3GPP TSG RAN Rel-18 workshop
Electronic Meeting, June 28 - July 2, 2021
Agenda: 4.3

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Duplex enhancement for Rel-18

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Motivation: dynamic FDD

- The traditional static partition of the DL and UL resource is not considered to be spectral efficient, since it can not adapt to the traffic with asymmetric DL/UL services and the changing ratio between DL/UL.
- In Rel-14 NR SI, performance benefits of flexible duplex with/without cross-link interference mitigation schemes were observed for paired/unpaired spectrum as in TR38.802:
  - » Observations for indoor hotspot scenario:
    - Evaluations show that duplexing flexibility with cross-link interference mitigation schemes and on a 4GHz and 30GHz provides better UPT compared to static UL/DL resource partition and duplexing flexibility without cross-link interference mitigation schemes
    - Evaluations show that duplexing flexibility without cross-link interference mitigation schemes on a 4GHz and 30GHz provides better UPT compared to static UL/DL resource partition at least for some cases
  - » Observations for urban macro scenario:
    - Evaluations show that duplexing flexibility with cross-link interference mitigation schemes on a 4GHz unpaired spectrum and on a 2GHz paired spectrum provides better average UPT compared to static UL/DL resource partition and duplexing flexibility without cross-link interference mitigation schemes.
    - Evaluations show that duplexing flexibility on a 2GHz paired spectrum with SRS on the DL part without dynamic DL/UL resource allocation provides better cell average/edge throughput compared to no SRS on the DL part of the spectrum.
  - » Observations for dense urban scenario,
    - Evaluations show that duplexing flexibility with cross-link interference mitigation schemes on a 4GHz and 30GHz unpaired spectrum provides better UPT compared to static UL/DL resource partition and duplexing flexibility without cross-link interference mitigation schemes

Motivation: dynamic FDD

- For the flexible utilizing of the unpaired spectrum, NR already supports flexible duplex in TDD where the transmission direction of most time resources can be dynamically changed to adapt the traffic condition.
- To handle the cross-link interference (CLI) brought by flexible duplex:

In NR Rel-14 SI evaluation:	The Rel-16 WI on TDD CLI handling (NR_CLI_RIM) had specified/evaluated:
» The cross-link interference mitigation schemes include sensing based methods, advanced receivers, coordinated scheduling/beamforming, power control, link adaptation, hybrid dynamic/static UL/DL resource assignment. » A common framework for cross-link interference mitigation schemes for both paired and unpaired spectrum was strived for.	» UE CLI-RSSI and SRS-RSRP measurements/reporting and exchange of intended DL/UL configuration between gNBs. » Coexistence among different operators in adjacent channels in TR38.828 with dynamic TDD operated.

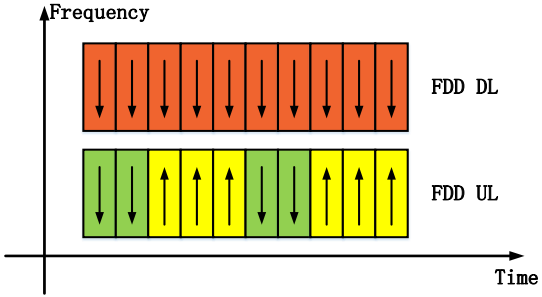
- Further enhancement for duplex needs to pursue the dynamical traffic adapted resource allocation for paired spectrum, i.e. dynamic DL and UL resource split for FDD (dynamic FDD) as well.

Motivation: dynamic FDD

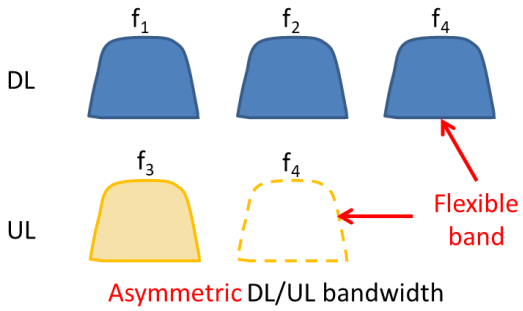
- The FDD paired spectrum will not change within tens of years before refarming or re-allocation. The expected benefits for dynamic FDD can be even higher compared to TDD as TDD has been able to offer various DL/UL configurations to address DL/UL traffic asymmetry in a static manner since LTE Rel-8 whereas FDD does not offer any means to effectively allocate the DL/UL resource split.
- To support dynamic FDD, the CLI handling could be studied take the outcome of the previous SI/WI as baseline.
- In terms of the regulatory, there was a SI “Study on regulatory aspects for flexible duplex for E-UTRAN” aiming to identify potential regulatory possibilities/constraints for the use cases of utilizing UL spectrum for transmission from the network to UEs. Based on the reply from regulators, it indicated that applying flexible duplex operations in UL spectrum is feasible from point of view of current regulations at least in some areas and bands.
- Considering the formulate and revision of the regulation may lag behind technological innovation, it is not impossible to apply for the change of regulations in the future due to the proved gain of dynamic FDD and the controllable interferences.

Potential scope: dynamic FDD

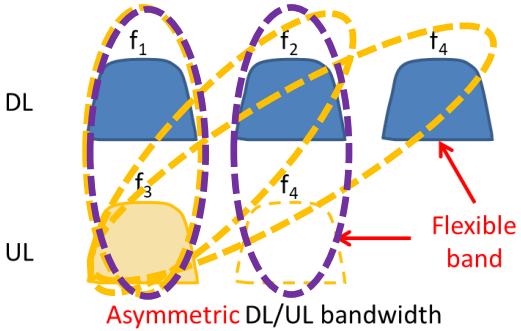
- Dynamic FDD includes the dynamic mechanism in time domain or frequency domain.
  - » Dynamic in time domain: allow DL transmission in part of the slots in UL spectrum, or UL transmission in part of the slots in DL spectrum



  - » Dynamic in frequency domain: flexible bands for asymmetric DL/UL bandwidth allocation for FDD



CA case



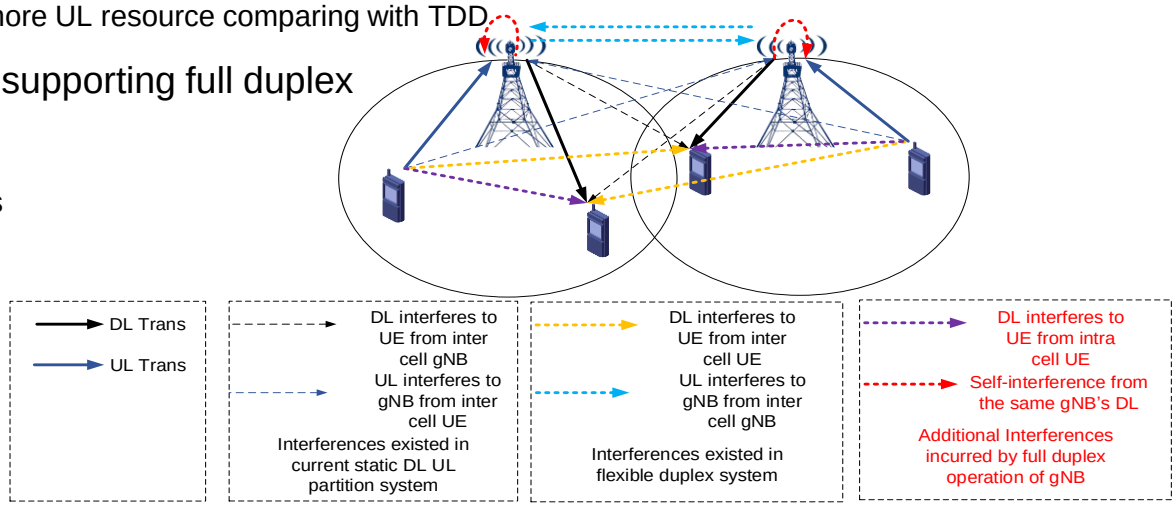
Non-CA case

Potential scope: dynamic FDD

- Potential study objectives to support dynamic UL/DL resource utilization of FDD spectrum
  - » Identify the regulatory and potential scenarios/bands under which DL/UL transmission in FDD UL/DL spectrum can be considered [RAN1, RAN4]
  - » Identify and evaluate the potential technologies to allow DL/UL transmission in UL/DL spectrum, e.g., configuring a TDD cell in UL/DL spectrum or flexible band in UL/DL spectrum [RAN1, RAN4]
  - » Identify and evaluate the potential detailed mechanisms in physical layer, including consideration of performance improvement and inter-cell interference issues in the same and adjacent frequency scenarios, considering at least unsynchronized case for adjacent frequency scenarios [RAN1]
  - » Study any necessary and relevant RF requirements [RAN4]
  - » Identify and define design targets for coexistence among cells in the same and adjacent frequency [RAN1, RAN4]

Motivation：full duplex

- High spectrum efficiency is always the design target in techniques evolution to meet the ever-increasing wireless communication service demands.
- Full duplex technology allows simultaneous DL and UL transmission by removing restriction of mutually exclusive DL UL time-frequency resources, which benefits from:
  - » Doubling the spectrum efficiency in theory
  - » Shorten DL/UL transmission latency due to DL and UL resource at any time
  - » UL coverage enhancement as a result of more UL resource comparing with TDD
- Additional interference introduced by supporting full duplex
  - » Self-interference
  - » CLI exists not only inter cell, but also exists intra cell from UE to UE

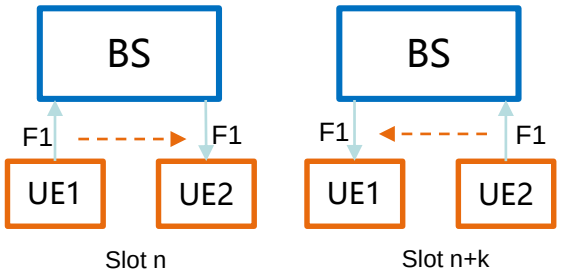


Motivation：full duplex

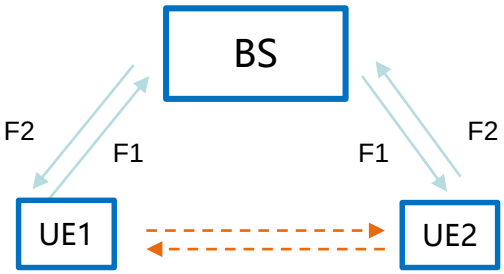
- Self-interference (SI) cancellation techniques grow mature: considerable researches in academia and industry
  - » Joint SI cancellation from spatial domain, RF domain and digital domain
    - Spatial domain SI cancellation: suppresses SI at the propagation stage through antennas' placement, zero-forcing beamforming and highly isolated transmit-receive antennas
    - RF domain SI cancellation: cancels the SI signal at the analog domain, where an inverted SI signal in phase and amplitude is added at the RF frontend
    - Digital domain SI cancellation: further suppresses the SI by reconstructing and removing its linear and nonlinear residuals.
  - » By applying joint SI cancellation, it is already verified more than 115 dB SI cancellation can be achieved for 2T2R and the residual SI is down to the level of the noise floor.
- CLI mitigation: close coordination between BSs to mitigate BS-to-BS CLI, avoid scheduling simultaneous UL/DL for UEs with serious UE-to-UE CLI, etc.
- Feasibility of full duplex network needs more investigation and evaluation.
  - » Different scenarios have different interference cancellation requirement.

Potential scope: full duplex

- Considering the complexity, power consumption, and cost to implement full duplex, the application of full duplex can be step by step.
- The first phase to support full duplex could be
  - » Full duplex at gNB, and the UE remains traditional TDD or FDD



(a) TDD at UE



(b) FDD at UE

Potential scope: full duplex

- Potential study objectives to support full duplex at gNB side
  - » Study the feasibility and identify the potential scenarios for full duplex operation at gNB side [RAN1, RAN4]
    - Identify prior scenarios in terms of deployment scenario (e.g. rural, urban, indoor, isolated, etc.), frequency range, antenna configuration, etc
    - Evaluation of potential performance improvement for full duplex
    - Evaluation of interference cancellation requirement for self-interference and cross-link interference
    - Perform coexistence study to identify conditions of coexistence among different operators in adjacent channels
  - » Investigation of possible standardization impacts of applying the full duplex transmission at gNB side [RAN1]
    - Study the signaling to enable full duplex (static, semi-static, dynamic, sub-band/BWP based full duplex, etc.)
    - Study the frame structure design for full duplex
    - Study the self-interference and cross-link interference handling techniques

Thank you!