TSG-RAN Working Group 2 (Radio layer 2 and Radio layer 3) **TSGR2#6(99)853**
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Title: Description of DRX for TDD

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1. Introduction

The use of discontinuous reception in UMTS is an important feature to reduce battery consumption in PCH state. This paper discusses the DRX concept for TDD. The goal of the DRX concept is to provide a high flexibility for configuration of battery lifetime, call setup delay, and usage of air interface resources.

2. Definitions

The following definitions from 25.304 are used in this contribution:

Initial paging information: This information indicates if the UE need to continue to read more page information and eventually receive a page message.

Paging occasions: The time instances where it is possible to receive initial page information.

DRX cycle: The individual time interval between reading initial page information for a specific UE.

3. Discussion

A detailed DRX concept, which is based on the use of the PICH as an addition to the PCH, has recently been presented for the FDD mode. A similar approach is presented here for TDD. In the RAN WG1, the use of a PICH for TDD was already approved. This PICH has different characteristics from the FDD PICH, and therefore different handling in the higher layers is needed.
The PICH of TDD requires a complete resource unit for transmission. However, that much capacity is not needed in all frames for transmission of paging indicators.
In TDD, the time component is used to use one resource unit (one code in one timeslot) for different physical channels in different frames of the 72-frame superframe. In the case of common channels, a physical channel carrying the BCH, a second physical channel carrying PCH and FACH, and a third physical channel (PICH), carrying the Paging Indicators can share one resource unit.

3.1 Paging Blocks

With this time division, one PICH transmission can indicate the presence of Paging Messages in a number of following PCH frames. The combination of one PICH transmission (over 2 or more frames) and all PCH transissions until the next PICH transmission, is called a Paging Block. An example of a Paging Block is given in the following figure.

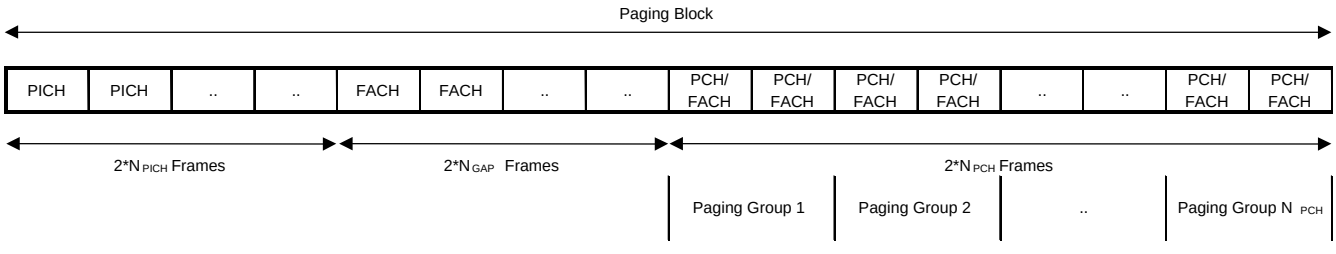

Figure 1 Example configuration of a Paging Block

The Paging Block always starts with the transmission of $2*N_{PICH}$ PICH frames. These frames are independently decodable and the

PI information is not interleaved over more than one frame. Therefore only decoding of one PICH burst is necessary for the UE to decode its corresponding Paging Indicator.
After the PICH frames, $2*N_{GAP}$ frames without PCH transmissions follow. These frames allow a sufficient processing delay for the decoding of PICH bursts, before PCH data has to be received. In theses frames, FACH or BCH data can be transmitted.

3.2 Paging Groups

The PCH transmissions of one Paging Block are divided in N_{PCH} Paging Groups. Each Paging Group has a length of 2 frames, over which the PCH transport blocks are interleaved.
All UEs are distributed equally to the different paging groups, depending on the IMSI of the UE. This can be done in a smilar way as described in section 4.1 for the Paging Occasions.

3.3 Paging Occasions and Paging Indicators

In the DRX concept of FDD, one Paging Occasion corresponds to the transmission of one Paging Indicator. This results in several Paging Occasions per frame. In TDD, the situation is different. One Paging Occasion in TDD corresponds to one Paging Block. Paging Occasions therefore occur only once for a number of frames.
The second difference is the number of Paging Indicators per Paging Occasion. In TDD, a large number of Paging Indicators can be transmitted for one Paging Occasion. The mapping of UEs to Paging Indicators can be derived from the IMSI of the UE and the number of Paging Indicators with a similar algorithm as described in section 4.1 for the Paging Occasions.

4 DRX cycles in TDD

The Paging Blocks are transmitted periodically, at least once per 72 frame superframe. The following figure shows an example configuration with three Paging Blocks per 72 frame superframe, i.e. one Paging Block every 24 frames.

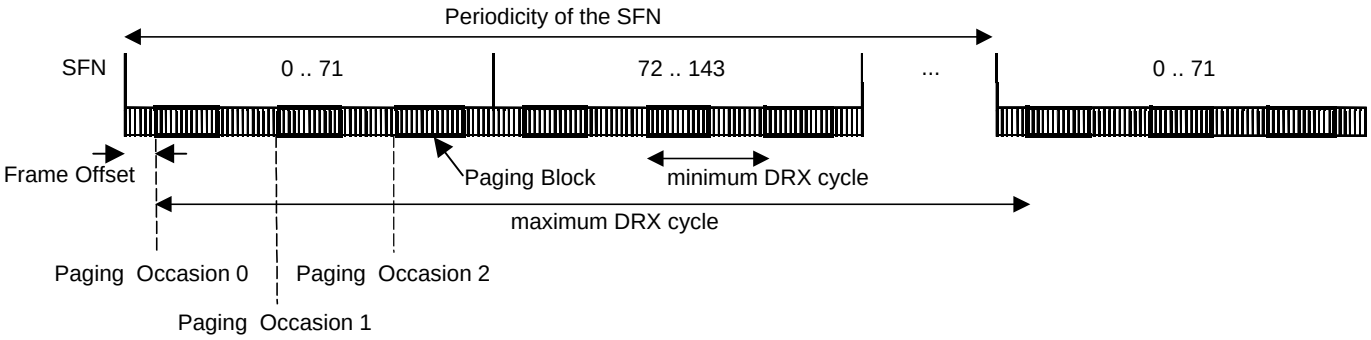

Figure 2 Example configuration of the PCH structure for TDD

In this figure, the minimum DRX cycle, which is equal to the periodicity of the paging blocks, and the maximum DRX cycle, which is depending on the periodicity of the Cell System Frame Number (SFN) are shown.

4.1 Example of DRX cycles

This example of the usage of the DRX concept is the same as presented for FDD in [1]. Paging Occasions are Paging Blocks in case of TDD. For one Paging Occasion, a number of Paging Indicators are transmitted. The UE only has to decode the Paging Indicator that it is valid for it.

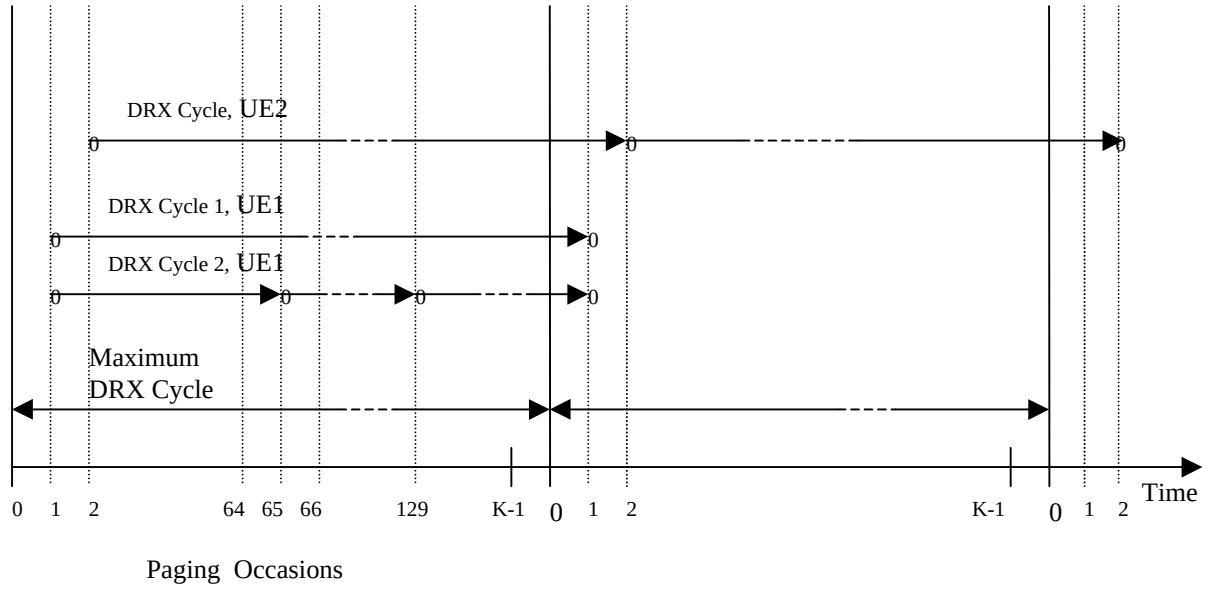

Figure 3 Example of DRX cycles for two UEs

Because Paging Occasions are not available every frame, the DRX cycles have to be based on the "Minimum DRX cycle" which equals the periodicity of the Paging Occasions. To calculate the frame numbers, in which such Paging Occasions, i.e. Paging Blocks, commence, this parameter and the parameter "Frame Offset" (offset of the first Paging Block in the 72 frame superframe) have to be taken into account. The UE shall use the IMSI to determine the UE specific time offset for a specific DRX cycle length. The Paging Occasions occur at the frame numbers:

$$\text{Cell SFN} = \left((\text{IMSI mod M}) \bmod \left(\frac{\text{DRX cycle length}}{\text{Minimum DRX cycle length}} \right) \right) * \text{Minimum DRX cycle length} + \text{Frame Offset}$$

where M is a constant used to simplify the calculations (FFS). M will depend on the coding used for IMSI. M must be significantly greater than the maximum possible DRX cycle length.

The "0" used in the figure indicates the paging occasions, where the UE reads initial paging information. This is done by decoding the correct PICH frame of a Paging Block.
If the initial paging information indicates a paging message for the UE, the next PCH transport block of the Paging Group of that UE is decoded.

5 Proposal

The text in Section 8 of TS25.304 should be changed according to the following text proposal to harmonize the description of FDD and TDD Discontinuous Reception:

The UE may use Discontinuous Reception (DRX) in idle mode in order to save power consumption. When DRX is used the UE needs only to receive at one paging occasion per DRX cycle.

~~The DRX cycle length shall be 2^k frames, where k is an integer.~~

The UE may be attached to different CN domains with different DRX cycle lengths. In this case, the UE shall use the shortest of those DRX cycle lengths. The DRX cycle lengths for each CN domain are broadcast in UTRAN cells. An UE may also be assigned an individual DRX cycle length by a CN.

For FDD, the Paging Occasions are calculated according to the following scheme:

The DRX cycle length shall be 2^k frames, where k is an integer.

The UE shall use the IMSI, the Cell System Frame Number and the DRX cycle length to determine the Paging Occasions. The Paging Occasions occur at the frame numbers:

Cell SFN = (IMSI mod M) mod (DRX cycle length)

where M is a constant used to simplify the calculations (FFS). M will depend on the coding used for IMSI. M must be significantly greater than the maximum possible DRX cycle length.

The actual Paging Indicator within the frame that the UE shall read is similarly determined based on IMSI. The same applies for the PICH in case more than one exists.

For TDD, the Paging Occasions are calculated according to this scheme:

The DRX cycle length shall be (2^k * Minimum DRX cycle) frames, where k is an integer.

The UE may be attached to different CN domains with different DRX cycle lengths. In this case, the UE shall use the shortest of those DRX cycle lengths. The DRX cycle lengths for each CN domain are broadcast in UTRAN cells. An UE may also be assigned an individual DRX cycle length by a CN.

The UE shall use the IMSI, the Cell System Frame Number and the DRX cycle length to determine the Paging Occasions. The Paging Occasions occur at the frame numbers:

$$\text{Cell SFN} = \left((\text{IMSI mod M}) \bmod \left(\frac{\text{DRX cycle length}}{\text{Minimum DRX cycle length}} \right) \right) * \text{Minimum DRX cycle length} + \text{Frame Offset}$$

where M is a constant used to simplify the calculations (FFS). M will depend on the coding used for IMSI. M must be significantly greater than the maximum possible DRX cycle length.

6 References

[1] 3GPP TSGR2#4(99)413, Discontinuous Reception in Idle and Connected mode, Source: Ericsson
[2] 3GPP TSGR2#5(99)590, Description of DRX, Source: Ericcson