TSG-RAN Working Group 1 meeting #18 *TSGR1#18(01)0035*

Agenda item: "HSDPA discussion"

Source: Ericsson

Title: Discussion on topics and issues raised on fast Hybrid ARQ proposals for HSDPA

Document for: Discussion

---

1 Introduction

Document [1] presented a list of topics and raised a number of issues/questions related to the fast Hybrid ARQ schemes proposed for HSDPA. In this paper we present the Ericsson understanding of these topics. We ask the proponents of the different fast HARQ proposals to confirm/ point-out where our understanding agrees/deviates from the intention with the proposals.

2 Comments to the topics raised in [1]

Processing time

As a reference, Figure 1 illustrates the N-channel Stop-&-Wait protocol with N=4 (example).

Processing time at UE

The key property of the N-channel Stop-&-Wait protocol is that the received timing of an Ack/Nack identifies the acknowledged data block. This is the reason why N-channel Stop-&-Wait allows for multiple not-yet-acknowledged data blocks without explicit sequence numbers. As a consequence there are strict requirements on the transmission timing of the Ack/Nack (relative to the receive timing of the data block) and thus strict limits on the available UE processing time $?_{UE\text{-}proc}$. Thus the time needed to decode data received in an HSDPA TTI and to generate a corresponding Ack/Nack is one of the critical issues to be studied for HSDPA HARQ.

Processing time at Node B

Contrary to the processing time at the UE, the available Node B processing time can be made flexible by allowing for variations in the number of HARQ channels (N), i.e. N can be a cell specific (actually HS-DSCH-specific) parameter. It could e.g. be reasons to have different values of N (different number of HARQ channels) depending on the cell size. A larger N would allow for larger maximum propagation time $?_{prop}$, i.e. larger cell sizes but would lead to larger delay between fast Hybrid ARQ retransmissions. Thus there is a possibility for a flexible Node-B-complexity/performance trade-off.

Buffering requirements at the UE

A larger N will, in general, increase the buffering requirements in the UE. However, there could be a flexibility in the UE buffering requirements by having e.g. flexibility in the number of HARQ channels that can simultaneously be directed to a single UE. This would give the possibility for a flexible UE complexity/peak-data-rate trade-off.

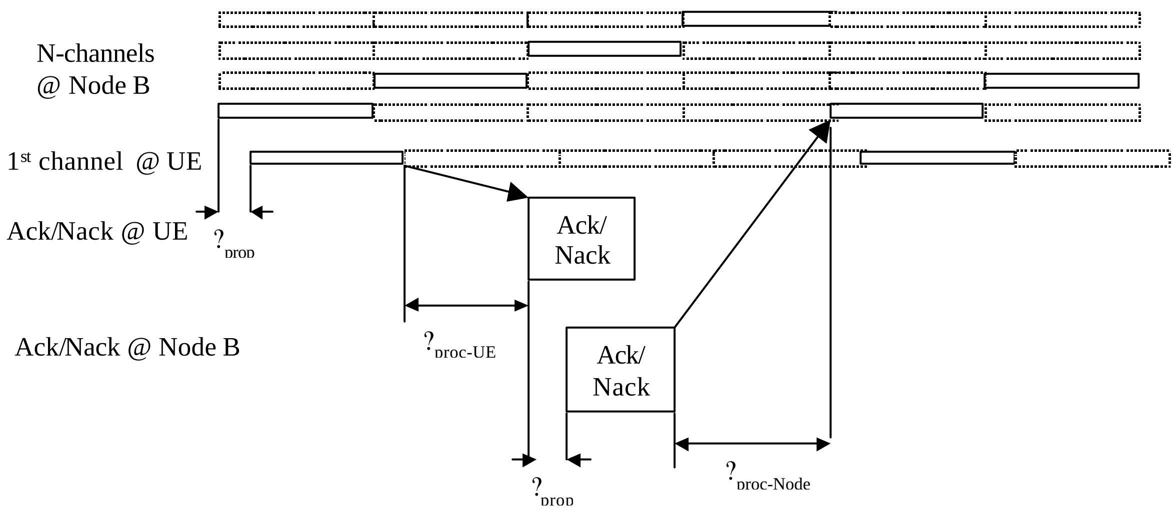

Figure 1

It is not clear from material presented on A^2IR 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.

Thus it is our understanding that there is no difference between N-channel Stop-&-Wait and A^2IR in this respect.

Multiple transport blocks per TTI and variations of number of transport blocks in a TTI

It is our understanding that all data transmitted to a UE within one HSDPA TTI, i.e. in normal case multiple transport blocks, should be acknowledged with a single Ack/Nack. The benefits of individual Ack/Nack per Transport block should be limited, as there is a high correlation between errors in transport blocks transmitted within the same TTI.

?? Most transport blocks that are encoded in the same turbo encoder block are likely to be erroneous if the turbo decoding fails.

?? Errors in the fast link adaptation implies that, in many cases, transmission will be done too high up the error curve (very high error probability) or too far down curve (basically no errors) on the error curves.

Obviously further quantitative evaluations are needed.

The benefits with a single Ack/Nack per HSDPA TTI are:

- Reduced downlink signalling, e.g. less CRC
- Simplified uplink signalling, e.g. no need for sequence numbers in the Ack/Nack.

Once again, the later is especially desirable if the uplink signalling (Ack/Nack signalling) is to be carried as "Layer-1" signalling on the uplink DPCCH.

There does not seem to be any differences between N-channel Stop-&-Wait and A^2IR in this respect.

Multiplexing of users in time

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.

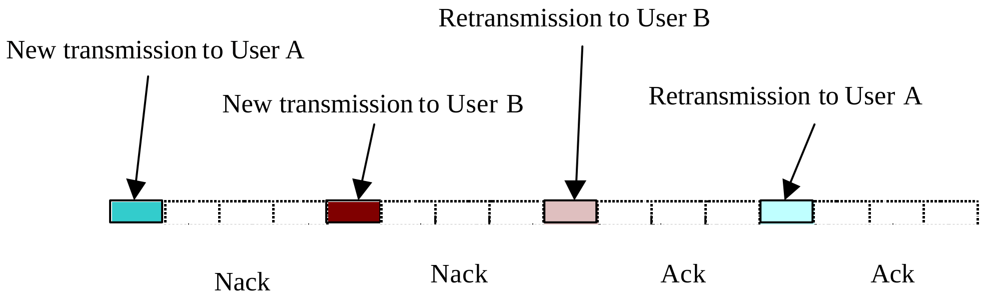

Figure 2

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

Note that it is not clear that there actually are any significant advantages with support of this kind of asynchronous operation. On the other hand, the cost, e.g. in terms of complexity and overhead, to support this is most likely very limited. What is needed is that, for every HSDPA TTI, the network must indicate the target-UE for the data on HS-DSCH. Such signaling may anyway be beneficial, in order to better recover from error events, e.g. errors in the uplink Ack/Nack signaling.

Regarding potential problems with N-channel Stop-&-Wait when the number of codes allocated to HS-DSCH varies:

The total number of codes allocated to HS-DSCH can be expected to change only on a slow basis. Thus, the infrequent situation when the number of codes are not sufficient to handle a retransmission could be handled by specific means, e.g. by simply restarting the HARQ processing, i.e. reset the soft combining in the UE.

A^2IR offers somewhat more flexibility in that retransmissions are not restricted to occur within a single HARQ channel. However, the potential benefits of this, in terms of multi-user diversity, may be limited. Quantitative evaluation of the gain is needed together with an evaluation of possible increased signaling and increased complexity.

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^2IR.

New/continue indication.

Our understanding is that a New/Continue indication is a downlink signal that indicates if data in an HSDPA TTI is a new data block or a retransmission of a previously transmitted data block. Thus, a New/Continue indication is simply an echo of the last Ack/Nack received by the Node B from the specific UE, i.e. in principle a downlink acknowledgement of the uplink Ack/Nack. Thus a New/Continue indication could be used by the UE as an indication whether Node B correctly detected the uplink Ack/Nack or not.

On the other hand, there is obviously a non-zero probability for errors for the New/Continue flag itself. Thus a mis-match between transmitted Ack/Nack and received New/Continue indication does not necessarily imply that an uplink error has occurred. Consequently, further studies are needed to determine the potential benefits with a New/Continue indication.

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

Chase combining / Incremental Redundancy

Our understanding is that the current rate-matching algorithm is not rate compatible and thus needs some modifications to be applicable if Incremental Redundancy is to be used for HSDPA HARQ.

Interaction with Fast Cell Selection

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.

Interaction with Adaptive Modulation and Coding scheme

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.

Also not that there are reasons to keep the number of transport blocks unchanged between retransmission as it is preferred to acknowledge all transport blocks within one TTI and not each transport block separately, see above.

3 References

[1] "Discussion on ARQ aspects for High Speed Downlink Packet Access", TSGR1#17(00)1442