INTERFERENCE MANAGEMENT WITHIN 3GPP LTE ADVANCED – PART II

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OUTLINE

Series of two seminars

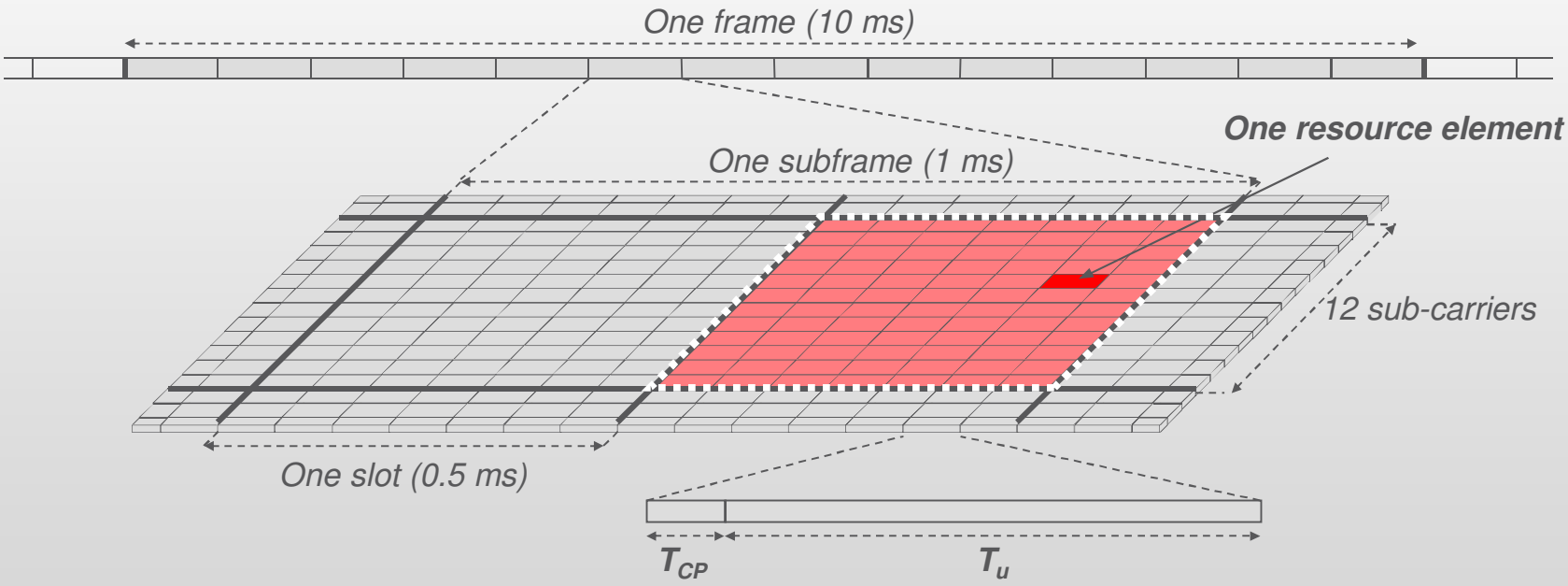
I. Part I

- Introduction to 3GPP LTE (Advanced)
- Interference Management
  - Inter-system Interference
  - Intra-LTE Interference
    - Inter-Cell Interference
    - Inter-Cell Interference Coordination (ICIC)

II. Part II

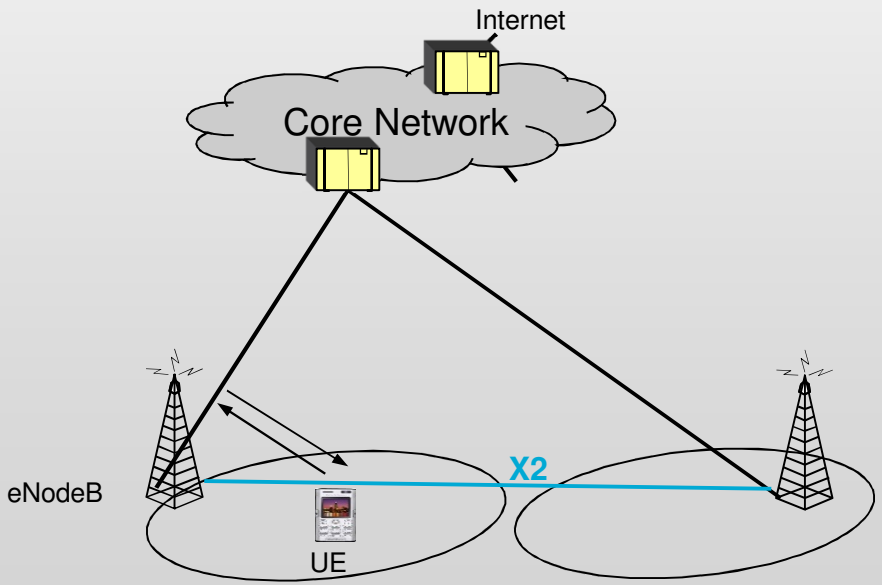
- Cell-autonomous schemes
- Coordinated Schemes
  - Interference Management for Heterogeneous Networks
    - Control Channels
    - Data Channels

PHYSICAL RESOURCE

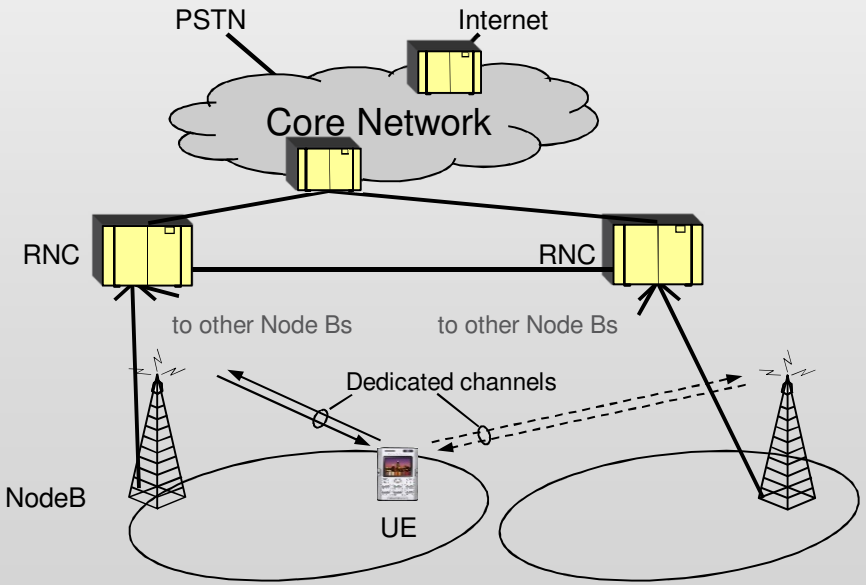


ARCHITECTURE

- Core network evolved in parallel to LTE
  - EPC – *Evolved Packet Core*
- Flat architecture, single RAN node, the *eNodeB*
  - Compare HSPA, which has an RNC



LTE

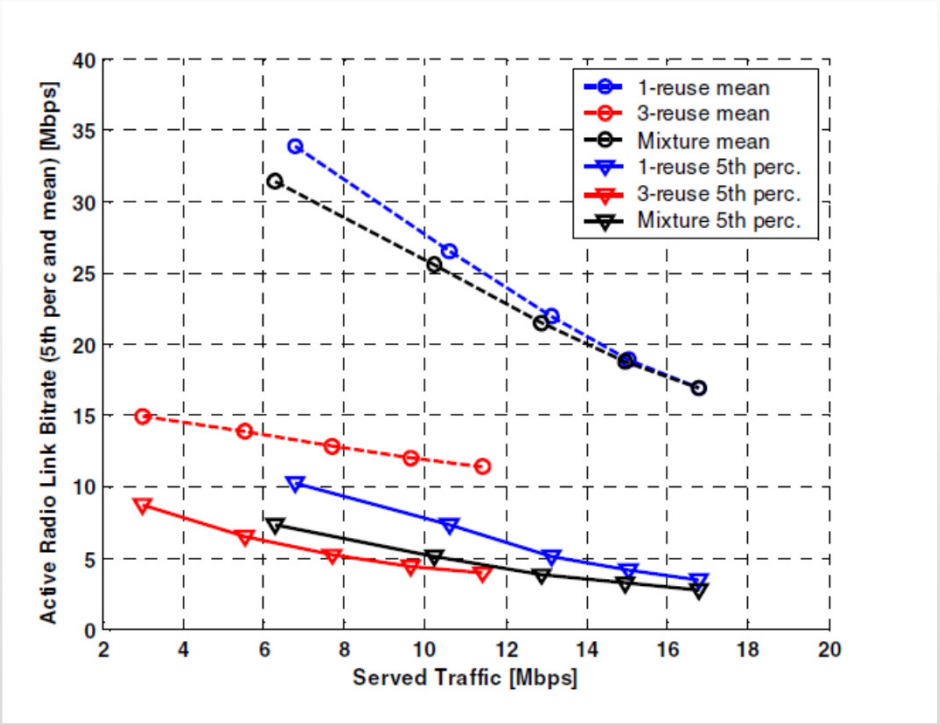


HSPA

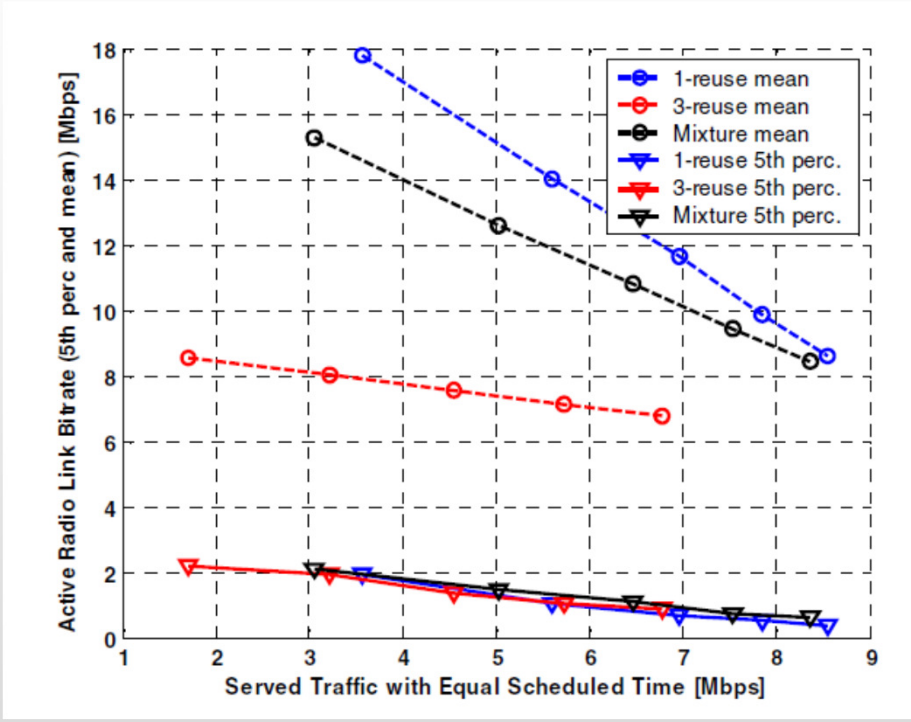
SUMMARY FROM PREVIOUS SEMINAR

- Intercell inteference situation within 3GPP LTE Advanced
  - Collisions
    - Collision cost
    - Trade-off
  - Comparison between full reuse vs 3 reuse case
  - Conclusion
    - **Cost for collision avoidance higher than cost of collision**

WHAT IS THIS RESULT OF THIS TRADE-OFF?



Downlink: 2X2, Maximum Ratio Combining (MRC)

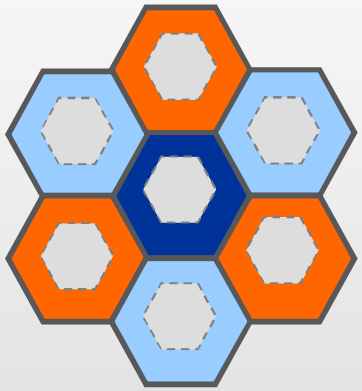


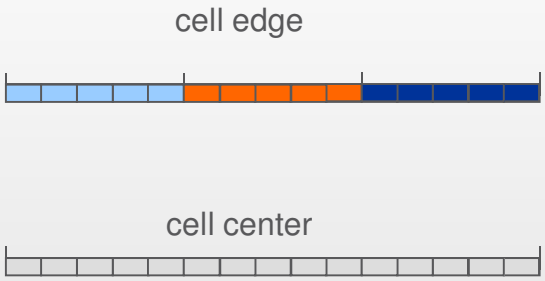
Uplink: 1X1, Single Input Single Output (SISO)

Avoiding a collision results in higher loss in radio resource usage than the gain in interference reduction

HOW CAN THE EFFECTS OF A COLLISION BE MINIMIZED? - 1

- Radio Resource Management (RRM)
  - Scheduling
  - Fractional Frequency Reuse (FFR)



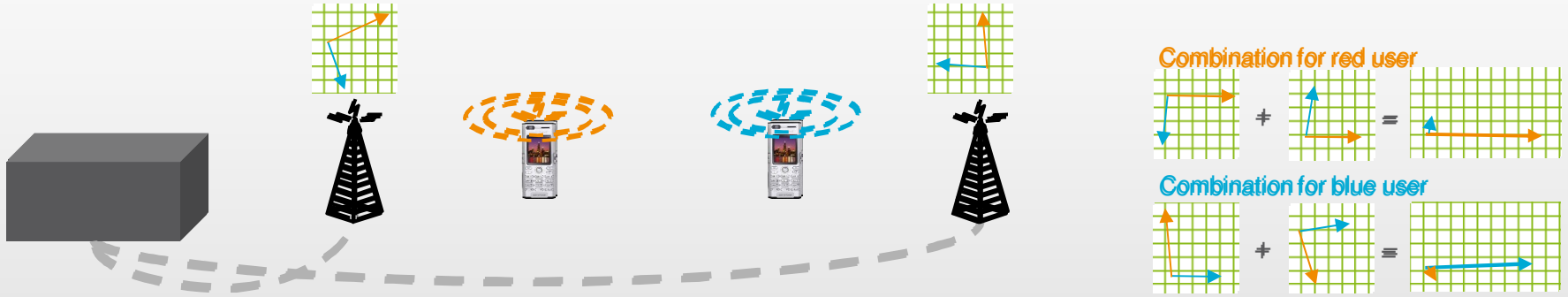


  - Fractional Power Control (FPC)

- Coordinated RRM
  - Joint scheduling
  - Joint power control

HOW CAN THE EFFECTS OF A COLLISION BE MINIMIZED? - 2

- Advanced Receivers, e.g.
  - Interference Rejection Combining (IRC)



Weighted signals combined to maximize SINR (reject interference and amplify desired signal)

- Coordinated RRM Combined with Advanced Receivers aka as Coordinated Multipoint Transmission & Reception (COMP)
  - IRC
  - Successive Interference Cancellation (SIC)

"COST" FOR REDUCING THE EFFECTS OF A COLLISION

- Advanced receivers
  - Hardware complexity, higher processing power, cost
- Coordinated schemes
  - Hardware complexity, higher processing power
  - Backhaul cost
    - Requirements on
      - Latency
      - Capacity

ICIC ALGORITHMS

AUTONOMOUS-COORDINATED SCHEMES

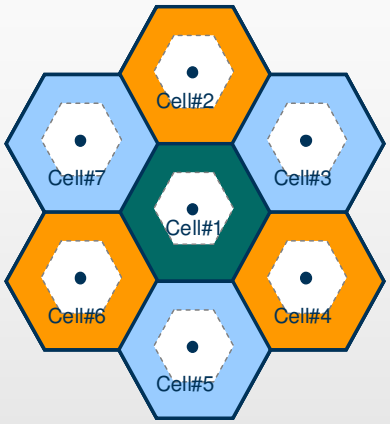
- ICIC schemes can be either:
  - cell autonomous or
  - Coordinated between eNBs (aka "X2-based")
- Cell autonomous schemes
  - No coordination between neighbor cells
- Coordination schemes
  - exchanging scheduling information between cells
    - time scale of information exchange depends on the backhaul latency

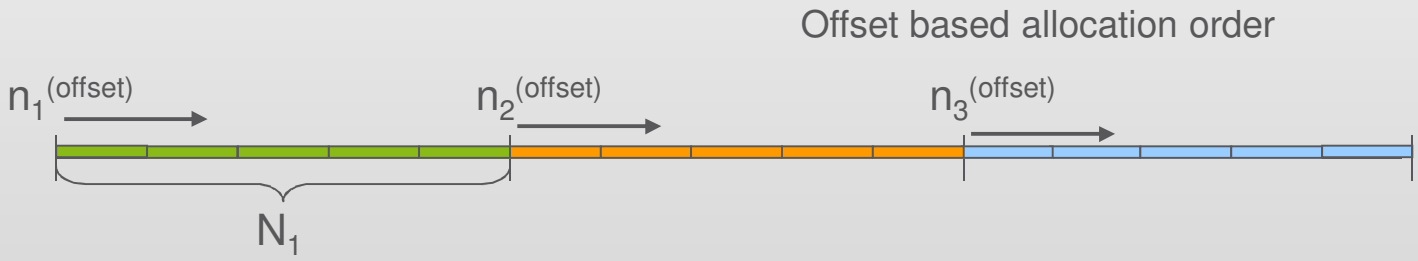
AUTONOMOUS ICIC

EXAMPLE OF AUTONOMOUS ICIC ALGORITHMS

STARTING OFFSET-BASED

- Offset based allocation order

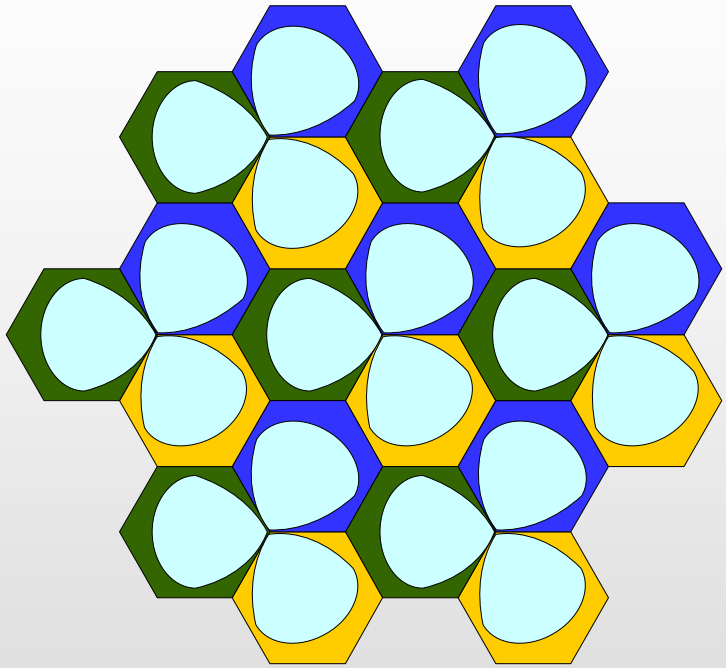


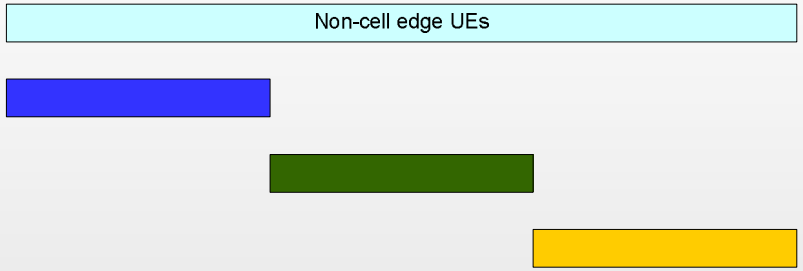


- Random Start index
  - Starting PRB selected randomly

Well performing schemes @ low loads

ICIC BASED ON FFR



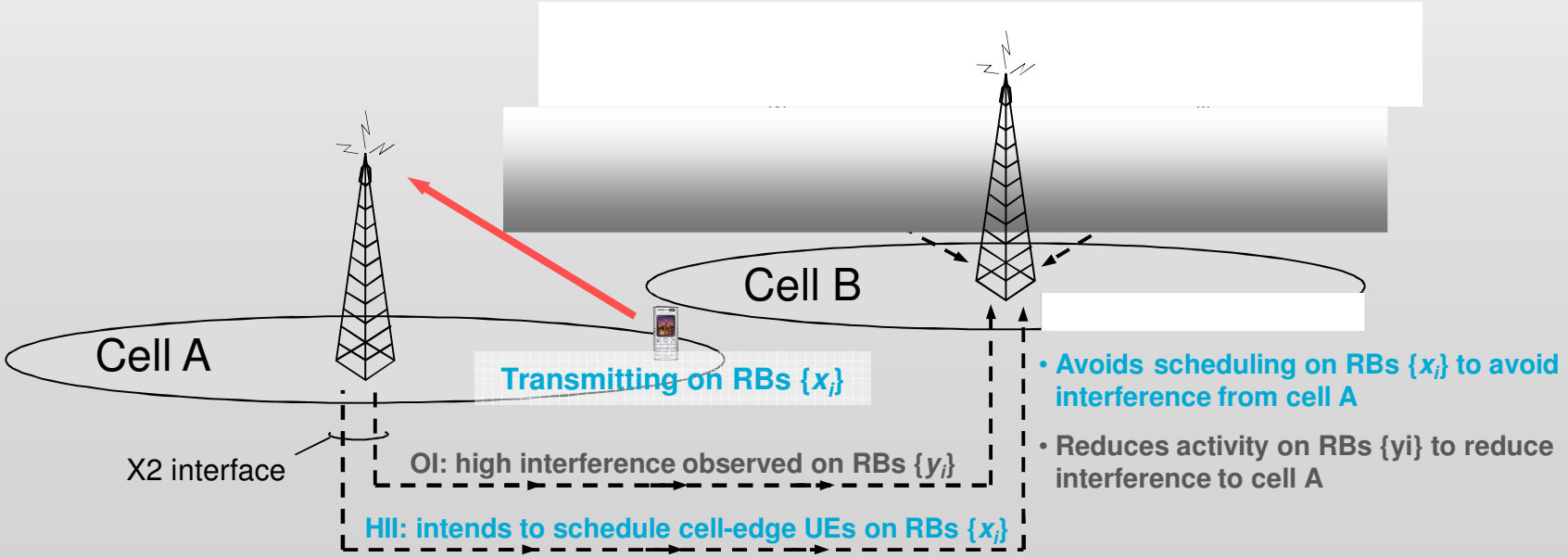


- Cell edge user determined by averaged geometry
- Predefined resources for cell edge users

REL. 8-9 SUPPORT FOR ICIC

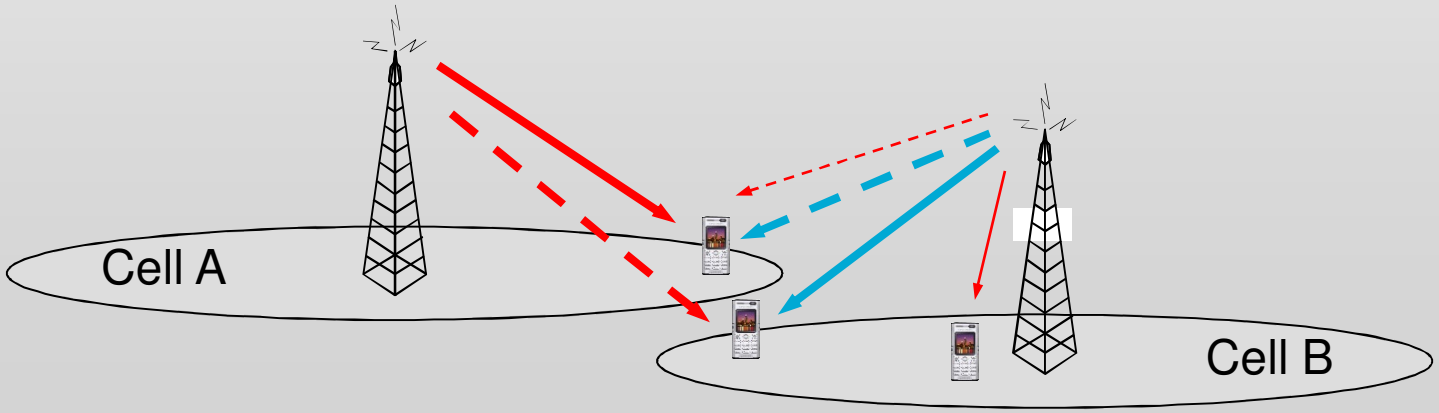
UPLINK ICIC

- Overload Indicator – OI (*"Reactive" mechanism*)
  - Bit map per resource block sent over X2 to neighbor cells
  - Signals if cell experiences low, medium, or high interference
- High Interferance Indicator – HII (*"Proactive" mechanism*)
  - Bit map per resource block sent over X2 to neighbor cells
  - Indicates intention to schedule cell edge users in specific bands



DOWNLINK ICIC

- Less beneficial compared to uplink
  - Enough power available also for wide bandwidth transmission
  - Cost in DL data rate from power limitation
- Relative Narrow band TX Power Indicator (RNTPI)
  - Own intention to limit DL TX power in e.g red subband (per RB)
  - Soft intention that can be broken in case if needed

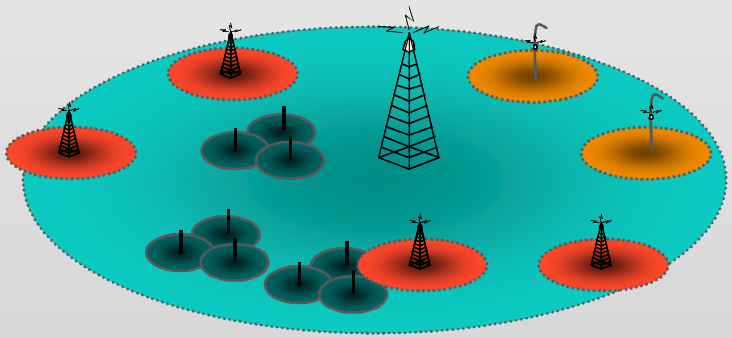


RELEASE 10 FEATURES

HETEROGENEOUS NETWORKS

HETEROGENEOUS NETWORKS

- Refer to deployments of a mixture of cells with different characteristics, mainly in terms of output power, operating (partially) on same set of frequencies
  - "*Low power nodes are placed throughout a macro-cell layout*"



Cluster of femto cells (20 dBm)

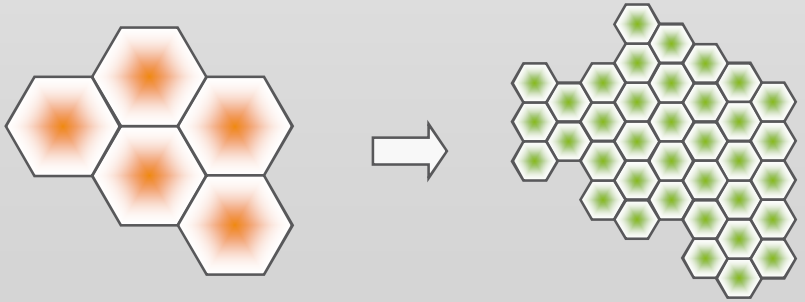
Pico cell (24-37 dBm)

Relay (20 dBm)

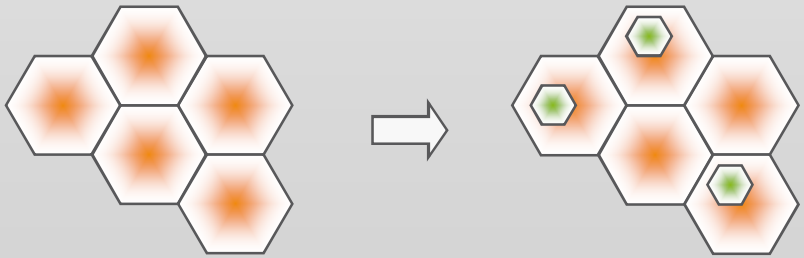
WHY HETEROGENEOUS NETWORKS?

- Higher data rates ➡ need denser infrastructure
  - …but user distribution and traffic density is often non-uniform

- Alt 1 – Denser "macro cells"
  - Not cost efficient (in case of non-uniform traffic)
  - Issues with rapidly moving users – frequent handovers

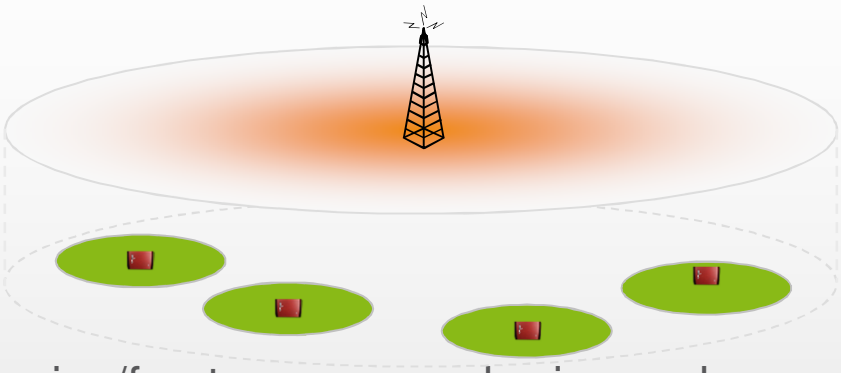


- Alt 2 – Heterogeneous Networks
  - Macro for coverage, pico for capacity
  - Semi-static, or dynamic, sharing of resources across macro - pico layers



HOW DO THEY DEFER FROM EXISTING TYPES OF NETWORKS?

- In its simplest form similar to Hierarchical Cell Structures (HCS)...



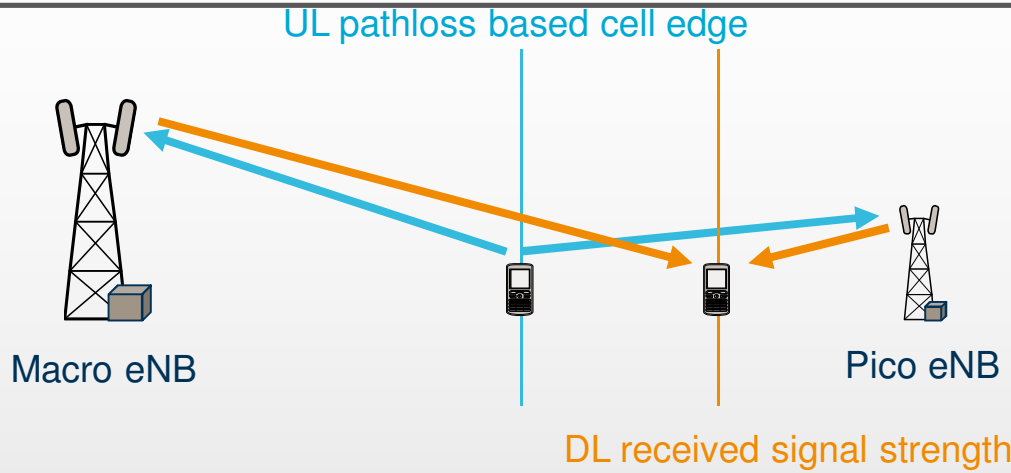
- ...but
  - LTE offers/will offer tools for efficient macro-pico/femto resource sharing and interference coordination
  - Different types of small base stations

- Open Access (OA)
  - "Any user" can connect to the small (pico) cell

- Closed Subscriber Group (CSG)
  - Only a subset of users can connect to the small (femto) cell (e.g. home eNodeB)

  - Possibly mixing open access and closed subscriber group small base stations in the same spectrum

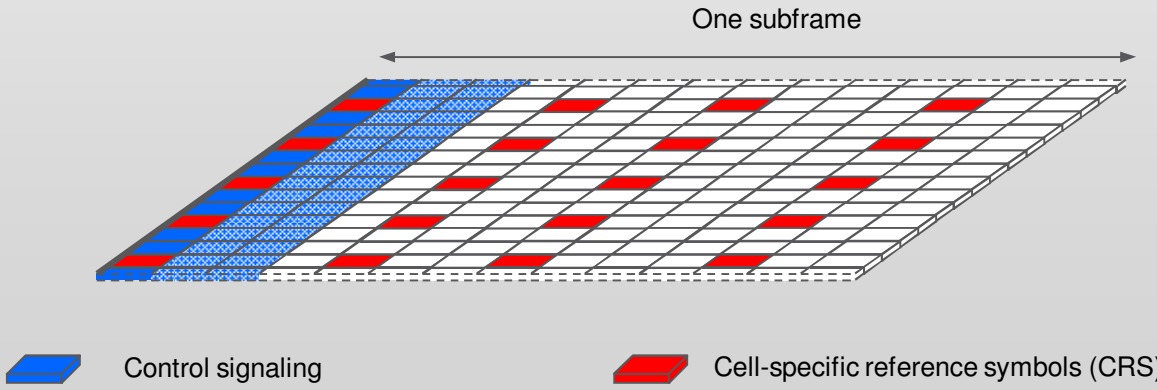
INTERFERENCE DESCRIPTION



- Significant imbalance in the DL Tx powers of macro eNB & low power NBs
- Scenario: Open Access Picos, No Extended Range, No Interference Management
  - **Similar interference situation as within homogeneous networks**
    - **Sometimes more pronounced UL interference to pico eNBs**
- Scenarios with pico cells using extended range or with CSG low power nodes
  - **Interference problems on DL Control Channel Region**
  - New interference management mechanisms needed

LTE – DL PHYSICAL CHANNEL STRUCTURE

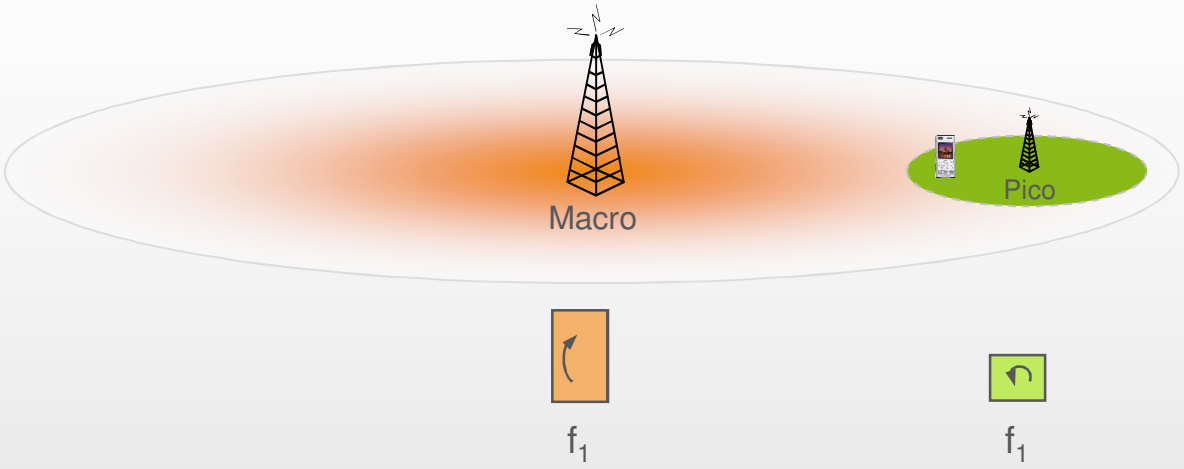
- Transmitted within first 1-3 OFDM symbols of each DL subframe
  - Transmission over all system bandwidth
- Layer 1 control signaling
  - UL/DL channel allocations
    - Physical Dedicated Control Channel (PDCCH)
  - Format of the L1 control signaling channel
    - Physical Control Format Indicator Channel (PCFICH)



Physical Control Channel Transmission with QPSK modulation

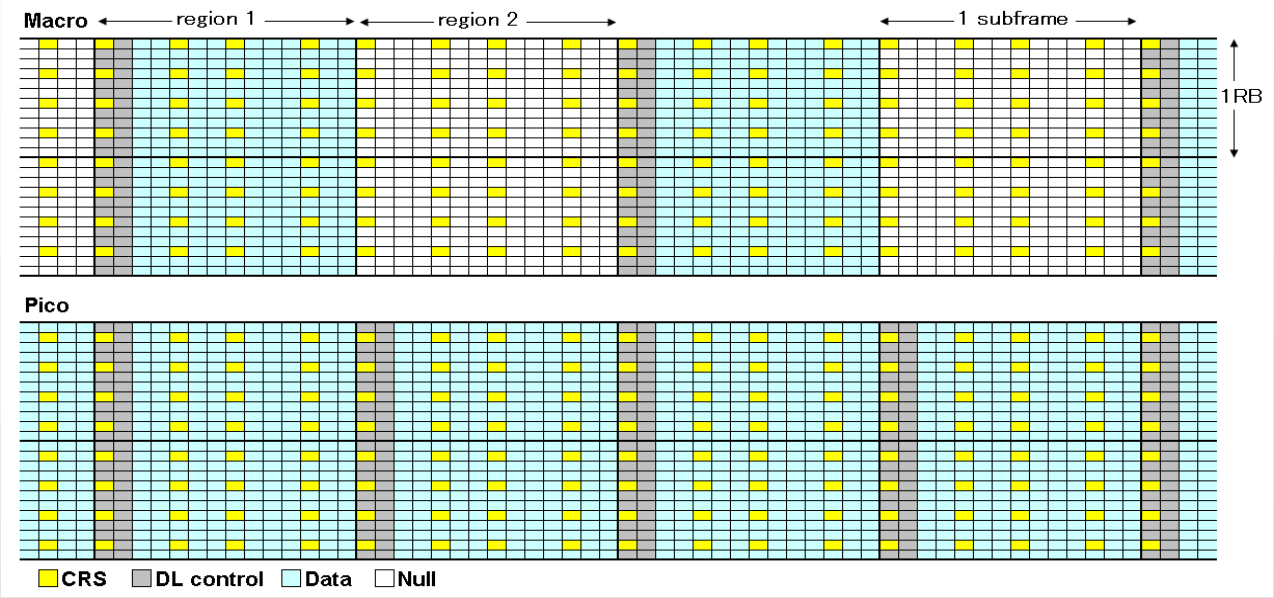
INTERFERENCE MANAGEMENT FOR HETEROGENEOUS NETWORKS

"SAME-CARRIER" APPROACH



- L1 Control signaling (PDCCH, PCFICH)
  - interference avoidance only in time domain
    - Almost blank subframes (ABSF)
      - One layer does not transmit L1 control signaling within given subframes

ALMOST BLANK SUBFRAMES (ABSF)



- During certain subframes
  - no L1 control signaling is transmitted
  - CRS are still present
- Data not transmitted during ABSF (neither DL or UL)
  - Resources not fully utilized
- Cross subframe scheduling might improve this non-efficient use of resources

SUMMARY

- Interference Management Mechanisms
  - Based on
    - RRM
    - Advanced Receivers
    - Coordination between neighbor base stations
    - Combination of the above
  - Deployments of heterogeneous networks challenging for interference management techniques

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