# MOBILE BACKHAUL AND SYNCHRONIZATION FOR HETEROGENEOUS NETWORKS

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WSTS 2013: Synchronization in Telecommunication Systems

16-18 April, San Jose, USA

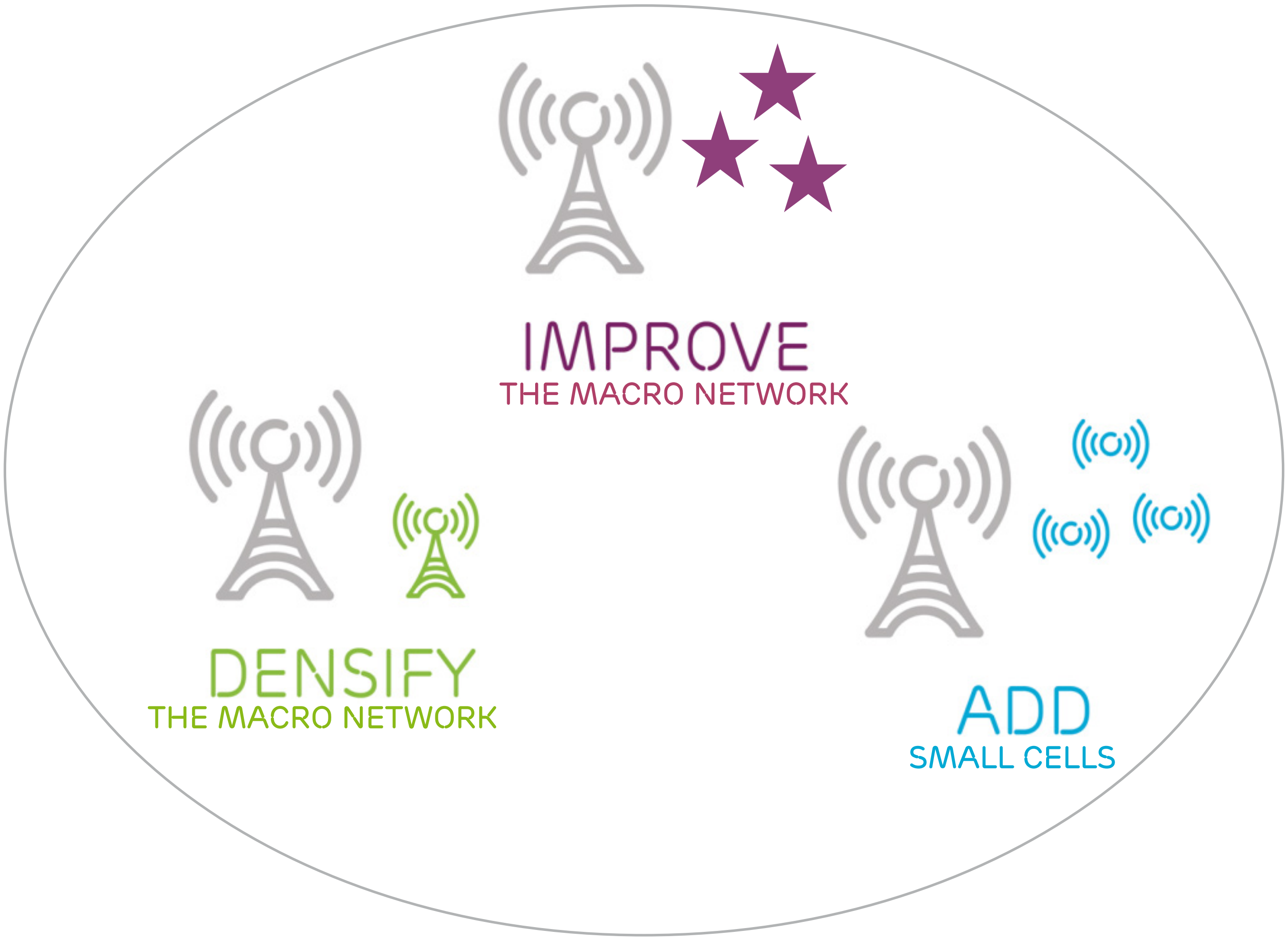
# HETEROGENOUS NETWORKS……






# … PROVIDING SEAMLESS USER EXPERIENCE–EVERYWHERE

# HETEROGENEOUS NETWORK CHOICES

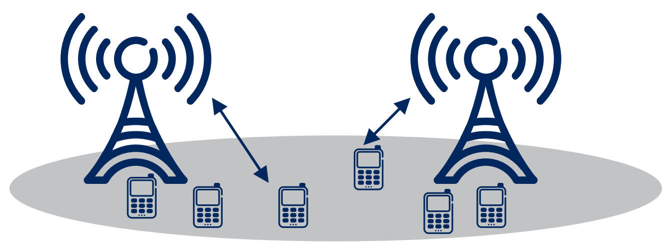


# BACKHAUL IMPLICATIONS

1. Improve Macro

Backhaul modernization and capacity upgrades

2. Densify macro



Backhaul expansion and densification

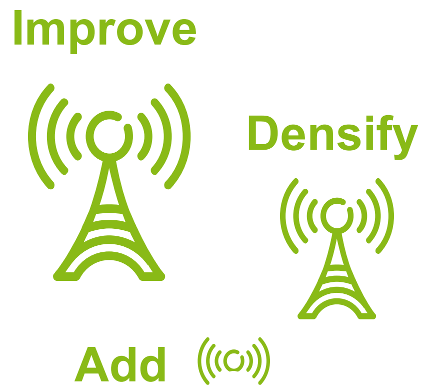
3. Add Small Cells

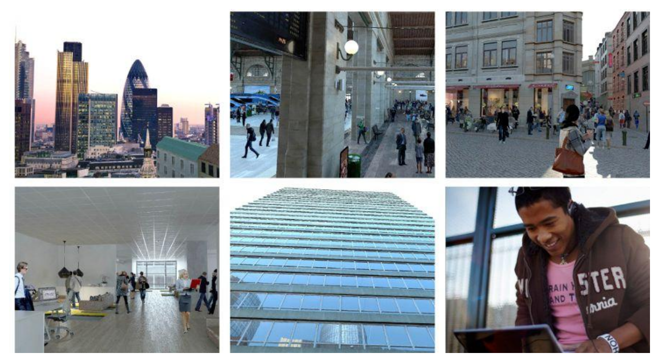
Additional low power nodes

Backhaul ⇔ coordination

# WHY DEPLOY SMALL CELLS?

- To improve uplink coverage
  - cell edge throughput
- To increase capacity
  - Capacity improves as coverage improves
- To offload congested macro cells
  - Target problem users, areas of high path loss, low user throughput
- Why is Radio coordination needed?
  - Interference coordination between macro and small cells will
    - Boost coverage
    - Boost capacity

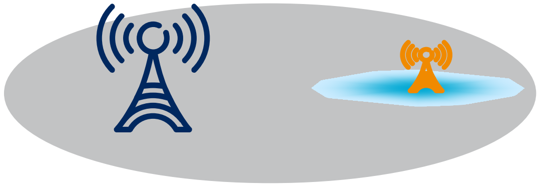


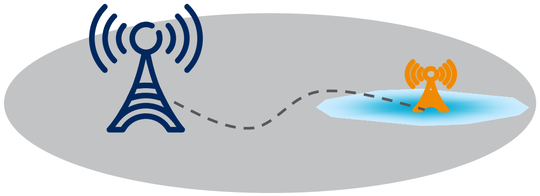
SMALL CELLS FOR COVERAGE AND CAPACITY

# MACRO-SMALL CELL COORDINATION OPTIONS

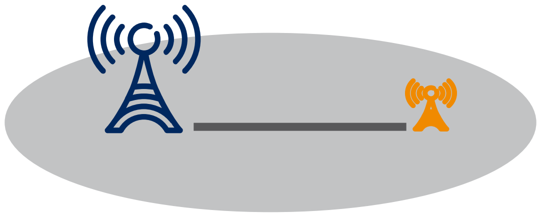
- No coordination
  - Example: Uncoordinated deployment with femtos in a macro network



- Moderate to tight coordination
  - Example: Coordinated deployment of pico RBSs in a macro network
  - SON , OAM, Transport, Radio

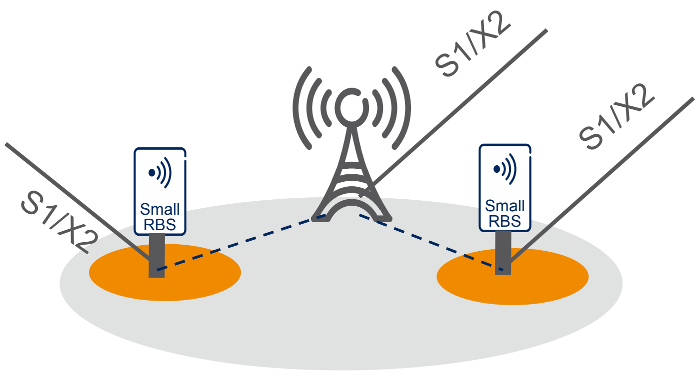


- Very tight coordination
  - Example: Main/remote radio network with joint scheduling (air interface) using CPRI



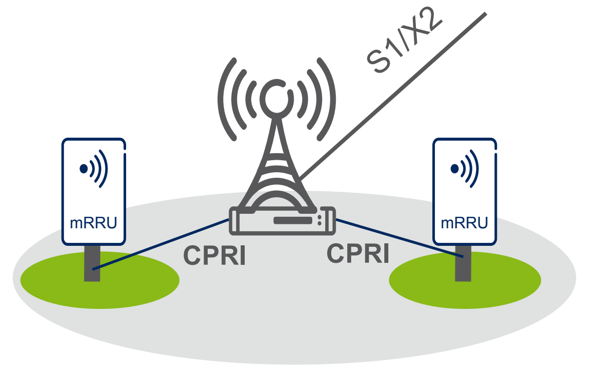
# SMALL CELLS
# ARCHITECTURE OPTIONS

## DISTRIBUTED BASEBAND ARCHITECTURE ('NORMAL' BACKHAUL)




- BACKHAUL: AS FOR MACRO S1/X2
- PERFORMANCE POTENTIAL: GOOD
- COORDINATION: MODERATE / TIGHT

## COMMON BASEBAND ARCHITECTURE (CPRI)



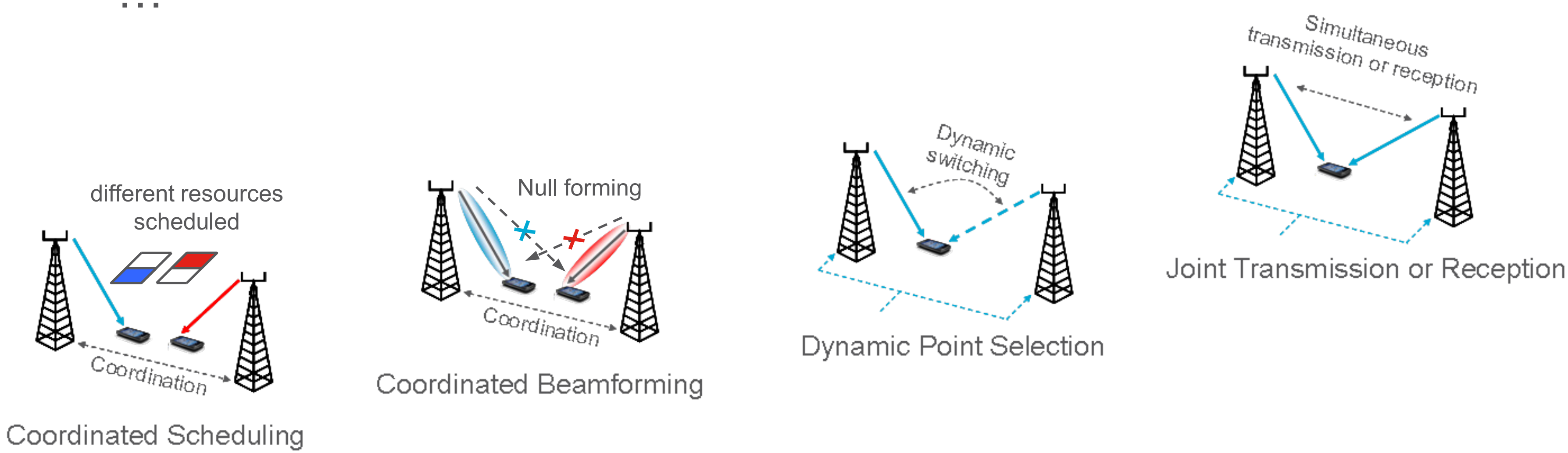

- BACKHAUL: AS FOR MACRO S1/X2
- CPRI: DEDICATED FIBRE
- PERFORMANCE POTENTIAL: BEST
- COORDINATION: VERY TIGHT

**[ ADDRESSES DIFFERENT DEPLOYMENT SCENARIOS - WHAT BACKHAUL IS AVAILABLE? ]**

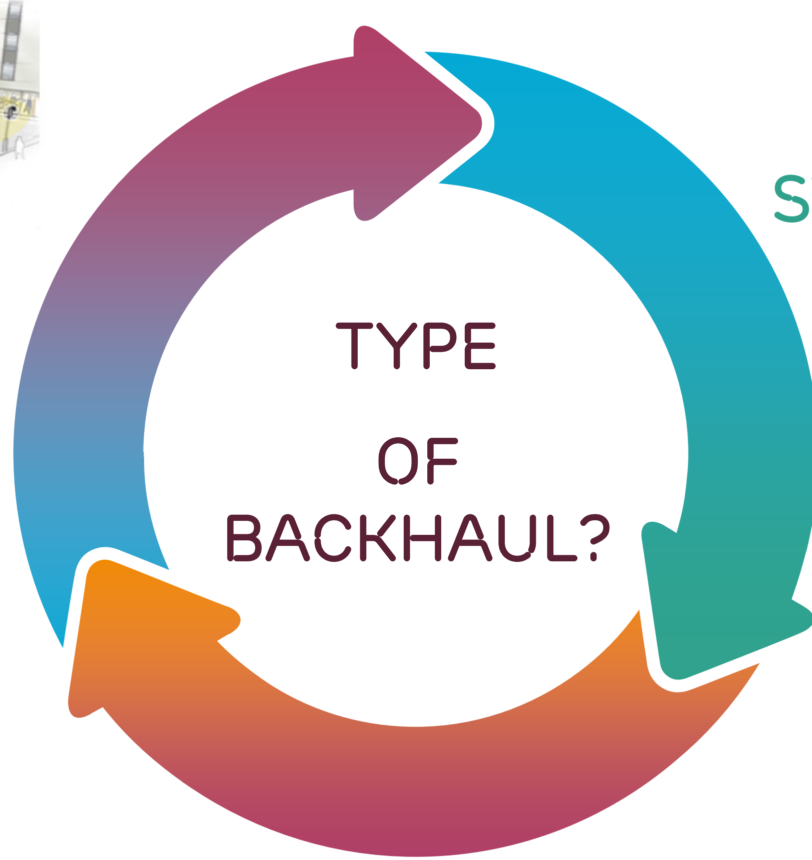
# “WHAT IS COMP?”

## - RADIO COORDINATION USING COORDINATED MULTIPOINT (COMP) SCHEMES

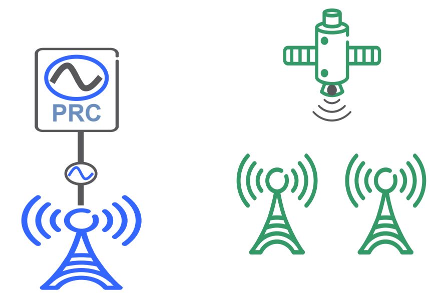
› Multiple schemes, often used in combination
  - Coordinated scheduling
  - Coordinated beamforming (null forming)
  - Dynamic point selection
  - Joint transmission/reception
  - …



# TRANSPORT REQUIREMENTS
## - FROM RADIO COORDINATION FEATURES



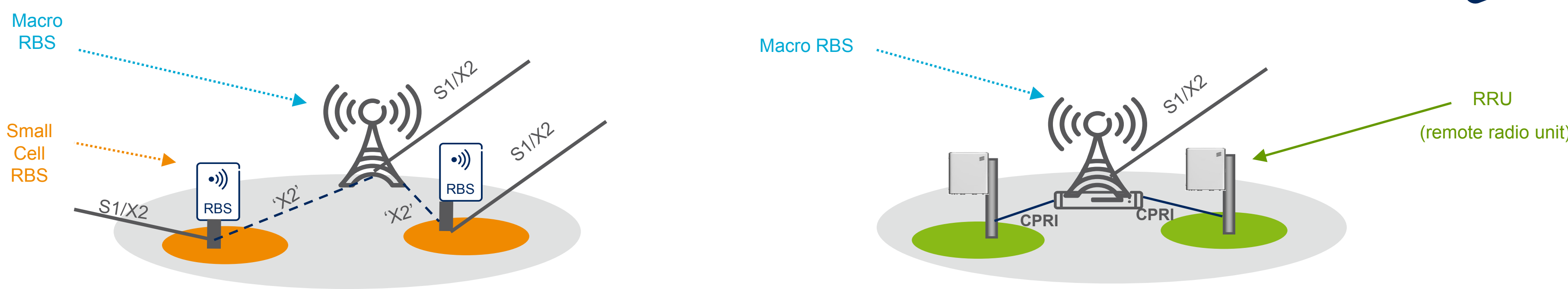

SYNCHRONIZATION?




LATENCY?

BANDWIDTH?

# TRANSPORT REQUIREMENTS
## - RADIO COORDINATION FEATURES FOR LTE




✓ MODERATE CO-ORDINATION
- WITH TIME ALIGNMENT
  - +/-5US ABSOLUTE TIME ACCURACY
- WITHOUT TIME ALIGNMENT
- LOW BW DEMANDS

? TIGHT CO-ORDINATION
- +/-1.5 US ABSOLUTE TIME ACCURACY
- 1..10MS MACRO-SMALL CELL LATENCY
- LOW..MEDIUM BW DEMANDS

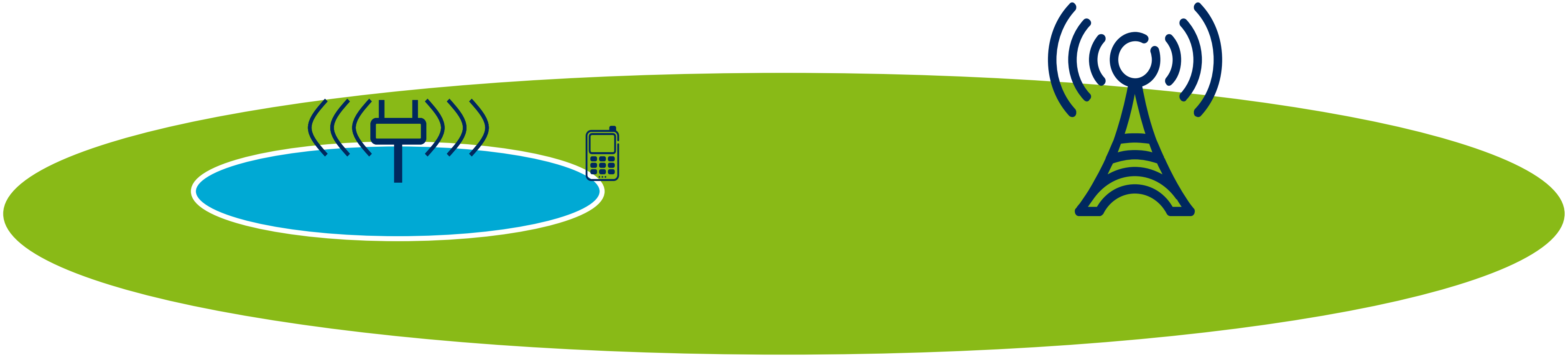
✕ VERY TIGHT CO-ORDINATION

✓ MODERATE CO-ORDINATION

✓ TIGHT CO-ORDINATION

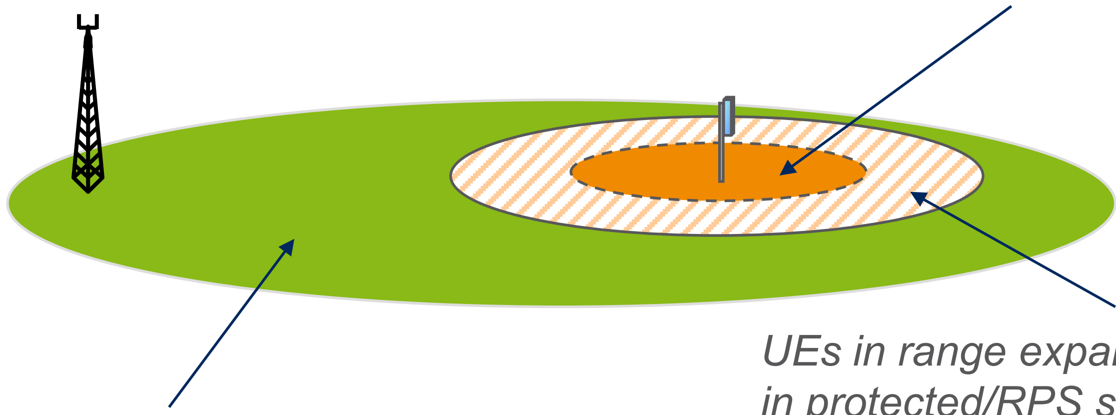
✓ VERY TIGHT CO-ORDINATION
- +/-1.5 US ABSOLUTE TIME ACCURACY
- < 0.5MS MACRO-SMALL CELL LATENCY
- UP TO 1GBPS/ANTENNA BW DEMANDS

# EXAMPLES OF RADIO COORDINATION FEATURES



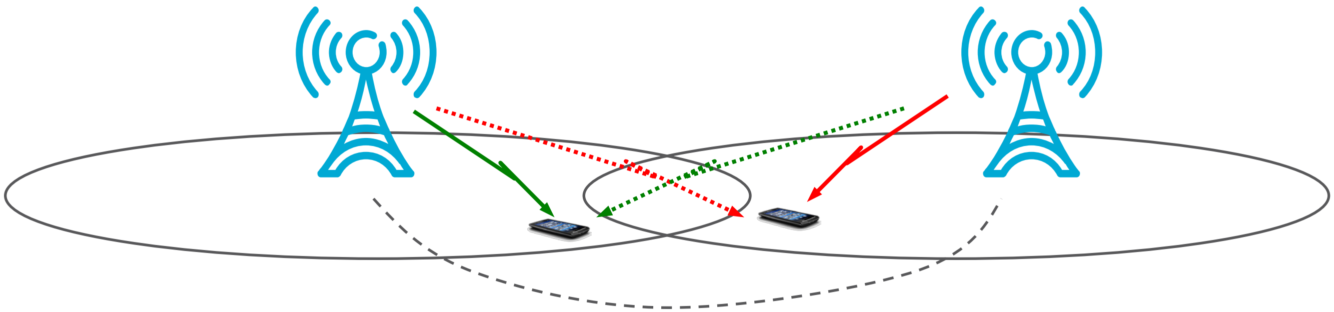
# MODERATE COORDINATION
## - EXAMPLE: eICIC (ENHANCED ICIC)

- Macro cell avoids scheduling in or reduces power in “protected” subframes (ABS vs RPS)
  - Reduced interference from macro cell in “protected” subframes
- Advanced Rx in Ue required for range expansion
- Cell size: Dense urban environment
- Time alignment: +/-5us required between macro and small cell
- Latency: No special demands
- Bandwidth: Low




TIME ALIGNMENT NEEDED

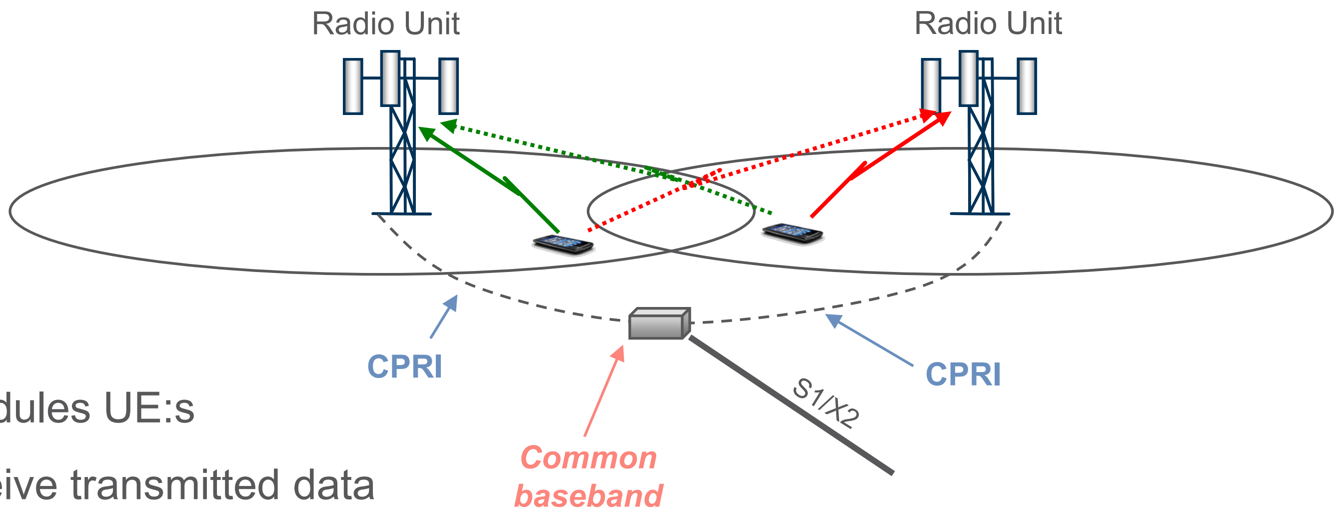
# TIGHT COORDINATION
## - EXAMPLE: DOWNLINK COORDINATED SCHEDULING




- Baseband(s) share information about different UEs
- Baseband performs coordinated scheduling towards the UEs
- Cell size: Dense urban environment
- Time alignment: +/-1.5us required between macro and small cell
- Latency: 1..10ms – the lower the latency, the better the cell edge gain
- Bandwidth: Up to 20Mbps, per coordinated cell pair

[ TIME ALIGNMENT & LOW LATENCY NEEDED ]

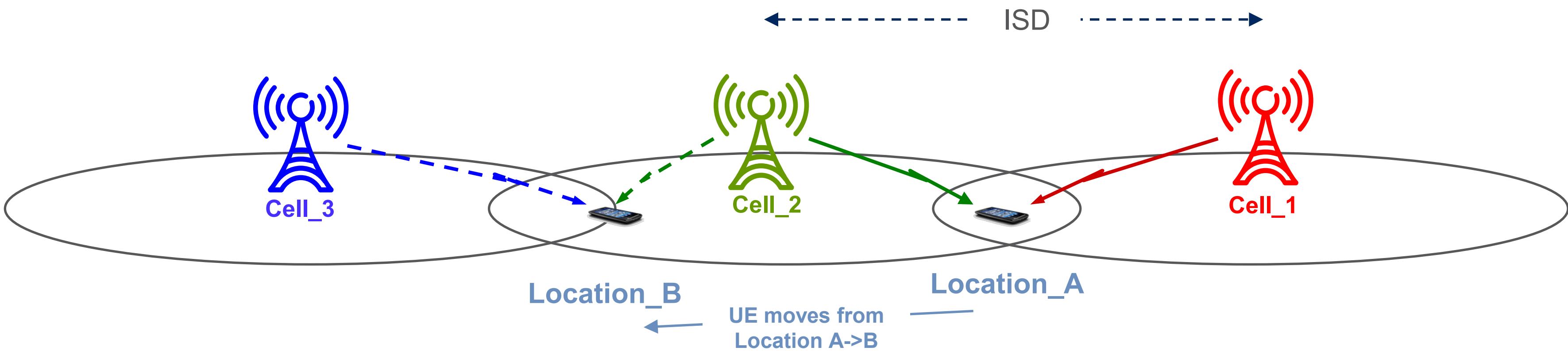
# VERY TIGHT COORDINATION
## - EXAMPLE: UL JOINT RECEPTION (UL L1 COMP)




- Baseband schedules UE:s
- Radio units receive transmitted data
- Radios share received data and jointly process it
- Cell size: Dense urban environment
- Time alignment: +/-1.5us required between cells
- Latency: <0.5ms one way
- Bandwidth: 1Gbps per antenna, internal RBS interface

TIME ALIGNMENT, HIGH BW & VERY LOW LATENCY => BASEBAND INTERNAL ONLY

# COMP JOINT PROCESSING
## - REALISTIC SCENARIO FOR ANY CELLSIZE




- UE starts in Location_A
- UE moves to Location_B
- Stops running CoMP between Cell_1 and Cell_2 (non-optimal CoMP performance in this location)
- Start running CoMP between Cell_2 and Cell_3 instead (better CoMP performance in this location)
- Reasoning: Performance of CoMP schemes is beneficial when the signals from the two Cells are of similar strength
- For example, for DL CoMP, path propogation delay difference should be <1us, otherwise there is little benefit from using DL CoMP => time aligment accuracy +/-1.5us

[ Budget for time error +/- 1.5 us ]

# SUMMARY
## - SMALL CELL SYNC NEEDS FROM MOBILE BACKHAUL

› Coordination between macro and small cells improves performance

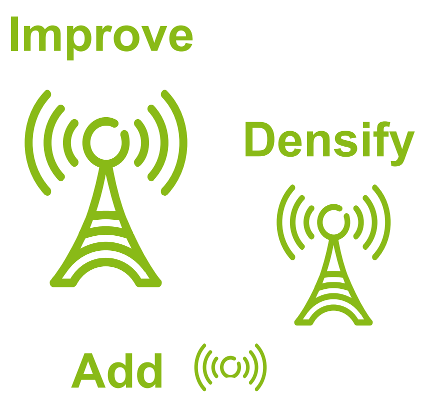
› Radio coordination features

  – Manage interference between small & macro cells

  – Some features require Time Alignment between radio subframes

  – Consider cost vs gain when deploying over 'normal' backhaul ('X2')

  – If very stringent synchronization, BW and latency demands, realistically only possible over CPRI*




[ TIME ALIGNMENT OF +/-1-5US..+/-5US OVER X2 FOR *SOME* FEATURES ]

**** CPRI is an internal RBS interface, not part of mobile backhaul***

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# ACRONYMS

- **ABS**: Almost Blank Subframes
- **BB:** Baseband
- **CPRI**: Common Public Radio Interface
- **CoMP**: Coordinated Multipoint
- **DL:** Downlink
- **EPC**: Evolved Packet Core
- **JP:** Joint Processing
- **RPS**: Reduced Power Subframes
- **RU:** Radio Unit
- **RRU**: Remote Radio Unit
- **S1**: Standardized interface between LTE RBS and EPC
- **SON**: Self Optimizing Networks
- **UE**: User Equipment
- **UL:** Uplink
- **X2**: Standardized interface between LTE RBSs