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3GPP TSG RAN Meeting #102 RP-233050

Edinburgh, Scotland, December 11-15, 2023

Agenda Item: 9.1.1.3

Source: vivo

Title: Views on Rel-19 duplex evolution

Document for: Discussion

Outline

- Justification on evolution of NR duplex operation
- Rel-19 WI scope
  - SBFD operation at gNB side
  - Potential enhancement for CLI handling
- Rel-19 WI Time budget
- Annex

Justification: SBFD operation

Based on LLS and SLS evaluation results in TR 38.858, following are observed:

- UL Coverage for outdoor scenario:
  - Compared to legacy TDD (DDDSU) with single slot PUSCH, Semi-static SBFD (XXXXU) with PUSCH repetition type A/TBoMS provide MCL gain in median value of 5.41/5.09dB in FR1 UMa, 6.92/5.72dB in FR2-1 Dense UMa
- UPT for FR1 indoor scenario and SBFD deployment case 1 (Non-coexistence case with single SBFD subband config) with large packet size:
  - Compared to semi-static TDD (DDDSU),
    - Semi-static SBFD (XXXXX) provides {1.86%, 2.21%, 2.73%}/{1.73%, -1.19%, 0.54%} for mean/5% DL UPT gain/loss; {10.78%, 13.38%, 13.75%}/{14.13%, 19.91%, 17.70%} for mean/5% UL UPT gain for {low, medium, high} load
    - Semi-static SBFD (XXXXU) provides {-20.38%, -26.30%, -33.95%}/{-22.88%, -29.57%, -53.83%} for mean/5% DL UPT loss; {78.53%, 93.92%, 113.75%}/{81.03%, 106.39%, 150.17%} for mean/5% UL UPT gain for {low, medium, high} load
  - Compared to semi-static SBFD (XXXXX),
    - Dynamic SBFD (XXXXX) Opt.3 (X symbol can be used as an SBFD symbol, fall back to a full DL or a full UL symbol), provides {10.5~33%, 9.8~35%, 10.6~32%}/{6.5~33%, 11~39%, 8.7~45%} for mean/5% DL UPT gain; {109~264%, 93~253%, 77.5~201%}/{119.7~256%, 112~238.8%, 96~255.9%} for mean/5% UL UPT gain for {low, medium, high} load
  - Compared to semi-static SBFD (XXXXU),
    - Dynamic SBFD (XXXXU) Opt.3 provides {19.3~33%, 18.4~49%}/{1.78~33.4%, 6~72%} for mean/5% DL UPT gain; {27.1~58.4%, -1~7.86%}/{28.3~53.8%, -16.6~14.2%} for mean/5% UL UPT gain/loss for {low, medium} load

- **Semi-static SBFD can improve UL coverage for UMA scenario**
- **Semi-static SBFD can improve UL UPT but may decrease DL UPT for some cases**
- **Dynamic fallback operation for SBFD can better adapt to the UL/DL resource requirements based on UL/DL traffic loads, e.g. UPT improvement in both DL and UL for indoor and large packet size.**

Justification: Dynamic fallback operation

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Interpretation for dynamic SBFD i.e., dynamic **fallback** SBFD symbol to non-SBFD symbol

- The legacy DL/flexible symbols configured with UL subband by semi-static RRC signaling can fallback to legacy DL/flexible symbols by dynamic signalling
  - The fallback operation is on demand and the fall-backed symbols in current period can be re-used as SBFD symbols in the next period
  - There is no intention to support the case to use the dynamic signaling to covert a symbol that is NOT configured with UL subband by RRC signaling into a SBFD symbol

If dynamic fallback operation is NOT supported,

- Hard resource splitting in both time and frequency domain cannot accommodate the instantaneous more DL heavy traffic, resulting in DL throughput loss
- gNB loses one effective tool and flexibility to avoid strong interference or severe CLI
- Performance degradation for Rel-19 SBFD aware UE compared to legacy UE which can be scheduled for DL transmission in the configured UL sub-band in a transparent manner

Justification: CLI handling for dynamic/flexible TDD and/or SBFD

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	Schemes		Study outcome	Our views
Inter-gNB CLI handling	#1: gNB-to-gNB co-channel CLI measurement and/or channel measurement based on SSB/CSI-RS		Discussed. No evaluation. No conclusion.	CD-SSB: by gNB implementation NCD-SSB/CSI-RS: may consider information of configs. exchange btw gNBs (RAN3 work)
	#2: UL Resource Muting-based scheme for measuring the gNB-to-gNB CLI interference covariance matrix		Discussed. Evaluated by 3 sources. No conclusion. Transparent UL resource muting can be used without spec. impact.	The gain of non-transparent way is questionable. "larger overhead of muted UL resources assumed for the transparent scheme, i.e., up to 4 symbols per slot for the transparent scheme and 1 symbol per slot for the non-transparent scheme"
	#3: Coordinated scheduling for time/frequency resources between gNBs		Observation in TR 38.858: The knowledge among gNBs of semi-static SBFD time and frequency configuration can be beneficial.	Can support (RAN3 work)
	#4: Spatial Domain Coordination Scheme: gNB Tx-Beam Nulling		Discussed. Evaluated by 3 sources. No conclusion.	Can be enabled if NCD-SSB/CSI-RS config. information exchange btw gNBs is supported in Inter-gNB CLI handling Scheme#1
	#5: Power control based solutions	gNB Tx Power Adjustment	Discussed. Evaluated by 2 sources with conflict results. No conclusion.	The gain is questionable.
		UE Tx Power Adjustment	Discussed. Evaluated by 2 sources. No conclusion. Can improve UL UPT, may decrease DL UPT.	For DG, current spec is sufficient. For CG, use multiple CG configs.
Inter-UE CLI handling	#1: UE-to-UE co-channel CLI measurement		Discussed. No evaluation. No conclusion.	Benefit is not justified.
	#2: Spatial domain coordination		Discussed. No evaluation. No conclusion. Increase UE measurement complexity.	No support

Rel-19 NR Duplex Evolution: objectives

- **1st priority:** Specify SBFD operation at gNB side within a TDD carrier for SBFD-aware UEs in RRC_CONNECTED state [RAN1]:
  - Semi-static indication of time domain and frequency domain locations of SBFD subbands to UEs
  - Dynamic fall back the SBFD symbol to non-SBFD symbol
    - E.g., allow the legacy DL or flexible symbol configured with UL subband fallback to legacy full DL or flexible symbol
    - Notes:
      - SBFD symbol is defined as symbol with subbands that gNB would use for SBFD operation
      - Up to one UL subband is configured in an SBFD symbol (excluding legacy UL symbol) within a TDD carrier
      - The subband frequency resources across different SBFD symbols are the same
      - SBFD is operated within a single configured DL and UL BWP pair with aligned center frequencies
  - UE transmission, reception, measurement behavior and procedures in SBFD symbols and/or non-SBFD symbols
    - No support of contention based random access (CBRA) using SBFD subbands
- **1st priority:** Specify the RF requirements at gNB side considering the self-interference, the inter-subband CLI, and the inter-operator CLI [RAN4]
  - No RF impact at the UE side due to network side SBFD operation
- **2nd priority:** Specify the following CLI handling enablers for dynamic TDD and/or SBFD [RAN3]:
  - Information exchange among gNBs of semi-static SBFD time and frequency configuration
  - Information exchange among gNBs of CSI-RS and/or NCD-SSB configurations

Rel-19 NR Duplex Evolution - WI Time budget

Expected WI Time Unit:

- Leading WG: RAN1
- Target: June 2025
- RAN1: Up to 2 TU per meeting
- RAN3: Up to 0.5 TU per meeting
- RAN4: 0.5~1 TU per meeting

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THANK YOU.
谢谢。

Indoor UPT performance for SBFD (XXXXX)

- For Indoor scenarios with slot config. {XXXXX} and large packet size,
  - Compared to dynamic TDD {FFFFF}, dynamic SBFD Opt.3 has similar mean and 5% DL/UL Average-UPT for low load level and higher mean and 5% DL/UL Average-UPT for medium and high load levels
  - Compared to semi-static SBFD {XXXXX}, dynamic SBFD Opt.3 has higher mean and 5% DL/UL Average-UPT for all load levels.

Table 7.4.1.1.1.2-1: Indoor (FR1) dynamic SBFD vs. dynamic TDD, {XXXXX} vs. {FFFFF}

Simple description of key assumptions (RSI based on 1dB desense, Twice area & same TxRUs (Option 2), dynamic SBFD slot configuration {XXXXX}, dynamic TDD slot configuration {FFFFF}, dynamic SBFD Option 3)				
		[33]		
		DL: 0.5Mbytes, UL: 0.125Mbyte		
		Low load	**Medium load**	**High load**
DL average-UPT gain	**Mean**	0.95%	5.48%	12.45%
	5%	1.32%	17.72%	20.94%
UL average-UPT gain	**Mean**	1.62%	8.01%	18.29%
	5%	1.24%	7.95%	31.10%

Table 7.4.1.1.2.2-1: Indoor (FR1) dynamic SBFD vs. semi-static SBFD, {XXXXX}

Simple description of key assumptions (RSI based on 1dB desense, Twice area & same TxRUs (Option 2), SBFD slot configuration {XXXXX}, dynamic SBFD Option 3, DL: 0.5Mbytes, UL: 0.125Mbyte)							
		[24]			**[33]**		
		Low load	**Medium load**	**High load**	**Low load**	**Medium load**	**High load**
DL average-UPT gain	**Mean**	32.65%	35.00%	31.96%	10.49%	9.87%	10.60%
	5%	33.23%	39.11%	44.69%	6.47%	11.10%	8.71%
UL average-UPT gain	**Mean**	264.37%	253.52%	201.41%	109.34%	92.93%	77.47%
	5%	255.85%	238.76%	161.13%	119.78%	112.31%	96.01%

Indoor UPT performance for SBFD (XXXXU)

- For Indoor scenarios with slot config. {XXXXU} and large packet size,
  - Compared to dynamic TDD {FFFFU}, dynamic SBFD Opt.3 has similar or higher mean and 5% DL/UL Average-UPT for low load level; and dynamic SBFD has lower, similar or higher mean and 5% DL/UL Average-UPT for medium load level.
  - Compared to semi-static SBFD {XXXXU}, dynamic SBFD Opt.3 has higher mean and 5% DL/UL Average-UPT for low load level; and dynamic SBFD has similar or higher mean DL/UL Average-UPT for medium load level.

Table 7.4.1.1.1.1-2: Indoor (FR1) dynamic SBFD vs. dynamic TDD, {XXXXU} vs. {FFFFU}

Simple description of key assumptions (RSI based on 1dB desense, Twice area & same TxRUs (Option 2), dynamic SBFD slot configuration {XXXXU}, dynamic TDD slot configuration {FFFFU}, dynamic SBFD Option 3, DL: 0.5Mbytes, UL: 0.125Mbyte)							
		[41]		[40]		[33]	
		Low load	Medium load	Low load	Medium load	Low load	Medium load
DL average-UPT gain	Mean	-0.87%	-9.72%	-3.37%	-3.69%	17.98%	19.56%
	5%	-0.63%	-14.56%	-3.87%	-4.46%	15.14%	19.32%
UL average-UPT gain	Mean	0.09%	-0.81%	6.48%	6.74%	2.74%	5.18%
	5%	-0.27%	-0.08%	9.47%	10.53%	9.91%	5.53%

Table 7.4.1.1.2.1-2: Indoor (FR1) dynamic SBFD vs. semi-static SBFD, {XXXXU}

Simple description of key assumptions (RSI based on 1dB desense, Twice area & same TxRUs (Option 2), SBFD slot configuration {XXXXU}, dynamic SBFD Option 3, DL: 0.5Mbytes, UL: 0.125Mbyte)					
		[33]		[41]	
		Low load	Medium load	Low load	Medium load
DL average-UPT gain	Mean	19.30%	18.43%	32.90%	49.05%
	5%	1.78%	5.96%	33.37%	72.40%
UL average-UPT gain	Mean	27.08%	7.86%	58.40%	-1.07%
	5%	28.25%	14.21%	53.82%	-16.62%