TSG-RAN Working Group1 meeting #17 TSGR1#17(00)1442

Stockholm, Sweden, November, 21st – 24th, 2000

Agenda Item : **AH24**

Source : **Nortel Networks**

Title : **Discussion on ARQ aspects for High Speed Downlink Packet Access**

Document for : **Discussion**

1. Introduction

This documents discusses aspects of ARQ in the context of HSDPA. The mandate of RAN WG1 on the ARQ aspects is restricted to the analysis of the feasibility/benefit of hybrid ARQ vs. the ARQ method which is part of Release99, as HARQ was identified as a potential technology for introduction in the framework of HSDPA. RAN WG2 should on the other side, consider ARQ as a whole, in particular impact on the transmission model and protocol architecture. Whereas initial discussion that took place in RAN WG1 did concentrate on the evaluation of HARQ in general, discussion seems to be expanding outside the assigned scope of RAN WG1. Indeed detailed proposals for the ARQ have been made in [1][2][3], which in effect address two main proposals which we may characterise as a Synchronous ARQ proposal on one side [1][3] and asynchronous proposal on the other side[2].

In the following, we would like to identify which aspects of these proposals should be further evaluated in the scope assigned to RAN 1 in order to avoid duplication of discussion in RAN WG2, leaving the remaining aspects for discussion in RAN 2. Then both proposals are analysed in terms of commonalities and differences and technical issues are identified, as a way to initiate discussion with RAN WG2.

Where relevant, the impact on signalling content and dimensioning is provided. But no scheme for signalling is presented since the requirements must be settled before a specific scheme can be considered.

2. Aspects of the proposals which are of primary interest to RAN WG1

The two main aspects which RAN WG1 should definitely be considering are the performance improvement we may get from Hybrid ARQ and the complexity aspects, mostly for the UE, when considering memory requirements.
For the HARQ, RAN WG1 should describe, as was done in the frameworks of HARQ work item, the different methods that may be considered, Incremental redundancy based method and the Chase combining based methods among others. Though the specification does not specify the receiver signal processing in particular whether the UE should systematically combine all blocks corresponding to the repetition of the same piece of information.

For the complexity aspects, we may well derive that some limitation is to be imposed on the protocol operation in order to avoid extensive buffering. We understand that the ARQ proposals in [1][2][3] are indeed methods that decrease memory requirement and improve feasibility of HARQ in the node B vs. a Selective and repeat based method where the ARQ would lie in the RNC introducing hence further delay and buffering requirements. It is our understanding that details about the techniques and impact on the protocol architecture and the user model should primarily be discussed in RAN WG2. RAN WG1 may consider these techniques and evaluate their impact on the processing chain, the impact on the complexity as a way to remove complexity issues potentially associated with a SR ARQ located in the RNC. Still many aspects that may influence conclusion are related to the interaction with other processes, adaptive modulation and coding, Fast cell selection and the potential introduction of a second level ARQ and these can only thoroughly be evaluated by RAN WG2.

Further, in terms of working procedures we recommend not to document these detailed techniques so far but do the analysis work and start documenting them in a co-ordinated way with RAN 2, meaning most probably at our next meeting.

3. Analysis of the two currently discussed in RAN 1 proposals ARQ

In the following we analyse the two main proposals and identify commonalities and differences towards several criteria as listed below :

?? processing time
?? variation of number of blocks in each TTI
?? multiplexing of users in time
?? New/Continue indication
?? Chase versus/ Incremental redundancy
?? Interaction with Fast Cell Selection
?? Interaction with Adaptive Modulation and Coding
?? Aspects specific to one of the methods

Potential problems or missing parts of the proposals are identified, which should be considered by RAN 1 and RAN 2 when evaluating the feasibility of the proposed techniques .

Aspects	Synchronous HARQ [1][3]	Asynchronous HARQ[2]
Processing time	The definition of the transmission time of successive blocks for a UE must take into account the block processing time in the UE. Else the UE is not able to send the ack/nack in time for the transmitter to analyse it before transmitting the next block. The delta between two transmissions must also take into account some processing time in the Node B so that it can analyse the feedback and act accordingly. In case of N-al channel HARQ, there is an incompatibility between dual-channel ARQ and ack/nack transmission duration of one block.	There must be a minimal delay between transmission of two blocks for the same UE. This is to allow this UE to receive the block, treat it and send a feedback before the transmitter sends the next block to it.
Multiple transport block per TTI	One issue is the number of ack/nack per TTI. If there is one ack/nack per TrBlk, then the feedback channel must support different number of ack/nack. A global ack/nack would mean that all blocks are to be retransmitted if one of them is erroneous. Also in this case, Transport Block concatenation removal might not be needed. Ack/nack on a per transport block would allow specific re-transmission.	
Variation of number of Transport Blocks in a TTI	The number of TrBlks in a TTI can vary for a same user due to several reasons: variations of the number of codes allocated for this user although these codes may be at the same SF, variation of MCS for this user. One issue is the number of ack/nack per TTI. If there is one ack/nack per TrBlk, then the feedback channel must support a variable number of ack/nack, and the number of TrBlks sent in “re-transmission” TTI is variable according to the number of nacks understood by the receiver..	

	In the case of synchronous ARQ, retransmission must occur at specific times. If the number of codes and or the modulation is changed between successive occurrence of a particular n-sub-channel, there may not be enough room for blocks to retransmit, unless rate matching is adapted to support a constant number of blocks or restriction must be imposed on the variation of available bit rate. In the former case, the amount of redundancy depends on the radio resource variation.	In case of asynchronous HARQ, the transmitter is free to choose the number of , consecutive blocks it send to one user, and when retransmission should occur independently of any feedback. Still there are may be some restriction to consider depending on the HARQ method (Chase or incremental redundancy), in particular the variation in amount of redundancy sent. Considering that the TFC encompasses both physical channels and code rate, there may be some restrictions on the transition between TFC.
Multiplexing of users in time	It is not fully clear which is the user time multiplexing capability in the synchronous approach. For example it is possible to send blocks from a user B, if there are blocks pending positive acknowledgement. from user A. If this is not possible, a number of blocks may need to be left empty.	Given the freedom the transmitter has to send blocks for different users, an indication of the user ID must be provided for each block.
New/ Continue Indication	For both HARQ methods, a New/Continue indication can help protocol recovery in case of errors on the feedback channel. In case of incremental Redundancy, this indication might also provide some information on the redundancy version.	
		In case of asynchronous HARQ, providing indication to the UE whether the block is new or a continuation of previous block is necessary since the transmitter is free to ignore the ack/nack feedback and to send new block or re-transmissions when it wants.
Chase combining / Incremental redundancy	Both methods could apply to synchronous and asynchronous ARQ. In case of incremental redundancy how does the current 3GPP rate matching algorithm interact with the redundancy? Actually ,in case of flexible positions of TrChs, the rate matching positions vary according to the amount of rate matching applied. Also the rate matching positions depend on the maximum number of bits in a TTI and static RM parameter. Enhancement of this algorithm is needed if we want to obtain other RM patterns.	
		In case the transmitter is free to chose the number and size of re-transmitted blocks, incremental redundancy might give it more flexibility to optimise the content of the re-transmissions.
Interaction with Fast Cell Selection	There are strong interactions between ARQ and fast cell selection. In particular if ARQ is managed at the node B level, there may be some difficulties in synchronisation ARQ when performing the cell change. It is not clear how the synchronisation time disturb the ARQ in particular the synchronous one since the cells' timing is not aligned, HSDPA allocated resource varies between cells. Memory requirements at the UE and node B need to be clarified. For the Node B, all non acknowledged block may need to be buffered to be possibly retransmitted for multiple fast cell selections. As for the user multiplexing case, is it possible to perform a cell selection when blocks are pending positive acknowledgements ?	

Interaction with Adaptive Modulation and Coding scheme	It should be studied whether it is possible to change the MCS in the middle of re-transmissions, or whether change of MCS should occur only on new block transmission. Changing MCS modifies the amount of bits that can be transmitted in a TTI. Thus either the number of L2 blocks transmitted in the TTI, or the channel coding scheme (including rate matching) is modified. Changing MCS in the middle of re-transmission has thus an impact on the coding of the re-transmitted block.	
		Asynchronous HARQ can be evolved into the AMCS scheme, where the transmitter adapts the MCS and thus the number of blocks transmitted to channel conditions.
Specific aspects	In case of N-al channels HARQ, design of the number of channels N Initialisation of each channel. Determination of the granularity of information which can be affected to each channel: blockwise? TTIwise? How is this to be indicated to UE?	

4. Conclusion

In this document, the scope of the discussions taking place in RAN 1 on ARQ is reviewed. It appears that some proposals although addressing the complexity issue associated with HARQ, go a lot further than the RAN 1 scope. In this document we propose a way forward to proceed with the discussion. RAN 1 should review the impact of these proposals on the channel coding and multiplexing, and benefits in terms of UE and node B complexity compared to ARQ locating in the RNC. As most aspects of the proposal are in effect RAN 2 issues, it is proposed to wait for guidance from RAN 2 as to the documentation aspect (update of the RAN 1 Technical Report), while moving forward with the analysis work. In a second step the contribution analyses the asynchronous and synchronous ARQ proposals in [1]-[3] and identifies a number of issues that need to be clarified/solved before concluding on the feasibility of the said proposals. This analysis may be communicated to RAN 2 is felt appropriate.

5. References

[1] : Text proposal on HARQ for HSDPA TR, R1-00-1369, Nokia

[2]: Asynchronous and Adaptive Incremental Redundancy (A^2IR) Proposal for HSDPA, Lucent, R1-00-1382

[3] : High Speed Downlink packet data Access, R1-00-0727, Motorola