3GPP TSG RAN WG1 Meeting #76bis **R1-141366**
Shenzhen, China, 31th March– 4th April, 2014

Agenda item: **7.2.4.1**

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Title: **Discussion on CQI/MCS table design for 256QAM**

Document for: **Discussion and Decision**

1 Introduction

In order to introduce the 256QAM modulation, the CQI, MCS and TBS tables need to be re-designed. At RAN1#76 meeting, the 256QAM design principles were discussed and the following agreements were achieved [1]:

Agreement:

- *CQI table*
  - *Support SE in the entire range from X1 bps/Hz to X2 bps/Hz*
  - *Down-sample low CQI entries by removing Y1 entries, and add Y1 new entries for 256QAM region with even spacing*
    - ***Note:*** *One company (Panasonic) express a concern that test and implied spec change is unnecessary high*
  - *CQI #0 to be equaled to out of range*
  - *Switching point of 64QAM and 256QAM should be CQI Z (Z=14 or 15 in the existing table)*
  - *FFS the positions of the CQI entries in the Rel-12 CQI table – to be decided between the following two options*
    - *Option1: order the CQI indices according to the spectral efficiencies]*
    - *Option2: keep the CQI indices the same for the common CQIs between Rel-8 and Rel-12 CQI table*
- *Modulation and TBS index table*
  - *Definition of N (N=3 or 4) reserved entries for adaptive retransmission*
  - *Modulation and TBS table design should provide the support of all the VoIP TBS at least for Format 1A, FFS for Format 2x*
  - *The need of overlapping spectral efficiency of different modulations is FFS*
  - *FFS the position of Modulation and TBS entries in the Rel-12 Modulation and TBS table*

In this contribution, we will further discuss the design for new CQI table and Modulation and TBS index table and provide our suggestions.

2 Discussion

2.1 CQI table design

In order to support 256QAM in downlink for higher spectral efficiency, the new CQI table that include 256QAM need to be defined in the specification. At the RAN1#76 meeting, it was agreed that down-sample low CQI entries by removing Y1 entries, and add Y1 new entries for 256QAM region with even spacing. Therefore, we need to determine how many entries and which entries to be removed from the legacy CQI table.

For the legacy CQI table, it starts with -7dB as the first point and the step size is 1.892dB, the MCSs are derived by uniformly quantizing SNR over the SNR range of [-7, 19.488] dB. Therefore, for the new CQI table, it seems reasonable to follow the previous principle, the 256QAM MCSs could be introduced with the same SNR step size of 1.892dB. Moreover, considering the maximum code rate for 256QAM is about 0.93 and the corresponding SNR to support this MCS is about 25dB. Therefore, the SNRs for 256QAM can be 21.380dB, 23.272dB and 25.164dB. In other words, it is reasonable to introduce three CQI entries for 256QAM transmission with the same SNR step size of 1.892dB to form the new CQI table. Since three new CQI entries will be introduced for 256QAM modulation, three lower entries need to be removed to keep the table size as before. Considering CQI index #0 should be reserved for out of range indication andCQI index #1 should be reserved for PDCCH transmission. Thus, it is reasonable to remove the current CQI entries #2, #4 and #6.

Petitioners' Exhibit 1030
Google et al. v. KT Corporation et al.
IPR2025-00293

Therefore, according to the above analysis, we have the following proposal:

Proposal 1: Current CQI entries #2, #4 and #6 should be removed to down-sample low CQI entries and add three new entries for 256QAM.

If the 256QAM modulation is introduced, the maximum spectral efficiency of the current CQI table will be changed. Considering the maximum efficiency supported by current CQI table is 5.5547, therefore, the maximum spectral efficiency with 256 QAM can be 5.5547×8/6 = 7.4063. In the above section, we proposed to add 3 new entries for 256QAM, so the spectral efficiency of two more 256QAM entries can be 5.1151×8/6 = 6.0313 and 4.5234×8/6 = 6.8203. Moreover, CQI index#1 with spectral efficiency = 0.1523 is used for PDCCH. Therefore, we have the following proposal:

Proposal 2: The new CQI table should support spectral efficiency from 0.1523 bps/Hz to 7.4063 bps/Hz.

For the switching point of 64QAM and 256QAM, we think the 256QAM will outperforms 64QAM when the CQI index is 15 in the current CQI table under frequency selective channel. Therefore, it is reasonable to change the CQI index 15 to 256QAM and the spectral efficiency value should be maintained. For the positions of the CQI entries in the Rel-12 CQI table, there are two options:

- *Option1: order the CQI indices according to the spectral efficiencies*
- *Option2: keep the CQI indices the same for the common CQIs between Rel-8 and Rel-12 CQI table*

Obviously, the option 1 is a straightforward way since the Rel-8 CQI table is designed with the option 1. The main advantage of option 2 is to mitigate the problem of RRC configuration ambiguity during the new CQI table configuration. However, even the option 2 used, the RRC configuration ambiguity still existed since the some QPSK entries are replaced by the 256QAM. Moreover, we can use special DCI format during the RRC configuration ambiguity period to resolve the ambiguity issues. These special DCI formats do not support 256QAM, such as DCI format 1A and DCI format 2C. Therefore, we have the following proposal:

Proposal 3: We suggest that the new CQI table should order the CQI indices according to the spectral efficiencies.

According to the above discussion, we propose the following Table 1 as the new CQI table for a UE configured with 256QAM.

Table 1 4-bit proposed CQI table

CQI index	modulation	code rate x 1024	efficiency
0	out of range		
1	QPSK	78	0.1523
2	QPSK	193	0.3770
3	QPSK	449	0.8770
4	16QAM	378	1.4766
5	16QAM	490	1.9141
6	16QAM	616	2.4063
7	64QAM	466	2.7305
8	64QAM	567	3.3223
9	64QAM	666	3.9023
10	64QAM	772	4.5234
11	64QAM	873	5.1152
12	256QAM	711	5.5547
13	256QAM	772	6.0313
14	256QAM	873	6.8203
15	256QAM	948	7.4063

2.2 Modulation and TBS index table design

In order to align with the CQI table design, some low spectral efficiency MCS entries in the legacy table need to be deleted and 256QAM MCS entries need to be added. According to the design in Table 1, current CQI entries #2, #4 and #6 are removed, thus the MCS entries interpolated by #2, #4 and #6 need to be removed. Moreover, considering don't

removing the MCS entries that directly come from the CQI entries, thus the Modulation and TBS index table entries mapped to CQI entries #2, #4 and #6 are maintained.

Moreover, in Rel-8 Modulation and TBS index table, in order to support both frequency-flat and frequency-selective channel, the overlapping TBS indices between modulation switching points are introduced. Nevertheless, channel under small cell deployment is expected to be frequency-flat. As a result, overlapping TBS indices at each modulation switching point is not necessary. Moreover, considering I_{MCS} = 9 and 16 will be more robust than I_{MCS} = 10 and 17 respectively under small cell deployments. Therefore, we think there is no need to introduce the overlapping TBS indices at modulation switching point and remove I_{MCS} = 10 and I_{MCS} = 17.

Proposal 4: It is not necessary to introduce the overlapping TBS indices at modulation switching point and we suggest to remove I_{MCS} = 10 and I_{MCS} = 17.

Furthermore, in the Rel-8 Modulation and TBS index table, there are three modulation orders and thus three reserved entries for adaptive re-transmission. For the new Modulation and TBS index table, the retransmission procedure may use one of the four modulation schemes. Therefore, it is reasonable to define four reserved entries for adaptive retransmission.

According to the above discussion, we propose the following Table 2 as new Modulation and TBS index table for introducing 256QAM.

Table 2 Proposed Modulation and TBS index table for PDSCH

MCS Index I_{MCS}	Modulation Order Q_m	TBS Index I_{TBS}
0	2	0
1	2	2
2	2	4
3	2	6
4	2	8
5	4	10
6	4	11
7	4	12
8	4	13
9	4	14
10	4	15
11	6	16
12	6	17
13	6	18
14	6	19
15	6	20
16	6	21
17	6	22
18	6	23
19	6	24
20	6	25
21	6	26
22	8	27
23	8	28
24	8	29
25	8	30
26	8	31
27	8	32
28	2	reserved
29	4	
30	6	
31	8	

3 Conclusion

In this contribution, we discuss the CQI/MCS table design for introducing 256QAM and we kindly suggest that RAN1 agree on the following proposals:

Proposal 1: Current CQI entries #2, #4 and #6 should be removed to down-sample low CQI entries and add three new entries for 256QAM.

Proposal 2: The new CQI table should support spectral efficiency from 0.1523 bps/Hz to 7.4063 bps/Hz.

Proposal 3: We suggest that the new CQI table should order the CQI indices according to the spectral efficiencies.

Proposal 4: It is not necessary to introduce the overlapping TBS indices at modulation switching point and we suggest to remove IMCS = 10 and IMCS = 17.

4 References

[1] R1-14xxxx, “Draft Report of 3GPP TSG RAN WG1 #76 v0.2.0”, February, 2014