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Agenda Item:

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Title: Proposal for a modified PCH structure

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Summary

We propose a new physical channel structure for paging that is more efficient than the current structure in terms of DL code and power usage. Furthermore, it allows for greater flexibility in terms of paging payload. The new structure is split into a Paging Flag part and a Paging Message part, transmitted on two separate physical channels. The Paging Flag is time-multiplexed with the Acquisition Indicator Flag on what is presently called AICH, and the Paging Message is proposed to be incorporated into the FACH.

1 Introduction

The Paging Channel (PCH) of UTRA/FDD is mapped to an SF=64 S-CCPCH (according to ARIB Vol.3), onto which paging flags and paging messages are time-multiplexed in a rather intricate manner [1]. While the sleep mode properties of this structure are very good, the structure is somewhat inefficient in terms of DL power usage. This is due to the fact that the duty-cycle is typically very low, while the peak power is rather high. Furthermore, the structure does not allow paging messages to share the same immediate code-resource (sub-tree) as other messages with similar properties and requirements. This reduces the efficiency of the overall power and code-resource utilisation.
Another drawback of the current 3GPP PCH is its limited flexibility. It is anticipated that paging messages may be of varying sizes. It is not obvious that the current scheme supports this in a good way.

2 Proposed new paging channel structure

We propose that paging makes use of two physical channels instead of only one physical channel, which is currently the case. The first physical channel ("Paging Flag Channel") is used to carry the <u>paging flags</u> while the second physical channel ("Paging Message Channel") is used to carry the <u>paging messages</u>, see Figure 1.

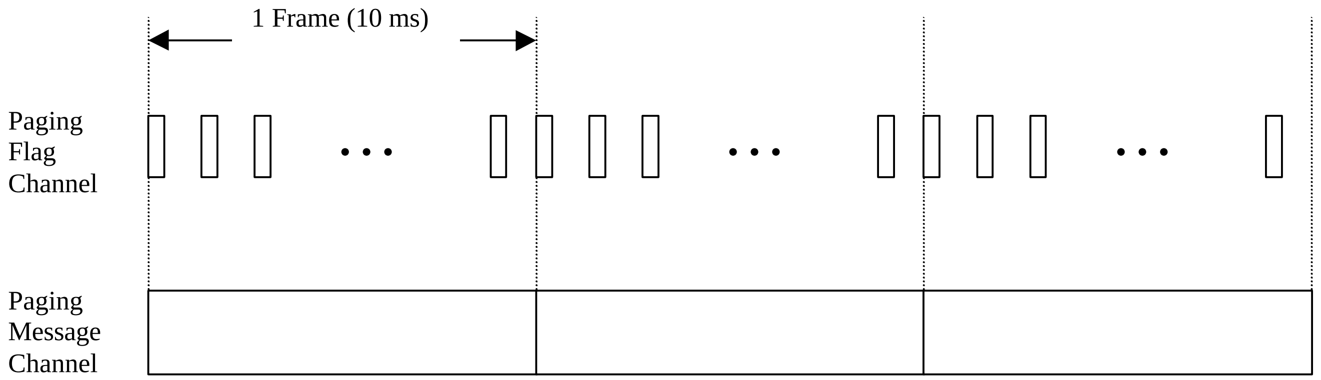

Figure 1 New PCH structure

The Paging Flag (PF) indicates to an UE that there may be a paging message intended for it. They thus serve exactly the same function as the PI part of the current paging channel. For good PF detection reliability, each flag is repeated once, as in the current 3GPP PCH proposal. An UE monitors its PFs, and if determined to be "on", it reads the paging message that follows on the paging message channel, a predetermined time after the PFs.

3 The Paging Flag

We propose that the paging flags are transmitted time multiplexed with the Acquisition Indicator Flag (AIF). Due to processing-time requirements, the AIF is discontinuous, with guard times in-between consecutive AIFs, see [1]. Clearly, since the PF does not have the same roundtrip-timing requirements, the guard times surrounding the AIFs could be filled with PFs. By doing this, the paging flags can be transmitted with virtually zero cost in terms of Node B power budget impact and DL channelisation code usage, see Figure 2.

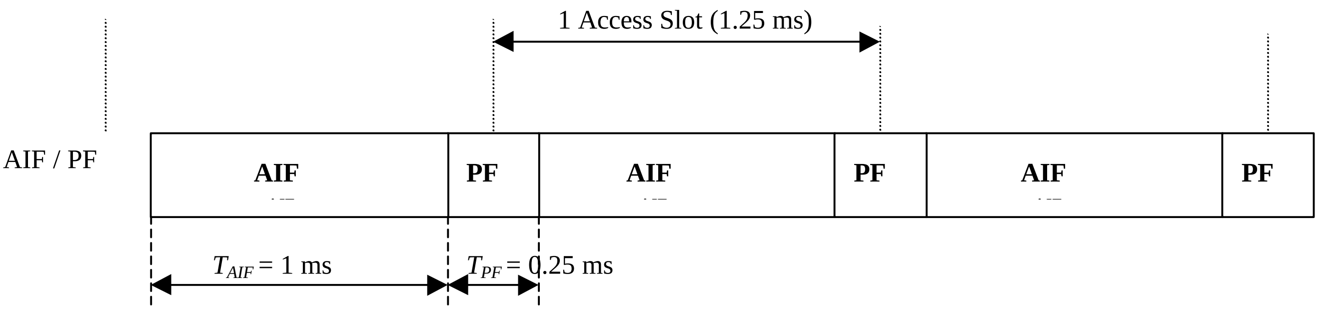

Figure 2 PF/AIF Multiplexing

With 8 Access Slots per 10 ms, there will be 8 PFs per 10 ms. In order to reduce the false detection probability of the PF, repetition encoding should be used. In the current 3GPP PCH proposal, the PF is repeated once after 2.5 ms [1]. It may be advantageous to make this time longer in order to improve the performance in slower fading. For example, the repetition time could be in the order of one or more 10 ms frames.

4 The Paging Message

The paging message is a control message requiring in-band identification of the UE. As such, there is no principal difference as compared to any other L3 control message sent on a common TrCH, e.g. an "Access Grant" message. Therefore, we propose that the paging message is sent on the FACH. This will lead to a more efficient use of the code resource, due to trunking effects. Furthermore, the flexibility in terms of payload will increase significantly as compared with the present 3GPP PCH structure.

Obviously, there needs to be a predetermined time between the PF(s) and the paging message. Figure 3 shows the principle, where the shaded areas are a paging message and its corresponding PFs.

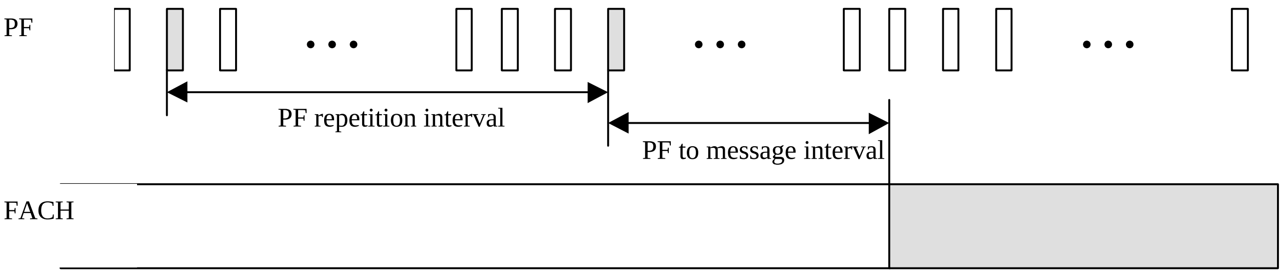

Figure 3 Paging message timing

5 Concept proposal

Assume that we have 2M PFs during what we call a "paging interval", I_P=Nx10ms, (N=1,2…). . This represents M PFs that are all repeated once. When a PF among the first group of M PFs is "on", then the corresponding PF among the second group of M PFs is also "on" and vice-versa.
In order to achieve a good time-diversity for the repetition encoding of the PF, the second group of M PFs may be displaced from the first group by a certain time-distance T_1=LxI_P, (L=0,1,…) after the paging interval containing the first PF.
The actual message then follows a certain time T_2=KxI_P , (K=1,2,…), after the paging interval containing the second PF, and is transmitted during a time-interval of I_P. Figure 4 shows this in detail, where the second group of M PFs in each paging interval PF are dashed.

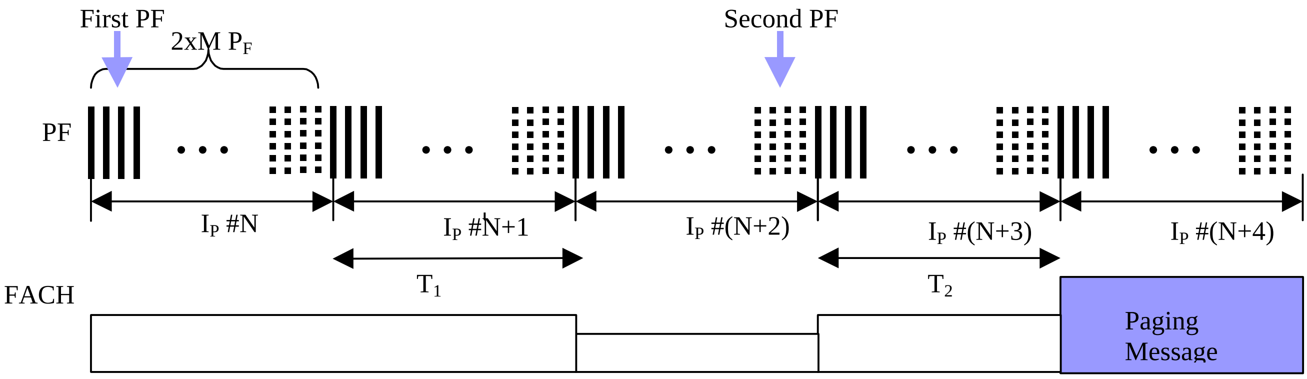

Figure 4 Detailed concept

6 Discussion on parameter choices

It is clear that a large I_P gives a better time diversity gain for the message part. Furthermore, since there will be more PFs contained within the interval I_P, it also reduces the probability of unnecessary paging message reading.
On the other hand, a large I_P leads to a slower overall paging process and a longer minimum sleep-mode cycle. It also leads to processing time for the UE receiver whenever it has to do an unnecessary paging message reading.

A large value of T_1 increases the time-diversity gain for the PF detection, but on the other hand it also gives a slower overall paging process and a longer minimum sleep-mode cycle. A large value of T_2 does not affect the time-diversity, but may lead to easier scheduling of messages onto FACH. Clearly it has to be at least 1x I_P, in order not to inflict harsh timing requirements on the UE.

Clearly, the selection of these parameters is a trade-off between link-performance (indirectly affecting DL capacity), paging process speed, ease of scheduling, and last but not least UE standby time.

7 Discussion on paging message payload requirements

Either only one message is sent at a time (i.e during Ip), or multiple messages may be multiplexed. In the former case, only one of the M PFs may be “on” in a given paging interval, Ip, while in the latter case, multiple PFs may be “on”.
If the messages are mapped to FACH at e.g. SF=64, i.e. a gross channel bit rate of 128 kb/s, there is roughly 300 bits/10 ms (600 bits/20 ms, 1200 bits/40 ms etc.) for the paging message, assuming R=1/3 channel coding.
Since the paging message sizes are expected to vary much in size, it is clear that there is a possibility to multiplex several messages onto the FACH. If that is done, then whenever there is less than the maximum number of simultaneous messages, DTX may be used.

There are indications that the paging message will contain a header part of less than 16 bits, and then an address field. The address filed could be anything from 20 bits for a CRNTI, 48 bits for a SRNCID+SRNTI, to 128 bits for an IP v6 address. The current paging channel has a fixed message size of about 120 bits, which could be a bit in-flexible.

8 Proposal

We propose that the PCH is modified into:

- Paging Flags (PF) time-multiplexed with the Acquisition Indicator Flags (AIF), indicating the existence of paging messages to groups of UEs.
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- The actual paging message is sent on FACH, a predetermined time after the corresponding PF.

The benefit of this modification is a better utilisation of the DL resources, both in terms of peak power and channelisation codes.

The following issues of the proposal are for further study:

- Mapping of paging groups to PF
- Paging interval, I_P = Nx10 ms, N=1,2…
- PF repetition time, T_1 = Lx I_P, L=0,1,…
- PF to message time, T_2 = Kx I_P, K=1,2…
- L2/L3 and I_{ub} impact of the PCH split onto different physical channels and different time instants.

9 References

[1] 3GPP RAN S1.11 V2.0.0 (1999-04), UTRA FDD Transport Channels and Physical Channels.