**3GPP TSG RAN WG1 #109-e R1-2205173**

**e-Meeting, May 9th – 20th, 2022**

**Source: Moderator (Intel Corporation)**

**Title: Summary#1 of AI: 9.9.1 NR PDCCH reception in symbols with LTE CRS REs**

**Agenda item: 9.9.1**

**Document for: Discussion and Decision**

# Introduction

In RAN#94-e meeting a work item on enhanced MIMO support was agreed for Rel-18 [1]. The objectives of the WID include enhancements to NR PDCCH reception as shown below:

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| The following objectives shall be included for improvement of NR spectrum efficiency for LTE-NR co-existence (RAN1):• Study and if needed specify NR PDCCH reception in symbols with LTE CRS REs. [RAN1] |

This document contains summary of the companies’ and moderator’s proposals.

# Review and observations

The following are observations from the FL based on tdoc review. This is not meant for agreement.

Multiple companies point out that the following existing methods enabling NR PDCCH capacity for DSS:

* UE supporting FG 3-2, FG 3-5, or the newly introduced Rel-16 UE capability to support monitoring PDCCH within the first 4 symbols.
* Rel-17 SCell PDCCH scheduling P(S)Cell PDSCH/PUSCH

Multiple companies point out the following consideration for UE implementation:

* Increase in UE complexity for channel estimation due to irregular DM-RS patterns for certain types of puncturing. The DMRS mapping/pattern may depend on the LTE-CRS pattern/configuration or PDCCH monitoring occasion.

Performance related:

* Multiple companies point out that enabling NR PDCCH reception in symbols with LTE CRS REs bring additional symbols for NR PDCCH allocation which contributes to NR PDCCH system capacity gain (e.g. 2 NR PDCCH symbols overlapped with 1 CRS symbol with puncturing improves the PDCCH capacity compared with 1 NR PDCCH symbol)
	+ For individual link performance a UE using a higher AL with puncturing (AL=2X) compared to the case with no puncturing and lower AL (AL=X) show gains. Higher AL compensates for loss due to puncturing.
	+ At least one company points out that the extent of gain over the existing capability of monitoring PDCCH in the first 4 symbols without puncturing may not be significant
* Multiple companies point out that the benefits of a potential Rel-18 solution depend on various factors including the ratio of UEs supporting legacy FGs, co-existence of LTE PDCCH/PCFICH/PHICH, number of LTE CRS ports and CRS BW relative to NR system BW.

# Enhancements for NR-PDCCH for DSS

## Possible specifications impact

Some companies have mentioned new or modified DMRS patterns for NR-PDCCH but given the TUs for this WID, such option is not included in this round. Pls. comment if you feel otherwise.

**Proposal #1:**

* Tx procedure: In the REs comprising an OFDM symbol that is overlapped between a NR-PDCCH candidate and LTE-CRS:
	+ Option-1: No NR-PDCCH-DMRS is transmitted, NR-PDCCH is transmitted on REs not colliding with LTE-CRS, NR-PDCCH is punctured on REs colliding with LTE-CRS, NR-PDCCH must span at least 2 consecutive symbols with at least 1 symbol not overlapping with LTE-CRS
	+ Option-2: NR-PDCCH or NR-PDCCH-DMRS is transmitted on REs not colliding with LTE-CRS, NR-PDCCH and NR-PDCCH-DMRS is punctured on REs colliding with LTE-CRS
	+ Option-3: NR-PDCCH or NR-PDCCH-DMRS is transmitted on REs colliding as well as not colliding with LTE-CRS (superposition)
* Applicability (in addition to UE feature):
	+ Case-1: Applicable to NR-PDCCH candidate spanning 2 [or 3] consecutive symbols where the first 1 [or 2] symbol is overlapping with LTE CRS
	+ Case-2: Applicable to NR-PDCCH reception within the first 3 [or 4] consecutive symbols in a slot
	+ Case-3: Not applicable to Type-0/0A/1/2 CSS SS-sets reception
	+ Case-4: No additional applicability restrictions
* NR-PDCCH reception with LTE CRS REs: A UE is expected to monitor a PDCCH candidate where at least one RE of the candidate is overlapping with LTE-CRS according to one of the following options (other options not precluded):
	+ Option-1: Tx procedure option-1 + Applicability cases-1, 2, 3
	+ Option-2: Tx procedure option-2 + Applicability case-4
	+ Option-3: Tx procedure option-2, 3 + Applicability cases-1, 2

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# Evaluation assumptions

## LLS assumptions

**Proposal #2:** LLS simulations assumptions:

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| **Parameters** | **Values** |
| Carrier frequency | 2 GHz |
| SCS | 15 kHz  |
| Bandwidth  | 10 MHz |
| Channel model | TDL-C 300-100 |
| Correlation | Low |
| Number of BS antennas | 4 Tx (Two cross-polarized antenna pairs) |
| Number of UE antennas | 2 Rx (One cross-polarized antenna pair) |
| DCI payload (excluding CRC) | 60 bits |
| Interleaving | Non-Interleaved |
| Precoding | Precoder cycling per REG bundle |
| REG bundle size | 6 PRBs |
| CRS | 4 port CRS |
| Channel estimation | practical – companies to report details |
| CORESET configuration | companies to report |

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## SLS assumptions

**Proposal #3:** SLS simulations assumptions:

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| **Parameters** | **Values** |
| Carrier frequency | 2.1 GHz |
| SCS | 15 kHz |
| Simulation bandwidth  | 20 MHz |
| BS antenna height | 25 m |
| UE height | 1.5m  |
| TRP transmit power | 49 dBm 20 MHz |
| Scenario | Urban Macro |
| ISD | 500m |
| Device deployment | 80% indoor, 20% outdoor  |
| UE speeds | Indoor users: 3km/h |
| Outdoor users (in-car): 30 km/h |
| BS noise figure | 5 dB |
| BS antenna element gain | 8 dBi |
| UE noise figure | 9 dB |
| Thermal noise level | -174 dBm/Hz |
| Traffic | Full Buffer |
| Macro sites | 19 |
| Downtilt | 102° |
| Minimum BS to UE distance | 35m |

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# References

[1] RP-213575, New WI: Enhancement of NR Dynamic spectrum sharing (DSS), Ericsson, 3GPP TSG RAN Meeting #94e, Electronic Meeting, Dec. 6 - 17, 2021.

[2] R1-2203137, Discussion on NR PDCCH reception in symbols with LTE CRS REs Huawei, HiSilicon

[3] R1-2203210 Discussion on NR PDCCH reception for DSS ZTE

[4] R1-2203344 Discussion on NR PDCCH reception in symbols with LTE CRS Res Spreadtrum Communications

[5] R1-2203581 Discussion on PDCCH reception on CRS symbol vivo

[6] R1-2203648 Evaluation of NR PDCCH overlapping with LTE CRS InterDigital, Inc.

[7] R1-2203834 Discussion on NR PDCCH reception in symbols with LTE CRS REs xiaomi

[8] R1-2203923 Considerations on PDCCH receptions in symbols with LTE CRS Samsung

[9] R1-2204024 Discussion on NR PDCCH reception in symbols with LTE CRS REs OPPO

[10] R1-2204260 Discussion on NR PDCCH reception in symbols with LTE CRS REs Apple

[11] R1-2204323 Discussion on NR PDCCH reception in symbols with LTE CRS REs CMCC

[12] R1-2204395 Discussion on NR PDCCH reception in symbols with LTE CRS REs NTT DOCOMO, INC.

[13] R1-2204630 Discussion on NR PDCCH reception in symbols with LTE CRS REs LG Electronics

[14] R1-2204709 Discussion on NR PDCCH reception in symbols with LTE CRS REs MediaTek Inc.

[15] R1-2204815 Discussion on NR PDCCH reception in DSS Intel Corporation

[16] R1-2204823 NR PDCCH overlapping with LTE CRS Nokia, Nokia Shanghai Bell

[17] R1-2204885 NR PDCCH reception in symbols with LTE CRS REs Ericsson

[18] R1-2205049 NR PDCCH reception in symbols with LTE CRS REs Qualcomm Incorporated

# Appendix (Summary of the agreements)

The agreements made in RAN1#TBD meetings are provided below.