

3GPP TSG RAN WG1 Meeting #56bis
Seoul, S. Korea
23 – 27 March, 2009

R1-091356

Effect of Relaying on Coverage

**Agenda Item: 15.3 Study Item on LTE-Advanced, Relaying
(Performance)**

Source: Nokia Siemens Networks & Nokia

Document for: Discussion

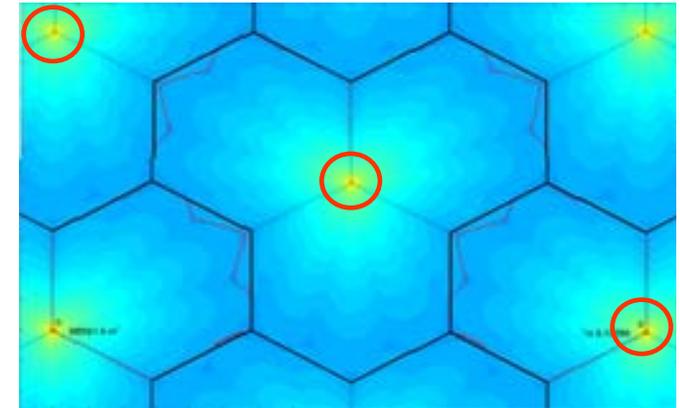
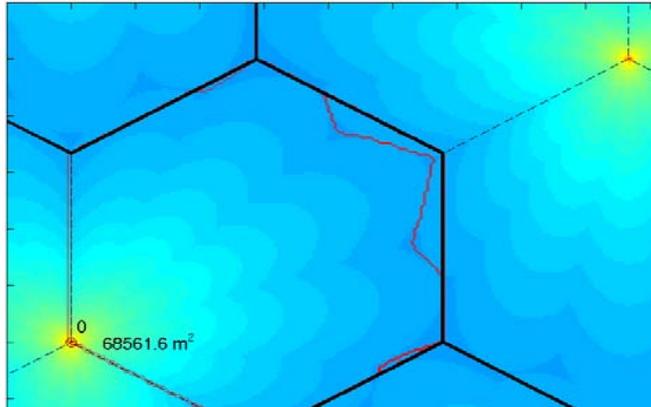
Introduction

- The impact of relays can be investigated either from network capacity or coverage perspective.
- In former case the inter-site distance (ISD) is fixed and increase in cell throughput defines the gain of relaying.
 - This is the evaluation usually done e.g. for the LTE performance evaluations
- In latter case we fix a certain throughput criterion and positive impact of relaying is used to increase the ISD with respect to the deployment without relays assumed as reference scenario.

Illustration

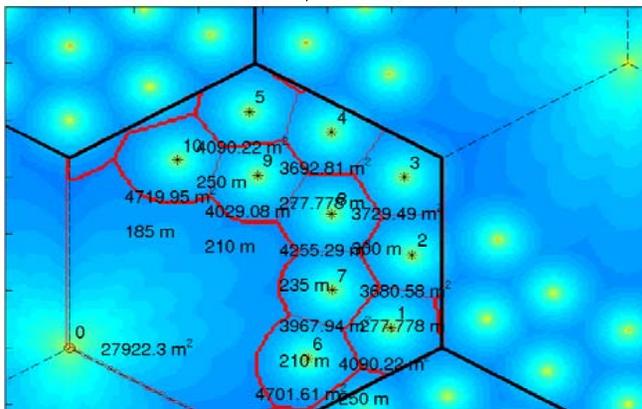
- If we face insufficient coverage, relays can substitute additional eNBs to offer increased cell edge data rates (coverage)

Starting point: existing sites give **insufficient** in **house** data coverage



Conventional approach: decrease ISD, use **more sites**

In our simulation: Increase number of eNBs



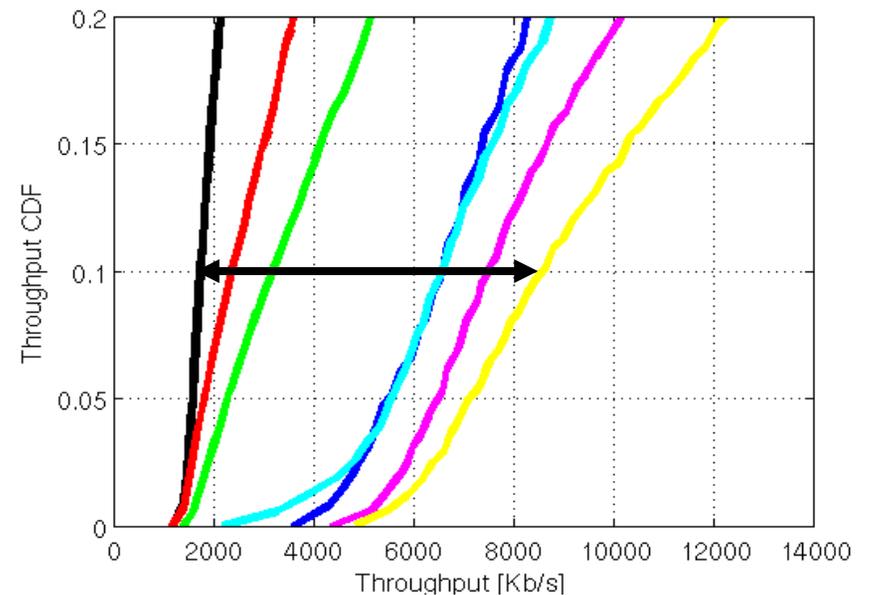
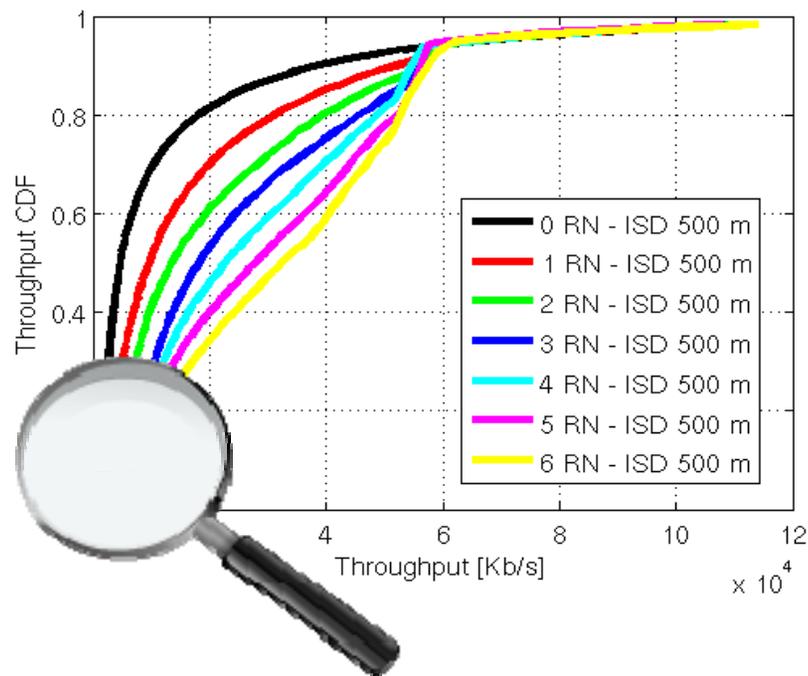
Relay approach: no new eNBs, **add relays** to each eNB instead

Coverage extension

- In the following we have adopted the coverage perspective applying the following steps:
 1. Determine gain in throughput CDF for a given ISD with and without relays (as usually evaluated in LTE performance evaluations)
 2. Determine dependence of throughput CDF on ISD
 3. Convert throughput gain in ISD increase

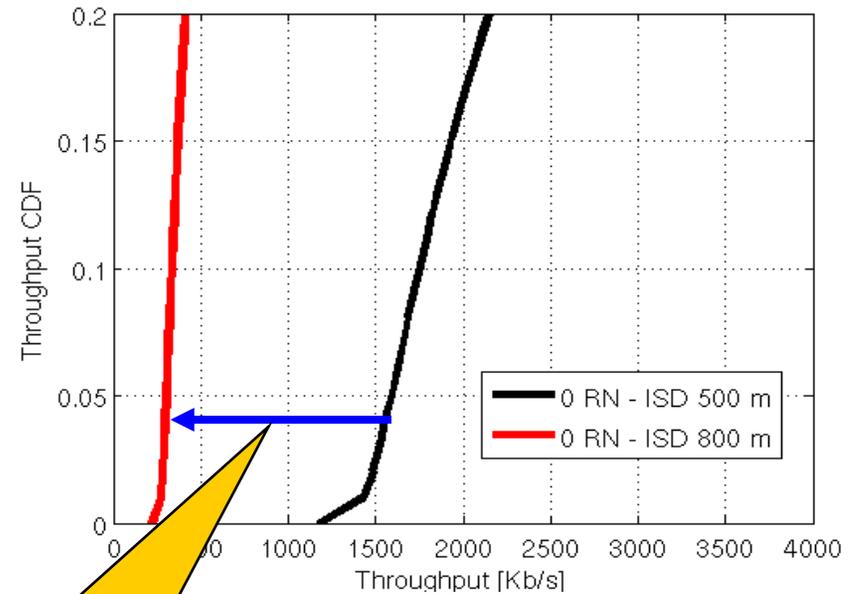
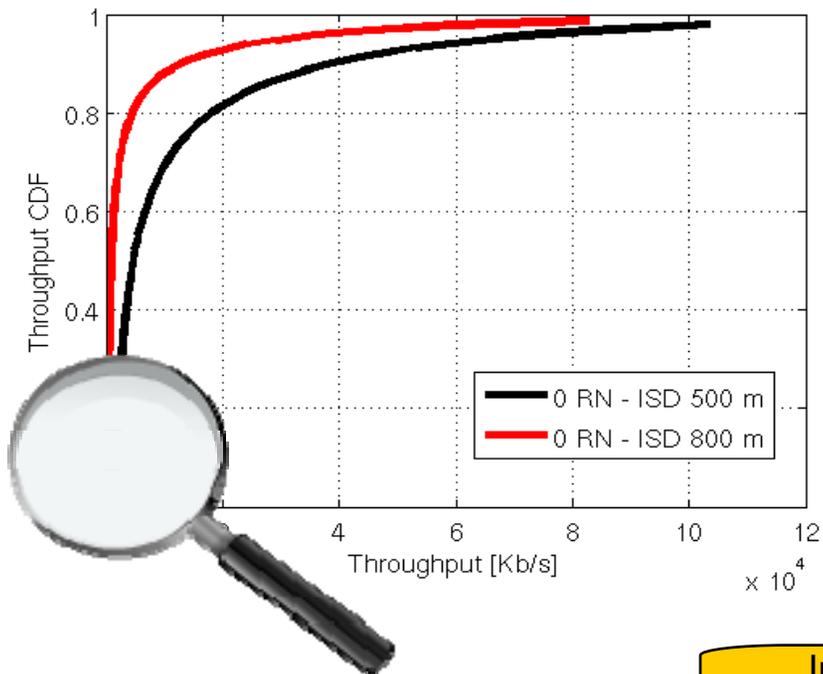
Coverage extension – Step 1

- The 10%-tile throughput CDF can be used as coverage indication (UEs at cell border)
- Adding relays we observe a gain at the 10% CDF point.
- How can this be translated to higher coverage?



Coverage extension – Step 2

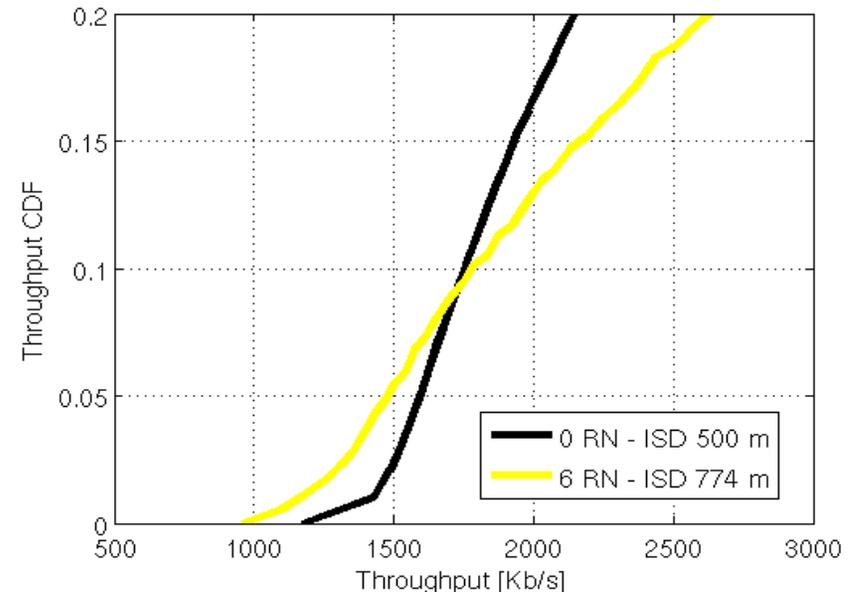
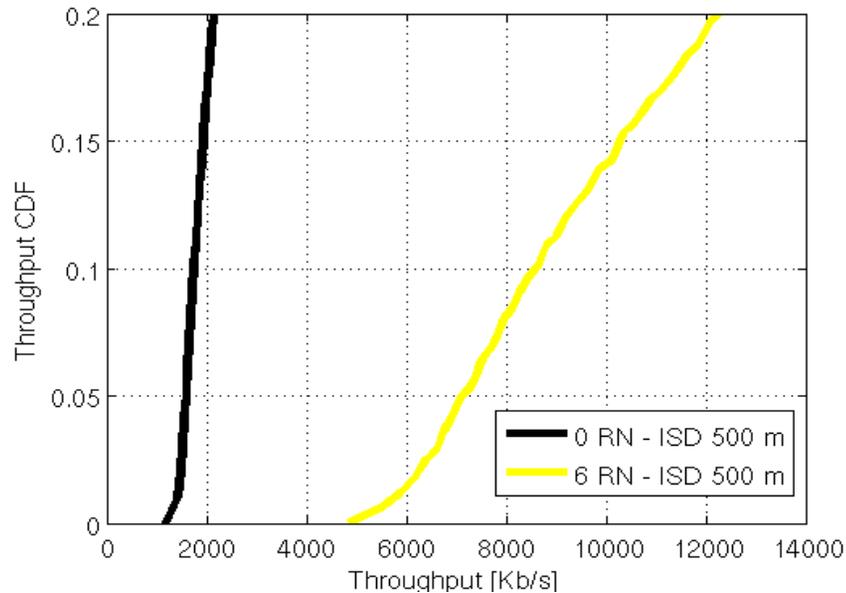
Throughput is distance depending



Increasing the ISD

Coverage extension – Step 3

Vary ISD until the performance matches the reference performance without relays at 10%-tile throughput CDF



Example 1 (1/3): Throughput CDF for ISD 500m WINNER channel models

Variable number of RNs per sector: 0, 1, ..., 12

RN height 5m placed outdoor

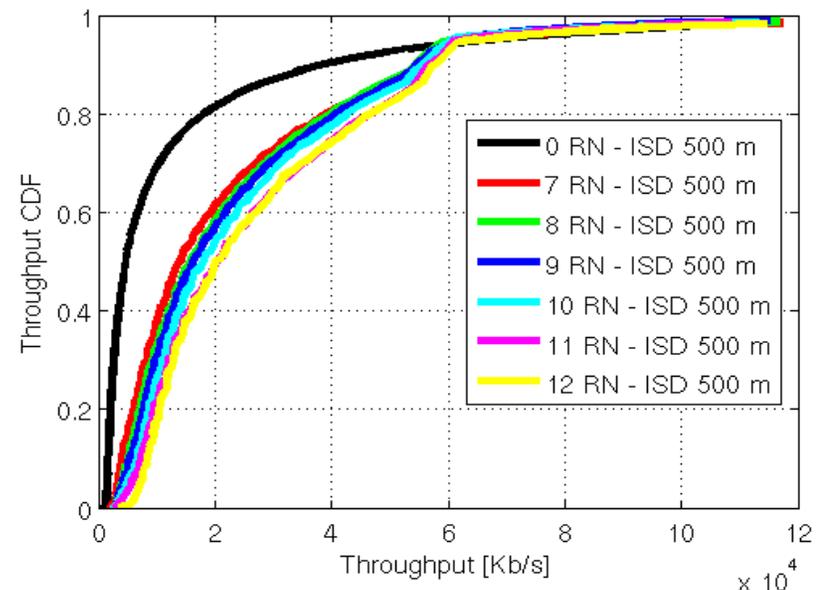
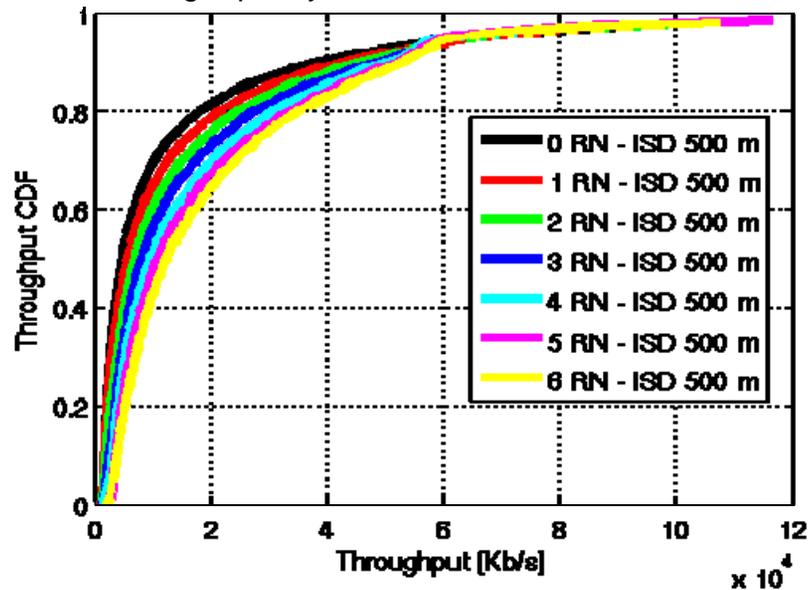
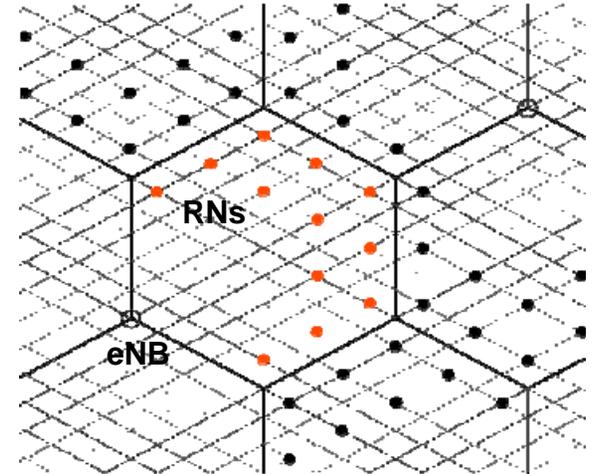
UE indoor (20dB penetration loss)

Single user in the network distributed with equal probability over cell area

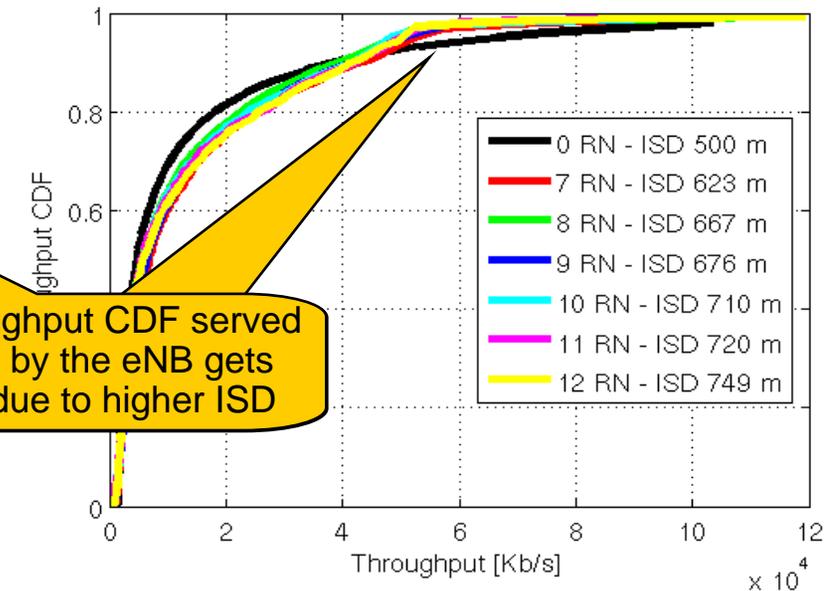
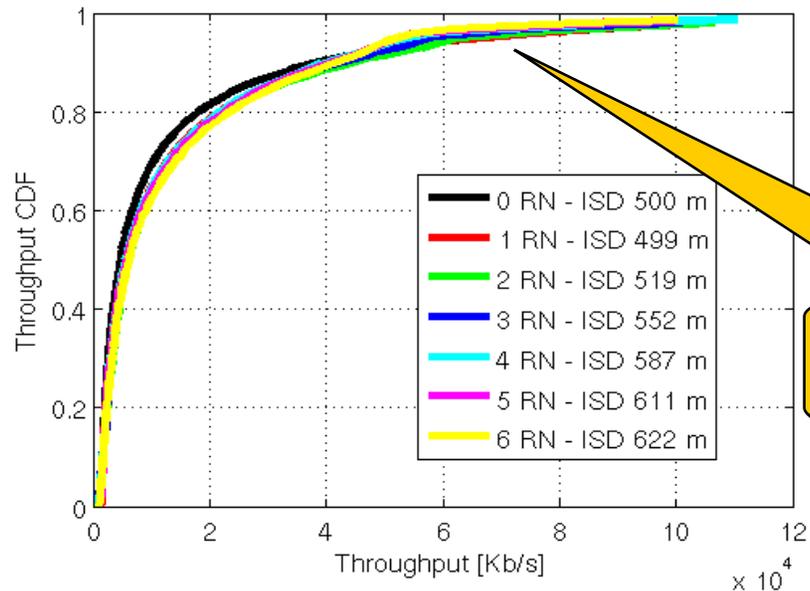
Optimal resource partitioning eNB-RN and RN-UE links

Simulation parameters are not fully aligned with 36.814 [1]:

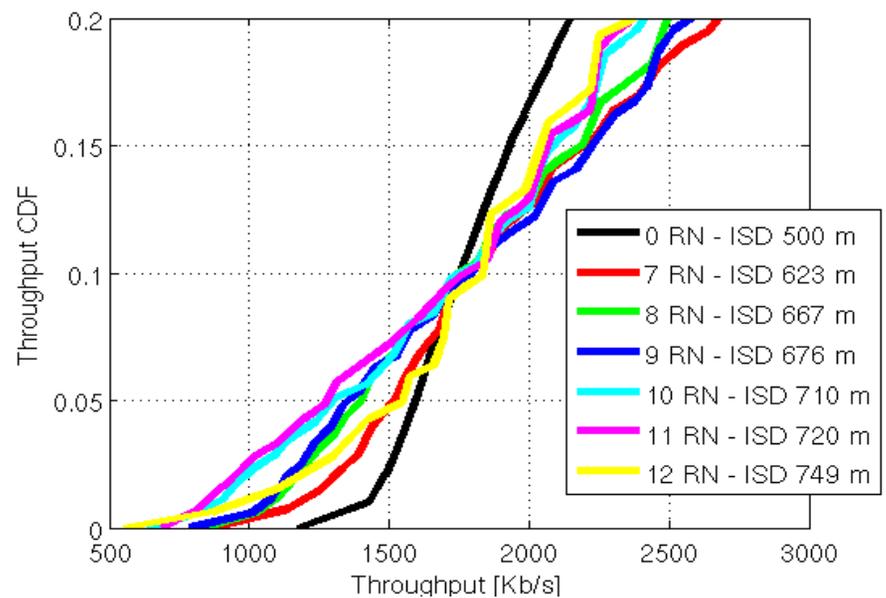
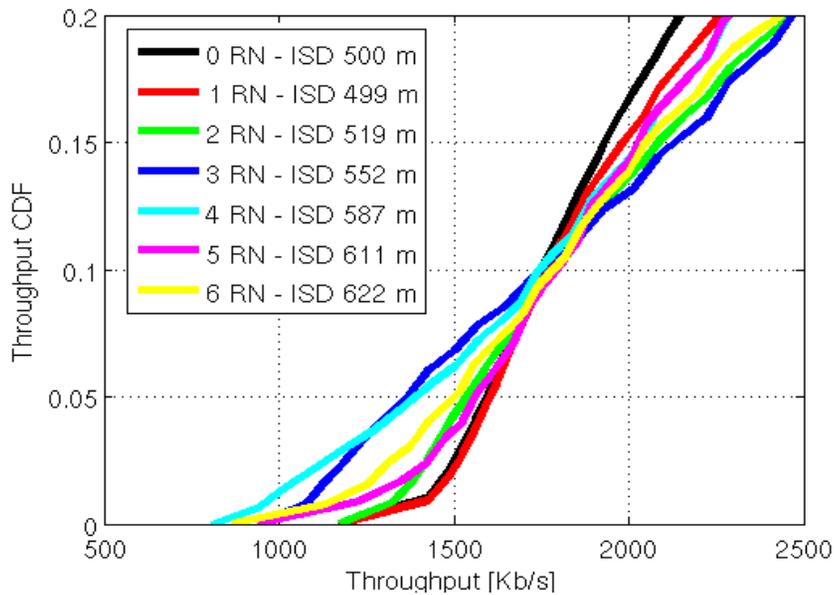
- 20 MHz bandwidth
- WINNER channel models (see [2])
- RN max tx power: 24 dBm
- Worst case shadow fading assumed (30dB)
 - worst scenario for coverage
 - allow the determination of the ISD with same 10%-tile throughput CDF to converge quickly



Example 1 (2/3): Throughput CDF varying ISD WINNER channel models

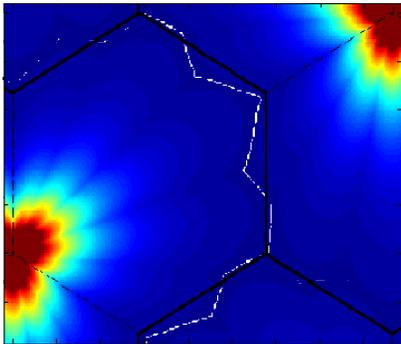


UE throughput CDF served directly by the eNB gets worse due to higher ISD



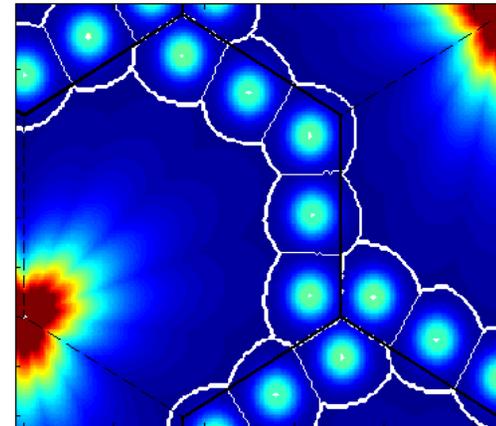
Example 1 (3/3): Throughput distribution [kbps] WINNER channel models

ISD 500m

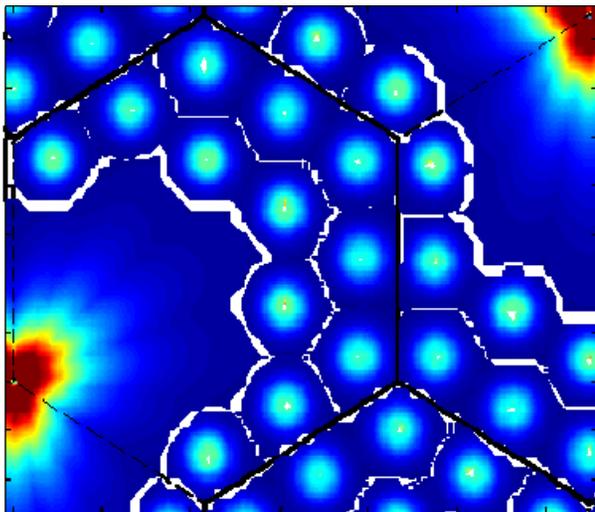


Coverage extension
provided by relays

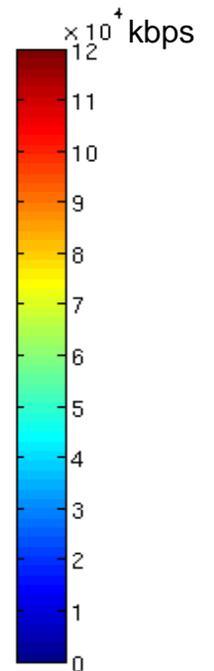
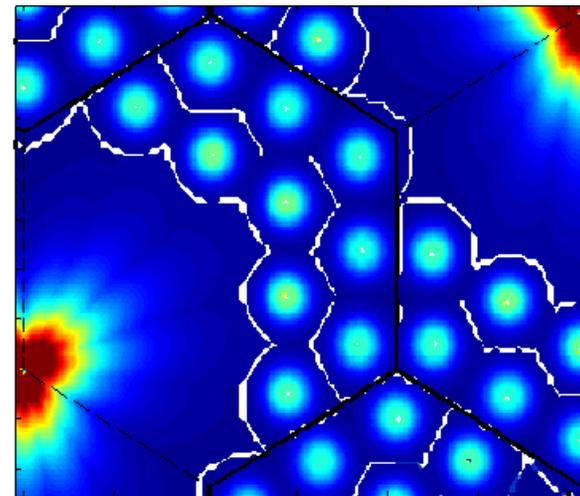
ISD 611m



ISD 749m



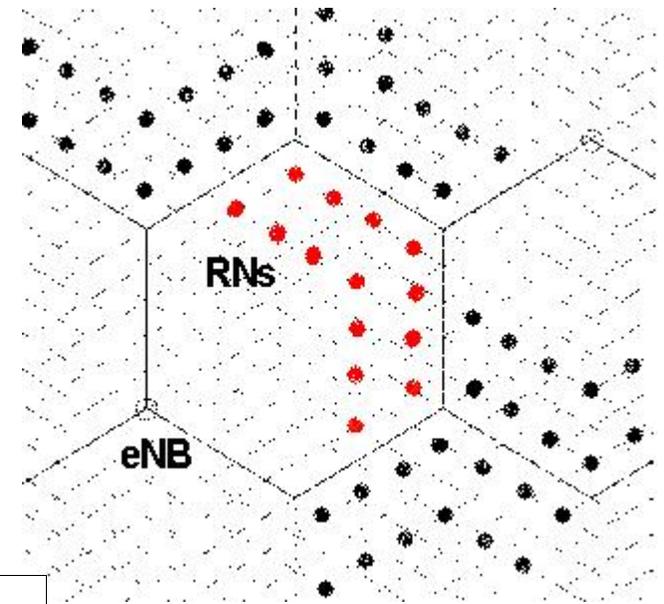
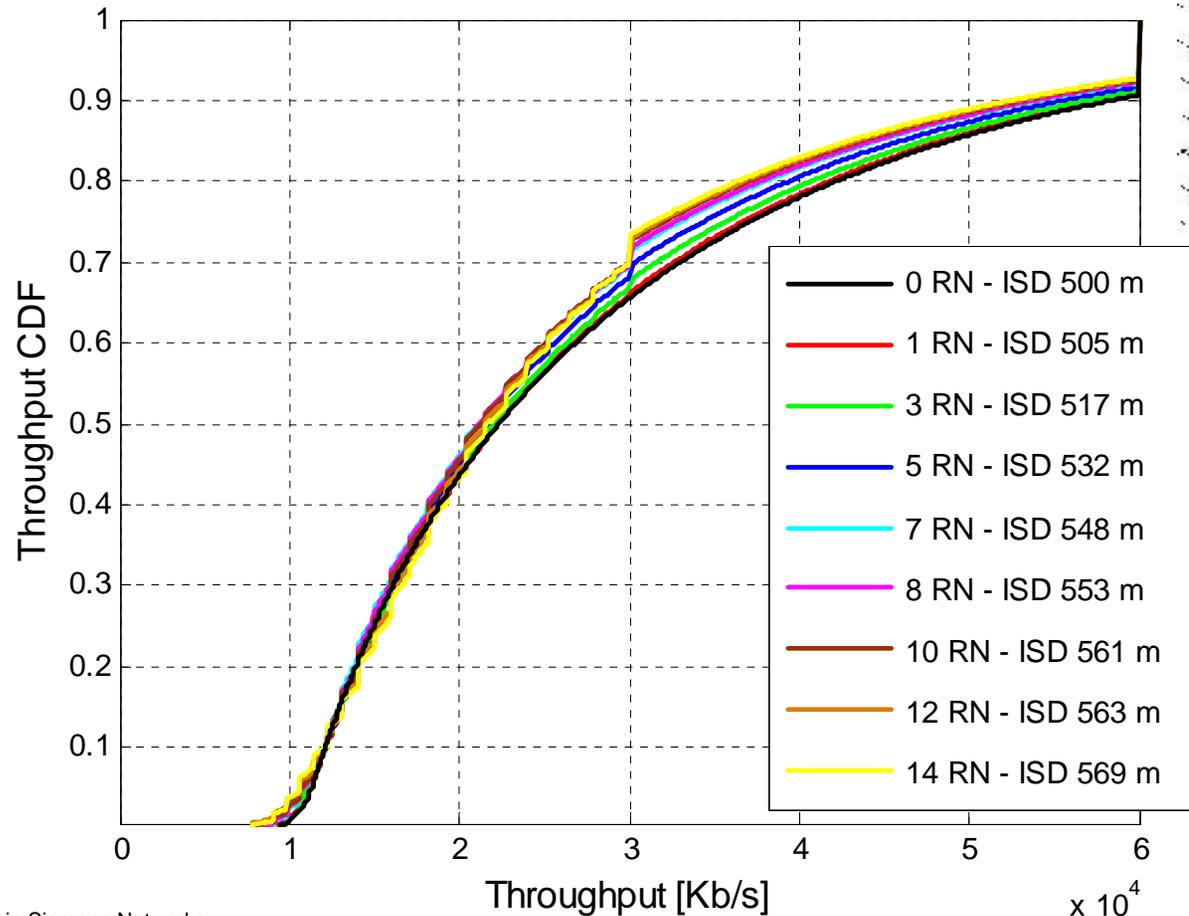
ISD 710m



Example 2 (1/2): Throughput CDF for ISD 500m

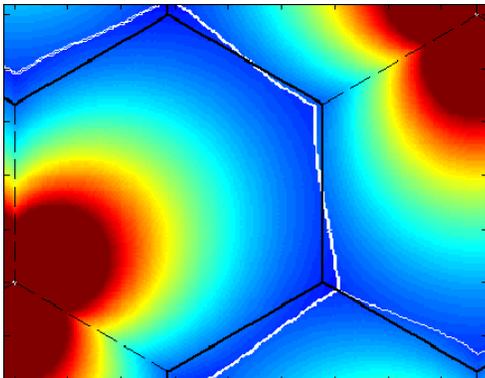
36.814 channel models

Simulation parameters aligned with 36.814 [1]
Variable number of RNs per sector: 0, 1, ..., 14
Other simulation parameters same as before
— except 10MHz bandwidth



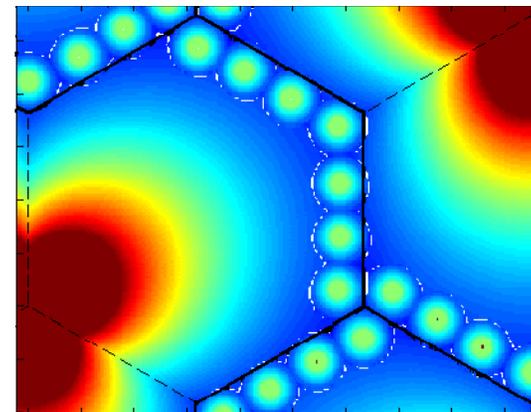
Example 1 (2/2): Throughput distribution [kbps] 36.814 channel models

ISD 500m

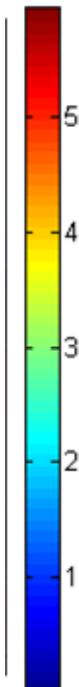


Coverage extension
provided by relays

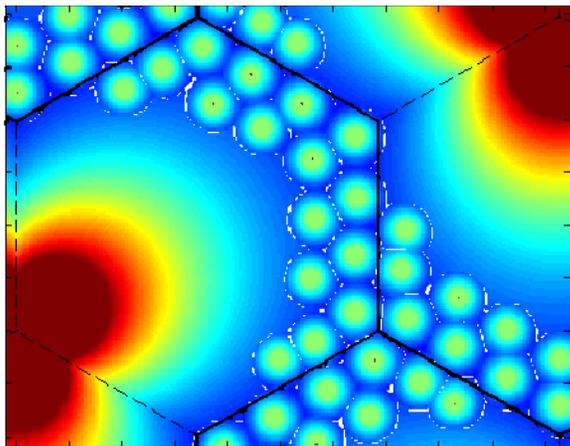
ISD 548m



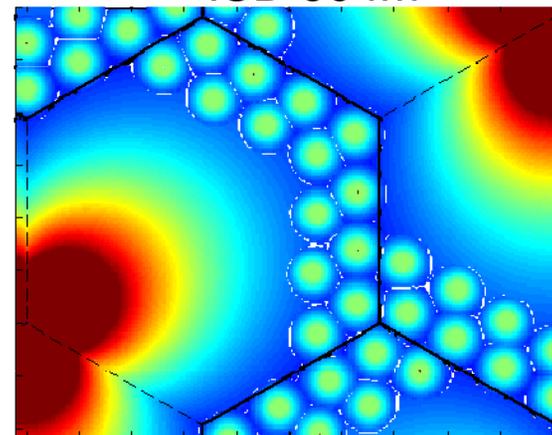
$\times 10^4$ kbps



ISD 582m



ISD 594m



Note: these results are for bandwidth 10 MHz while in slide 10 results are for 20 MHz bandwidth

Conclusions

- This contribution shows how the throughput improvement (as usually evaluated in LTE performance evaluations) can be traded into coverage extension (and eventually cost savings, not usually evaluated for LTE).
- We do not need to introduce an explicit evaluation of coverage gain on top of cell edge throughput improvement.
- The methodology illustrated in this contribution allows manufactures and operators to translate a cell edge throughput gain to a coverage gain, if the latter is more suitable for specific evaluations.
- Relays have been shown to be an efficient tool to provide a significant gain in cell edge throughput and in coverage
- Performance of relay deployment is lower in the scenario assuming 36.814 channel models compared to WINNER, e.g. in WINNER scenario an ISD of 587m can be obtained with 4 relays per sector where in 36.814 scenario 14 relays per sector are needed to increase the ISD to 569m
 - ☞ the coverage area of a RN is lower in 36.814 scenario compared to WINNER scenario
 - ☞ a higher number of relays in 36.814 scenario is needed in order to increase the throughput of a substantial part of the cell edge users

References

- [1] 3GPP TR 36.814 V1.0.0, Further Advancements for E-UTRAN Physical Layer Aspects.
- [2] IST-4-027756 WINNER II - D1.1.1 V1.2 - WINNER II interim channel models, February 2007. Available from <https://www.ist-winner.org>.