3GPP TSG RAN Rel-19
Edinburgh, Scotland, December 11-15, 2023

RP-233287

Agenda Item: 9.1.1.3
Source: Xiaomi
Document for: Discussion

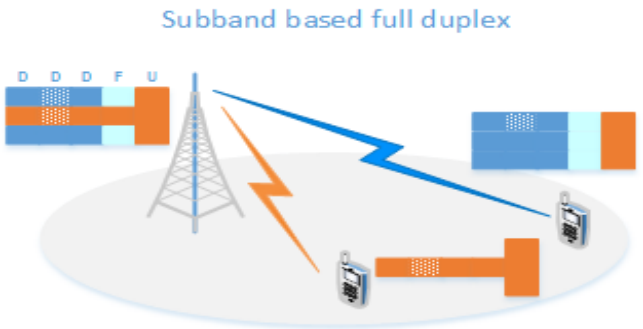
Views on Rel-19 duplex evolution

Xiaomi

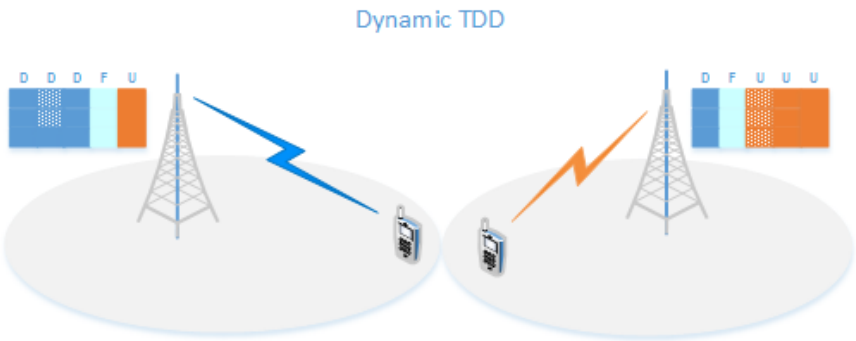
Background and overall progress in Rel-18 duplex evolution SI

BACKGROUND

- SBFD operation
  - RAN1 focuses on SBFD within a carrier at gNB side
  - UL subband is only visible to SBFD aware UE



- Dynamic TDD
  - CLI mitigation is the major challenge on commercialization of DTDD



OVERALL PROGRESS

- System-level simulation has been conducted to verify feasibility and evaluate gain/loss for SBFD technology
  - Comprehensive simulation results for different scenarios with various assumptions have been submitted from companies
- Link-level simulation has been conducted to evaluate gain/loss in terms of coverage for SBFD technology
  - Comprehensive simulation results with different CE schemes have been submitted from companies
- SBFD operation
  - Very good progress on SBFD operation, UL subband configuration, UE behavior, procedure, etc.
- Dynamic TDD
  - Efficient discussion on UE-to-UE CLI and gNB-to-gNB CLI mitigation
- 100% progress in RAN1 and 100% progress in RAN4

Observations from SLS and LLS conducted during SI

System-Level Simulation

- Deployment case#1 - Non-coexistence case with same SBFD configuration amongst gNBs
  - Despite of simulation assumptions, UL UPT can be improved
  - DL UPT is improved in some cases while is degraded in the other
  - Improvement of UL performance is much more significant
  - For indoor scenarios, both UL and DL benefit from Semi-SBFD
- Deployment case#3-2 – Co-channel co-existence case
  - Despite of simulation assumptions, UL UPT can be improved
  - DL UPT suffers degradation is some cases
- Deployment case#4 - Adjacent channel co-existence
  - Semi-static SBFD provides performance improvement for UL but suffers from degradation for DL for all load levels for SBFD operator
  - There may be limited improvement or degradation for UL and DL performance for legacy operator.

Link-Level Simulation

- Combined with PUSCH repetition type A
  - Semi-static SBFD with PUSCH repetition type A without/with joint channel estimation provides the UL coverage gain in range of {0.00~6.75}dB and median value of 5.41dB from 13 sources in FR1 UMa and in range of {5.86~8.76}dB and median value of 6.92dB from 4 sources in FR2-1 Dense UMa, respectively.
- Combined with TBoMS
  - Semi-static SBFD with TBoMS with/without joint channel estimation provides the UL coverage gain in range of {2.83~6.88}dB and median value of 5.09dB from 4 sources in FR1 UMa and in range of {4.49~7.82}dB and median value of 5.72dB from 2 sources in FR2-1 Dense UMa, respectively.

Assumption for semi-static SBFD and recommendation

Feasibility and assumption

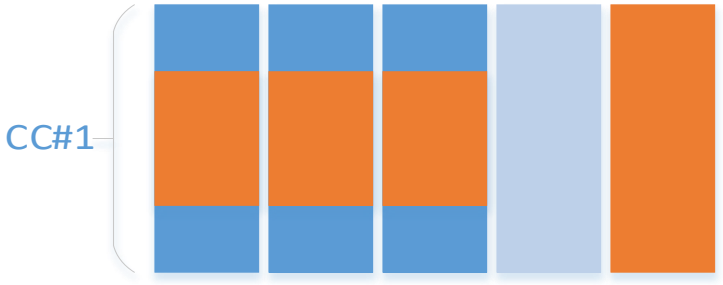
- SBFD operation at gNB for UEs was studied under the following assumptions,
  - SBFD operation within a TDD carrier,
  - SBFD scheme within a single configured DL and UL BWP pair with aligned center frequencies, and
  - Up to one UL subband for SBFD operation in an SBFD symbol (excluding legacy UL symbol) within a TDD carrier.
- RAN1 concluded SBFD operation Option 4 is feasible for RRC_CONNECTED state from the RAN1 specification perspective

Benefits on UPT and coverage

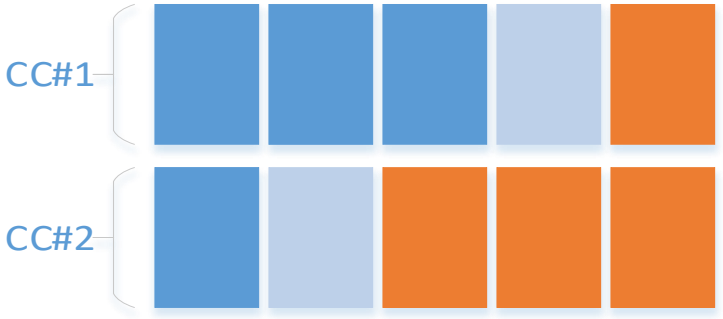
- Semi-static SBFD provides solid improvement for UL UPT across all scenarios.
- Semi-static SBFD provides improvement for DL UPT in some scenarios while UE may suffer DL UPT degradation in some scenarios
- Semi-static SBFD provides significant improvement in terms of UL coverage combined with PUSCH repetition type A
- Semi-static SBFD provides significant improvement in terms of UL coverage combined with PUSCH TBoMS

Observation 1: Semi-static subband-based full duplex within a carrier is feasible, which provides solid performance gain in terms of UPT and coverage.

SBFD operation schemes in Rel-19



a) SBFD operation within a carrier



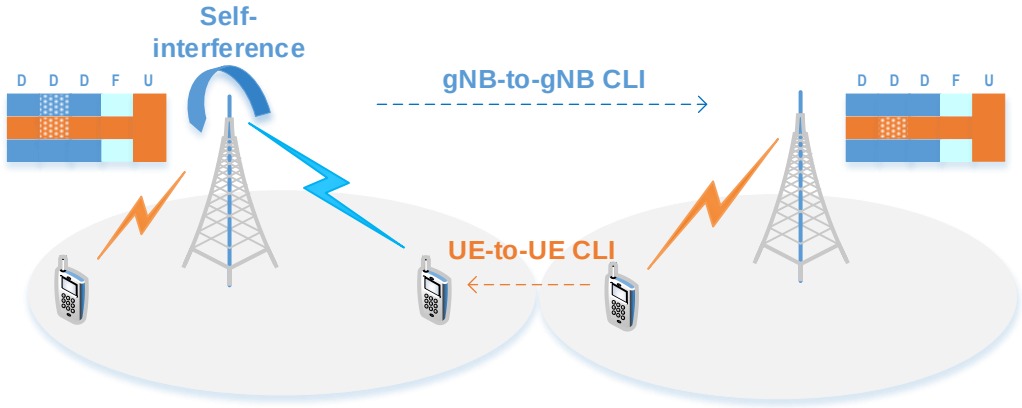
b) SBFD operation across carriers

- Case a is the baseline in RAN1 discussion which has been studied extensively and is pretty mature from study point of view
- Case b has not been discussed yet while the following shortages may bring uncontrollable standard efforts
  - How to define the priority among component carriers when collision happens
  - How to handle repetition and frequency hopping
  - How to handle the case if a UE doesn't support CA
- More importantly, there is no additional benefits by supporting HDCA-based SBFD compared to SBFD within a carrier.

Accordingly, we have the following proposal:

Proposal 1: Subband non-overlapping full duplex within a carrier is sufficient and the other full duplex schemes are not pursued in Rel-19.

Restrictions on SBFD operation in Rel-19(1/2)



Value range of RSIC

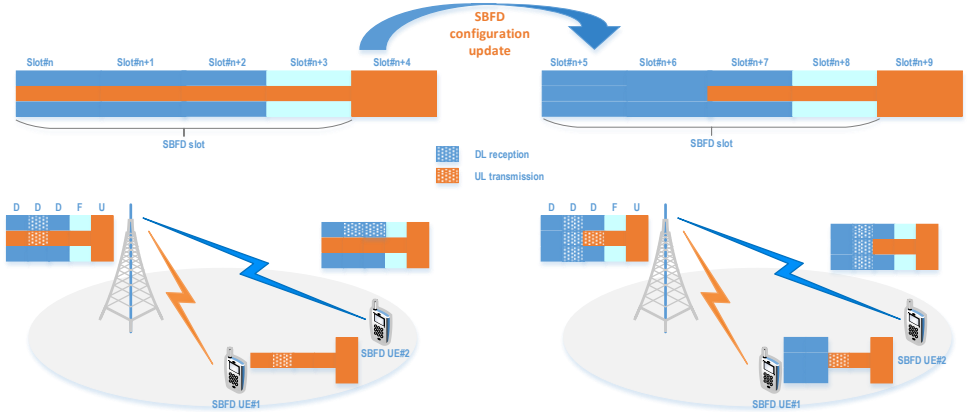
Parameter	FR1(Frequency Range 1)	FR2(Frequency Range 2)
Spatial isolation	50~80dBc	80-120 dBc
Frequency isolation	45 dBc	22.5~30 dBc
Beam nulling /isolation	0~40 dBc	0~40 dBc
Digital IC	0~50 dBc	0~50 dBc
Overall RSIC capability	95 ~185 dBc	102.5~ 205 dBc

- In Rel-18 Duplex evolution study item, the basic assumption is subband based non-overlapping full duplex operation happens only at gNB side.
- In order to sufficiently mitigate the above interference, spatial isolation/frequency isolation/beam isolation/digital IC are needed which require advanced hardware capability.
- Accordingly, subband non-overlapping full duplex should be assumed at gNB side in Rel-19.
- Full duplex operation at UE side should NOT be assumed in Rel-19.

Accordingly, we have the following proposal:

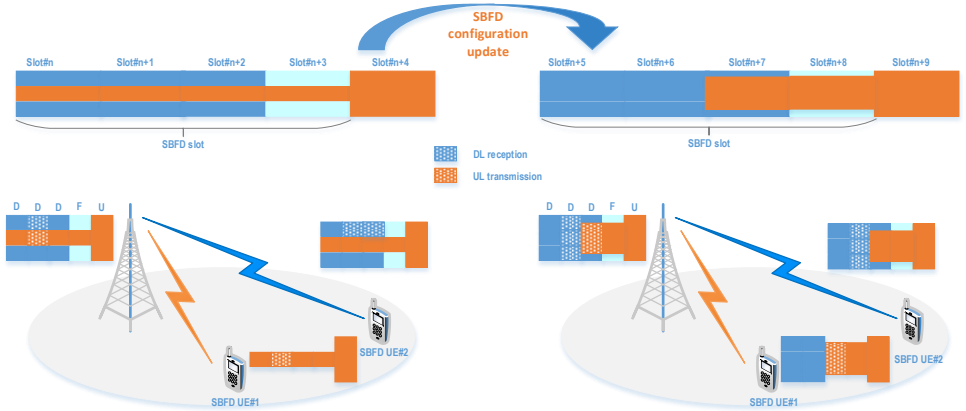
Proposal 2: Spectrum sharing full duplex at gNB side, i.e. overlapping UL subband and DL subband, is not pursued in Rel-19.
Proposal 3: Full duplex operation is confined at gNB side and there should be no impacts on UE hardware in Rel-19.

Restrictions on SBFD operation in Rel-19(2/2)



- Dynamic SBFD option#2-DL reception is allowed within UL subband while UL transmission is only allowed within UL subband
  - Limited sources – 2 sources for different assumptions
  - Compared with d-TDD, there is no convincing benefits

- Dynamic SBFD option#3-DL reception is allowed within UL subband and UL transmission is allowed outside UL subband
  - Limited sources – 3 sources for different assumptions
  - Compared with d-TDD, there is no convincing benefits



Observation 2: There is no convincing performance gain observed from dynamic SBFD during study item for Rel-18 duplex evolution while there are jumbo specification impacts.

Potential specification impacts on SBFD

- Non-transparent SBFD operation in semi-static DL symbols and semi-static flexible symbols is the baseline in RAN1
  - SBFD aware UE need to know the configuration of UL subband

- In order to support SBFD operation as well as expedite commercialization, Rel-19 duplex enhancement should focus on **basic functionality** which provides solid performance gain.
  - Semi-static UL subband configuration and indication, including time domain and frequency domain **within a carrier**
  - UE behavior for SBFD aware UE, including **the inter-action** with SFI and UE-dedicated TDD, collision handling, switching between DL reception and UL transmission, etc.
  - Enhancement on **DL reception** and **UL transmission**, including time domain enhancement and frequency domain enhancement

Accordingly, we have the following proposal.

Proposal 4: In the work item of Rel-19 duplex enhancement, at least the following objectives should be considered:

- Semi-static UL subband configuration and indication, including time domain and frequency domain within a carrier
- UE behavior for SBFD aware UE, including the inter-action with SFI and UE-dedicated TDD, collision handling, switching between DL reception and UL transmission, etc.
- Enhancement on DL reception and UL transmission, including time domain enhancement and frequency domain enhancement
- Enhancement on measurement and reporting

Candidate objectives for Rel-19 Duplex Evolution

Accordingly, we propose the following candidate objectives for Rel-19 Duplex Evolution:

Objective 1: Specify semi-static signalling support to configure the time and frequency locations of SBFD subbands and/or guard band [RAN1, RAN2]

- Time domain and frequency domain within a carrier, granularity, period, inter-action with SFI and UE-dedicated TDD configuration, etc.

Objective 2: Specify transmission, reception and measurement behaviour and procedure for SBFD-aware UEs, including [RAN1, RAN2]

- Transmission and reception behaviours on SBFD subbands configured at DL and/or flexible symbol in *TDD-UL-DL-ConfigCommon*
- Enhancement on resource allocation in frequency domain in SBFD symbol
- Enhancements on physical channels/signals and procedure across SBFD symbols and non-SBFD symbols in different slots, where each transmission/reception within a slot has either all SBFD or all non-SBFD symbols
- Collision handling between DL reception in DL subband(s) and UL transmission in UL subband in a SBFD symbol

Objective 3: Specify UE-UE CLI measurement and reporting enhancements and gNB-gNB CLI handling for SBFD operation, including [RAN1, RAN2, RAN3]

Objective 4: Specify SBFD operation to support random access using SBFD subbands by UEs in RRC connected mode [RAN1, RAN2]

Objective 5: RF requirements for SBFD operation at gNB [RAN4]

Thanks!