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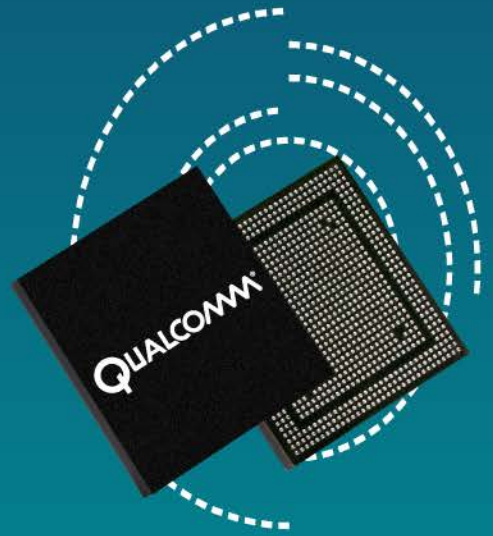

LTE Connected Mode and Data Transfer

80-N9812-1 D

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Revision History

Revision	Date	Description
A	Feb 2012	Initial release
B	May 2012	Revised slides 12, 15, 19, 20, 22, 27; added slides 11 and 45 to 50
C	Jan 2013	Revised slide 39
D	Apr 2014	Updated slides 8, 15, 18, 25, 27, 32, and 40

Contents

- Connected Mode
- Attach Procedure/Setup Default Bearer and RRC Connection Establishment
- RRC Connection Reconfiguration
- Dedicated Bearer Setup
- Data Transfer
- References
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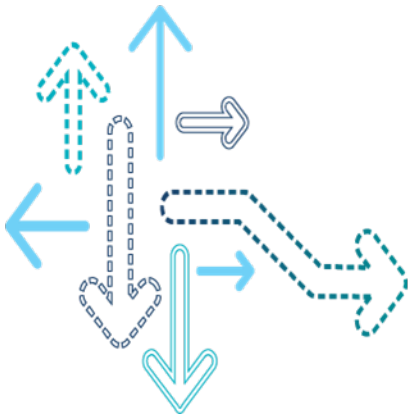
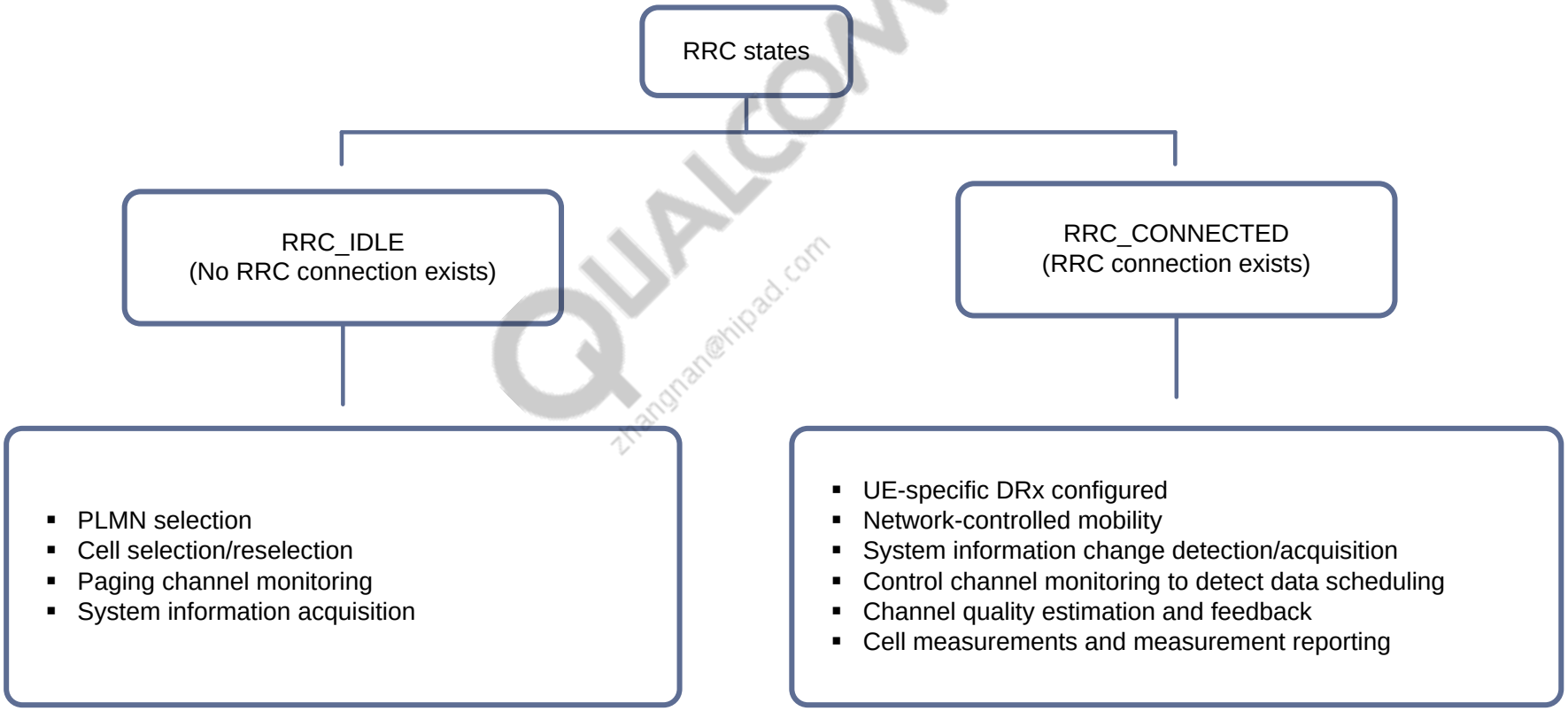
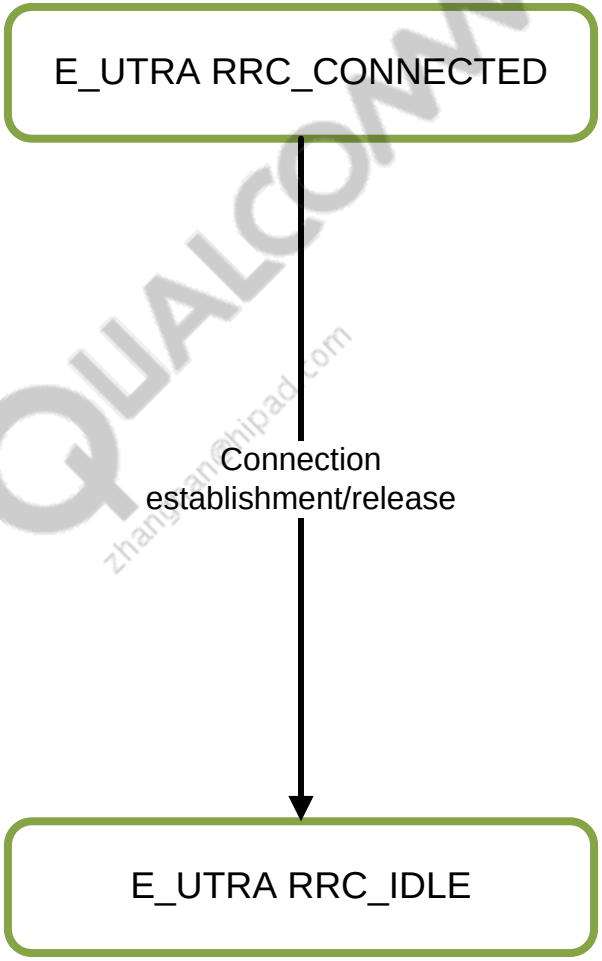
Connected Mode



RRC Idle and Connect State



RRC Idle and Connected State

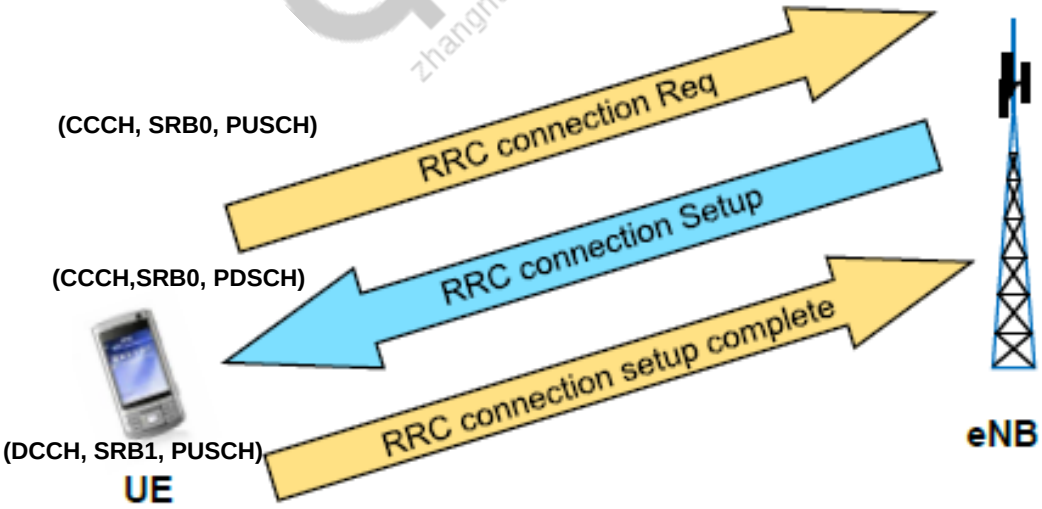


RRC Connection Establishment

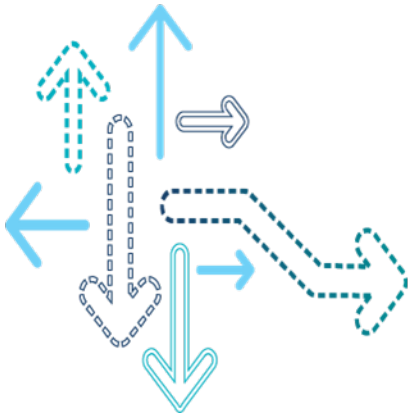
- RRC connection establishment is used to make the transition from RRC Idle mode to RRC Connected mode. Once in Connected mode, the UE can transfer user data and/or NAS signaling.
- The RRC connection establishment procedure is initiated by the UE but can be triggered by either the UE (user initiates application data or mobile-originated signaling such as attach request/tracking area update request) or the network (network pages the UE to deliver SMS, mobile terminated voice call).
- The RRC Connection Request message is sent in MSG3 during the Random Access procedure.
- In the RRC Connection Request message, the UE identity is set to S-TMSI if available, a random value otherwise.
- In a RRC Connection Request message, an establishment cause is set in accordance with information passed down from the upper layers.

RRC Connection Establishment (cont.)

- On receiving a RRC connection setup, the UE shall:
  - Establish Signaling Radio Bearer 1 (SRB1), subsequent signaling starts to use the Dedicated Control Channel (DCCH)
  - Enter RRC_CONNECTED state
  - Stop the cell reselection procedure
  - Stop applicable timers
  - Send a RRC Connection Setup Complete to the network

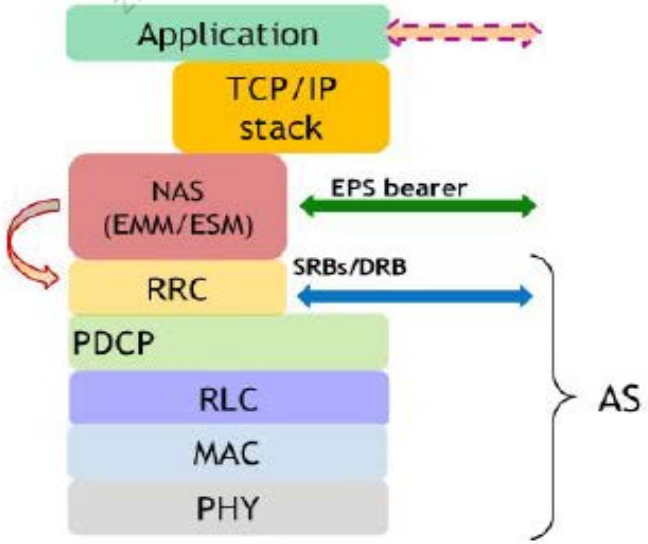


Attach Procedure/Setup Default Bearer and RRC Connection Establishment

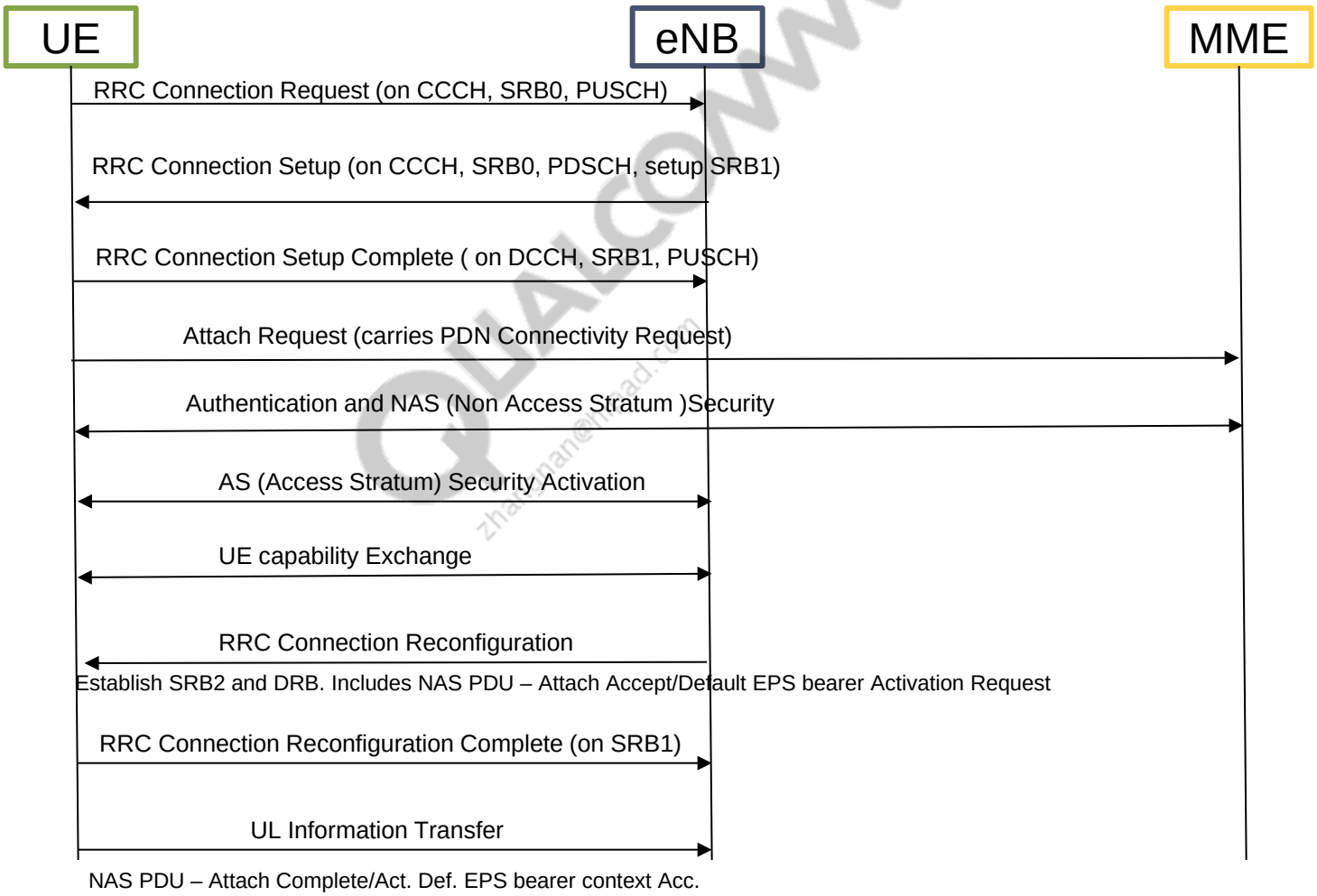


EPS Attach Procedure

1. NAS (UE) initiates registration with EPS (MME)
2. EMM generates Attach Request
3. ESM generates PDN Connectivity Request to establish connectivity with the Packet Data Network (PDN)
   - Obtains IPv4 and/or IPv6 addresses
   - Establishes EPS bearer(s) to transfer application data
4. RRC establishes Signaling Radio Bearers (SRB) and Data Radio Bearers (DRB) to exchange NAS layer signaling messages or to transport user's application data



Attach Procedure, Default Bearer Setup



Attach Request

- The initial Attach procedure results in establishment of SRB1 between the UE and eNB. The UE also requests PDN connectivity (default bearer) along with the Attach Request.
- The purpose of the PDN Connectivity Request is to establish connectivity with the PDN for transporting user data.

```
2011 Nov 15  19:34:14.117  [00]  0xB0ED  LTE NAS EMM Plain OTA Outgoing Message  --
Attach
msg_type = 65 (0x41) (Attach request)
lte_emm_msg
  emm_attach_request
    tsc = 0 (0x0) (cached sec context)
    nas_key_set_id = 0 (0x0)
    att_type = 2 (0x2) (combined EPS/IMSI attach)
    eps_mob_id
      ……
    ue_netwk_cap
      ……
    esm_msg_container
      ……
      msg_type = 208 (0xd0) (PDN connectivity request)
      lte_esm_msg
        pdn_connectivity_req
          pdn_type = 1 (0x1) (Ipv4)
          req_type = 1 (0x1) (initial request)
        ……
    tracking_area_id
      ……
```


RRC Connection Request

- RRC Connection Request is sent on default SRB0. SRB0 is always available.

```
2011 Nov 15  19:34:14.122  [00]  0xB0C0  LTE RRC OTA Packet  --  UL_CCCH
Radio Bearer ID = 0, Physical Cell ID = 0
Freq = 5230
PDU Number = UL_CCCH Message,    Msg Length = 6
value UL-CCCH-Message ::=
{
  message c1 : rrcConnectionRequest :
      {
        criticalExtensions rrcConnectionRequest-r8 :
          {
            ue-Identity randomValue : '11110110 00111111 10100101 11111000 00101011'B,
            establishmentCause mo-Signalling,
            spare '0'B
          }
      }
}
```


RRC Connection Request (Lower Layers)

- RRC Connection Request message (MSG3) is sent on PUSCH. In this example, at Sequence Frame Number 758 subframe 3; network acks 4 subframes later at 758-7.

2011 Nov 15 19:34:14.145 [00] 0xB139 LTE LL1 PUSCH Tx Report

Version = 4
Serving Cell ID = 0
Number of Records = 1
Dispatch SFN SF = 7583
Records

Current SFN SF	ACK	CQI	RI	Frequency Hopping	Re-tx Index	Redund Ver	Mirror Hopping	Cyclic Shift of DMRS Symbols Slot 0 (Samples)	Cyclic Shift of DMRS Symbols Slot 1 (Samples)	DMRS Root 0	UE SRS	DMRS Root Slot 1	Start RB Slot 0	Start RB Slot 1	Num of RB	PUSCH TB Size (bytes)	Num ACK Bits (bits)	ACK Payload	Rate Matched ACK Bits	Num RI Bits (bits)
7583	None	None	None	Disabled	First	0	0	9	8	12	OFF	16	0	0	1	32	0	0000	0	0

2011 Nov 15 19:34:14.176 [00] 0xB16B LTE PDCCH-PHICH Indication Report

Version = 1
Number of Records = 50
Info Records

#	Num PDCCH Results	PDCCH Timing SFN	PDCCH Timing Sub-fn	PHICH Included	PHICH PHICH Timing SFN	PHICH Timing Sub-fn	PHICH Value	PDCCH Info CRC Status	PDCCH Info RNTI Type	PDCCH Info Payload Size	PDCCH Info Aggregation Level
0	0	756	5	No							
1	0	756	6	No							
2	0	756	7	No							
3	0	756	8	No							
4	0	756	9	No							
5	0	757	0	No							
6	0	757	1	No							
7	0	757	2	No							
8	0	757	3	No							
9	0	757	4	No							
10	0	757	5	No							
11	0	757	6	No							
12	1	757	7	No				Pass	RA_RNTI	43	2
13	0	757	8	No							
14	0	757	9	No							
15	0	758	0	No							
16	0	758	1	No							
17	0	758	2	No							
18	0	758	3	No							
19	0	758	4	No							
20	0	758	5	No							
21	0	758	6	No							
22	0	758	7	Yes	758	7	ACK				

RRC Connection Setup (Lower Layers)

- RRC Connection Setup message is received on PDSCH; its scheduling information comes from PDCCH.

2011 Nov 15 19:34:14.166 [00] 0xB130 LTE LL1 PDCCH Decoding Result

Version = 3
Sub-frame Number = 3
System Frame Number = 760
Number of Hypothesis = 3
Hypothesis

#	Payload	Aggregation Level	Candidate	Search Space Type	DCI Format	Decode Status	Start CCE	Payload Size	Tail Match	Prune Status	Energy Metric	Symbol Mismatch Count
0	0x84000840000000000	Agg1	1	User	1A	C_RNTI	20	43	Match	FAIL_SURVIVOR_SELECT	2232	32
1	0x84000840000000000	Agg2	0	User	1A	C_RNTI	20	43	Match	SUCCESS_DCI1A	3999	0
2	0x84000840000000000	Agg4	1	User	1A	C_RNTI	20	43	Match	FAIL_SURVIVOR_SELECT	2353	20

2011 Nov 15 19:34:14.342 [00] 0xB173 LTE PDSCH Stat Indication

Version = 3
Num Records = 12
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	Discarded reTx Present	Did Recombining	TB Size (bytes)	MCS
0	5	748	4	1	1	0	0	0	Pass	SI	0	None	No	21	5
1	1	752	4	1	1	1	0	0	Pass	SI	0	None	No	29	4
2	7	757	4	1	1	1	0	0	Pass	RA	0	None	No	10	1
3	8	758	2	1	1	0	0	0	Pass	Temp-C	0	None	No	10	1
4	9	759	1	1	1	0	0	0	Pass	C	0	None	No	5	0
5	3	760	3	1	1	1	0	0	Pass	C	0	None	No	21	2
6	8	762	1	1	1	2	0	0	Pass	C	0	None	No	6	1
7	4	764	9	1	1	3	0	0	Pass	C	0	None	No	50	2
8	8	772	1	1	1	4	0	0	Pass	C	0	None	No	6	1
9	6	773	4	1	1	5	0	0	Pass	C	0	None	No	29	3
10	8	776	1	1	1	6	0	0	Pass	C	0	None	No	6	1
11	3	777	3	1	1	7	0	0	Pass	C	0	None	No	25	3

RRC Connection Setup

- RRC Connection Setup establishes SRB1

```
2011 Nov 15  19:34:14.167  [00]  0xB0C0  LTE RRC OTA Packet  --
    DL_CCCH
Radio Bearer ID = 0, Physical Cell ID = 0
Freq = 5230
SysFrameNum = 760, SubFrameNum = 3
value DL-CCCH-Message ::=
{
  message c1 : rrcConnectionSetup :
      {
        criticalExtensions c1 : rrcConnectionSetup-r8 :
            {
              radioResourceConfigDedicated
              {
                srb-ToAddModList
                {
                  {
                    srb-Identity 1,
                    rlc-Config defaultValue : NULL,
                    logicalChannelConfig defaultValue : NULL
                  }
                },
                mac-MainConfig explicitValue :
                  {
                    ul-SCH-Config
                    {
                      maxHARQ-Tx n5,
                      periodicBSR-Timer sf20,
                      retxBSR-Timer sf320,
                      ttiBundling FALSE
                    },
                    drx-Config release : NULL,
                    timeAlignmentTimerDedicated sf750,
                    phr-Config setup :
                      {
                        periodicPHR-Timer sf500,
                        prohibitPHR-Timer sf200,
                        dl-PathlossChange dB3
                      }
                  },
              physicalConfigDedicated
              {
                pdsch-ConfigDedicated
                {
                  p-a dB-3
                },
                pucch-ConfigDedicated
                {
                  ackNackRepetition release : NULL
                },
                pusch-ConfigDedicated
                {
                  betaOffset-ACK-Index 9,
                  betaOffset-RI-Index 6,
                  betaOffset-CQI-Index 6
                },
                uplinkPowerControlDedicated
                {
                  ……
                }
```


RRC Connection Setup Complete

- RRC Connection Setup Complete acknowledges SRB1 setup; it is sent on SRB1.
- The Attach Request is sent as part of the RRC Connection Setup Complete message; this reduces connection establishment delay.

```
2011 Nov 15  19:34:14.171  [00]  0xB0C0  LTE RRC OTA Packet  --  UL_DCCH
Radio Bearer ID = 1, Physical Cell ID = 0
Freq = 5230
PDU Number = UL_DCCH Message,    Msg Length = 86

value UL-DCCH-Message ::=
{
  message c1 : rrcConnectionSetupComplete :
      {
        rrc-TransactionIdentifier 0,
        criticalExtensions c1 : rrcConnectionSetupComplete-r8 :
            {
              selectedPLMN-Identity 1,
              registeredMME
              {
                mmegi '10000000 00000001'B,
                mmec '00000001'B
              },
              dedicatedInfoNAS
'17144A5300060741020BF600F110800101123456780 2E0E0002A0203D011D1272380802110010000108106000
0000083060000000000030000 0D00000100000C00000A005200F11000019011034F18A6'H
            }
      }
}
```


RRC Connection Setup Complete (Lower Layers)

- RRC Connection Setup Complete is sent 4 frames after getting UL grant (762-3); grant is received at 761-9 on PDCCH after reading DCI information.

2011 Nov 15 19:34:14.181 [00] 0xB130 LTE LL1 PDCCH Decoding Result

Version = 3
Sub-frame Number = 9
System Frame Number = 761
Number of Hypothesis = 1
Hypothesis

#	Payload	Aggregation Level	Candidate	Search Space Type	DCI Format	Decode Status	Start CCE	Payload Size	Tail Match	Prune Status	Energy Metric	Symbol Mismatch Count
0	0x2582480000000000	Agg2	1	User	0	C_RNTI	20	43	Match	SUCCESS_DCI0	3999	0

2011 Nov 15 19:34:14.430 [00] 0xB16C LTE DCI Information Report

Version = 2
Number of Records = 18
DCI Info Records

#	SFN	Sub-fn	UL Grant Present	UL Grant Info: 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
0	758	8	No															
1	759	9	No															
2	760	3	No															
3	761	9	Yes	11	1200	Disabled	9	0	1	0	FDD	0		0	0	25	9	QPSK
4	762	8	No															
5	764	4	No															
6	765	9	Yes	11	1200	Disabled	9	1	1	0	FDD	0		0	0	25	9	QPSK
7	771	9	Yes	11	1200	Disabled	9	0	1	0	FDD	0		0	0	25	9	QPSK
8	772	8	No															
9	773	6	No															
10	775	9	Yes	11	1200	Disabled	9	1	1	0	FDD	0		0	0	25	9	QPSK
11	776	8	No															
12	777	3	No															
13	779	9	Yes	11	1200	Disabled	9	0	1	0	FDD	0		0	0	25	9	QPSK
14	780	8	No															
15	781	3	No															
16	783	9	Yes	11	1200	Disabled	9	1	1	0	FDD	0		0	0	25	9	QPSK
17	784	8	No															

2011 Nov 15 19:34:14.184 [00] 0xB139 LTE LL1 PUSCH Tx Report

Version = 4
Serving Cell ID = 0
Number of Records = 1
Dispatch SFN SF = 7623
Records

Current SFN SF	ACK	CQI	RI	Frequency Hopping	Re-tx Index	Redund Ver	Mirror Hopping	Cyclic Shift of DMRS Symbols Slot 0 (Samples)	Cyclic Shift of DMRS Symbols Slot 1 (Samples)	DMRS Root Slot 0	UE	DMRS Root Slot 1	Start RB Slot 0	Start RB Slot 1	Num of RB	PUSCH TB Size (bytes)	Num ACK Bits (bits)	ACK Payload
7623	None	None	None	Disabled	First	0	0	9	8	123	OFF	161	0	0	25	501	0	0000

Authentication Request

- Once SRB1 is established, the UE and network exchange NAS PDUs in the RRC OTA message's dedicatedInfoNAS IE. The RRC layer is transparent for this information. This log packet shows the authentication request in the downlink (DL) RRC message.

```
2011 Nov 15  19:34:14.208  [00]  0xB0C0  LTE RRC OTA Packet  --  DL_DCCH
Pkt Version = 2
RRC Release Number.Major.minor = 9.3.0
Radio Bearer ID = 1, Physical Cell ID = 0
Freq = 5230
SysFrameNum = N/A, SubFrameNum = 0
PDU Number = DL_DCCH Message,    Msg Length = 39

Interpreted PDU:

value DL-DCCH-Message ::=
{
  message c1 : dlInformationTransfer :
      {
        rrc-TransactionIdentifier 0,
        criticalExtensions c1 : dlInformationTransfer-r8 :
            {
              dedicatedInfoType dedicatedInfoNAS :
   '075200A3DE0C6D363E30C364A4078F1BF8D577106E323B36C46C8000A3DF0E6E323BB6C4'H
            }
      }
}
```


Authentication Request (cont.)

- This is the authentication request seen in the NAS layer.

```
2011 Nov 15  19:34:14.209  [00]  0xB0EC  LTE NAS EMM
   Plain OTA Incoming Message  --  Authentication
   request Msg
pkt_version = 1 (0x1)
rel_number = 8 (0x8)
rel_version_major = 2 (0x2)
rel_version_minor = 0 (0x0)
security_header_or_skip_ind = 0 (0x0)
prot_disc = 7 (0x7) (EPS mobility management messages)
msg_type = 82 (0x52) (Authentication request)
lte_emm_msg
  emm_auth_req
    tsc = 0 (0x0) (cached sec context)
    nas_key_set_id = 0 (0x0)
    auth_param_RAND
      rand_val[0] = 163 (0xa3)
      rand_val[1] = 222 (0xde)
      rand_val[2] = 12 (0xc)
      rand_val[3] = 109 (0x6d)
      rand_val[4] = 54 (0x36)
      rand_val[5] = 62 (0x3e)
      rand_val[6] = 48 (0x30)
      rand_val[7] = 195 (0xc3)
      rand_val[8] = 100 (0x64)
      rand_val[9] = 164 (0xa4)
      rand_val[10] = 7 (0x7)
      rand_val[11] = 143 (0x8f)
      rand_val[12] = 27 (0x1b)
      rand_val[13] = 248 (0xf8)
      rand_val[14] = 213 (0xd5)
      rand_val[15] = 119 (0x77)
    auth_param_AUTN
      autn_len = 16 (0x10)
      autn[0] = 110 (0x6e)
      autn[1] = 50 (0x32)
      autn[2] = 59 (0x3b)
      autn[3] = 54 (0x36)
      autn[4] = 196 (0xc4)
      autn[5] = 108 (0x6c)
      autn[6] = 128 (0x80)
      autn[7] = 0 (0x0)
      autn[8] = 163 (0xa3)
      autn[9] = 223 (0xdf)
      autn[10] = 14 (0xe)
      autn[11] = 110 (0x6e)
      autn[12] = 50 (0x32)
      autn[13] = 59 (0x3b)
      autn[14] = 182 (0xb6)
      autn[15] = 196 (0xc4)
```


Authentication Response

- NAS authentication response PDU is sent to the network in a RRC ULInformationTransfer message.

```
2011 Nov 15  19:34:14.266  [00]  0xB0ED  LTE NAS EMM Plain OTA Outgoing Message  --  Authentication response Msg
prot_disc = 7 (0x7) (EPS mobility management messages)
msg_type = 83 (0x53) (Authentication response)
lte_emm_msg
  emm_auth_resp
    auth_resp_param
      len_auth_resp = 8 (0x8)
      res[0] = 163 (0xa3)
      res[1] = 223 (0xdf)
      res[2] = 14 (0xe)
      res[3] = 110 (0x6e)
      res[4] = 50 (0x32)
      res[5] = 59 (0x3b)
      res[6] = 54 (0x36)
      res[7] = 196 (0xc4)

2011 Nov 15  19:34:14.270  [00]  0xB0C0  LTE RRC OTA Packet  --  UL_DCCH
Radio Bearer ID = 1, Physical Cell ID = 0
Freq = 5230
value UL-DCCH-Message ::=
{
  message c1 : ulInformationTransfer :
      {
        criticalExtensions c1 : ulInformationTransfer-r8 :
            {
              dedicatedInfoType dedicatedInfoNAS : '17B23635C807075308A3DF0E6E323B36C4'H
            }
      }
}
```


Attach Procedure – Overview

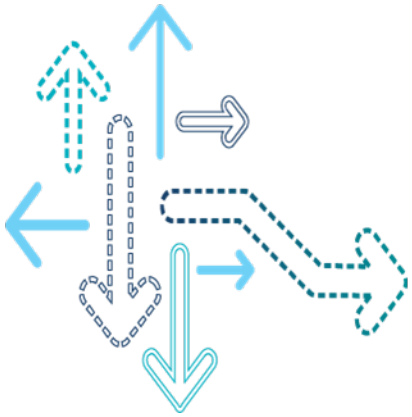
#	Time	Type	Description	Subtitle	Direction	Size
1...	19:34:14.049	0xB0C0	LTE RRC OTA Packet	BCCH_DL_SCH	BS >>> MS	43
1...	19:34:14.085	0xB0C0	LTE RRC OTA Packet	BCCH_DL_SCH	BS >>> MS	51
2...	19:34:14.117	0xB0ED	LTE NAS EMM Plain OTA Outgoing Message	Attach request Msg	BS <<< MS	96
2...	19:34:14.121	0xB0EB	LTE NAS EMM Security Protected Outgoing Msg			96
2...	19:34:14.122	0xB0C0	LTE RRC OTA Packet	UL_CCCH	BS <<< MS	31
3...	19:34:14.167	0xB0C0	LTE RRC OTA Packet	DL_CCCH	BS >>> MS	42
4...	19:34:14.171	0xB0C0	LTE RRC OTA Packet	UL_DCCH	BS <<< MS	111
4...	19:34:14.208	0xB0C0	LTE RRC OTA Packet	DL_DCCH	BS >>> MS	64
4...	19:34:14.209	0xB0EC	LTE NAS EMM Plain OTA Incoming Message	Authentication request Msg	BS >>> MS	52
4...	19:34:14.266	0xB0ED	LTE NAS EMM Plain OTA Outgoing Message	Authentication response Msg	BS <<< MS	33
4...	19:34:14.270	0xB0EB	LTE NAS EMM Security Protected Outgoing Msg			33
4...	19:34:14.270	0xB0C0	LTE RRC OTA Packet	UL_DCCH	BS <<< MS	45
4...	19:34:14.300	0xB0C0	LTE RRC OTA Packet	DL_DCCH	BS >>> MS	41
4...	19:34:14.300	0xB0EA	LTE NAS EMM Security Protected Incoming Msg			29
4...	19:34:14.300	0xB0EC	LTE NAS EMM Plain OTA Incoming Message	Security mode command Msg	BS >>> MS	23
4...	19:34:14.306	0xB0ED	LTE NAS EMM Plain OTA Outgoing Message	Security mode complete Msg	BS <<< MS	24
4...	19:34:14.313	0xB0EB	LTE NAS EMM Security Protected Outgoing Msg			24
4...	19:34:14.313	0xB0C0	LTE RRC OTA Packet	UL_DCCH	BS <<< MS	36
4...	19:34:14.337	0xB0C0	LTE RRC OTA Packet	DL_DCCH	BS >>> MS	37
4...	19:34:14.337	0xB0EA	LTE NAS EMM Security Protected Incoming Msg			25
4...	19:34:14.344	0xB0E2	LTE NAS ESM Plain OTA Incoming Message	ESM information request Msg	BS >>> MS	19
4...	19:34:14.345	0xB0E3	LTE NAS ESM Plain OTA Outgoing Message	ESM information response Msg	BS <<< MS	34
4...	19:34:14.352	0xB0E1	LTE NAS ESM Security Protected Outgoing Msg			34
4...	19:34:14.353	0xB0C0	LTE RRC OTA Packet	UL_DCCH	BS <<< MS	46
4...	19:34:14.377	0xB0C0	LTE RRC OTA Packet	DL_DCCH	BS >>> MS	37
4...	19:34:14.377	0xB0EA	LTE NAS EMM Security Protected Incoming Msg			25
4...	19:34:14.384	0xB0E2	LTE NAS ESM Plain OTA Incoming Message	Unknown Msg	BS >>> MS	19
4...	19:34:14.392	0xB0C0	LTE RRC OTA Packet	UL_DCCH	BS <<< MS	36
4...	19:34:14.442	0xB0C0	LTE RRC OTA Packet	DL_DCCH	BS >>> MS	28
5...	19:34:14.449	0xB0C0	LTE RRC OTA Packet	UL_DCCH	BS <<< MS	27
5...	19:34:14.481	0xB0C0	LTE RRC OTA Packet	DL_DCCH	BS >>> MS	28
5...	19:34:14.482	0xB0C0	LTE RRC OTA Packet	UL_DCCH	BS <<< MS	41
5...	19:34:14.535	0xB0C0	LTE RRC OTA Packet	DL_DCCH	BS >>> MS	141
5...	19:34:14.540	0xB0EA	LTE NAS EMM Security Protected Incoming Msg			94
5...	19:34:14.541	0xB0C0	LTE RRC OTA Packet	UL_DCCH	BS <<< MS	27
5...	19:34:14.550	0xB0EC	LTE NAS EMM Plain OTA Incoming Message	Attach accept Msg	BS >>> MS	88
5...	19:34:14.550	0xB0E2	LTE NAS ESM Plain OTA Incoming Message	Activate default EPS bearer context request Msg	BS >>> MS	75
7...	19:34:14.589	0xB0C0	LTE RRC OTA Packet	BCCH_DL_SCH	BS >>> MS	43
7...	19:34:14.605	0xB0EB	LTE NAS EMM Security Protected Outgoing Msg			24
7...	19:34:14.605	0xB0ED	LTE NAS EMM Plain OTA Outgoing Message	Attach complete Msg	BS <<< MS	29
7...	19:34:14.612	0xB0EB	LTE NAS EMM Security Protected Outgoing Msg			29

NAS Security Command

AS Security Command and UE Capability Exchange

RRC Connection Reconfiguration

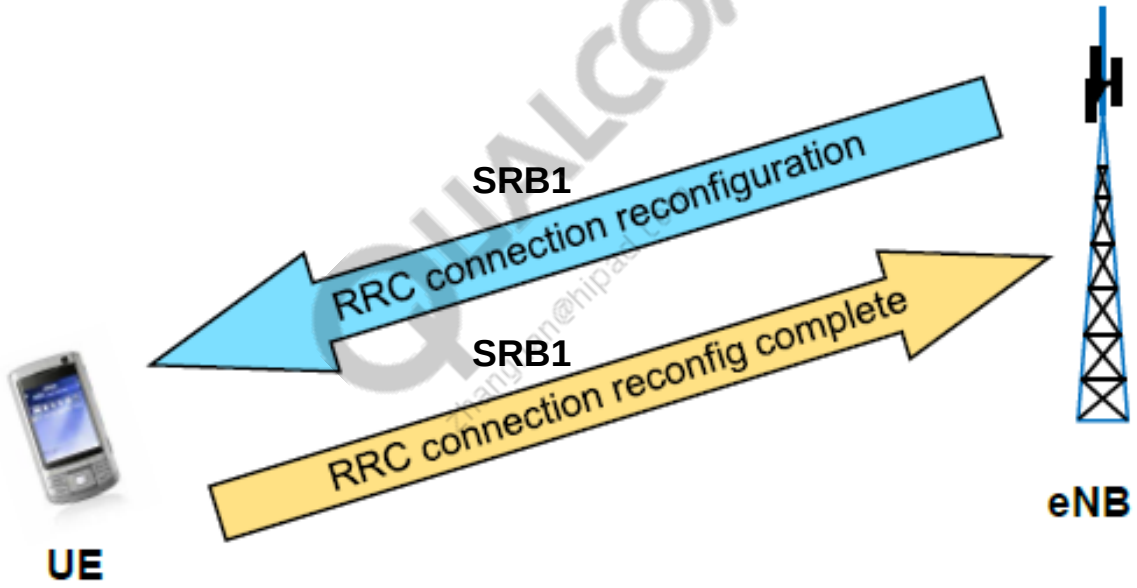
RRC Connection Reconfiguration



RRC Connection Reconfiguration Procedure

- Purpose
  - Establish, modify, or release an RRC connection
  - Perform handover
  - Measurement configuration
  - Security configuration
  - Carry certain NAS dedicated information
- Procedure
  - Only happens during RRC_CONNECTED state
  - Activated only after Access Stratum (AS) security has been activated
  - If nas-dedicatedInformationList is included, forward each element to upper layer
  - If MeasurementConfiguration is included, configure measurements
  - Submit RRCConnectionReconfigurationComplete to the lower layer for transmission using the new configuration
  - In RRC_CONNECTED, the network controls UE mobility; mobility control can be done through the RRC connection reconfiguration procedure

RRC Connection Reconfiguration (cont.)



RRC Connection Reconfiguration – SRB2 and DRB Setup

- SRB2 is configured only after AS security is activated. Attach Accept/Activate Default EPS Bearer Request is included as NAS PDU. DRB ID 1 is tied to the default EPS bearer ID 5.

```
2011 Nov 15  19:34:14.535  [00]  0xB0C0  LTE RRC OTA Packet  --  DL_DCCH
value DL-DCCH-Message ::=
{
  message c1 : rrcConnectionReconfiguration :
      {
        rrc-TransactionIdentifier 0,
        criticalExtensions c1 : rrcConnectionReconfiguration-r8 :
            {
              dedicatedInfoNASList
              {
                '2708C6AFEB03413166D7177A663C89201539AE68A114058FE4DFFD8E270
409E45279EC1AA2BCF4F6D8F194D2BCB09750E691AD9C73CC0913DF731A3F440E
840955C9105B2228439366DAD529A0CD'H
              },
              radioResourceConfigDedicated
              {
                srb-ToAddModList
                {
                  {
                    srb-Identity 2,
                    rlc-Config defaultValue : NULL,
                    logicalChannelConfig defaultValue : NULL
                  }
                },
                drb-ToAddModList
                {
                  {
                    eps-BearerIdentity 5,
                    drb-Identity 1,
                    pdcp-Config
                   {
                       discardTimer infinity,
                       rlc-AM
                       {
                         statusReportRequired TRUE
                       },
                       headerCompression notUsed : NULL
                     },
                     rlc-Config am :
                       {
                         ul-AM-RLC
                         {
                           t-PollRetransmit ms80,
                           pollPDU p128,
                           pollByte kB125,
                           maxRetxThreshold t4
                         },
                         dl-AM-RLC
                         {
                           t-Reordering ms80,
                           t-StatusProhibit ms60
                         }
                       },
                     logicalChannelIdentity 3,
                     logicalChannelConfig
                      ...
                                 }
                },
                mac-MainConfig explicitValue :
                  …
physicalConfigDedicated
                …
soundingRS-UL-ConfigDedicated setup :
                  …
                antennaInfo defaultValue : NULL
```


RRC Connection Reconfiguration Complete

- Attach Accept assigns UE its IPv4/v6 address. Also in Attach Accept, the network asks to activate default EPS bearer context, associated with the default EPS bearer ID 5.

```
2011 Nov 15  19:34:14.541  [00]  0xB0C0  LTE RRC OTA Packet  --
    UL_DCCH
message c1 : rrcConnectionReconfigurationComplete :
      {
        rrc-TransactionIdentifier 0,
        criticalExtensions
    rrcConnectionReconfigurationComplete-r8 :
          {
          }
      }
2011 Nov 15  19:34:14.550  [00]  0xB0EC  LTE NAS EMM Plain OTA
    Incoming Message  --  Attach accept Msg
attach_result = 2 (0x2) (comb EPS/IMSI attach)
...
      mcc_mnc
          mcc_1 = 0 (0x0)
          mcc_2 = 0 (0x0)
          mcc_3 = 1 (0x1)
          mnc_3 = 15 (0xf)
          mnc_1 = 0 (0x0)
          mnc_2 = 1 (0x1)
        tac[0] = 1 (0x1)
 esm_msg_container
      eps_bearer_id = 5 (0x5)
      prot_disc = 2 (0x2) (EPS session management messages)
      trans_id = 3 (0x3)
      msg_type = 193 (0xc1) (Activate default EPS bearer
    context request)
      lte_esm_msg
        act_def_eps_bearer_context_req
          eps_qos ……
      access_point
            num_acc_pt_val = 7 (0x7)
            acc_pt_name_val[0] = 6 (0x6) (length)
            acc_pt_name_val[1] = 118 (0x76) (v)
            acc_pt_name_val[2] = 122 (0x7a) (z)
            acc_pt_name_val[3] = 119 (0x77) (w)
            acc_pt_name_val[4] = 105 (0x69) (i)
            acc_pt_name_val[5] = 109 (0x6d) (m)
            acc_pt_name_val[6] = 115 (0x73) (s)
          pdn_addr
            pdn_addr_len = 5 (0x5)
            pdn_type = 1 (0x1) (IPv4)
            ipv4_addr = 16908554 (0x102010a) (1.2.1.10)
          ...
      guti_incl = 1 (0x1)
      guti
        …
        MME_group_id = 32769 (0x8001)
        MME_code = 1 (0x1)
        m_tmsi = 305419896 (0x12345678)
      loc_id_incl = 1 (0x1)
      loc_area_id
    ...
emm_cause_incl = 0 (0x0)
…
      eps_netwk_feature_support_incl = 1 (0x1)
      eps_netwk_feature_support
        length = 1 (0x1)
        IMSVoPS = 1 (0x1) (IMS Vo PS Session in S1 Mode
    supported)
      add_update_result_incl = 0 (0x0)
```

Completion of the Attach Procedure and Establishment of Default EPS Bearer

- UE sends Attach Complete and Activate Default EPS Bearer Context Accept as NAS PDU in RRC ULInformationTransfer message

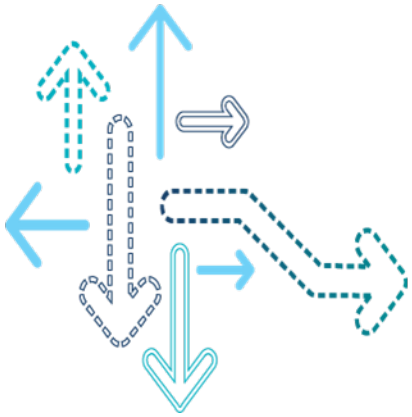
```
2011 Nov 15  19:34:14.605  [00]  0xB0ED  LTE NAS EMM Plain OTA Outgoing Message  --  Attach complete Msg
msg_type = 67 (0x43) (Attach complete)
lte_emm_msg
  emm_attach_complete
    esm_msg_container
      eps_bearer_id = 5 (0x5)
      prot_disc = 2 (0x2) (EPS session management messages)
      trans_id = 0 (0x0)
      msg_type = 194 (0xc2) (Activate default EPS bearer context accept)
      lte_esm_msg
        act_def_eps_bearer_context_accept
          prot_config_incl = 0 (0x0)

2011 Nov 15  19:34:14.612  [00]  0xB0EB  LTE NAS EMM Security Protected Outgoing Msg
Raw Data = {     01 08 02 00 27 96 49 1A 53 03 B3 ED 17 5D 5A 42 82  }

2011 Nov 15  19:34:14.612  [00]  0xB0C0  LTE RRC OTA Packet  --  UL_DCCH
value UL-DCCH-Message ::=
{
  message c1 : ulInformationTransfer :
      {
        criticalExtensions c1 : ulInformationTransfer-r8 :
            {
              dedicatedInfoType dedicatedInfoNAS : '2796491A5303B3ED175D5A4282'H
            }
      }
}
```


RRC Connection Release

- RRC goes back to Idle mode after RRC Connection Release

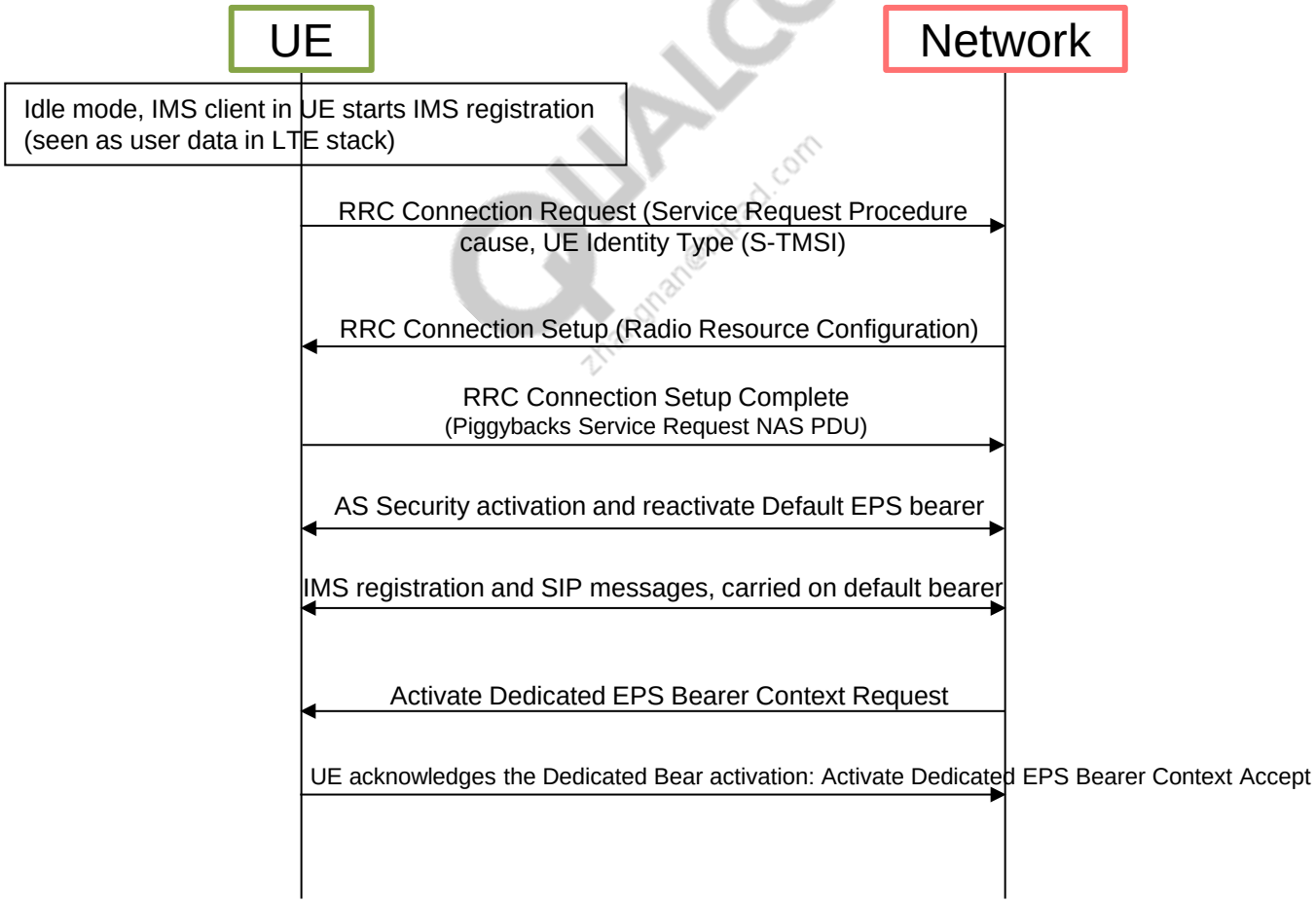
```
2011 Nov 15  19:34:16.165  [00]  0xB0C0  LTE RRC OTA Packet  --
DL_DCCH
Pkt Version = 2
RRC Release Number.Major.minor = 9.3.0
Radio Bearer ID = 1, Physical Cell ID = 0
Freq = 5230
SysFrameNum = N/A, SubFrameNum = 0
PDU Number = DL_DCCH Message,    Msg Length = 2

Interpreted PDU:

value DL-DCCH-Message ::=
{
  message c1 : rrcConnectionRelease :
      {
        rrc-TransactionIdentifier 0,
        criticalExtensions c1 : rrcConnectionRelease-r8 :
            {
              releaseCause other
            }
      }
}
```


Dedicated Bearer Setup

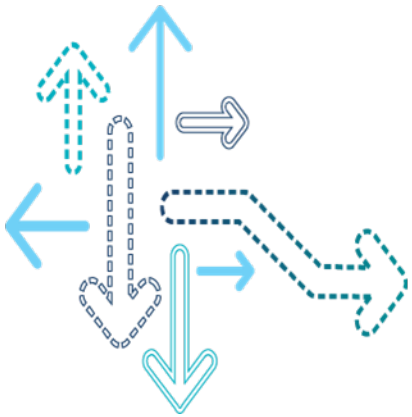


Dedicated EPS Bearer Establishment

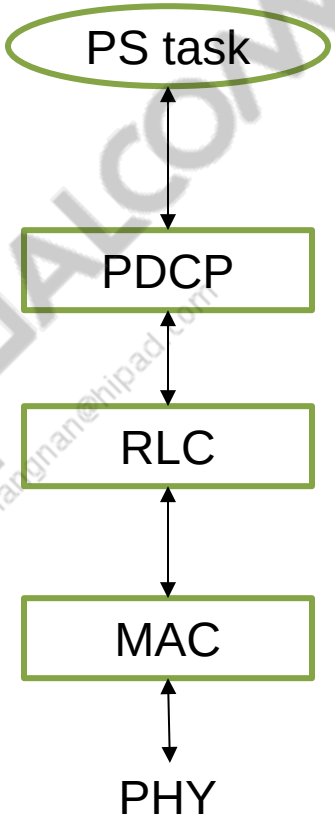
- Default EPS bearer enables Best Effort transport of user data
- QoS can be provided with Dedicated EPS bearers (UE-initiated or network-initiated)
- Network-initiated Dedicated EPS bearers setup is explained below. It is triggered, for example, by UE registering with IMS core to establish VoIP service; IMS node will then trigger PCRF to establish corresponding dedicated bearers.



Data Transfer



Data Flow in LTE Protocol Stack



Data Transfer in Connected Mode (on Default EPS Bearer)

- The network pages the UE in PS domain

```
2011 Nov 15  19:34:16.165  [00]  0xB0C0  LTE RRC OTA Packet  --  DL_DCCH
message c1 : rrcConnectionRelease :

2011 Nov 15  19:34:18.302  [00]  0xB0C0  LTE RRC OTA Packet  --  PCCH
Radio Bearer ID = 0, Physical Cell ID = 0
Freq = 5230
SysFrameNum = 149, SubFrameNum = 9
PDU Number = PCCH Message,    Msg Length = 7

value PCCH-Message ::=
{
  message c1 : paging :
       {
         pagingRecordList
         {
           {
             ue-Identity s-TMSI :
               {
                 mmec '00000001'B,
                 m-TMSI '00010010 00110100 01010110 01111000'B
               },
             cn-Domain ps
           }
         }
       }
}
```


Data Transfer in Connected Mode

- UE responds with Service Request

```
2011 Nov 15  19:34:18.302  [00]  0xB0ED  LTE NAS EMM Plain OTA Outgoing Message  --  Service Request Msg
pkt_version = 1 (0x1)
rel_number = 8 (0x8)
rel_version_major = 2 (0x2)
rel_version_minor = 0 (0x0)
security_header_or_skip_ind = 12 (0xc)
prot_disc = 7 (0x7) (EPS mobility management messages)
emm_serv_req_msg
  ksi = 0 (0x0)
  seq_num = 0 (0x0)
  short_mac_value = 0 (0x0)

2011 Nov 15  19:34:18.307  [00]  0xB0C0  LTE RRC OTA Packet  --  UL_CCCH
message c1 : rrcConnectionRequest :

2011 Nov 15  19:34:18.383  [00]  0xB0C0  LTE RRC OTA Packet  --  DL_CCCH
message c1 : rrcConnectionSetup :

2011 Nov 15  19:34:18.387  [00]  0xB0C0  LTE RRC OTA Packet  --  UL_DCCH
message c1 : rrcConnectionSetupComplete :

2011 Nov 15  19:34:18.443  [00]  0xB0C0  LTE RRC OTA Packet  --  DL_DCCH
message c1 : securityModeCommand

2011 Nov 15  19:34:18.450  [00]  0xB0C0  LTE RRC OTA Packet  --  UL_DCCH
message c1 : securityModeComplete :
```


Data Transfer in Connected Mode – Set Up SRB2 and DRB

```
2011 Nov 15  19:34:18.484  [00]  0xB0C0  LTE RRC OTA Packet  --  DL_DCCH
criticalExtensions c1 : rrcConnectionReconfiguration-r8 :
            {
              radioResourceConfigDedicated
              {
                srb-ToAddModList
                {
                  {
                    srb-Identity 2,
                    rlc-Config defaultValue : NULL,
                    logicalChannelConfig defaultValue : NULL
                  }
                },
                drb-ToAddModList
                {
                  {
                    eps-BearerIdentity 5,
                    drb-Identity 1,
                    pdcp-Config
                    {
                      discardTimer infinity,
                      rlc-AM
                      {
                        statusReportRequired TRUE
                      },
                      headerCompression notUsed : NULL
                    },
                    rlc-Config am :
                    logicalChannelIdentity 3,
```

Data Transfer in Connected Mode – Loopback Test

- Start Loopback Test mode, ULInformationTransfer piggybacks the Closed UE Test Loop Complete message.

```
2011 Nov 15  19:34:18.490  [00]  0xB0C0  LTE RRC OTA Packet  --  UL_DCCH
message c1 : rrcConnectionReconfigurationComplete :

2011 Nov 15  19:34:18.536  [00]  0xB0E2  LTE NAS ESM Plain OTA Incoming Message  --  Unknown Msg
eps_bearer_id = 0 (0x0)
prot_disc = 15 (0xf) (by tests procedures)
trans_id = 128 (0x80)
msg_type = 0 (0x0) (unknown)
lte_esm_msg

2011 Nov 15  19:34:18.543  [00]  0xB0C0  LTE RRC OTA Packet  --  UL_DCCH
message c1 : ulInformationTransfer :
      {
        criticalExtensions c1 : ulInformationTransfer-r8 :
            {
              dedicatedInfoType dedicatedInfoNAS : '27850931B4059976'H
            }
      }
```


Data Transfer in Connected Mode – Data Transfer

- DL data that needs to be looped back – 3 bytes of new data in PDCP without RLC and MAC headers, 5 bytes in RLC with 2 bytes RLC header, 8 bytes in MAC with 3 bytes MAC header.

```
2011 Nov 15  19:34:18.705  [00]  0xB063  LTE MAC DL Transport Block
Version = 1
Number of SubPackets = 1
SubPacket ID = 7
SubPacket - ( DL Transport Block Subpacket )
   Version = 1
   Subpacket Size = 20
   Downlink Transport Block :
      Number of samples = 1
```

SFN	Sub-FN	RNTI Type	HARQ ID	DL TBS (bytes)	RLC PDUs	Padding	HDR LEN	Mac Hdr + CE	LC ID	LEN	BI Val	Rapid Val	TA Val	Hop Flag	RB Assign	Coding Scheme	TBS Index	TPC dB	UL Del
188	9	C-RNTI	7	13	1	5	3	23 05 1F	3	5									
									Padding	-1									

```
2011 Nov 15  19:34:18.700  [00]  0xB082  LTE RLC DL AM All PDU
Version = 1
Number of SubPackets = 1
Subpacket ID = 65
SubPacket - ( RLCDL PDU )
   Version = 3
   Subpacket Size = 32 bytes
   RB Cfg Idx = 1, RB Mode = AM, SN Length = 10 bits
   Reserved = 255
   Enabled PDU Log Packets: {
      RLCDL Config (0xB081) = 1
      RLCDL AM ALL PDU (0xB082) = 1
      RLCDL AM CONTROL PDU (0xB083) = 1
      RLCDL AM POLLING PDU (0xB084) = 1
      RLCDL AM SIGNALING PDU (0xB085) = 1
      RLCDL UM DATA PDU (0xB086) = 1
      RLCDL STATISTICS (0xB087) = 1
   }
   VR(R) = 1, VR(X) = 0, VR(MS) = 1, VR(H) = 1
   Number of PDUs = 1
   RLCDL PDU[0]
      PDU TYPE = RLCDL DATA, rb_cfg_idx =   1, Status = PDU DATA, SN      =     0, sys_fn = 188, sub_fn = 9, pdu_bytes = 5, RF = 0, P = 1, FI = 00, E = 0
      Hex Dump =  A0 00
```

```
2011 Nov 15  19:34:18.700  [00]  0xB0A3  LTE PDCP DL Cipher Data PDU
Version = 1
Num Subpackets = 1
Subpacket[0]
   Subpacket ID = PDCP PDU with Ciphering (0xC3)
   Subpacket Version = 1
   Subpacket Size = 56 bytes
   SRB Ciphering Keys (hex) =  24 F1 3D 0F 6C 42 16 8A E2 32 74 C4 9F 1E 52 9A
   DRB Ciphering Keys (hex) =  FF 45 43 0B 01 04 43 43 DD 9B BA 6D 04 75 EE 5B
   SRB Cipher Algo = LTE SNOW-3G
   DRB Cipher Algo = LTE SNOW-3G
   Num PDUs = 1
```

PDCPDL CIPH DATA	cfg idx	mode	sn length	bearer id	valid pdu	pdu size	logged bytes	sys_fn	sub_fn	count (hex)	sn	log_buffer (hex)
PDCPDL CIPH DATA	1	AM	12 bit	0	Yes	3	3	N/A	N/A	0x0	0	80 00 72

Data Transfer in Connected Mode

- In uplink (UL), the UE loops back received data – 3 bytes of PDCP PDU, plus the RLC header, 5 bytes of payload in MAC, as shown in 0xB064.

```
2011 Nov 15  19:34:18.730  [00]  0xB0B3  LTE PDCP UL Cipher Data PDU
Version = 1
Num Subpackets = 1
Subpacket[0]
   Subpacket ID = PDCP PDU with Ciphering (0xC3)
   Subpacket Version = 1
   Subpacket Size = 56 bytes
   SRB Ciphering Keys (hex) =  24 F1 3D 0F 6C 42 16 8A E2 32 74 C4 9F 1E 52 9A
   DRB Ciphering Keys (hex) =  FF 45 43 0B 01 04 43 43 DD 9B BA 6D 04 75 EE 5B
   SRB Cipher Algo = LTE SNOW-3G
   DRB Cipher Algo = LTE SNOW-3G
   Num PDUs = 1
   ---------------------------------------------------------------------------------------------------------------
   |                  |cfg|    |sn     |bearer|valid|pdu   |logged|       |       |count|    |                    |
   |PDCPUL CIPH DATA  |idx|mode|length|id     |pdu  |size  |bytes |sys_fn|sub_fn|(hex)|sn  |log_buffer (hex)    |
   ---------------------------------------------------------------------------------------------------------------
   | PDCPUL CIPH DATA|  1|  AM|12 bit|     0|  Yes|     3|     3|   190|     3|  0x0|   0| 80 00 FF           |
```

```
2011 Nov 15  19:34:18.720  [00]  0xB064  LTE MAC UL Transport Block
Version = 1
Number of SubPackets = 1
SubPacket ID = 8
SubPacket - ( UL Transport Block Subpacket )
   Version = 1
   Subpacket Size = 24
   Uplink Transport Block :
      Number of samples = 1
      ---------------------------------------------------------------------------------------------------------------------------------------------------------
      |     |      |          |       |Grant  |RLC  |Padding|                |         |HDR  |                          |          |     |BSR  |BSR  |BSR  |
      |SFN  |Sub-FN|RNTI Type |HARQ ID|(bytes)|PDUs |(bytes)|BSR event       |BSR trig |LEN  |Mac Hdr + CE              |LC ID     |LEN  |LCG 0|LCG 1|LCG 2|
      ---------------------------------------------------------------------------------------------------------------------------------------------------------
      |  190|     3|     C-RNTI|      1|   2673|    2|   2659|High Data Arrival|     S-BSR|    7| 3D 23 02 23 05 1F 80     |      S-BSR|    1|     |     |    0|
      |     |      |           |       |       |     |       |                |         |     |                          |         3|    2|     |     |     |
      |     |      |           |       |       |     |       |                |         |     |                          |         3|    5|     |     |     |
      |     |      |           |       |       |     |       |                |         |     |                          |   Padding|   -1|     |     |     |
```


Data Transfer in Connected Mode (cont.)

- In UL, the UE loops back the same amount of received data on DRB ID 1. The data is seen in RLC as RLCUL DATA PDUs. The network receives it and acknowledges with RLC DL control PDUs. In this example, UL data PDU of SN 0 is sent, and the network acks with a control PDU stating the next expected SN is 1.

```
2011 Nov 15  19:34:18.730  [00]  0xB092  LTE RLC UL AM All PDU
Version = 1
Number of SubPackets = 1
Subpacket ID = 70
SubPacket - ( RLCUL PDU )
   Version = 3
   Subpacket Size = 44 bytes
   RB Cfg Idx = 1, RB Mode = AM, SN Length = 10 bits
   Reserved = 0
   Enabled PDU Log Packets: {
      RLCUL Config (0xB091) = 1
      RLCUL AM ALL PDU (0xB092) = 1
      RLCUL AM CONTROL PDU (0xB093) = 1
      RLCUL AM POLLING PDU (0xB094) = 1
      RLCUL AM SIGNALING PDU (0xB095) = 1
      RLCUL UM DATA PDU (0xB096) = 1
      RLCUL STATISTICS (0xB097) = 1
   }
   VT(A) = 0, VT(S) = 1, PDU Without Poll = 0, Byte Without Poll = 0, Poll SN = 0
   Number of PDUs = 2
   RLCUL PDU[0]
      PDU TYPE = RLCUL CTRL, rb_cfg_idx =   1, ACK_SN =    1, sys_fn = 190, sub_fn = 3, pdu_bytes = 2, cpt = STATUS (0)
      RLCUL CTRL : ACK_SN = 1
      Hex Dump =  00 04
   RLCUL PDU[1]
      PDU TYPE = RLCUL DATA, rb_cfg_idx =   1, SN     =    0, sys_fn = 190, sub_fn = 3, pdu_bytes = 5, RF = 0, P = 1, FI = 00, E = 0
      Hex Dump =  A0 00
```

```
2011 Nov 15  19:34:18.740  [00]  0xB082  LTE RLC DL AM All PDU
Version = 1
Number of SubPackets = 1
Subpacket ID = 65
SubPacket - ( RLCDL PDU )
   Version = 3
   Subpacket Size = 32 bytes
   RB Cfg Idx = 1, RB Mode = AM, SN Length = 10 bits
   Reserved = 255
   Enabled PDU Log Packets: {
      RLCDL Config (0xB081) = 1
      RLCDL AM ALL PDU (0xB082) = 1
      RLCDL AM CONTROL PDU (0xB083) = 1
      RLCDL AM POLLING PDU (0xB084) = 1
      RLCDL AM SIGNALING PDU (0xB085) = 1
      RLCDL UM DATA PDU (0xB086) = 1
      RLCDL STATISTICS (0xB087) = 1
   }
   VR(R) = 1, VR(X) = 0, VR(MS) = 1, VR(H) = 1
   Number of PDUs = 1
   RLCDL PDU[0]
      PDU TYPE = RLCDL CTRL, rb_cfg_idx =   1, Status = PDU CTRL, ACK_SN =    1, sys_fn = 191, sub_fn = 6, pdu_bytes = 2, cpt = STATUS (0)
      RLCDL CTRL : ACK_SN = 1
      Hex Dump =  00 04
```


Data Transfer in Connected Mode (cont.)

- This PDCP packet gives a statistical overview of the packet transmission status on the UL.

```
2011 Nov 15  19:34:54.241  [00]  0xB0B4  LTE PDCP UL Statistics Pkt
Version = 1
Number of SubPackets = 1
Subpacket ID = 197
SubPacket - ( UL Statistics )
   Version = 1
   Subpacket Size = 344
   Num RBs = 3
   PDCPUL Errors = 0
   RBs[0]
      Rb Cfg Idx = 1, Mode = AM, PDCP Hdr Len = 2, Num RST = 0
                          Cumulative Total,                                  Total since last re-establishment
      PDCP UL Stats, 1,   Num Flow Ctrl Trigger          =          0, Num Flow Ctrl Trigger Rst       =          0
      PDCP UL Stats, 1,   Num Data PDU Tx                =        529, Num Data PDU Tx Rst             =        529
      PDCP UL Stats, 1,   Num Data PDU Tx Bytes          =     243973, Num Data PDU Tx Bytes Rst       =     243973
      PDCP UL Stats, 1,   Num Control PDU Tx             =          0, Num Control PDU Tx Rst          =          0
      PDCP UL Stats, 1,   Num Control PDU Tx Bytes       =          0, Num Control PDU Tx Bytes Rst    =          0
      PDCP UL Stats, 1,   Num Status Report              =          0, Num Status Report Rst           =          0
      PDCP UL Stats, 1,   Num ROHC Fail                  =          0, Num ROHC Fail Rst               =          0
      PDCP UL Stats, 1,   Num ROHC Ctrl PDU Tx           =          0, Num ROHC Ctrl PDU Tx Rst        =          0
      PDCP UL Stats, 1,   Num Discard SDU                =          0, Num Discard SDU Rst             =          0
      PDCP UL Stats, 1,   Num Discard SDU Bytes          =          0, Num Discard SDU Bytes Rst       =          0
      PDCP UL Stats, 1,   Num PDU HO ReTx                =          0, Num PDU HO ReTx Rst             =          0
      PDCP UL Stats, 1,   Num PDU HO ReTx Bytes          =          0, Num PDU HO ReTx Bytes Rst       =          0
      PDCP UL Stats, 1,   reserved                       =          0, reserved                        =          0
   RBs[1]
      Rb Cfg Idx = 33, Mode = AM, PDCP Hdr Len = 1, Num RST = 0
                          Cumulative Total,                                  Total since last re-establishment
      PDCP UL Stats, 33,   Num Flow Ctrl Trigger         =          0, Num Flow Ctrl Trigger Rst       =          0
      PDCP UL Stats, 33,   Num Data PDU Tx               =          3, Num Data PDU Tx Rst             =          3
      PDCP UL Stats, 33,   Num Data PDU Tx Bytes         =         26, Num Data PDU Tx Bytes Rst       =         26
      PDCP UL Stats, 33,   Num Control PDU Tx            =          0, Num Control PDU Tx Rst          =          0
      PDCP UL Stats, 33,   Num Control PDU Tx Bytes      =          0, Num Control PDU Tx Bytes Rst    =          0
      PDCP UL Stats, 33,   Num Status Report             =          0, Num Status Report Rst           =          0
      PDCP UL Stats, 33,   Num ROHC Fail                 =          0, Num ROHC Fail Rst               =          0
      PDCP UL Stats, 33,   Num ROHC Ctrl PDU Tx          =          0, Num ROHC Ctrl PDU Tx Rst        =          0
      PDCP UL Stats, 33,   Num Discard SDU               =          0, Num Discard SDU Rst             =          0
      PDCP UL Stats, 33,   Num Discard SDU Bytes         =          0, Num Discard SDU Bytes Rst       =          0
      PDCP UL Stats, 33,   Num PDU HO ReTx               =          0, Num PDU HO ReTx Rst             =          0
      PDCP UL Stats, 33,   Num PDU HO ReTx Bytes         =          0, Num PDU HO ReTx Bytes Rst       =          0
      PDCP UL Stats, 33,   reserved                      =          0, reserved                        =          0
   RBs[2]
      Rb Cfg Idx = 34, Mode = AM, PDCP Hdr Len = 1, Num RST = 0
                          Cumulative Total,                                  Total since last re-establishment
      PDCP UL Stats, 34,   Num Flow Ctrl Trigger         =          0, Num Flow Ctrl Trigger Rst       =          0
      PDCP UL Stats, 34,   Num Data PDU Tx               =          1, Num Data PDU Tx Rst             =          1
      PDCP UL Stats, 34,   Num Data PDU Tx Bytes         =         16, Num Data PDU Tx Bytes Rst       =         16
      PDCP UL Stats, 34,   Num Control PDU Tx            =          0, Num Control PDU Tx Rst          =          0
      PDCP UL Stats, 34,   Num Control PDU Tx Bytes      =          0, Num Control PDU Tx Bytes Rst    =          0
      PDCP UL Stats, 34,   Num Status Report             =          0, Num Status Report Rst           =          0
      PDCP UL Stats, 34,   Num ROHC Fail                 =          0, Num ROHC Fail Rst               =          0
      PDCP UL Stats, 34,   Num ROHC Ctrl PDU Tx          =          0, Num ROHC Ctrl PDU Tx Rst        =          0
      PDCP UL Stats, 34,   Num Discard SDU               =          0, Num Discard SDU Rst             =          0
      PDCP UL Stats, 34,   Num Discard SDU Bytes         =          0, Num Discard SDU Bytes Rst       =          0
      PDCP UL Stats, 34,   Num PDU HO ReTx               =          0, Num PDU HO ReTx Rst             =          0
      PDCP UL Stats, 34,   Num PDU HO ReTx Bytes         =          0, Num PDU HO ReTx Bytes Rst       =          0
      PDCP UL Stats, 34,   reserved                      =          0, reserved                        =          0
```

Data Transfer in Connected Mode – RLC PDUs

- Data transfer continues; the UE continues to receive DL data and loops them back.

2011 Nov 15 19:34:56.662 [00] 0xB082 LTE RLC DL AM All PDU
RLCDL PDU[0]
PDU TYPE = RLCDL DATA, rb_cfg_idx = 1, Status = **PDU DATA, SN = 529**, sys_fn = 911, sub_fn = 9, pdu_bytes = 741, RF = 0, P = 1, FI = 00, E = 0
Hex Dump = A2 11

2011 Nov 15 19:34:56.692 [00] 0xB092 LTE RLC UL AM All PDU
RLCUL PDU[0]
PDU TYPE = RLCUL DATA, rb_cfg_idx = 1, **SN = 529**, sys_fn = 914, sub_fn = 3, pdu_bytes = 741, RF = 0, P = 1, FI = 00, E = 0
Hex Dump = A2 11
RLCUL PDU[1]
PDU TYPE = RLCUL CTRL, rb_cfg_idx = 1, ACK_SN = 530, sys_fn = 916, sub_fn = 3, pdu_bytes = 2, cpt = STATUS (0)
RLCUL CTRL : ACK_SN = 530
Hex Dump = 08 48

2011 Nov 15 19:34:56.702 [00] 0xB082 LTE RLC DL AM All PDU
RLCDL PDU[0]
PDU TYPE = RLCDL CTRL, rb_cfg_idx = 1, Status = PDU CTRL, ACK_SN = 530, sys_fn = 915, sub_fn = 6, pdu_bytes = 2, cpt = STATUS (0)
RLCDL CTRL : ACK_SN = 530
Hex Dump = 08 48

2011 Nov 15 19:34:56.742 [00] 0xB082 LTE RLC DL AM All PDU
RLCDL PDU[0]
PDU TYPE = RLCDL DATA, rb_cfg_idx = 1, Status = **PDU DATA, SN = 530**, sys_fn = 919, sub_fn = 9, pdu_bytes = 831, RF = 0, P = 1, FI = 00, E = 0
Hex Dump = A2 12

Data Transfer in Connected Mode – RLC PDUs (cont.)

2011 Nov 15 19:34:56.782 [00] 0xB092 LTE RLC UL AM All PDU
RLCUL PDU[0]
PDU TYPE = RLCUL DATA, rb_cfg_idx = 1, **SN = 530**, sys_fn = 922, sub_fn = 3, pdu_bytes = 831, RF = 0, P = 1, FI = 00, E = 0
Hex Dump = A2 12
RLCUL PDU[1]
PDU TYPE = RLCUL CTRL, rb_cfg_idx = 1, ACK_SN = 531, sys_fn = 924, sub_fn = 3, pdu_bytes = 2, cpt = STATUS (0)
RLCUL CTRL : ACK_SN = 531
Hex Dump = 08 4C

2011 Nov 15 19:34:56.782 [00] 0xB082 LTE RLC DL AM All PDU
RLCDL PDU[0]
PDU TYPE = RLCDL CTRL, rb_cfg_idx = 1, Status = PDU CTRL, ACK_SN = 531, sys_fn = 923, sub_fn = 6, pdu_bytes = 2, cpt = STATUS (0)
RLCDL CTRL : ACK_SN = 531
Hex Dump = 08 4C

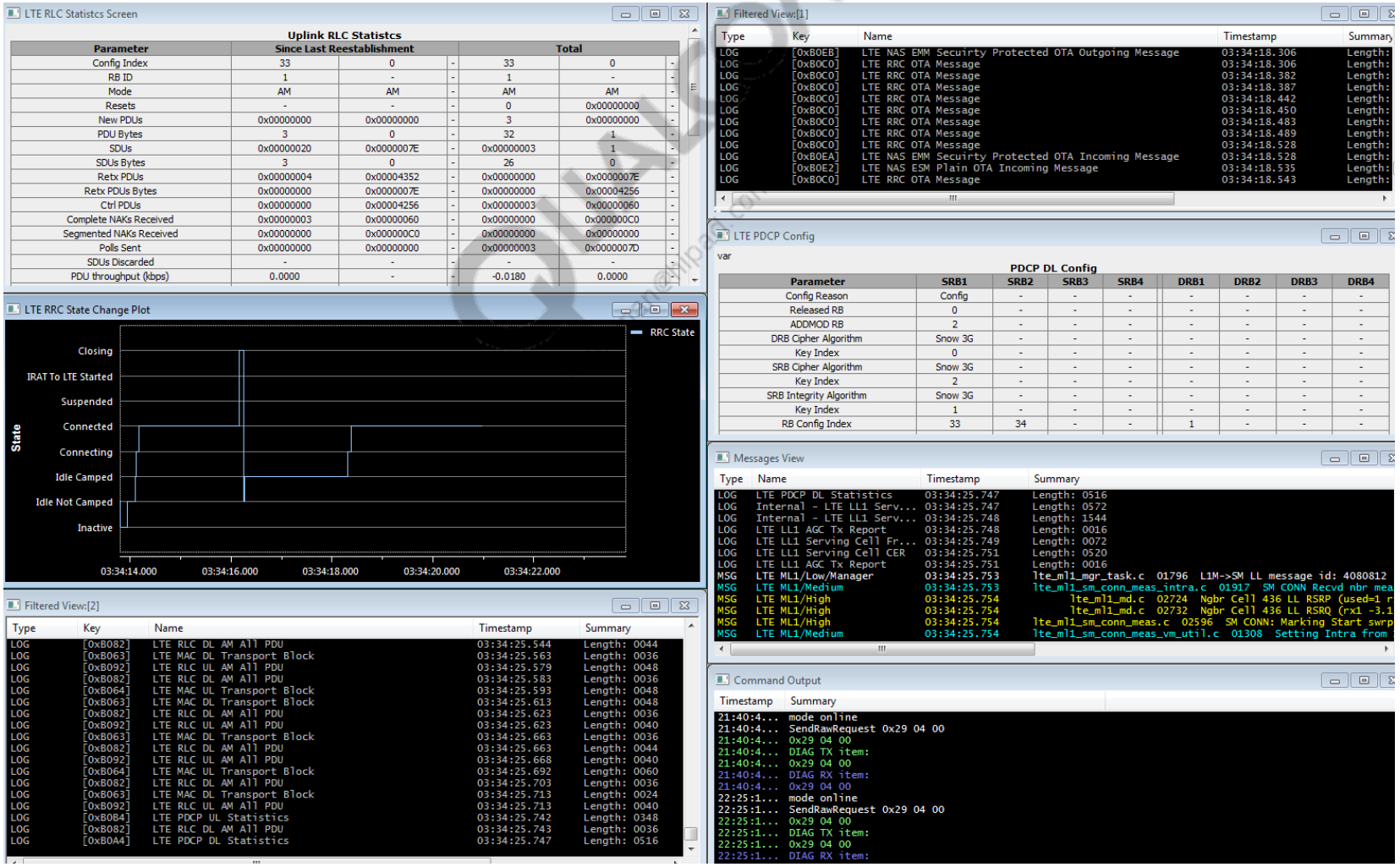
2011 Nov 15 19:34:56.821 [00] 0xB082 LTE RLC DL AM All PDU
RLCDL PDU[0]
PDU TYPE = RLCDL DATA, rb_cfg_idx = 1, Status = **PDU DATA, SN = 531**, sys_fn = 927, sub_fn = 9, pdu_bytes = 927, RF = 0, P = 1, FI = 00, E = 0
Hex Dump = A2 13

2011 Nov 15 19:34:56.827 [00] 0xB092 LTE RLC UL AM All PDU
RLCUL PDU[0]
PDU TYPE = RLCUL DATA, rb_cfg_idx = 1, **SN = 531**, sys_fn = 930, sub_fn = 3, pdu_bytes = 927, RF = 0, P = 1, FI = 00, E = 0
Hex Dump = A2 13

2011 Nov 15 19:34:56.861 [00] 0xB082 LTE RLC DL AM All PDU
RLCDL PDU[0]
PDU TYPE = RLCDL CTRL, rb_cfg_idx = 1, Status = PDU CTRL, ACK_SN = 532, sys_fn = 931, sub_fn = 6, pdu_bytes = 2, cpt = STATUS (0)
RLCDL CTRL : ACK_SN = 532
Hex Dump = 08 50

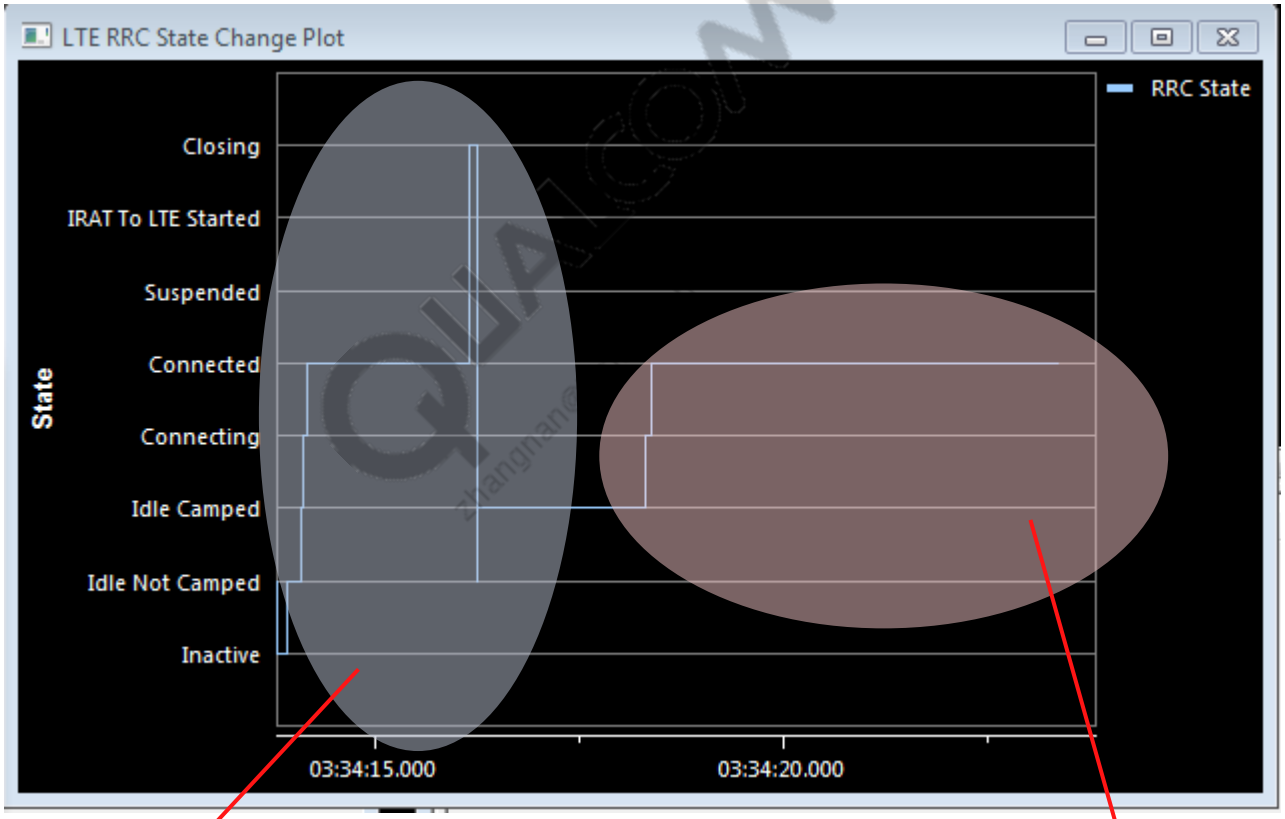
LTE Connected Mode and Data Transfer – QXDM Professional™ (QXDM Pro) Dashboard

- QXDM Pro dashboard, with Filtered Views monitoring NAS/RRC OTA messages and RLC/MAC data transfer, RRC state Change Plot monitoring RRC state changes, PDCP configuration, and RLC statistics monitoring the data transfer status



LTE Connected Mode and Data Transfer – LTE RRC State Change Plot

- RRC state change plot shows the RRC states.

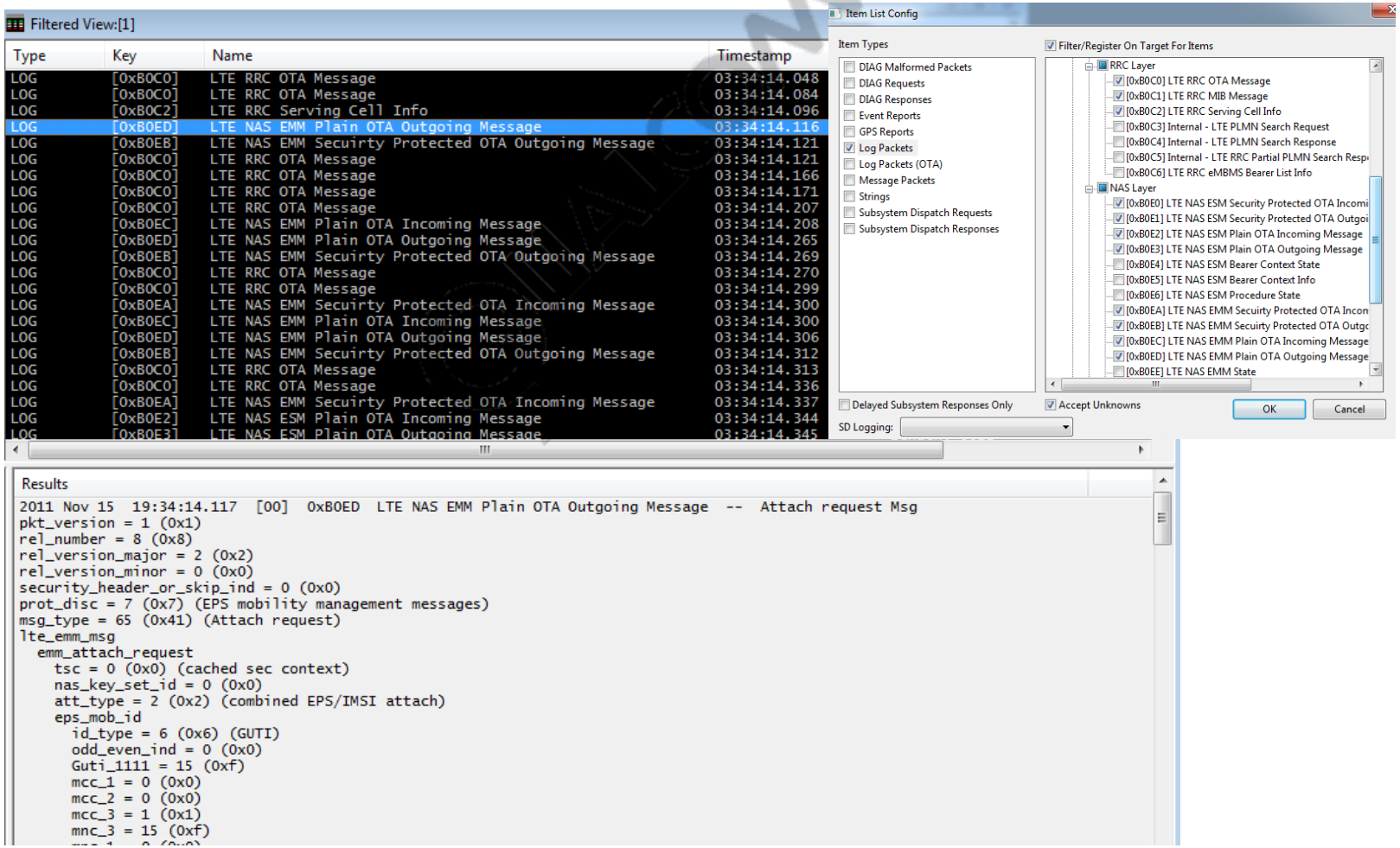


Registration to EPS, RRC state from inactive to camping to Connected; UE briefly enters Connected mode during initial registration

UE enters Connected mode to transfer loopback data

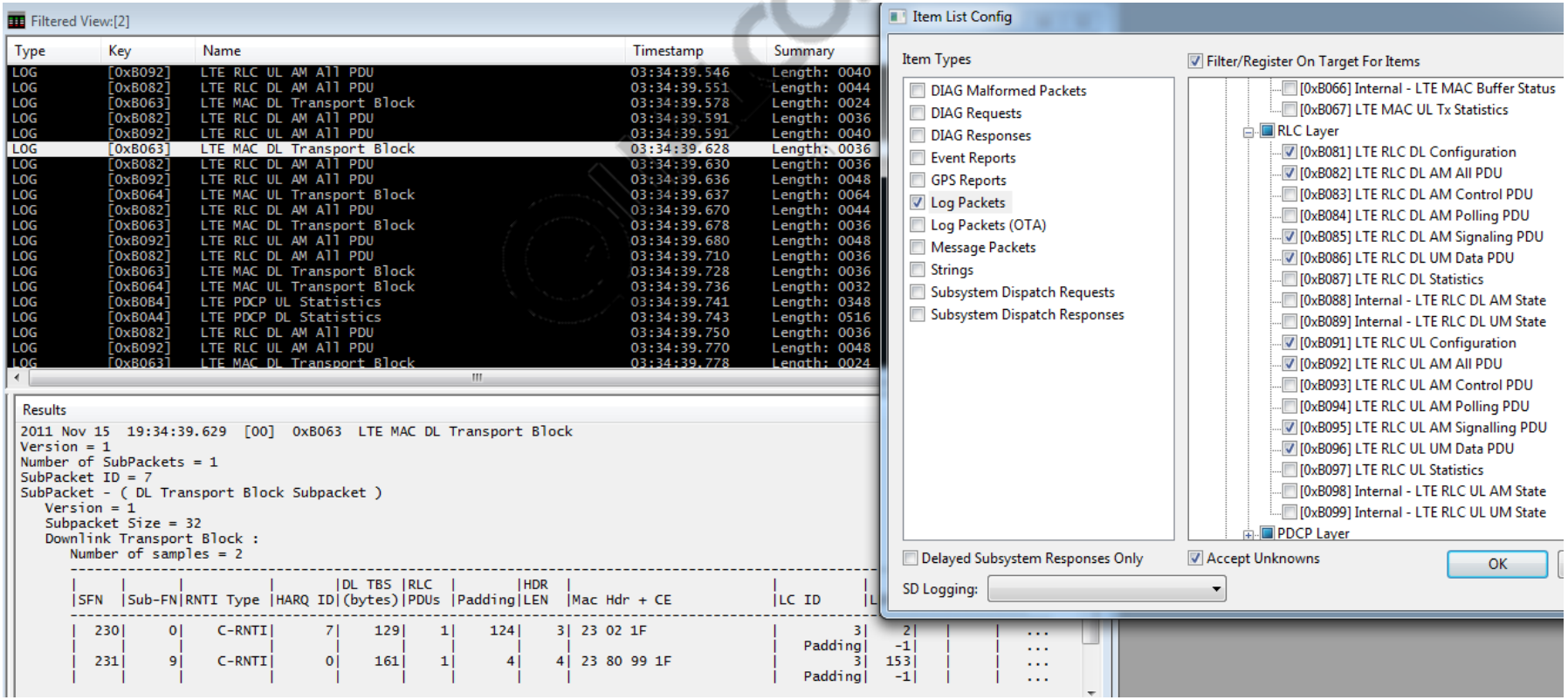
LTE Connected Mode and Data Transfer – NAS and RRC Filtered View

- Filtered NAS and RRC OTA messages show the call flow.



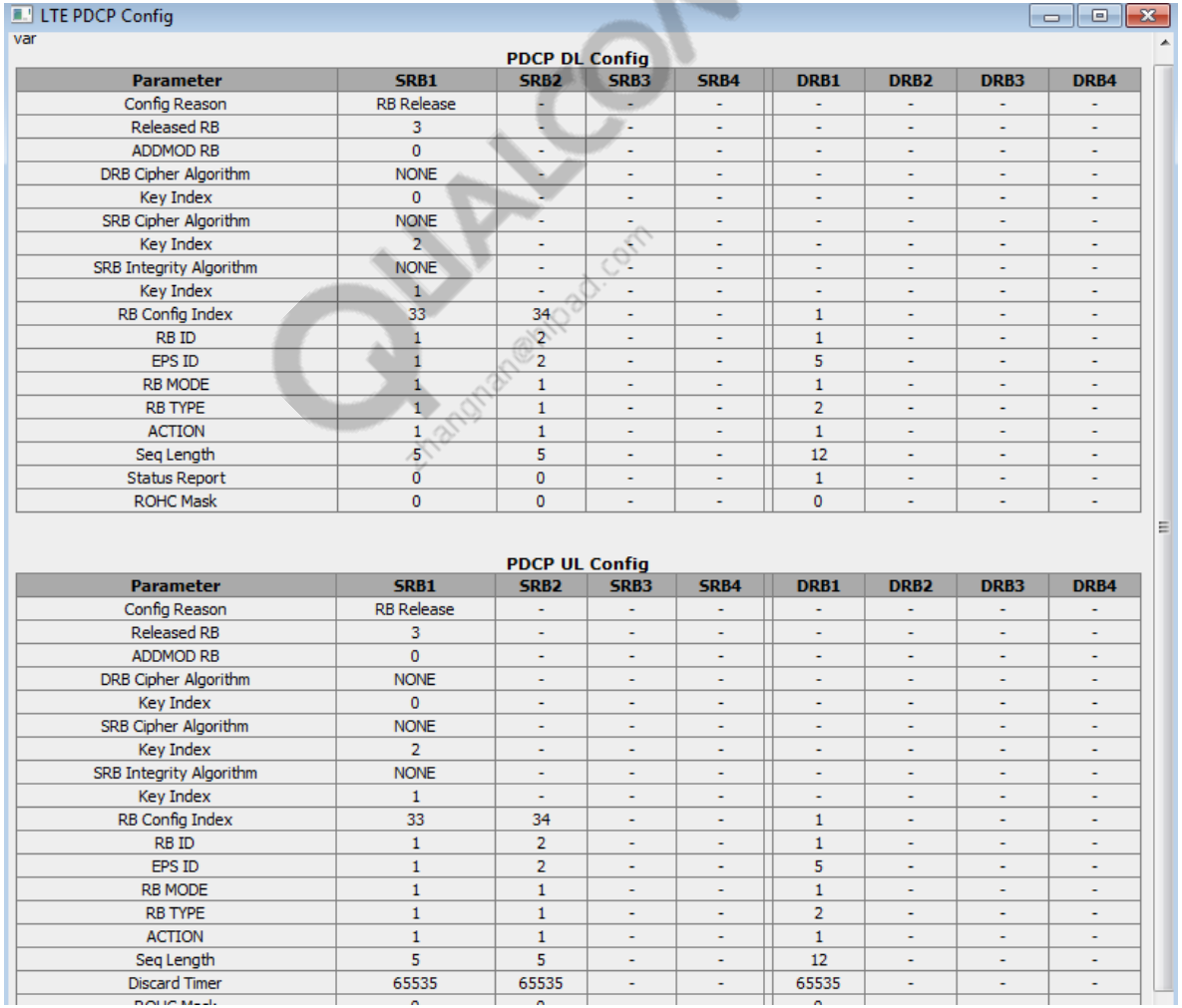
LTE Connected Mode and Data Transfer – RLC, PDCP, and MAC Views

- Filtered RLC, PDCP, and MAC messages provide details of RLC AM PDUs with their sequence numbers, ack/nack status, logic channel IDs, PDU sizes, etc.



LTE Connected Mode and Data Transfer – PDCP Configuration Window

- A general overview of the configuration of SRBs and DRBs, which indicates their RB IDs, RB indices, EPS IDs, etc.



LTE PDCP Config

var

PDCP DL Config

Parameter	SRB1	SRB2	SRB3	SRB4	DRB1	DRB2	DRB3	DRB4
Config Reason	RB Release	-	-	-	-	-	-	-
Released RB	3	-	-	-	-	-	-	-
ADDMOD RB	0	-	-	-	-	-	-	-
DRB Cipher Algorithm	NONE	-	-	-	-	-	-	-
Key Index	0	-	-	-	-	-	-	-
SRB Cipher Algorithm	NONE	-	-	-	-	-	-	-
Key Index	2	-	-	-	-	-	-	-
SRB Integrity Algorithm	NONE	-	-	-	-	-	-	-
Key Index	1	-	-	-	-	-	-	-
RB Config Index	33	34	-	-	1	-	-	-
RB ID	1	2	-	-	1	-	-	-
EPS ID	1	2	-	-	5	-	-	-
RB MODE	1	1	-	-	1	-	-	-
RB TYPE	1	1	-	-	2	-	-	-
ACTION	1	1	-	-	1	-	-	-
Seq Length	5	5	-	-	12	-	-	-
Status Report	0	0	-	-	1	-	-	-
ROHC Mask	0	0	-	-	0	-	-	-

PDCP UL Config

Parameter	SRB1	SRB2	SRB3	SRB4	DRB1	DRB2	DRB3	DRB4
Config Reason	RB Release	-	-	-	-	-	-	-
Released RB	3	-	-	-	-	-	-	-
ADDMOD RB	0	-	-	-	-	-	-	-
DRB Cipher Algorithm	NONE	-	-	-	-	-	-	-
Key Index	0	-	-	-	-	-	-	-
SRB Cipher Algorithm	NONE	-	-	-	-	-	-	-
Key Index	2	-	-	-	-	-	-	-
SRB Integrity Algorithm	NONE	-	-	-	-	-	-	-
Key Index	1	-	-	-	-	-	-	-
RB Config Index	33	34	-	-	1	-	-	-
RB ID	1	2	-	-	1	-	-	-
EPS ID	1	2	-	-	5	-	-	-
RB MODE	1	1	-	-	1	-	-	-
RB TYPE	1	1	-	-	2	-	-	-
ACTION	1	1	-	-	1	-	-	-
Seq Length	5	5	-	-	12	-	-	-
Discard Timer	65535	65535	-	-	65535	-	-	-

LTE Connected Mode and Data Transfer – RLC Statistics Window

- As an example, the UL RLC statistics summarizes the activities of each RB; it lists the RB config index, RB ID, mode, PDUs sent, etc.

LTE RLC Statistcs Screen

Uplink RLC Statistcs

Parameter	Since Last Reestablishment			Total		
Config Index	33	0	-	33	0	-
RB ID	1	-	-	1	-	-
Mode	AM	AM	-	AM	AM	-
Resets	-	-	-	0	0x00000000	-
New PDUs	0x00000000	0x00000000	-	3	0x00000000	-
PDU Bytes	3	0	-	32	1	-
SDUs	0x00000020	0x0000033F	-	0x00000003	1	-
SDUs Bytes	3	1	-	26	0	-
Retx PDUs	0x00000004	0x000A1A1F	-	0x00000000	0x000003DD	-
Retx PDUs Bytes	0x00000000	0x000003DD	-	0x00000000	0x000A123D	-
Ctrl PDUs	0x00000000	0x000A123D	-	0x00000003	0x000002EC	-
Complete NAKs Received	0x00000003	0x000002EC	-	0x00000000	0x000005D8	-
Segmented NAKs Received	0x00000000	0x000005D8	-	0x00000000	0x00000001	-
Polls Sent	0x00000000	0x000000DC	-	0x00000003	0x0000033C	-
SDUs Discarded	-	-	-	-	-	-
PDU throughput (kbps)	0.0000	-	-	-0.0025	0.0000	-
SDU throughput (kbps)	0.0000	-	-	-0.0023	-0.0003	-

Downlink RLC Statistcs

Parameter	Since Last Reestablishment			Total		
Config Index	-	-	-	-	-	-
RB ID	-	-	-	-	-	-
Mode	-	-	-	-	-	-
Resets	-	-	-	-	-	-

References

Ref.	Document	
Qualcomm Technologies		
Q1	*Application Note: Software Glossary for Customers*	CL93-V3077-1
Q2	*LTE RRC Overview*	80-VR075-1
Q3	*LTE Call Processing Overview*	80-W2598-1

Questions?

https://support.cdmatech.com