**3GPP TSG-RAN WG4 Meeting #109 R4-232xxxx**

**Chicago, US, November 13 – 17, 2023**

**Agenda item:** 8.18.4

**Source:** Apple

**Title:** Offline meeting minutes for [109] [323] NR\_demod\_enh3\_Part1

**Document for:** Information

# Introduction

This contribution summarizes the discussion on select open issues, candidate options as well as the recommended WF for the advanced receiver for MU-MIMO part of the Rel-18 NR demodulation requirement evolution WI under agenda 8.18.

# Topic #1: Receiver assumption and NWA signaling

### Sub-topic 1-4 UE capability aspects

**Issue 1-3-1: Capability signalling for advanced receiver for MU-MIMO**

* Status in the last meeting WF in R4-2316915

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| --- |
| *UE advanced receiver to cancel inter-user interference for MU-MIMO is an optional feature with UE capability signalling**Candidate options on capability definition for R-ML with modulation order blind detection:** + *Option 1: Blind modulation order detection is based on UE capability signaling*
		- *Option 1A: Define different capability in the scenarios indicated by DCI index 6 and 7 respectively*
		- *Option 1B: Introduce 3 level UE capabilities: 1) Low-end UE: Support DCI 0-5; 2) Medium-end UE supporting DCI 0-6; 3) High-end UE supporting DCI 0-7*
	+ *Option 2: Blind modulation order detection is based on UE declaration*

*Candidate options on capability definition for Maximum number of layers:** + *Option 1: Introduce UE capability for Maximum number of layers of co-UE or total number of layers for joint detection*
	+ *Option 2: Not to introduce such capability definition*
		- *Option 2A: The maximum number of layers of co-UE can be derived by subtracting the scheduled MIMO layers for the target UE from maxNumberMIMO-LayersPDSCH*

*Candidate options on capability definition for Maximum number of DMRS ports:** + *Option 1: Introduce UE capability signalling for maximum DMRS ports to be detected*
	+ *Option 2: Not to introduce such capability definition*

*Candidate options on capability definition for Maximum modulation orders of interfering DMRS ports supported:** + *Option 1: UE capability signaling to inform network of the maximum modulation orders of interfering DMRS port supported*
	+ *Option 2: Not to introduce such capability definition*
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* Proposals on capability definition for R-ML with modulation order blind detection:
	+ Option 1: Blind modulation order detection is based on UE capability signaling (MTK, Apple, Nokia, Samsung, ZTE, Spreadtrum)
		- Option 1A: Define different capability in the scenarios indicated by DCI index 6 and 7 respectively (Spreadtrum)
		- Option 1B: Introduce 3 level UE capabilities: 1) Low-end UE: Support DCI 0-5; 2) Medium-end UE supporting DCI 0-6; 3) High-end UE supporting DCI 0-7 (MTK)
	+ Option 2: Blind modulation order detection is based on UE declaration (Qualcomm, Huawei)
* Proposals on capability definition for Maximum number of layers:
	+ Option 1: Introduce UE capability for Maximum number of layers of co-UE or total number of layers for joint detection (Spreadtrum)
	+ Option 2: Not to introduce such capability definition (China Telecom, MTK, Apple, Ericsson, ZTE, Huawei, Samsung if the max number of layers is no more than 4)
		- Option 2A: The maximum number of layers for R-ML (target +co-UE(s)) is upper bounded by UE capability of *maxNumberMIMO-LayersPDSCH*. (MTK, Apple, Ericsson, Spreadtrum, Nokia)
* Proposals on capability definition for Maximum number of DMRS ports:
	+ Option 1: Introduce UE capability signalling for maximum DMRS ports to be detected. (MTK, Apple, Nokia, ZTE)
	+ Option 2: Not to introduce such capability definition (China Telecom, Spreadtrum, Huawei, Samsung if the max number of DMRS ports is no more than 4)
* Proposals on capability definition for Maximum modulation orders of interfering DMRS ports supported:
	+ Option 1: UE capability signaling to inform network of the maximum modulation orders of interfering DMRS port supported (MTK, Nokia, Ericsson, Spreadtrum)
	+ Option 2: Not to introduce such capability definition (China Telecom, ZTE, Huawei, Samsung if the max number of DMRS ports is no more than 4)
* Proposals on capability definition for supported DMRS configurations:
	+ Option 1: Introduce UE capability signaling for supported DMRS configuration for R-ML (Apple)
* Recommended WF
	+ For R-ML with modulation order blind detection:
		- Need discussion.
	+ For Maximum number of layers and Maximum number of DMRS ports:
		- Need further check the necessity after UE types definition is made in Issue 1-1-1.
	+ For Maximum modulation orders of interfering DMRS ports:
		- Need discussion.
	+ For supported DMRS configurations:
		- Need discussion.

Agreements/ Options

1. Basic capability - UE capability for advanced receiver for MU-MIMO [Already agreed, need to discuss components]

Agreement: Agreed online
The basic UE capability with R-ML receiver for MU-MIMO (for all UE types):

* UE is capable of MU-MIMO with R-ML for 2 layers across target and co-scheduled UEs under 2RX conditions
* UE is capable of MU-MIMO with R-ML up to 2,3, or 4 layers across target and co-scheduled UEs under 4RX conditions
1. UE Types

Agreement: Agreed online

The UE Types to be covered in terms of #layers it can process with R-ML:

1. Capability when modulation order is signaled (index 1-5)
	1. Up to *maxNumberMIMO-LayersPDSCH* layers across target and co-scheduled UEs in 2 RX and 4RX condition
2. Capability when modulation order is not signalled (index 6)
	1. UE cannot support R-ML
	2. UE can support 2 layers across target and co-scheduled UEs with 2RX and 4RX
	3. UE can support 2 layers across target and co-scheduled UEs with 2RX and can support *maxNumberMIMO-LayersPDSCH* layers across target and co-scheduled UEs with 4RX
3. Capability when modulation order is not signalled (index 7)
	1. UE is not expected to support R-ML
4. For R-ML with blind modulation order detection
	* Option 1: Blind modulation order detection is based on UE capability signaling (MTK, Apple, Nokia, Samsung, ZTE, Spreadtrum)
		1. Option 1A: Define different capability in the scenarios indicated by DCI index 6 and 7 respectively (Spreadtrum)
		2. Option 1B: Introduce 3 level UE capabilities: 1) Low-end UE: Support DCI 0-5; 2) Medium-end UE supporting DCI 0-6; 3) High-end UE supporting DCI 0-7 (MTK)
	* Option 2: Blind modulation order detection is based on UE declaration (Qualcomm, Huawei)
5. For Maximum number of layers
	1. Option 1: Introduce UE capability signalling for maximum DMRS ports to be detected. (MTK, Apple, Nokia, ZTE)
	2. Option 2: Not to introduce such capability definition (China Telecom, Spreadtrum, Huawei, Samsung if the max number of DMRS ports is no more than 4)

Offline Recommended WF:

We don’t need to discuss this as we have covered this in different UE types.

MTK: IN this WI we have 4 ports since we only consider DMRS type 1+len 1.

Mod: This is for total #layers to be processed

Tentative agreement:

Don’t define separate UE capability on # layers. This is discussed in UE types.

1. For Maximum number of DMRS ports
	* Option 1: Introduce UE capability signalling for maximum DMRS ports to be detected. (MTK, Apple, Nokia)
	* Option 2: Not to introduce such capability definition (China Telecom, Spreadtrum, Huawei, Samsung if the max number of DMRS ports is no more than 4, ZTE)

Offline Recommended WF:

Further discuss. This is related to number of ports UE can detect, not process.

QC: Detecting ports itself doesn’t help, since the # of layers processed is already up to 4.

MTK: UE can detect more ports than ports you need to process. UE has to down select the ports to process

Spreadtrum: Why number of DMRS ports detected matters. How this is used by scheduler

MTK: We could limit it to 4 port DMRS

HW: Understand MTK’s concern. It is difficult to expect gNB to help UE to reduce the effort on DMRS port detection. BS can assume UE to perform MMSE-IRC to cancel inter-layer interference.

Apple: UE has more ports to detect in depending on DMRS config, although the number of layers is max 4, it has to detect up to 11 ports potentially in DMRS type 2 len 2 config.

QC: When DMRS total number of ports > 4in an ideal world the UE and NW should be in sync. In this case we leave it to UE implementation. Only UE can indicate, but NW cannot limit or honor the # of ports. We can only limit the total # layers. Its up to UE implementation how it detects up to 4.

HW: In the real deployment BS will always try to reduce the interference from TX side, will not consider the receiver side interference. This capability report to the BS may restrict the MU-MIMO scheduling schemes, and potentially increase complexity of scheduling.

Ericsson: Share similar view as HW. In MU-MIMO transmission if we limit the #of layers as UE reports, the NW will consider the whole situation to schedule the layers. NW can still transmit 8 layers with MU-MIMO. From NW point this capability is not useful. If UE can only process 4 ports, the benefit is not large compared to processing 4 and detecting 6 ports

Spreadtrum: As E// and QC said – UE should find out the strongest interference ports at RX side, this is UE capability to implement R-ML for MU-MIMO. For R15 DMRS config, then UE can handle. Now with R18 eDMRS, it can be up to 24 ports. Can we add some capability of DMRS type or configuration.

QC: R18 is out of scope, only limit to R15.

Spreadtrum: What scheduler can do to reduce UE side BD complexity for DMRS ports. UE has to find the exact co-scheduled ports by itself. Can gNB inform or aid UE in someway to limit its search – with a range

HW: What is the tentative agreement trying to capture? There is no use of the capability reporting.

QC: This is understanding of R-ML processing. If 8 ports are scheduled, cannot expect UE to detect all 8 and process 8 ports. This agreement is saying that UE will only try to detect up to 4 ports and process up to 4 ports

Nokia: No big concerns on detecting lot of ports to select the best 4. If there is a way to potential help the UEs in its search to detec the ports

Tentative agreement:

There is no UE capability for # of DMRS ports to detect. The UE is expected to detect up to 4 ports. It’s up to UE implementation which ports are detected. Discussion is limited to R15 DMRS configurations.

FFS on NWA to inform the UE on potential co-scheduled ports.