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Agenda Item:

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Title: **Paging channel configuration for improving the UE standby time in FDD**

Document for: Discussion

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1. Introduction

The standby time of a UE is an important design factor. It is also critical to the success of a commercial radio communications system and terminal products. Long standby times can be achieved by having both a low duty-cycle for the activities and having a low current consumption during the sleep mode.
During the sleep mode the UE is idle for most of the time. However, there are two tasks that a UE has to wake up to perform:
(1) Reading the paging messages transmitted in the paging channel (PCH) and
(2) Monitoring the neighboring base-stations.
Reading the paging message is necessary for a UE to receive a mobile station terminated call. Monitoring neighboring base-stations allows a UE to maintain synchronization and connection to the network. Thereby it can be paged or initiate a UE originated call even when it moves across cell boundaries. Each time when the UE wake up, it has to re-tune the synthesizer, refine the frequency and timing errors, open the receive RF chain, and perform baseband signal processing. The current consumption of the baseband signal processing is much less than that of the RF functions. Thus, it would be advantageous if a system allows a UE to perform all the idle mode activities simultaneously when it wakes up.

2. Structure of Paging Indicator Channel

The Paging Channel (PCH) described in [1] is transmitted on the Secondary Common Control Physical Channel. Here N paging indicators are transmitted every frame where N is between 18 and 144.
Each UE must read a specific paging indicator which is transmitted with a certain periodicity given by the **Paging occasion** which is the frame the UE shall monitor and by the **PICH Monitoring occasion,** which is the time instance where the UE monitors PICH within the Paging Occasion. When PI=1 the UE must read a paging message transmitted after the paging indicator.

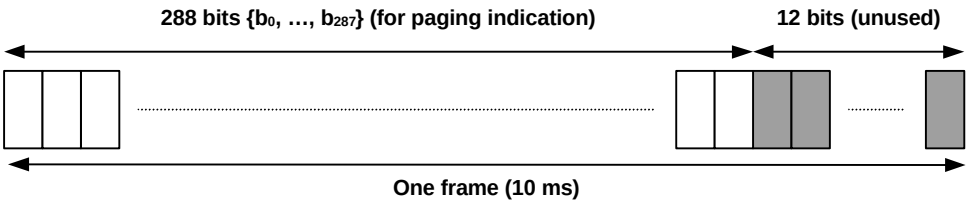

Figure 1: Structure of Page Indicator Channel (PICH)

Table 1: Mapping of Page Indicators (PI) to PICH bits

Number of PI per frame (N)	$PI_i = 1$	$PI_i = 0$
N=18	$\{b_{16i}, \ldots, b_{16i+15}\} = \{1,1,\ldots,1\}$	$\{b_{16i}, \ldots, b_{16i+15}\} = \{0,0,\ldots,0\}$
N=36	$\{b_{8i+}, \ldots, b_{8i+7}\} = \{1,1,\ldots,1\}$	$\{b_{8i}, \ldots, b_{8i+7}\} = \{0,0,\ldots,0\}$
N=72	$\{b_{4i}, \ldots, b_{4i+3}\} = \{1, 1,\ldots,1\}$	$\{b_{4i}, \ldots, b_{4i+3}\} = \{0, 0,\ldots,0\}$
N=144	$\{b_{2i}, \ldots, b_{2i+1}\} = \{1,1\}$	$\{b_{2i}, \ldots, b_{2i+1}\} = \{0,0\}$

3. Neighboring BS measurement

A UE is required to, during sleep mode, maintain as good connection as possible to the network. Thereby, when a traffic channel shall be established, initiated either by the UE or by the network, the transmitted power is minimized to decrease the interference to other users when it comes out of the sleep mode. Hence, neighboring BS monitoring is necessary for a UE in the sleep mode. For an asynchronous system, monitoring a neighbor requires steps of synchronization, BS identification, and SIR measurement.
Synchronization with a BS further requires steps of slot synchronization and frame synchronization, whereas BS identification further consists of steps of scrambling code group identification, scrambling code identification, and sector identification. For frame synchronization and scrambling code group identification, it is advantageous for a UE to receive all of the 16 slots of a frame. This is because a length 16 frame timing sequence is used to encode the secondary synchronization code (SSC) to facilitate frame boundary detections and scrambling code group identification.

4. Sliding Paging Channel

Assume that the paging indicator is transmitted on a constant **PICH Monitor occasion,** the same position within a frame. Then from the previous two Sections, one can realize that when the UE wakes up to read the PICH information, it is not possible for a UE to receive the SSC from all the 15 different timeslots .
Therefore, a UE has to wake up at times other than its paging slots to perform neighboring cells monitoring. This is however not desirable, as it increases the standby current and power consumption, leading to a reduction in standby time.
A simple way for solving this problem is to modify the **PICH Monitor occasion** to allow the paging indicator to slide through the time intervals when a UE wakes up to read the paging indicator. Thereby, after a number of paging indicators all 15 SSC symbols are read.
Since it might be necessary to get the estimate of the channel impulse response for demodulating paging signal, it is very likely that a UE will stay awake for more than 8 symbols, which is the maximum length of a PI as shown in Table 1 when it wakes up. Therefore the sliding can e.g. be 16 or 24 symbols every paging occasion.

5. Conclusions

The sliding paging indicator is better than a paging indicator transmitted on the same position within a frame for all Paging occasions.

References

[1].TS 25.211, Physical channels and mapping of transport channels onto physical channels (FDD)