**3GPP TSG RAN WG1 #109-e R1-220XXXX**

**e-Meeting, May 9th – 20th, 2022**

**Title: Draft LS on interference modelling for duplex evolution**

**Response to:**

**Release: Rel-18**

**Work Item:** **FS\_NR\_duplex\_evo**

**Source:** **CMCC[RAN1]**

**To:** **RAN4**

**Cc:**

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1 Overall description

Regarding the interference types in Rel-18 NR duplex evolution study, RAN1 made the following agreement:

**Agreement**

For discussion for duplex evolution study (all agenda items), consider the following as the common understanding in RAN1 on the definition of interference types for SBFD operation:

* gNB self-interference (SI): Interference caused by DL transmission on a set of DL RBs in a carrier to UL reception on a set of UL RBs in the same carrier at the gNB side, where the two RB sets are non-overlapping in frequency.
* gNB-UE co-channel intra-subband interference: This is the same as the legacy DL interference type in legacy TDD network with static TDD UL/DL configuration.
* UE-gNB co-channel intra-subband interference: This is the same as the legacy UL interference type in legacy TDD network with static TDD UL/DL configuration.
* (inter-cell) inter-site gNB-gNB co-channel intra-subband CLI: CLI caused by DL transmission of the aggressor gNB on a set of RBs in one carrier to UL reception of the victim gNB in a different site on the same set of RBs in the same carrier.
* (inter-cell) co-site inter-sector co-channel intra-subband CLI: CLI caused by DL transmission of the aggressor gNB on a set of RBs in one carrier to UL reception of the victim gNB in another sector of the same site on the same set of RBs in the same carrier.
* (inter-cell) UE-UE co-channel intra-subband CLI: CLI caused by UL transmission of the aggressor UE on a set of RBs in one carrier to DL reception of the victim UE on the same set of RBs in the same carrier.
* (inter-cell) inter-site gNB-gNB co-channel inter-subband CLI: CLI caused by DL transmission of the aggressor gNB on a first set of RBs in a carrier to UL reception of the victim gNB in a different site on a second set of RBs in the same carrier, where the two RB sets are non-overlapping in frequency.
* (inter-cell) co-site inter-sector co-channel inter-subband CLI: CLI caused by DL transmission of the aggressor gNB on a first set of RBs in a carrier to UL reception of the victim gNB in another sector of the same site on a second set of RBs in the same carrier, where the two RB sets are non-overlapping in frequency.
* (intra-cell/inter-cell) UE-UE co-channel inter-subband CLI: CLI caused by UL transmission of the aggressor UE on a first set of RBs in a carrier to DL reception of the victim UE on a second set of RBs in the same cell or neighboring cell in the same carrier, where the two RB sets are non-overlapping in frequency.
* gNB-gNB adjacent-channel CLI: CLI caused by DL transmission of the aggressor gNB in a carrier to UL reception of the victim gNB in another adjacent carrier.
	+ This includes adjacent-channel CLI between gNBs in the same and different sectors of the same site, i.e., co-site intra and inter-sector adjacent-channel CLI.
* UE-UE adjacent-channel CLI: CLI caused by UL transmission of the aggressor UE in a carrier to DL reception of the victim UE in another adjacent carrier.

Note: Some of the interferences may not be used according to the deployment scenarios, e.g, whether the SBFD subband configurations are the same or different across gNBs.

Note: This does not imply we need to consider all the above interference types in evaluation for SBFD.

Furthermore, regarding the interference modelling for SBFD operation in system level simulation in Rel-18 NR duplex evolution study item, RAN1 made the following agreements and relevant questions:

1. ***Agreements and questions on self-interference modelling for system level simulation***

**Agreement**

Regarding gNB self-interference modelling for system level simulation purpose, consider introducing ratio of self-interference (RSI) to represent the overall self-interference suppression capability of gNB by means of spatial isolation, subband frequency isolation, digital interference cancellation and beamform nulling/isolation, etc. RSI also takes into account the impact of Tx/Rx antenna element gain on self-interference. The RSI, denoted as $α\_{SI}^{\left(m,n\right)}$, can be defined as the ratio of the total power transmitted by gNB across all transmit chains on a frequency unit *m* (e.g., subband/RB/subcarrier *m*) in a SBFD carrier to the residual self-interference received by the same gNB on a single receiver chain on a different frequency unit *n* (e.g., another subband/RB/subcarrier *n*) in the same SBFD carrier.

* FFS: Model for link level simulations and relevant questions to ask RAN4
* FFS: details of gNB self-interference modelling using RSI in SLS. As one example based on per-RB-RSI, the gNB self-interference on a single receiver chain at UL RB *n* can be modelled as
	+ $I\_{SI}^{\left(n\right)}=\sum\_{\begin{array}{c}m\ne n\\m\in DL subband\end{array}}^{}I\_{SI}^{\left(m,n\right)}$, wherein,
		- $dBm\left(I\_{SI}^{\left(m,n\right)}\right)=P\_{tx}^{m}-dB\left(α\_{SI}^{\left(m,n\right)}\right)$
		- $I\_{SI}^{\left(m,n\right)}$is the gNB self-interference on a single receiver chain at UL RB *n* caused by DL transmission on DL RB *m.*
		- *m* is the DL RB index in DL subbands.
		- $P\_{tx}^{m}$is gNB’s DL transmission power across all transmit chains at RB *m* (in dBm).
		- $α\_{SI}^{\left(m,n\right)}$ is the per-RB-RSI.
	+ FFS: consider a statistical clutter model based on statistics of clutter strength and AoA.
* The following should be asked to RAN4:
	+ **Question 1-1:** What is the value range of RSI $α\_{SI}^{(n,m)}$ for each frequency range, and under what assumptions on the self-interference suppression means the value range of RSI is provided?
		- RAN1 understands the RSI can be described per subband, per RB, or per subcarrier depending on the granularity of the frequency unit, and it is up to RAN4 to provide the RSI in which granularity.
	+ **Question 1-2:** Whether it is possible for RAN4 to provide RAN1 the respective capabilities of different self-interference suppression means? e.g., is it possible to provide the separate estimates for spatial isolation, subband frequency isolation, beamform nulling/isolation, and digital cancellation, etc., as below?
		- $dB(α\_{SI}^{(m,n)})= dB(α\_{SI-spatial})+dB(α\_{SI-frequency }^{(m,n)})+dB(α\_{SI-beam})+dB(α\_{SI-digtial})$ +…
			* $α\_{SI-spatial}$ denotes the spatial isolation.
			* $α\_{SI-frequency }^{(m,n)}$ denotes the suband frequency isolation between the Tx frequency unit *m* and the Rx frequency unit *n.*
			* $α\_{SI-beam}$ denotes the beamform nulling or beam isolation.
			* $α\_{SI-digtial}$ denotes the digital cancellation capability.
	+ **Question 1-3:** Whether it is possible to simplify the RSI as frequency flat model, and under which condition(s) the dependency of the RSI on frequency can be ignored?
	+ **Question 1-4:** The feasibility of provided value range of RSI regarding factors such as blocking, AGC, etc.
	+ **Question 1-5:** Does RSI have any dependency with the following factors or any other factors? What are the dependencies?
		- gNB’s antenna aspects, e.g., the assumed antenna architecture, the number of transmit chains and receive chains, etc.
		- Frequency aspects, e.g., the frequency distance between the Tx frequency unit *m* and the Rx frequency unit *n*,the number of RBs allocated for DL transmission, etc.
		- Beam aspects, e.g., Tx/Rx beam-pair for FR1/FR2 especially for clutter echo, etc.
* Note: RAN1’s consideration on the frequency locations and sizes of SBFD DL subband and SBFD UL subband assumed in SBFD operation can be provided to RAN4.
1. ***Agreements and questions on gNB-gNB and UE-UE co-channel inter-subband CLI modelling for system level simulation***

**Agreement**

For discussion of gNB-gNB and UE-UE co-channel inter-subband CLI modelling in system level simulation, RAN1 understands at least the following two aspects need to be considered:

* **Aspect 1:** The unwanted emissions due to Tx non-linearity at the transmitter of the aggressor from the allocated RBs to the non-allocated RBs in the same carrier.
* **Aspect 2:** The receiver selectivity at the victim to receive the desired signal in the allocated RBs in the presence of the unwanted signals at the non-allocated RBs. (e.g. receiver blocking at the victim, overload of the receiver dynamic range, etc)

The following questions should be asked to RAN4:

* **Question 2-1:** Whether it is feasible to consider the above two aspects for gNB-gNB and UE-UE co-channel inter-subband CLI modelling in system level simulation? Are there any other aspects should also be taken into account?
* **Question 2-2:** For a specific pair of DL frequency unit *m* (e.g., subband/RB *m*) and UL frequency unit *n* (e.g., subband/RB *n*) of gNB-gNB link, where the DL frequency unit *m* and UL frequency unit *n* are in the same carrier and non-overlapping in frequency, and assuming the aggressor gNB transmits on the DL frequency unit *m* and the victim gNB receives on the UL frequency unit *n*,
	+ How to model the interference from DL frequency unit *m* to UL frequency unit *n* due to Aspect 1 (defined above) at the gNB transmitter?
	+ How to model the interference from DL frequency unit *m* to UL frequency unit *n* due to Aspect 2 (defined above) at the gNB receiver?
	+ How to model the above interferences for the following two cases:
		- inter-site gNB-gNB co-channel inter-subband CLI
		- co-site inter-sector co-channel inter-subband CLI
* **Question 2-3:** For a specific pair of DL frequency unit *m* (e.g., subband/RB *m*) and UL frequency unit *n* (e.g., subband/RB *n*) of UE-UE link, where the DL frequency unit *m* and UL frequency unit *n* are in the same carrier and non-overlapping in frequency, and assuming the aggressor UE transmits on the UL frequency unit *n* and the victim UE receives on the DL frequency unit *m*,
	+ How to model the interference from UL frequency unit *n* to DL frequency unit *m* due to Aspect 1 (defined above) at the UE transmitter?
	+ How to model the interference from UL frequency unit *n* to DL frequency unit *m* due to Aspect 2 at the UE receiver?

FFS: Usage of the above model provided by RAN4 in the evaluation

1. ***Agreements and questions on gNB-gNB and UE-UE adjacent-channel CLI modelling for system level simulation***

Agreement

Regarding gNB-gNB and UE-UE adjacent-channel CLI modelling for system level simulation, RAN1 understands at least the following aspects need to be considered:

* Aspect 1: The unwanted emissions due to Tx non-linearity at the transmitter of the aggressor from the allocated RBs in one carrier to the non-allocated RBs in the adjacent carrier.
* Aspect 2: The receiver selectivity at the victim to receive the desired signal in the allocated RBs in one carrier in the presence of the unwanted signals at the non-allocated RBs in the adjacent carrier. (e.g. receiver blocking at the victim, overload of the receiver dynamic range, etc)

The following questions should be asked to RAN4:

* **Question 3-1:** Whether it is feasible to consider the above two aspects for gNB-gNB and UE-UE adjacent-channel CLI modelling in system level simulation? Are there any other aspects should also be taken into account?
* **Question 3-2:** For a specific pair of DL frequency unit *m* (e.g., subband/RB *m*) and UL frequency unit *n* (e.g., subband/RB *n*) of gNB-gNB link, where the DL frequency unit *m* and UL frequency unit *n* are in adjacent carriers and non-overlapping in frequency, and assuming the aggressor gNB transmits on the DL frequency unit *m* and the victim gNB receives on the UL frequency unit *n*,
	+ How to model the interference from DL frequency unit *m* to UL frequency unit *n* due to Aspect 1 (defined above) at the gNB transmitter?
	+ How to model the interference from DL frequency unit *m* to UL frequency unit *n* due to Aspect 2 (defined above) at the gNB receiver?
	+ How to model the above interferences for the following cases:
		- the two gNBs are from the same sector of the same site in adjacent carriers, i.e., co-site co-sector gNB-gNB adjacent-channel CLI
		- the two gNBs are from different sectors of the same site in adjacent carriers, i.e., co-site inter-sector gNB-gNB adjacent-channel CLI
		- the two gNBs are from different sites in adjacent carriers, i.e., inter-site gNB-gNB adjacent-channel CLI
	+ Whether it is feasible to define a similar interference ratio as BS-BS ACIR in TR38.828 but in the subband of the adjacent carrier, with finer granularity (e.g., per subband or per RB), to represent the overall effect of the Aspect 1 and Aspect 2 described above?
		- For example, whether it is feasible to define gNB-gNB-adjacent-channel-per-RB/subband interference ratio as the ratio of the power transmitted by the aggressor gNB on DL frequency unit *m* to the interference received by the victim gNB on UL frequency unit *n*? If it is feasible, then what is the value range of the gNB-gNB-adjacent-channel-per-RB/subband interference ratio for each frequency range?
* **Question 3-3:** For a specific pair of DL frequency unit *m* (e.g., subband/RB *m*) and UL frequency unit *n* (e.g., subband/RB *n*) of UE-UE link, where the DL frequency unit *m* and UL frequency unit *n* are in adjacent carriers and non-overlapping in frequency, and assuming the aggressor UE transmits on the UL frequency unit *n* and the victim UE receives on the DL frequency unit *m*,
	+ How to model the interference from UL frequency unit *n* to DL frequency unit *m* due to Aspect 1 (defined above) at the UE transmitter?
	+ How to model the interference from UL frequency unit *n* to DL frequency unit *m* due to Aspect 2 at the UE receiver?
	+ Whether it is feasible to define a similar interference ratio as UE-UE ACIR in TR38.828 but in the subband of the adjacent carrier, with finer granularity (e.g., per subband or per RB), to represent the overall effect of the Aspect 1 and Aspect 2 described above?
		- For example, whether it is feasible to define UE-UE-adjacent-channel-per-RB/subband interference ratio as the ratio of the power transmitted by the aggressor UE on UL frequency unit *n* to the interference received by the victim UE on DL frequency unit *m*? If it is feasible, then what is the value range of the UE-UE-adjacent-channel-per-RB/subband interference ratio for each frequency range?

FFS: How to make use of the interference model in RAN1

In addition, RAN1 is still discussing link level simulations and the need for a net-effect model and will come back to RAN4 with further questions.

2 Actions

**To: RAN4**

**ACTION:** RAN1 respectfully asks RAN4 to take the above agreements into account and provide feedback on the questions in them (Question 1-1/1-2/1-3/1-4/1-5/2-1/2-2/2-3/3-1/3-2/3-3).

3 Dates of next TSG RAN WG1 meetings

TSG RAN WG1 Meeting #110 22nd Aug – 26th Aug, 2022 Toulouse, FR

TSG RAN WG1 Meeting #110bis-e 10th Oct – 19th Oct, 2022 E-meeting