

NR Repeaters

Motivation

AI: 9.1.2

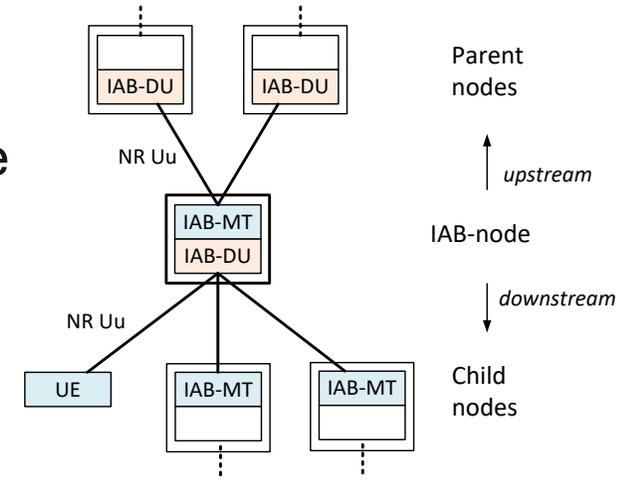
Background

- Coverage is a fundamental aspect of cellular network deployments
- NR operation heavily relies on
 - New spectrum:
 - Majority of new bands are **TDD** and at higher frequencies
 - ~4GHz for FR1 and above 24GHz for FR2
 - Multi-antenna **beamforming** techniques:
 - Massive MIMO for FR1
 - Analog beamforming for FR2
- Network nodes:
 - Full-stack gNBs
 - **IAB nodes** enabling in-band self-backhauling
 - **RF repeaters**

IAB

Overview

- IAB nodes are a type of relay node building over the front-haul architecture
- Dual personality consisting of:
 - Distributed Unit (**DU**) component
 - It makes possible for IAB node to appear as a regular cell to the UEs it serves
 - Mobile Terminal (**MT**) component
 - Connects to its donor parent node(s) inheriting many properties of a regular UE
- IAB node is based on a **Layer 2** architecture with end-to-end PDCP layer from donor IAB node to the UE for CP and UP
- IAB nodes can also be classified as **regenerative relays**
 - Every packet traversing backhaul-link has to be properly decoded and re-encoded for transmission on the access link.
- Rel-16 IAB assumes **half duplex** operation between access and backhaul for Tx and Rx
 - Rel-17 IAB will enable **full duplex** implementations of IAB nodes



RF Repeaters

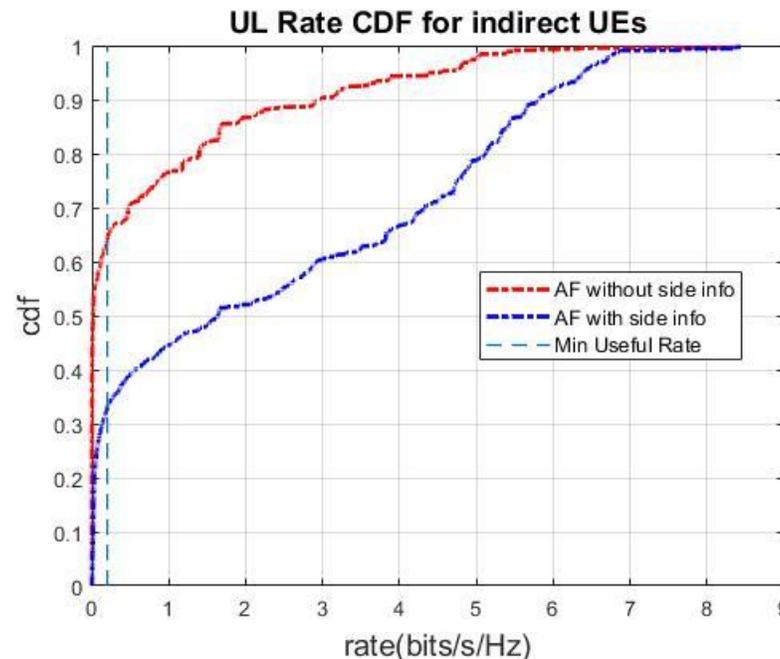
Overview

- **RF repeaters** are **non-regenerative** type of relay nodes that simply *amplify-and-forward* everything that they receive
 - Different categories depending on:
 - Power characteristics and spectrum that they are configured to amplify (e.g., single band, multi-band, etc.)
 - Typically **full-duplex** capable not differentiating UL and DL
- Main **advantages** of RF repeaters are their low-cost, their ease of deployment and the fact that they do not increase latency
 - Simplest and most cost-effective way to improve network coverage
- Main **disadvantage** is that they amplify signal and noise and, hence, may contribute to an increase of interference (pollution) in the system
- **There is no definition of RF repeaters for NR as of yet**

Observation

Importance of side information availability

- Prelim evaluations indicate that **substantial performance advantages** over RF repeaters can be attained if **side control information** becomes **available**, namely:
 - **Timing information**: DL/UL split (slot and symbol level)
 - **Spatial Tx/Rx information**: Tx/Rx beam information



Legend:

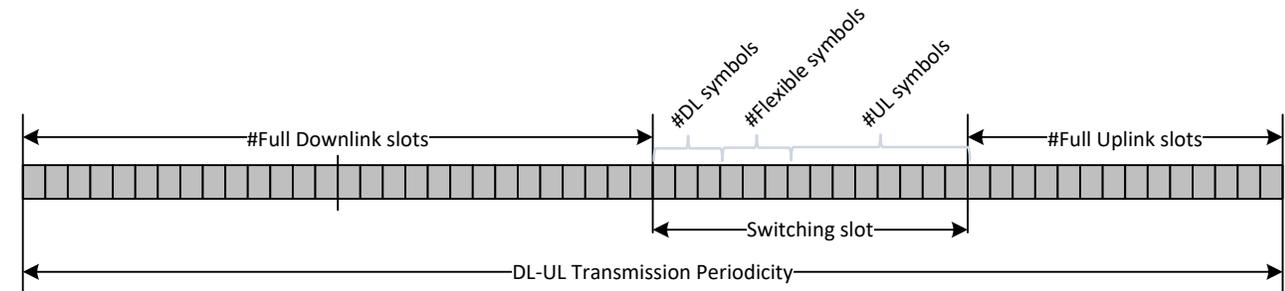
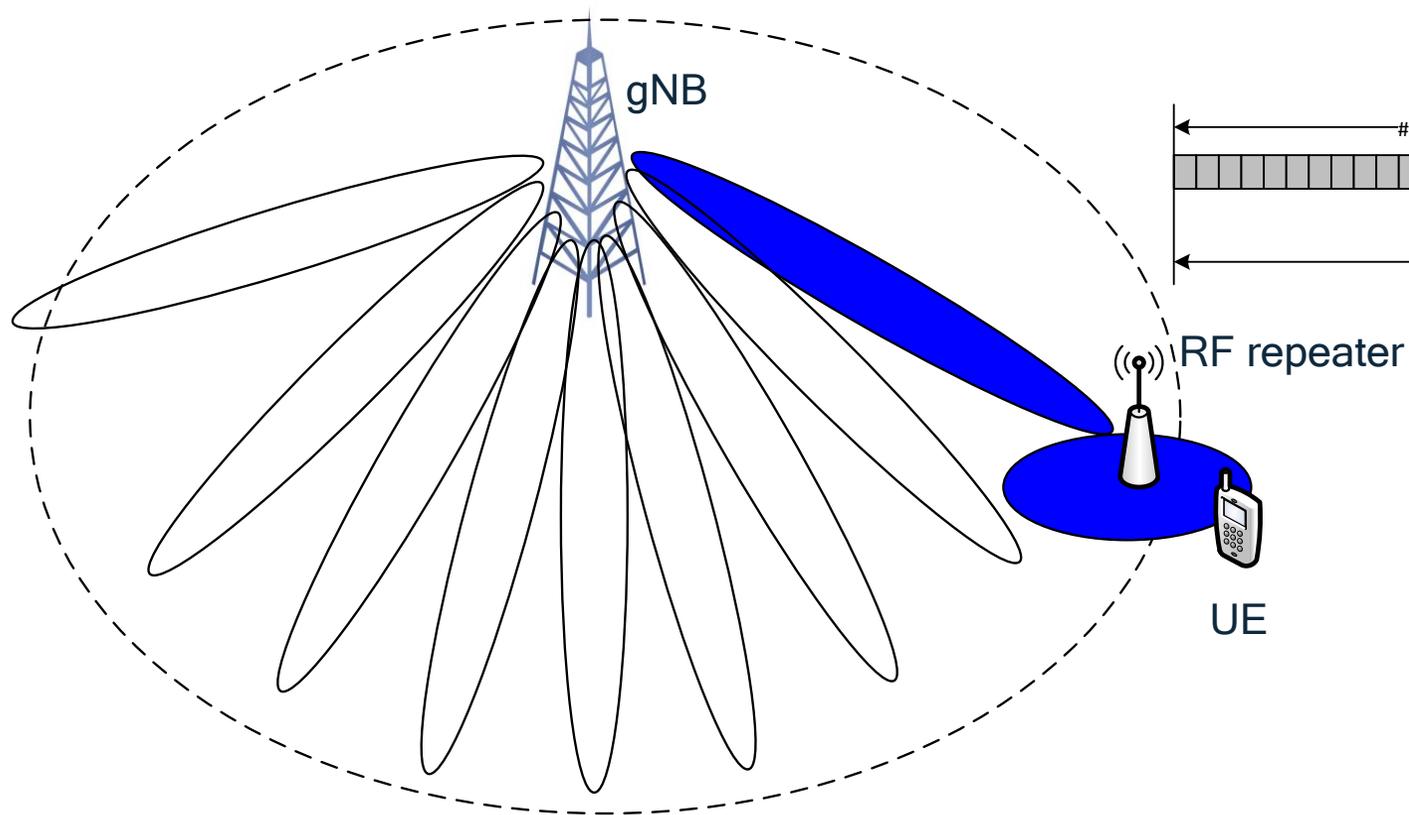
AF: Amplify and Forward

indirectUE: UEs served by Repeater

RF Repeater

In context of TDD and multi-beam operation

- Typically omni* or fixed directional Tx/Rx (not adaptive over time)
- Typically no distinction between UL/DL (high complexity, implementation based if possible)

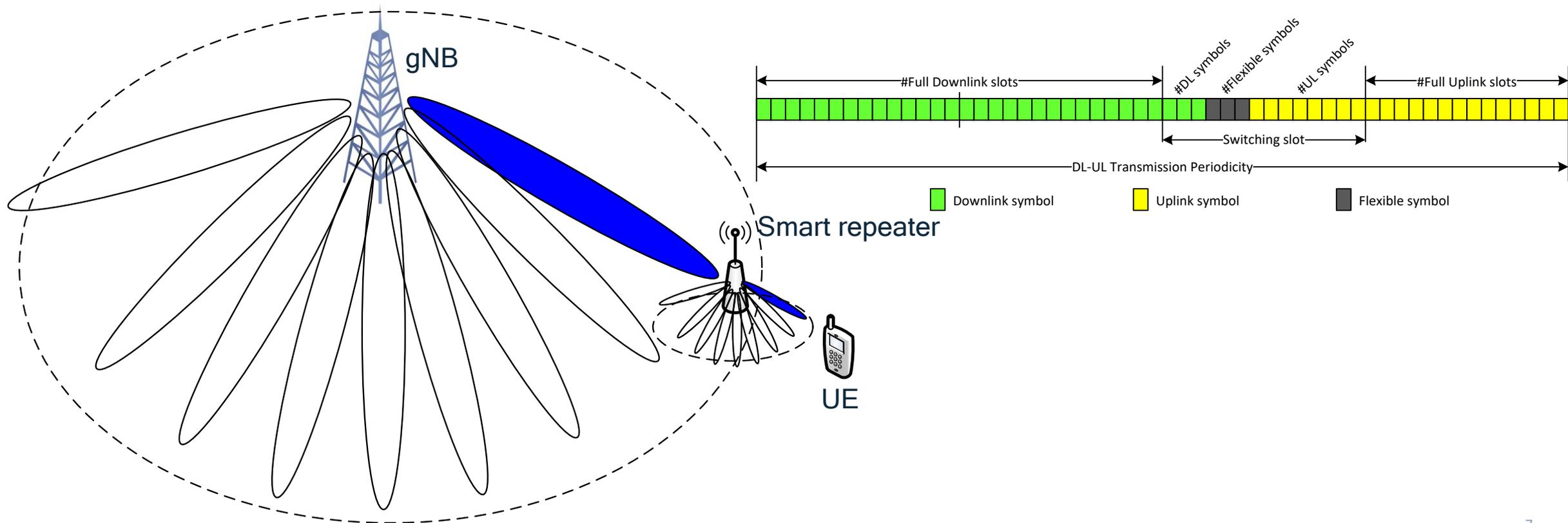


* RF repeater shown with omni Tx/Rx

Smart Repeater

In context of TDD and multi-beam operation

- Multi-beam adaptive over time capable
- Fully aware of DL/UL split

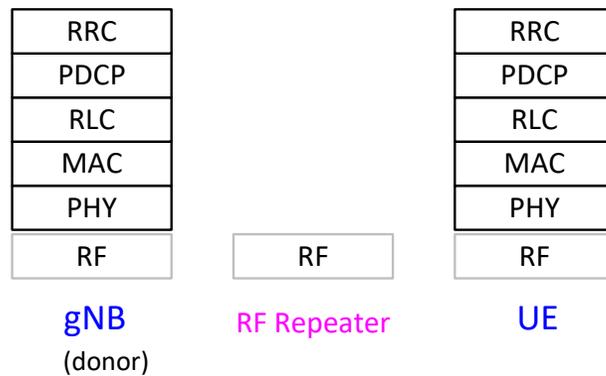


RF Repeaters vs. Smart Repeaters

Protocol Stacks

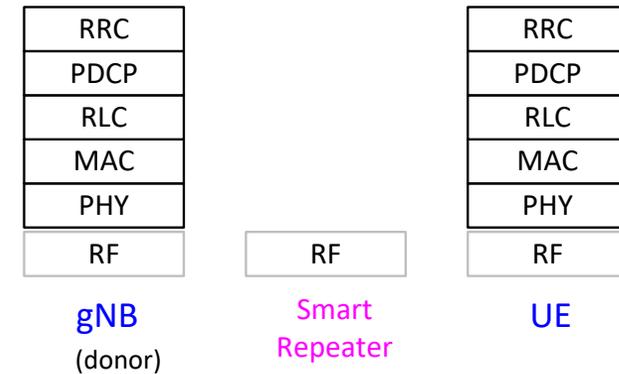
- Protocol stack for RF repeater:

User and Control Plane:

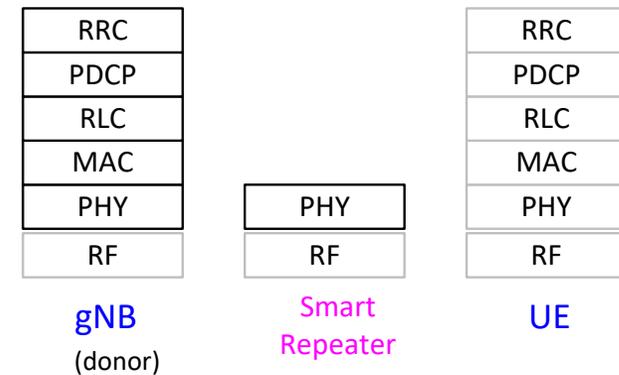


- Protocol stack for Smart Repeater:

User Plane:



Control Plane:

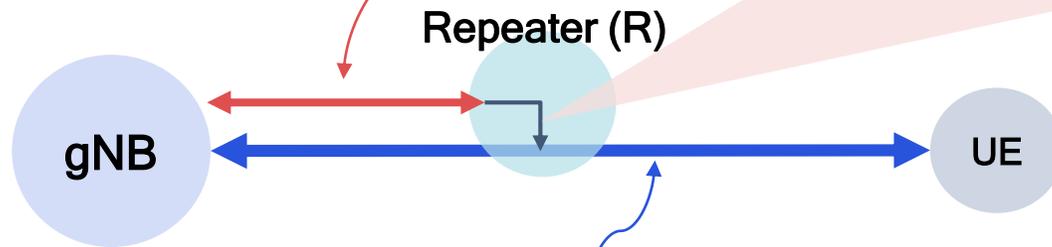


Smart Repeaters

Fronthaul and Access links

- Fronthaul link
- Control path (e.g. FR2, [small] BWP)
 - Carries UL/DL signals to configure repeater

- Control information
- TDD configuration (UL/DL)
 - Beamforming configuration



- Access link
- Data path (e.g. FR2) that carries analog UL/DL signals from/to UEs
 - It is a (analog) pass through
 - Fully controlled by gNB (DU) via the control path (FH)

Proposed Objectives

WID objectives (RAN4 primary, RAN1/2 secondary)

- Specify requirements for RF repeaters [RAN4]
- Study the performance advantages over RF repeaters offered by having side control information to intelligently apply amplify-and-forward relay operation assuming availability of the following [RAN4]:
 - Timing information, i.e., slot and symbol UL/DL configuration
 - Transmitter and receiver spatial information, i.e., beam information
- Assess specification impact to convey side control information related to timing and spatial characteristics as required by RAN4 [RAN1]
- Assess air-interface protocol impact to support smart repeaters as required by RAN4 [RAN2]
- Checkpoint at RAN#93 on the specification impact of smart repeaters and decision on how to proceed with normative work

For all of the above objectives, the leveraging of specifications for IAB should be sought while targeting a substantial simplification of the overall specification and associated cost and implementation.



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