NOKIA

NB-IoT 空闲态过程

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小区选择和重选

NB-IoT与LTE的主要区别如下：

- 不支持系统间测量和重选；
- 小区选择和空闲态测量采用S准则，但不支持$Q_{rxlevminoffset}$ ；
- 不支持基于优先级的重选策略，小区重选仅采用R准则，不支持S准则；
- 不支持基于小区偏置的重选策略，即R准则中不支持$Q_{offsets,n}$；

5.2.3.2a Cell Selection Criterion for NB-IoT

The cell selection criterion S is fulfilled when:

$Srxlev > 0 \ \ AND \ \ Squal > 0$

where:

S准则

$$Srxlev = Q_{rxlevmeas} - Q_{rxlevmin} - Pcompensation - Qoffset_{temp}$$

$$Squal = Q_{qualmeas} - Q_{qualmin} - Qoffset_{temp}$$

where:

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)
Pcompensation	If the UE supports the *additionalPmax* in the *NS-PmaxList-NB*, if present, in SIB1-NB, SIB3-NB and SIB5-NB: $\max(P_{EMAX1} - P_{PowerClass}, 0) - (\min(P_{EMAX2}, P_{PowerClass}) - \min(P_{EMAX1}, P_{PowerClass}))$ (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 [33]. P_{EMAX1} and P_{EMAX2} are obtained from the *p-Max* and the *NS-PmaxList-NB* respectively in SIB1-NB, SIB3-NB and SIB5-NB 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 [33]

5.2.4.6 Intra-frequency and equal priority inter-frequency Ce

The cell-ranking criterion R_s for serving cell and R_n for neighbouring cells is defined b

R准则

$$R_s = Q_{meas,s} + Q_{Hyst} - Qoffset_{temp}$$

$$R_n = Q_{meas,n} - Qoffset - Qoffset_{temp}$$

where:

Q_{meas}	RSRP measurement quantity used in cell reselections.
Qoffset	For intra-frequency: Equals to $Qoffset_{s,n}$, if $Qoffset_{s,n}$ is valid, otherwise this equals to zero. For inter-frequency: Equals to $Qoffset_{s,n}$ plus $Qoffset_{frequency}$, if $Qoffset_{s,n}$ is valid, otherwise and for NB-IoT this equals to $Qoffset_{frequency}$.
$Qoffset_{temp}$	Offset temporarily applied to a cell as specified in [3]

系统消息的调度：MIB-NB

- NB-IoT系统消息包含MIB-NB、SIB1-NB、SIB2-NB、SIB3-NB、SIB4-NB、SIB5-NB、SIB14-NB、SIB15-NB，除SIB1-NB外的SIB块组成SI message，通过NPDSCH信道承载
- MIB-NB承载于NPBCH，传输周期为640ms，被分成8个编码子块（皆可自解码），每个编码子被重复传输8次，扩展到80ms的时间间隔上（即在80ms内的每个子帧#0对应一次传输），Payload大小为34bit，具体格式如下：

MasterInformationBlock-NB

```
-- ASN1START

MasterInformationBlock-NB ::=   SEQUENCE {
    systemFrameNumber-MSB-r13     BIT STRING (SIZE (4)),
    hyperSFN-LSB-r13              BIT STRING (SIZE (2)),
    schedulingInfoSIB1-r13        INTEGER (0..15),
    systemInfoValueTag-r13        INTEGER (0..31),
    ab-Enabled-r13                BOOLEAN,
    operationModeInfo-r13         CHOICE {
        inband-SamePCI-r13            Inband-SamePCI-NB-r13,
        inband-DifferentPCI-r13       Inband-DifferentPCI-NB-r13,
        guardband-r13                 Guardband-NB-r13,
        standalone-r13                Standalone-NB-r13
    },
    spare                         BIT STRING (SIZE (11))
}

ChannelRasterOffset-NB-r13 ::= ENUMERATED {khz-7dot5, khz-2dot5, khz2dot5, khz7dot5}

Guardband-NB-r13 ::=            SEQUENCE {
    rasterOffset-r13                ChannelRasterOffset-NB-r13,
    spare                            BIT STRING (SIZE (3))
}

Inband-SamePCI-NB-r13 ::=       SEQUENCE {
    eutra-CRS-SequenceInfo-r13      INTEGER (0..31)
}

Inband-DifferentPCI-NB-r13 ::=  SEQUENCE {
    eutra-NumCRS-Ports-r13          ENUMERATED {same, four},
    rasterOffset-r13                ChannelRasterOffset-NB-r13,
    spare                           BIT STRING (SIZE (2))
}

Standalone-NB-r13 ::=           SEQUENCE {
    spare                           BIT STRING (SIZE (5))
```

- 指示系统帧号高4位（LTE中为高8位），低6位由MIB-NB编码和辅同步信道携带
- 指示超系统帧号低2位，由于SIB1-NB保持不变的周期为40.96s，因此低2位不适合放在SIB1-NB中
- 指示SIB1-NB的TBS和重复次数
- 指示系统消息是否发生更新
- 接入阻止使能开关，若为True，则需读取SIB14-NB，决定能否发起RRC连接
- 操作模式，4种不同模式下携带参数不同

系统消息的调度：SIB1-NB

- SIB1-NB承载于NPDSCH，传输周期固定为2560ms，重复次数可配置为4、8、16，分别对应每64、32、16个无线帧重复发送一次，SIB1-NB一次重复传输被映射至16个连续无线帧中的8个无线帧的子帧4上完成

***SystemInformationBlockType1-NB* message**

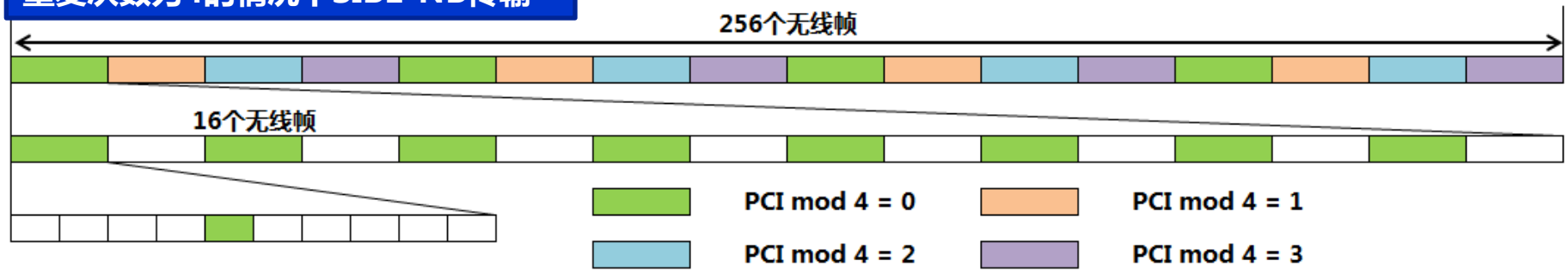
```
-- ASN1START

SystemInformationBlockType1-NB ::=  SEQUENCE {
    hyperSFN-MSB-r13                    BIT STRING (SIZE (8)),
    cellAccessRelatedInfo-r13           SEQUENCE {
        plmn-IdentityList-r13               PLMN-IdentityList-NB-r13,
        trackingAreaCode-r13                TrackingAreaCode,
        cellIdentity-r13                    CellIdentity,
        cellBarred-r13                      ENUMERATED {barred, notBarred},
        intraFreqReselection-r13            ENUMERATED {allowed, notAllowed}
    },
    cellSelectionInfo-r13               SEQUENCE {
        q-RxLevMin-r13                      Q-RxLevMin,
        q-QualMin-r13                       Q-QualMin-r9
    },
    p-Max-r13                           P-Max                       OPTIONAL,   -- Need OP
    freqBandIndicator-r13               FreqBandIndicator-NB-r13,
    freqBandInfo-r13                    NS-PmaxList-NB-r13                  OPTIONAL,   -- Need OR
    multiBandInfoList-r13               MultiBandInfoList-NB-r13            OPTIONAL,   -- Need OR
    downlinkBitmap-r13                  DL-Bitmap-NB-r13                    OPTIONAL,   -- Need OP,
    eutraControlRegionSize-r13          ENUMERATED {n1, n2, n3}             OPTIONAL,   -- Cond inband
    nrs-CRS-PowerOffset-r13             ENUMERATED {dB-6,       dB-4dot77, dB-3,
                                                    dB-1dot77, dB0,       dB1,
                                                    dB1dot23,  dB2,       dB3,
                                                    dB4,       dB4dot23,  dB5,
                                                    dB6,       dB7,       dB8,
                                                    dB9}        OPTIONAL,   -- Cond inband-SamePCI
    schedulingInfoList-r13              SchedulingInfoList-NB-r13,
    si-WindowLength-r13                 ENUMERATED {ms160,  ms320,  ms480,  ms640,
                                                    ms960,  ms1280, ms1600, spare1},
    si-RadioFrameOffset-r13             INTEGER (1..15)     OPTIONAL,   -- Need OP
    systemInfoValueTagList-r13          SystemInfoValueTagList-NB-r13   OPTIONAL,   -- Need OR
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}
```

- 指示超系统帧号高8位
- 指示下行传输的有效子帧，所有有效子帧为S1 message和PDSCH等可使用的子帧，如不配置，则除NPSS、NSSS、NPBCH和SIB1-NB外的所有下行子帧都是有效子帧
- in-band模式下，LTE控制区域大小
- Inband-SamePCI模式下，NB-IoT NRS功率与LTE CRS功率比值
- SI-Window偏置，用于减小相邻小区发送SI-message的时域资源的相互干扰
- 指示每个SI是否发生更新

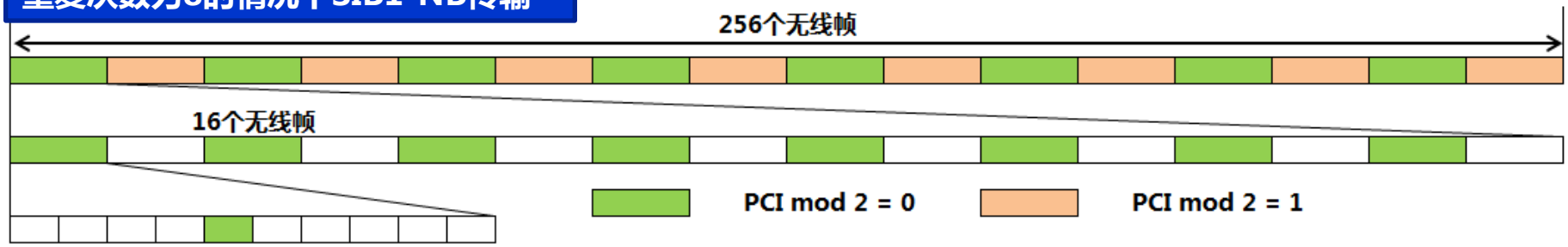
系统消息的调度：SIB1-NB

- 为避免相邻小区SIB1-NB干扰， 在2560ms调度周期中，SIB1-NB无线帧具体位置，与重复次数和PCI有关

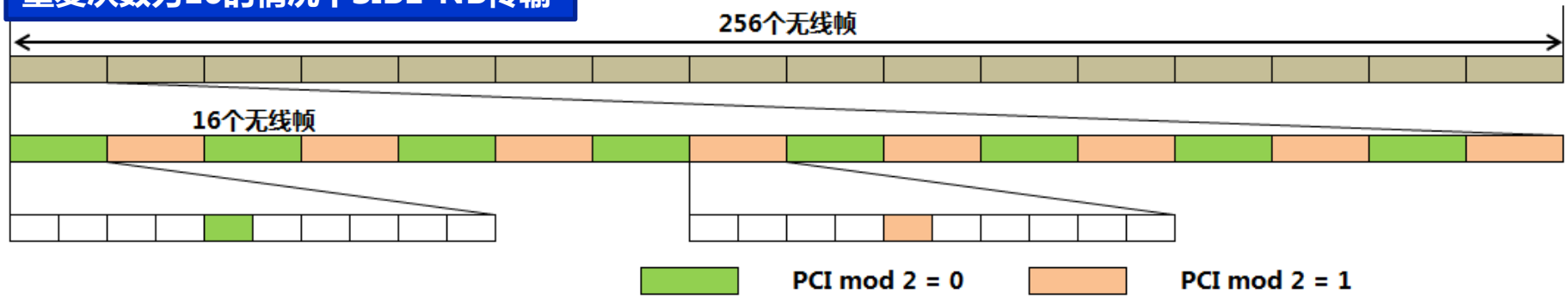
重复次数为4的情况下SIB1-NB传输



重复次数为8的情况下SIB1-NB传输



重复次数为16的情况下SIB1-NB传输



系统消息的调度：SI message

- NB-IoT中多个相同周期性的SIB-NB可组成一个SI message，以SI message为单位进行调度
- 每个SI message都配置SI-Window，不同SI message的SI-Window互不重叠
- 在配置的SI-Window内，SI message 重复模式被定义为每2、4、8、16个无线帧的第一个有效子帧开始发送，连续占用2或8个有效的无线子帧，直至发送一次完整的重复
- SI message的SI-Window的起始位置计算如下：

$$(H\text{-}SFN * 1024 + SFN) \bmod T = FLOOR((n-1)*w/10) + Offset$$

其中：

T= si-Periodicity

Offset= si-RadioFrameOffset

w= si-WindowLength

n=SI message的排列顺序

Table 16.4.1.5.1-1: Transport block size (TBS) table.

I_{TBS}	I_{SF}							
	0	1	2	3	4	5	6	7
0	16	32	56	88	120	152	208	256
1	24	56	88	144	176	208	256	344
2	32	72	144	176	208	256	328	424
3	40	104	176	208	256	328	440	568
4	56	120	208	256	328	408	552	680
5	72	144	224	328	424	504	680	
6	88	176	256	392	504	600		
7	104	224	328	472	584	680		
8	120	256	392	536	680			
9	136	296	456	616				
10	144	328	504	680				
11	176	376	584					
12	208	440	680					

***SystemInformationBlockType1-NB* message**

```
-- ASN1START
...
    schedulingInfoList-r13              SchedulingInfoList-NB-r13,
    si-WindowLength-r13                 ENUMERATED {ms160,  ms320,  ms480,  ms640,
                                                    ms960,  ms1280, ms1600, spare1},
    si-RadioFrameOffset-r13             INTEGER (1..15)     OPTIONAL,    -- Need OP
    systemInfoValueTagList-r13          SystemInfoValueTagList-NB-r13   OPTIONAL,    -- Need OR
...
SchedulingInfoList-NB-r13 ::= SEQUENCE (SIZE (1..maxSI-Message-NB-r13)) OF SchedulingInfo-NB-r13

SchedulingInfo-NB-r13::=        SEQUENCE {
    si-Periodicity-r13              ENUMERATED {rf64, rf128, rf256, rf512,
                                                rf1024, rf2048, rf4096, spare},
    si-RepetitionPattern-r13        ENUMERATED {every2ndRF, every4thRF,
                                                every8thRF,  every16thRF},
    sib-MappingInfo-r13             SIB-MappingInfo-NB-r13,
    si-TB-r13           ENUMERATED {b56, b120, b208, b256, b328, b440, b552, b680}
}

SystemInfoValueTagList-NB-r13 ::=   SEQUENCE (SIZE (1.. maxSI-Message-NB-r13)) OF
                                        SystemInfoValueTagSI-r13

SIB-MappingInfo-NB-r13 ::=          SEQUENCE (SIZE (0..maxSIB-1)) OF SIB-Type-NB-r13

SIB-Type-NB-r13 ::=                 ENUMERATED {
                                        sibType3-NB-r13, sibType4-NB-r13, sibType5-NB-r13,
                                        sibType14-NB-r13, sibType16-NB-r13, spare3, spare2, spare1}
```

系统消息的调度：有效性与更新通知

- NB-IoT系统消息的有效时间为24h（LTE为3h）
- NB-IoT系统消息只能在其修改周期的边界发生变更，当网络更新了系统消息，首先通过PAGING或DCI Format N2通知UE系统消息的更新
- 与LTE不同，由于NB-IoT引入eDRX，eDRX周期可能大于修改周期，因此更新机制略有不同
  - 当eDRX周期小于修改周期，收到systemInfoModification的UE，在“(H-SFN * 1024 + SFN) mod m=0”（m为修改周期，即*modificationPeriodCoeff * defaultPagingCycle*）处开始接收更新的系统消息
  - 当eDRX周期大于或等于修改周期，收到systemInfoModification-eDRX的UE，在“H-SFN mod 1024 =0”处开始接收更新的系统消息

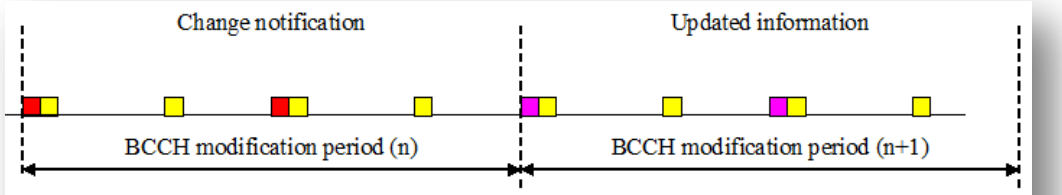


Figure 5.2.1.3-1: Change of system Information

***Paging-NB* message**

```
-- ASN1START

Paging-NB ::=                       SEQUENCE {
    pagingRecordList-r13                PagingRecordList-NB-r13         OPTIONAL,   -- Need ON
    systemInfoModification-r13          ENUMERATED {true}               OPTIONAL,   -- Need ON
    systemInfoModification-eDRX-r13     ENUMERATED {true}               OPTIONAL,   -- Need ON
    nonCriticalExtension                SEQUENCE {}                     OPTIONAL
}

PagingRecordList-NB-r13 ::=         SEQUENCE (SIZE (1..maxPageRec)) OF PagingRecord-NB-r13

PagingRecord-NB-r13 ::=             SEQUENCE {
    ue-Identity-r13                     PagingUE-Identity,
    ...
}

-- ASN1STOP
```

***Paging-NB* field descriptions**
systemInfoModification If present: indication of a BCCH modification other than for *SystemInformationBlockType14-NB* (SIB14-NB) and *SystemInformationBlockType16-NB* (SIB16-NB). This indication does not apply to UEs using eDRX cycle longer than the BCCH modification period.
systemInfoModification-eDRX If present: indication of a BCCH modification other than for *SystemInformationBlockType14-NB* (SIB14-NB) and *SystemInformationBlockType16-NB* (SIB16-NB). This indication applies only to UEs using eDRX cycle longer than the BCCH modification period.

6.7.5 Direct Indication Information

Direct Indication information is transmitted on NPDCCH using P-RNTI but without associated *Paging-NB* message. Table 6.7.5-1 defines the Direct Indication information, see TS 36.212 [22, 6.4.3.3].

When bit n is set to 1, the UE shall behave as if the corresponding field is set in the *Paging-NB* message, see 5.3.2.3. Bit 1 is the least significant bit.

Table 6.7.5-1: Direct Indication information

Bit	Field in *Direct Indication information*
1	*systemInfoModification*
2	*systemInfoModification-eDRX*
3, 4, 5, 6, 7, 8	Not used, and shall be ignored by UE if received

PAGING/DRX/eDRX

NB-IoT寻呼机制与LTE不同：

① 用户面优化方案中，UE CONTEXT SUSPEND REQUEST（ENB->MME）会携带推荐小区及基站信息、小区识别及覆盖增强等级信息，用于后续的寻呼优化处理

② 默认DRX IE用于指示小区级默认DRX周期

参数传递：

1、SystemInformationBlockType2-NB（ENB->UE）；

2、S1 SETUP REQUEST（ENB->MME）；

3、ENB CONFIGURATION UPDATE（ENB->MME）；

① eDRX IE用于指示用户级eDRX寻呼周期和寻呼传输窗，DRX周期扩展至将近3小时，详细机制见36.304-7.1、23.401-5.13a节，本文不赘述

参数传递：

1、ATTACH/TAU REQUEST（UE->MME）

2、ATTACH/TAU ACCEPT（MME->UE）

3、PAGING（MME->ENB）；

9.2.1.105 Information on Recommended Cells and eNBs for Paging

This IE provides information on recommended cells and eNBs for paging.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Recommended Cells for Paging	M		9.2.1.106	
Recommended eNBs for Paging	M		9.2.1.107	

9.2.1.109 Cell Identifier and Coverage Enhancement Level

This IE provides information for paging CE capable UEs.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Global Cell ID	M		E-UTRAN CGI 9.2.1.38	
Coverage Enhancement Level	M		OCTET STRING	Includes either the *UEPagingCoverageInformation* message as defined in 10.2.2 of TS 36.331 [16], or the *UEPagingCoverageInformation-NB* message as defined in 10.6.2 of TS 36.331 [16].

9.2.1.114 NB-IoT Default Paging DRX

This IE indicates the NB-IoT Default Paging DRX as defined in TS 36.304 [20].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
NB-IoT Default Paging DRX	M		ENUMERATED(128, 256, 512, 1024, …)	Unit: [number of radioframes]

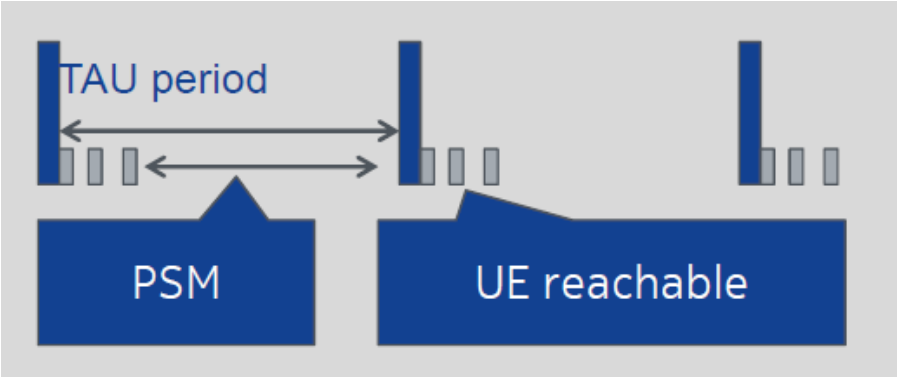
9.2.1.115 NB-IoT Paging eDRX Information

This IE indicates the NB-IoT Paging eDRX parameters as defined in TS 36.304 [20].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
NB-IoT Paging eDRX Cycle	M		ENUMERATED (hf2, hf4, hf6, hf8, hf10, hf12, hf14, hf16, hf32, hf64, hf128, hf256, hf512, hf1024, …)	T_{eDRX} defined in TS 36.304 [20]. Unit: [number of hyperframes].
NB-IoT Paging Time Window	O		ENUMERATED (s1, s2, s3, s4, s5, s6, s7, s8, s9, s10, s11, s12, s13, s14, s15, s16, …)	Unit: [2.56 seconds]

PSM（Power Saving Mode）

- 终端应用PSM功能满足其节电需求，该模式近似于关机，但保留注册状态，因此不需要触发重附着或PDN重建立流程，机制如下：
  - UE和MME通过ATTACH/TAU流程实现T3324和T3412同步
  - T3324 value：终端在ATTACH/TAU ACCEPT消息中收到该定时器时， T3324启动，正常监听寻呼信道； T3324超时，进入PSM状态，但T3412仍处于活动中，取值范围2秒～32小时
  - T3412 extended value： T3412超时，终端发起周期性TAU流程，取值范围10分钟～约427天



T3324 value

Table 10.5.172/3GPP TS 24.008: GPRS *Timer* information element

Timer value (octet 2)

Bits 5 to 1 represent the binary coded timer value.

Bits 6 to 8 defines the timer value unit for the GPRS timer as follows:
Bits
8 7 6
0 0 0 value is incremented in multiples of 2 seconds
0 0 1 value is incremented in multiples of 1 minute
0 1 0 value is incremented in multiples of decihours
1 1 1 value indicates that the timer is deactivated.

Other values shall be interpreted as multiples of 1 minute in this version of the protocol.

T3412 extended value

Table 10.5.163a/3GPP TS 24.008: GPRS *Timer 3* information element

GPRS Timer 3 value (octet 3)

Bits 5 to 1 represent the binary coded timer value.

Bits 6 to 8 defines the timer value unit for the GPRS timer as follows:
Bits
8 7 6
0 0 0 value is incremented in multiples of 10 minutes
0 0 1 value is incremented in multiples of 1 hour
0 1 0 value is incremented in multiples of 10 hours
0 1 1 value is incremented in multiples of 2 seconds
1 0 0 value is incremented in multiples of 30 seconds
1 0 1 value is incremented in multiples of 1 minute
1 1 0 value is incremented in multiples of 320 hours (NOTE)
1 1 1 value indicates that the timer is deactivated.

NOTE: This timer value unit is only applicable to the T3312 extended value IE and T3412 extended value IE (see 3GPP TS 24.301 [120]). If it is received in an integrity protected message, value shall be interpreted as multiples of 320 hours. Otherwise value shall be interpreted as multiples of 1 hour.