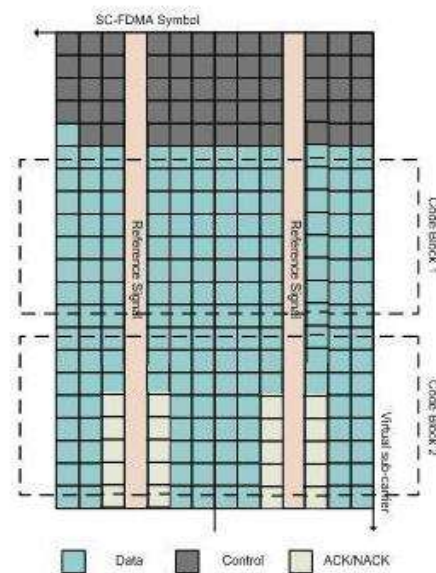


Source: Samsung, LGE, Texas Instruments, Panasonic
Title: Multiplexing of Rank and CQI/PMI in PUSCH Channel
Agenda Item: 7.1.2
Document for: Discussion

1. Introduction

In the 3GPP RAN1#52 meeting in February 2008, the following was agreed for uplink control/data multiplexing according to [3]:

- Multiplexing of control and data on PUSCH
 - ACK/NACK mapping consecutive to RS, CQI time-first mapping
 - A/N resources punctured into data starting from the bottom of the figure below
 - Max number of resources for A/N: 4 SC-FDMA symbols
 - CQI resources placed at the beginning of the data resources



Meanwhile, in the same meeting, the following is agreed for rank, CQI and PMI feedback carried on PUSCH channel [4]

- Aperiodic PUSCH report:
 - Aperiodic reporting of rank information (RI) and CQI/PMI on PUSCH, where RI and CQI/PMI are always reported in the same subframe. The CQI/PMI is calculated assuming the simultaneously reported rank.
- Periodic PUSCH report

- Periodic reporting of RI and CQI/PMI on PUSCH, where RI and CQI/PMI are always reported in the same subframe, and hence reported with the same periodicity. The CQI/PMI is calculated assuming the simultaneously reported rank.

In this contribution, we propose the following for the data, rank, A/N and CQI/PMI multiplexing in PUSCH: Rank should be separately coded from CQI/PMI, and placed next to the A/N bits in PUSCH. Meanwhile, in the case of 2 rank bits, (3,2) simplex code is used to capture the 1dB coding gain.

2. Multiplexing of Rank, CQI/PMI and A/N bits

Two options exist in how to multiplex rank bits together with CQI/PMI and A/N bits

1. Rank bits are jointly coded with CQI/PMI bits;
2. Rank bits are separately coded and on a fixed location in PUSCH. Note (3,2) code mentioned above is applicable to the case of 2 rank bits as well. In the case of 1 rank bit, simple repetition code is sufficient.

Our preference is option 2, since if we use Option 1, the BER performance of the rank bits will be likely similar to the performance of the CQI/PMI bits, which is not desirable since we typically would like to have better protection on the rank bits than the CQI/PMI bits. Furthermore, we think a good location for the rank bits is the REs right next to those assigned to the A/N bits, as shown in Figure 1. We note that results in [5] have shown that by placing the bits 2 OFDM symbols away from the RS, the BER performance of the bits is very similar to the case where it is placed only 1 OFDM symbol away from the RS, even in high speed cases.

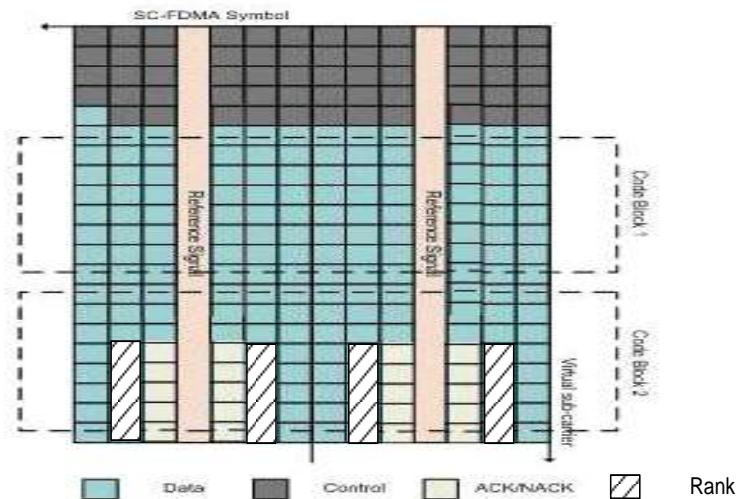


Figure 1: Location of the Rank and A/N bits in PUSCH.

3. (3,2) Simplex coding for 2 rank bits

Table 1: Simplex (3,2) code used for 2 bits bits.

Two information bits (Either A/N bits or Rank bits)	Component codeword $c_1c_2c_3$ (Simplex (3,2) codebook)
00	000
01	011
10	101
11	110

During the study for PCFICH coding, it was well understood that (3,2) simplex codes provides around **1dB** performance gain in most fading channel situations. The situation of 2 bit rank coding is very similar to that of the PCFICH coding, and therefore we suggest to apply the simplex (3,2) code in the case of 2 rank bits to be transmitted in the PUSCH.

The following are proposed for the channel coding of the rank bits, assuming the number of coded bits is Q_{RI} .

Step 1: Map the two rank bits $[o_1^{RI} o_0^{RI}]$ to a 3-bit codeword according to the Simplex (3,2) code shown in table 1.

Step 2: In this step, the codeword $c_1c_2c_3$ is repeated $\lfloor Q_{RI} / 3 \rfloor$ times, and the resulting sequence is concatenated with the first $Q_{RI} - 3\lfloor Q_{RI} / 3 \rfloor$ bits in the codeword $c_1c_2c_3$. This concatenated bit sequence is the final coded bit sequence to be modulated and mapped into channel symbol.

We show an example of the final codewords given by the above two steps, for the case of $Q_{RI} = 8$ in table 2.

Table 2: 2bit rank coding for the case of $Q_{RI} = 8$.

Two Rank bits	Example of Final codeword with $Q_{RI}=8$
00	000 000 00
01	011 011 01
10	101 101 10
11	110 110 11

4. Summary

In summary, we propose the following for the data, rank, A/N and CQI/PMI multiplexing in PUSCH:

1. Rank should be separately coded from CQI/PMI, and placed next to the A/N bits in PUSCH. Meanwhile, in the case of 2 rank bits, (3,2) simplex code is used to capture the 1dB coding gain.

Reference

- [1] R1-081155, "CR to 3GPP spec 36.211 Version 8.1.0", RAN1#52, Feb 2008, Sorrento, Italy
- [2] R1-081157, "CR to 3GPP spec 36.212 Version 8.1.0", RAN1#52, Feb 2008, Sorrento, Italy
- [3] "Chairman's note", 3GPP RAN1#52 meeting, Feb 2008, Sorrento, Italy
- [4] R1-081137, "Summary of AH on AI 6.3.4 "UE Procedures for downlink shared channel"
- [5] R1-081005, "Multiplexing of Control and Data in PUSCH", LGE, Feb 2008, Sorrento, Italy
- [6] R1-081225, "Multiplexing of Rank, CQI and Data in PUSCH", March 2008, Shenzhen, China
- [7] R1-081370, "Coding for control information on PUSCH", March 2008, Shenzhen, China
- [8] R1-081616, "Multiplexing of rank and CQI/PMI in PUSCH channel, March 2008, Shenzhen, China