3GPP TSG-RAN WG1 Rel-6 Ah Hoc **R1-04-0746**
Cannes, France (R1-04-0532)
June 21 – 24, 2004

Agenda item: **5 FDD Enhanced Uplink – RAN1/RAN2 Joint Session**

Source: **Nokia**

Title: **Requirements for UL Signalling**

Document for: **Discussion**

1 Introduction

RAN plenary meeting #23 in March 2004 concluded the E-DCH Study Item and approved the SI TR [1] as well as initiated a FDD Enhanced Uplink Work Item as proposed in [2]. This document discusses different possibilities on how the uplink signalling could be designed to meet the needs of the features under specification.

2 Discussion

The WI scope is as recommended in the SI TR [1]. Node B controlled scheduling, hybrid ARQ, and shorter TTI are parts of the work item. Adoption of Node B controlled scheduling, hybrid ARQ or both will set new requirements to uplink signalling. Additionally, adoption of a shorter (than 10 ms) TTI can be considered as such being a new requirement to uplink physical layer structure which has a direct impact on how the signalling can be introduced in the physical layer.

The requirements for the uplink signalling agreed during the study item are captured in 7.5.2.1 of the SI TR [1]:

----- Start of a quotation from [1] -----

There are some requirements for the physical channel structure for L1 signalling on uplink:

- *The L1 signalling in uplink should be independent from HS-DSCH operation: UE should not be required to support HS-DSCH operation at the same time with E-DCH in uplink, but it should be possible to have E-DCH in uplink and HS-DSCH in downlink at the same time.*
- *Delays should be kept low.*
- *Signalling should be possible also when the UE's DCH is in SHO. The support of E-DCH in SHO is FFS.*
- *The effect of PAR needs to be taken into consideration when designing signalling channel for the uplink.*
- *The relative power offsets between various uplink channels needs to be set appropriately so as to achieve reliable signalling while at the same time optimising peak and average power requirements at the UE.*
- *Signalling reliability should be balanced with minimizing overhead.*
- *Signalling channel can be sent time aligned or not time-aligned with the enhanced uplink DCH. The effect of time aligned or not time aligned control channel on Node-B decoding time, sector throughputs etc. should be considered.*

----- End of a quotation from [1] -----

2.1 Node B Controlled Scheduling

Assuming that the Node B controlled scheduling requires new dedicated uplink signalling, the design of the uplink channel structures should enable conveying required scheduling related information with a sufficient reliability and frequency and with sufficiently low latency. (With some scheduling approaches the uplink scheduling signalling could

be eliminated completely, see e.g. [4]) Introducing new signalling brings also certain penalties, and thus the chosen uplink physical layer design should

- Minimize the instantaneous Tx power required for the signalling to minimize the impact to the uplink coverage
- Minimize the average Tx power required for the signalling to minimize the impact to the uplink capacity

Parameters that are to be considered with the above points are at least:

- How many (uncoded) bits per uplink message needs to be transmitted (size of a single message)
- How reliably the message needs to be transmitted (affects the ECR and required power)
- How long signalling latency can be accepted (affects the instantaneous power requirement)
- How often the message needs to be transmitted (affects the average power requirement)

Thus the signalling penalty would be minimized, if the

- Size of the (uncoded) uplink scheduling message transmitted in the uplink would be as small as possible
- The uplink scheduling message would be transmitted as seldom as possible (e.g. only when needed)
- The uplink scheduling message would be relatively error-tolerant (omit the need for CRC, reduce the required amount of redundancy and/or transmitted power)
- The coded uplink scheduling message bits would be spread over the longest sensible time period (Reduces the peak power requirement and thus increases the coverage)

2.2 Hybrid ARQ

----- Start of a quotation from [1] -----

The necessary information needed by the Node B to operate the hybrid ARQ mechanism can be grouped into two different categories: information required prior to soft combining/decoding (outband signaling), and information required after successful decoding (inband signaling). Depending on the scheme considered, parts of the information might either be explicitly signaled or implicitly deduced, e.g., from CFN or SFN.

The information required prior to soft combining consists of:

- *Hybrid ARQ process number.*
- *New data indicator. The new data indicator is used to control when the soft combining buffer should be cleared in the same way as for the HS-DSCH.*
- *Redundancy version. If multiple redundancy versions are supported, the redundancy version needs to be known to the Node B. The potential gains with explicit support of multiple redundancy versions should be carefully weighted against the increase in overhead due to the required signaling. Note that, unlike the HS-DSCH, the number of users simultaneously transmitting data in the uplink using hybrid ARQ may be significant.*
- *Rate matching parameters (number of physical channel bits, transport block size). This information is required for successful decoding. In R99/4/5, there is a one-to-one mapping between the number of physical channel bits and the transport block size, given by the TFCI and attributes set by higher layer signaling. This assumption does not hold for hybrid ARQ schemes if the number of available channel bits varies between (re)transmissions, e.g., due to multiplexing with other transport channels. Hence, individual knowledge of these two quantities is required in the Node B.*

The information required after successful decoding can be sent as a MAC header. The content is similar to the MAC-hs header, e.g., information for reordering, de-multiplexing of MAC-d PDUs, etc.

----- End of a quotation from [1] -----

The uplink physical layer design is affected by the information required to be signalled prior to decoding (i.e. the HARQ outband information). The physical layer should enable conveying the required HARQ outband information with a sufficient reliability and with sufficiently low latency. The parameters that are to be optimized are at least

- How many (uncoded) outband information bits per data packet needs to be transmitted
- How the sufficient reliability level is reached (e.g. CRC, channel coding, Tx Power)
- How long signalling latency can be accepted (affects the instantaneous power requirement and thus the coverage)

2.3 Shorter TTI

If a new, shorter TTI is introduced for data transmission, at least the HARQ outband signalling frequency has to be increased to meet the increased TTI frequency. Additionally signalling a new E-TFCI may be required. It is probably safe to assume that regardless of the TTI length, the same signalling needs to be transmitted in a TTI, thus with a shorter TTI more power is required to transmit the same signalling with a same reliability than with the existing TTI.

Thus introducing a shorter TTI will make the uplink physical layer design more challenging, e.g. in terms of signalling coverage, number of bits that can feasibly be transmitted and penalty in the capacity.

3 Possible Uplink Channel Structures

The general approaches for the coding, multiplexing and mapping of the uplink signalling are captured in 7.5.2.2 of the SI TR [1]:

- Mapping on (E-)DPDCH
- Mapping on DPCCH
- Mapping on E-DPCCH

These approaches should be reviewed against the above mentioned requirements before making the final decisions.

4 Conclusions

In order to maximize the coverage of the FDD Enhanced Uplink, the required instantaneous transmit power for the new uplink signalling should be minimized. In order to minimize the capacity penalty from the new signalling and thus maximize the capacity benefits of the features, the long term average power of the uplink signalling should also be minimized.

- The instantaneous transmit power of the signalling is minimized, when the number of transmitted information bits is minimized, the energy of the bits is spread over as long a time period as possible and the reliability requirements for the signalled information can be made loose.
- In addition to the above list, the long term average power of the uplink signalling is minimized when the frequency of the signalling is kept as low as possible.

Thus when making the FDD Enhanced Uplink design choices the above points should be kept in mind. It is worth noting that introducing a shorter TTI length would increase both the instantaneous and average required uplink signalling power.

References

[1] TR25.896, Feasibility Study for Enhanced Uplink for UTRA FDD, v6.0.0, March 2004

[2] RP-040081, Proposed Work Item on FDD Enhanced Uplink, Ericsson

[3] R1-030670, Impact of DL Support Channels on E-DPDCH, Qualcomm

[4] R1-040535, Signalling aspects of the rate scheduling, Nokia