

3GPP RAN #84

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Proposals for Rel. 17

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Topics for Discussion

- ❑ IAB Enhancement
- ❑ In band Full Duplex enabled gNB
- ❑ Demodulation Reference Signal (DMRS) Enhancements

IAB Enhancement

Integrated Access and Backhaul (IAB): System Description

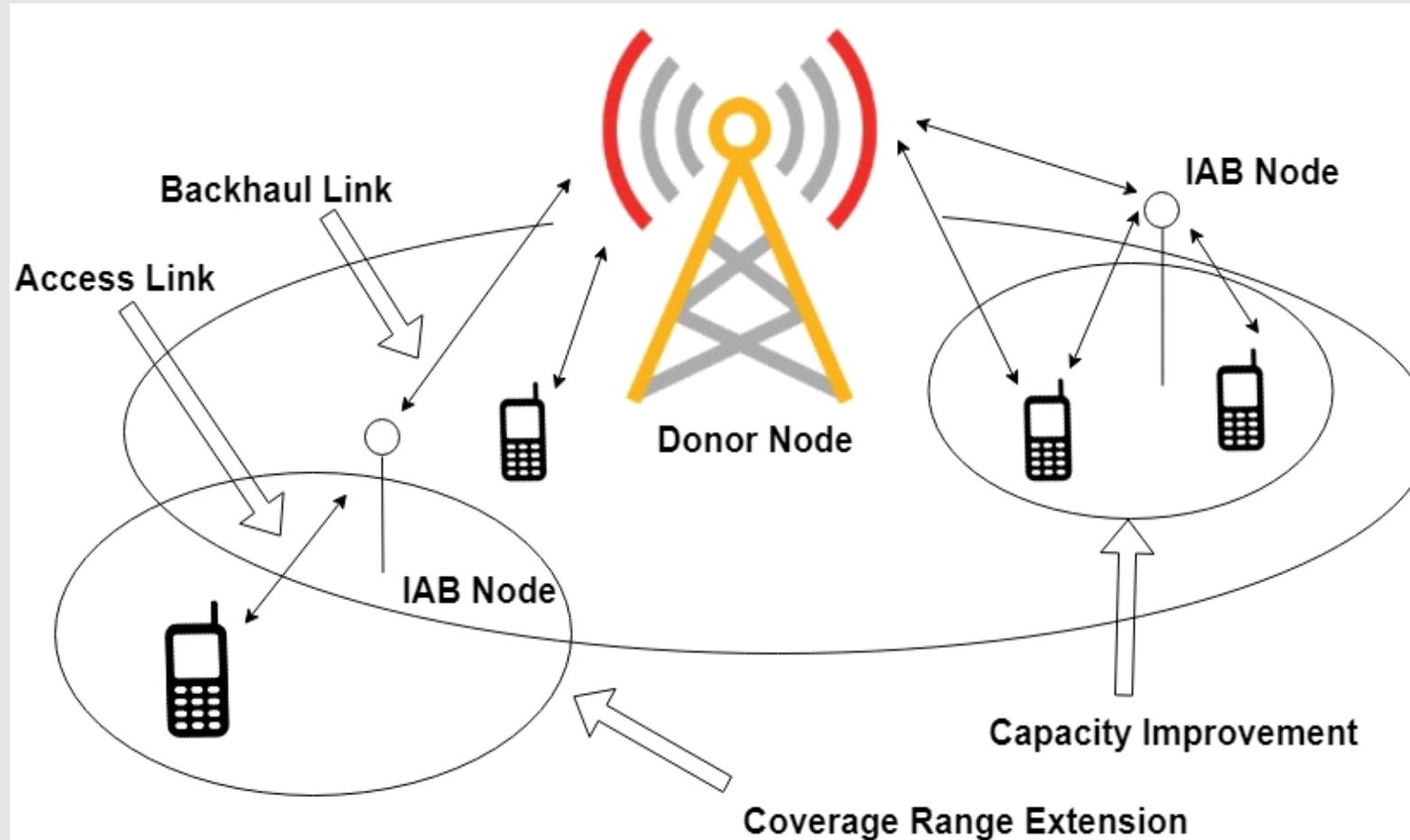


Fig. 1 IAB network

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- ❑ Enormous bandwidth available in mm wave spectrum

- ❑ Wireless link used in backhaul

- ❑ Backhaul link and access link share the same spectrum
 - Ease of deployment of small cells
 - Enable densification of cells
 - Increased network capacity

- ❑ Multiplexed resources for access and backhaul over the same spectrum

IAB enhancements

- ❑ Resource allocation between backhaul and access links
 - FDM and SDM techniques

- ❑ Power control enhancements
 - To handle Tx from child IAB to parent that overwhelm access UE Tx

- ❑ Multiple numerologies across backhaul and access
 - Cross link interference mitigation

- ❑ In-band full duplex (IBFD) enabled only at IAB node for efficient spectrum utilization

In band Full Duplex enabled gNB

Problem Statement

❑ Spectrum at FR1

- Bandwidth is limited in developing countries and most operators have the lowest per bit pricing in the world
- The current cells operating at full capacity
 - Similar scenario envisioned for 5G NR

❑ Capacity enhancements are critical for low costs

- Technology that complements Massive MIMO or lack of it

Provide a framework for more efficient spectrum utilization through In-Band Full-Duplex communications

In-Band Full Duplex (IBFD) gNB

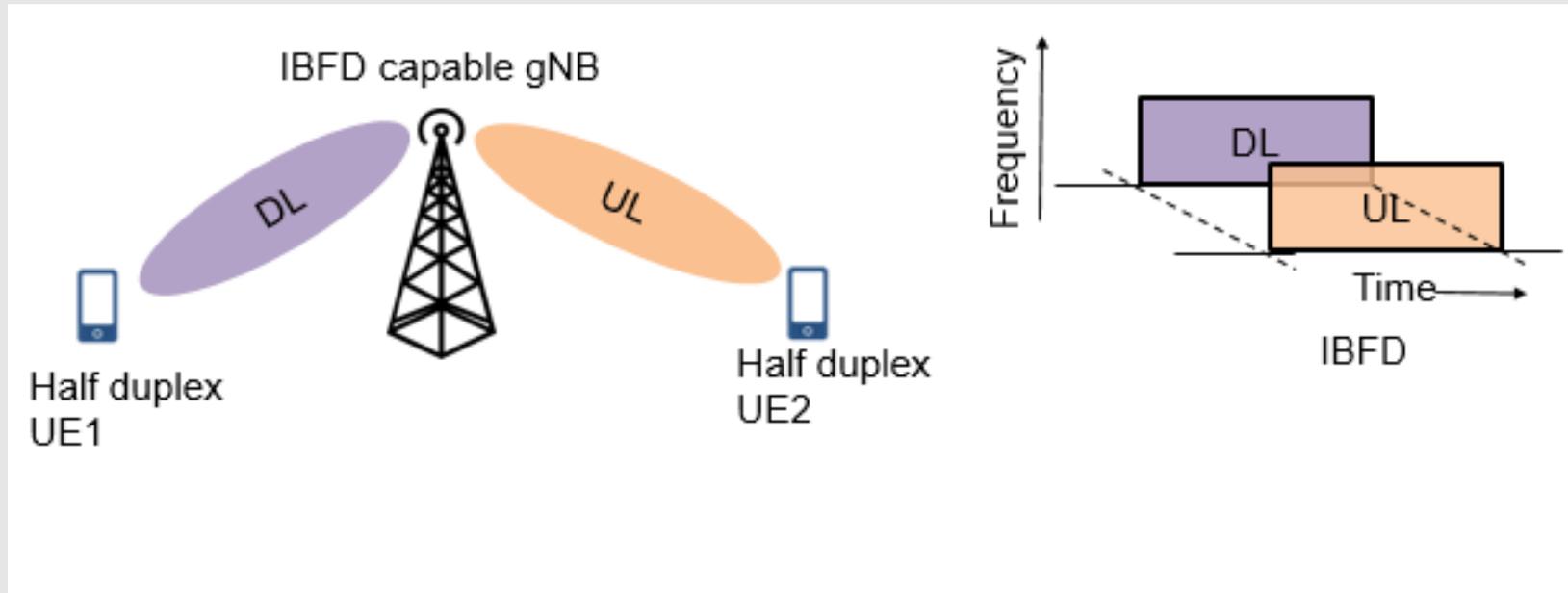


Fig. 2 In-band full duplex (IBFD) enabled gNB

Benefits and Challenges in IBFD

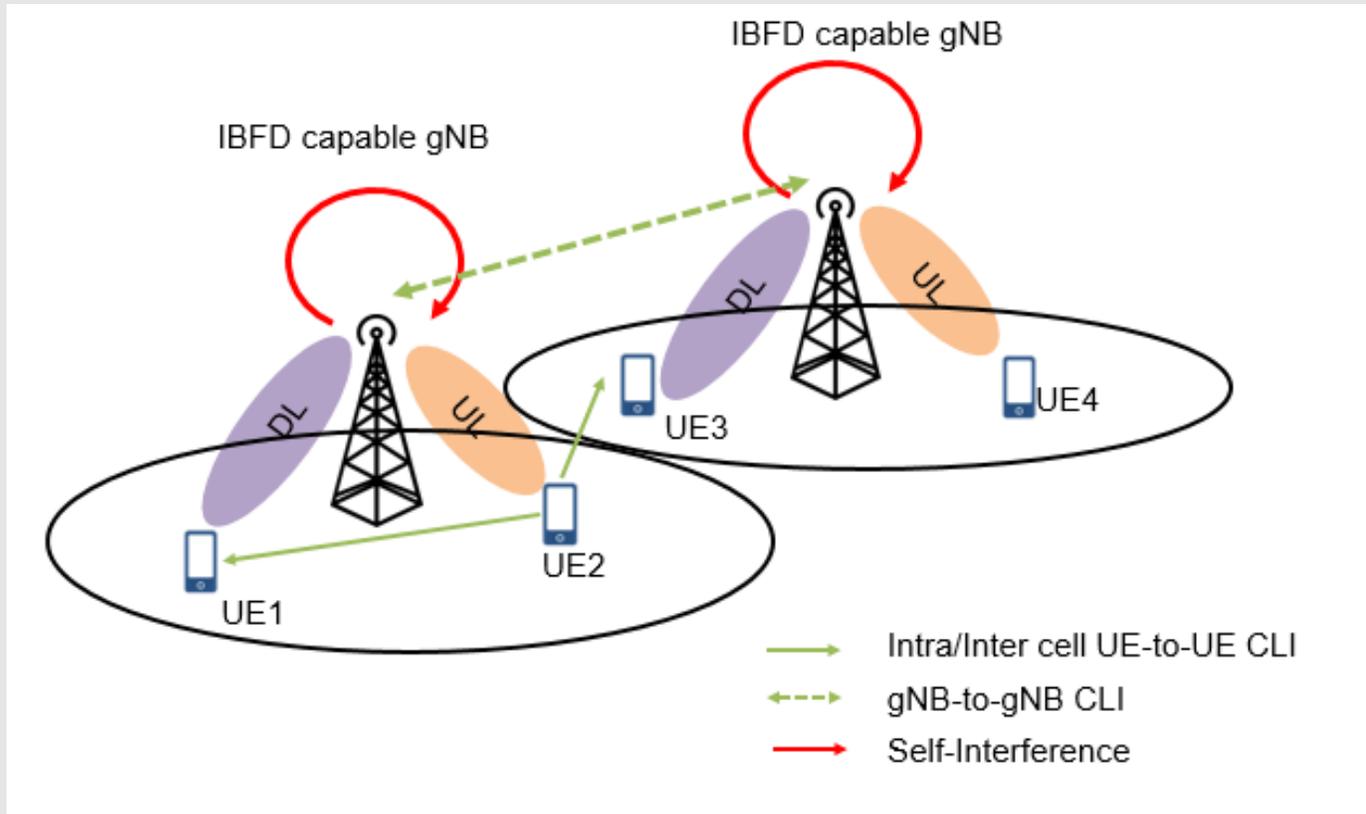


Fig. 3 Network with IBFD enabled gNBs

□ Benefits

- Increase in spectral efficiency
- Better resource utilization

□ Challenges

- Self-Interference cancellation (SIC) required at gNB
- Manage inter/intra UE-to-UE and gNB-to-gNB cross link interference (CLI)

Status of Current Technology

- ❑ Mature technology
 - IBFD capable nodes are a reality
 - Good self-interference cancellation techniques
- ❑ Self-Interference suppression spans antenna isolation techniques, RF techniques, digital baseband techniques
- ❑ Sufficient isolation for cellular-communications is demonstrated
 - Several cancellation architectures exist that can enable IBFD radios [1][2][3][4]

1. *F. Chen, R. Morawski and T. Le-Ngoc, "Self-Interference Channel Characterization for Wideband 2 × 2 MIMO Full-Duplex Transceivers Using Dual-Polarized Antennas," in IEEE Transactions on Antennas and Propagation*

2. *Dinesh Bharadia, Emily McMilin, and Sachin Katti. 2013. Full duplex radios. SIGCOMM Comput. Commun. Rev. 43, 4 (August 2013)*

3. *T. Huusari, Y. Choi, P. Liikkanen, D. Korpi, S. Talwar and M. Valkama, "Wideband Self-Adaptive RF Cancellation Circuit for Full-Duplex Radio: Operating Principle and Measurements," 2015 IEEE 81st Vehicular Technology Conference (VTC Spring), Glasgow, 2015*

4. *D. Korpi, Y. Choi, T. Huusari, L. Anttila, S. Talwar and M. Valkama, "Adaptive Nonlinear Digital Self-Interference Cancellation for Mobile Inband Full-Duplex Radio: Algorithms and RF Measurements," 2015 IEEE Global Communications Conference (GLOBECOM), San Diego, CA, 2015*

IBFD Scenarios

- ❑ Latency Reduction in eMBB and URLLC
- ❑ IAB system performance improvement
- ❑ Transmission and reception using multiple TRPs

Latency in eMBB and URLLC

- ❑ legacy TDD systems drawback: Delay between scheduling grant and UL transmission will depend upon the slot structure
 - This will increase the delay which becomes more critical in URLLC operations

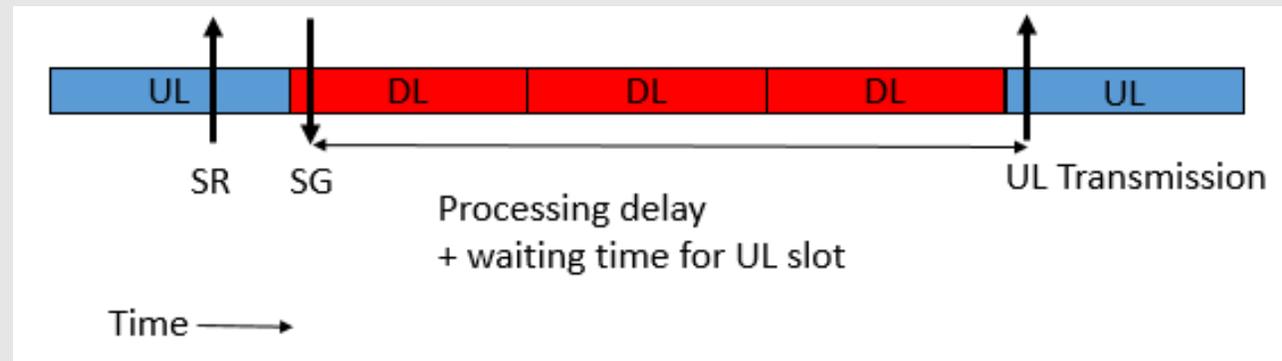


Fig. 4 Delay between SG and UL transmission in legacy TDD systems

SR : Scheduling request
SG : Scheduling grant

Latency reduction Using IBFD

- In IBFD system: Delay between scheduling grant and UL transmission only depends upon the processing delay

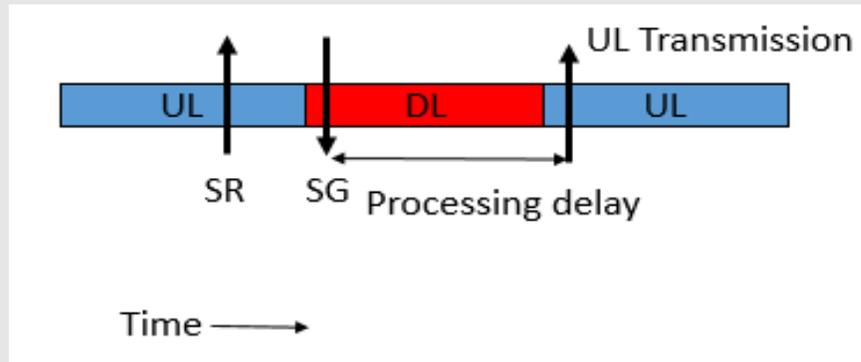


Fig. 5 Delay between SG and UL transmission in IBFD systems w.r.t. UE

SR : Scheduling request
SG : Scheduling grant

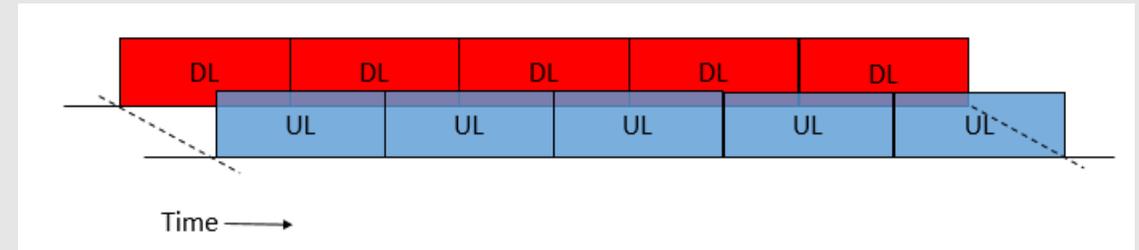


Fig. 6 Effective slot structure at IBFD gNB

- The UL transmission can consist of control information like HARQ

IAB enhancement using IBFD

- ❑ TDM based allocation currently explored in Rel. 16
 - Resources are shared between access and backhaul which limits the access and backhaul performance
 - Latency in IAB is increased due to TDM restriction
- ❑ More flexible resource allocation and simultaneous Tx/Rx at IAB node to be adopted
 - IBFD is an effective solution

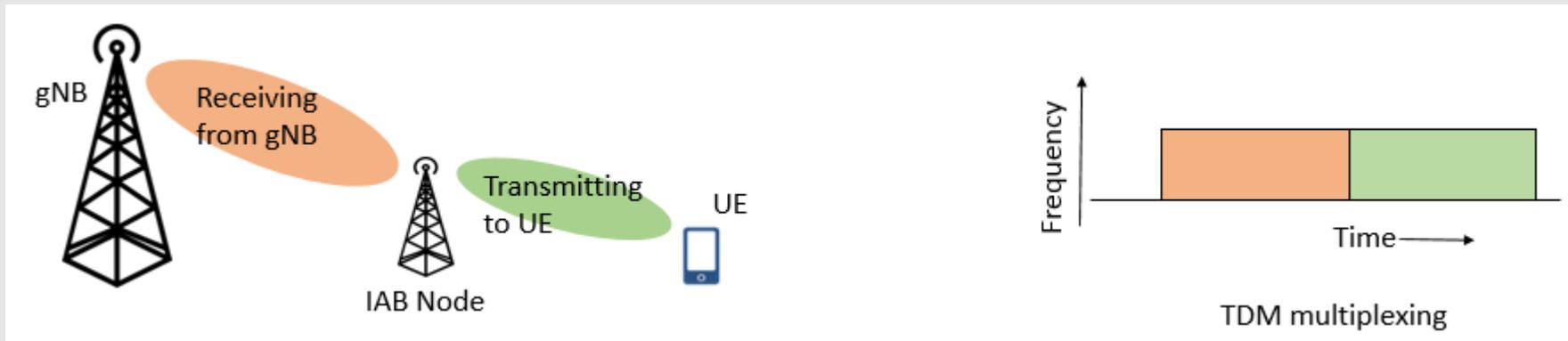


Fig. 7 IAB node with TDM

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- ❑ Backhaul link is mostly LOS link
 - Therefore the rank will be limited to 2
 - This limits MIMO capability in backhaul
- ❑ In such case spectral efficiency of backhaul can be improved by simultaneous Tx/Rx
- ❑ IAB with 2x2 MIMO is a potential scenario for IBFD application
 - Self interference cancellation is less complex

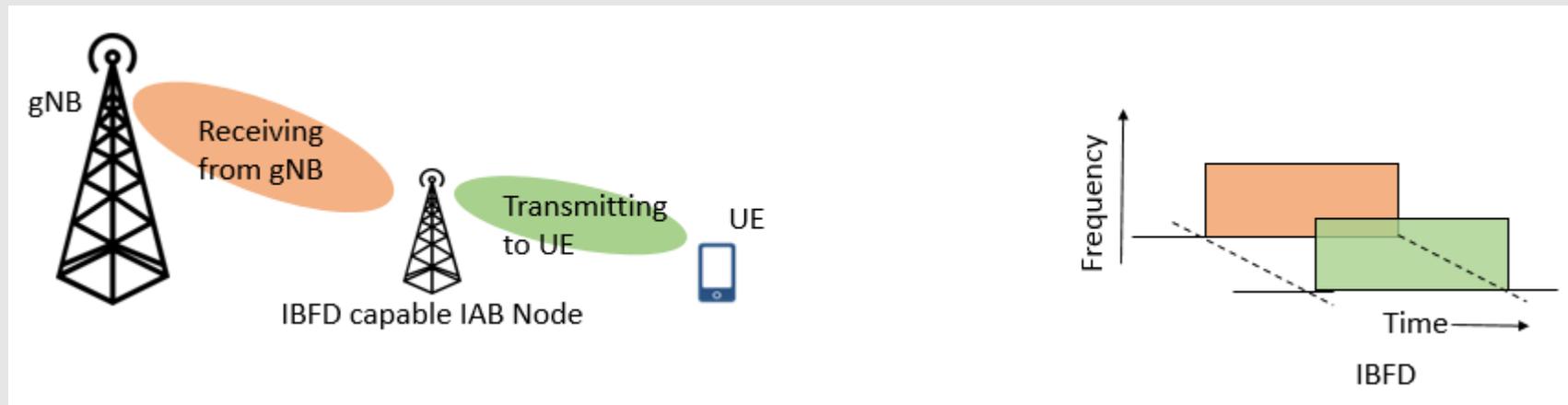


Fig. 8 IBFD capable IAB node

Transmission and reception using multiple TRPs

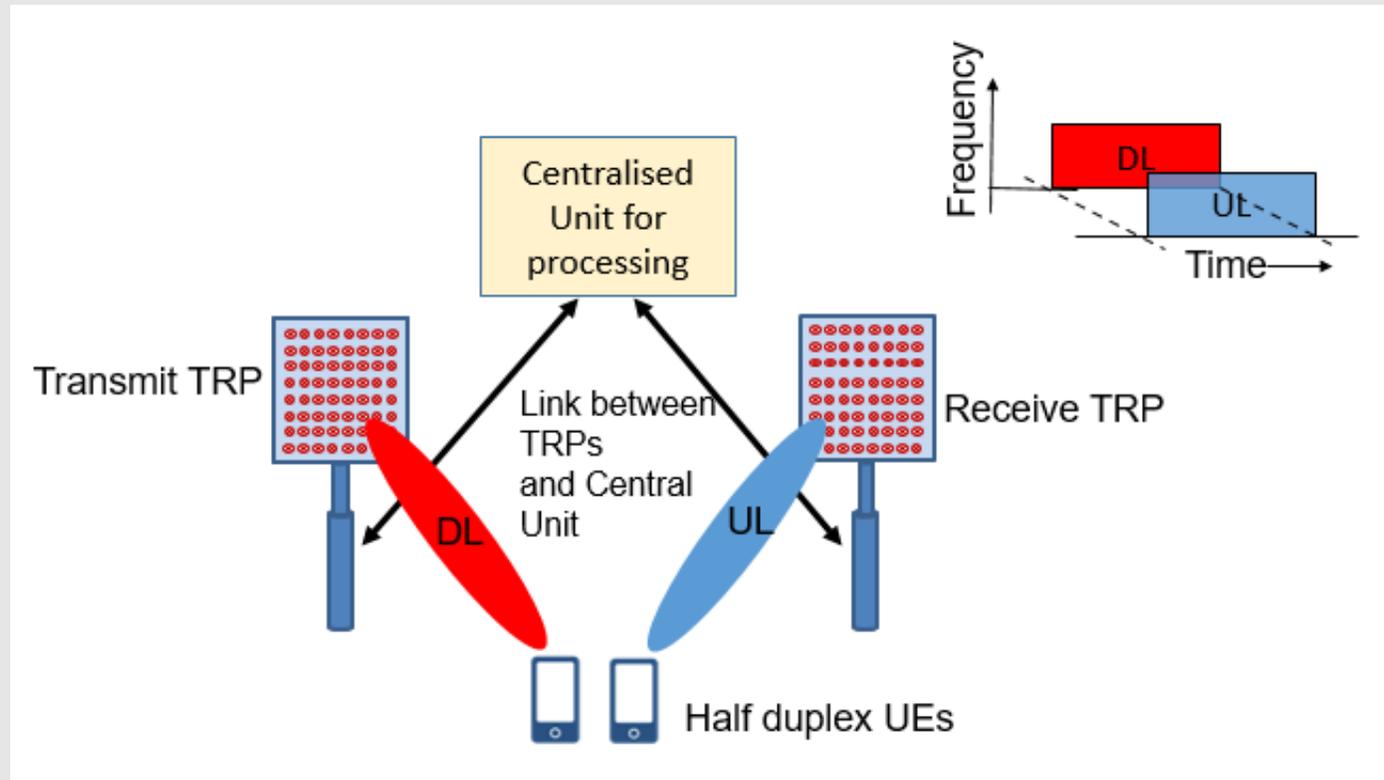


Fig. 9 Multi-TRP transmission and reception scenario

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- ❑ Simultaneous Tx/Rx can be realized by using multiple TRPs using Tx and Rx direction
- ❑ This will reduce the latency in case of eMBB, URLLC and IAB
- ❑ Distance between transmit and receive TRPs gives more isolation for self-interference
- ❑ Inter TRP CLI is need to be handled

IBFD schemes

- ❑ IBFD at gNB for data transmission
- ❑ Obtain Full CSI Using Reciprocity
- ❑ Feedback Full CSI
- ❑ Control Overhead Reduction

IBFD for Data

□ Current status

- Release 16 for gNB supports duplexing via FDD or TDD

□ Benefits

- IBFD enabled gNB theoretically doubles the spectral efficiency
- Utilize the same spectrum for uplink and downlink

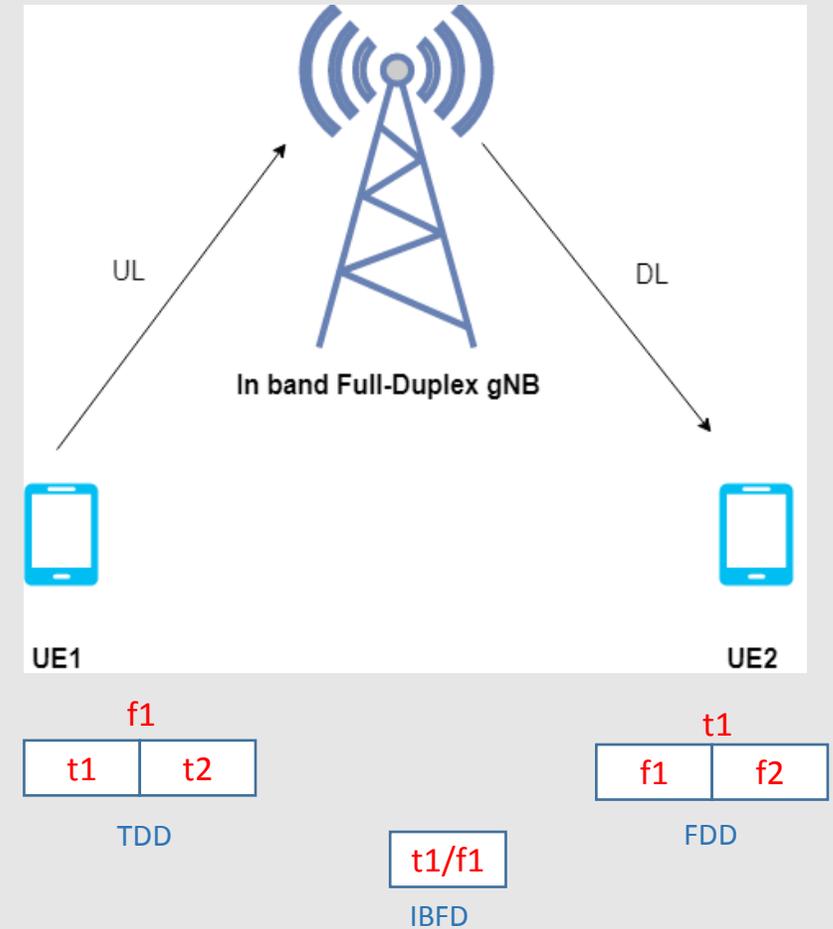


Fig. 10 IBFD enabled gNB

Obtain Full CSI Using Reciprocity

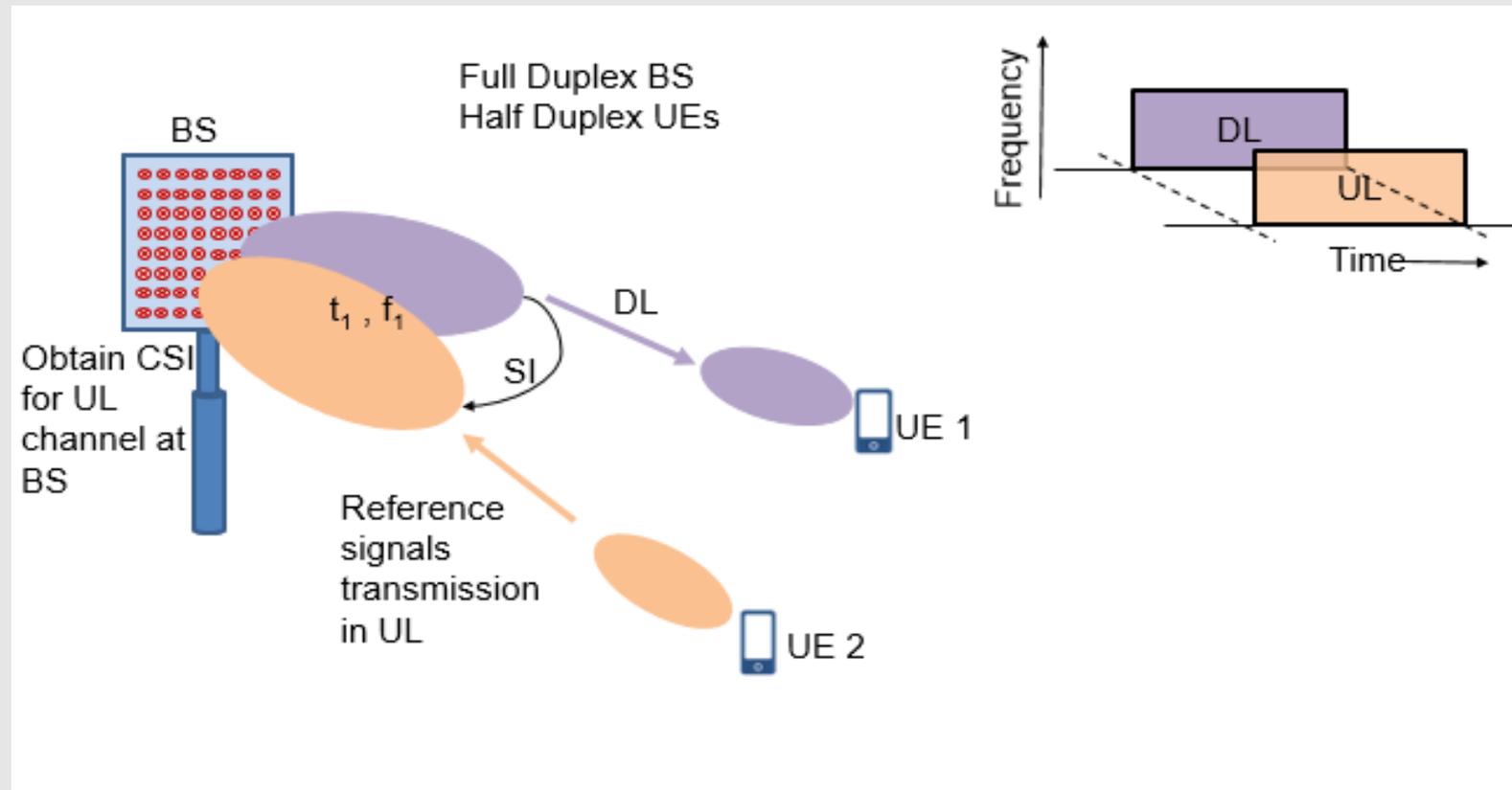


Fig. 11 Reference signal transmission in UL to obtain CSI

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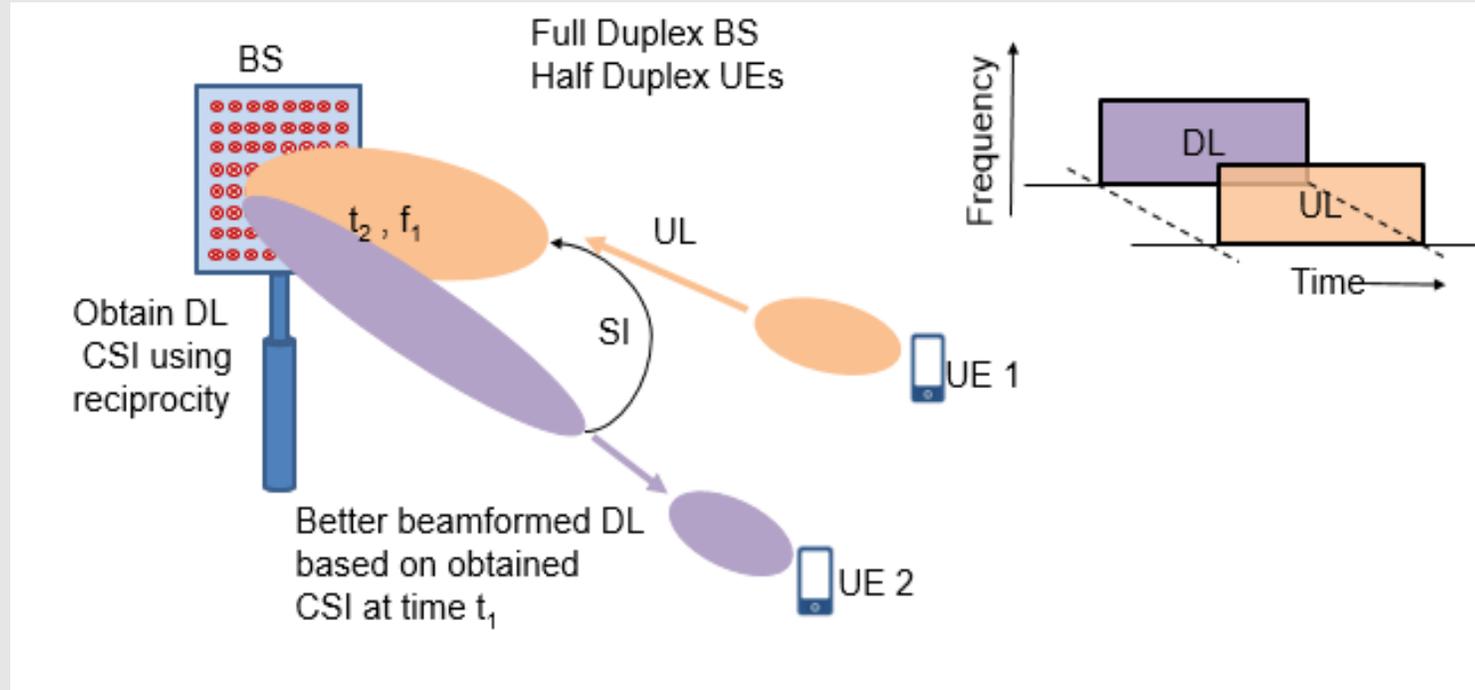


Fig. 12 Better beamformed DL based on the CSI obtained

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❑ Benefits

- Reference signal and CSI overhead reduction
- Reduced feedback delay error
- Support high speed mobility
- Better channel estimation as more number of reference signal resources available
- Can be used in eMBB and URLLC applications

❑ Challenges

- Effective management of co-channel BS-BS and UE-UE interference
- Efficient reference signal design to utilize full benefit

Feedback Full CSI

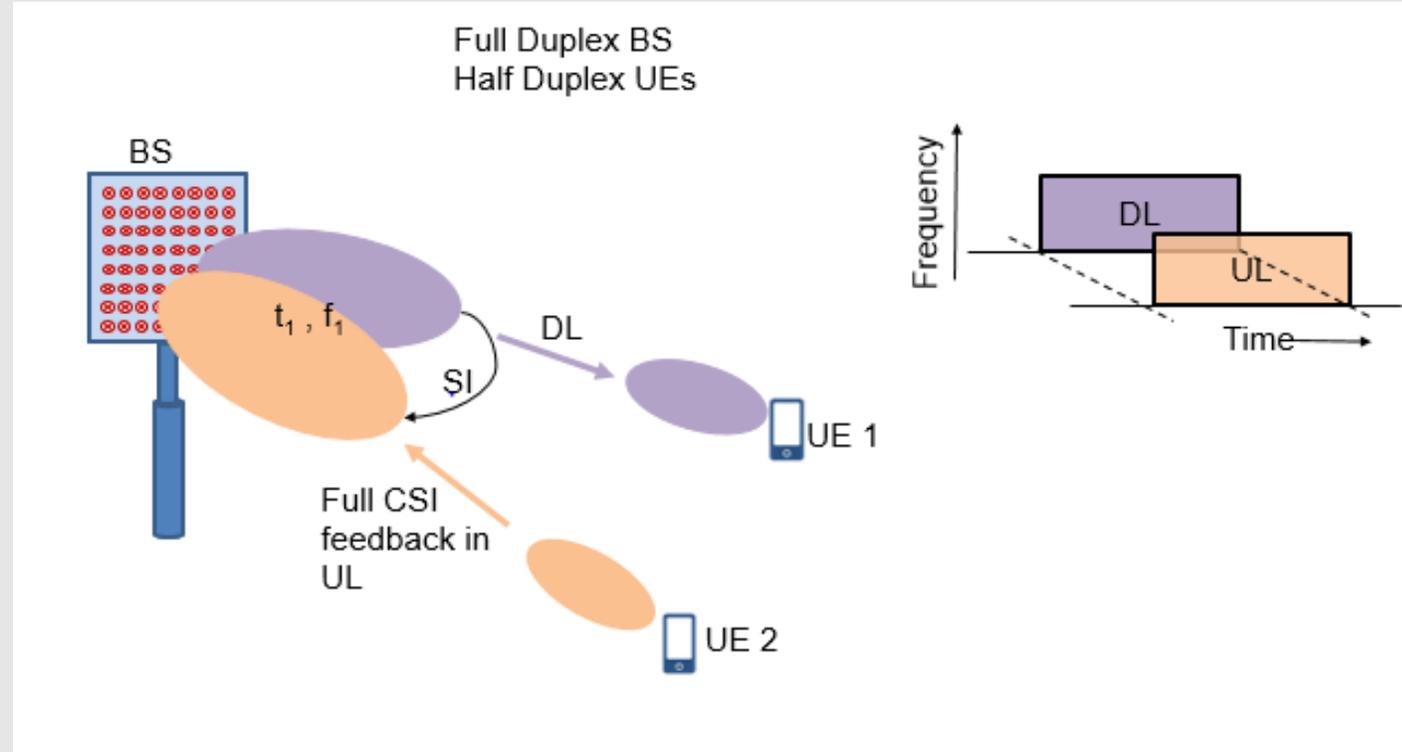


Fig. 13 Full CSI feedback in UL

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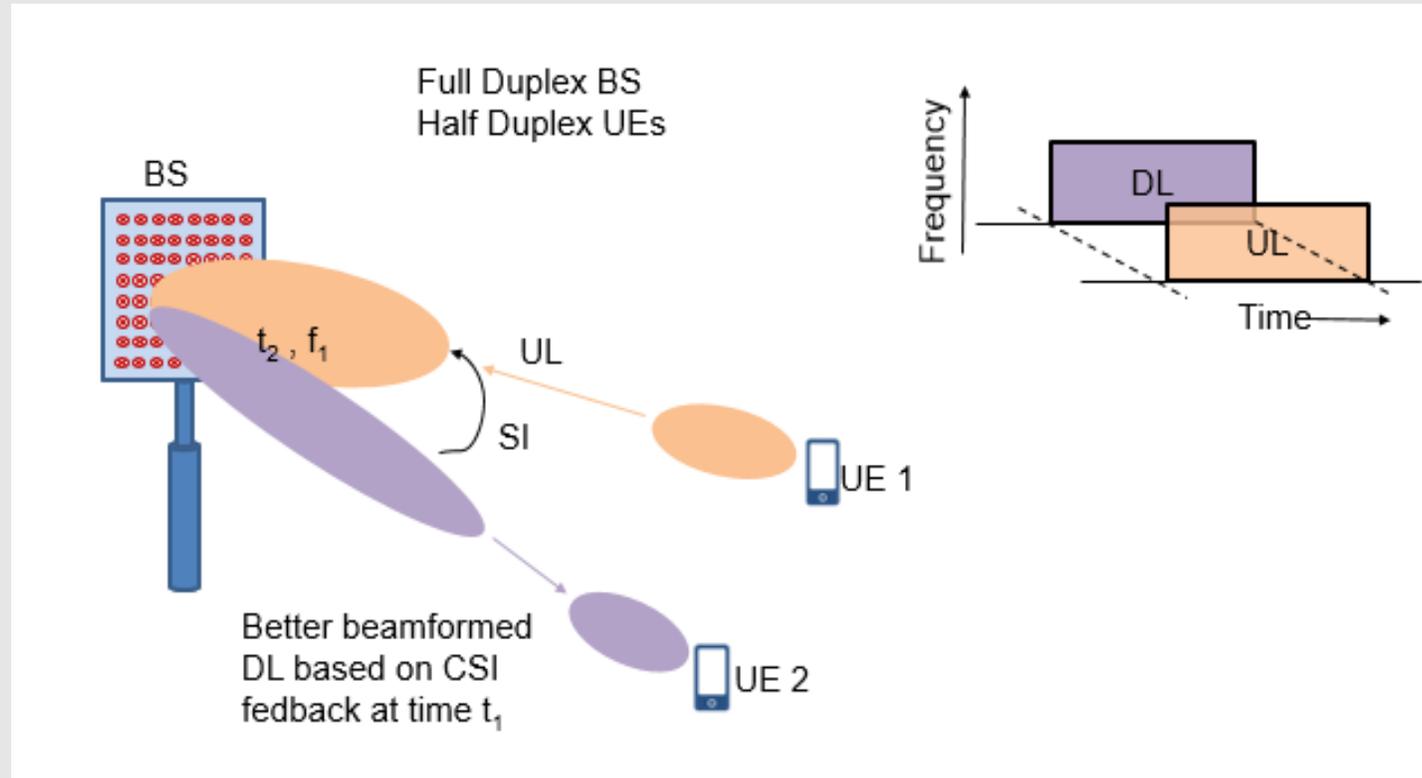


Fig. 14 Better beamformed DL based on the CSI obtained

Contd...

❑ Benefits

- CSI overhead reduction
- Reduced feedback delay error
- Reduced CSI quantization error
- Reduced latency
- Can be used in eMBB and URLLC applications

❑ Challenges

- Effective management of co-channel BS-BS and UE-UE interference
- CSI framework modification to get full benefit

Control Overhead Reduction

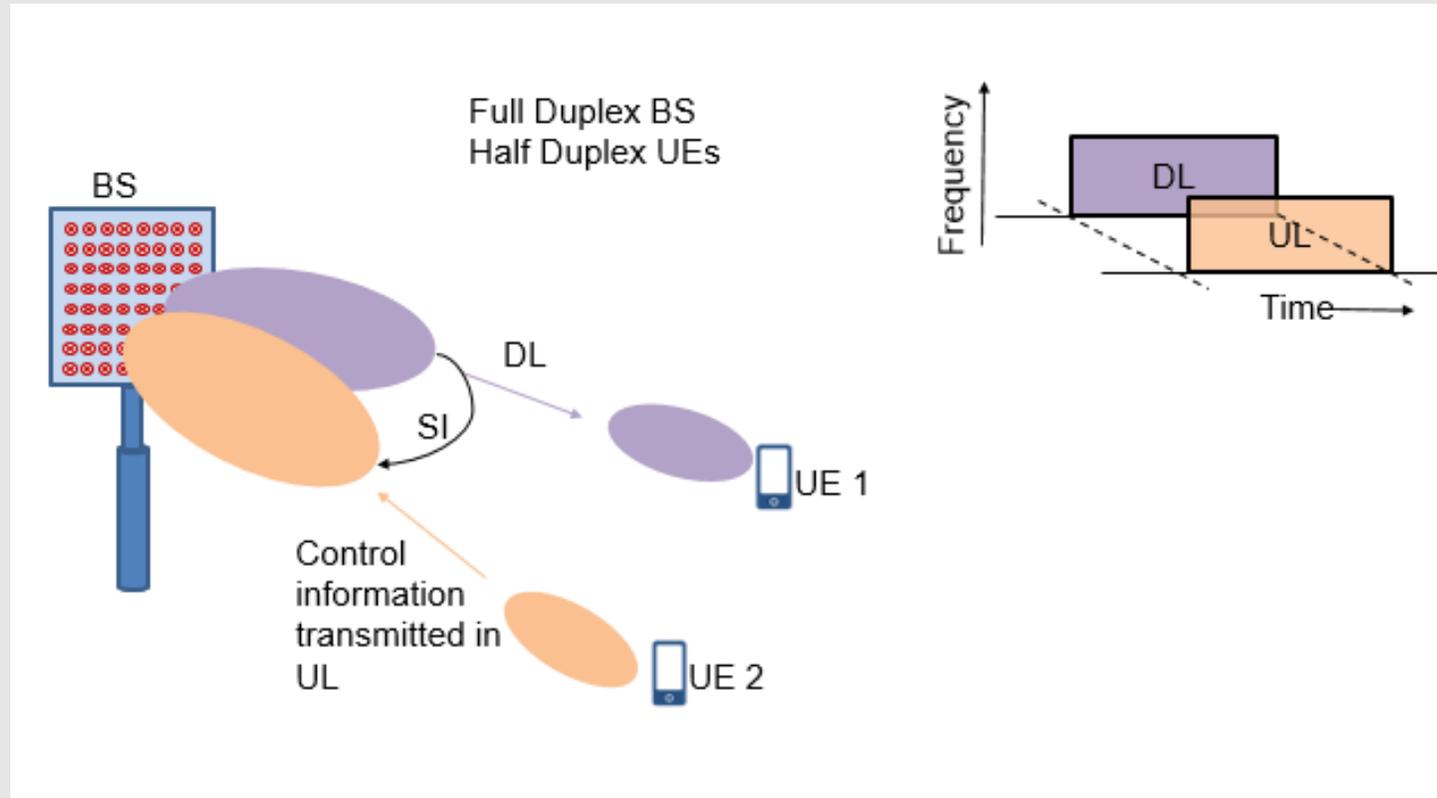


Fig. 15 Control information transmission in UL

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❑ Benefits

- Control signal overhead reduction
- Low latency HARQ feedback
 - Applicable in URLLC like latency critical operations

❑ Challenges

- Effective management of co-channel BS-BS and UE-UE interference
- Efficient control channel design to utilize full benefit

Objective

- Looking at a study-item for exploring the the feasibility of FD at gNB
 - RAN1
 - Investigate UE-to-UE interference within a BS
 - Look at signalling and the current duplexing options
 - Study the throughput gains and feasibility of FD within 5G NR framework
 - RAN4
 - Implication of FD on RAN4 specifications

DMRS Enhancement

Need for DMRS Enhancement

- ❑ Present DMRS types limits the MU-MIMO pairing capability
 - This limits the capacity improvement for massive MIMO scenario

Possible improvement:

- ❑ Introduction of new DMRS port combinations
 - It will increase network capacity by efficient spectrum utilization

THANK YOU