**3GPP TSG-RAN WG1 #103-e R1-20xxxxx**

**eMeeting, Oct 26th – Nov 13th, 2020**

**Source: Moderator (Ericsson)**

**Title: Summary of Email discussion [103-e-NR-1024QAM-01]**

**Agenda item:** **8.16**

**Document for:** **Discussion and Decision**

# 1 Introduction

This document summarizes the discussions for email thread [103-e-NR-1024QAM-01] under agenda item 8.16 for Introduction of DL 1024QAM for NR FR1.

# 2. Discussion

Below is a short moderator summary based on the tdocs [2-11] submitted for RAN1#103-e.

1. **1024-QAM Constellation** 
   * Most companies propose reuse LTE 1024-QAM constellation [2] [3] [4] [5] [6] [9][10][11]
2. **CQI table with 1024-QAM**
   * Reuse LTE CQI table with 1024-QAM entries [3][4][5][6][7][10] ([9] unless conflicts with MCS table)
   * At least 4 CQI entries for 1024-QAM [2]
   * Remove N entries from 256-QAM table, and add N new entries for 1024-QAM [11]
3. **MCS table with 1024-QAM entries**
   * 5-bit vs 6-bit
     + Most companies seem to be OK with having a 5-bit MCS table [2][3][4][5] [6][7][9][10][11]
     + Some companies also suggest using a six-bit MCS table also [7][11]
       - Six-bit MCS table since five-bit MCS table may lead to reduced number of entries affecting transition point, non-uniform SE between MCS entries, better account for overhead
       - Adopt both 5-bits and 6-bits MCS tables [7]
         * Six-bit MCS table to indicate MCS and an overhead parameter to account for variable overhead.
     + Note the WI objective specifies the DCI overhead for MCS indication should be the same as in Rel-15.
   * MCS design principles
     + Most companies suggest starting with 256-QAM MCS table and remove M entries to accommodate M entries for 1024-QAM MCSes [2][3][4][5][6][7][10][11]
       - Several companies seem to be OK with M=5 [3][4][5][6][7][10], while one company mentioned M = 7 ([2]).
     + Implicit MCS entries
       - Most companies seem to prefer having five total implicit MCS entries with one modulation order per MCS entry ([2][3][4][5][6][7][9][10]) while one company proposed to consider multiple modulation order per MCS entry with less than five total implicit MCS entries([11]).
     + Explicit MCS entries (with modulation order/Target Code rate/Spectral efficiency)
       - Four entries for 1024-QAM [3][4][5][6][7][10]
       - Six entries for 1024-QAM [2]
       - Evaluate more [9][11] (including evaluation assumptions)
       - Regarding M=5 entries to be removed, different alternatives were mentioned:
         * remove {5,7,9,12,14} from the 256-QAM table [4][5][7]
         * remove {6, 8, 10, 12, 14} from the 256QAM table [3]
         * remove {2,4,6,8,10} from the 256-QAM table [10]
         * remove {1,3,5,7,9} from the 256-QAM table [11]
4. **RRC configuration and DCI formats**
   * Configuration of 1024QAM CQI/MCS[3][9][10]
   * DCI formats and RNTIs for which 1024QAM is used/not used [3][5][9][10]
5. **Remaining aspects of 1024-QAM including spec impacts, etc**
   * Specification impacts [6][9][10] – 38.201, 38.211, 38.212 38.214, including
     + PTRS reception procedure
     + LBRM procedure
   * Processing time relaxation [6]
   * UE capability reporting[3]
   * System-level simulation to identify the cell size(s) [2]

# 1st round

### Proposal 1

* For supporting 1024-QAM in NR downlink, adopt the LTE 1024-QAM constellation.

Companies are requested to indicate their view about the above proposal in the Table below.

|  |  |  |
| --- | --- | --- |
| **Company Name** | **support/not support** | **Comments (Proposal 1)** |
| Intel | Support |  |
| Samsung | Support |  |
| vivo | Support |  |
| CATT | Support |  |
| ZTE,Sanechips | Support |  |

### Proposal 2

* For supporting 1024-QAM in NR downlink, adopt the LTE 1024-QAM CQI table.

Companies are requested to indicate their view about the above proposal in the Table below.

|  |  |  |
| --- | --- | --- |
| **Company Name** | **support/not support** | **Comments (Proposal 2)** |
| Intel | Support |  |
| Samsung | Support |  |
| vivo | Support | Suggest to replace the entry {853, 8.3321} by {853, 8.3301} to ensure that the value of SE can be calculated according to the value of code rate. (853/1024\*10≈8.3301) |
| CATT | Support | Fine with vivo’s proposal. |
| ZTE,Sanechips | Support |  |

### Proposal 3

* For supporting 1024-QAM in NR downlink, adopt a five-bit MCS table with 1024-QAM entries.
  + Remove M (=5) entries from the NR 256QAM MCS table and add M new entries for 1024QAM
  + Introduce one implicit MCS entry corresponding to 1024QAM
  + Introduce 4 explicit MCS entries corresponding to 1024-QAM modulation
    - Highest MCS corresponding to code rate 948/1024, 1024-QAM

Companies are requested to indicate their view about the above proposal in the Table below.

|  |  |  |
| --- | --- | --- |
| **Company Name** | **support/not support** | **Comments (Proposal 3)** |
| Intel | Support |  |
| Samsung | Support |  |
| vivo | Support |  |
| CATT | Support |  |
| ZTE,Sanechips | Support |  |

### Discussion point 1

* Indicate your preference on which M=5 MCS entries from 256-QAM can be removed, in order of preference from 1st to last.
  + - Alt 1: remove {5,7,9,12,14} from the 256-QAM table
    - Alt 2: remove {6, 8, 10, 12, 14} from the 256QAM table
    - Alt 3: remove {2,4,6,8,10} from the 256-QAM table
    - Alt 4: remove {1,3,5,7,9} from the 256-QAM table

Companies are requested to indicate their view about the above discussion point in the Table below.

|  |  |  |
| --- | --- | --- |
| **Company Name** | **Preferred Alternative (most preferred first)** | **Comments (Discussion point 1)** |
| Intel | Alt 1 | Low MCS should be kept as they were already sub-sampled for 256QAM, i.e. Alt 3 and Alt 4 are not good options |
| Samsung | Alt. 1 | Do not support alts. 3 and 4 as these are not quite aligned with LTE 1024 QAM table. |
| vivo | Alt 2 | Follow NR MCS table design principle, CQI entries should be kept, so {5,7,9} should be kept as they were already included in the 1024-QAM CQI table. In addition, SE vs SNR curves at BLER=10% in fig.1 indicate that more equally spaced SNR can be obtained by adopting Alt 2, instead of Alt 1.  C:\Users\vivo\AppData\Roaming\vchat\ChatFiles\2020-11\01c68289-1373-4997-83e6-86ce0e04a7cb.png  Fig.1 SE vs SNR curves at BLER=10% by using NR LDPC coding |
| CATT | Alt. 1 |  |
| ZTE,Sanechips | Alt 1 | Firstly, we agree with the comments from Intel.  Secondly, Alt 1 is based on the following agreements in LTE.   |  | | --- | | Agreements in RAN1#90bis:   * For introduction of 1024QAM MCS table:   + Remove M entries from the 256QAM table while maintaining (close to) uniformly spaced SE, while keeping the lowest MCS   + Add M new entries for 1024QAM, with (close to) uniformly spaced SE     - Including 1 entry to support re-transmission with 1024 QAM   Agreements in RAN1#92:  The removed entries from 256QAM table are {5, 7, 9, 12, 14}. |   Hence, we think Alt 1 is aligned with the following objective.   * + Specify corresponding MCS table with 1024QAM entries as defined in E-UTRA |

### Discussion point 2

* Indicate your preference on which 4 explicit MCS entries for 1024-QAM can be added.
  + Alt 1:

|  |  |  |
| --- | --- | --- |
| Modulation Order Qm | Target code Rate R x [1024] | Spectral efficiency |
| 10 | 806 | 7.8711 |
| 10 | 853 | 8.3321 |
| 10 | 900.5 | 8.7939 |
| 10 | 948 | 9.2578 |

* + Alt 2:

|  |  |  |
| --- | --- | --- |
| Modulation Order Qm | Target code Rate R x [1024] | Spectral efficiency |
| 10 | 841 | 8.2129 |
| 10 | 885 | 8.6426 |
| 10 | 916.5 | 8.9502 |
| 10 | 948 | 9.2578 |

* + Alt 3:

|  |  |  |
| --- | --- | --- |
| Modulation Order Qm | Target code Rate R x [1024] | Spectral efficiency |
| 10 | 805.5 | 7.8662 |
| 10 | 853 | 8.3301 |
| 10 | 900.5 | 8.7939 |
| 10 | 948 | 9.2578 |

Companies are requested to indicate their view about the above discussion point in the Table below.

|  |  |  |
| --- | --- | --- |
| **Company Name** | **Preferred Alternative** | **Comments (Discussion point 2)** |
| Intel | Alt 1 | Alt 2 doesn’t have the entry {853, 8.3321} from CQI table |
| Samsung | Alt 1 | According to proposal 2, if LTE CQI table is just reused, alt 1 is straightforward way. |
| vivo | Alt 3 | Prefer to replace the entry {853, 8.3321} by {853, 8.3301} to ensure that the value of SE can be calculated according to the value of code rate. (853/1024\*10≈8.3301)  Then for {805.5, 7.8662}, which SE is closer to the mean of the SEs of the previous and next entries compared to{806, 7.8711}, can be obtained by interpolating. |
| CATT | Alt 1 or Alt 3 |  |
| ZTE,Sanechips | Alt 1 | We support Alt 1. Reasons are as follows:   1. The spacing of SE in Alt1 is uniform, which satisfies with the following agreements in LTE, but it is obvious that the SE spacing in Alt2 is unequal .   Agreements in RAN1#90bis:   * For introduction of 1024QAM MCS table:   + Remove M entries from the 256QAM table while maintaining (close to) uniformly spaced SE, while keeping the lowest MCS   + Add M new entries for 1024QAM, with (close to) uniformly spaced SE     - Including 1 entry to support re-transmission with 1024 QAM  1. Alt 1 includes the entry {853, 8.3321} from CQI table, but Alt 2 does not. 2. Simulation results in R1-2007977 show an equal SNR spacing between the adjacent MCS entries of Alt 1. |

### Proposal 5

* Introduce new RRC signaling to indicate use of 1024-QAM CQI table.

|  |  |  |
| --- | --- | --- |
| **Company Name** | **support/not support** | **Comments (Proposal 5)** |
| Intel | Support |  |
| Samsung | Support |  |
| vivo | Support |  |
| CATT | Support |  |
| ZTE,Sanechips | Support |  |

### Proposal 6

* Introduce new RRC signaling to indicate use of 1024-QAM MCS table for DCI format 1\_1.

Companies are requested to indicate their view about the above proposal in the Table below.

|  |  |  |
| --- | --- | --- |
| **Company Name** | **support/not support** | **Comments (Proposal 6)** |
| Intel |  | The proposal should be modified to include “at least for DCI format 1\_1” given the discussion point #3 |
| Samsung | Support |  |
| vivo | Support |  |
| CATT | Support | Agree with Intel’s addition. |
| ZTE,Sanechips | Support |  |

### Discussion point 3

* Can 1024-QAM MCS table can be used with DCI format 1\_2 ?
  + If yes, indicate your preferred alternative for enabling it.
    - Alt 1: Separate RRC signaling is used for DCI format 1\_2
    - Alt 2 : Same RRC signaling applies to both DCI format 1\_1 and DCI format 1\_2

Companies are requested to indicate their view about the above discussion point in the Table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Company Name** | **Yes/No** | **Preferred Alternative (if yes)** | **Comments (Discussion point 3)** |
| Intel | Yes | Alt 2 | Open to consider DCI specific modulation, but the gains should be justified. |
| Samsung | Yes | Alt. 1 | Can provide better flexibility. It is noted that almost RRC parameters for DCI format 1\_2 have been designed separately with DCI format 1\_1. No strong point to have same RRC signaling. |
| vivo | No |  | DCI format 1\_2 is used for URLLC scheduling, the motivation is unclear to use 1024QAM to achieve high reliability and low latency. |
| CATT | Yes | Alt. 1 | Agree with Samsung. |
| ZTE,Sanechips | No |  | DL 1024QAM is mainly deployed in FWA, IAB backhaul link and CPE link,etc. DCI format 1\_2 is designed for URLLC. Hence, 1024-QAM MCS table cannot be used with DCI format 1\_2. |

### Proposal 7

* 1024-QAM MCS table can be used only with DCI format with CRC scrambled by C-RNTI or CS-RNTI.

Companies are requested to indicate their view about the above proposal in the Table below.

|  |  |  |
| --- | --- | --- |
| **Company Name** | **support/not support** | **Comments (Proposal 7)** |
| Intel | Support |  |
| Samsung | Support |  |
| vivo | Support |  |
| CATT | Support |  |
| ZTE,Sanechips | Support |  |

# 2nd round proposals (TBD)

Including spec impacts, etc

# 3 Conclusions

TBD

# 4 References

1. *[RP-202044](http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_89e/Docs/RP-202044.zip),* New WID on Introduction of DL 1024QAM for NR FR1, RAN Meeting #89e,Sep 2020
2. R1-2007617 On support of DL 1024QAM for NR FR1 Huawei, HiSilicon
3. R1-2007700 On supporting DL 1024QAM for NR FR1 vivo
4. R1-2007846 DL 1024QAM for NR FR1 CATT
5. R1-2007977 Discussion on DL 1024QAM for NR FR1 ZTE
6. R1-2008201 Discussion on DL 1024QAM for NR FR1 Samsung
7. R1-2009009 Support of 1024QAM Intel Corporation
8. R1-2009171 Work plan on supporting 1024 QAM Rapporteurs (Nokia, Ericsson)
9. R1-2009172 Considerations for NR DL 1024 QAM in FR1 Nokia, Nokia Shanghai Bell
10. R1-2009209 1024QAM for NR DL Ericsson
11. R1-2009282 Introduction of 1024-QAM modulation for NR PDSCH Qualcomm Incorporated