台灣資通產業標準協會
Taiwan Association of Information and Communication Standards

3GPP NB-IoT物聯網技術發展現況

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- **2013/7 ~ now** 資訊工業策進會/智慧網通系統研究所/正工程師
  - Delegate of 3GPP RAN2 meeting
  - Research Interest:
    - Small cell related
    - Transient performance analysis
    - Random Access procedure
- **2010/9 ~ 2013/1** 國立台灣科技大學 電子工程系 博士 畢

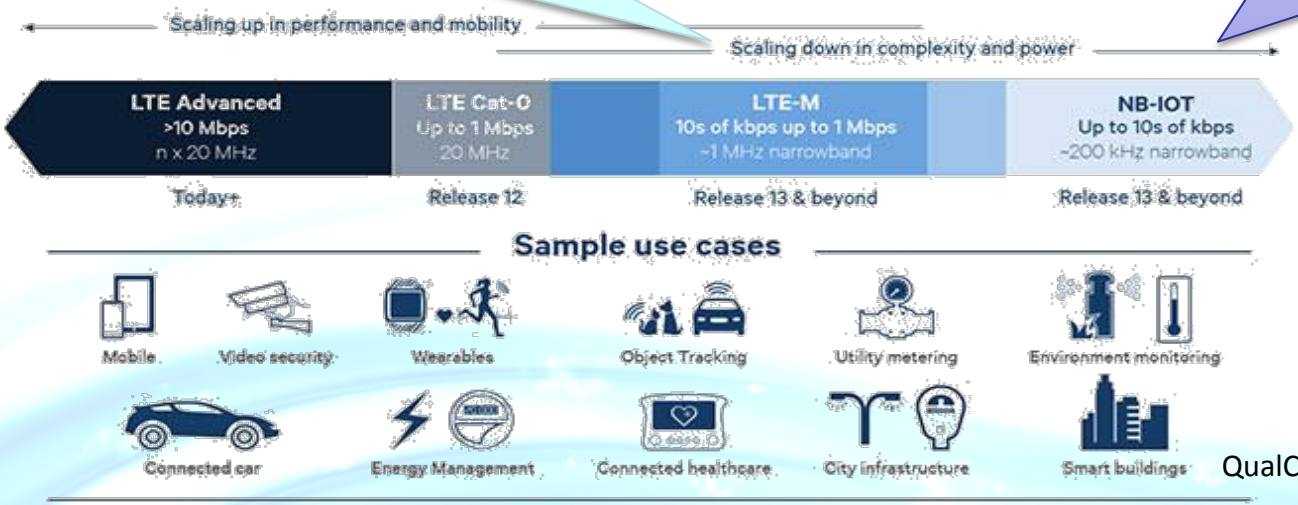
3GPP LTE-M, NB-IoT (R13)

LTE-M

- An evolution of LTE optimized for IoT in 3GPP RAN. First released in Rel. 12 in Q4 2014 and further optimization will be included in Rel. 13 with specifications complete in Q1 2016

NB-IOT

- Narrowband operation with 180 kHz bandwidth (in-band, guard band, stand alone)
- DL: OFDMA, UL: FDMA with GMSK modulation and/or SC-FDMA
- Being discussed as part of RAN Rel. 13 standardization starting in Q4 2015 with specifications to be completed by Q2 2016



QualComm

Comparison of 3GPP IoT Proposals

- LTE-M, based on LTE evolution
- EC-GSM, a narrowband solution based on GSM evolution, and
- NB-LTE, a narrowband cellular IoT solution, also known as Clean Slate technologies

	LTE-Evolution	Narrowband Solutions		Next Generation
	LTE-M Rel-13	**NB-LTE Rel-13**	**EC-GSM Rel-13**	**5G**
Range (Outdoor)	< 11 km	< 15 km	< 15 km	< 15 km
MCL	156 dB	164 dB	164 dB	164 dB
Spectrum	Licensed (7-900 MHz)	Licensed (7-900 MHz)	Licensed (8-900 MHz)	Licensed (7-900 MHz)
Bandwidth	1.4 MHz or shared	200 kHz or shared	2.4 MHz or shared	shared
Data Rate	<1 Mbps	<150 kbps	10 kbps	<1 Mbps
Battery Life	>10 years	>10 years	>10 years	>10 years
Availability	2016	2016	2016	2025

In October 2015, the 3GPP RAN body mutually agreed to study the combination of the two different narrowband IoT technical solutions, EC-GSM and NB-LTE, for standardization as a single NB-IoT technology, which would support three modes of operation as follows:

- 'Stand-alone operation' utilizing, for example, the spectrum currently being used by GERAN systems as a replacement of one or more GSM carriers,
- 'Guard band operation' utilizing the unused resource blocks within a LTE carrier's guard-band, and
- 'In-band operation' utilizing resource blocks within a normal LTE carrier.

Proprietary LPWA and Cellular IoT

	SIGFOX	LoRa	clean slate cIoT	NB LTE-M Rel. 13	LTE-M Rel. 12/13	EC-GSM Rel. 13	5G (targets)
Range (outdoor) MCL	<13km 160 dB	<11km 157 dB	<15km 164 dB	<15km 164 dB	<11km 156 dB	<15km 164 dB	<15km 164 dB
Spectrum Bandwidth	Unlicensed 900MHz 100Hz	Unlicensed 900MHz <500kHz	Licensed 7-900MHz 200kHz or dedicated	Licensed 7-900MHz 200kHz or shared	Licensed 7-900MHz 1.4 MHz or shared	Licensed 8-900MHz 2.4 MHz or shared	Licensed 7-900MHz shared
Data rate	<100bps	<10 kbps	<50kbps	<150kbps	<1 Mbps	10kbps	<1 Mbps
Battery life	>10 years	>10 years	>10 years	>10 years	>10 years	>10 years	>10 years
Availability	Today	Today	2016	2016	2016	2016	beyond 2020

SigFox and LoRa are both proprietary technologies deployed in the 8-900 MHz license exempt bands. Three separate tracks for licensed Cellular IoT technologies are being standardized in 3GPP

Releases of MTC

Working Item

Study Item

R10	R11	R12	R13	R14

Machine type communications

RP-090991

RAN technical enhancements for machine-type communications for UTRA and EUTRA.

Radio resource allocation/Low mobility consideration/Power saving mechanisms/Ultra-low duty cycle

RAN overload control for Machine-Type Communications

RP-111373

RAN congestion due to the mass concurrent data and signaling

Low Cost MTC for LTE

RP-140522

Reduced DL channel BW of 1.4 MHz for data channel in baseband

Further LTE Physical Layer Enhancements for MTC

RP-150492

15 dB Coverage improvement for FDD

Narrowband IOT

RP-151621

180 kHz UE RF BW for DL/UL

5G MTC

Progress of NB-IoT in 3GPP until Feb,2016

- **Estimated level of completion of the work/study item**
  - Core part: 75 %
- **per WG (mandatory to be provided) for Core part or SI:**
  - RAN WG1: 80%
  - RAN WG2: 70%
  - RAN WG3: 70%
  - RAN WG4: 55%
- **The Core part WI is planned to be 100% complete in:**
  - June 2016 **which is:** RAN #72
- **The Performance part WI is planned to be 100% complete in:**
  - September 2016 **which is:** RAN #73

Performance objectives

- Support of massive number of low throughput devices
- Reduced complexity
- Improved power efficiency
- Latency

Related Modifications for Protocol

- **Data transfer mode**
- **HARQ**
- **Mobility**
- **UE Capabilities**
- **RLF**
- **RRC Procedure**

- DRX
- Access Barring
- System Information
- Idle mode procedure
  - Cell Selection and Reselection

NOT supported in NB-IoT

Inter-rat mobility

Emergency call and CS fallback

CSG

Dual connectivity

Sidelink communication/discovery

Carrier aggregation

MDT

Public warning functions

Interference avoidance for in-device coexistence

NAICS

GBR

Real-time services

Measurement reports

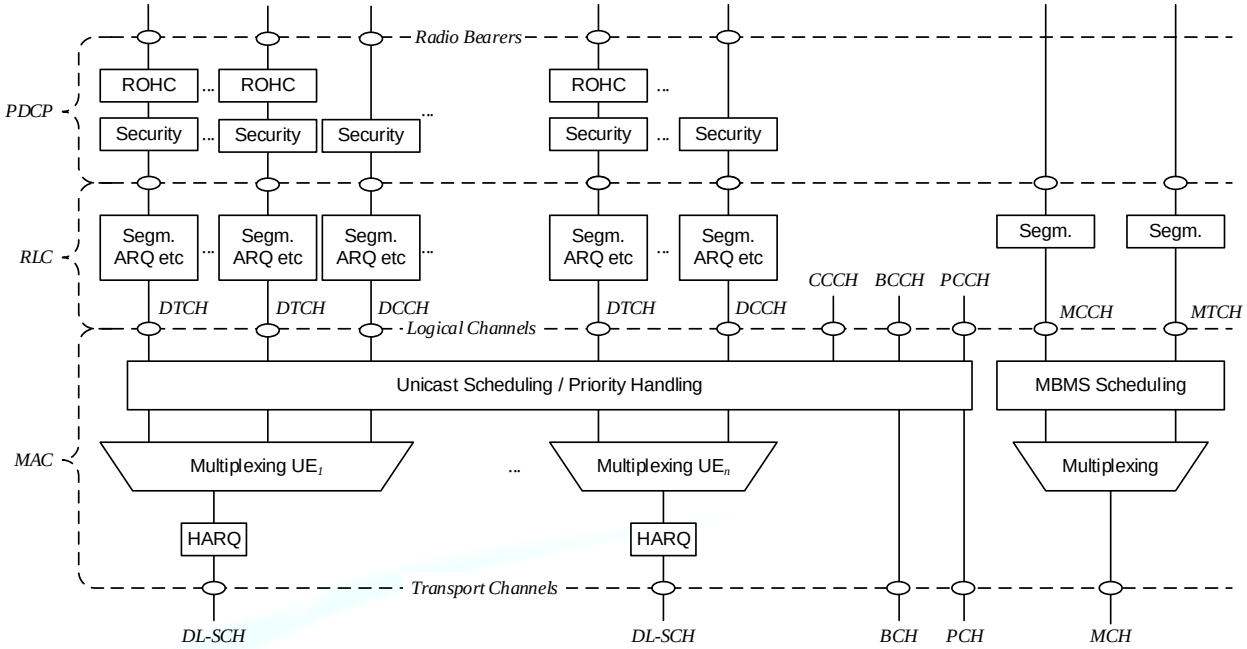
Handover

Relaying

MBMS

RAN assisted WLAN interworking

Radio Protocol Aspects

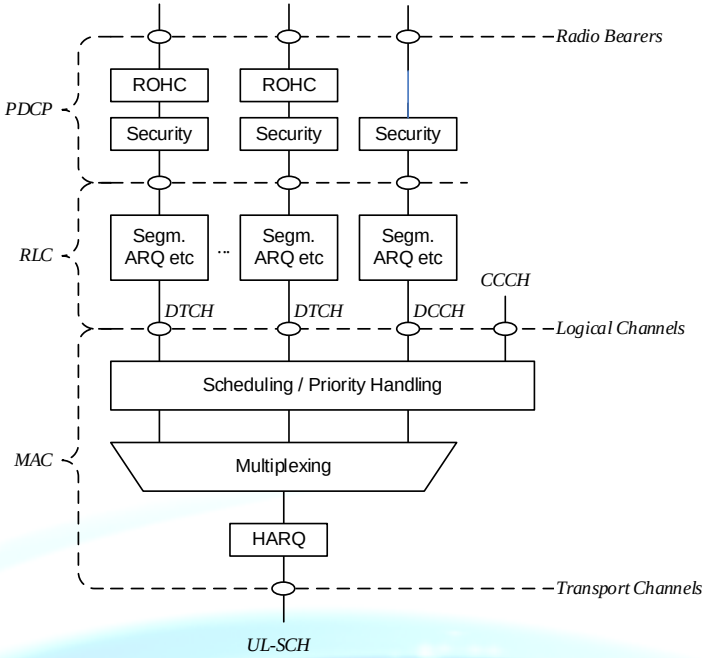


Layer 2 Structure for DL

- The radio interface protocol architecture
- MAC, RLC, PDCP, and RRC protocols
- UE capabilities

CP Solution, no AS security on DCCH.
CP Solution, only one dedicated logical channel per UE (i.e. no priority handling between logical channels of one UE).

Radio Protocol Aspects



Layer 2 Structure for UL

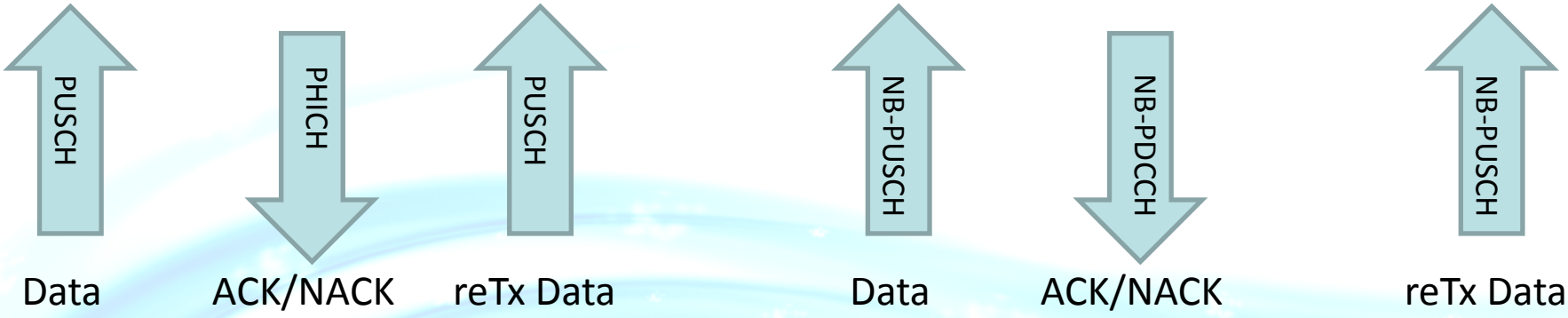
CP solution:
SRB 0
SRB 1

no AS security on DCCH
(PDCP is not used)

UP solution:
SRB 0
SRB 1
SRB 2 (no motivation)
1 DRB

HARQ

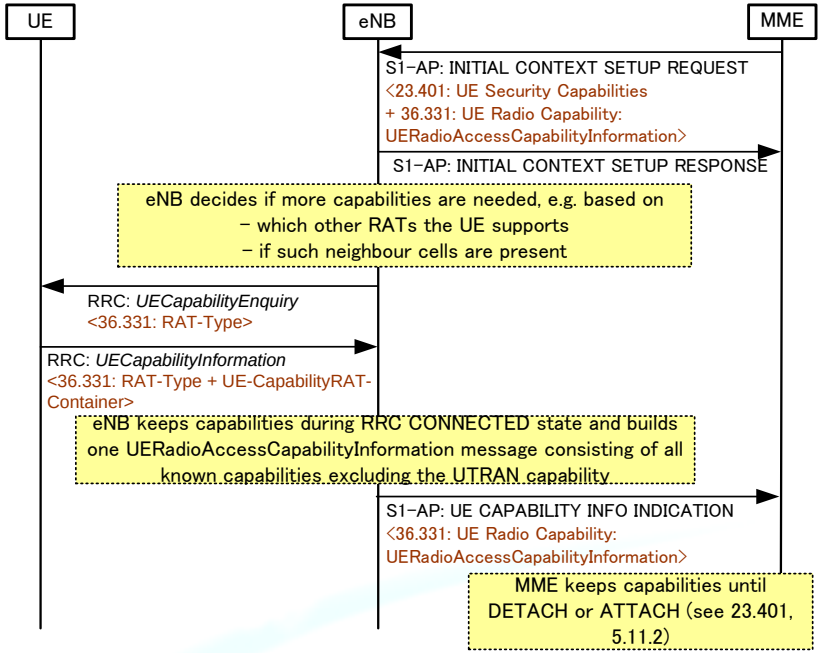
- **Both DL/UL**
  - 1-process Stop-And-Wait
- **UL: Asynchronous adaptive HARQ**
- **DL ACK/NAKs in response to uplink (re)transmissions are sent on NB-PDCCH, and uplink re-transimissions are always triggered according to Downlink ACK/NAK on the NB-PDCCH;**



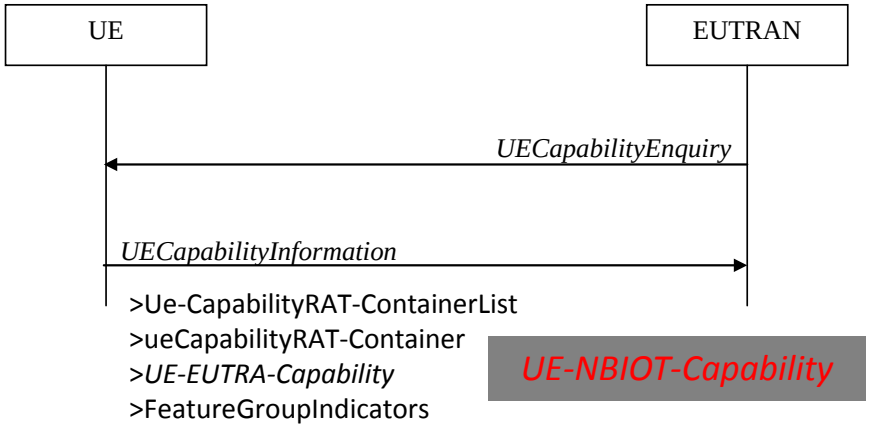
Mobility

- Key usage: Stationary UE.
- Reduce UE complexity and UE power consumption.
- Not to consider some of the legacy LTE procedures: HO.

UE capability transfer



Initial UE Capability Handling



For E-UTRA: the encoding of UE capabilities is defined in IE *UE-EUTRA-Capability*.
For UTRA: the octet string contains the INTER RAT HANDOVER INFO message defined in TS 25.331 [19].
For GERAN CS: the octet string contains the concatenated string of the Mobile Station Classmark 2 and Mobile Station Classmark 3.

TS 36.331 [1]

5.6.3.3 Reception of the *UECapabilityEnquiry* by the UE

Editor's note: This section needs further updates when the details on capability have been agreed in RAN2.

The UE shall:

1> for NB-IoT, set the contents of *UECapabilityInformation* message as follows:

2> include the *UE-NBIOT-Capability* within the *ue-CapabilityRAT-Container*;

2> submit the *UECapabilityInformation* message to lower layers for transmission, upon which the procedure ends;

1> except for NB-IoT, set the contents of *UECapabilityInformation* message as follows:

2> if the *ue-CapabilityRequest* includes *eutra*:

3> include the *UE-EUTRA-Capability* within a *ue-CapabilityRAT-Container* and with the *rat-Type* set to *eutra*;

Capabilities

- **A new UE capability container in ASN.1 is defined for NB-IoT UEs.**
- **Potential fields for the new UE capability**
  - accessStratumRelease (FFS if we have it already in Rel-13 or if we add it in a later release)
  - ue-Category (FFS depending on RAN1)(single UE category applicable to DL/UL (i.e. not separate).
  - rf-Parameters (to indicate supported frequency bands, for load balancing, FFS).
- **Do not define or use Feature Group Indicators. Introduce capability**
- **For the purpose of MSG3 size determination we assume that we may need to signal a bit for single-tone/multi-tone capability indication, but otherwise (in all other aspects) we consider this FFS.**

Data transfer mode

- **RAN2 assumes that the NB-IoT UEs will not use / transfer data using solution 2 and solution 18 [2] at the same time, i.e. both will never be configured by the network at any point in time.**

- **The selection which solution to be used is done between UE and network on NAS level.**

RLF

- **Radio link monitoring and the associated radio link failure criterion shall be supported by NB-IOT UEs, assuming RAN 1 provides the means of measuring the DL quality.**
- **We assume we use the physical channel problem detection mechanism (i.e. N310, T310 and N311) as described in RRC (TS36.331) for NB-IOT (i.e. legacy LTE behaviour).**
- **Handle coverage level FFS.**
- **Radio link failure criterion (when UE is in connected mode) due to Random Access failure indication from MAC should also be supported.**
- **Radio link failure criterion due to maximum RLC retransmissions being reached should also be supported (similar to legacy).**
- **Solution 2**
  - reestablishment is not supported so the UE would released to Idle.
- **Solution 18**
  - it would be possible to do reestablishment (it is FFS if at reestablishment failure the UE would be released to Idle, as for legacy LTE).
- **It is FFS what are the cause values used at the RRC connection release**

RRC Procedure

- The LTE RRC Connection Release procedure to be supported. Other methods for RRC release is FFS.
- We assume that RRC Connection Reconfiguration is supported for UP solution, for aspects unique to the UP solution.
- Provision of system information (e.g. SystemInformationBlockType1) via dedicated signalling i.e., within an RRCConnectionReconfiguration message, is not supported in NB-IoT
- Use C-RNTI as a part of the resume ID.
- From RRC point of view there are two RRC states i.e. RRC_CONNECTED and RRC_IDLE and when NB-IoT UE is given suspend command the UE moves to RRC_IDLE and transitions to RRC_CONNECTED on resume.
- Suspend is performed by the RRC release procedure.

Connection control procedures applicable

Sub-clause	Procedures	UE configured to use "Data transfer over NAS"	UE configured to use "AS context caching"
5.3.2	Paging	X	X
5.3.3	RRC connection establishment	X	X
	RRC connection resume	-	X
5.3.4	Initial security activation	-	X
5.3.5	RRC connection reconfiguration	-	X
5.3.7	RRC connection re-establishment	-	X
5.3.8	RRC connection release	X	X
5.3.9	RRC connection release requested by upper layers	X	X
5.3.10	Radio resource configuration	X	X
5.3.11	Radio link failure related actions	X	X
5.3.12	UE actions upon leaving RRC_CONNECTED	X	X

Access Barring

- One barring bitmap is used for both MO signaling and MO data.
- Do not introduce an additional separate flag for MO signaling.
- Update of AC information does not impact the SI value tag in MIB for general SI (FFS when AC SIB transmission is started / ended).
- Changes in SIB1 normally affects the SI value tag in MIB.
- SI for AC can be updated asynchronously to other SI updates

- When AC is enabled, UE that was barred should not retry, i.e. recheck the SI for AC, too often (for battery consumption reasons), FFS if this is implementation dependent (NAS handles such retries).

System Information

- **Legacy:**
  - MIB:
    - BCCH→BCH
    - 40ms period
  - SIBs:
    - BCCH → BCH /DL-SCH (dynamically, SI-RNTI)
    - SIB1: 80 ms period
    - Other SIBs scheduled by SIB1

- NB-IoT:
  - MIB-nb:
    - BCCH→BCH
    - 640ms period
    - all information required to acquire SIB1-nb
  - SIBs:
    - BCCH → BCH (?)
    - SIB1-nb: TBD ms period
    - Other SIBs scheduled by SIB1-nb

For NB-IoT, the UE is not required to detect SIB changes when in RRC_CONNECTED, and the network may release the NB-IoT UE to RRC_IDLE if it wants the NB-IoT UE to acquire changed SIB(s).

20 SIBs → 7 SIBs

- **System information for NB-IoT is divided into the *MasterInformationBlock –nb* (MIB-nb) and a number of *SystemInformationBlocks –nb* (SIBs-nb):**
  - *MasterInformationBlock-nb* defines the most essential information of the cell required to receive further system information;
  - *SystemInformationBlockType1-nb* cell access/selection, other SIB scheduling;
  - *SystemInformationBlockType2-nb* radio resource configuration information;
  - *SystemInformationBlockType3-nb* cell re-selection information for intra-frequency, inter-frequency;
  - *SystemInformationBlockType4-nb* neighboring cell related information relevant for intra-frequency cell re-selection;
  - *SystemInformationBlockType5-nb* neighboring cell related information relevant for inter-frequency cell re-selection;
  - *SystemInformationBlockType14-nb* access barring;
  - *SystemInformationBlockType16-nb* GPS time and UTC info.

RRC Idle

This specification is applicable to NB-IoT, except for the following functionality which is not applicable to NB-IoT:

- Acceptable cell
- Accessibility measurements
- Access Control based on ACDC categories (FFS)
- Camped on Any cell state
- CSG, including support for manual CSG selection and CSG or Hybrid cell related functionality in PLMN selection, Cell selection and Cell reselection.
- Emergency call
- E-UTRA inter-frequency redistribution (FFS)
- Inter-RAT Cell Reselection
- Limited service
- Logged measurements
- MBMS, including support for MBMS frequency prioritization
- Mobility History Information
- Mobility states of a UE
- Priority based reselection
- Public warning system including CMAS, ETWS, PWS.
- RAN-assisted WLAN interworking
- RSRQ measurements (FFS)
- Sidelink operation

Cell Selection Criterion S

The UE shall perform ranking of all cells that fulfil the cell selection criterion S

$Srxlev > 0$ AND $Squal > 0$ is True Candidate Cell

$$Srxlev = Q_{rxlevmeas} - (Q_{rxlevmin} + Q_{rxlevminoffset}) - Pcompensation - Qoffset_{temp}$$

$$Squal = Q_{qualmeas} - (Q_{qualmin} + Q_{qualminoffset}) - Qoffset_{temp}$$

S_{Intra}

intra-frequency measurements

$Srxlev > S_{IntraSearchP}$ and $Squal > S_{IntraSearchQ}$

$S_{NonIntra}$

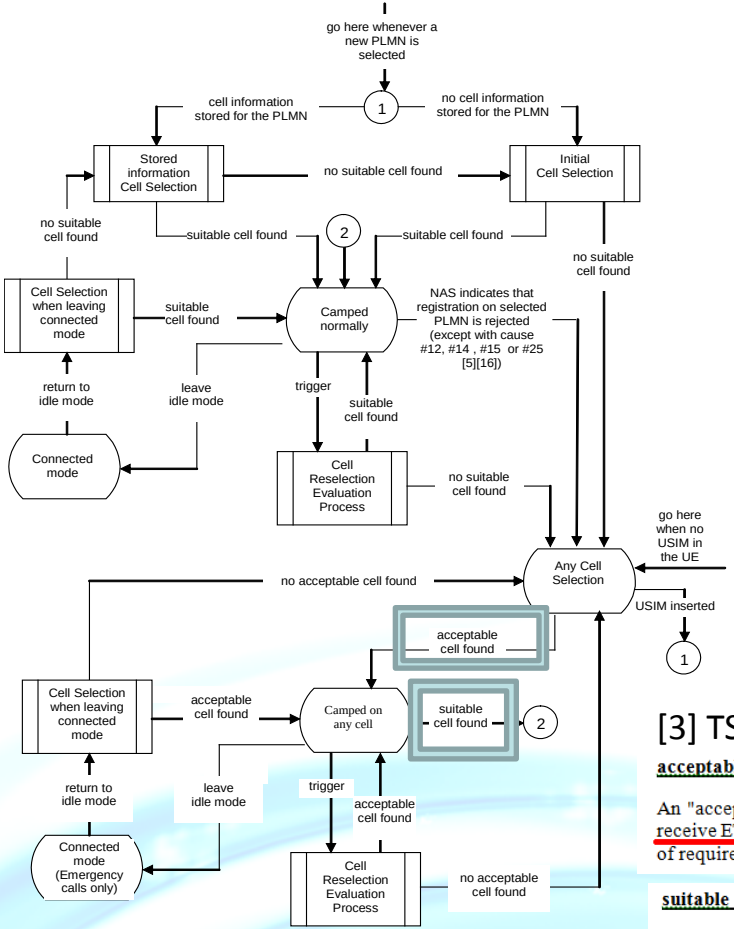
inter-frequency measurements

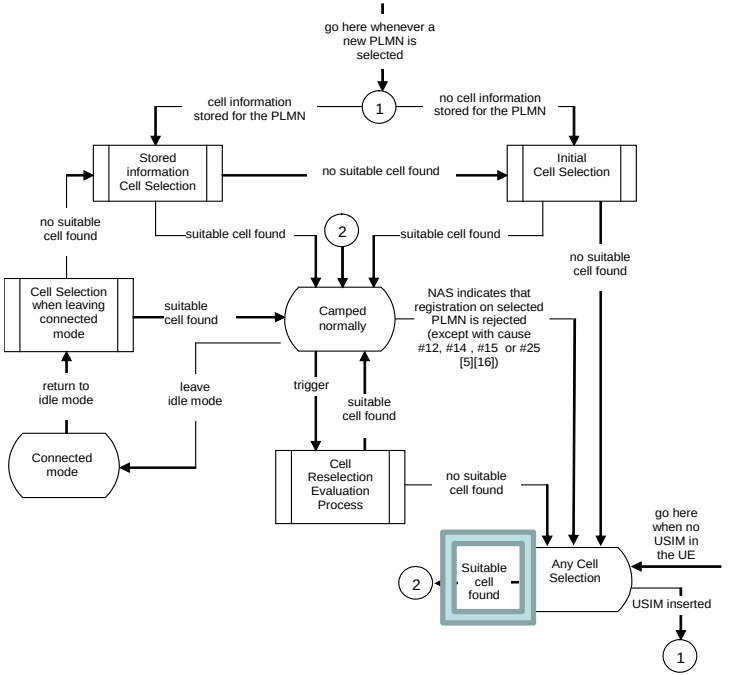
$Srxlev > S_{nonIntraSearchP}$ and $Squal > S_{nonIntraSearchQ}$

SIB 1	· Provides information relating to granting/restricting cell access · Defines scheduling of other SIBs	Access restriction info, Cell selection info, Scheduling info for other SIBs
SIB 3	· Information commonly used in all types of cell reselection (intra-frequency, inter-frequency and/or inter-RAT) · Intra-frequency cell reselection information other than neighbor cell related	q-Hyst, s-NonIntraSearch, threshServingLow, cellReselectionPriority, q-RxLevMin, p-Max, s-IntraSearch, t-ReselectionEUTRA, q-QualMin
SIB 4	· Information on neighbor cells related only to intra-frequency cell reselection	intraFreqNeighCellList (*physCellId, q-OffsetCell*), intraFreqBlackCellList (*physCellId Range*), CSG-PCI Range

Srxlev	Cell selection RX level value (dB)
Squal	Cell selection quality value (dB)
$Qoffset_{temp}$	Offset temporarily applied to a cell as specified in [3] (dB)
$Q_{rxlevmeas}$	Measured cell RX level value (RSRP)
$Q_{qualmeas}$	Measured cell quality value (RSRQ)
$Q_{rxlevmin}$	Minimum required RX level in the cell (dBm)
$Q_{qualmin}$	Minimum required quality level in the cell (dB)
$Q_{rxlevminoffset}$	Offset to the signalled $Q_{rxlevmin}$ taken into account in the Srxlev evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
$Q_{qualminoffset}$	Offset to the signalled $Q_{qualmin}$ taken into account in the Squal evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
Pcompensation	If the UE supports the *additionalPmax* in the *NS-PmaxList*, if present, in SIB1, SIB3 and SIB5: $\max(P_{EMAX1} - P_{PowerClass}, 0) - (\min(P_{EMAX2}, P_{PowerClass}) - \min(P_{EMAX1}, P_{PowerClass}))$ (dB); else: $\max(P_{EMAX1} - P_{PowerClass}, 0)$ (dB);
P_{EMAX1}, P_{EMAX2}	Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as P_{EMAX} in [TS 36.101]. P_{EMAX1} and P_{EMAX2} are obtained from the *p-Max* and the *NS-PmaxList* respectively in SIB1, SIB3 and SIB5 as specified in TS 36.331 [3].
$P_{PowerClass}$	Maximum RF output power of the UE (dBm) according to the UE power class as defined in [TS 36.101]

Cell Selection and Reselection





[3] TS 36.304

acceptable cell:

An "acceptable cell" is a cell on which the UE may camp to obtain limited service (originate emergency calls and receive ETWS and CMAS notifications). Such a cell shall fulfil the following requirements, which is the minimum set of requirements to initiate an emergency call and to receive ETWS and CMAS notification in a E-UTRAN network:

suitable cell:

A "suitable cell" is a cell on which the UE may camp on to obtain normal service. The UE shall have a valid USIM and such a cell shall fulfil all the following requirements.

RLC Sublayer

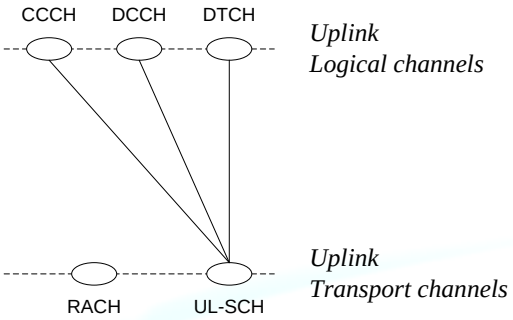
- RLC UM is not supported
- NO Reordering of RLC data PDUs

Channel mapping

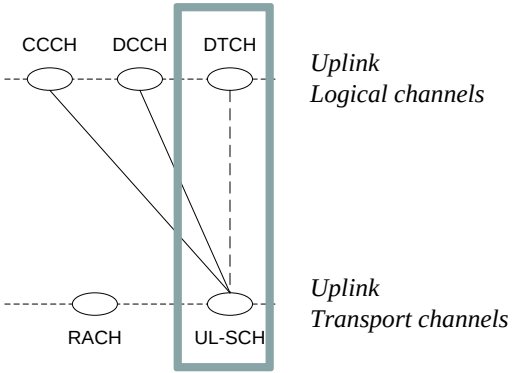
- The MCH, SL-BCH, SL-DCH and SL-SCH transport channels are not supported and concepts of other transport channels in LTE can be reused as a baseline.
- The MCCH and SBCCH logical channels are not supported.
- The MTCH and STCH logical channels are not supported, and the DTCH logical channel is only supported for user plan solution.

Channel Mapping

- **Mapping between logical channels and transport channels**
  - Uplink



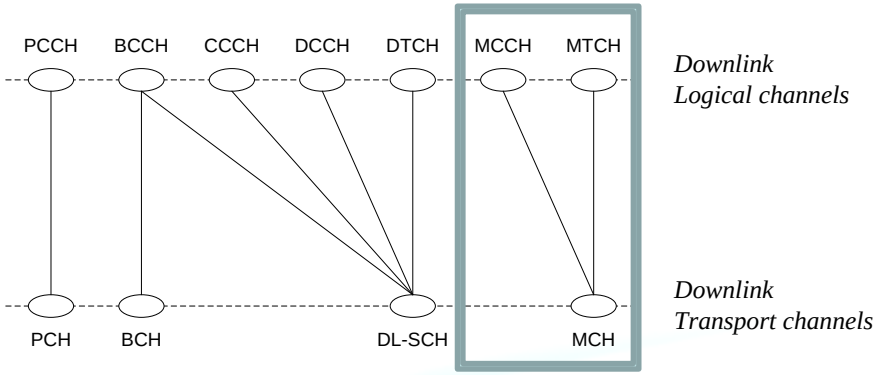
Legacy



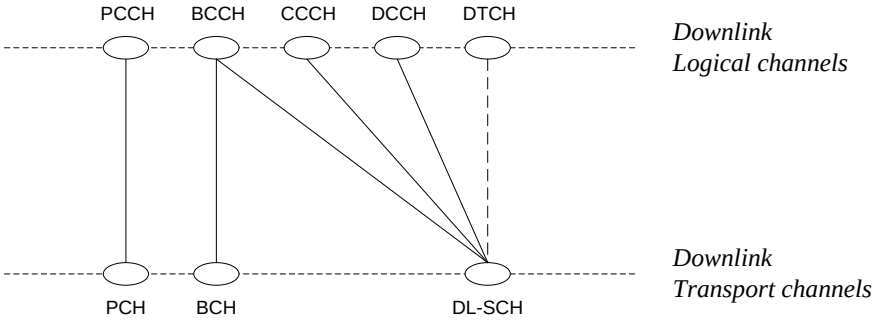
NB-IoT

Channel Mapping

- **Mapping between logical channels and transport channels**

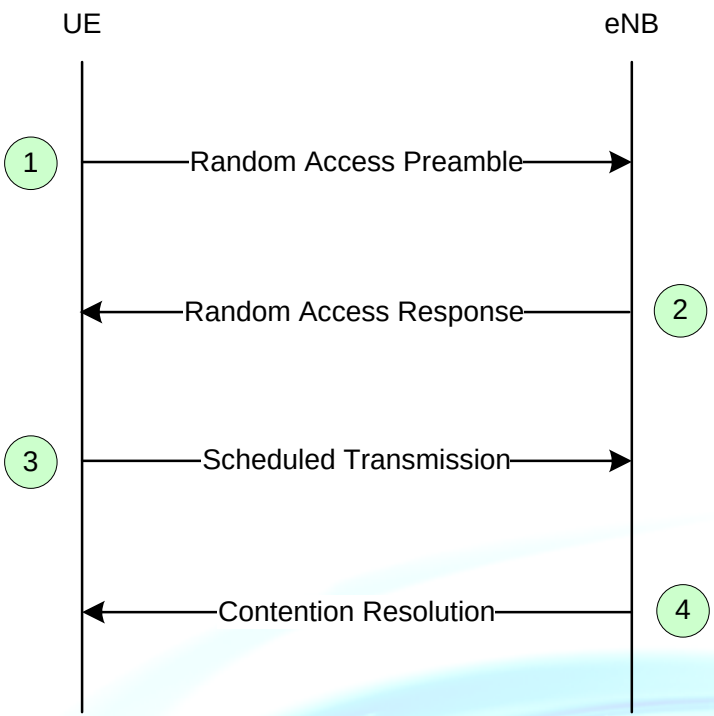


Legacy



NB-IoT

Random Access



- **Perform on anchor PRB;**
- **In the procedure to resume the RRC connection:**
  - Conveys identifier(s) to resume the RRC connection.

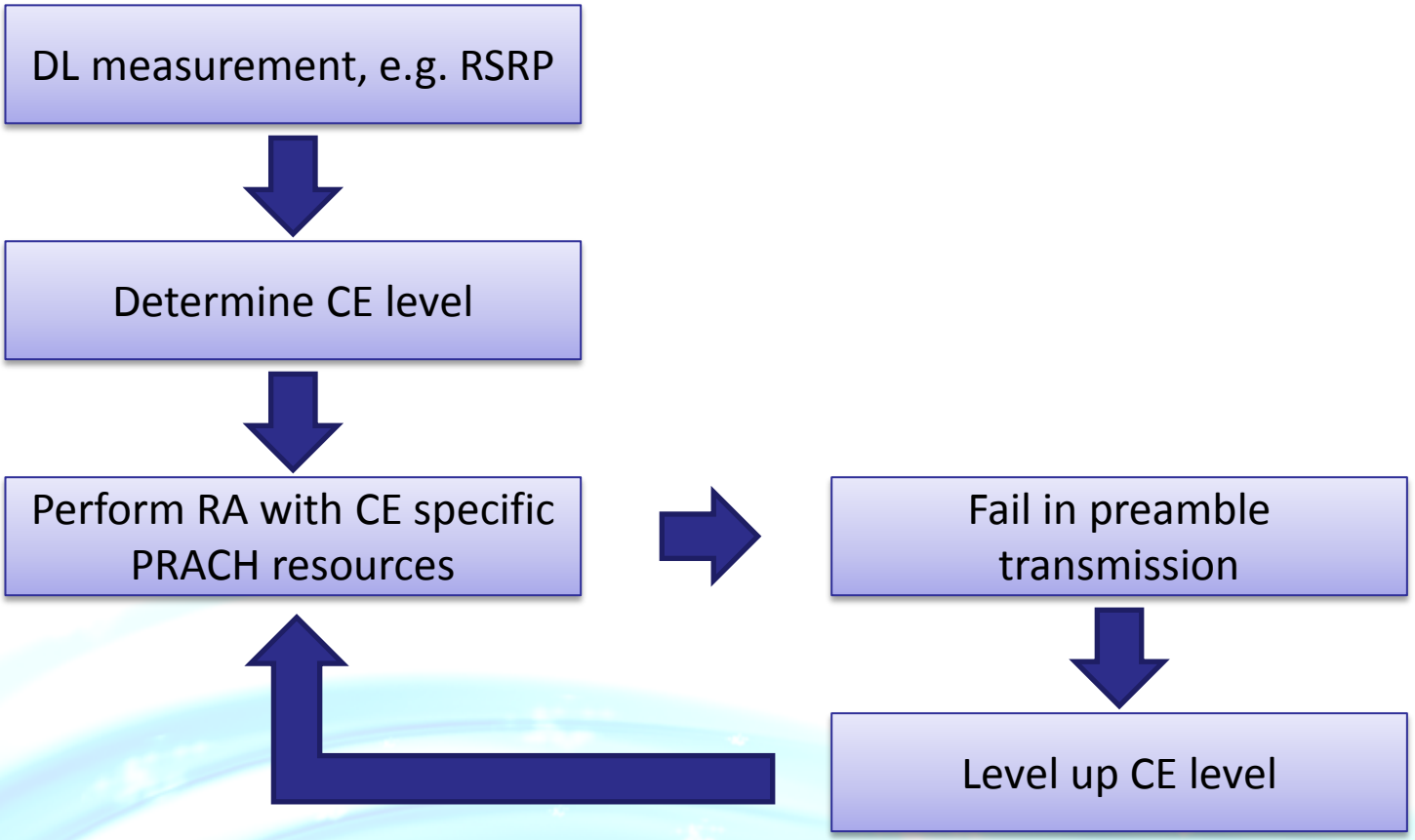
Note: the identifier(s) is/are FFS.

- **In the procedure to setup the RRC connection:**
  - An indication of the amount of data for subsequent transmission(s) on SRB or DRB can be indicated.

Random Access

- A set of PRACH resources (e.g. time, frequency, and preamble sequences) is provided for each coverage level, e.g. a number of preamble sequences for each level.
- The PRACH resources per coverage level are configurable by System Information.
- The UE selects PRACH resources based on coverage level given by a UE DL measurement, e.g. RSRP.
- Do not support contention free RACH / dedicated preambles for Handover or other reconfigurations in this release. The need for contention free RACH in the future or for other purposes, e.g. PDCCH order is FFS.
- In the SI signalling support it shall be possible to indicate that only a subset of RACH resources are available for contention RACH.
- FFS the behavior at contention resolution failure (need to check).
- Global PREAMBLE_TRANSMISSION_COUNTER and per coverage level PREAMBLE_TRANSMISSION_COUNTER_CE are used for NB-IoT
- Global PREAMBLE_TRANSMISSION_COUNTER is used to achieve power ramping for the received target preamble power

Random Access Procedure



Random Access

- MAC contention resolution timer for NB-IoT is configured per-CEL [4].
- The MAC will reattempt at a higher coverage level if it does not receive RAR after the allowed number of attempts of a certain level.
- If the Contention Resolution is considered not successful the UE should continue in the same PRACH CE level to proceed to the transmission of preamble.
- NB-IoT supports only cross-subframe scheduling and no same-subframe scheduling
- The transmission duration in number of sub-frames for the NB-PDCCH, the NB-PDSCH and the NB-PUSCH is variable

DRX

- **We confirm that at least the legacy parameters drxStartOffset, longDRX-Cycle and OnDurationTimer are re-used as is for connected mode DRX with value ranges suitable for NB-IoT**
- **Connected mode DRX configuration parameters for NB-IoT can be included as part of RRC message in MSG 4.**

- **The LTE legacy DRX (timers, triggering conditions, etc.) is reused as baseline.**
- **Maximum value of the DRX cycle**
  - Legacy: longDRX-Cycle sf2560=256 radio frame
  - eMTC/eDRX: 2621.44 seconds (43.69 minutes).
  - NB-IoT: 10485.76 seconds (2.91 hours).

DRX

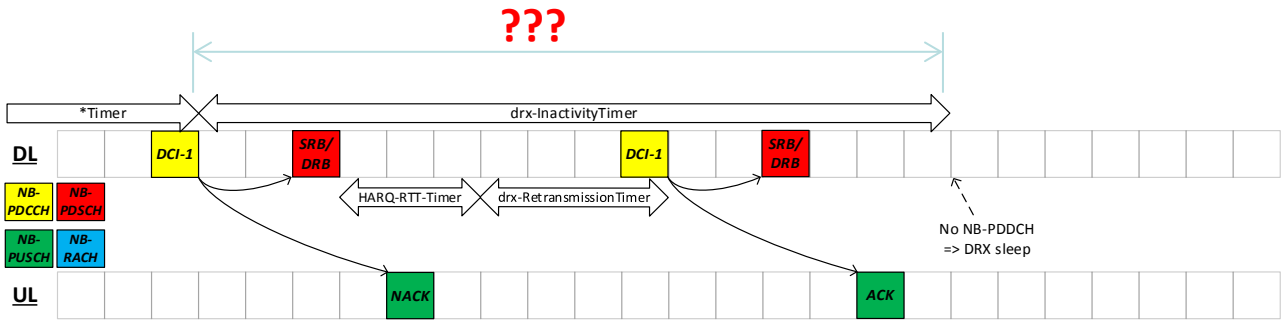
- **Running CR for TS 36.300**

X.4.2.4 DRX in connected mode

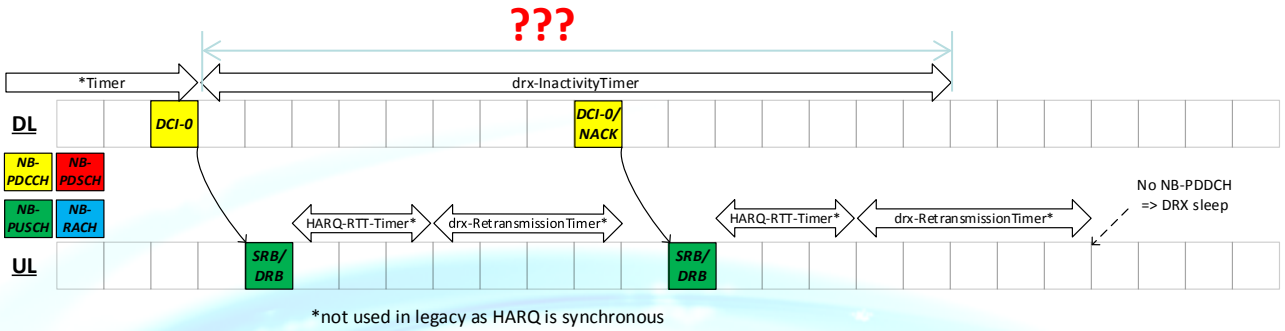
DRX in connected mode is supported, but only one DRX cycle, i.e. "long DRX" is supported. Further signalling optimization is not precluded.
It is beneficial to enable DRX also for short connections, as early as possible.

- **Parameters in legacy LTE and eMTC (excluding the short DRX parameters):**
  - *onDurationTimer*
  - *drxStartOffset* (signaled as *longDRX-CycleStartOffset* in 36.331)
  - *longDRX-Cycle* (signaled as *longDRX-CycleStartOffset* in 36.331)
  - *drx-InactivityTimer*
  - *HARQ-RTT-Timer*
  - *drx-RetransmissionTimer*

DRX



Legacy LTE DRX behavior for one DL HARQ re-transmission [5]



Legacy LTE DRX timers applied for one UL HARQ re-transmission [5]

Multi-carrier operation

- **In-band, guardband and standalone are supported.**
- **RRC_IDLE**
  - Camps on the carrier on which it has received NPSS/NSSS, NPBCH and SIB transmissions.
- **RRC_CONNECTED**
  - can be configured, via UE-specific RRC signaling, to a PRB, for all unicast transmissions, different than the NB-IoT carrier on which the UE has received NPSS/NSSS, NPBCH and SIB transmissions.
- **If the different PRB is not configured for the UE, all transmissions occur on the NB-IoT carrier on which the UE has received NPSS, NSSS, NPBCH and SIB transmissions.**
- **The UE is not expected to receive NPBCH, and NPSS/NSSS and any transmissions other than unicast transmissions in the configured PRB.**

Note: Receives paging on an anchor carrier.

Scheduling

- Scheduling information for downlink data is transmitted on a downlink physical control channel denoted NB-PDCCH. The scheduled downlink data is transmitted on shared data channels denoted NB-PDSCH;
- Only cross-subframe scheduling is supported. The transmission duration in number of sub-frames for the NB-PDCCH and the NB-PDSCH is variable;
- The transmission duration in number of sub-frames is semi-static for the NB-PDCCH and is indicated for the NB-PDSCH as part of the scheduling information transmitted on the NB-PDCCH;
- The start time of the NB-PDSCH relative to the NB-PDCCH is signaled as part of the scheduling message.

Cell Reselection

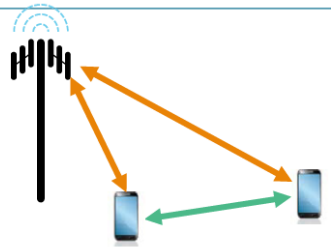
- **Based on cell reselection criteria which involve measurements of the serving and neighbor cells as follows:**
  - Intra-frequency reselection is based on ranking of cells
  - Inter-frequency reselection is based on raking of frequencies
  - **Blind redirection supported for load balancing.**

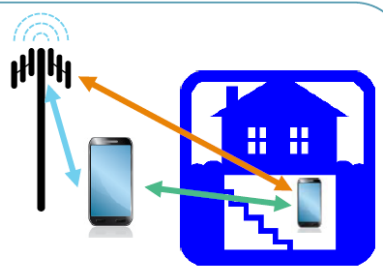
3GPP Rel. 14

Further Enhancements LTE Device to Device, UE to Network Relays for IoT and Wearables

Use Cases

IoT

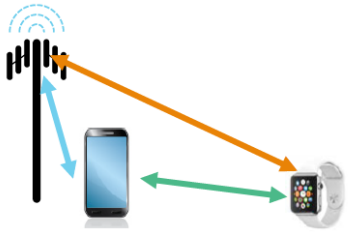




- Single modem solution for proximal and cellular communication
- Operator controlled proximal communication

- Deep coverage operation (MCL 165dB)
- Large amount of bundling needed – power impact
- Relaying can reduce the power consumption

Wearables



- Wearables getting increasingly complex
- Moving towards independent operation with full LTE modem
- D2D advantages: range, security, power, throughput, & device cost
- Example: lower end device with lower max transmit power and throughput capability

Key considerations

- Cost
- Power consumption

- Cost
- Power consumption
- Throughput

RP-160677 New SI proposal on Further Enhancements LTE Device to Device, UE to Network Relays for IoT and Wearables

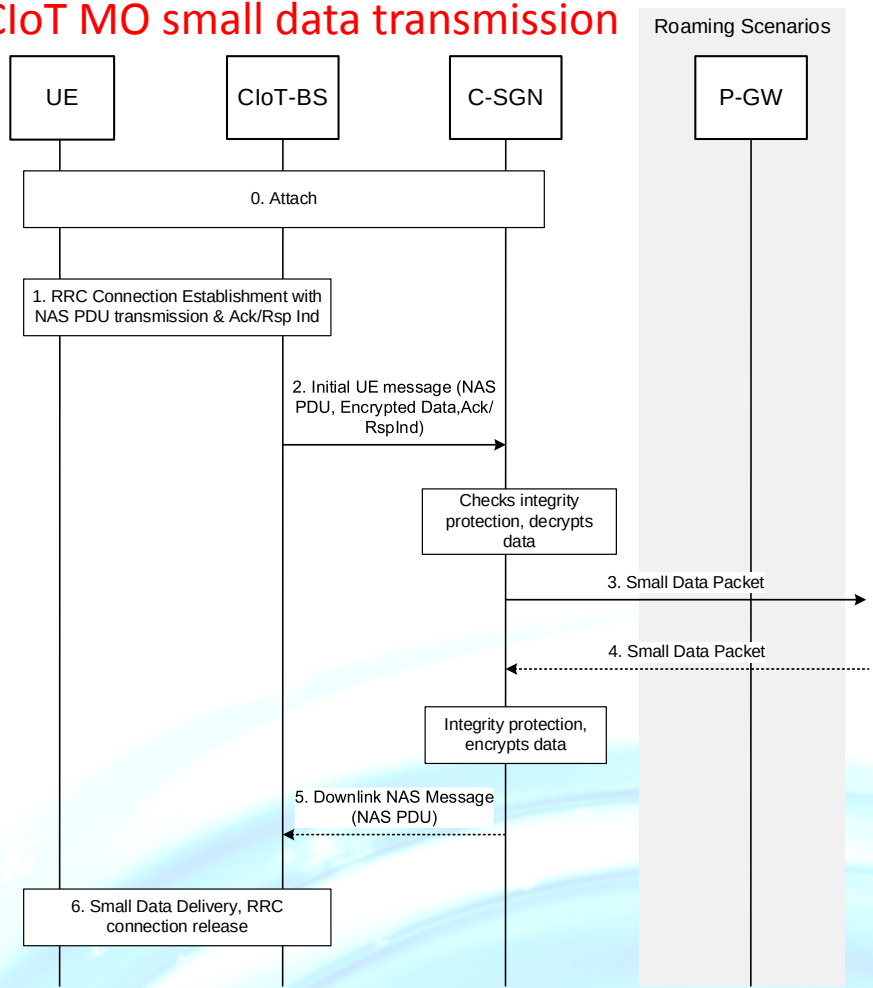
References

[1] 3GPP R2-162070 36.331 Running CR to capture agreements on NB-IoT
[2] 3GPP TR 23.720 Architecture enhancements for Cellular Internet of Things
[3] 3GPP TS 36.304 User Equipment (UE) procedures in idle mode
[4] 3GPP R2-162072 36.321 running CR to capture agreements on NB-IoT
[5] 3GPP R2-160471 Connected Mode DRX for NB-IoT

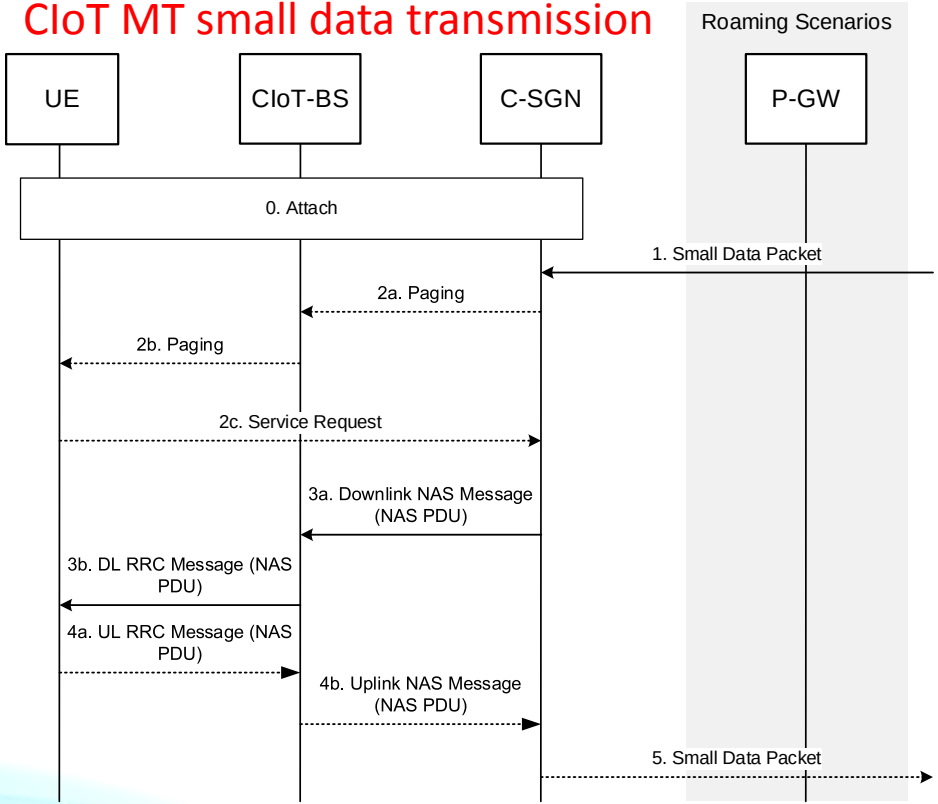
Appendix

Control Plane Solution

CIoT MO small data transmission

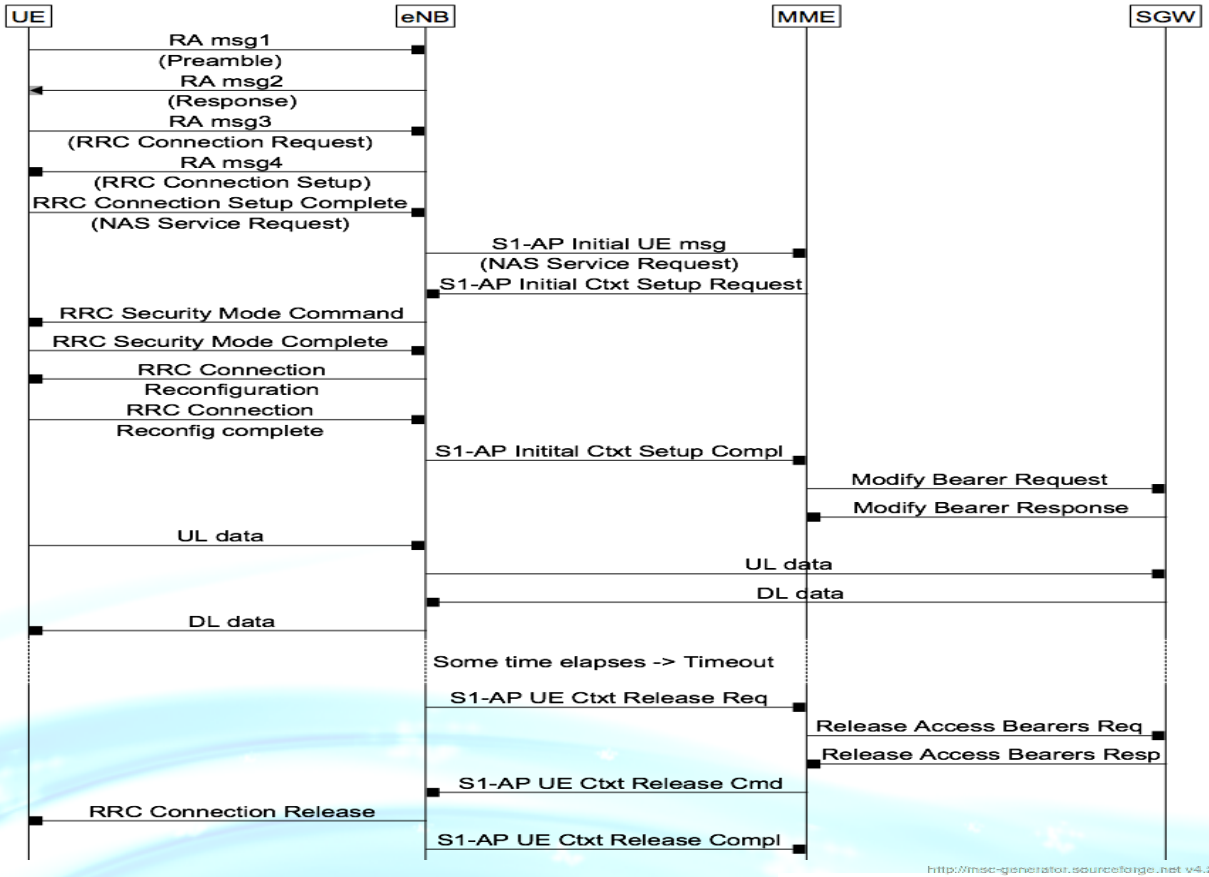


CIoT MT small data transmission

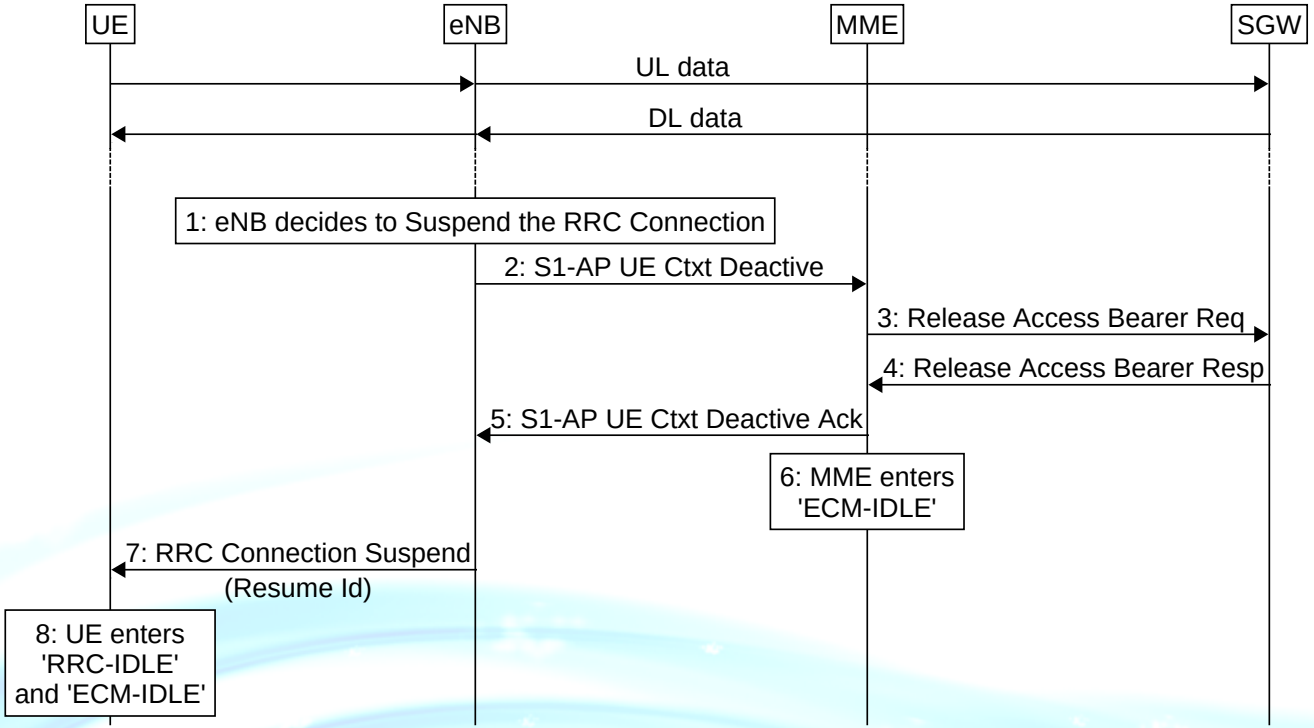


User Plane Solution

Legacy idle to connected transition connection setup

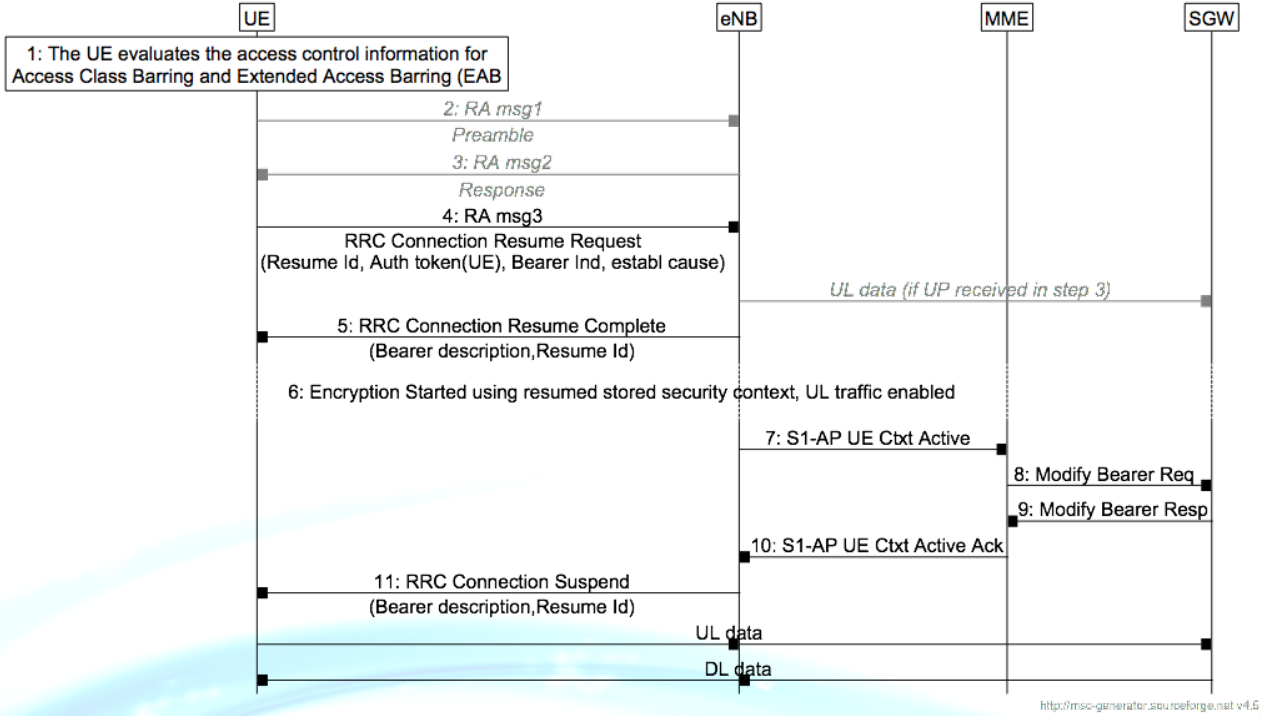


RRC Suspension procedure for solution 18

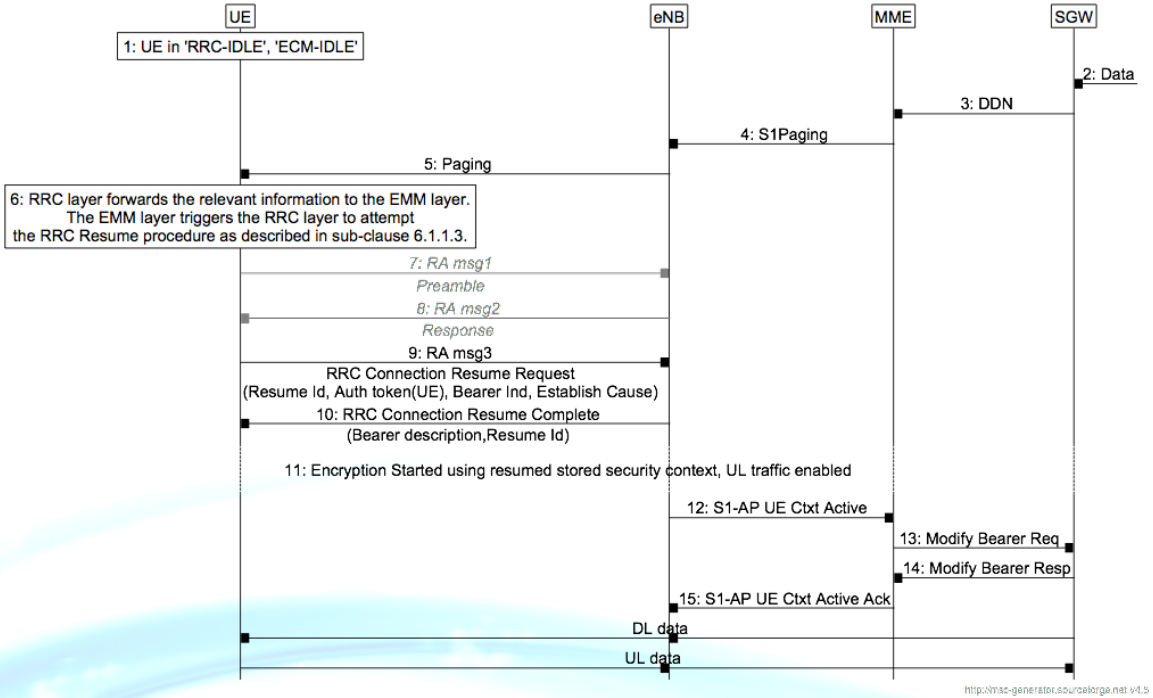


http://msc-generator.sourceforge.net v4.5

RRC Resumption procedure for solution 18



Resumption of a previously suspended RRC connection for MT case



THANK YOU