Methods for Interference Coordination in LTE Networks

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Outline

- What’s already there?
  Overview on Interference Coordination in LTE Release 8

- What’s going to come?
  Multi Layer Networks with Femto Cells

- Exemplary interference coordination algorithms from literature

- Conclusions
What’s already there?

Overview on Interference Coordination in LTE Release 8
Overview on Interference Coordination in LTE Release 8

Existing mechanisms in the standard

- Three indicators to be transmitted via X2 interface
- Scheduler using CQI feedback

Communication via X2 interface:
- Overload indicator (Uplink)
- High interference indicator (Uplink)
- Relative narrowband transmission power indicator (Downlink)
What’s going to come?

Multi Layer Networks with Femto Cells
Multi Layer Networks with Femto Cells

Overview

Macro Cell
Femto Cell
Multi Layer Networks with Femto Cells

**What’s realistic to assume?**
- Very high number of femto cells in one macro cell sector
- Femto cells have to be cheap!
  - Reduced functionality
- Macro cell will most probably have no information about femto cells in it’s area
- Communication between femto cells and macro cells for interference coordination would have to be standardized and is complicated
- Closed subscriber group

**Implications**
- Configuration by operator not realistic (too high effort)
- Self-configuration
  - Femto cell has to sense it’s environment via
  - Integrated receiver
  - UE measurement report
- Interference coordination algorithms without communication more realistic
- Close subscriber groups create new interference scenario

New methods for interference coordination needed!
Multi Layer Networks with Femto Cells
Closed subscriber group interference scenario

Downlink interference for user of macro base station not admitted to femto cell

Uplink interference for femto cell by macro cell user nearby
Multi Layer Networks with Femto Cells
Spectrum allocation

Sharing of spectrum between macro and femto cells

Dedicated Channel Assignment
Partitioned spectrum usage: licensed spectrum divided into separate portions

Partial Co-channel
Spectrum usage mode chosen, depending on the trade off between larger BW and cross-layer interference.

Co-channel Assignment
Shared spectrum: Co-channel frequency reuse
Exemplary interference coordination algorithms from literature
Exemplary interference coordination algorithms from literature

**Femto Interference Pool**

Source: Yi Wu “A Novel Spectrum Arrangement Scheme for Femto Cell Deployment in LTE Macro Cells”

Criteria for adding a user into the FIP:

- **UE moving speed:** (Low speed macro UE is threat to femtocell)
- **Doppler Frequency Estimation**
- **Handover rate**

**Femto aware CQI reporting:**
If CQI difference between the two bands exceeds a certain threshold

Femto-interference Pool:
Macro BS schedules UE having potential threat on femtocells here

No communication between femto and macro cell needed.
Exemplary interference coordination algorithms from literature

Femto cells divided into inner and outer cells
- Inner femto cells: Orthogonal mode with macro BS
- Outer femto cells: Co-channel mode with macro BS

Uplink: Outer femto cell always has a spectrum part that is not used by macro UEs (MUEs)
→ UL interference from MUEs to femto cell can be avoided.

Downlink: FBS interfering MUE remains
- Two approaches proposed to solve this
- Require communication from macro cell to femto cell or MUE to femto cell.
Exemplary interference coordination algorithms from literature

**Limited access**


- Femto Cell: Closed user group, but:
  - Allow non-subscribers to access a limited amount of the femto cell resources
  - Non-subscribers should first try to connect to macro cell
  - A non-subscriber can be denied due to insufficient PRBs, i.e. if there are not enough PRBs left to guarantee minimal necessary throughput for this user.

- As soon non-subscriber is granted access it does not:
  - Produce uplink interference to the femto cell
  - Suffer from downlink interference by femto cell

- Commercially challenging, but not as much as open femto cell
Conclusions
Summary

- Multi layer networks create new interference scenarios
  - Esp. femto cells with closed user groups
- LTE release 8 interference coordination mechanisms not sufficient for multi layer networks
- Many promising concepts in literature
- Communication for interference coordination is critical
  - Mass market (home use): Maybe no communication possible at all
  - Enterprise solutions (office buildings): Communication between femto cells via backbone might be possible (→WiFi controllers)
Thanks for your attention!