

# **[RAN1 led] Device Collaborative Tx and Rx**

## [SI+WI]

# Device Collaborative Tx & Rx – Motivation

## Enhancement for Personal Area Network

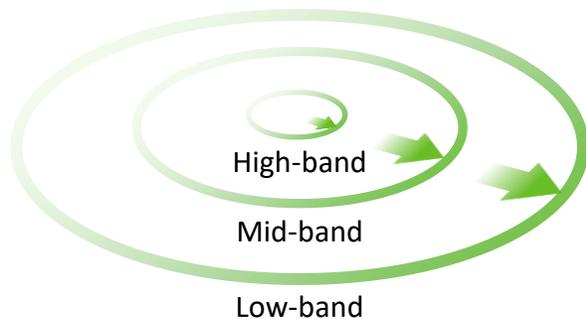
- Issue 1: Device form-factor restrictions

- Bottleneck of MIMO gain, due to physical limitations in the number of feasible Tx and Rx antennas



- Issue 2: Worse propagation/coverage properties in higher frequencies

- Limit maximizing MIMO gain even in case more device antennas are feasible



- More and more users carry a multiplicity of devices

- incl. smartphones, tablet, wearables, etc. – a trend we expect will strengthen (e.g. XR, new form-factors)
  - These devices often operate “together” e.g. via BT tethering (voice calls, remote phone camera shutter etc.)
- Such personal network of devices open some opportunity for greater collaboration that can address Issues 1 and 2.

**The collective PHY capability of devices in close proximity can offer much greater performance than with a device alone.**

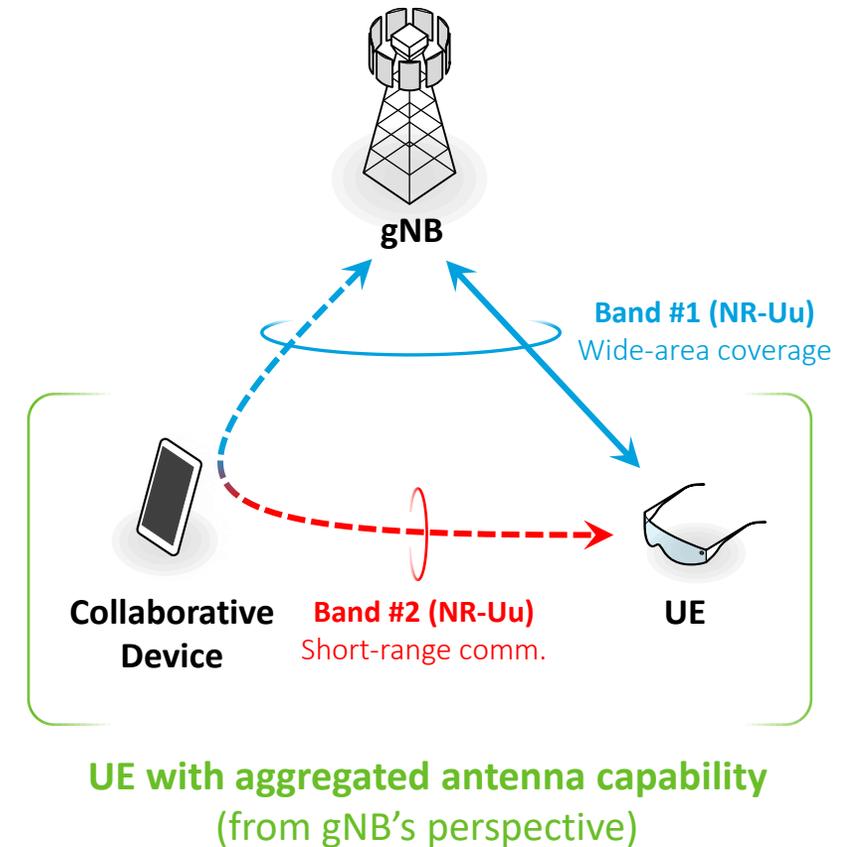


# Proposal: Device Collaborative Tx & Rx

## General

[1/4]

- NR should support means for a UE to aggregate its own antenna capability with the antenna capability of a collaborative device in proximity to obtain UL/DL MIMO performance beyond the UE's own antenna capability, where
  - UE: typ. form-factor constrained e.g., XR glasses
  - Collaborative device: e.g., smartphone, CPE
  - gNB: sees a single UE with the resulting aggregated antenna capability

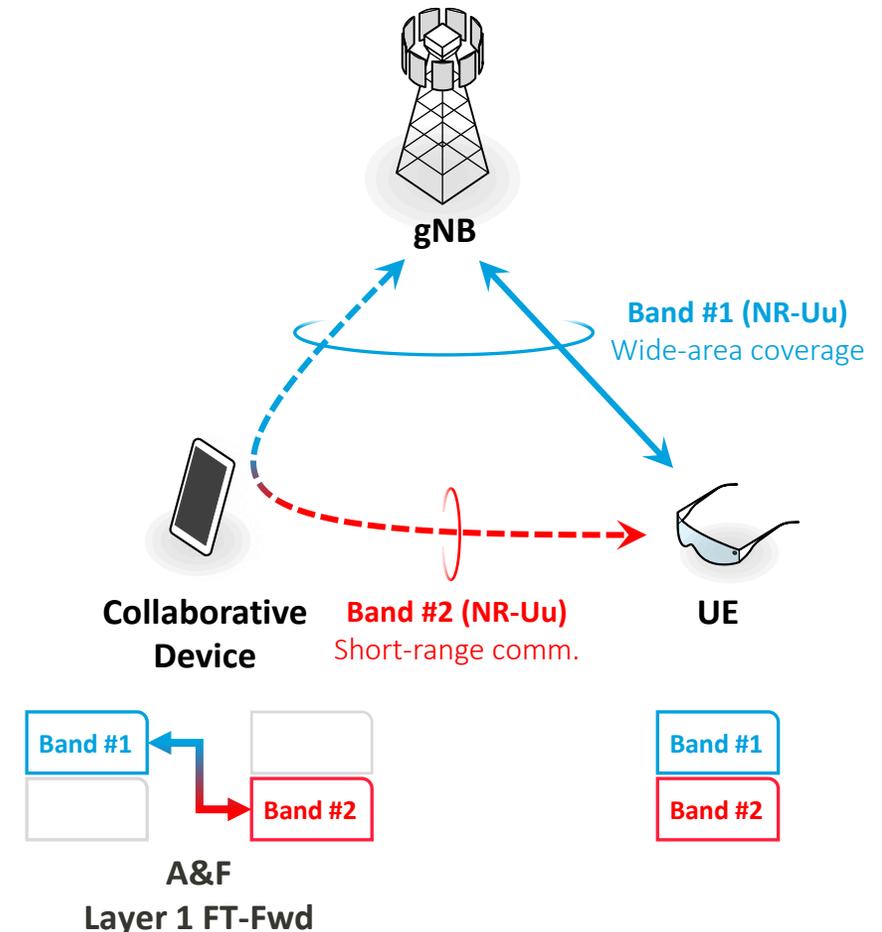


# Proposal: Device Collaborative Tx & Rx

## Layer-1 based antenna capability aggregation

[2/4]

- A *collaborative* device acts as an external antenna panel wirelessly connected to the UE
  - Performs **amplify-and-forward** with frequency translation (*Layer-1 FT-Fwd*) between Bands **#1** and **#2** with ~zero latency
    - **Band #1**: e.g., wide area coverage for gNB deployment, e.g., low-band or mid-band (2.5 or 3.5 GHz)
    - **Band #2** e.g., limited geographical coverage, e.g., mid-band (4.7 or 6 GHz)
  - Transparent to the gNB (when operating as such device)
  - gNB can be informed by the UE of the intention to use the “remote panel”
- The gNB/UE performs data transfer:
  - On a **direct path** <> directly to/from gNB on **Band #1**; and
  - On an **indirect path** <> indirectly to/from gNB via the collaborative device with A&F and Layer-1 FT-Fwd between Bands **#1** and **#2**
  - See this [slide](#) for possible operating schemes

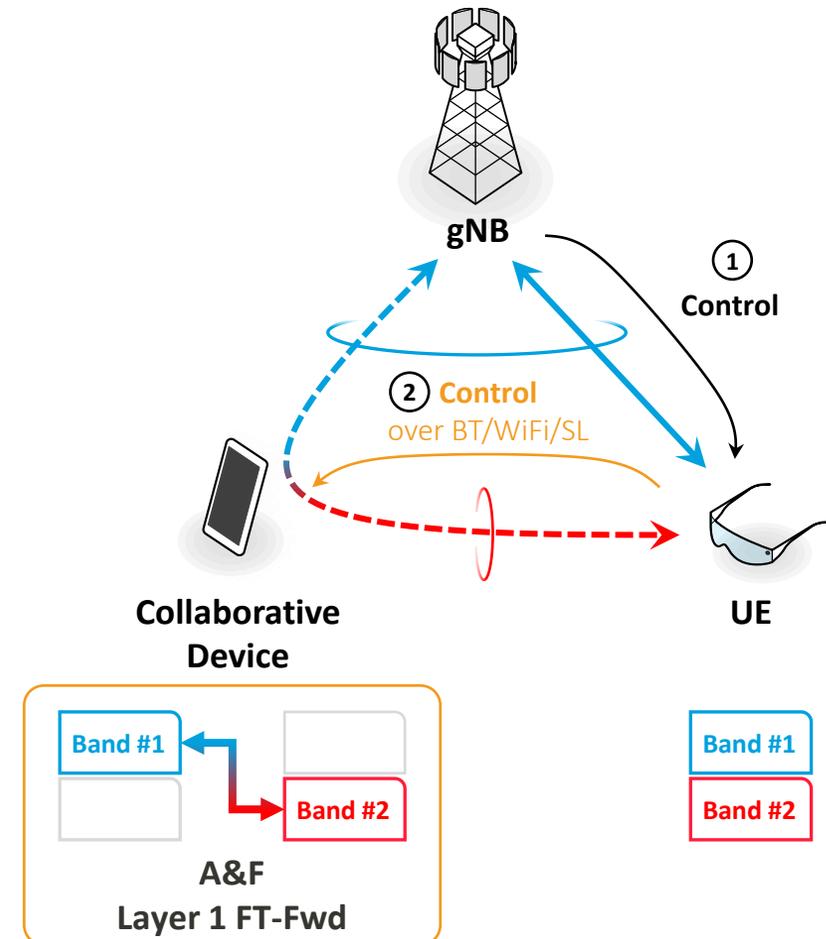


# Proposal: Device Collaborative Tx & Rx

## Collaborative Device control

[3/4]

- A **Control Interface** between the UE and the Collaborative Device allows the UE to control the **Layer-1 FT-Fwd** behavior under constraints imposed by the gNB (interference mitigation)
  - It operates over a paired connection (e.g., via BT, WiFi, NR Sidelink) between the UE and the Collaborative Device
  - The UE provides **Layer-1 FT-Fwd control information** including Layer-1 FT-Fwd on/off, Band #1 configuration information, Band #2 configuration information, Tx power in Band #1, Tx power in Band #2, DL/UL split, etc.
  - The **Layer-1 FT-Fwd control information** is determined based on **gNB control information** (configuration/indication) including max Tx power in Band #2 (e.g. 10 dBm), candidate bands for Band #2, TDD pattern config, in order to minimize interference
  - The **Layer-1 FT-Fwd control information** could be specified at Stage 2 level
  - The **gNB control information** could be specified as side control information (similar to what was done for Rel-18 NCR)



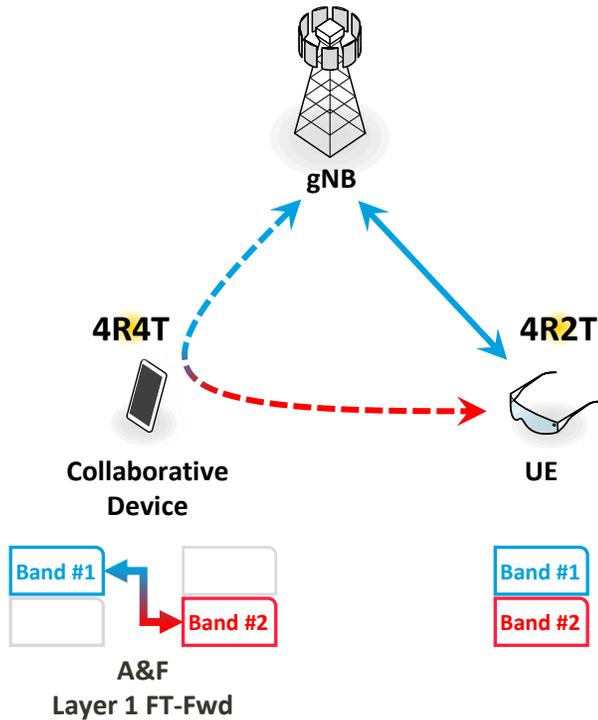
# Proposal: Device Collaborative Tx & Rx

[4/4]

## Tx/Rx schemes at the UE with aggregated antenna capability

- Scheme #1: Path Combining**

- Use both direct and indirect paths between gNB and UE for data transfer with joint transmission/reception



### Rank Augmentation

DL: 4Rx → 4Rx + 4Rx:

- Mean DL UPT +~37%;
- 40% UEs with RI≥4

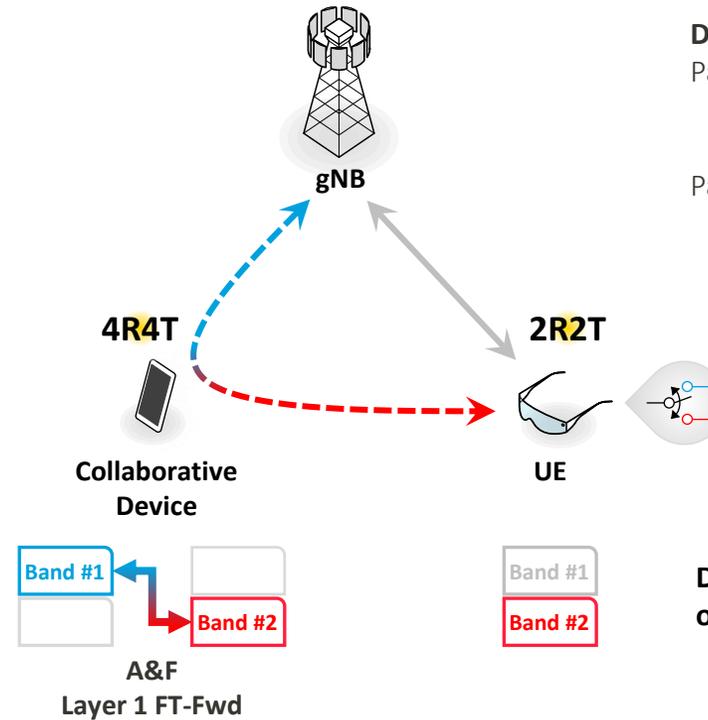
UL: 2Tx → 2Tx + 2Tx :

- Mean UL UPT +~51%;
- 90% UEs with RI>2

Requires joint Tx/Rx operation on Bands 1 and 2

- Scheme #2: Path Selection**

- Select either direct path or indirect path between gNB and UE for data transfer at any one time



### Diversity Augmentation

Path-selection:

- Mean DL UPT +~14%

Path-selection + Rx BF at UE:

- Mean DL UPT +~28%

Does not require joint Tx/Rx operation on Bands 1 and 2

# Proposal

SA/CT Dependency: No

**Key Message:** NR to support means for a UE to aggregate its own antenna capability with the antenna capability of a collaborative device in proximity in order to obtain UL/DL MIMO performance beyond the UE's own antenna capability, using Layer-1 forwarding (amplify-and-forward) with frequency-translation.

- The objective of this study is to identify and evaluate the potential mechanism(s) to support (joint) transmission/reception on a UE to/from a gNB using a direct path and an indirect path between the gNB and the UE, where
  - The direct path operates on a first frequency band (B1); and
  - The indirect path operates both on B1 between the gNB and a collaborative device, and on a second frequency band (B2) between the UE and the collaborative device; and
  - The indirect path is enabled by the collaborative device performing amplify-and-forward Layer-1 forwarding with frequency-translation (Layer-1 FT-Fwd) of signals exchanged between the gNB and the UE, translating between B1 and B2; and
  - the DL and UL performance of the UE is improved by aggregating the antenna capabilities of the UE and of the collaborative device
- The study includes the following aspects:
  - Develop an evaluation methodology to evaluate the performance gain as well as interference impact, and identify potential enhancement(s) to support this type of operation [RAN1]
  - To control the Layer 1 FT-Fwd behavior, identify the necessary control information to be transferred directly between the UE and the collaborative device, and the necessary side control information to be transferred from the gNB to the UE [RAN1]
  - Identify possible procedures/signaling to inform the gNB of the establishment/termination of collaboration with the collaborative device [RAN2, RAN1]
  - Identify potential impact to RAN4 performance requirements to support this type of operation [RAN4]
- The following scenarios and assumptions are applied to focus the direction of the study:
  - The application scenario consists of a collaborative device and a UE constrained in terms of Tx/Rx antennas
  - The UE and collaborative device are assumed to be in close proximity (e.g.  $\leq 10$  meters) of each other to strictly limit the Tx power on the B2 for both UE and collaborative device
  - The collaborative device is connected to the UE using a non-3GPP-standardized UE-device connection, or NR sidelink: establishing and managing this connection is not in scope of the Study. This connection is used by the UE to control the Layer-1 FT-Fwd behavior on the collaborative device via exchange of necessary control information.
  - The collaborative device is transparent to the gNB
  - The collaboration establishment/termination (including discovery, pairing, and unpairing) with the intermediate device is always initiated by the UE
  - B1 and B2 are FR1 licensed bands
  - The gNB shall be able to control/restrict the usage and radio operation of the Layer 1 FT-Fwd (indirectly) on first and second frequency bands, by means of side control info sent from the gNB to the UE.
- Note: No SA/CT impact are expected

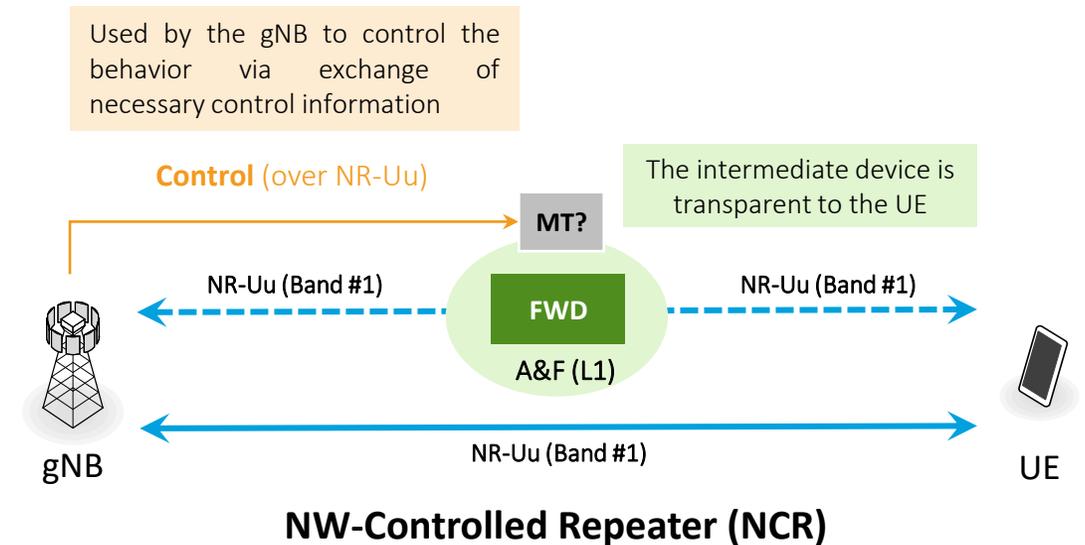
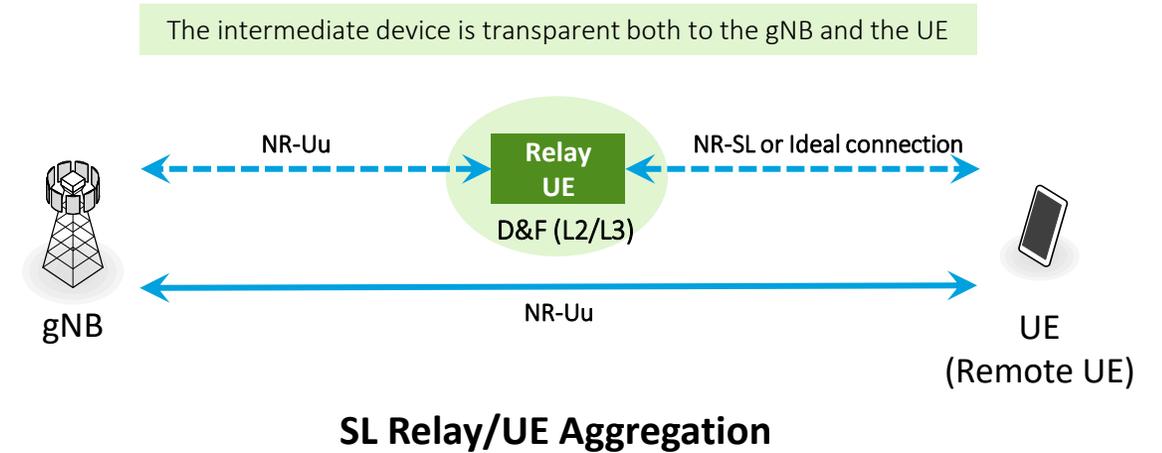
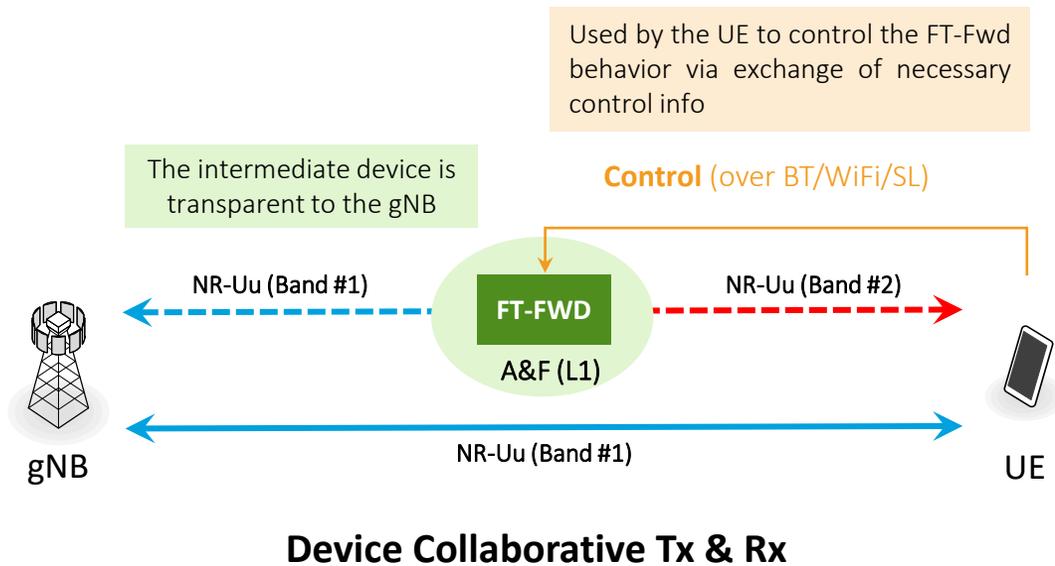
# Expected TU

RAN	2024												2025 [Calendar TBC at the time of writing]												2026		
	Q1			Q2			Q3			Q4			Q1			Q2			Q3			Q4			Q1		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
	103			104			105			106			107			108			109			110			111		
R1	115b	116		116b	117			118		118b	119		119b	120		120b	121			122		122b	123		123b	124	
R2	124b	125		125b	126			127		127b	128		128b	129		129b	130			131		131b	132				
R3	122b	123		123b	124			125		125b	126		126b	127		127b	128			129		129b	130				
R4	109b	110		110b	111			112		112b	113		113b	114		114b	115			116		116b	117		117b	118	
R1		1		1	1			1		1	1			1		1	1										
R2					0.5			0.5		0	1			0.5		0	1			1							
R3				N/A	N/A			N/A		N/A	N/A			N/A		N/A	N/A			N/A							
R4 RD										0.25	0.25			0.5		0.5	0.5			0.5							
R4 RF										0.25	0.25			0.5		0.5	0.5			0.5							



# Appendix

# Comparison with other Techniques



**Thank you!**