3GPP TSG RAN Meeting #66
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RP-141895
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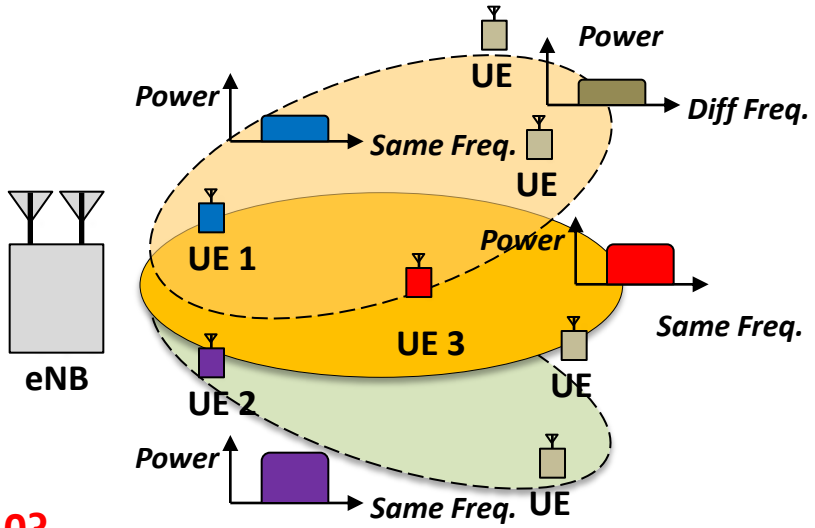
Agenda Item: **14.1.1**

Motivation for

Enhanced Multiuser Transmissions and Network Assisted Interference Cancellation for LTE

Multi-User Transmission in LTE

- What is DL MU-MIMO (or SDMA)
  - Simultaneous (superposed) transmission to >=2 UEs on the same radio resources
  - Linear precoding (i.e., beamforming) at eNB to control cross-user interference
- Why/When perform MU transmission vs. SU
  - High loading in a cell
  - Multi-user diversity provides system level throughput gain, while maintaining fairness among UEs



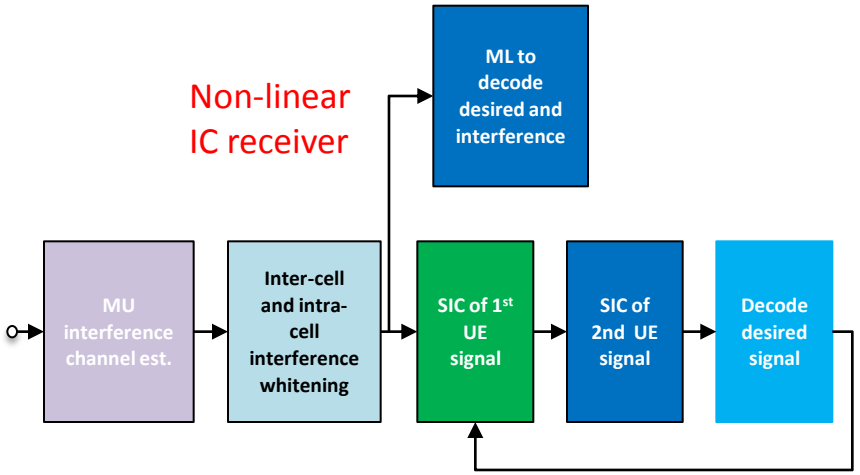
What do we want to do MU differently versus R8/9/10?

Rel-8	Rel-9	Rel-10 (LTE-Advanced)	What is new in our idea of "MUIC"?
• **Codebook based** (TM5) • Precoding weights are chosen from a predefined Precoding Matrices Index (PMI) •PMI signaled to the target UE only •UE constructs the effective channel from unprecoded pilots (CRS) and PMI	• **Non-codebook based** (TM8) •eNB can use any precoding weights •UE only relies on precoded pilots (DMRS)	• **Non-codebook based enhancement** (TM9) • Also support 8-Tx codebook-based feedback using CSI-RS	"Interference non-agnostic" MU • eNB dynamically provides transmission information of co-scheduled UE

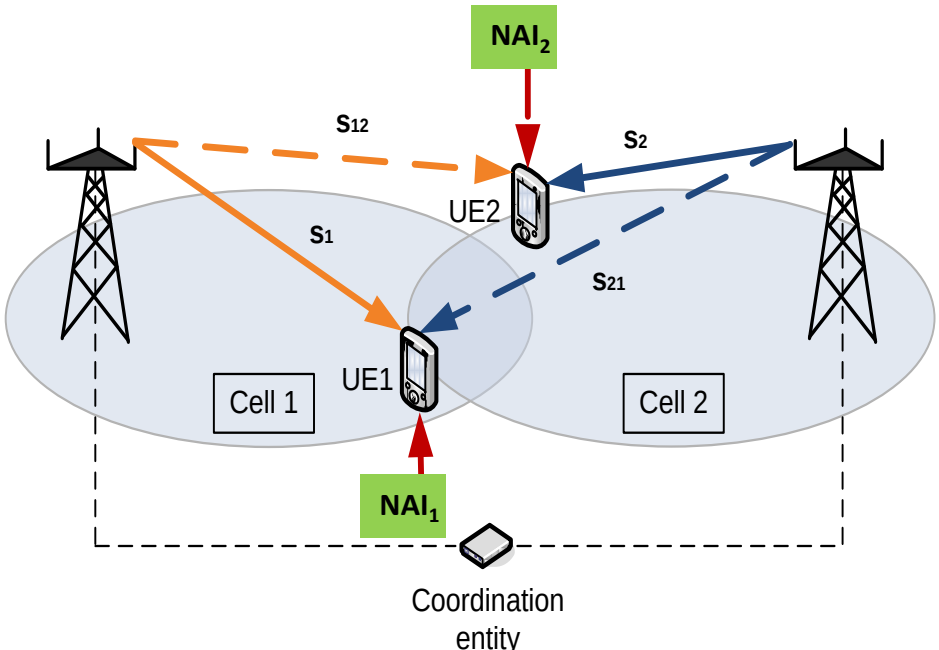
"Interference-agnostic" from the UE perspective

Multi-User Interference Cancellation (MUIC)

- MU interference is a big problem
  - eNB determines the linear precoding weights based on **limited UE feedback** in FDD (based on codebook) or sounding in TDD → Inevitable cross-user interference
- Advanced IC capability can help to mitigate MU interference, instead of relying only on eNB precoding
  - Joint detection of desired and interference (e.g., maximum likelihood "ML")
  - Successive Interference Cancellation "SIC" (symbol-level or codeword-level IC)



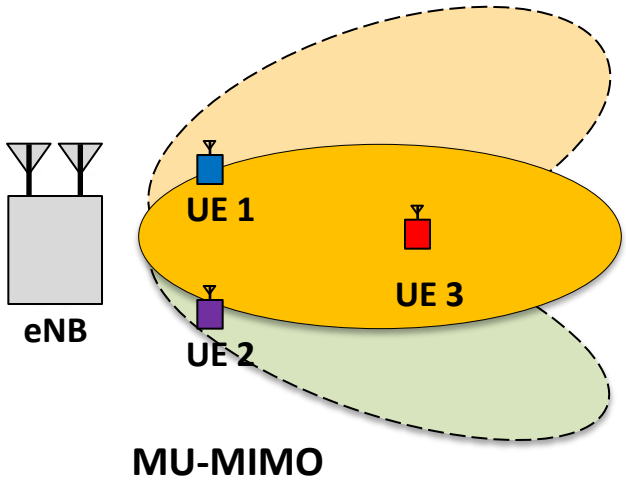
ML or SIC type of IC receivers studied in Rel-12 NAICS can be extended to MUIC

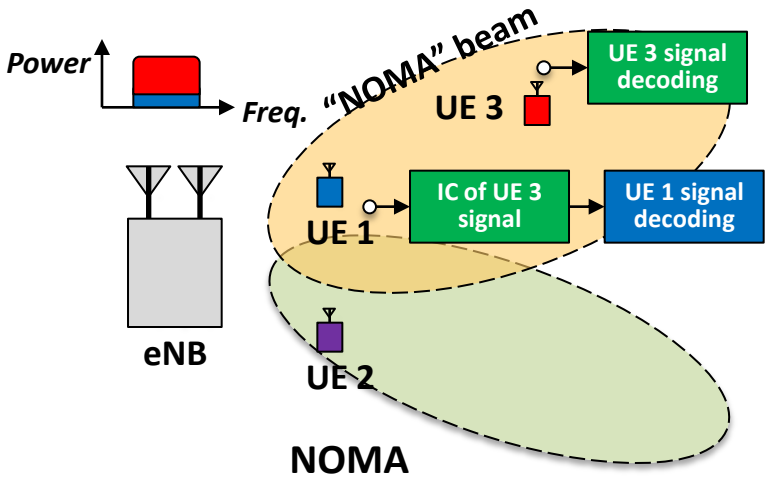


	Rel-12 NAICS	MUIC
Target scenarios	• Cell-edge users dominated by inter-cell interference	• UEs with mid- to high-SINR, suffering from additional intra-cell MU interference
Signaling	• Assisted by **semi-static signaling** on neighboring cells, **plus blind detection** of all dynamic parameters	• **Dynamic signaling** of the co-scheduled transmission information, including MCS
IC receiver	• ML or Symbol-Level IC	• Additional, **codeword-level IC**, turbo-IC

Study on MU System Enhancements

- **MU system enhancements include**:
  - Enhancement to MU-MIMO schemes
    - Simultaneous transmission of multiple beams with one layer of data transmission in each beam
    - Users' signals are separated in spatial domain
    - Based on SLIC/RML/CWIC receivers and with improved interference information over the existing MU operation
  - NOMA [1]
    - A special implementation of MU-MIMO
    - Simultaneous transmission of multiple beams with more than one layer of data transmission in a beam
    - NOMA UEs' signals are separated in power domain
    - In the figure, power allocation between UE1 and UE3 to allow UE3 to decode without IC and UE1 to decode after UE3's signal cancellation





[1] METIS D2.3, "Components of a new air interface - building blocks and performance," Apr. 2014.

Can IC Make MU Deployment Attractive? Enhancement to MU-MIMO

- **Current MU-MIMO is not competitive enough to SU, why?**

  UE is unable to well handle inter-layer interference due to lack of interference information

- **Can IC itself make MU attractive?**

  Network assisted IC can help MU significantly. The gain of network assisted ML-IC over MMSE-IC increases when MU interference is stronger due to a larger number of layers of interference

- **Higher Order MU to unleash MU potential:**
  - Previously: $N_{layer} <= N_{rx}$
  - Rel-13: $N_{rx} < N_{layer} <= N_{tx}$
    - ML processing at UE is possible even when $N_{rx} < N_{layer}$, but with high complexity

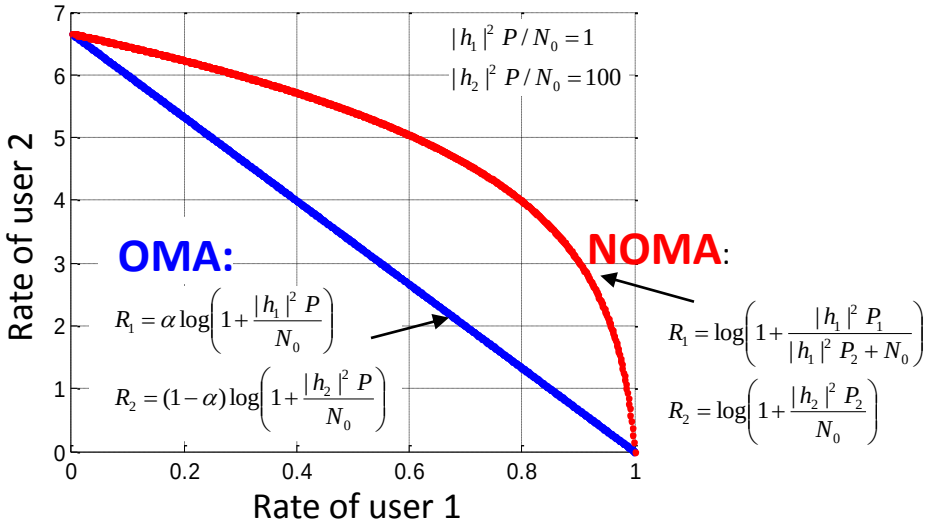
- **MU is more about system design than just a receiver design. The key challenge is on MU scheduling.**

  eNB must be able to predict IC effectiveness under High Order MU transmission (yet, the prediction can only based on limited UE feedback). Adaptive power allocation among layers can better realize users fairness

MUIC spectral efficiency (bps/Hz) [Preliminary]			
	w/o MUIC	**w/ MUIC**	**Gain**
Cell average	2.47	2.97	**20.2 %**
Cell edge	0.046	0.055	**19.6 %**

Can IC Make MU Deployment Attractive?
NOMA

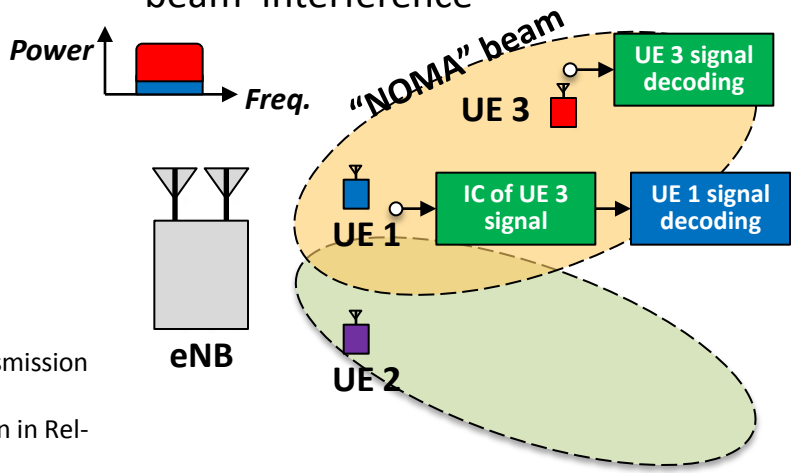
- Fundamental concept



NOMA spectral efficiency (bps/Hz) [Preliminary]			
	OMA	**NOMA + OMA**	**Gain**
Cell average	2.18	2.61	**19.7 %**
Cell edge	0.026	0.034	**30.8 %**

Assume perfect IC

- **Transmitter**
  - Intra-beam signal separation in power domain (signals of UEs 1 and 3)
  - Inter-beam signal separation in spatial domain (signals of UEs 1 and 2)
- **Receiver**
  - UE 1: Codeword level interference cancellation for intra-beam interference
  - UEs 1, 2, and 3: MMSE-IRC for inter-beam interference



[2] RP-141936, "Justification for NOMA in New Study on Enhanced Multi-User Transmission and Network Assisted Interference Cancellation for LTE," NTT DoCoMo, Dec. 2014.
[3] RP-141917, " Motivation for a study on enhancements for multiuser transmission in Rel-13," Huawei, Dec. 2014.

Simulation Assumptions

Parameters	Values
Cell layout	Homogeneous, 19 sites, 3 cells per site
Inter-site distance	500 meter
System bandwidth	1.4 MHz
Subband bandwidth	6 resource blocks
Users per sector	10 for MUIC; 30 for NOMA
Traffic model	Full buffer model
Scheduling algorithm	Proportional fairness
CSI feedback	LTE Rel-8 codebook and CQI
PMI/RI feedback period	5 msec
Control delay in scheduling w.r.t. feedback timing	5 msec
Precoder assignment	Non-codebook based preceding; Zero-forcing precoder based on PMI feedback
HARQ	Not enabled
Number of transmit antennas	4 for MUIC; 2 for NOMA and OMA
Number of receive antennas	2
Antenna configuration	MUIC: X X -> || channels, 4λ antenna spacing
UE receiver	• MUIC: ML receiver • NOMA: SIC receiver for high geometry UEs; LMMSE-IRC receiver for low geometry UEs • OMA: LMMSE-IRC receiver