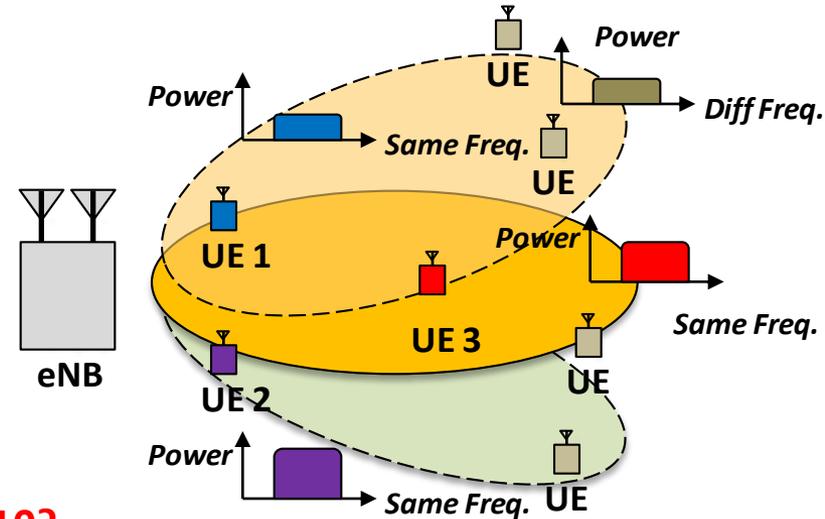


# Motivation for Enhanced MU-MIMO and Network Assisted Interference Cancellation

# Multi-User Transmission in LTE

- What is DL MU-MIMO (or SDMA)
  - Simultaneous (superposed) transmission to  $\geq 2$  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

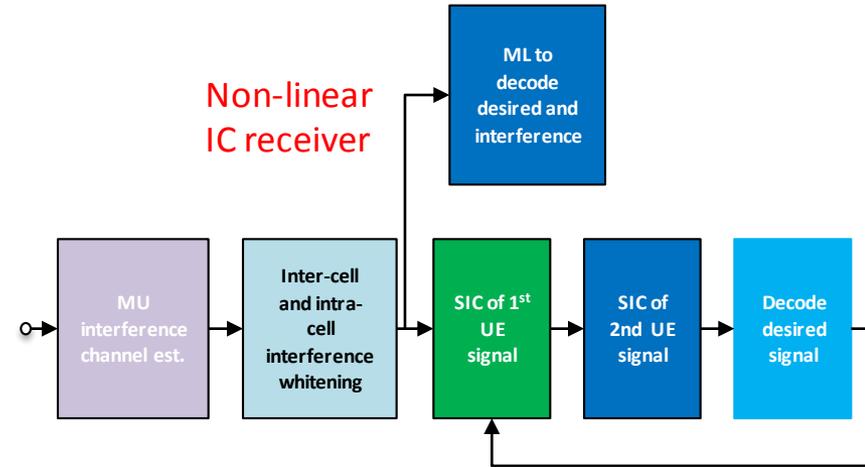


## What do we want to do MU differently versus R8/9/10?

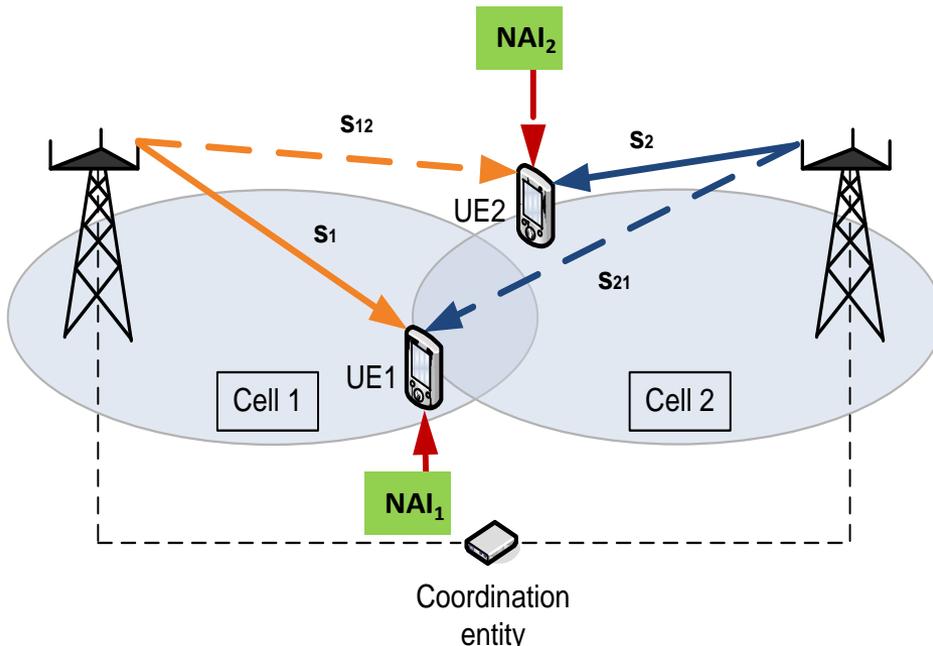
Rel-8	Rel-9	Rel-10 (LTE-Advanced)	What is new in our idea of "MUIC"?
<ul style="list-style-type: none"> <li>• <b>Codebook based (TM5)</b> <ul style="list-style-type: none"> <li>• Precoding weights are chosen from a predefined Precoding Matrices Index (PMI)                             <ul style="list-style-type: none"> <li>• PMI signaled to the target UE only</li> <li>• UE constructs the effective channel from unprecoded pilots (CRS) and PMI</li> </ul> </li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Non-codebook based (TM8)</b> <ul style="list-style-type: none"> <li>• eNB can use any precoding weights                             <ul style="list-style-type: none"> <li>• UE only relies on precoded pilots (DMRS)</li> </ul> </li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Non-codebook based enhancement (TM9)</b> <ul style="list-style-type: none"> <li>• Also support 8-Tx codebook-based feedback using CSI-RS</li> </ul> </li> </ul>	<p><b>"Interference non-agnostic" MU</b></p> <ul style="list-style-type: none"> <li>• eNB dynamically provides transmission information of co-scheduled UE</li> </ul>
<p><b>"Interference-agnostic" from the UE perspective</b></p>			

# 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)



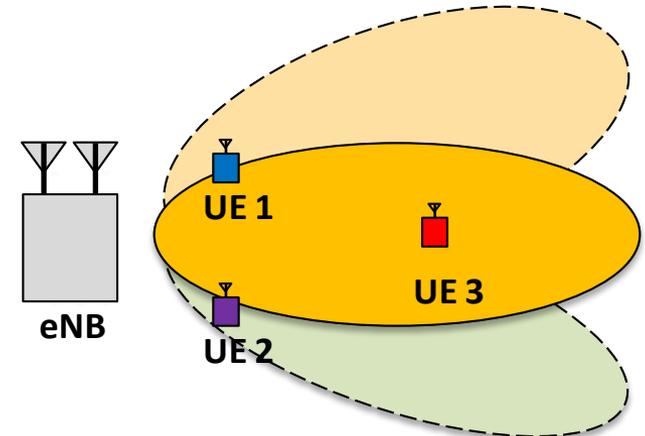
**ML or SIC type of IC receivers studied in Rel-12 NAICS can be extended to MUIC**



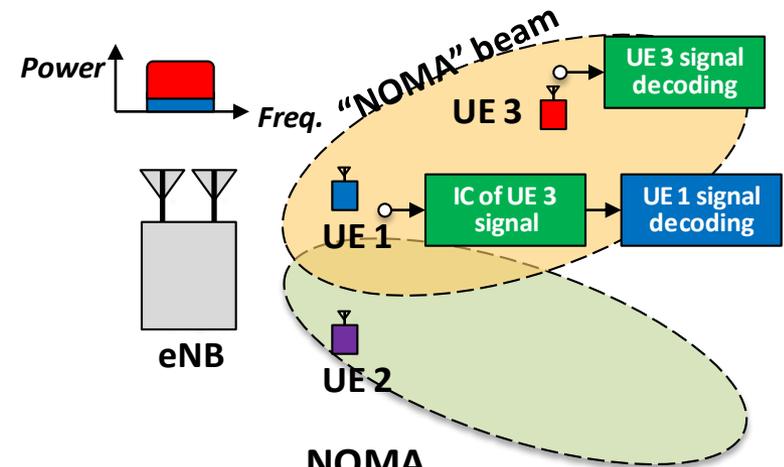
	Rel-12 NAICS	MUIC
<b>Target scenarios</b>	• Cell-edge users dominated by inter-cell interference	• UEs with mid- to high-SINR, suffering from additional intra-cell MU interference
<b>Signaling</b>	• Assisted by <b>semi-static signaling</b> on neighboring cells, <b>plus blind detection</b> of all dynamic parameters	• <b>Dynamic signaling</b> of the co-scheduled transmission information, including MCS
<b>IC receiver</b>	• ML or Symbol-Level IC	• Additional, <b>codeword-level IC</b> , 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 [1,2]
    - 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



MU-MIMO



NOMA

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

[2] RP-141165, "Justification for NOMA in New Study on Enhanced MU-MIMO and Network Assisted Interference Cancellation,"

NTT DoCoMo, Sep. 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

- **What is the full potential of MU?**

A theoretical upper bound for  $N_{\text{layer}}$  is  $(N_{\text{tx}})^2$

- **Higher Order MU to unleash MU potential:**

- Previously:  $N_{\text{layer}} \leq N_{\text{rx}}$

- Rel-13:  $N_{\text{rx}} < N_{\text{layer}} \leq N_{\text{tx}}$

- MU interference at the UE cannot be suppressed via linear processing

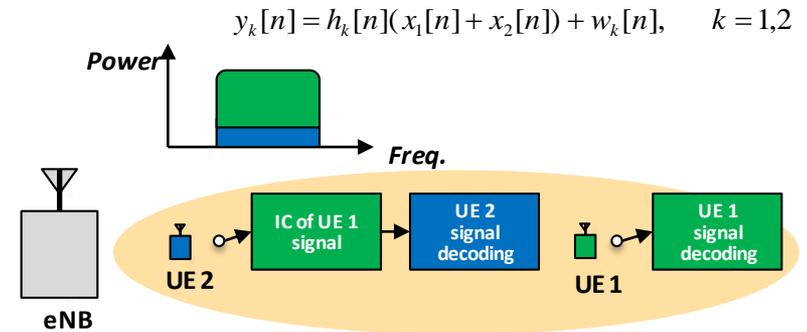
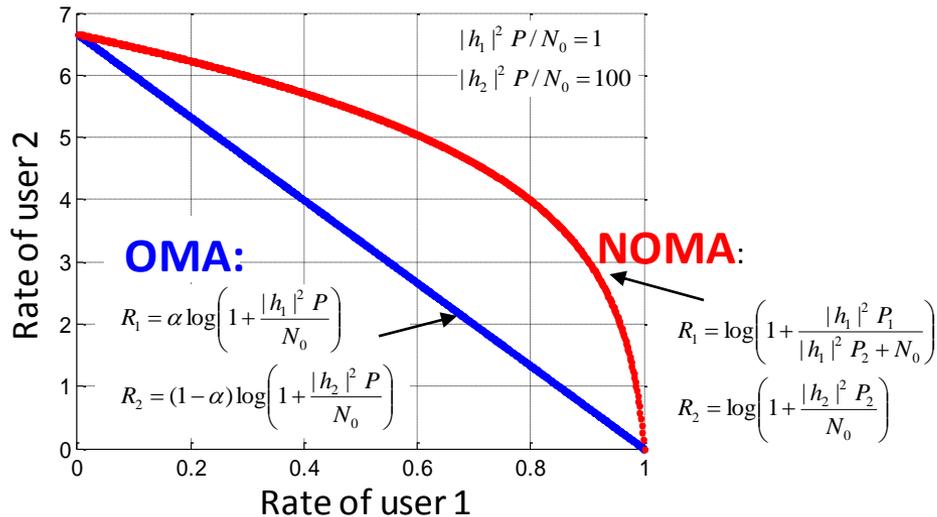
- ML processing at UE is possible even when  $N_{\text{rx}} < N_{\text{layer}}$ , but with high complexity

- **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)

# Can IC Make MU Deployment Attractive? NOMA

- Fundamental concept



Average spectral efficiency (bps/Hz)		
OMA spectral efficiency	NOMA + OMA	
	Spectral efficiency	Gain
2.180	2.605	19.5 %

Cell edge spectral efficiency (bps/Hz)		
OMA spectral efficiency	NOMA + OMA	
	Spectral efficiency	Gain
0.0259	0.0337	30.6 %

Assume perfect IC