

NR Repeaters

Motivation

AI: 9.1.5

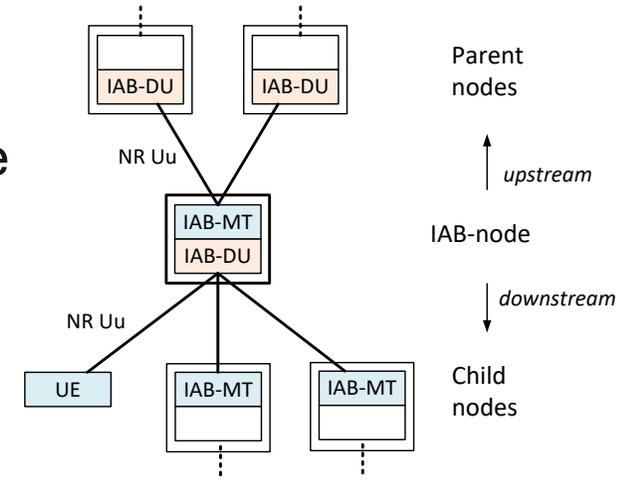
Background

- 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

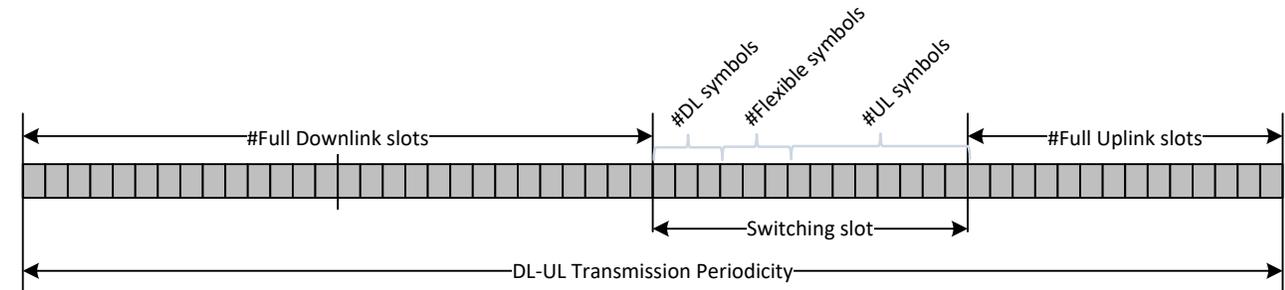
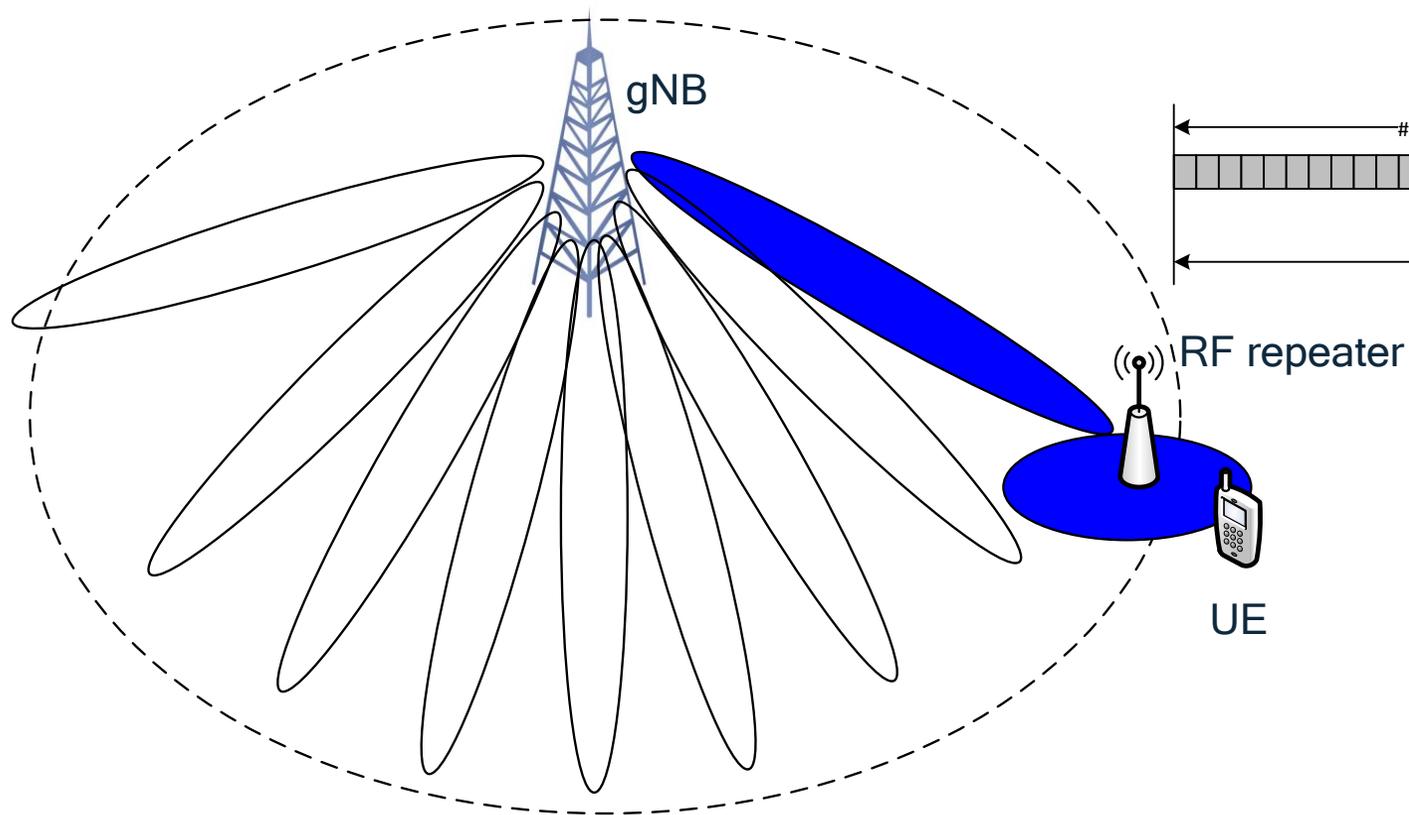
- Prelim evaluations indicate that **substantial performance advantages** over RF repeaters can be attained if **side control information** becomes **available**, namely:
 - **Timing information**: DL/UL split (slot and symbol level)
 - **Spatial Tx/Rx information**: Tx/Rx beam information
- Slide 12 shows simulation performance comparison of various Repeater Types for Urban Canyon scenario

Repeater Type
Class A Repeater = RF repeater
Class A+ = Class A Repeater + Dynamic TDD
Class A++ = Class A + + RU On/Off
Class B = Class A++ + UE specific beamforming

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)

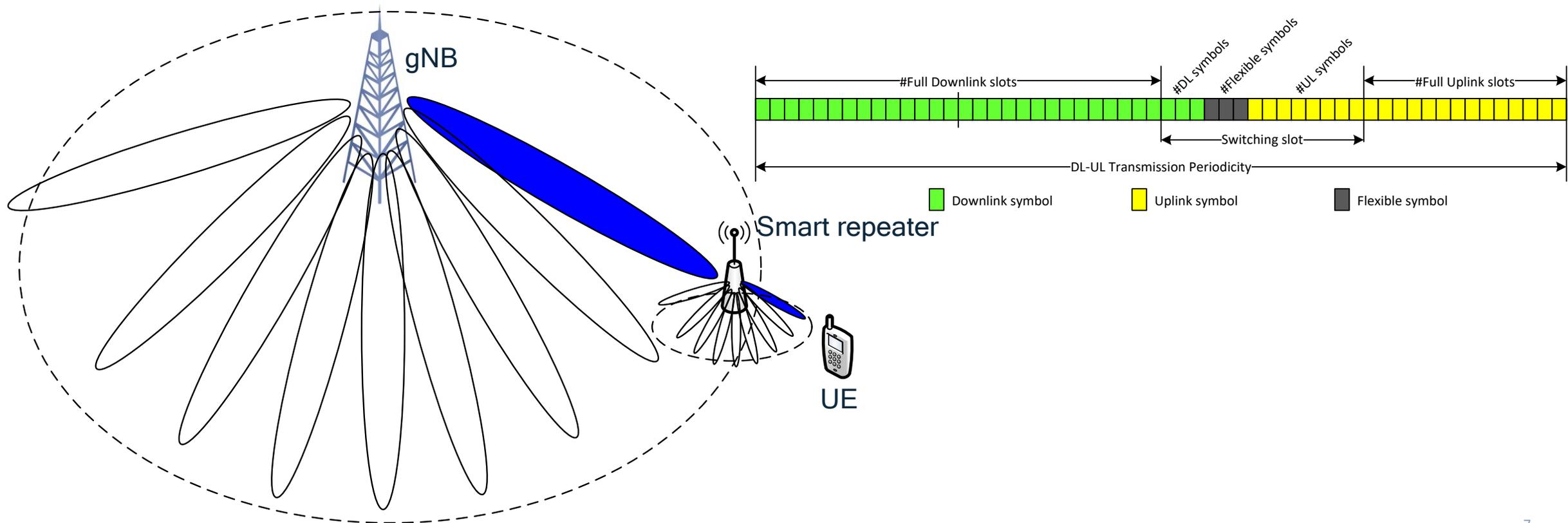


* RF repeater shown with omni Tx/Rx

Smart Repeater

In context of TDD and multi-beam operation

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

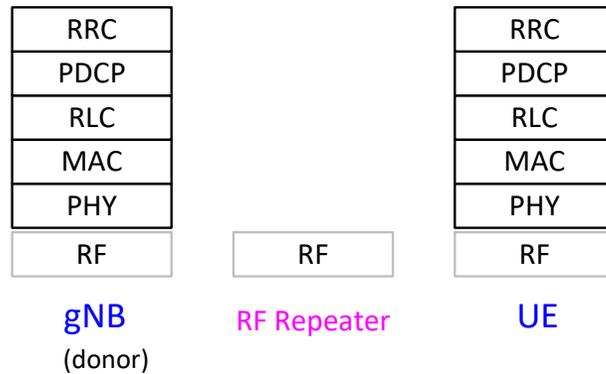


RF Repeaters vs. Smart Repeaters

Protocol Stacks

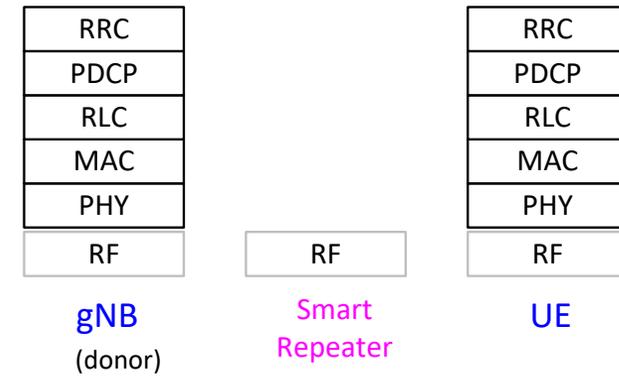
- Protocol stack for RF repeater:

User and Control Plane:

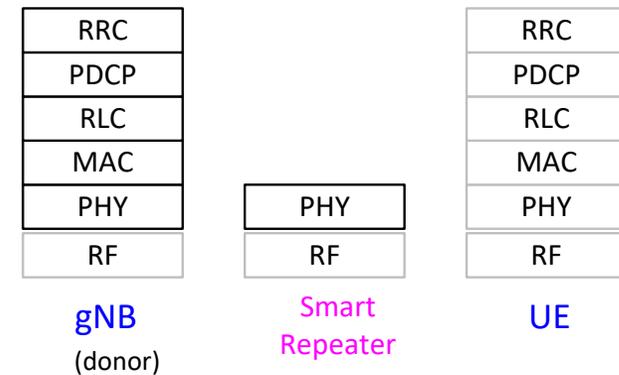


- Protocol stack for Smart Repeater:

User Plane:



Control Plane:

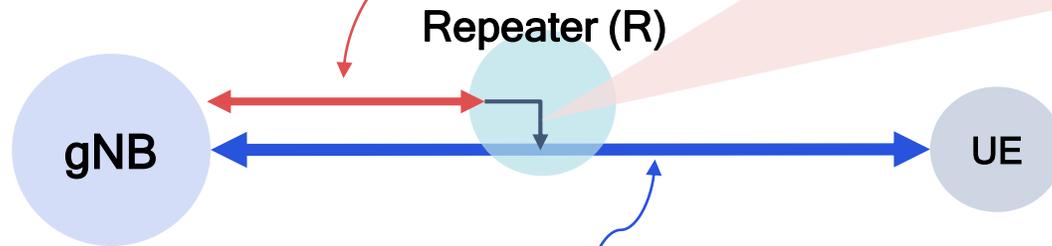


Smart Repeaters

Fronthaul and Access links

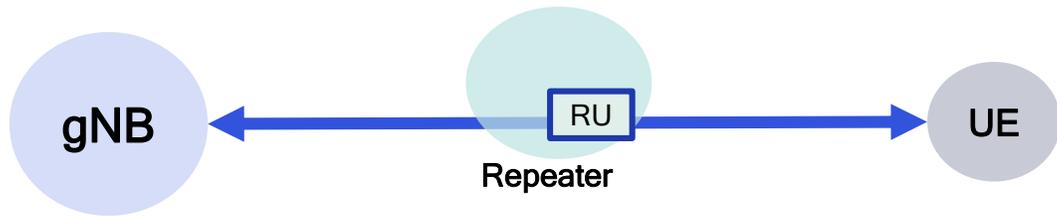
- Fronthaul link
- Control path (e.g. FR2, [small] BWP)
 - Carries UL/DL signals to configure repeater

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

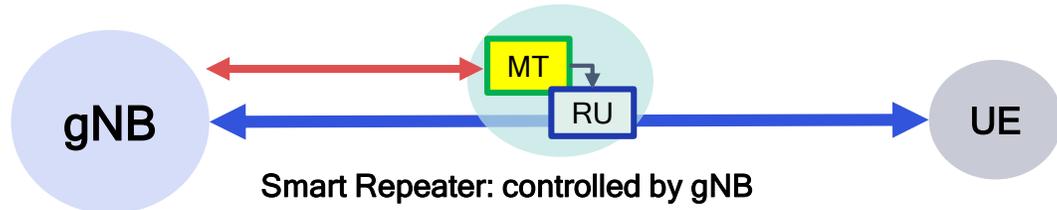


- Access link
- Data path (e.g. FR2) that carries analog UL/DL signals from/to UEs
 - It is a (analog) pass through
 - Fully controlled by gNB (DU) via the control path (FH)

Types of Repeaters and vs. IAB

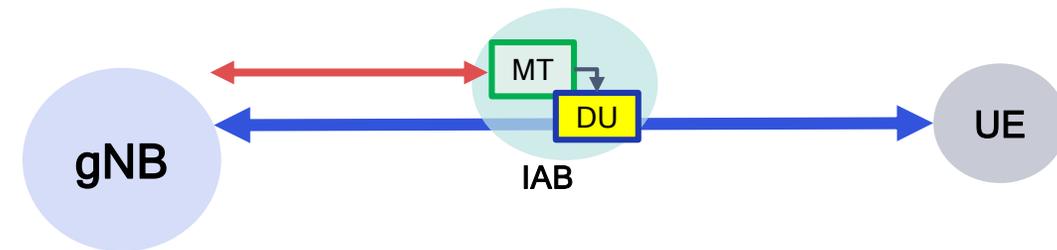


[Static TDD awareness]
Cell specific beamforming (RU and UE)
RU On **always**

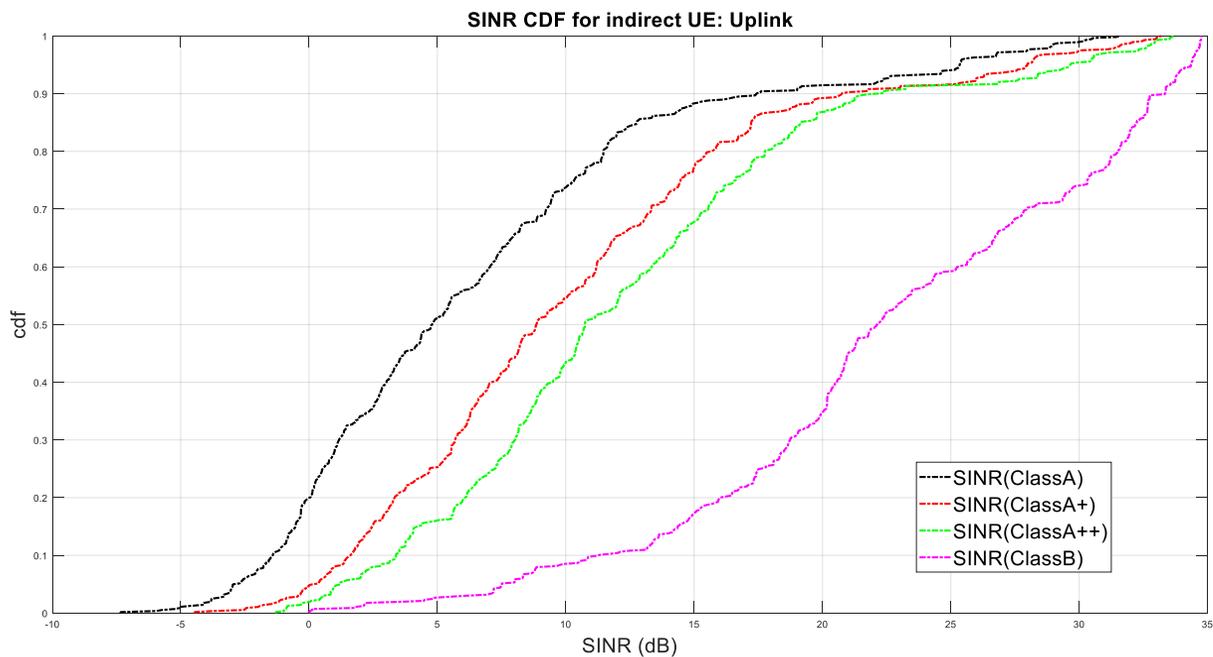
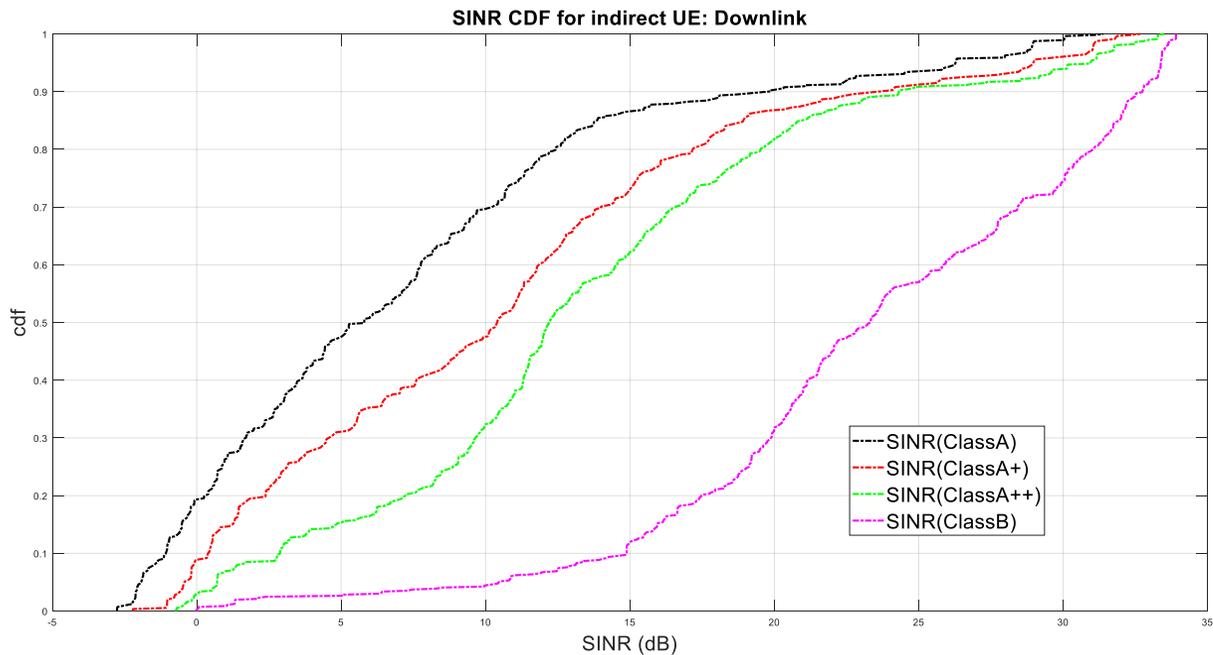


Dynamic TDD awareness
UE specific beamforming
RU On/Off

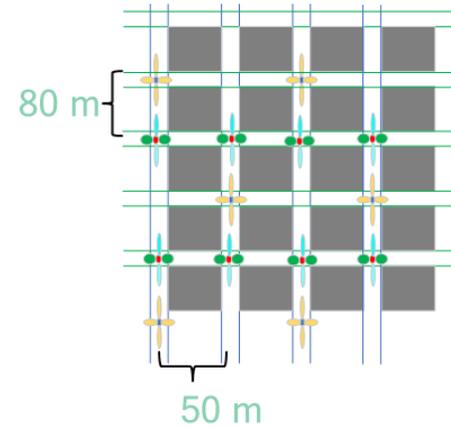
Enabled by side control information from gNB to MT



Full DU function with integrated wireless backhaul



Node Type	DL Outage (SNR _{th} =0dB)
Class A Repeater	19%
Class A+ = Class A Repeater + Dynamic TDD	8.8%
Class A++ = Class A + RU On/Off	3%
Class B = Class A++ + UE specific beamforming	0.18%



Node Type	UL Outage (SNR _{th} =0dB)
Class A Repeater	20%
Class A+ = Class A Repeater + Dynamic TDD	4.8%
Class A++ = Class A + RU On/Off	1.8%
Class B = Class A++ + UE specific beamforming	0.1%

Proposed WID Objectives

- Specify RF and EMC requirements for NR repeaters [RAN4]
 - Consider FR1 (FDD and TDD) and FR2 (TDD) bands
- Assess the coverage/performance advantages over RF repeaters offered by having side control information to selectively 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
- Checkpoint at RAN#93 on whether to task RAN1 and RAN2 to assess the specification impact to support 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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