gain Log[0]	DVGA Gain Log[1]	LNA Gain Log[0]	LNA Gain Log[1]	Frame Boundary Ref Time[0]	Frame Boundary Ref Time[1]
0	183	0	-140.00	-140.00	-140.00	-30.00	-30.00	-30.00	-52.00	-60.00	-55.00	0	0	0	0	232676	232676
1	176	0	-140.00	-140.00	-140.00	-30.00	-30.00	-30.00	-52.00	-60.00	-55.00	0	0	0	0	79060	79060

Connected Serving & Neighbor Measurements 0xB179

- This ML1 packet contains:
  1. Filtered serving and neighbor cell RSRPs
  2. Filtered serving and neighbor cell RSRQs
  3. List of detected cells from neighbor search
- These filtered RSRPs are used to trigger measurement reports. RSRQs can be also used.
- Note:
- The frequency ML1 packet is logged depends on the setting of the filter coefficient

```
Version                        = 1
E-ARFCN                        = 5780
Serving Physical Cell ID       = 12
Sub-frame Number               = 9460
Serving Filtered RSRP          = -57.75 dBm
Serving Filtered RSRQ          = -7.13 dB
Number of Neighbor Cells       = 2
Number of Detected Cells       = 2
Neighbor Cells
   ------------------------------------
   |   |          |Filtered  |Filtered  |
   |   |Physical  |RSRP      |RSRQ      |
   |#  |Cell ID   |(dBm)     |(dB)      |
   ------------------------------------
   |  0|         5|  -74.50  | 8168.13  |
   |  1|       104| -112.25  | 8132.00  |

Detected Cells
   --------------
   |   |Physical  |
   |#  |Cell ID   |
   --------------
   |  0|        96|
   |  1|       189|
```

Log Analysis – RRC Layer

Intra Frequency Handover Procedure

- **PHY Layer**
- **RRC Layer**

RRC Reconfiguration Message (0xB0C0)

- This RRC Reconfiguration OTA Message contains key handover parameters:

1. Measurement object that configures type of measurement (e.g., intra-frequency)
2. Report configuration parameters such as Event A3 offset, Report on leave, Hysteresis, Time to Trigger, Trigger Quantity, Report Quantity, Max Report Cells, and Report Interval
3. Measurement ID which links measurement object, and report configuration
4. Quantity configuration parameters such as filter Coefficient RSRP and filter Coefficient RSRQ
5. S-measure to trigger measurements

```
message c1 : rrcConnectionReconfiguration :
    {
      rrc-TransactionIdentifier 0,
      criticalExtensions c1 : rrcConnectionReconfiguration-r8 :
          {
            measConfig
            {
              measObjectToAddModList
              {
                {
                  measObjectId 1,
                  measObject measObjectEUTRA :
                    {
                      carrierFreq 5780,
                      allowedMeasBandwidth mbw6,
                      presenceAntennaPort1 FALSE,
                      neighCellConfig '01'B
                    }
                }
              },
              reportConfigToAddModList
              {
                {
                  reportConfigId 1,
                  reportConfig reportConfigEUTRA :
                    {
                      triggerType event :
                        {
                          eventId eventA3 :
                            {
                              a3-Offset 6,
                              reportOnLeave FALSE
                            },
                          hysteresis 2,
                          timeToTrigger ms40
                        },
                      triggerQuantity rsrp,
                      reportQuantity both,
                      maxReportCells 4,
                      reportInterval ms480,
                      reportAmount infinity
                    }
                }
              },
              measIdToAddModList
              {
                {
                  measId 1,
                  measObjectId 1,
                  reportConfigId 1
                }
              },
              quantityConfig
              {
                quantityConfigEUTRA
                {
                  filterCoefficientRSRQ fc11
                }
              },
              s-Measure 0,
```

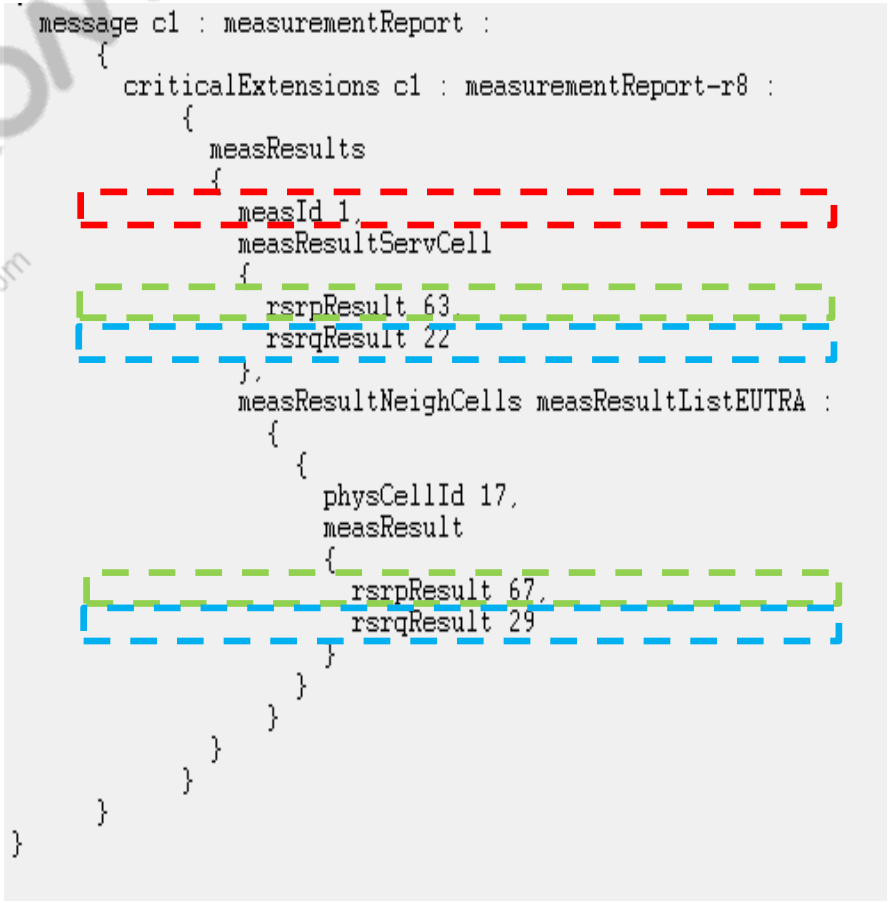
RRC Measurement Report Message (0xB0C0)

- This Measurement Report OTA Message includes:

1. Results for a certain measurement ID (e.g., event based, periodical)
2. Filtered RSRP measurements from serving cell and neighboring cell
3. Filtered RSRQ measurements from serving and neighboring cells

- MRM is triggered if Filtered Neighbor RSRP > Filtered Serving RSRP + (a3-offset + hysteresis)/2 dB

- Filtered RSRP reported = - (140 – rsrpResult) dBm
- Filtered RSRQ reported = - (30 – rsrqResult) dB



Handover Command (RRC Reconfiguration Message) (0xB0C0)

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- Network makes determination regarding handover.
- Network issues this message to command handover.
- This message includes:
  1. Target cell ID
  2. T304: Max time to execute handover
  3. Tolerance for RACH response.

  In the example on the side:
  - MSG1 tolerance
    - Transmitted at most 10 times
  - MSG2 tolerance
    - Response window is 4 SFs
  - MSG4 tolerance
    - Contention Resolution Timer is 48 SFs for a Contention Based (CB) RACH
    - If a Contention Free (CF) RACH is configured Contention Resolution Timer is not set

```
message c1 : rrcConnectionReconfiguration :
    {
      rrc-TransactionIdentifier 0,
      criticalExtensions c1 : rrcConnectionReconfiguration-r8
        {
          mobilityControlInfo
          {
            targetPhysCellId 17,
            carrierBandwidth
            {
              dl-Bandwidth n50
            },
            additionalSpectrumEmission 1,
            t304 ms1000,
            newUE-Identity '00000000 11001001'B,
            radioResourceConfigCommon
            {
              rach-ConfigCommon
              {
                preambleInfo
                {
                  numberOfRA-Preambles n64
                },
                powerRampingParameters
                {
                  powerRampingStep dB2,
                  preambleInitialReceivedTargetPower dBm-116
                },
                ra-SupervisionInfo
                {
                  preambleTransMax n10,
                  ra-ResponseWindowSize sf4,
                  mac-ContentionResolutionTimer sf48
                },
                maxHARQ-Msg3Tx 1
```

Handover Complete (RRC Reconfiguration Complete)

- After the RRC Reconfiguration message, the UE synchronizes with the target cell and then immediately acquires PBCH and triggers the RACH procedure.
- After HO is complete, UE sends RRC Reconfiguration complete message to target cell.
- After RACH is complete, UE decodes SIBs on the new serving cell.

```
{
  message c1 : rrcConnectionReconfigurationComplete :
      {
        rrc-TransactionIdentifier 0,
        criticalExtensions rrcConnectionReconfigurationComplete-r8 :
          {
          }
      }
}
```

Events (0x1FFB)

EVENT_LTE_RRC_STATE_CHANGE indicates UE transition to different RRC state:

1. **Cause** indicates which type of RRC state was performed (e.g., Inactive, Idle Not Camped, Idle Camped, Connecting, Connected)

```
00:00:09.602 Event   0 : EVENT_LTE_RRC_STATE_CHANGE (ID=1606)  Payload = 0x04
      Payload String = RRC State = Connected
```

EVENT_LTE_RRC_NEW_CELL_IND indicates UE handover to a new cell:

1. **Cause** indicates whether handover occurs.
2. **Cell ID** indicates the cell to which the UE has performed handover.

```
Jan 6    00:02:10.849 [38]      0x1FFB Event -- EVENT_LTE_RRC_NEW_CELL_IND
  00:02:10.849 Event   0 : EVENT_LTE_RRC_NEW_CELL_IND (ID=1611)  Payload = 0x02 94 16 11 00
      Payload String = Cause = handover, Frequency = 5780, Cell ID = 17
```

Events (0x1FFB)

EVENT_LTE_RRC_RADIO_LINK_FAILURE indicates UE has lost connection:

1. A **Counter** indicates how many times UE has gone into Radio Link Failure

```
Jan 6    00:00:30.791 [00]      0x1FFB Event -- EVENT_LTE_RRC_RADIO_LINK_FAILURE
  00:00:30.791 Event   0 : EVENT_LTE_RRC_RADIO_LINK_FAILURE (ID=1608)  Payload = 0x01 00
       Payload String = Counter = 1
```

EVENT_LTE_RRC_HO_FAILURE indicates UE failed to handover to a new cell:

1. **Cause** indicates the reason of the failure (e.g., NONE, INVALID_CFG, CPHY, RACH, RACH_MEAS)
2. **Cell ID** indicates the cell to which UE was supposed to handover

```
Jan 6    00:02:48.680 [00]      0x1FFB Event -- EVENT_LTE_RRC_HO_FAILURE
  00:02:48.680 Event   0 : EVENT_LTE_RRC_HO_FAILURE (ID=1613)  Payload = 0x6E 14 33 00 03
       Payload String = Frequency = 5230, Cell ID = 51, Cause = RACH
```

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Questions?

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THANK YOU!