TSG-RAN WG1#46bis **R1-062771**
Seoul, Korea
October 9th – 13th 2006

Agenda Item: **6.12.1**
Source: **NEC Group**
Title: **Downlink ACK/NACK Mapping for E-UTRA**
Document for: Discussion and decision

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1 Introduction

Previous RAN1 meetings have focussed on the structure and contents of the downlink shared control channel while discussions on the exact mapping of the channel onto the time/frequency plane is still largely open. Also open for discussion is the coding for the control channel and an estimate of the benefits of joint coding as opposed to individual coding as in Release 5 WCDMA. In this document we analyse the control channel overhead and propose multiple options for the mapping of the control channel on the time/frequency resources.

2 Downlink Control Channel Structure

In the last RAN1 meeting, the basic information to be carried in the control channel has been agreed and incorporated in the TR.

Given the different types of information that the control channel must carry, it is imperative that the size of the control channel will depend on the individual UE's situation. Examples of situations which lead to different control channel sizes are given below –

Case		**DL Scheduling Information**	**UL Scheduling Information**	**ACK/NACK**
1	UE scheduled on UL and DL, and awaiting ACK/NACK	Required	Required	Required
2	UE scheduled on DL only, and awaiting ACK/NACK	Required		Required
3	UE scheduled on UL only, and awaiting ACK/NACK		Required	Required
4	UE not scheduled on UL or			Required

	DL, and awaiting ACK/NACK			
5	UE scheduled on UL and DL, not awaiting ACK/NACK	Required	Required	
6	UE scheduled on DL only, not awaiting ACK/NACK	Required		
7	UE scheduled on UL only, not awaiting ACK/NACK		Required	

At the very least, the control channel needs to contain information on the resource allocation and an identity for the scheduled UE. In order to reduce the number of options on the control channel size, it is beneficial to remove the ACK/NACK field from the control channel itself into a dedicated (semi-static) time/frequency resource. In addition, if a UE is scheduled on both UL and DL then the UL scheduling information can be contained within the allocated DL resource block. This leaves two cases for the DL control channel size:

Type 1: DL Scheduling Information (used in cases 1, 2, 5 and 6 above)

Type 2: UL Scheduling Information (used in cases 3 and 7 above)

3 Proposed ACK/NACK Channel Mapping in Downlink

It is proposed that one or more subcarriers in the downlink be reserved for carrying ACK/NACK information for UE's expecting such information in the downlink. The number of resources reserved for such usage and their locations in the time/frequency plane can be intimated to the UE's through common signalling. The UE knows when to expect the ACK/NACK, and it can work out (from knowledge of the UL chunks used for the UL transmission) on which sub-carriers the ACK/NACK will be transmitted.

It is assumed that an ACK/NACK command is transmitted over $M*N$ sub-carriers, where N is the number of UL chunks transmitted by the UE and M is the number of subcarriers allocated to each ACK/NACK channel. The transmitted power of each ACK/NACK command is inversely proportional to N, so that the total energy per ACK/NACK command is independent of the number of chunks being acknowledged. Figure 1 and Figure 2 show two examples of possible ACK/NACK resource multiplexing exploiting the maximum frequency diversity for the 5 MHz case. In the FDM multiplexing case, all the ACK/NACK's are multiplexed within the second OFDM symbol. These resources will obviously reduce the number of subcarriers available in that symbol for the downlink control channel. This structure also allows support of micro-sleep mode at the UE, since an UE expecting an ACK/NACK need monitor only the first two OFDM symbols.

The structure in Figure 1 is designed to support a maximum of 12 simultaneous users within 5 MHz (each user with one chunk) with each chunk being acknowledged by a six subcarrier ACK/NACK channel.

Assuming a chunk size of L subcarriers, N chunks within the allocated bandwidth, M subcarriers per ACK/NACK channel and an ACK/NACK subcarrier position offset within a chunk of Δ, the mapping between the uplink transmitted chunk number i and the corresponding downlink ACK/NACK is as below –

Position[0] = L*(i div M) + (i mod M) + Δ

where $0 <= \Delta < L$

For $j > 0$

Position[j] = Position[j – 1] + L*N/M

Figure 1 demonstrates the case for $N = 12$, $L = 25$, $M = 6$ and $\Delta = 0$. It can be noted that M needs to be a factor of N in order to exploit the full frequency diversity with an equally spaced ACK/NACK subcarrier distribution.

Another mechanism of the TDM mapping scheme is to spread the N*M ACK/NACK subcarriers uniformly over the entire band within the second OFDM symbol. However, if M is not a factor of L, the ACK/NACK spacing will be non-uniform in this case.

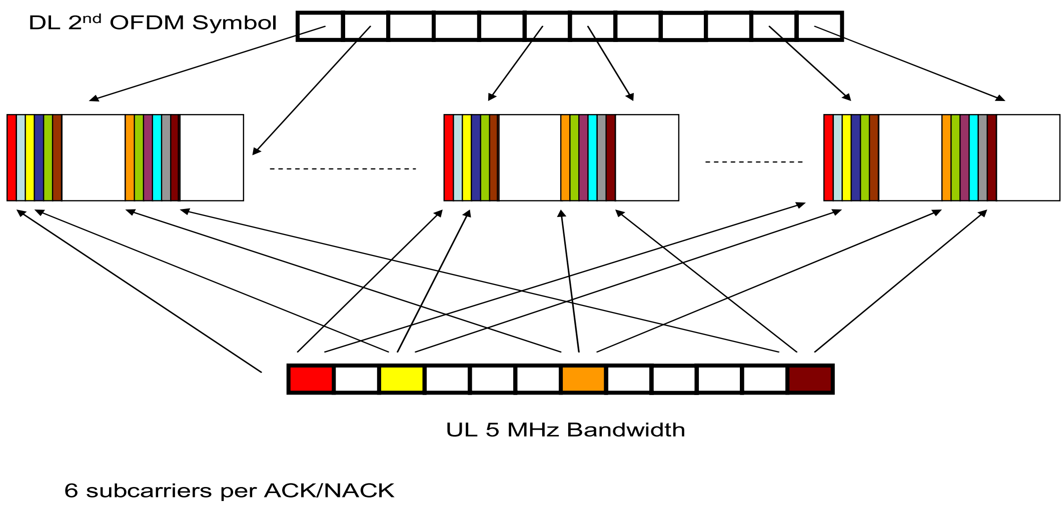

Figure 1 : FDM Multiplexing of ACK/NACK

Alternatively in the scatter (i.e. FDM/TDM) multiplexing case, the ACK/NACK resource is scattered over the remaining (all but the first OFDM symbol which contains the pilot and control channels only) OFDM symbols as shown in Figure 2. In this case, the chunk bandwidth for user data is reduced by a single subcarrier and micro-sleep possibility is reduced.

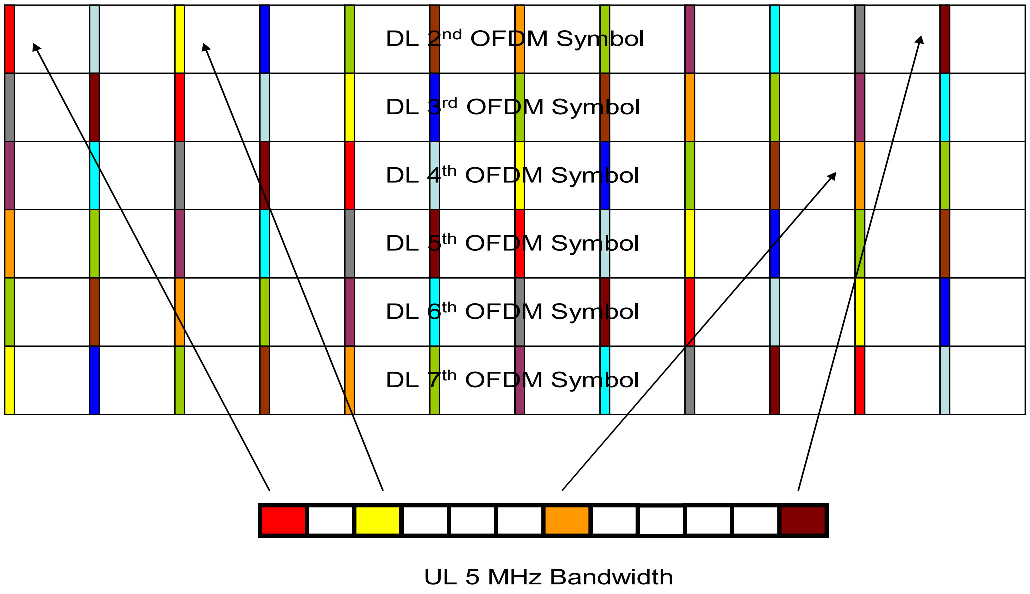

Figure 2 : Scatter Multiplexing of ACK/NACK

Assuming a chunk size of L subcarriers, N chunks within the allocated bandwidth, M subcarriers per ACK/NACK channel, an ACK/NACK subcarrier position offset within a chunk of Δ and N_{sym} number of available OFDM symbols, the mapping between the uplink transmitted chunk number i and the corresponding downlink ACK/NACK is as below –

Position[0] = $L*i + \Delta$

where $0 <= \Delta < L$

For $j > 0$ and $j < M$

Position[j] = ((Position[j – 1] + $L*N/M$) mod $L*N$) in symbol $j*N_{sym}/M$

Figure 2 illustrates the case for $N = 12, L = 25, M = 6, \Delta = 0$ and $N_{sym} = 6$.

It can be noted that M needs to be a factor of N_{sym} to enable a uniform spacing of the ACK/NACK commands in the time domain.

Figure 3 shows another alternative structure for the downlink ACK/NACK channel. Similar structures have already been proposed in WG1 in [2] and [3]. In this structure, each uplink resource block is associated with an orthogonal Hadamard sequence of a length equal to the number of resource blocks within the entire bandwidth. The downlink

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