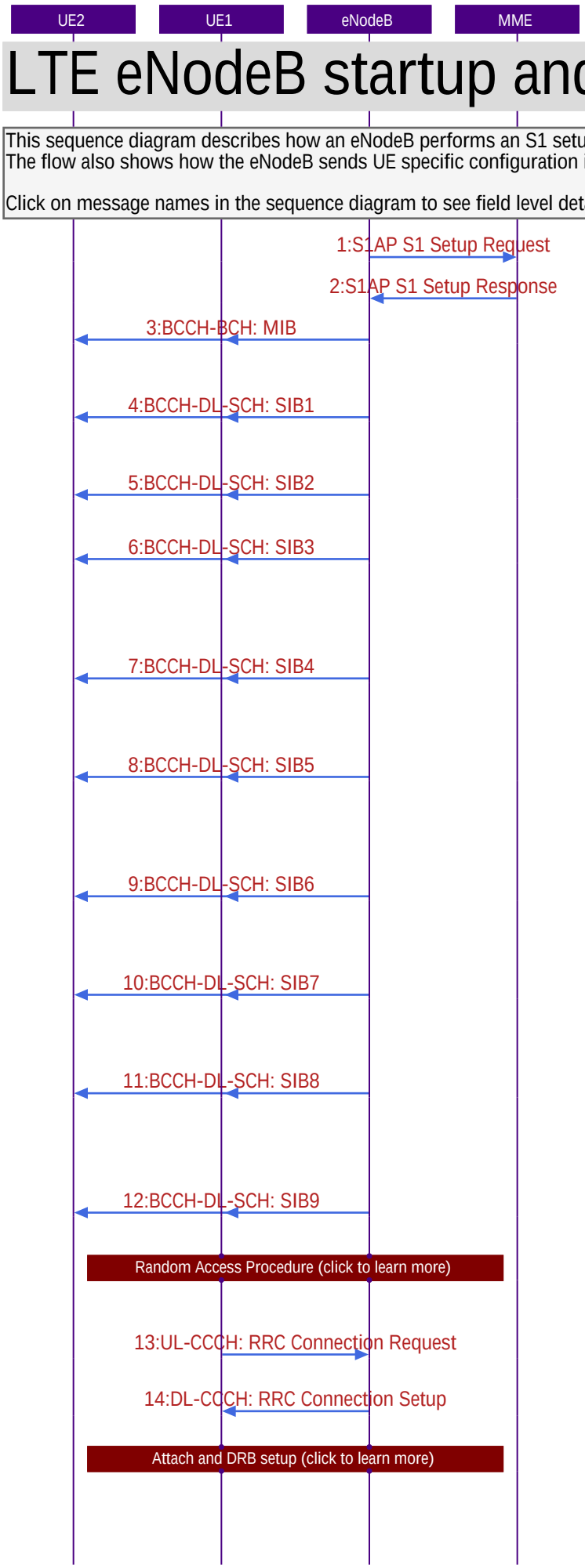


LTE eNodeB startup and UE setup (summary)

This sequence diagram describes how an eNodeB performs an S1 setup with the EPC and then initiates MIB and SIB broadcast to the UEs. The flow also shows how the eNodeB sends UE specific configuration information via the RRC Connection Setup message.

Click on message names in the sequence diagram to see field level details for individual messages.

1:S1AP S1 Setup Request
eNodeB initiates an S1 connection with the MME.

2:S1AP S1 Setup Response
The MME accepts the S1 connection

3:BCCH-BCH: MIB
Master Information Block carries PHY related information about the LTE cell. This information is essential for further decoding of the system information.

4:BCCH-DL-SCH: SIB1
System Information Block Type 1 contains information relevant when evaluating if a UE can access a cell and defines the scheduling of other system information.

5:BCCH-DL-SCH: SIB2
The IE System Information Block Type 2 contains radio resource configuration information that is common for all UEs.

6:BCCH-DL-SCH: SIB3
The IE System Information Block Type 3 contains cell re-selection information common for intra-frequency, inter- frequency and/ or inter-RAT cell re-selection (i.e. applicable for more than one type of cell re-selection but not necessarily all) as well as intra-frequency cell re-selection information other than neighboring cell related.

7:BCCH-DL-SCH: SIB4
The IE System Information Block Type 4 contains neighboring cell related information relevant only for intra-frequency cell re-selection. The IE includes cells with specific re-selection parameters as well as blacklisted cells.

8:BCCH-DL-SCH: SIB5
The IE System Information Block Type 5 contains information relevant only for inter-frequency cell re-selection i.e. information about other E-UTRA frequencies and inter-frequency neighboring cells relevant for cell re-selection. The IE includes cell re-selection parameters common for a frequency as well as cell specific re-selection parameters.

9:BCCH-DL-SCH: SIB6
The IE System Information Block Type 6 contains information relevant only for inter-RAT cell re-selection i.e. information about UTRA frequencies and UTRA neighboring cells relevant for cell re-selection. The IE includes cell re-selection parameters common for a frequency.

10:BCCH-DL-SCH: SIB7
The IE System Information Block Type 7 contains information relevant only for inter-RAT cell re-selection i.e. information about GERAN frequencies relevant for cell re-selection. The IE includes cell re-selection parameters for each frequency.

11:BCCH-DL-SCH: SIB8
The IE System Information Block Type 8 contains information relevant only for inter-RAT cell re-selection i.e. information about CDMA2000 frequencies and CDMA2000 neighboring cells relevant for cell re-selection. The IE includes cell re-selection parameters common for a frequency as well as cell specific re-selection parameters.

12:BCCH-DL-SCH: SIB9
The IE SystemInformationBlockType9 contains a home eNB name (HNB Name).

Random Access Procedure (click to learn more)
UE and eNodeB perform the random-access procedure to synchronize the UT and assign resources for transmission of the RRC connection setup message.

13:UL-CCCH: RRC Connection Request
UE uses the uplink grant assigned in the random access procedure to request the eNodeB to establish an RRC connection.

14:DL-CCCH: RRC Connection Setup
The eNodeB sets up SRB1 and passes UE specific configuration via the RRC Connection Setup message.

Attach and DRB setup (click to learn more)
The UE then proceed to attach and setup the default bearer.

LTE eNodeB startup and UE setup (detailed)

We will now analyze the complete flow with field level detail. Important parameters in each message are explained. You can also click on the message titles to see the complete structure of the messages.

1:S1AP S1 Setup Request — eNodeB initiates an S1 connection with the MME.

```
Global-eNB-ID:                Global eNodeB identifier
  S1AP PLMN ID                  PLMN id associated with the eNodeB
  MCC                           Mobile country code
  MNC                           Mobile network code
  eNodeB Id                     eNodeB id within the network
Supported Tracking Areas:     List of supported tracking areas in the eNodeB
  Tracking Area [0]
    Tracking Area Code            Code assigned to the tracking area
   Broadcast PLMNs:             List of PLMNs being broadcast from this eNodeB
      { PLMN Id1, MCC, MNC }
      { PLMN Id2, MCC, MNC }
DefaultPagingDRX              The default paging discontinuous transmission configuration
```

2:S1AP S1 Setup Response — The MME accepts the S1 connection

```
Served GUMMEIs                          List of served GUMMEIs (One entry for each Radio Access
Technology)
  Served GUMMEI 0                         LTE pool information is listed as the first entry
    Served PLMN { PLMN Id, MCC, MNC }       PLMN being served
    Served Group Id                         MME Group identifier
    Served MMECs                            MME codes belonging to this group
      MME Code                                Identifies individual MMEs within the group
Relative MME Capacity                   Relative processing capacity of an MME with respect
                                        to the other MMEs in the pool.
```

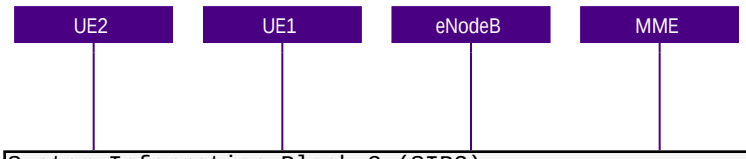
3:BCCH-BCH: MIB — Master Information Block carries PHY related information about the LTE cell. This information is essential for further decoding of the system information.

```
Master Information Block (MIB):
  Downlink Bandwidth                    Downlink bandwidth for the cell
  PHICH Configuration:
    PHICH Duration                        Normal or extended PHICH
    PHICH Resource                        PHICH group value (Ng)
  System Frame Number                   Used to frame synchronize the UE
  Scheduling Information for SIB1 BR R13 (PDSCH repetitions)
```

4:BCCH-DL-SCH: SIB1 — System Information Block Type 1 contains information relevant when evaluating if a UE can access a cell and defines the scheduling of other system information.

```
System Information Block 1 (SIB):

  Cell Access Related Information:
    PLMN Identity List                  List of PLMNs supported by this cell
      { PLMN Id1, MCC, MNC }            PLMN identifier, Mobile country code and network codes
      { PLMN Id2, MCC, MNC }
    Tracking Area Code
    Cell Barred Flag

  Cell Selection Information:
    q_RxLevMin                          Minimum Required Signal Quality in the Cell
    q_RxLevMinOffset                    Adjustment applied to the minimum required signal quality
                                        in the search for a higher priority PLMN when the UT is
                                        camped on a VPLMN (Visited PLMN).

  p-Max                                 Maximum UT power permitted in the cell

  SI Scheduling Information List        Specifies the periodicity of SIB elements
    Item 0:
      SI Periodicity: rf16 (16 frames)
      Mapping Information: {SIB3, SIB4}
    Item 1:
      SI Periodicity: rf32 (32 frames)
      Mapping Information: {SIB5}
    Item 2:
      SI Periodicity: rf64 (64 frames)
      Mapping Information: {SIB6, SIB7, SIB8, SIB9}
```

UE2
UE1
eNodeB
MME
SI Window length: 5ms
Window for transmission of an SI message. Only one message and its repetitions may be sent in an SI window.
5:BCCH-DL-SCH: SIB2
The IE System Information Block Type 2 contains radio resource configuration information that is common for all UEs.
System Information Block 2 (SIB2):
ac-BarringInfo
Prohibit access under overload or emergency conditions
ac-BarringForEmergency
Is access barring supported for emergency calls?
ac-BarringForMO-Signalling
Access barring parameters for mobile originated signaling.
ac-BarringForMO-Data
Access barring parameters for mobile originated data
radioResourceConfigCommon
rach-ConfigCommon
numberOfRA-Preambles
Number of random-access preambles
powerRampingStep
Step size for increasing transmit power on preamble retry
preambleInitialReceivedTargetPower
preambleTransMax
Maximum number of preambles
ra-ResponseWindowSize
Window for receiving preamble response
mac-ContentionResolutionTimer
bcch-Config {modificationPeriodCoeff}
pcch-Config { defaultPagingCycle, nB}
prach-Config
rootSequenceIndex
Root Zadoff-Chu sequence for preambles
prach-ConfigInfo
prach-ConfigIndex
Preamble format and PRACH subframe assignment index
highSpeedFlag
Supporting preambles from fast moving vehicles (typically trains)
zeroCorrelationZoneConfig
N-CS configuration that defines the N-CS value
prach-FreqOffset
Identifies the RBs for PRACH
pdsch-ConfigCommon
referenceSignalPower
Transmit power of a resource element carrying the reference symbol
p-b
PDSCH power offset when the OFDM symbol carries a reference symbol
pusch-ConfigCommon
n-SB
Number of frequency hopping subbands
hoppingMode
Uplink frequency hopping mode
pusch-HoppingOffset
Uplink frequency hopping offset
enable64QAM
Is 64-QAM modulation supported in uplink?
pucch-ConfigCommon
deltaPUCCH-Shift
Cyclic shift delta to be used in selecting UT specific ZC code
nRB-CQI
RB assignment for CQI
nCS-AN
Cyclic shifts reserved for PUCCH Format 1
n1PUCCH-AN
PUCCH resources assigned for HARQ
soundingRS-UL-ConfigCommon
srs-BandwidthConfig
Bandwidth assigned to the SRS
srs-SubframeConfig
Defines the frequency resource assignment for SRS
ackNackSRS-SimultaneousTransmission
If true: UE shortens the PUCCH to accommodate SRS
uplinkPowerControlCommon
p0-NominalPUSCH
Nominal power level on PUSCH to overcome interference
alpha
Fractional power control (alpha=1 implies full compensation)
p0-NominalPUCCH
Nominal power level on PUCCH to overcome interference
deltaFList-PUCCH
Power adjustment w.r.t. PUCCH Format 1a
deltaPreambleMsg3
Power adjustment applied to a Msg3 transmission
ul-CyclicPrefixLength
Normal or extended cyclic prefix
ue-TimersAndConstants
t300
Timer awaiting RRC connection setup
t301
Timer awaiting RRC connection reestablishment
t310
Timer started after receiving n310 out of sync indications
n310
Consecutive out of sync indications
t311
Timer awaiting cell selection after link failure
n311
Consecutive in sync indications
freqInfo
ul-CarrierFreq
Uplink carrier frequency
ul-Bandwidth
Bandwidth of the uplink carrier
mbsfn-SubframeConfigList
Multi-cast Broadcast Single Frequency Network
timeAlignmentTimerCommon
Controls how long the UE is considered uplink time aligned.
6:BCCH-DL-SCH: SIB3
The IE System Information Block Type 3 contains cell re-selection information common for intra-frequency, inter- frequency and/ or



inter-RAT cell re-selection (i.e. applicable for more than one type of cell re-selection but not necessarily all) as well as intra-frequency cell re-selection information other than neighboring cell related.

```
System Information Block 3 (SIB3)
  q-Hyst                            Specifies the hysteresis value to be added to the serving cells
                                    measurement when ranking against neighboring cells.
  speedStateReselectionPars         Speed dependent reselection parameters
  cellReselectionServingFreqInfo    Information about cell reselection for inter-frequency and inter
                                    radio technology handovers.
    s-NonIntraSearch                  Threshold for performing inter-frequency or inter-RAT
                                      measurements.
    threshServingLow                  Threshold a serving cell should fall before selecting lower
                                      priority RAT frequency
    cellReselectionPriority           Absolute reselection priority for E-UTRA or inter-RAT frequency.

  intraFreqCellReselectionInfo      Cell reselection information for intra-frequency cell selection.
    q_RxLevMin                        Minimum required RSRP for cell selection
    s-IntraSearch                     Threshold for performing intra-frequency measurement.

  neighCellConfig                   MBSFN and TDD DL/UL config in neighboring cells.
  t-ReselectionEUTRA                Cell selection timer value and trigger for cell reselection
  p-Max                             Maximum allowed uplink transmit power
```

7:BCCH-DL-SCH: SIB4

The IE System Information Block Type 4 contains neighboring cell related information relevant only for intra-frequency cell re-selection. The IE includes cells with specific re-selection parameters as well as blacklisted cells.

```
System Information Block 4 (SIB4)
  intraFreqNeighCellList          List of intra frequency neighboring cells
    intraFreqNeighCellInfo[0]       Individual cell entry # 0 in the list
      physCellId                      Physical cell id for the neighbor
      q-OffsetCell                    Offset to be applied to the cell during reselection
    intraFreqNeighCellInfo[1]       Individual cell entry # 1in the list

  intraFreqBlackCellList          List of intra frequency cells that are blacklisted for reselection
```

8:BCCH-DL-SCH: SIB5

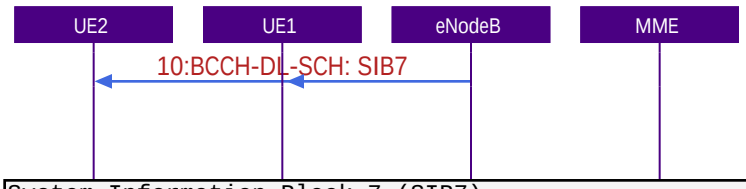
The IE System Information Block Type 5 contains information relevant only for inter-frequency cell re-selection i.e. information about other E-UTRA frequencies and inter-frequency neighboring cells relevant for cell re-selection. The IE includes cell re-selection parameters common for a frequency as well as cell specific re-selection parameters.

```
System Information Block 5 (SIB5)
  interFreqCarrierFreqList          List of inter frequency neighboring carriers
    interFreqCarrierFreqInfo[0]       Individual carrier entry # 0 in the list
      dl-CarrierFreq                    Downlink frequency of the carrier
      q-RxLevMin                        Minimum RSRP level for the carrier to be eligible
      p-Max                             Maximum uplink transmit power permitted in the cell
      t-ReselectionEUTRA                Time to trigger reselection
      t-ReselectionEUTRA-SF             Medium and high mobility scaling factor
      threshX-High                      Threshold for cell reselection to higher priority
      threshX-Low                       Threshold for cell reselection to lower priority
      allowedMeasBandwidth              Measurement bandwidth in resource blocks
      cellReselectionPriority           Absolute priority for cell reselection
      neighCellConfig                   Configuration for the neighboring cells
      q-OffsetFreq                      RSRP measurement offset to be applied for cell selection
    interFreqCarrierFreqInfo[1]       Individual carrier entry # 0 in the list
  interFreqBlackCellList              Cells to be ignored in cell reselection
```

9:BCCH-DL-SCH: SIB6

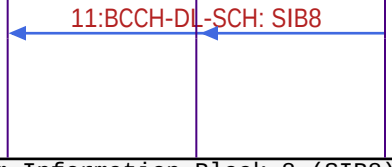
The IE System Information Block Type 6 contains information relevant only for inter-RAT cell re-selection i.e. information about UTRA frequencies and UTRA neighboring cells relevant for cell re-selection. The IE includes cell re-selection parameters common for a frequency.

```
System Information Block 6 (SIB6)
  carrierFreqListUTRA_FDD
    carrierFreqListUTRA_FDD_element[0]      Entry #0
      carrierFreq                           Carrier frequency
      cellReselectionPriority               Absolute cell selection priority for UMTS
      threshX-High                          Threshold for cell reselection to higher priority
      threshX-Low                           Threshold for cell reselection to lower priority
      q-RxLevMin                            Minimum RSRP for UMTS cell
      p-Max                                 Maximum uplink transmit power permitted in the cell
      q-QualMin                             Minimum Ec/Io for UMTS cell candidate
      t-ReselectionEUTRA                    Time to trigger reselection
      t-ReselectionEUTRA-SF                 Medium and high mobility scaling factor
    carrierFreqListUTRA_FDD_element[1]      Entry #1
```



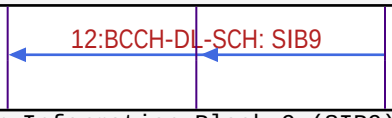
The IE System Information Block Type 7 contains information relevant only for inter-RAT cell re-selection i.e. information about GERAN frequencies relevant for cell re-selection. The IE includes cell re-selection parameters for each frequency.

```
System Information Block 7 (SIB7)
  t_ReselectionGERAN                    Time to trigger for reselection for GERAN.
  carrierFreqsInfoList[0]                GERAN Entry #0
    startingARFCN                          Start of the ARFCN
    bandIndicator                          GERAN frequency band (dcs1800 or pcs1900)
    followingARFCNs                        ARFCN groups
    cellReselectionPriority                Absolute priority of the GERAN layer
    ncc-Permitted                          Network Color Code. Is a bitmap value
    q-RxLevMin                            minimum RSSI value required
    p-MaxGERAN                            maximum allowed UL transmit power
    threshX-High                          Threshold for cell reselection to higher priority
    threshX-Low                            Threshold for cell reselection to lower priority
  carrierFreqsInfoList[1]                GERAN Entry #1
```



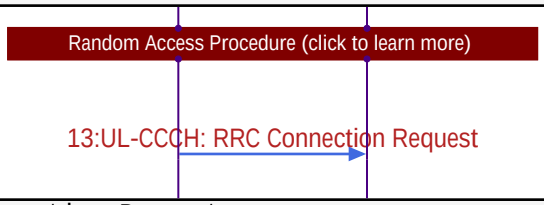
The IE System Information Block Type 8 contains information relevant only for inter-RAT cell re-selection i.e. information about CDMA2000 frequencies and CDMA2000 neighboring cells relevant for cell re-selection. The IE includes cell re-selection parameters common for a frequency as well as cell specific re-selection parameters.

```
System Information Block 8 (SIB8)
  systemTimeInfo      Signals if E-UTRAN and CDMA2000 networks are synchronized
  searchWindowSize    Information to assist in searching for CDMA2000 pilots
  parametersHRPD      Information about neighbors in CDMA2000 High Rate Packet Data mode
  parameters1XRTT     Information about neighbors in CDMA2000 Radio Transmission Technology mode
```



The IE SystemInformationBlockType9 contains a home eNB name (HNB Name).

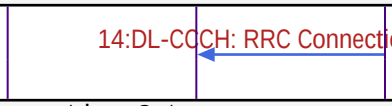
```
System Information Block 9 (SIB9)
  hnb-Name            Home eNodeB name
```



UE and eNodeB perform the random-access procedure to synchronize the UT and assign resources for transmission of the RRC connection setup message.

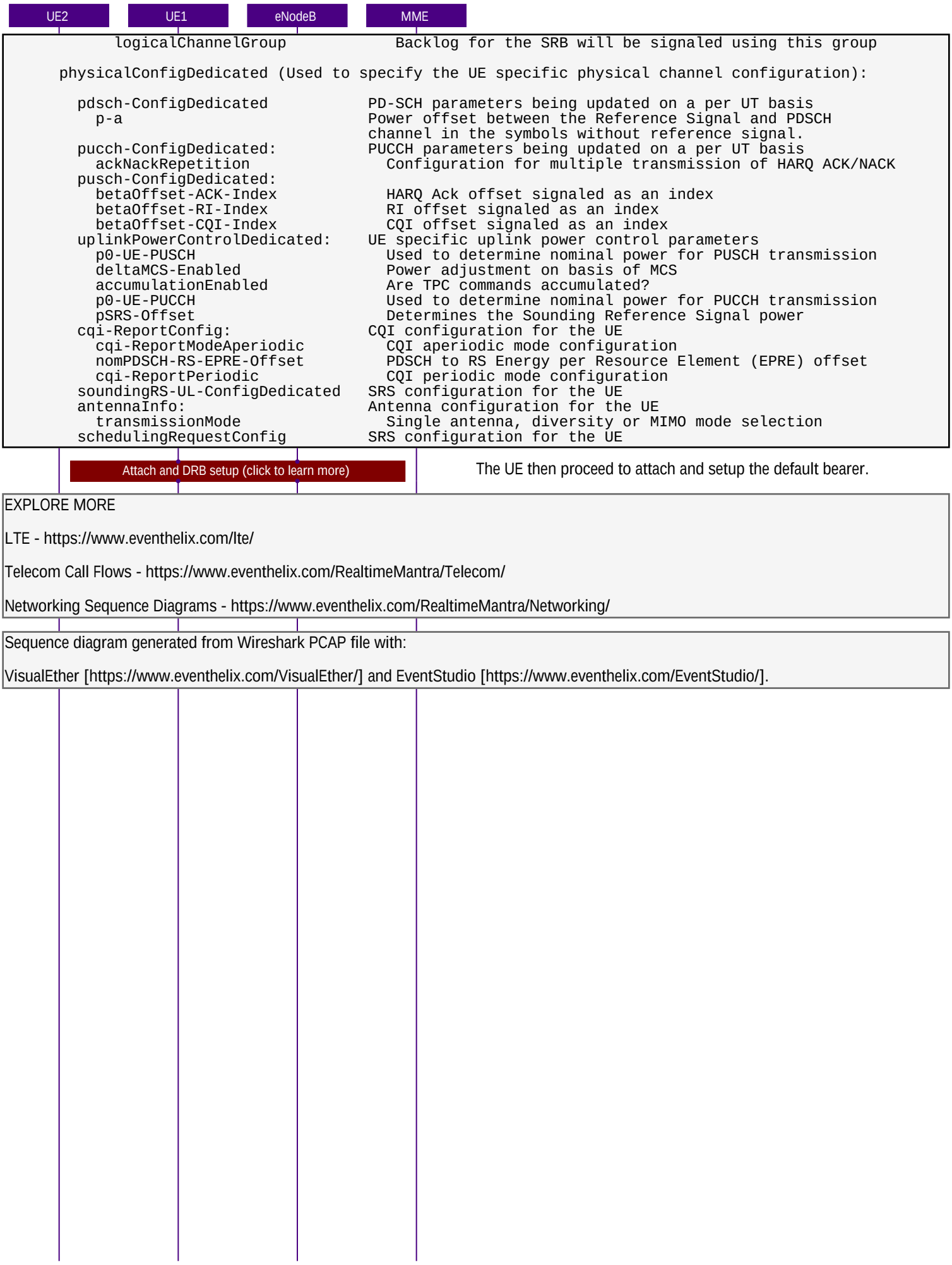
UE uses the uplink grant assigned in the random access procedure to request the eNodeB to establish an RRC connection.

```
RRC Connection Request:
  UE Identity:                UE identity
    Random value                UE uses a random value as the initial identity

  Establishment Cause           Establishment cause can be emergency, highPriorityAccess,
                                mobile terminated-Access, mobile originated-Signalling,
                                mobile originated-Data
```



The eNodeB sets up SRB1 and passes UE specific configuration via the RRC Connection Setup message.

```
RRC Connection Setup:
    radioResourceConfigDedicated (Used to setup/modify/release RBs, to modify the MAC main
    configuration, to modify the SPS configuration and to modify dedicated physical configuration):

      srb-ToAddModList:             List of signaling radio bearers being added or modified.
        SRB-ToAddMod[0]:              SRB entry #0
          srb-Identity                  Identifier for SRB (SRB1 in this case)
          rlc-Config                    RLC configuration for the SRB
            ul-AM-RLC                   Uplink RLC acknowledged mode configuration
              PollRetransmit              Used by the Tx side of an AM RLC entity to retransmit a poll
              pollPDU                     Insert a poll after the count of PDUs specified here
              pollByte                    Insert a poll after the count of bytes specified here
              maxRetxThreshold            Limits the number of retransmissions of an AMD PDU
            dl-AM-RLC                    Downlink RLC acknowledged mode configuration
              t-Reordering                Used by the receiving side of an AM RLC entity to
                                          detect loss of RLC PDUs at lower layer.
              StatusProhibit              Used by the receiving side of an AM RLC entity in
                                          order to prohibit transmission of a STATUS PDU.

          logicalChannelConfig          Logical channel configuration parameters
            ul-SpecificParameters         Uplink logical channel configuration
              priority                      Priority assigned to the SRB
              prioritisedBitRate            Prioritized throughput for the SRB
            bucketSizeDuration            Flow control bucket size
```


UE2
UE1
eNodeB
MME
logicalChannelGroup Backlog for the SRB will be signaled using this group
physicalConfigDedicated (Used to specify the UE specific physical channel configuration):
pdsch-ConfigDedicated PD-SCH parameters being updated on a per UT basis
p-a Power offset between the Reference Signal and PDSCH channel in the symbols without reference signal.
pucch-ConfigDedicated: PUCCH parameters being updated on a per UT basis
ackNackRepetition Configuration for multiple transmission of HARQ ACK/NACK
pusch-ConfigDedicated:
betaOffset-ACK-Index HARQ Ack offset signaled as an index
betaOffset-RI-Index RI offset signaled as an index
betaOffset-CQI-Index CQI offset signaled as an index
uplinkPowerControlDedicated: UE specific uplink power control parameters
p0-UE-PUSCH Used to determine nominal power for PUSCH transmission
deltaMCS-Enabled Power adjustment on basis of MCS
accumulationEnabled Are TPC commands accumulated?
p0-UE-PUCCH Used to determine nominal power for PUCCH transmission
pSRS-Offset Determines the Sounding Reference Signal power
cqi-ReportConfig: CQI configuration for the UE
cqi-ReportModeAperiodic CQI aperiodic mode configuration
nomPDSCH-RS-EPRE-Offset PDSCH to RS Energy per Resource Element (EPRE) offset
cqi-ReportPeriodic CQI periodic mode configuration
soundingRS-UL-ConfigDedicated SRS configuration for the UE
antennaInfo: Antenna configuration for the UE
transmissionMode Single antenna, diversity or MIMO mode selection
schedulingRequestConfig SRS configuration for the UE
Attach and DRB setup (click to learn more)
The UE then proceed to attach and setup the default bearer.
EXPLORE MORE
LTE - https://www.eventhelix.com/lte/
Telecom Call Flows - https://www.eventhelix.com/RealtimeMantra/Telecom/
Networking Sequence Diagrams - https://www.eventhelix.com/RealtimeMantra/Networking/
Sequence diagram generated from Wireshark PCAP file with:
VisualEther [https://www.eventhelix.com/VisualEther/] and EventStudio [https://www.eventhelix.com/EventStudio/].