



LTE Data Call Flow

Korea Telecom Experts Group 2016



Global No.1 KT

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01 Intro

- What is Data service in LTE ?



Facebook



SMS



Chrome



YouTube



Gmail

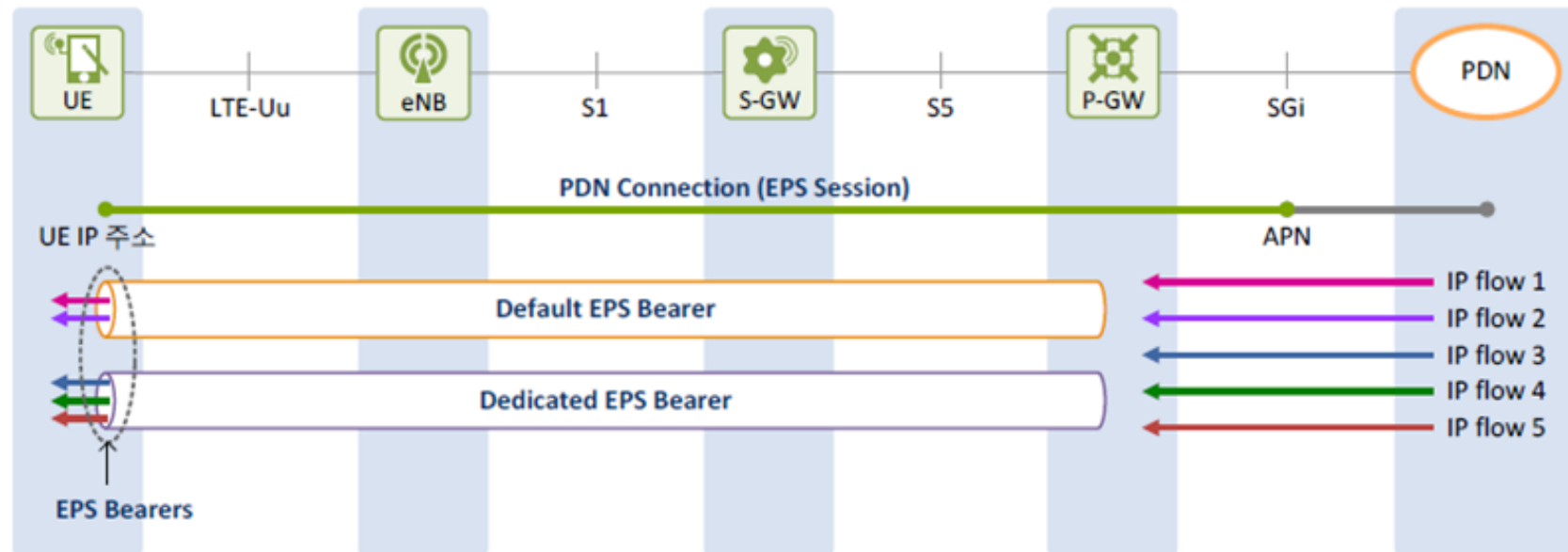


Messenger



Phone

- How to access PDN network through LTE network for data service ?



02 EPS bearer

- **How User Data is transferred?**

- EPS(Evolved Packet System) Bearers provide the UE access to PDN services

- **Quality of service**

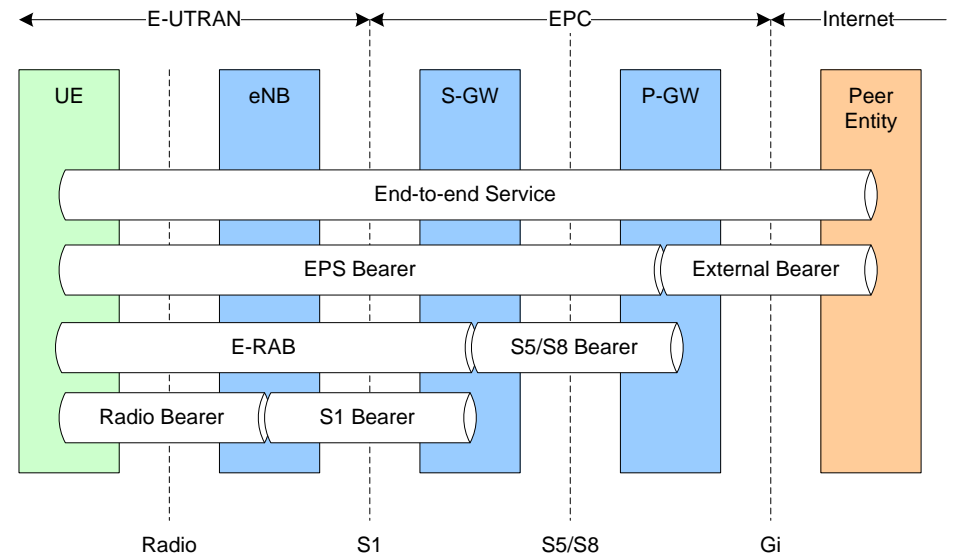
- GBR bearer: Guaranteed bit rate
- Non-GBR bearer: No guaranteed bit rate

- **Establishment time**

- Default bearer
 - ✓ Established when UE connects to PDN
 - ✓ Provides always-on connectivity
 - ✓ Always non-GBR
- Dedicated bearer established later
 - ✓ Can be GBR or non-GBR

- **Every EPS bearer**

- QoS class identifier (QCI): This is a number which describes the error rate and delay that are associated with the service.



03 QCI Characteristics

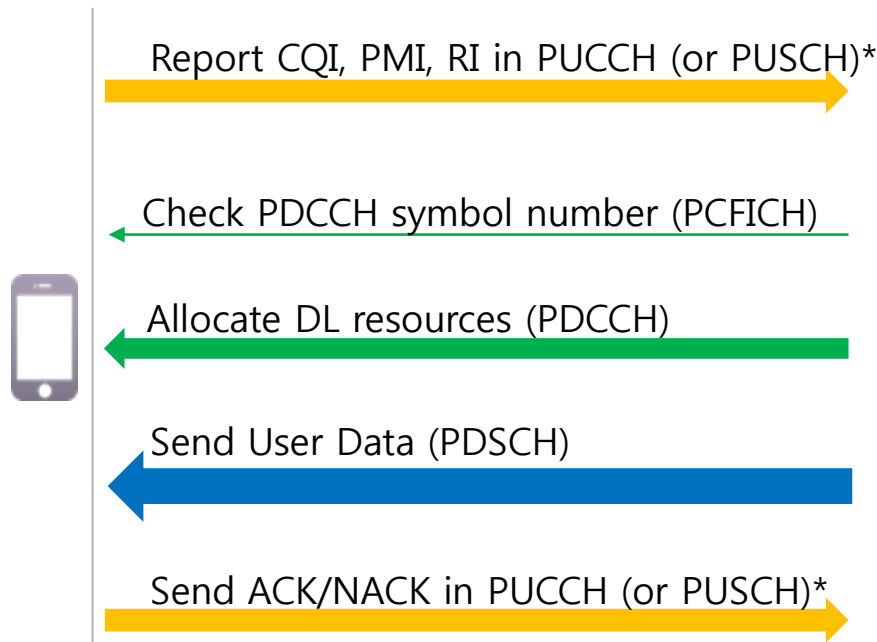
- **Internet/FTP/Video Streaming ... etc**
 - Data Packet : default bearer (QCI 9)
- **VoLTE**
 - IMS signaling: default bearer (QCI 5)
 - Voice packet: dedicated bearer (QCI 1)
- **PSVT(Packet Switched Video Telephony)**
 - IMS signaling: default bearer (QCI 5)
 - Voice packet: dedicated bearer (QCI 1)
 - Video packet: Dedicated bearer (QCI 2)

QCI	Bearer	Priority	Delay	PELR	Examples
1	GBR	2	100 ms	10^{-2}	Conversational voice
2		4	150 ms	10^{-3}	Conversational video
3		3	50 ms	10^{-3}	Real-time games
4		5	300 ms	10^{-6}	Streaming video
5	Non-GBR	1	100 ms	10^{-6}	IMS signalling
6		6	300 ms	10^{-6}	Streaming video, web, EMail
7		7	100 ms	10^{-3}	Voice, video, games
8		8	300 ms	10^{-6}	Streaming video, web, EMail
9		9			

PELR: Packet Error Loss Rate

04 Resource Allocation

- How to transfer Data on **Downlink**



* If UE take UL Resource, Then it use PUSCH

[DL resource Allocation DM log]

[2015 Nov 13 13:30:56.996] [0xB173] LTE ML1 PDSCH stat indication

Version : 5

Num_records : 22

DL RB
number

Index#	subframe_num	frame_num	num_rbs	num_layers	num_tb_present	Serv
[0]	1	236	100	1	1	
[1]	3	236	100	1	1	
[2]	4	236	100	1	1	
[3]	5	236	96	1	1	
[4]	6	236	100	1	1	
[5]	8	236	100	1	1	

[2015 Nov 13 13:30:56.996] [0xB126] LTE LL1 PDSCH demapper configuration

Version : 23

Serving_cell_ID : 245

Subframe_number : 5

System_frame_number : 236

PDSCH_RNTI_ID : 22416

PDSCH_RNTI_type : C-RNTI

Number_of_Tx_antennas_M : 2 antennas

Number_of_Rx_antennas_N : 2 antennas

Transmission_Scheme : Closed-loop spatial multiplexing

Spatial_rank : rank 1

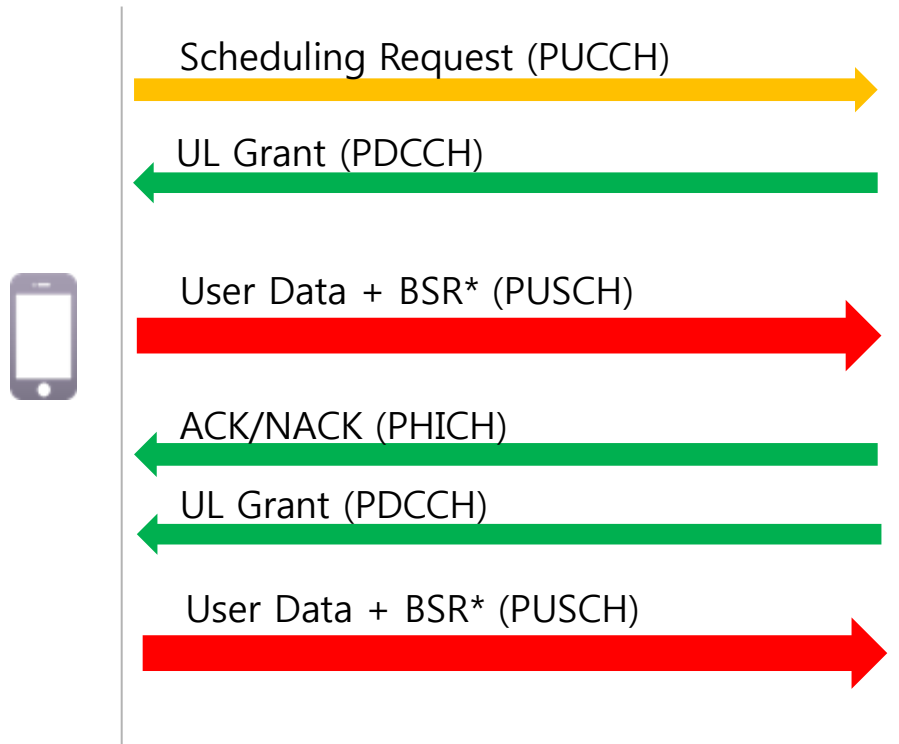
RB_allocation_slot0 : 0xFFFFFFFFFFFFFFFF, 0x000000FFFFFFFFF0

RB_allocation_slot1 : 0xFFFFFFFFFFFFFFFF, 0x000000FFFFFFFFF0

DL RB
allocation

05 Resource Allocation

- How to transfer Data on **Uplink**



* If UE need more UL data transmission, It request UL resource allocation using BSR(Buffer Status Report)

[UL resource Allocation log]

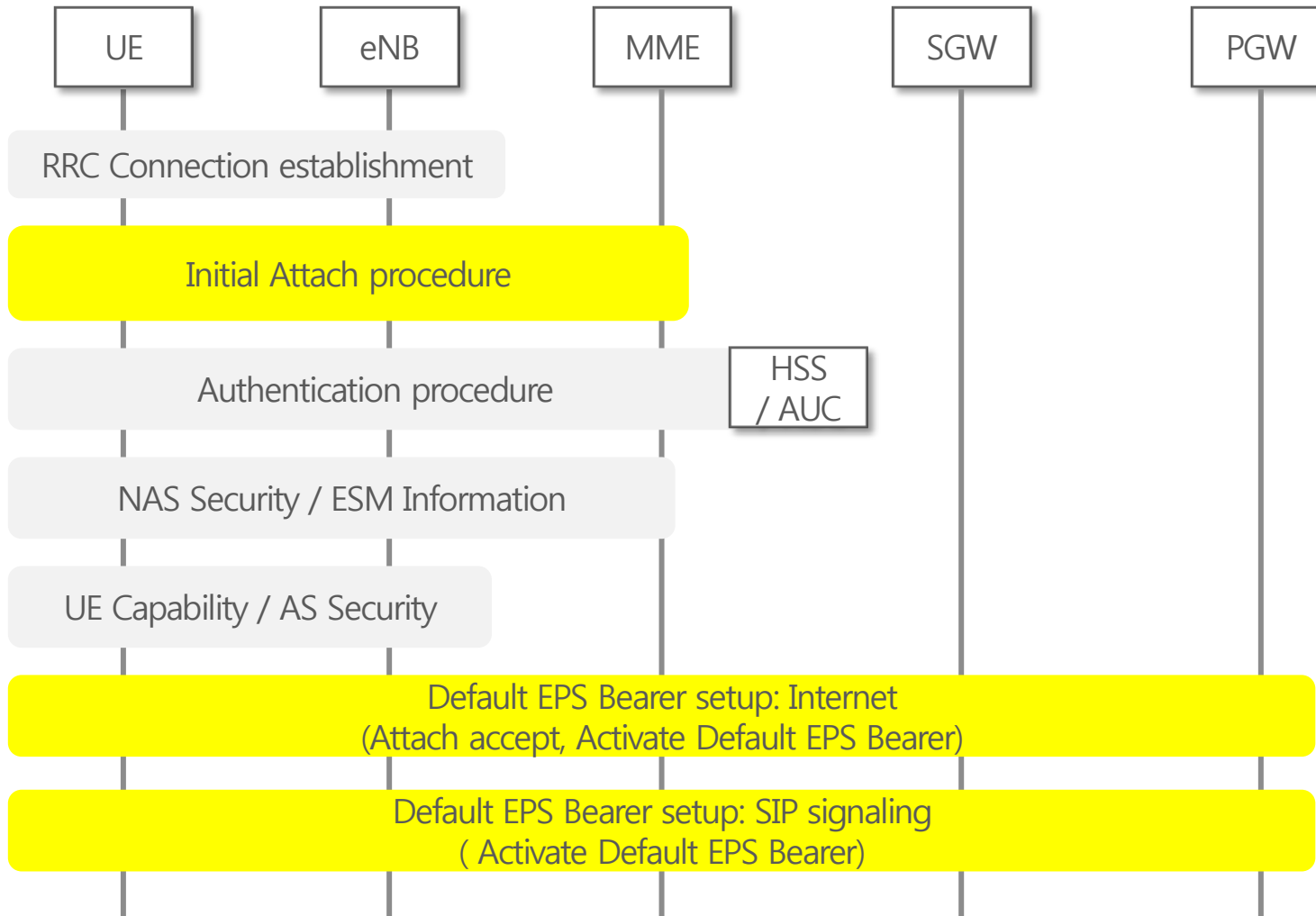
[2015 Nov 13 13:30:57.051] [0x8160] LTE ML1 DCI information report

Version : 6
Duplex_mode : TDD
Number_of_records : 20

UL RB number
& Start RB num.

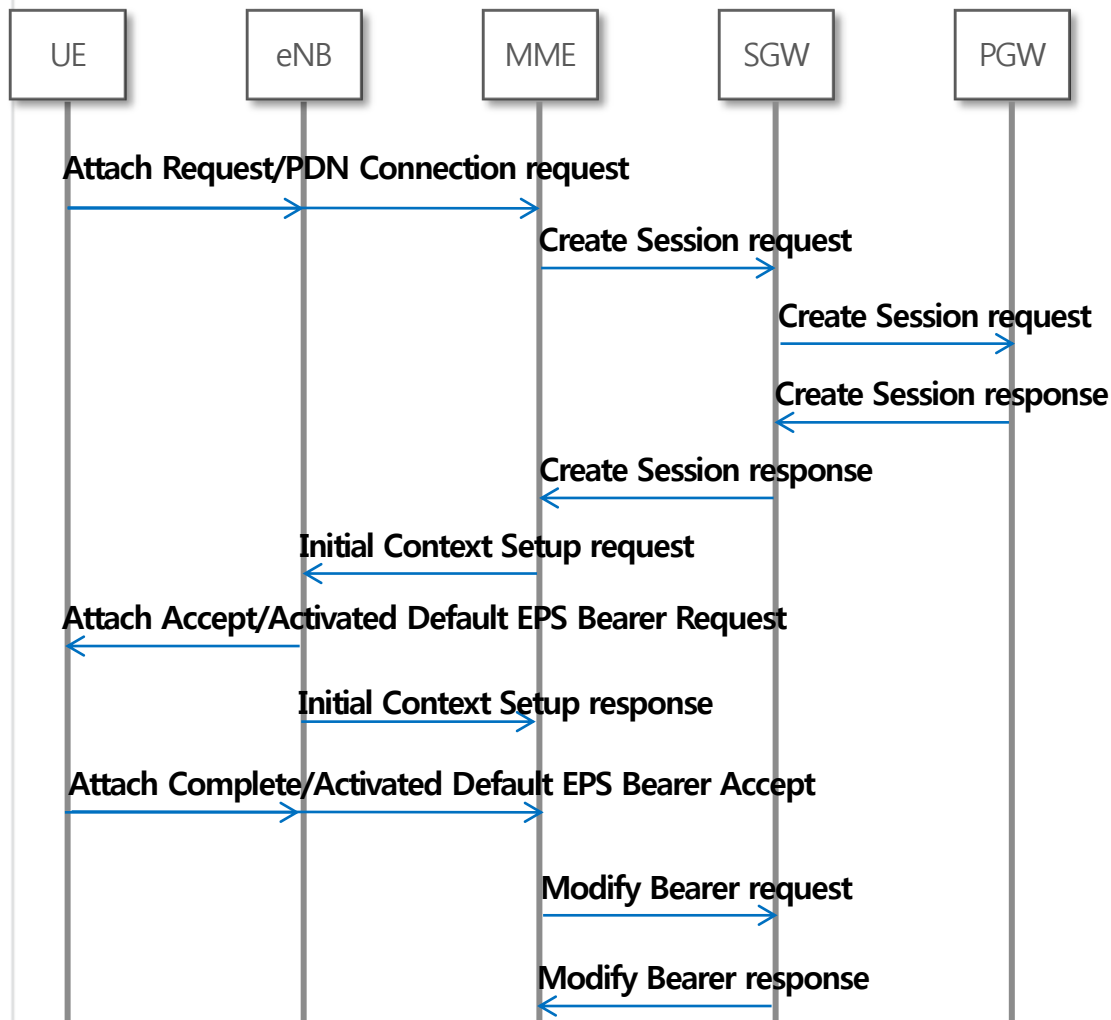
Record#	PDCCH_SFN	PDCCH_sub_num	UL_grant_valid	RIV_width	Start_of_rblock	Num_of_rblocks
[0]	240	6	not valid	N/A	N/A	N/A
[1]	240	8	Valid	13	9	2
[2]	240	9	not valid	N/A	N/A	N/A
[3]	241	0	not valid	N/A	N/A	N/A
[4]	241	1	not valid	N/A	N/A	N/A
[5]	241	3	Valid	13	3	2
[6]	241	4	not valid	N/A	N/A	N/A
[7]	241	5	not valid	N/A	N/A	N/A
[8]	241	6	not valid	N/A	N/A	N/A
[9]	241	8	Valid	13	9	50
[10]	241	9	not valid	N/A	N/A	N/A
[11]	242	0	not valid	N/A	N/A	N/A
[12]	242	1	not valid	N/A	N/A	N/A
[13]	242	3	Valid	13	3	72
[14]	242	4	not valid	N/A	N/A	N/A
[15]	242	5	not valid	N/A	N/A	N/A
[16]	242	6	not valid	N/A	N/A	N/A
[17]	242	8	Valid	13	9	50
[18]	242	9	not valid	N/A	N/A	N/A
[19]	243	0	not valid	N/A	N/A	N/A

06 Default EPS Bearer Setup



07 Default EPS Bearer Setup

Initial Attach / Default EPS bearer Setup for Internet



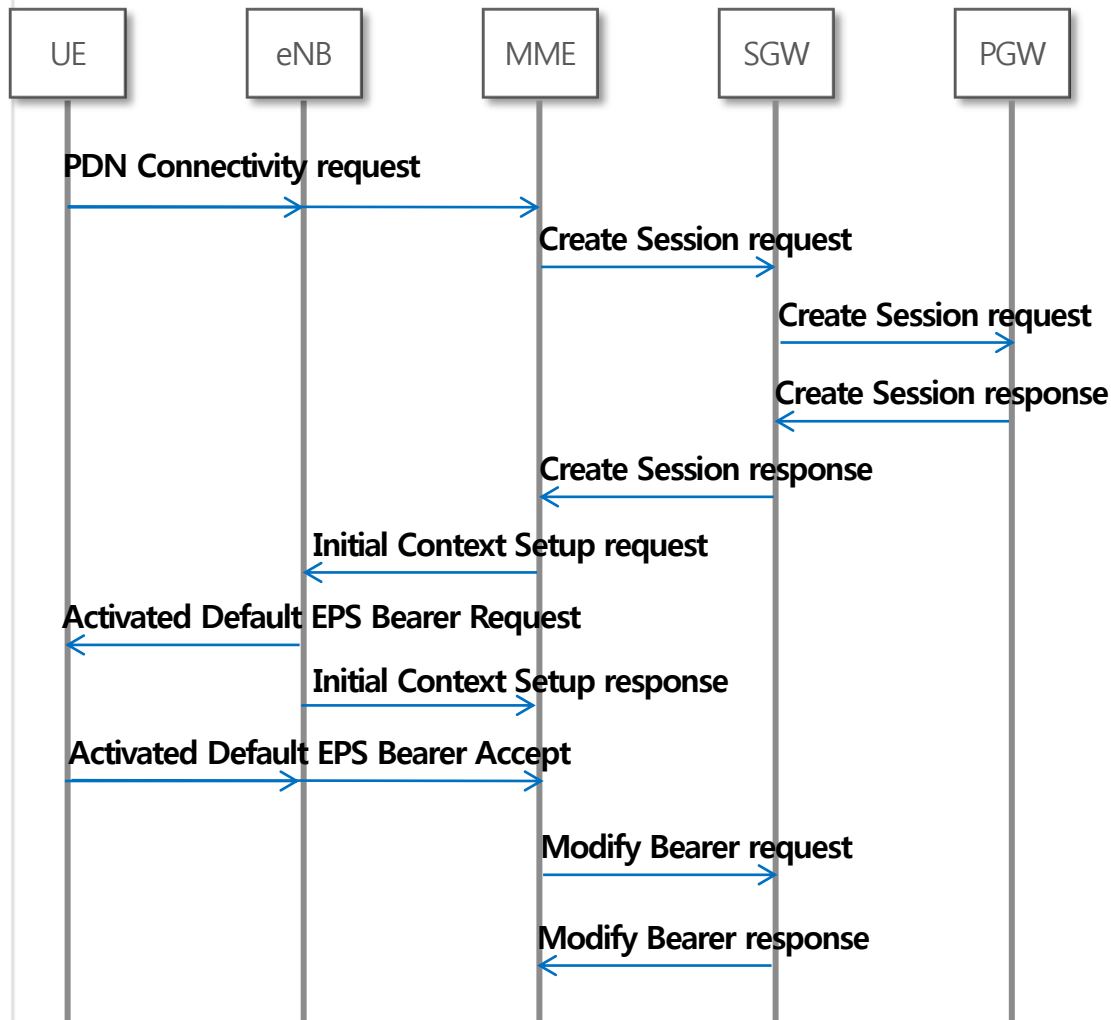
[DM log]

```
PDN_CONNECTIVITY_REQUEST:
EPSBearerIdentity: 0
ProcedureTransactionIdentity: 5
RequestType: 1 (initial attach)
PDNType: 3 (IPv4v6)
ESMInformationTransferFlag: 1 (sec
```

```
ACTIVATE_DEFAULT_EPS_BEARER_CONTEXT_REQUEST:
EPSBearerIdentity: 5
ProcedureTransactionIdentity: 5
EPSQoS:
  QCI: 9
AccessPointName: jionet.mnc873.mcc405.gprs
PDNAddress:
  PDNType: 3 (IPv4v6)
  PDNAddressInformation:
    IPv6: 0000:0000:0195:60a1
    IPv4: 100.72.199.41
APNAMBR:
  APN_AMBRDownlink: 254
  APN_AMBRUplink: 254
Extended:
  APN_AMBRDownlink: 162
  APN_AMBRUplink: 110
```

08 Default EPS Bearer Setup

Initial Attach procedure / Default EPS bearer Setup for IMS



[DM log]

```
PDN_CONNECTIVITY_REQUEST:
  EPSBearerIdentity: 0
  ProcedureTransactionIdentity: 6
  RequestType: 1 (initial attach)
  PDNType: 3 (IPv4v6)
  AccessPointName: IMS
  ProtocolConfigurationOptions:
```

```
ACTIVATE_DEFAULT_EPS_BEARER_CONTEXT_REQUEST:
  EPSBearerIdentity: 6
  ProcedureTransactionIdentity: 6
  EPSQoS:
    QCI: 5
  AccessPointName: ims.mnc873.mcc405.gprs
  PDNAddress:
    PDNType: 3 (IPv4v6)
    PDNAddressInformation:
      IPv6: 0000:0000:0195:68a1
      IPv4: 100.72.255.177
  APNAMBR:
    APN_AMBRDownlink: 254
    APN_AMBRUplink: 254
  Extended:
    APN_AMBRDownlink: 18
    APN_AMBRUplink: 18
```

09 Default EPS Bearer Setup

RRC Connection establishment

Initial Attach procedure

Authentication procedure

NAS Security / ESM Information

UE Capability / AS Security

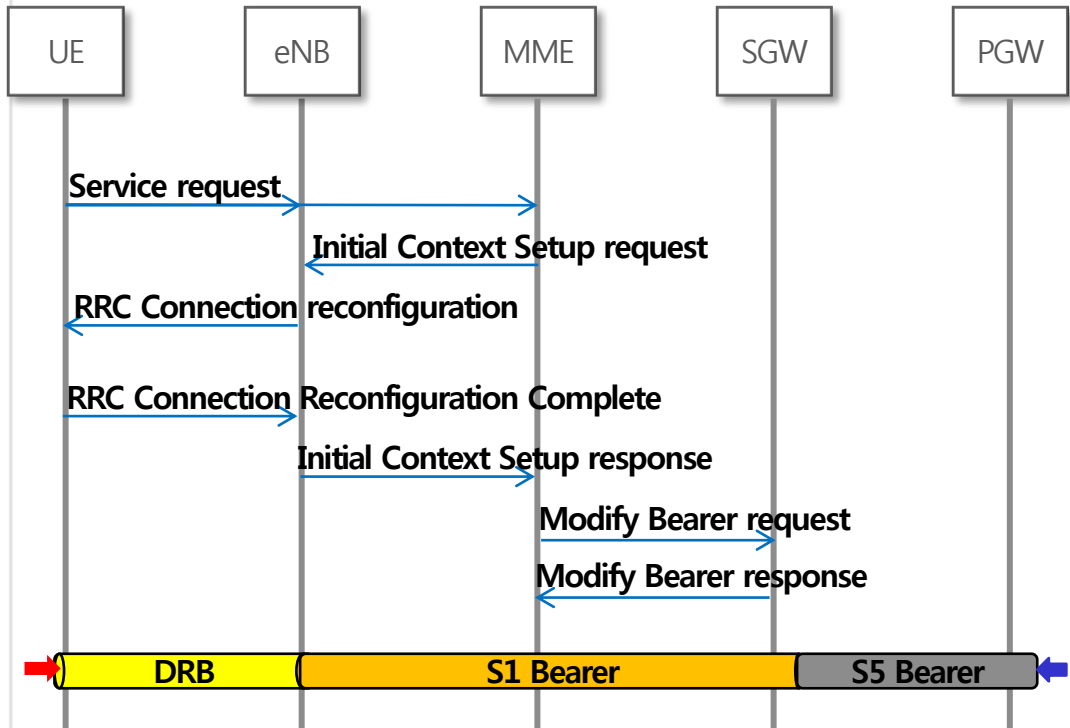
Default EPS Bearer setup: Internet
(Attach accept, Activate Default EPS Bearer)

Default EPS Bearer setup: SIP signaling
(Activate Default EPS Bearer)

Time	Technol	Code	Message	Detail
2015-11-13 13:27:29.867	LTE	BCCH-DL-SCH [Lte]	systemInformationBlockType1	
2015-11-13 13:27:30.064	LTE	BCCH-BCH [Lte]	masterInformationBlock	
2015-11-13 13:27:30.064	LTE	BCCH-DL-SCH [Lte]	systemInformation	
2015-11-13 13:27:30.064	LTE	EPS MM	Attach request	PDN connectivity request
2015-11-13 13:27:30.064	LTE	EPS MM	Security protected NAS message	Attach request/PDN connectivity request
2015-11-13 13:27:30.064	LTE	UL-CCCH [Lte]	rrcConnectionRequest	
2015-11-13 13:27:30.064	LTE	[0xB167] LTE ML1 ran		
2015-11-13 13:27:30.064	LTE	[0xB168] LTE ML1 ran		
2015-11-13 13:27:30.064	LTE	[0xB169] LTE ML1 UE		
2015-11-13 13:27:30.064	LTE	[0xB16A] LTE ML1 col		
2015-11-13 13:27:30.064	LTE	DL-CCCH [Lte]	rrcConnectionSetup	
2015-11-13 13:27:30.064	LTE	UL-DCCH [Lte]	rrcConnectionSetupComplete	Security protected NAS message/Attach request/PDN connectivity request
2015-11-13 13:27:30.067	LTE	BCCH-DL-SCH [Lte]	systemInformation	
2015-11-13 13:27:30.277	LTE	DL-DCCH [Lte]	dlInformationTransfer	Security protected NAS message
2015-11-13 13:27:30.277	LTE	EPS MM	Authentication request	
2015-11-13 13:27:30.277	LTE	EPS MM	Authentication response	
2015-11-13 13:27:30.277	LTE	UL-DCCH [Lte]	ulInformationTransfer	Security protected NAS message
2015-11-13 13:27:30.377	LTE	DL-DCCH [Lte]	dlInformationTransfer	Security protected NAS message/Security mode command
2015-11-13 13:27:30.377	LTE	EPS MM	Security protected NAS message	Security mode command
2015-11-13 13:27:30.377	LTE	EPS MM	Security mode command	
2015-11-13 13:27:30.377	LTE	EPS MM	Security mode complete	
2015-11-13 13:27:30.377	LTE	UL-DCCH [Lte]	ulInformationTransfer	Security protected NAS message
2015-11-13 13:27:30.477	LTE	DL-DCCH [Lte]	dlInformationTransfer	Security protected NAS message
2015-11-13 13:27:30.477	LTE	EPS SM	ESM information request	
2015-11-13 13:27:30.477	LTE	EPS SM	ESM information response	
2015-11-13 13:27:30.477	LTE	UL-DCCH [Lte]	ulInformationTransfer	Security protected NAS message
2015-11-13 13:27:30.592	LTE	DL-DCCH [Lte]	ueCapabilityEnquiry	
2015-11-13 13:27:30.592	LTE	UL-DCCH [Lte]	ueCapabilityInformation	
2015-11-13 13:27:30.592	LTE	DL-DCCH [Lte]	securityModeCommand	
2015-11-13 13:27:30.592	LTE	UL-DCCH [Lte]	securityModeComplete	
2015-11-13 13:27:30.677	LTE	DL-DCCH [Lte]	rrcConnectionReconfiguration	Security protected NAS message
2015-11-13 13:27:30.677	LTE	UL-DCCH [Lte]	rrcConnectionReconfigurationComplete	
2015-11-13 13:27:30.677	LTE	EPS MM	Attach accept	Activate default EPS bearer context request
2015-11-13 13:27:30.677	LTE	EPS SM	Activate default EPS bearer context request	
2015-11-13 13:27:30.677	LTE	EPS MM	Attach complete	Activate default EPS bearer context accept
2015-11-13 13:27:30.677	LTE	UL-DCCH [Lte]	ulInformationTransfer	Security protected NAS message
2015-11-13 13:27:30.677	LTE	DL-DCCH [Lte]	ueInformationRequest+r9	
2015-11-13 13:27:30.752	LTE	UL-DCCH [Lte]	ueInformationResponse+r9	
2015-11-13 13:27:30.752	LTE	DL-DCCH [Lte]	dlInformationTransfer	Security protected NAS message
2015-11-13 13:27:30.752	LTE	EPS MM	EMM information	
2015-11-13 13:27:31.170	LTE	BCCH-DL-SCH [Lte]	systemInformation	
2015-11-13 13:27:32.497	LTE	EPS SM	PDN connectivity request	
2015-11-13 13:27:32.497	LTE	UL-DCCH [Lte]	ulInformationTransfer	Security protected NAS message
2015-11-13 13:27:32.586	LTE	DL-DCCH [Lte]	rrcConnectionReconfiguration	Security protected NAS message
2015-11-13 13:27:32.586	LTE	UL-DCCH [Lte]	rrcConnectionReconfigurationComplete	
2015-11-13 13:27:32.586	LTE	EPS SM	Activate default EPS bearer context request	
2015-11-13 13:27:32.588	LTE	EPS SM	Activate default EPS bearer context accept	
2015-11-13 13:27:32.588	LTE	UL-DCCH [Lte]	ulInformationTransfer	Security protected NAS message

10 Service Request

E-RAB setup for data service



Time	Technol	Code	Message
2015-11-13 14:11:06.967	LTE	EPS MM	Service request
2015-11-13 14:11:06.967	LTE	UL-CCCH [Lte]	rrcConnectionRequest
2015-11-13 14:11:06.967	LTE	[0xB167] LTE ML1 random access request (MSG1) report	
2015-11-13 14:11:06.967	LTE	[0xB168] LTE ML1 random access response (MSG2) report	
2015-11-13 14:11:06.967	LTE	[0xB169] LTE ML1 UE identification message (MSG3) report	
2015-11-13 14:11:07.122	LTE	[0xB16A] LTE ML1 contention resolution message (MSG4) report	
2015-11-13 14:11:07.122	LTE	DL-CCCH [Lte]	rrcConnectionSetup
2015-11-13 14:11:07.122	LTE	UL-DCCH [Lte]	rrcConnectionSetupComplete
2015-11-13 14:11:07.122	LTE	BCCH-DL-SCH [Lte]	systemInformation
2015-11-13 14:11:07.167	LTE	DL-DCCH [Lte]	securityModeCommand
2015-11-13 14:11:07.167	LTE	UL-DCCH [Lte]	securityModeComplete
2015-11-13 14:11:07.167	LTE	DL-DCCH [Lte]	rrcConnectionReconfiguration
2015-11-13 14:11:07.167	LTE	UL-DCCH [Lte]	rrcConnectionReconfigurationComplete

[DM log]

```

SERVICE_REQUEST:
  SecurityHeaderType: 12
  KSIAndSequenceNumber:
    KSIasme: 0
    SequenceNumber: 4
  MessageAuthenticationCodeShort: 1024
  
```

```

c1 : rrcConnectionRequest :
criticalExtensions rrcConnectionRequest-r8 :
  ue-Identity s-TMSI :
    mmec '00000001'B,
    m-TMSI '11111000 00100000 10010101 10101101'B
  ,
  establishmentCause mo-Data,
  
```

[RRC Connection Reconfiguration]

```

eps-BearerIdentity 5,
drb-Identity 1,
pdcp-Config
  discardTimer infinity,
  rlc-AM
  statusReportRequired TRUE
  
```

```

eps-BearerIdentity 6,
drb-Identity 2,
pdcp-Config
  discardTimer infinity,
  rlc-AM
  statusReportRequired TRUE
  
```

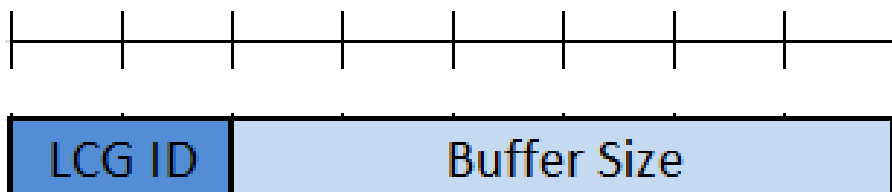
11 Appendix. PDCCH DCI

- DCI(Downlink Control info) carries the following information
 - UL resource allocation : DCI format 0
 - DL resource allocation
 - ✓ DCI format 1 for Non-MIMO DL scheduling
 - ✓ DCI format 2 for MIMO DL scheduling
 - ✓ DCI format 3 for UL power control

DCI Format	Usage	Major Contents
Format 0	UL Grant. Resource Allocation for UL Data	RB Assignment,TPC,PUSCH Hopping Flag
Format 1	DL Assignment for SISO	RB Assignment,TPC, HARQ
Format 1A	DL Assignment for SISO (compact)	RB Assignment,TPC, HARQ
Format 1B	DL Assignment for MIMO with Rank 1	RB Assignment,TPC, HARQ,TPMI, PMI
Format 1C	DL Assignment for SISO (minimum size)	RB Assignment
Format 1D	DL Assignment for Multi User MIMO	RB Assignment,TPC, HARQ,TPMI,DL Power Offset
Format 2	DL Assignment for Closed Loop MIMO	RB Assignment,TPC, HARQ, Precoding Information
Format 2A	DL Assignment for Open Loop MIMO	RB Assignment,TPC, HARQ, Precoding Information
Format 2B	DL Assignment for TM8 (Dual Layer Beamforming)	RB Assignment,TPC, HARQ, Precoding Information
Format 2C	DL Assignment for TM9	RB Assignment,TPC, HARQ, Precoding Information
Format 3	TPC Commands for PUCCH and PUSCH with 2 bit power adjustment	Power Control Only
Format 3A	TPC Commands for PUCCH and PUSCH with 1 bit power adjustment	Power Control Only
Format 4	UL Assignment for UL MIMO (up to 4 layers)	RB Assignment,TPC, HARQ, Precoding Information

12 Appendix. BSR (Buffer Status Report)

- **How much data is in UE buffer to be sent out**
 - UE provide the serving eNB with information about the amount of data available for transmission in the UL buffers of the UE.
- **UE send BSR to receive UL Grant from eNB**
- **Format**
 - LCG ID: The Logical Channel Group ID field identifies the group of logical channel
 - Buffer Size: the total amount of data is indicated in number of bytes

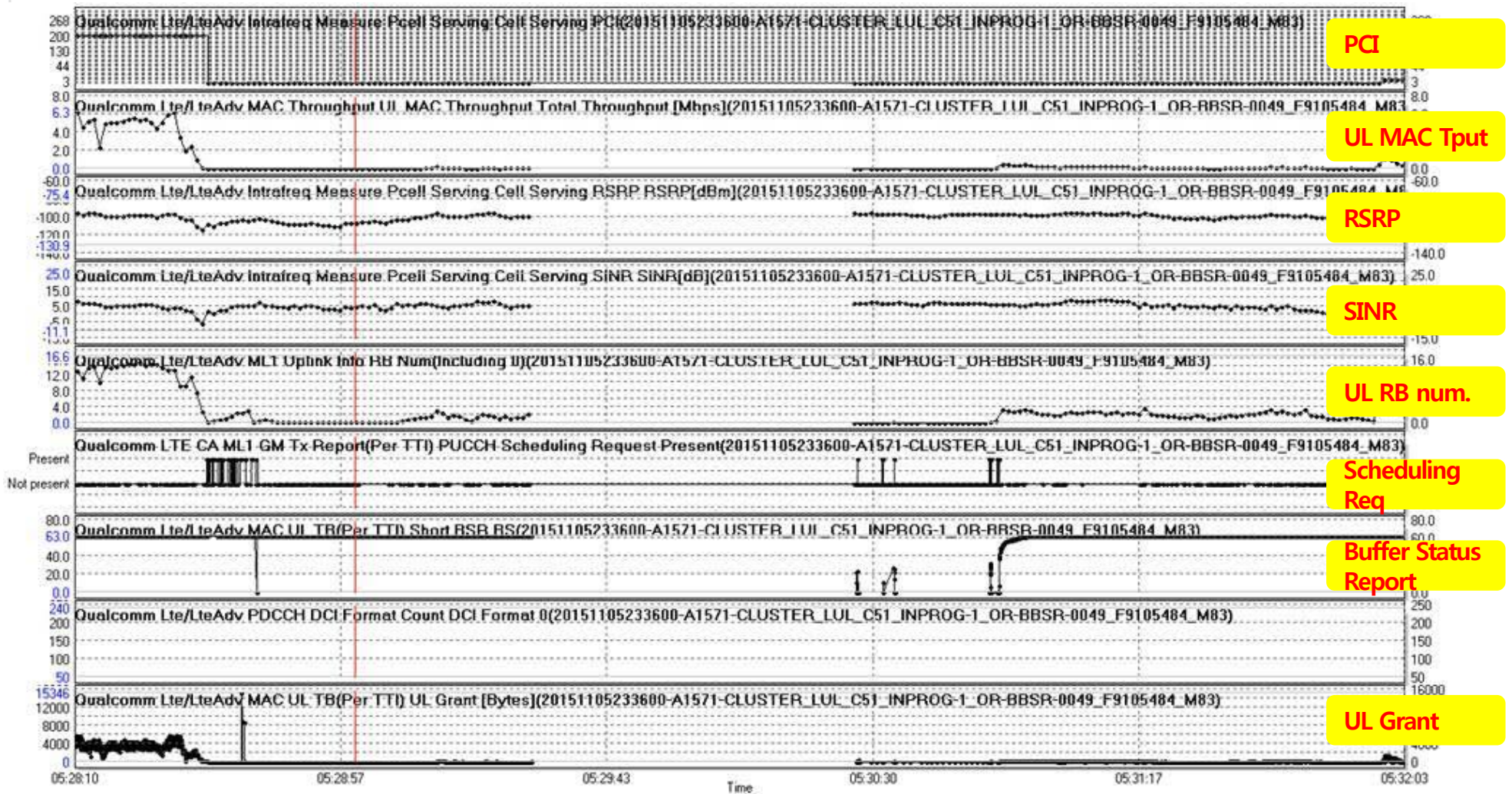


Short BSR and Truncated BSR MAC control element

Index	Buffer Size (BS) value [bytes]	Index	Buffer Size (BS) value [bytes]
0	BS = 0	32	1132 < BS ≤ 1326
1	0 < BS ≤ 10	33	1326 < BS ≤ 1552
2	10 < BS ≤ 12	34	1552 < BS ≤ 1817
3	12 < BS ≤ 14	35	1817 < BS ≤ 2127
4	14 < BS ≤ 17	36	2127 < BS ≤ 2490
5	17 < BS ≤ 19	37	2490 < BS ≤ 2915
6	19 < BS ≤ 22	38	2915 < BS ≤ 3413
7	22 < BS ≤ 26	39	3413 < BS ≤ 3995
8	26 < BS ≤ 31	40	3995 < BS ≤ 4677
9	31 < BS ≤ 36	41	4677 < BS ≤ 5476
10	36 < BS ≤ 42	42	5476 < BS ≤ 6411
11	42 < BS ≤ 49	43	6411 < BS ≤ 7505
12	49 < BS ≤ 57	44	7505 < BS ≤ 8787
13	57 < BS ≤ 67	45	8787 < BS ≤ 10287
14	67 < BS ≤ 78	46	10287 < BS ≤ 12043
15	78 < BS ≤ 91	47	12043 < BS ≤ 14099
16	91 < BS ≤ 107	48	14099 < BS ≤ 16507
17	107 < BS ≤ 125	49	16507 < BS ≤ 19325
18	125 < BS ≤ 146	50	19325 < BS ≤ 22624
19	146 < BS ≤ 171	51	22624 < BS ≤ 26487
20	171 < BS ≤ 200	52	26487 < BS ≤ 31009
21	200 < BS ≤ 234	53	31009 < BS ≤ 36304
22	234 < BS ≤ 274	54	36304 < BS ≤ 42502
23	274 < BS ≤ 321	55	42502 < BS ≤ 49759
24	321 < BS ≤ 376	56	49759 < BS ≤ 58255
25	376 < BS ≤ 440	57	58255 < BS ≤ 68201
26	440 < BS ≤ 515	58	68201 < BS ≤ 79846
27	515 < BS ≤ 603	59	79846 < BS ≤ 93479
28	603 < BS ≤ 706	60	93479 < BS ≤ 109439
29	706 < BS ≤ 826	61	109439 < BS ≤ 128125
30	826 < BS ≤ 967	62	128125 < BS ≤ 150000
31	967 < BS ≤ 1132	63	BS > 150000

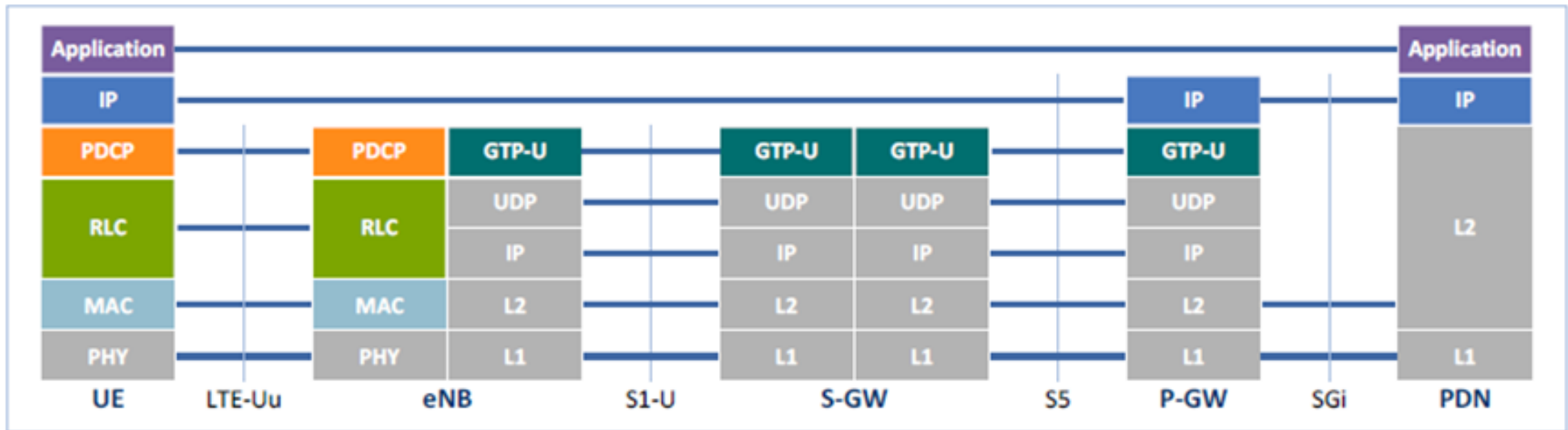
13 Appendix. BSR Example

- If UL low Throughput happened, check below conditions



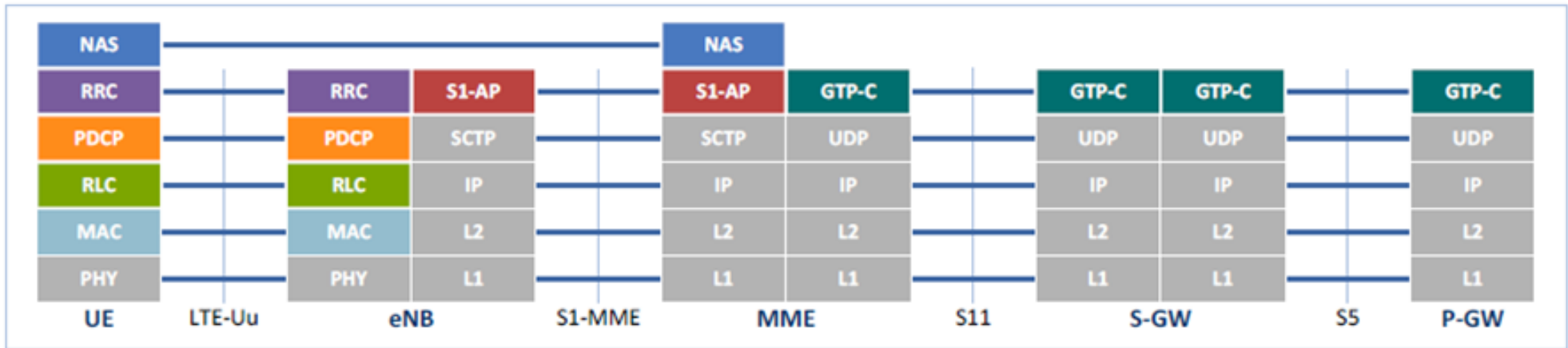
14 Appendix. LTE Protocol stack

- User plane



15 Appendix. LTE Protocol stack

- Control plane



Thank you



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