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Title: Uplink signalling for Hybrid ARQ

Document for: Discussion and decision

1 Introduction

Some new uplink signalling is needed for Hybrid ARQ.

- In case of the proposed N-channel Stop-and-Wait schemes (including the A^2IR scheme), there is a need for uplink acknowledgement signalling (Ack/Nack) corresponding to correctly/incorrectly decoded data in an HS-DSCH TTI.
- In case of a more elaborate Hybrid ARQ schemes, there may be a need for uplink signalling of e.g. sequence number(s) related to correctly decoded data in an HS-DSCH TTI.

This paper discusses the basic structure of this uplink Hybrid ARQ signalling.

2 Structure of Hybrid-ARQ signalling

The time duration of the Hybrid-ARQ signalling will contribute to the overall round-trip delay of the Hybrid ARQ protocol. This round-trip delay should be kept as low as possible to lower the requirements on UE soft buffering and also to reduce the HS-DSCH delay. Thus, the time duration of the uplink Hybrid ARQ signalling should be kept as short as possible. More exactly, it would be beneficial to limit the duration of the uplink Hybrid-ARQ signalling to one slot, even in case of an HS-DSCH TTI longer than one slot, see also Figure 1 below where the HS-DSCH TTI is assumed to be $3\times T_{slot}$ (example).

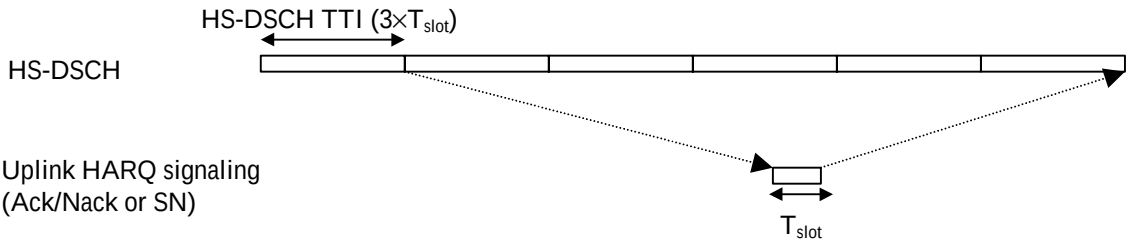

Figure 1

For the transmission of the uplink Hybrid-ARQ signalling, there are, in our view, two main alternatives, see also Figure 2 where, once again, HS-DSCH TTI = $3\times T_{slot}$ is used as an example.

- Time division multiplexing (TDM) of the uplink Hybrid-ARQ signalling onto current uplink DPCCH, i.e. the introduction of a set of new DPCCH slot formats that include fields for the uplink Hybrid-ARQ signalling. This alternative also implies that a lower spreading factor (SF=128) is needed for the uplink DPCCH.
- Code division multiplexing (CDM) of the uplink Hybrid-ARQ signalling with current uplink physical channels. This could be seen as the introduction of a second DPCCH (here referred to as "$DPCCH_{HARQ}$").

It should be noted that Figure 2 illustrates the case when uplink Hybrid ARQ signalling is actually transmitted, i.e. when HS-DSCH data is transmitted on the downlink to this UE. The figure also illustrates the fact that the Hybrid-ARQ signalling may need to be transmitted with a different power, compared to the other DPCCH fields, as the required power for the Hybrid-ARQ signalling may depend on e.g. whether the UE is in soft handover or not.

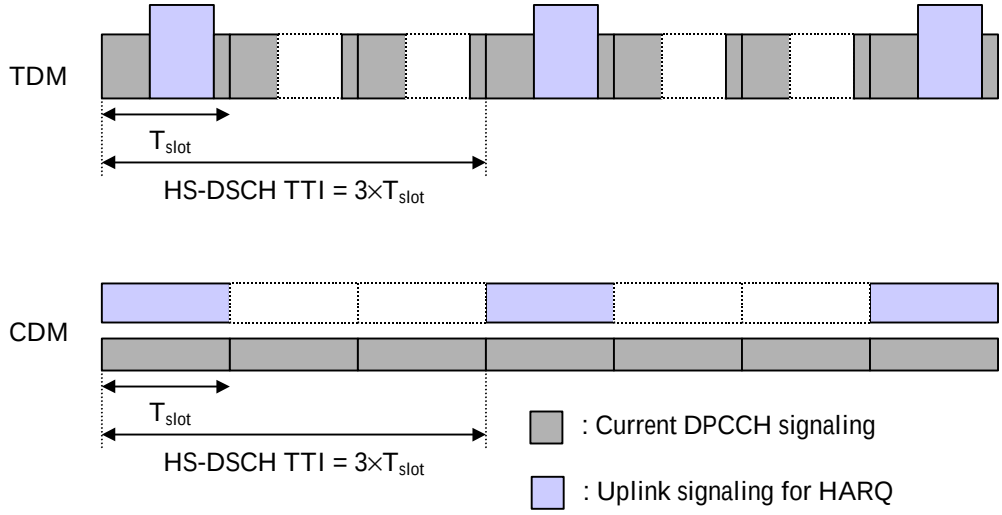

Figure 2 Structure of uplink signalling when HS-DSCH data is transmitted

However, in many cases, no HS-DSCH data will be transmitted to a specific UE, in which case no uplink Hybrid -ARQ signalling will be transmitted, see Figure 3.

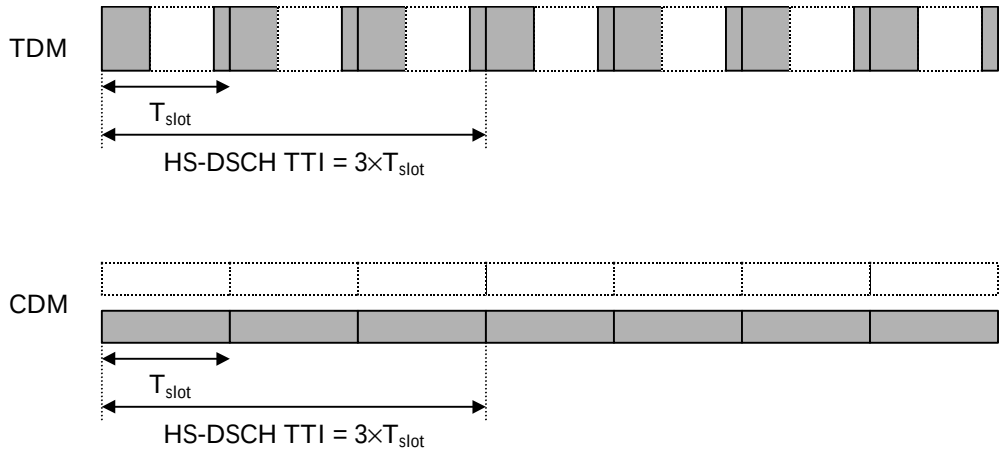

Figure 3 Structure of uplink signalling when HS-DSCH data is <u>not</u> transmitted

There are several arguments that favour the second alternative, i.e. the CDM approach.

- It allows for simple independent power setting for DPCCH and uplink Hybrid-ARQ signalling. As already mentioned, the required received energy per Hybrid-ARQ "acknowledgement" may vary significantly between a soft-handover and a non-soft-handover situation. For the TDM solution, unless independent power setting of the "DPCCH-part" and the "HARQ-part" is allowed, different slot formats would then be needed in soft handover.

- It is "backwards compatible" in the sense that a UE can be in soft handover with a Node B of existing releases, see also [1].

One may argue that the second argument would not be valid if other HS-DSCH-related uplink signalling is anyway needed and is to be carried on DPCCH, e.g. uplink signalling for MCS selection and Fast Cell Selection (FCS). However:

- FCS could reuse the SSDT signalling already present on current uplink DPCCH.

- MCS selection could alternatively be based on the transmit power of the downlink associated DPCH as discussed in e.g. [2]. This should always be a possibility and thus operation without the need for explicit uplink signalling related to MCS selection will always be one alternative.

The argument against the CDM approach is the increased peak-to-average-ratio (PAR), which is obvious from Figure 4.

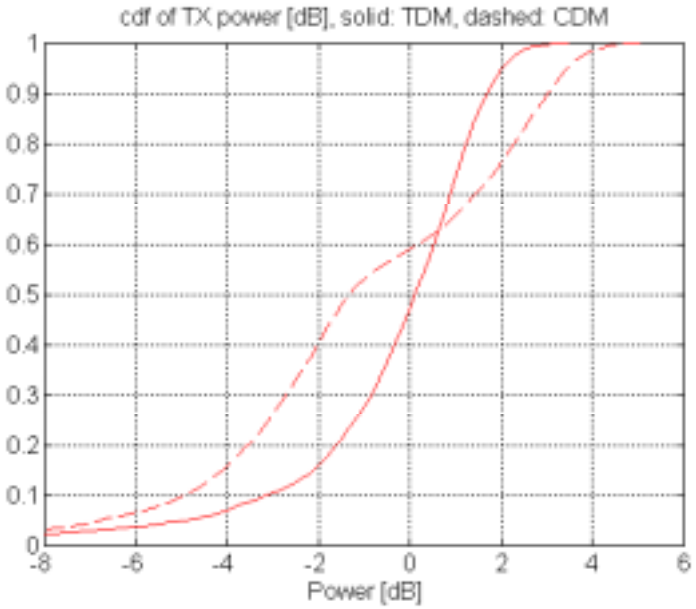

Figure 4

However, when considering the increased PAR with CDM, it is important to take the entire Figure 2 as well as Figure 3 into account. Figure 4 is only valid for the case when the $DPCCH_{HARQ}$ is actually transmitted, i.e. for every 3rd slot in Figure 2 and never in Figure 3. In most cases, $DPCCH_{HARQ}$ is not transmitted. In that case, the CDM approach obviously leads to at least as small PAR as the TDM approach. Thus, taken the potential low duty cycle of the uplink Hybrid-ARQ signalling into account, the higher PAR of the CDM approach will not be that critical. Taken into account the other benefits with the CDM approach, we believe that the CDM approach for uplink Hybrid-ARQ signalling is preferred, as also proposed in [1].

3 Conclusions and recommendations

The paper has discussed some aspects of the uplink Hybrid ARQ signalling.

The following is proposed to be included in [3]:

The duration of the uplink HARQ signalling should be as short as possible, to lower the Hybrid ARQ round-trip delay. Especially, the duration of the uplink Hybrid-ARQ signalling could be shorter than the HS-DSCH TTI and preferably only of length one slot.

The CDM approach for uplink Hybrid ARQ signalling provides many benefits in terms of flexibility and backwards compatibility. The main objection to the CDM approach is the increased transmit-power peak-to-average ratio (PAR). However, taken into account the typically very low duty cycle for the uplink Hybrid-ARQ signalling, the increased PAR may not be that critical. It is thus recommended that the CDM approach for uplink Hybrid-ARQ signalling, as proposed in [1], should be adopted.

References

[1] 3GPP TSG RAN1/RAN2 HSDPA Ad Hoc, April 5-6, 2001, 12A010009, " Uplink Channel Structure for HSDPA", Samsung

[2] 3GPP TSG RAN1/RAN2 HSDPA Ad Hoc, April 5-6, 2001, 12A010028, " Variable DL channel condition feedback rate for HSDPA ", Sony Corporation

[3] TR 25.855, “High Speed Downlink Packet Access: Overall UTRAN Description”