LTE-A, HetNet, Small Cells – What you Absolutely Need to Know

Azimuth Webinar – September 2015
LTE-A, a Disruptive Evolution

• Need for ubiquitous high capacity coverage

• **LTE-A takes a new approach to address this need**
  - HetNet to improve capacity
  - Small cells to improve coverage
  - Carrier aggregation to improve data rates
  - Other mechanisms such as CoMP
What is HetNet?

- LTE defines a mix of **Cell Sizes**, all using the same RAT (LTE) as HetNet
  - This causes interference and necessitates interference mitigation techniques (advanced receivers, xICIC)
  - Also changes the RRM equation – how does UE decide to hand over?

- Heterogeneous networks have in the past referred to a mix of RAT, e.g. LTE + other older RAT
  - This typically does not create interference
What does this Mean?

- Paradigm shift in the network environment:
  - Single link -> Multi-Link
  - Planned -> Unplanned
  - Controlled/minimal interference -> Interference dominated

- Complex mechanisms to ensure performance:
  - Mitigate and cancel interference - xICIC (ICIC, eICIC, FeICIC), SON
  - Enhance cell edge performance – CoMP
  - Support emerging class of devices (ex. IoT) - LTE-M

*HetNet signifies a disruptive change in the network environment, and operation*
A Quick Overview of Interference Mitigation

• Significant focus on interference mitigation, both on the network and device side

• **Network:**
  - ICIC (Inter-Cell Interference Coordination – Rel.8)
  - eICIC (Enhanced ICIC – Rel.10)
    - ABS, CRE
  - FeICIC (“Further enhanced non CA-based ICIC” – Rel.11)
    - Small Cell Study Item
      - Allowed CA to be worked into the mix
    - NAICS (Network Assisted Interference Cancelation & Suppression – Rel.12)
  - Dual Connectivity
  - …

• **Device:**
  - Advanced interference cancellation receivers
    - IRC – Interference Rejection/Cancellation (Rel. 11)
    - SIC – Successive Interference Cancellation (Rel. 12)
ICIC (Inter-Cell Interference Coordination)

- Added in Rel. 8

- Coordinated resource management between neighboring cells to mitigate interference

**Mechanism:**
1. eNBs measure and exchange interference information over X2
2. Decide ideal resource allocation based on this information

**There are different flavors/modes in which the resources are allocated**
- Variation based on the power/resource allocation strategy
eICIC (Enhanced ICIC)

- Added in Rel. 10

- Two main concepts:
  - Time domain interference mitigation through ABS ("Almost Blank Subframes")
  - Expansion of coverage area using Cell Range Expansion

- A quick intro to Cell Range Expansion (CRE)
  - Manipulate the handover threshold to keep a device connected to the small cell (helps with performance, system capacity, load balancing)
  - Cell Selection Bias (CSB)
eICIC - ABS

- CRE keeps the device on the small cell – but in a region with higher interference (from the macro)
- Almost Blank Sub-frames (ABS) provides a window of opportunity for the small cell to serve the device in the CRE region

- ABS is not perfect – there is still interference from the control channel and the cell reference signal
eICIC – ABS – Mechanism

- ABS pattern indicates when the Macro is going to blank
  - Exchanged over X2 interface

- How often the macro blanks is determined by the ABS ratio
  - Higher the ABS ratio, the more sub-frames the macro blanks

- ABS pattern selection choices:
  - Must pick a pattern that considers needs of uplink HARQ
  - Must not pick a pattern that obstructs guaranteed bit-rate services

- Two kinds of ABS
  - “Regular” – data channel muted; reference signals still present
  - “MBSFN” – uses MBSFN subframe to transmit zero power (no reference signals)

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eICIC – ABS – CRE – Tradeoffs

- **ABS:**
  - Provides the opportunity (resource) for the small cell(s) to serve devices in the CRE region
  - Want to enlarge CRE region to capture more devices at small cell to offset reduced macro capacity
  - Will need more ABS to support increased users at small cell
  - Takes away resources available for devices in the macro cell’s coverage

- While there is a trade off between link level macro, and small cell capacity, the hope is to have better overall system capacity

*Testing system level performance becomes critical*
FeICIC (Further Enhanced ICIC)

• Extension of Rel. 10 eICIC work, targeted for Rel. 11

• Addresses issues unable to be dealt with in the Rel. 10 time frame:
  - L2 signaling requirements
  - Cell-specific Reference Signal (CRS) interference
  - Interference from control channel (not addressed by eICIC)
  - Capacity tradeoff/cost of using ABS (introduced by ABS in eICIC)

• Mechanisms
  - Reduced Power ABS (RP-ABS), so that macro isn’t entirely giving up resources during ABS
  - Advanced interference cancellation receivers on the device side that can estimate and cancel the interferer

• Spawned many new Study/Work Items
  - Small Cell
  - NAICS
  - Dual Connectivity
  - CRS Mitigation for Small Cell...
TESTING LTE-A HETNET
Testing LTE-A in the Lab

- Testing LTE-A (primarily) in the field is not a viable option
  - Field testing is expensive, non-repeatable
  - Challenges increase significantly for complex technologies like LTE-A

- Testing LTE-A in the lab requires:
  1. Creating a HetNet environment
  2. Controlling the environment to create and run complex scenarios
Different Options for Testing LTE-A in the Lab

Option 1 – Use Sufficient Number of Interferer eNBs
- Complex to setup, use
- Too expensive
- Live infra Challenges

Option 2 – Use Minimal Number of Interferer eNBs
- Easier to manage
  - Significantly less accurate HetNet environment
  - Live infra Challenges

Option 3 – Use BSEs or Signal Gen Interferers
- Easier to manage
- Less expensive
- Inadequate/inaccurate HetNet environment
Better Option to Test LTE-A in the Lab?

Option 4 – Create a HetNet environment virtually using Virtual Network Emulation (VNE)

VNE emulates the interferer cells (highlighted in red)
VNE - Industry’s First—and Only—HetNet Environment Emulation Capability

• Embedded Advanced Environment Emulation Capability

• Generate and playback LTE downlinks
  - Emulate Macro cells, Small cells
  - Configure cell parameters
  - Add channel conditions

• Integrated LTE receivers for synchronization
  - Time or frame based synchronization
  - (Sync) needed to test xICIC, ABS
  - Eliminates the need for an external sync
  - Enables interoperability with live infrastructure and any base station emulator

VNE creates the interfering cells
How is the Industry Using VNE?

- Testing ICIC, eICIC, FeICIC, NAICS, Advanced interference cancellation receivers
- Pre-launch testing of small cells, device
  - Device qualification
  - Interoperability testing (with device, macro)
- Deployments
  - Identifying ideal deployment configurations & settings
- Post-Lauch testing
  - Regression testing
  - Recreating field environments for debugging