



# THINK AHEAD STAY AHEAD

#### STRATEGIC VISIONS

on future research directions in the wireless field

The Performance of Open Access Femtocells in 4G Macrocellular Networks

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#### Introduction

- Femtocells have the potential to offer significant performance benefits to future cellular networks
- RF interference issues are key risk area in the deployment of femtocells in macrocellular networks
- Paper addresses SNIR and resulting data rates that can be achieved
  - Downlink only RF performance using a generic 4G air interface protocol
  - Open Access femtocell operation
- Work conducted in collaboration with Vodafone and Multiple Access Communications under the MONOTAS\* Programme with UK Department of Trade & Industry funding

- Public deliverable available at <a href="http://www.macltd.com/monotas/">http://www.macltd.com/monotas/</a>

\* MONOTAS - MObile Network Optimisation Through Advanced Simulation





#### What are Femtocells?





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### **Simulation Scenario - 2**



- 2GHz
- 10dB Log-Normal σ
- Macrocell-to-user:
  - COST Hata single slope path loss model with correction for UE height ~r<sup>3.5</sup>
- Femtocell-to-user:
  - Higher path loss to reflect wall penetration losses
  - r<sup>3.5</sup> slope

Performance of Open Access Femtocells in 40

- Because they are unplanned, femtocells can be located close to windows, in an upper floor etc. This has a significant impact upon the propagation to users
- A single slope propagation model, with a significant loss, to reflect transmission from outside to inside, has been used to calculate initial system performance



Minimum SNIR -10dB before any data can get through

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Path losses & power levels for Macro- & Femtocell basestations combined to determine user SNIR

• User data rate determined by dividing raw data rate by number of users on a base station

# NØRTEL Open Access Performance - 1

**SNIR-Based Cell Selection** 



# For clarity, log normal shadowing is omitted



- Maps show open access operation of femtocells in a macrocell network. One dot = one user;
- Approximately 60% of users are served by femtocells, 40% by macrocells.
- Users served by femtocells enjoy very high SNIRs
- Macrocell users in the femtocell region often see lower SNIRs because of the increased interference from the femtocells.

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#### **Open Access Performance - 2**

**SNIR-Based Cell Selection** 



- Femtocell served users enjoy >100x increase in effective data rates because they are the only user on that femtocell
- Macrocell served users see a 1.23x increase in data rates because of the lower macrocell loading despite the lower SNIR





#### **Improving Data Rates Using EDR Based Cell Selection**



With SNIR-based cell selection, users very close to femtocells can remain served by the macrocell  Users moved over to the femtocells benefit from higher data rates due to the low femtocell loading even if their resulting SNIR is lower

 Best EDR cell selection technique proposed for improving the data rate distribution, rather than the highest SNIR cell selection as traditionally used

Performance of Open Access Femtocells in 4G Maci





# **Comparison of SNIR and EDR Based Cell Selection**







#### **Performance Impact of Femtocell Density**



A relatively small femtocell penetration is sufficient to reduce macrocell loading by 50%
EDR-based cell selection off-loads users onto femtocells faster than SNIR-based cell selection

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#### **Impact of EDR-based Cell Selection in Real Deployments**



• Use of an EDR-based cell selection mechanism is effective at improving performance in current deployments as well as in macro- / femtocell networks





#### Conclusions

- Introducing open-access Femtocells into Macrocell networks can significantly improve network capacity and user data rates
  - Data rates for users attached to femtocells can be improved by 2-3 orders of magnitude
  - Macrocell users also benefit due to the reduced loading on the cell despite a general increase in interference
- Femtocells can provide significant network performance improvements with relatively low penetration rates
  - a femtocell density of ~10% of households can displace ~50% of the macrocell load
- A Best-EDR based cell selection technique is very effective at promoting macrocell users onto femtocells
  - It is particularly beneficial to poorer served users, with improvements in data rates ~3.7x seen by poorest 10% of users
- Best EDR-based cell selection also offers benefits in macrocell-only networks
  - ~30% improvement in EDRs for the worst 10% of users in a real network