TSG-RAN Working Group 1
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Agenda item: AH24, HSDPA

Source: Lucent Technologies.

Title: Response to issues raised on Hybrid ARQ

Document for: Discussion

1 Introduction

Ericsson submitted a document [1] to 3GPP_TSG_RAN_WG1 mailing list and presented their understanding of issues related to the fast Hybrid ARQ schemes proposed for HSDPA. This document contains Lucent's response to the issues/questions raised in [1].

2 Clarifications on Issues regarding A^{2}IR

2.1 ACK/NACK feedback

Ericsson: It is not clear from material presented on A^{2}IR if there is a strict requirement on the timing of the Ack/Nack signaling. However, if that would not be the case, there is either a need for explicit identification of the acknowledged data block, i.e. explicit sequence numbers, or there could be only one not-yet-acknowledged data block (true Stop-&-Wait), i.e. the entire HS-DSCH capacity can not be assigned to a single UE. Neither alternative seems attractive. The need for explicit sequence numbers is especially undesirable if the Ack/Nack of fast Hybrid ARQ is to be carried as "Layer-1" signaling on the uplink DPCCH.

Lucent: A^{2}IR assumes a fixed round trip time in order to associate ACK/NACK with the code block transmission. Therefore, ACK/NACK in A^{2}IR requires a single bit indication. The A^{2}IR allows N-channel operation through the use of code block identifiers (CBI) [2] that enables fully asynchronous operation. Therefore, the entire HS-DSCH capacity can be assigned to a single user.

2.2 Effect of variations in the number of codes allocated to HS-DSCH

Ericsson: Regarding potential problems with variations in the number of codes allocated to HS-DSCH there does not seem to be any differences between N-channel Stop-&-Wait and A^{2}IR.

Lucent: The A^{2}IR operation is transparent to the variations in the number of codes allocated to HS-DSCH. The transmissions/retransmissions performed under different number of codes can still be IR/combined [2].

2.3 New/Continue Indication

Ericsson: For Hybrid ARQ based on Incremental Redundancy, some kind of retransmission-number indication (a generalised New/Continue indication) seems to be required.

Lucent: The A^{2}IR scheme provides generalized New/Continue indication by use of sub-block sequence numbers [2].

3 Asynchronous operation

Ericsson: Our understanding is that the N-channel Stop-&-Wait scheme allows for time-multiplexing of different users in the sense that a block of data transmitted to and not correctly decoded by User A in the M^{th} HSDPA TTI does not necessarily have to be retransmitted in the $(M+N)^{th}$ HSDPA TTI, i.e. the next TTI in the given HARQ channel. Instead, N-channel Stop-&-Wait allows for transmission to User B in $(M+N)^{th}$ HSDPA TTI while the retransmission to User A is postponed to a later TTI belonging to the N^{th} HARQ channel, see also Figure 2.

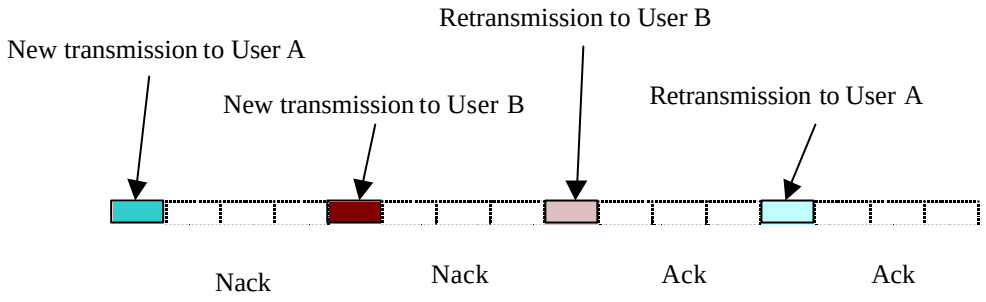

Figure 1

Thus also N-channel Stop-&-Wait supports a certain degree of so-called "asynchronous" operation.

Lucent: The N-channel Stop-&-Wait as explained above does not provide the flexibility of a full asynchronous operation. The retransmissions are restricted to happen at fixed times (only at integer multiple of N intervals for a given channel). This restriction on retransmissions will interact badly with the scheduler and limit the achievable multi-user diversity gains. The restriction on retransmission timing can be removed by explicit indication of the N-channel identifier through $\log_2(N)$ bits in the sub-block header [2].

4 HARQ operation with FCS

Ericsson: There are obviously interactions between Hybrid ARQ and FCS. A potential solution could be to not allow FCS between retransmission but only before transmission of a new data block.

Lucent: There are two issues regarding the interaction between HARQ and FCS. – a) transfer of the HARQ state to the selected cell for which a number of solutions have been outlined in [3] and b) the choice of MCS used for the retransmission as compared to the original transmission. Requiring that the retransmissions be made at the same MCS level as the original transmission is highly restrictive. This is due to the fact that channel conditions, available power and the code space will be different in the new cell. Therefore, a true HARQ scheme should be able to do IR/combining across transmissions/retransmissions from different cell sites.

5 Interaction with Adaptive Modulation and Coding scheme

Ericsson: Chase combining *implies* that the modulation and coding scheme should be unchanged between retransmissions. Similarly, Incremental Redundancy obviously implies that the coding is changed between retransmissions. However, this is a deterministic change (depending on the retransmission number) and not a true change of MCS. In general, there seems to be few reasons to change the MCS between retransmissions. If, for some reason, the modulation scheme should be changed, this could be seen as a new transmission, i.e. not requiring soft combining.

Lucent: The power available for HS-DSCH is continuously changing (on a slot-by-slot basis) due to large variations in the power used by power-controlled circuit switched users. At high Doppler, channel conditions are also varying quickly. Furthermore, with asynchronous IR operation, the time between the transmissions/retransmissions could be longer because a retransmission to a user can be preempted by a transmission to another user. Therefore, it is highly likely that the channel conditions, available power and Walsh code space are different between transmissions/retransmissions that need to be IR/combined. Under these conditions non-adaptive schemes that do not allow change of MCS on retransmissions will have to abort transmission that will result in degraded system performance. Note that even if the number of Walsh codes available for HS-DSCH changes comparatively slowly, a small change in

the number of Walsh codes make it impossible to perform a retransmission at the same MCS for non-adaptive HARQ schemes.

6 References:

[1] "Discussion on topics and issues raised on fast Hybrid ARQ proposals for HSDPA," Ericsson, R1-00-HARQ-Issues.

[2] "A^2IR – An Asynchronous and Adaptive Hybrid ARQ scheme for HSDPA", TSG-RAN #18(01) 0080, Lucent Technologies.

[3] "Physical-layer aspects of Fast Cell Selection for HSDPA," TSG-RAN1 #17(00) 1424, Ericsson.