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Motivation for study on non-orthogonal multiple access for NR

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Summary of NoMA status during Rel-14 NR SI

- Agreements from Rel-14 NR SI
  - NR should target to support non-orthogonal multiple access in UL at least for mMTC
  - NR should target to support UL “autonomous/grant-free/contention based” at least for mMTC
  - At least an UL transmission scheme without grant is supported for URLLC

- Observations from extensive link and system evaluations in Rel-14 NR SI
  - Non-orthogonal MA, in some of the evaluated scenarios, provides significant gain in terms of UL link-level sum throughput and overloading capability with ideal and realistic channel estimation.
  - Some non-orthogonal MA results combined with narrowband and/or repetition operations can reach -164 dB MCL @160bps data rate, which meets the coverage requirement for NR.
  - Non-orthogonal MA schemes using an advanced receiver have little or no performance loss due to MA signature (except RS) collision.
  - All simulated non-orthogonal MA schemes with grant-free with advanced receivers provide significant system capacity gain in terms of PAR at given system outage (e.g, 1% target packet drop rate), compared to a respective grant-free reference scheme assumed by each company
  - Evaluation simulators have been calibrated with agreed simulation assumptions (R1-1609442)

- It is motivated to continue the study on DL and UL non-orthogonal multiple access in Rel-15, for all possible use cases including eMBB, URLLC, and mMTC

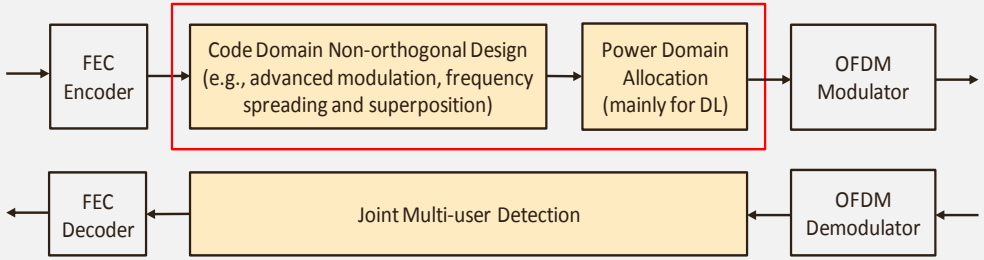
Motivations for NoMA

Usage Scenario	eMBB	mMTC	URLLC
Motivation for 5G Non-orthogonal MA	• Multi-user capacity to improve spectrum efficiency • Higher user density • Uniform user experience • Mixed traffic types	• Massive connectivity • Highly Efficient Small Packets Transmission	• Ultra high reliability • Ultra low latency

Benefits of non-orthogonal MA

- **High system capacity**: multi-user capacity, open-loop multiplexing relaxed precise CSI requirement
- **Massive connectivity**: support overloading, reduction of scheduling overhead especially for small packages
- **Uniform user experience**: multi-user multiplexing to improve latency and fairness, robust to network impairments, enabling open-loop multiplexing and open-loop CoMP
- **Low latency and high reliability**: enable grant-free transmission, spreading diversity, signal space diversity
- **Mixed traffic types**: superposition of sporadic small packets on big ones, no extra resource or waiting delay

Hybrid code and power domain non-orthogonal design



Limitation of power domain non-orthogonal MA

- Scheduling flexibility
- Diversity protection for small packets
- Robustness against colored interference
- Robustness against channel aging

— **Non-orthogonal multiple access** should be supported in order to fulfill the diverse service requirement from all the three 5G usage scenarios defined by IMT for 2020 and beyond.

— **Code domain** non-orthogonal design is needed in addition to the power domain superposition to deal with channel and interference uncertainties.

— **Sparse spreading** is an important feature in the code domain design to enable high level of overloading with reasonable ML decoding complexity.

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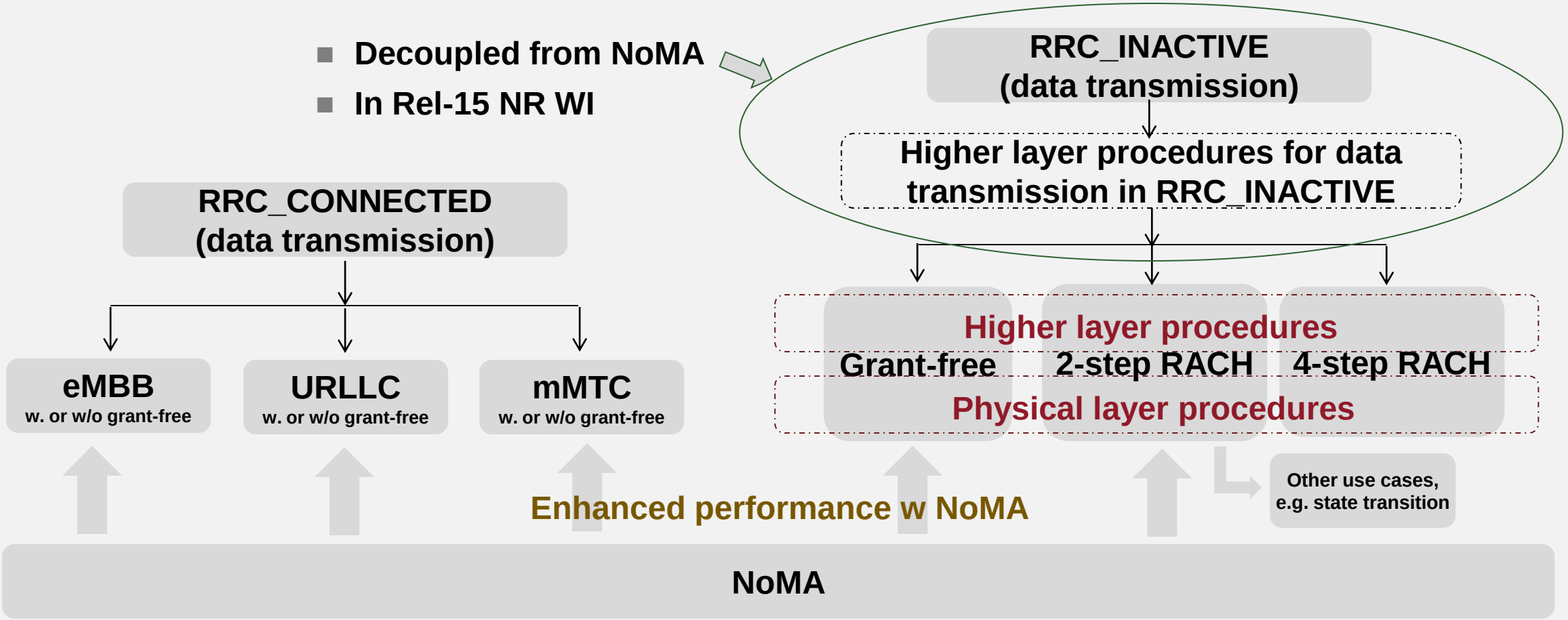
Rel-15 NR SI on NoMA (preferred scope)

- Transmitter side signal processing schemes for non-orthogonal data transmission [RAN1]:
  - Modulation and symbol level processing, including different kinds of spreading, repetition, interleaving, new constellation mapping, etc.
  - Coded bit level processing, including interleaving, scrambling, etc.
  - Symbols to resource elements mapping, sparse or not, etc.
- Multi-user receiver schemes for non-orthogonal multiple access: [RAN1, RAN4]
  - Successive interference cancellation receiver, joint detection type receiver, the combination of the above, etc.
  - Cost analysis, e.g, complexity, signal processing latency
- Signals/Procedures related to the non-orthogonal data transmission with/without grant-free [RAN1, RAN2]
  - Demodulation reference signal
  - System configuration signaling
  - HARQ, on transmission, feedback, and combining scheme
  - Link adaptation and resource selection
- Link and system level performance evaluation for non-orthogonal multiple access [RAN1, RAN2]
  - Traffic model, deployment scenarios, baseline, and metrics
  - Simulations with realistic channel estimation, different traffic loads for different deployment scenarios
  - Complementary analysis, e.g., power consumption, latency, and signaling overhead
  - Physical abstraction (link-to-system mapping model)

NoMA, grant-free, INACTIVE data transmission, 2-step RACH

- NoMA: a physical layer non-orthogonal multiple access scheme, more advanced than pure OFDM based transmission
- Grant-free: a mechanism/procedure that allows a UE to transmit UL data without receiving UL grant
- INACTIVE data transmission: A UE in RRC_INACTIVE can start data transmission with or without initiating state transition
- 2-step RACH: A simplified RACH procedure that intends to reduce the latency of RACH procedure



THANK YOU

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