Trend and Status of NB-IoT protocol in LTE-A

資策會

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Releases of MTC in LTE

Working Item

Study Item

Cat. 0 Cat. M

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*
- *coverage improvement target of 20dB*

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

Remaining Issues Currently

- RA problem reports to higher layers
- Data Value Indicator (DVI) usage
- Usage of Logical Channel Identity (LCID) values
- Start/stop of drxInactivityTimer during connected mode DRX

MAC remaining issues

- **Limit the number of preamble transmissions if RA problem is reported to higher layers.**

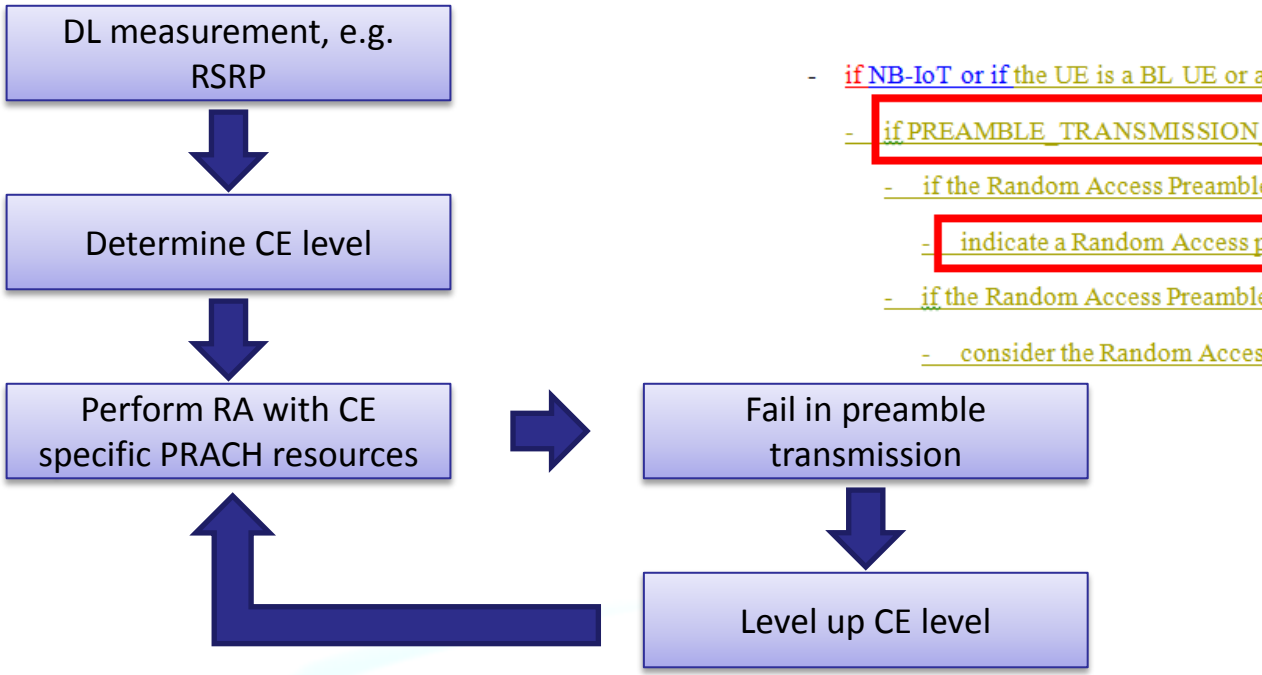
- if NB-IoT or if the UE is a BL UE or a UE in enhanced coverage:
  - if PREAMBLE_TRANSMISSION_COUNTER = *preambleTransMax-CE* + 1:
    - if the Random Access Preamble is transmitted on the SpCell:
      - indicate a Random Access problem to upper layers;

Then further down the following is specified:

- proceed to the selection of a Random Access Resource (see subclause 5.1.2).

TS 36.321

Random Access Problem



- if NB-IoT or if the UE is a BL UE or a UE in enhanced coverage:
  - if PREAMBLE_TRANSMISSION_COUNTER = *preambleTransMax-CE* + 1:
    - if the Random Access Preamble is transmitted on the SpCell:
      - indicate a Random Access problem to upper layers;
    - if the Random Access Preamble is transmitted on an SCell:
      - consider the Random Access procedure unsuccessfully completed.

- if NB-IoT or if the UE is a BL UE or a UE in enhanced coverage:
  - increment PREAMBLE_TRANSMISSION_COUNTER_CE by 1;
  - if PREAMBLE_TRANSMISSION_COUNTER_CE = *maxNumPreambleAttemptCE* for the corresponding coverage level + 1:
    - reset PREAMBLE_TRANSMISSION_COUNTER_CE;
    - consider to be in the next CE level, if exists, otherwise stay in the current CE level;

Data Value Indicator

- **DVI usage**

5.4.5 Buffer Status Reporting

The Buffer Status reporting procedure is used to provide the serving eNB with information about the amount of data available for transmission in the UL buffers of the UE. RRC controls BSR reporting by configuring the two timers *periodicBSR-Timer* and *retxBSR-Timer* and by, for each logical channel, optionally signalling *logicalChannelGroup* which allocates the logical channel to an LCG [8].

4-bit DVI is to be accommodated within msg 3

LCID

Values of LCID for DL-SCH

Index	LCID values
00000	CCCH
00001-01010	Identity of the logical channel
~~01011-10111~~	~~Reserved~~
~~11000~~	~~Activation/Deactivation (4 octets)~~
~~11001~~	~~SC-MCCH, SC-MTCH (see note)~~
11010	Long DRX Command
~~11011~~	~~Activation/Deactivation (1 octet)~~
11100	UE Contention Resolution Identity
11101	Timing Advance Command
11110	DRX Command
11111	Padding
NOTE: Both SC-MCCH and SC-MTCH cannot be multiplexed with other logical channels in the same MAC PDU except for Padding	

Values of LCID for UL-SCH

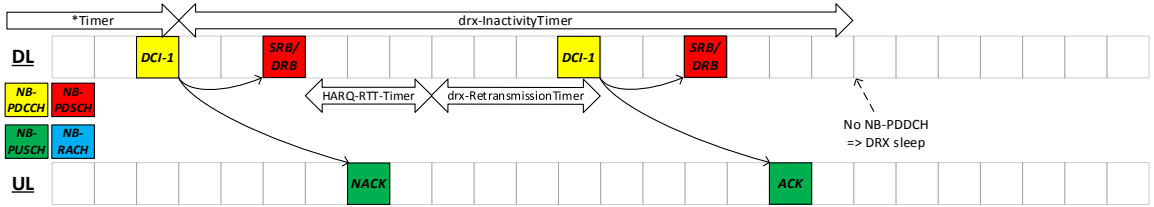
Index	LCID values
00000	CCCH
00001-01010	Identity of the logical channel
~~01011~~	~~CCCH~~
~~01100-10101~~	~~Reserved~~
~~10110~~	~~Truncated Sidelink BSR~~
~~10111~~	~~Sidelink BSR~~
~~11000~~	~~Dual Connectivity Power Headroom Report~~
~~11001~~	~~Extended Power Headroom Report~~
~~11010~~	~~Power Headroom Report~~
11011	C-RNTI
~~11100~~	~~Truncated BSR~~
~~11101~~	~~Short BSR~~
~~11110~~	~~Long BSR~~
11111	Padding

Data Value Indicator

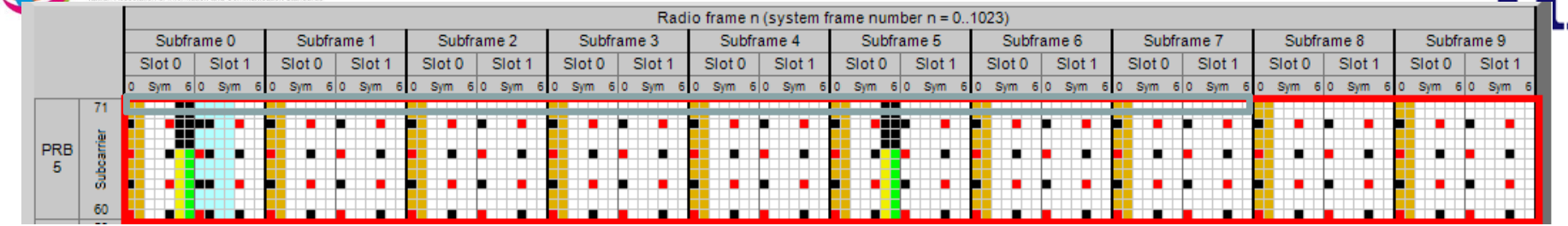
- Use NB-IoT specific DVI/PHR for MSG3.
- We use NB-IoT specific DVI/PHR for MSG3, and use LTE BSR for non-MSG3 cases.
- We don’t include PHR for other cases than MSG3 as RAN1 hasn’t asked for it.

drx-InactivityTimer

- **The drx-InactivityTimer should be started at the end of the transmission/re-transmission of each MAC PDU.**



Legacy LTE DRX behavior for one DL HARQ re-transmission



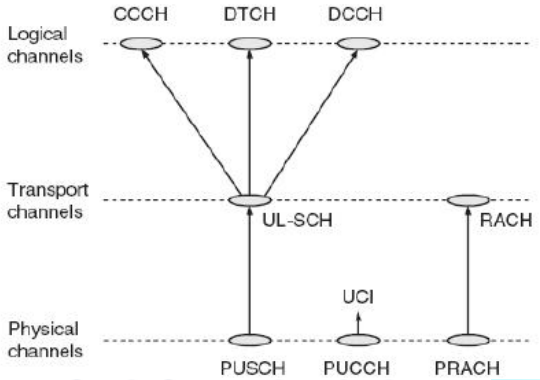
http://niviuk.free.fr/lte_resource_grid.html

10.1.2.3 Resource unit

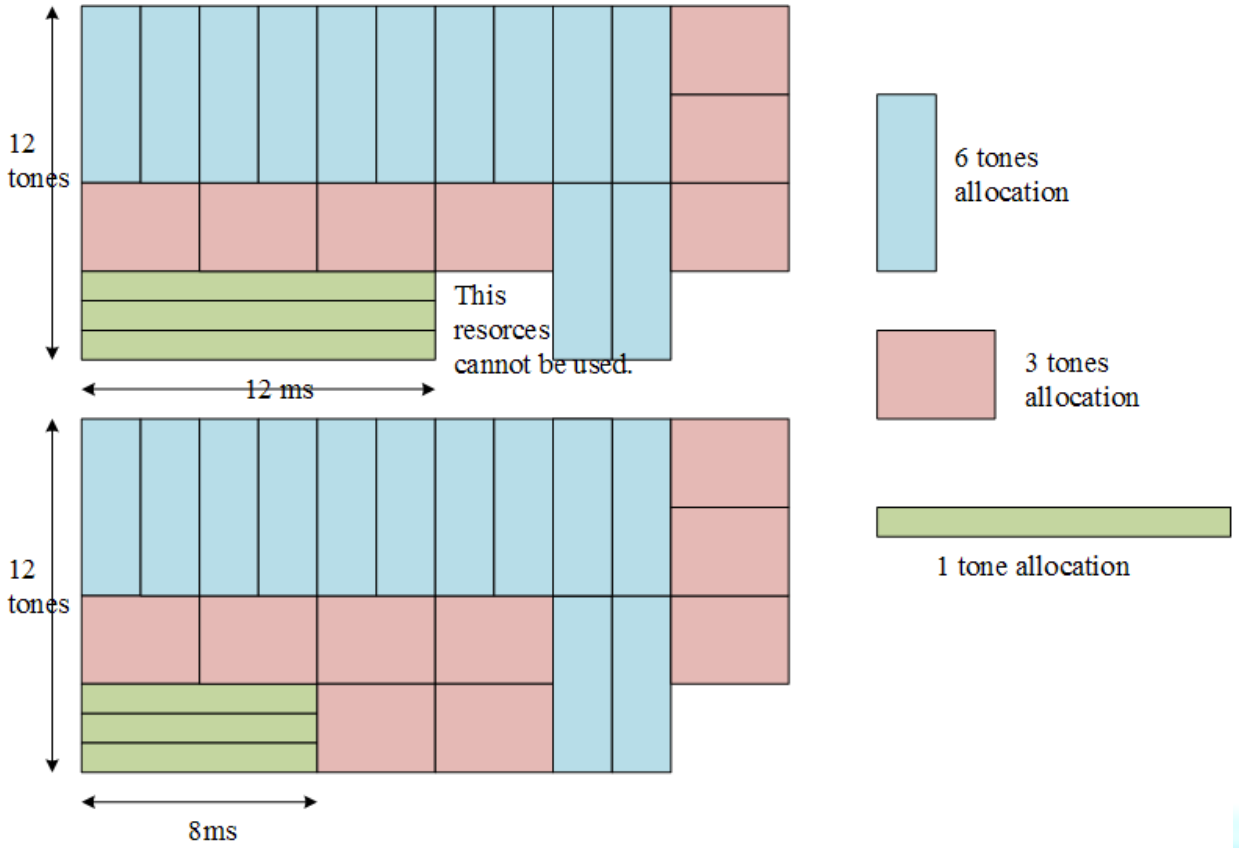
Resource units are used to describe the mapping of the NPUSCH to resource elements. A resource unit is defined as $N_{symb}^{UL} N_{slots}^{UL}$ consecutive SC-FDMA symbols in the time domain and N_{sc}^{RU} consecutive subcarriers in the frequency domain, where N_{sc}^{RU} and N_{symb}^{UL} are given by Table 10.1.2.3-1.

Table 10.1.2.3-1: Supported combinations of N_{sc}^{RU}, N_{slots}^{UL}, and N_{symb}^{UL}.
[TS 36.321]

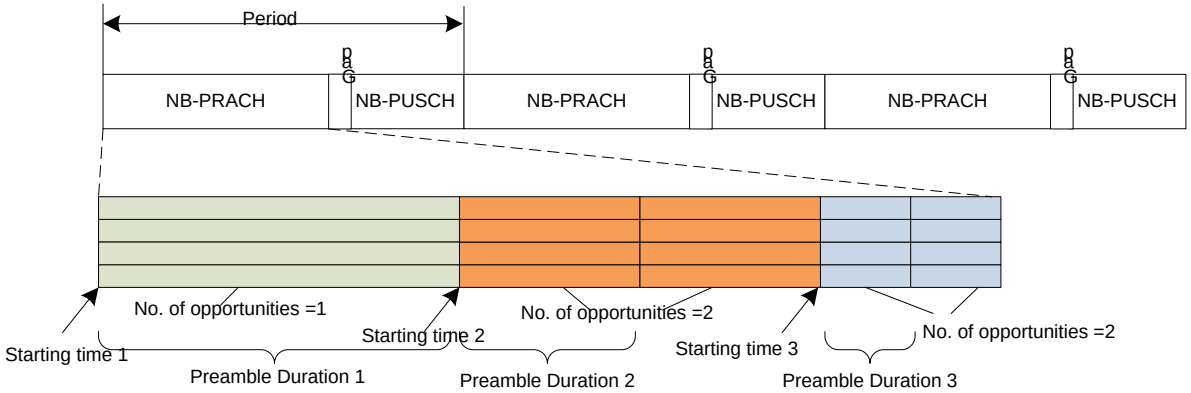
Physical channel	Δf	N_{sc}^{RU}	N_{slots}^{UL}	N_{symb}^{UL}
NPUSCH with UL-SCH data	3.75 kHz	1	16	7
	15 kHz	1	16	
		3	8	
		6	4	
		12	2	
NPUSCH without UL-SCH data	3.75 kHz	1	4	
	15 kHz	1	4	



NPUSCH Resource Unit Size



Time Units (1/2)

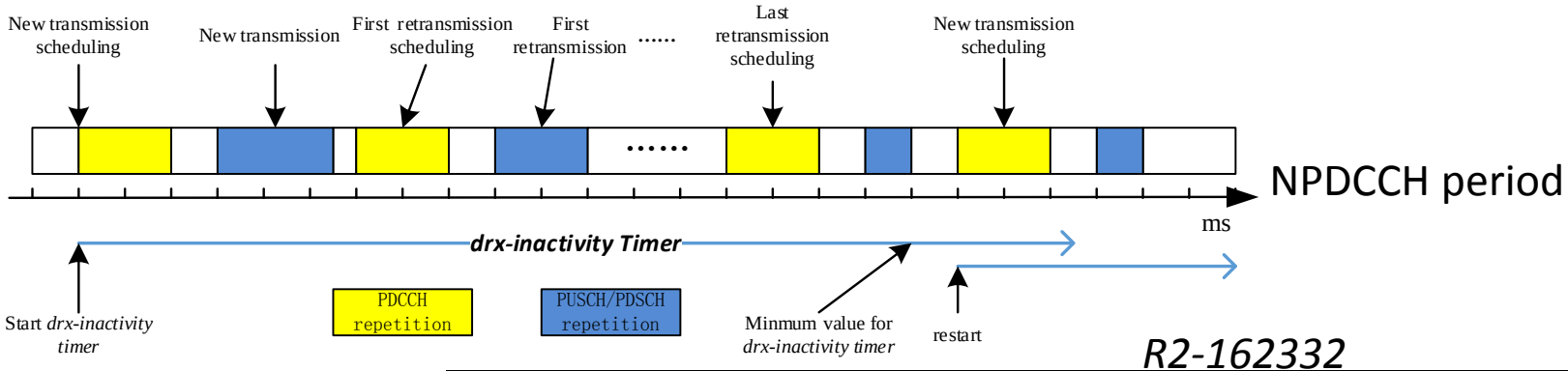


NPRACH period

R1-161812

Parameters	LTE/eMTC	NB-IoT
powerRampingStep	{dB0, dB2,dB4, dB6}	Designed by RAN4
preambleTransMax	{3, 4, 5, 6, 7, 8, 10, 20, 50, 100, 200}	Re-use: {3, 4, 5, 6, 7, 8, 10, 20, 50, 100, 200}
preambleInitialReceivedTargetPower	{dBm-120, dBm-118, dBm-116, dBm-114, dBm-112, dBm-110, dBm-108, dBm-106, dBm-104, dBm-102,dBm-100, dBm-98, dBm-96, dBm-94, dBm-92, dBm-90}	Designed by RAN4
DELTA_PREAMBLE	Defined in 36.321	Designed by RAN4
maxHARQ-Msg3Tx	{1, 2, 3, 4, 5, 6, 7, 8}	Not support because of the asynchronou and adaptive UL HARQ process, as analyzed in [3]
preambleMappingInfoList	Designed by RAN1	Not support
RSRP-ThresholdsPrachInfoList	Mapping to36.133	Designed by RAN4
maxNumPreambleAttemptNPRACH	{3, 4, 5, 6, 7, 8, 10}	Re-use: {3, 4, 5, 6, 7, 8, 10}
nprach-NumRepetitions	{1, 2, 4, 8, 16, 32, 64, 128}	RAN1 agreement: {1, 2, 4, 8, 16, 32, 64, 128}
ra-ResponseWindowSize	LTE: sf {2, 3, 4, 5, 6, 7, 8, 10} eMTC: sf {20, 50, 80, 120, 180, 240, 320, 400}	Using pp instead of sf directly, re-use the value in LTE: pp {2, 3, 4, 5, 6, 7, 8, 10}
mac-ContentionResolutionTimer	LTE: sf {8, 16, 24, 32, 40, 48, 56, 64} eMTC: sf {80, 100, 120, 160, 200, 240, 480, 960}	Using pp instead of sf directly, re-use the value in LTE: pp {8, 16, 24, 32, 40, 48, 56, 64}

Time Units (2/2)



R2-162332

Parameters	Analysis	LTE	NB-IoT
onDurationTimer	Using pp instead of psf directly	psf {1, 2, 3, 4, 5, 6, 8, 10, 20, 30, 40, 50, 60, 80, 100, 200}	pp {1, 2, 3, 4, 5, 6, 8, 10, 20, 30, 40, 50, 60, 80, 100, 200}
drx-InactivityTimer	As analysized in proposal 3 and using pp instead of psf. Remove some big values	psf {1, 2, 3, 4, 5, 6, 8, 10, 20, 30, 40, 50, 60, 80, 100, 200, 300, 500, 750, 1280, 1920, 2560}	pp {1, 2, 3, 4, 5, 6, 8, 10}
drx-RetransmissionTimer	Using pp instead of psf directly	psf {1, 2, 4, 6, 8, 16, 24, 33}	pp {1, 2, 4, 6, 8, 16, 24, 33}
HARQ RTT Timer	Re-use eMTC	8 subframes	Re-use: 8 subframes
longDRX-CycleStartOffset	Using pp instead of sf directly	sf10 INTEGER(0..9), sf20 INTEGER(0..19),	pp 10 INTEGER(0..9), pp 20 INTEGER(0..19),

POSSIBLE ISSUES IN FUTURE RELEASES

System Information Change

Ericsson

Legacy

SystemInformationBlockType1 message

```
-- ASN1START
SystemInformationBlockType1 ::=     SEQUENCE {
    cellAccessRelatedInfo               SEQUENCE {

        plmn-IdentityList               PLMN-IdentityList,
        trackingAreaCode                TrackingAreaCode,
        cellIdentity                    CellIdentity,
        cellBarred                      ENUMERATED {barred, notBarred},
        intraFreqReselection            ENUMERATED {allowed, notAllowed},
        csg-Indication                  BOOLEAN,
        csg-Identity                    CSG-Identity            OPTIONAL    -- N
    },
    cellSelectionInfo                   SEQUENCE {
        q-RxLevMin                      Q-RxLevMin,
        q-RxLevMinOffset                INTEGER (1..8)          OPTIONAL    -- N
    },
    p-Max                               P-Max                   OPTIONAL,
    freqBandIndicator                   FreqBandIndicator,
    schedulingInfoList                  SchedulingInfoList,
    tdd-Config                          TDD-Config              OPTIONAL,   -- C
    si-WindowLength                     ENUMERATED {
                                            ms1, ms2, ms5, ms10, ms15, ms20,
                                            ms40},
    systemInfoValueTag                  INTEGER (0..31),
    nonCriticalExtension                SystemInformationBlockType1-v890-IEs    OPTI
```

Indicates change of SI messages

NB-IoT

SI-specific value tags are fixed to 2 bits as in eMTC

Legacy

Paging message

```
-- ASN1START

Paging ::=                  SEQUENCE {
    pagingRecordList            PagingRecordList                    OPTIC
    systemInfoModification      ENUMERATED {true}                   OPTIC
    etws-Indication             ENUMERATED {true}                   OPTIC
    nonCriticalExtension        Paging-v890-IEs                     OPTIC
}

Paging-v890-IEs ::=         SEQUENCE {
    lateNonCriticalExtension    OCTET STRING                          C
    nonCriticalExtension        Paging-v920-IEs                       C
}

Paging-v920-IEs ::=         SEQUENCE {
    cmas-Indication-r9          ENUMERATED {true}                   OPTIC
    nonCriticalExtension            Paging-v1130-IEs                OPTIC
}

Paging-v1130-IEs ::=          SEQUENCE {
    eab-ParamModification-r11   ENUMERATED {true}                   OPTIC
    nonCriticalExtension        SEQUENCE {}                         OPTIC
}
```

NW notifies the UEs about which MIB/SIB(s) that have changed

"1" in the bitmap indicates upcoming change of system information. First and second positions in bitmap are used to indicate systemInfoModification and systemInfoModification-eDRX respectively. From third position onwards, the bits are used for indicating changes in MIB, SIB1, SIB2, SIB3, SIB4, SIB5. and SIB16

In Paging Msg

Bitmap in SI update notification message (i.e. Paging or DCI)

0	1	0	0	1	0	1	0	0	0

In this example, NW notifies the UEs in eDRX about upcoming changes in SIB2, and SIB4

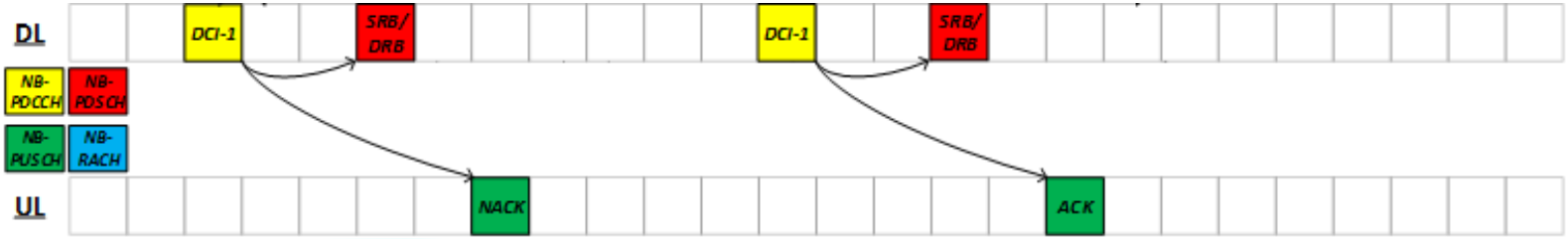
systemInfoModification
systemInfoModification-eDRX
MIB
SIB1
SIB2
SIB3
SIB4
SIB5
SIB16
spare

UE can skip reading some SI, e.g. MIB and SIB1.

PDCCH Monitoring

Ericsson, Huawei, ZTE

- Not be required to monitor the NPDCCH until after the transmission finished for a grant/assignment



R2-160471

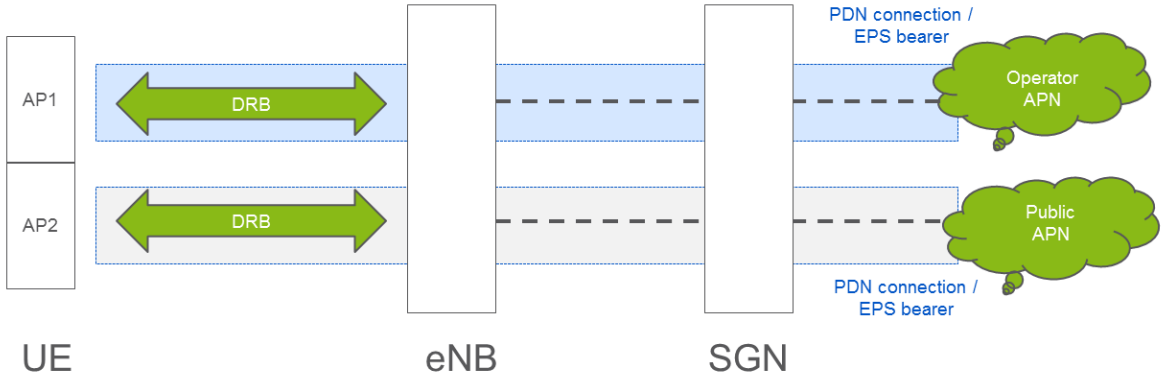
Multiple DRBs in NB-IoT

Ericsson, Vodafone, NTT DOCOMO

In RAN2#91bis it was agreed:

⇒ **NB-IOT devices only support at most 1 DRB.**

- **Different APNs per PDN connection (IP address) / EPS bearer**



- **Different IP version per EPS bearer in case NW does not support dual IPv4/IPv6**

Data transfer mode

Qualcomm

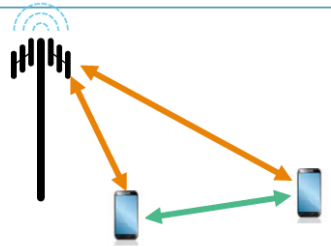
- **NB-IoT UEs will not use / transfer data using solution 2 (Mandatory) and solution 18 (Optional) at the same time.**
- **The selection which solution to be used is done between UE and network on NAS level.**
- **Transfer mode change**
  - Overload control
  - PDCP Operation

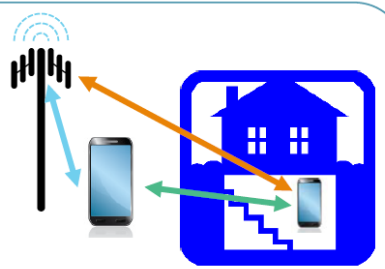
3GPP Rel. 14

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

Use Cases

IoT

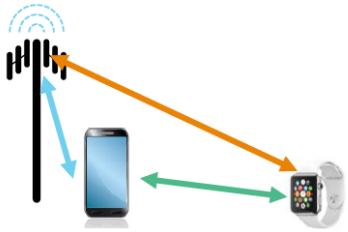




- Single modem solution for proximal and cellular communication
- Operator controlled proximal communication

- 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

THANK YOU