

Agenda Item: 6.1.4
Source: LG Electronics
Title: Handling problem with uplink ACK/NACK bundling
Document for: Discussion and decision

1. Introduction

In last meeting in Sorrento, the following is agreed [1].

- Single ACK/NAK feedback
 - ACK/NAKs from one or several DL subframes are combined (“bundled” by performing AND of all A/N) to a single ACK/NAK report
 - The PUCCH formats already defined for LTE are reused (PUCCH Format 0 and 1)
 - This scheme is supported by LTE TDD

One problem which should be solved with ACK/NACK bundling is that a missing downlink assignment can be responded by bundled ACK, which causes a high probability of RLC retransmission [2]. In this paper, we suggest a way of bundled ACK/NACK signalling in uplink to resolve the problem.

2. Method of resolving missing downlink assignment

We suggest combination of following two methods to cope with the problem of missing downlink assignment in case of uplink ACK/NACK bundling.

- Signalling counter of PDSCH transmissions to each UE within ACK/NACK bundling window

When a PDSCH is transmitted to a UE within an ACK/NACK bundling window, scheduling assignment for the PDSCH includes counter of the PDSCH transmission to that UE within that ACK/NACK bundling window. For this counter, maximum 4 bits are required when considering 9:1 configuration of downlink vs. uplink. However, the number of bits can be reduced if the number of

PDSCH transmission to a UE within an ACK/NACK bundling window is restricted. For example, we can set maximum 4 PDSCH transmissions to a UE so that 2 bits are required for the counter.

With this counter, a UE can identify if it has missed a PDSCH transmission within an ACK/NACK bundling window as long as it hasn't missed last PDSCH transmission to it within that ACK/NACK bundling window. When a UE detected missing count value within an ACK/NACK bundling window, it transmits NACK as a bundled ACK/NACK for that bundling window. However, additional method is necessary to handle the case where a UE misses last PDSCH transmission.

■ ACK/NACK resource relation to the downlink subframe carrying last PDSCH transmission

To fully cope with the missing downlink assignment problem, eNodeB should be able to identify whether a UE has missed the last PDSCH transmission to it or not within an ACK/NACK bundling window. Figure 1 illustrates an example of general CCE to uplink ACK/NACK mapping structure we suggest for TDD mode regardless whether ACK/NACK bundling is considered or not [3]

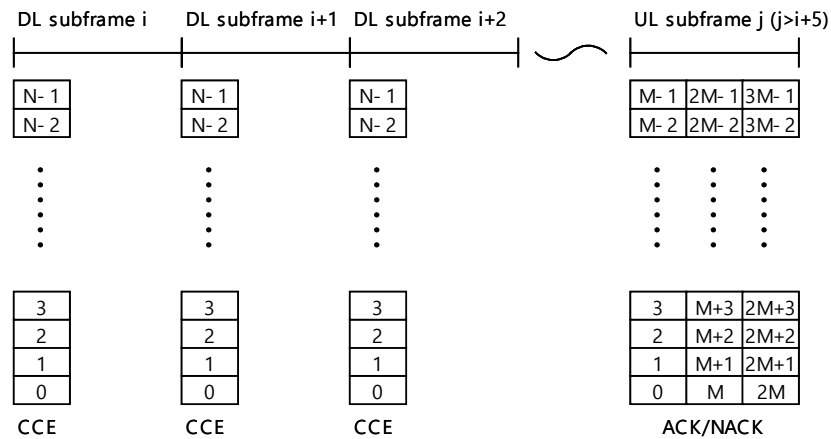


Figure 1 Generic structure for uplink ACK/NACK to CCE mapping

If an uplink subframe should carry ACK/NACK for 3 downlink subframes as in the figure, ACK/NACK resources (combinations of cyclic shift, orthogonal cover and RB) are divided by 3 resource sets where each set contains M ACK/NACK resources. Then, M ACK/NACK resources in each set are mapped to N CCEs in one of the 3 downlink subframes. M value can be configured to be equal to or less than N .

With this generic structure for uplink ACK/NACK to CCE mapping, it can be specified that a UE transmits bundled ACK/NACK using the ACK/NACK resource corresponding to the CCE in the downlink subframe in which that UE received last PDSCH within an ACK/NACK bundling window. Figure 2 shows an example when number of CCEs per downlink subframe is 8 and the number of ACK/NACK resources is 24 in an uplink subframe, where uplink ACK/NACK for 3 downlink subframes

is bundled. In the example, a (blue) UE is assigned PDSCH through subframe i and $i+1$ by CCE 2 and 5, then it transmits ACK/NACK using 13th ACK/NACK resource which corresponds to CCE 5 in subframe $i+1$. Another (green) UE is assigned PDSCH through subframe i and $i+2$ by CCE 5 and 1, then it transmits ACK/NACK using 17th ACK/NACK resource which corresponds to CCE 1 in subframe $i+2$. By doing so, eNodeB can identify which PDSCH the UE received as a last PDSCH within an ACK/NACK bundling window.

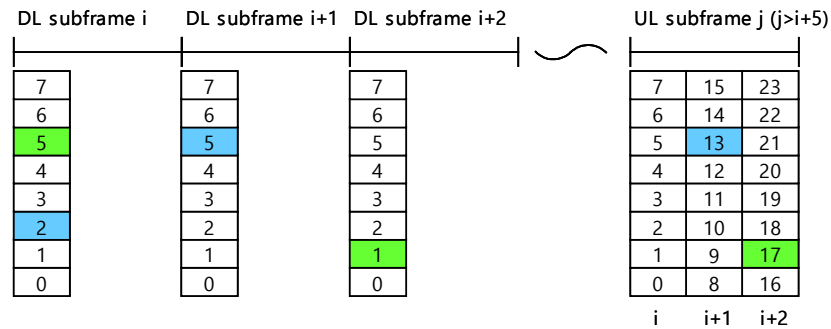
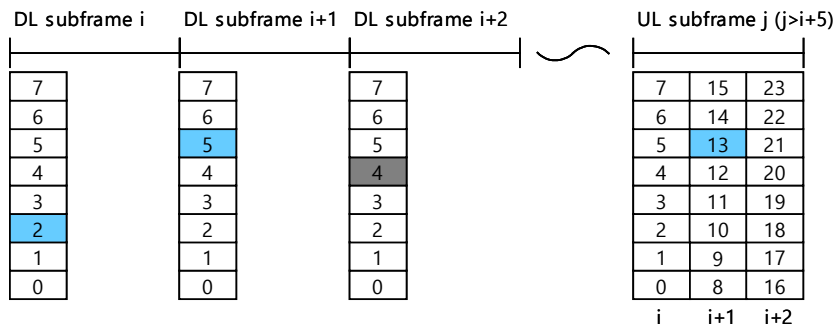


Figure 2 Example of bundled ACK/NACK resource allocation

Figure 3 shows an example when a UE misses the last PDSCH transmission. In this example, eNodeB assigned PDSCH to a (blue) UE in subframe i , $i+1$ and $i+2$ by CCE 2, 5 and 4, but the UE missed assignment in subframe $i+2$. Then, the UE will transmit bundled ACK/NACK using 13th ACK/NACK resource which corresponds to the CCE5 in subframe $i+1$. Therefore, eNodeB can detect that the UE has missed PDSCH assignment in subframe $i+2$.



By combining the two methods above, problem of missing downlink assignment with uplink ACK/NACK bundling can be resolved.

3. Summary

In this contribution, we suggest applying combination of the following two methods to resolve the problem of missing downlink assignment with uplink ACK/NACK bundling.

- When a PDSCH is transmitted to a UE within an ACK/NACK bundling window, scheduling assignment for the PDSCH includes counter of the PDSCH transmission to that UE within that ACK/NACK bundling window.
- A UE transmits bundled ACK/NACK using the ACK/NACK resource corresponding to the CCE in the downlink subframe in which that UE received last PDSCH within a ACK/NACK bundling window

4. References

- [1] R1-081110, 'Multiple ACK/NAK for TDD,' Ericsson, Motorola, Nokia, Nokia Siemens Networks, Qualcomm
- [2] R1-080870, 'Combination of ACK/NACKs for TDD,' Ericsson
- [3] R1-081257, 'Uplink ACK/NACK resource allocation in TDD,' LG Electronics