3GPP TSG RAN WG1 Meeting #92bis R1-180xxxx

Sanya, China, April 16th – 20th, 2018

Source: Ericsson

Title: Offline Discussion on Support of Separate CQI and MCS table(s) for URLLC

Agenda Item: 7.2.1

Document for: Discussion and Decision

# Introduction

In RAN1 #90bis and #92, the following agreements on CQI and MCS tables for URLLC have been made.

**Agreement:**

* N separate CQI table(s) are supported for URLLC
  + Downselect the value of N between 1 or 2
* Two target BLER are supported for URLLC
  + Note: RRC signalling is used by gNB to select one of the two target BLER
  + Note: The configuration of target BLER or CQI table is part of CSI report setting

**Agreements:**

* The two BLER targets for CQI reporting that are configurable for URLLC are to be down-selected from one of the following options:
* Option A. (10-1, 10-4)
* Option B. (10-1, 10-5)
* Option C. (10-3, 10-5)
* Option D. (10-2, 10-4)
* Companies are encouraged to consider the following when performing evaluations for down-selection of BLER targets for CQI reporting, e.g.,
  + Resource efficiency: e.g., number of RE occupied, probability of blocking
  + Feasibility of UE producing accurate CQI estimation for CQI reporting. Each company can provide views from their perspective. Assume existing definition of CSI reference resource.
  + The distance in SNR (dB) between the two target is sufficient to generate distinct CQI in typical operation.
  + UE complexity of being able to generate CQI report for 3 BLER targets (e.g., Option (C) and (D) in certain cases) vs 2 BLER targets (Option (A) and (B))
  + achieved latency

Conclusion:

* Regarding the number of CQI table to define for URLLC, finalize after the two BLER targets values for CQI reporting are agreed

**Agreements:**

* For new CQI table and MCS table constructed specifically for URLLC, 256QAM is not included.
* Lowest spectral efficiency in any/all CQI table is not lower than 30/1024 \* 2 (QPSK)
* Highest spectral efficiency in any/all CQI table is not greater than a value, where the value is selected from one of the following:
  1. 666/1024 \* 6
  2. 772/1024 \* 6
  3. 873/1024 \* 6
  4. 948/1024 \* 6
* Lowest spectral efficiency in any/all MCS table is not lower than 30/1024 \* 2.
* Highest spectral efficiency in any/all MCS table is not greater than a value, where the value is selected from the following:

1. 666/1024 \* 6
2. 772/1024 \* 6
3. 873/1024 \* 6
4. 948/1024 \* 6

**Agreements:**

* Only single transport block (i.e., a single CW) transmission is supported for URLLC in Rel-15.

This contribution provides a summary of offline discussion on the support of separate CQI/MCS tables for URLLC.

# Discussion on BLER Targets

In the following, the rationale provided by the proponents for supporting the various BLER targets are listed.

**Higher BLER target:**

* Reasons to support BLER target = 10-1:
  + 10-1 BLER target should be supported because it allows for reducing the complexity at the UE side and reduce the CSI overhead while minimizing the specifications effort wrt. eMBB. Configuring a UE with more than two BLER targets requires increased processing time and complexity. [4][9][12][13][14][15][5]
  + BLER target of 10-1 gives higher transmission efficiency than 10-2 and 10-3. [2][4][11]
  + BLER target of 10-1 allows UE to be less conservative in reporting CQI compared to lower BLER target values. A low BLER target will cause the UE to underreport the achievable spectral efficiency. [5]
* Reasons to support BLER target = 10-2:
  + BLER target of 1e-2 gives good SNR spacing to the lower BLER target. [13]
* Reasons to support BLER target = 10-3:
  + CQI reporting target BLER=10-3 is useful for gNB scheduling if UE is configured with repetition factor of 2 which may be the typical configuration considering the stringent latency requirement [3][6][16][1]
  + There may be URLLC services with relaxed BLER requirement compared with 10-5. [6][1]

The table below summarizes the supporters of higher BLER target options.

|  |  |
| --- | --- |
| **Higher BLER target** | **Supported by** |
| 10-1 | (9): AT&T, Intel, MediaTek, Panasonic, Qualcomm, Samsung, ZTE, E///, LG |
| 10-2 | (1): Nokia |
| 10-3 | (6): CATT, CMCC, E///, Huawei, Oppo, InterDigital |

**Lower BLER target:**

* Reasons to support BLER target = 10-4:
  + HARQ transmission based on target BLERs (10-1, 10-4) has better resource utilization rather than one shot transmission with 10-5. [11][5]
  + Accurate CQI for 10-5 is more difficult than 10-4 for UE implementation. Increased complexity for developing CQI estimation algorithm. [11][13]
  + There may be URLLC services with relaxed BLER requirement compared with 10-5. [11][13]
  + Very low BLER target value for CQI reporting might result in increased testing time from RAN4 perspective. [14]
  + CQI reporting with a very low BLER target can only be practically used under static channel conditions and with reasonably accurate CSI measurement. [5]
  + UE will significantly underreport the CQI when the BLER target is 1e-5. Additional margin needs to be built in the spectrum efficiency to CQI mapping to meet very low BLER target, since BLER becomes sensitive to many aspects of channel condition variations and estimation accuracies. [5]
  + BLER target of 1e-4 and 1e-5 are close enough that gNB can extrapolate from 1e-4 to 1e-5 with reasonable accuracy. [5][13]
* Reasons to support BLER target = 10-5:
  + There are many cases that only one-shot transmission should be supported considering the various numerologies and configurations. URLLC reliability requirement is 10-5. [1][2][3][6][10][12][15][16]
  + PDCP duplication is applicable only to CA or DC cases. The URLLC requirement needs to be fulfilled in the single carrier case. [1]
  + Without the introduction of target BLER of 1e-5 for CQI reporting, it is more difficult to claim that the URLLC performance can always be guaranteed. [1][2][10]
  + CQI reporting target BLER= 10-5 can be directly used for configurations where HARQ retransmission is not possible (or very limited) due to the latency constraint. [2][3]
  + If gNB performs extrapolation to schedule for BLER target 10-5, accuracy of such extrapolation can be very poor since UE capabilities are unknown. CQI reported by the UE takes channel condition and receiver algorithm into account. gNB has no knowledge of CQI reporting aspects that are dependent of UE implementation. [1][2][3]

The table below summarizes the supporters of lower BLER target options.

|  |  |
| --- | --- |
| **Lower BLER target** | **Supported by** |
| 10-4 | (4): Nokia, Panasonic, Qualcomm, Samsung |
| 10-5 | (10): AT&T, CATT, CMCC, E///, Huawei, Oppo, Intel, InterDigital, MediaTek, ZTE |

Outcome of offline discussion:

Proposal 1. The two BLER targets that are configurable for URLLC are:

* Option B. (10-1, 10-5)

Note: The definition of the test case for the BLER target of 10-5 should take into account channel and interference variations and estimation errors.

# Discussion on CQI Tables

## Number of CQI tables

For further discussion

* Alternative 1: URLLC uses two tables, one for each BLER target
* Alternative 2: URLLC uses a single CQI table for both BLER targets

## Highest spectral efficiency in any/all CQI table

Regarding the threshold for highest spectral efficiency in CQI table, the table below summarizes companies view.

|  |  |  |
| --- | --- | --- |
| **Highest SE in CQI table (/1024)** | **Reasons to support** | **Supporting companies** |
| 666 | - Code rate 666/1024 corresponds to rate 2/3 thus only LDPC BG2 is used for URLLC when TBS<=3824 bits  - Code rates higher than 666/1024 is not typical for URLLC | (5): ZTE, LG, Nokia, InterDigital, Qualcomm |
| 772 | - Code rates higher than 772/1024 is not typical for URLLC, and  - 772/1024 provides higher spectral efficiency than 666/1024 | (2): Qualcomm, InterDigital |
| 873 | - There is substantial percentage of URLLC UEs that experience high SNR and would benefit from high SE entry of 873/1024  - Removing the highest SE entry (948/1024) allows introducing a new CQI entry without increasing the CQI table size | (8): CATT, E///, MediaTek, ZTE, Panasonic, Intel, OPPO, Samsung |
| 948 | - There is substantial percentage of URLLC UEs that experience high SNR and would benefit from high SE entry of 948/1024 | (1): Huawei |

Outcome of offline discussion:

* Highest spectral efficiency in any/all CQI table introduced for URLLC is not greater than a value, where the value is selected from one of the following:

1. 666/1024 \* 6
2. ~~772/1024 \* 6~~
3. 873/1024 \* 6
4. ~~948/1024 \* 6~~

## CQI entries

For further discussion:

Possible design principles:

* Reuse majority of entries in the existing eMBB 64QAM CQI tables.
* FFS

# Discussion on MCS Tables

## Number of MCS tables

For further discussion:

* For a given DCI format, no new DCI field is introduced to indicate the selection of MCS table.

Companies that have concern of the above: Huawei, Nokia

For further discussion:

* For CP-OFDM, the total number of MCS tables available for scheduling URLLC service:
  + Alternative 1: URLLC uses a single MCS table
  + Alternative 2: URLLC uses two MCS tables
  + Alternative 3: URLLC uses three MCS tables

## Highest spectral efficiency in any/all MCS table

Outcome of offline discussion:

* Highest spectral efficiency in any/all MCS table introduced for URLLC is not greater than a value, where the value is selected from one of the following:

1. 666/1024 \* 6
2. ~~772/1024 \* 6~~
3. 873/1024 \* 6
4. ~~948/1024 \* 6~~

# Conclusions

In this contribution, the following is proposed according to offline discussion:

Proposal 1. The two BLER targets that are configurable for URLLC are:

* Option B. (10-1, 10-5)

Note: The definition of the test case for the BLER target of 10-5 should take into account channel and interference variations and estimation errors.

Offline discussion indicates that two existing agreements can be potentially updated to the following.

Potential proposals:

* Highest spectral efficiency in any/all CQI table introduced for URLLC is not greater than a value, where the value is selected from one of the following:

1. 666/1024 \* 6
2. ~~772/1024 \* 6~~
3. 873/1024 \* 6
4. ~~948/1024 \* 6~~

* Highest spectral efficiency in any/all MCS table introduced for URLLC is not greater than a value, where the value is selected from one of the following:

1. 666/1024 \* 6
2. ~~772/1024 \* 6~~
3. 873/1024 \* 6
4. ~~948/1024 \* 6~~

# References

1. R1-1803661 MCS/CQI design for URLLC Huawei, HiSilicon
2. R1-1805515 Considerations on CQI /MCS table(s) and related aspects for URLLC ZTE, Sanechips (Revision of R1-1803800)
3. R1-1803919 CQI and MCS Tables for URLLC Ericsson
4. R1-1804739 CQI and MCS tables for NR URLLC Intel Corporation
5. R1-1805511 Considerations for CQI and MCS for URLLC Qualcomm Incorporated (Revision of R1-1804817)
6. R1-1803765 CQI and MCS design for NR URLLC CATT
7. R1-1803845 Discussion on CSI report for URLLC vivo
8. R1-1804009 CQI and MCS design for URLLC OPPO
9. R1-1804078 On CQI and MCS Design for URLLC MediaTek Inc.
10. R1-1804105 Discussion on BLER requirement for URLLC CMCC
11. R1-1805519 CQI and MCS Tables for URLLC Samsung (Revision of R1-1804389)
12. R1-1804569 Discussion on CQI and MCS table design for URLLC LG Electronics
13. R1-1804615 Remaining details of CQI and MCS for URLLC Nokia, Nokia Shanghai Bell
14. R1-1804641 On details of CQI and MCS tables for NR URLLC Panasonic
15. R1-1804658 CQI/MCS table design for URLLC AT&T
16. R1-1804851 Remaining Details of CQI and MCS Tables for URLLC InterDigital, Inc.