

3GPP TSG RAN WG1 #55-bis  
Ljubljana, Slovenia. January 12-16, 2009  
Agenda Item: 12.6

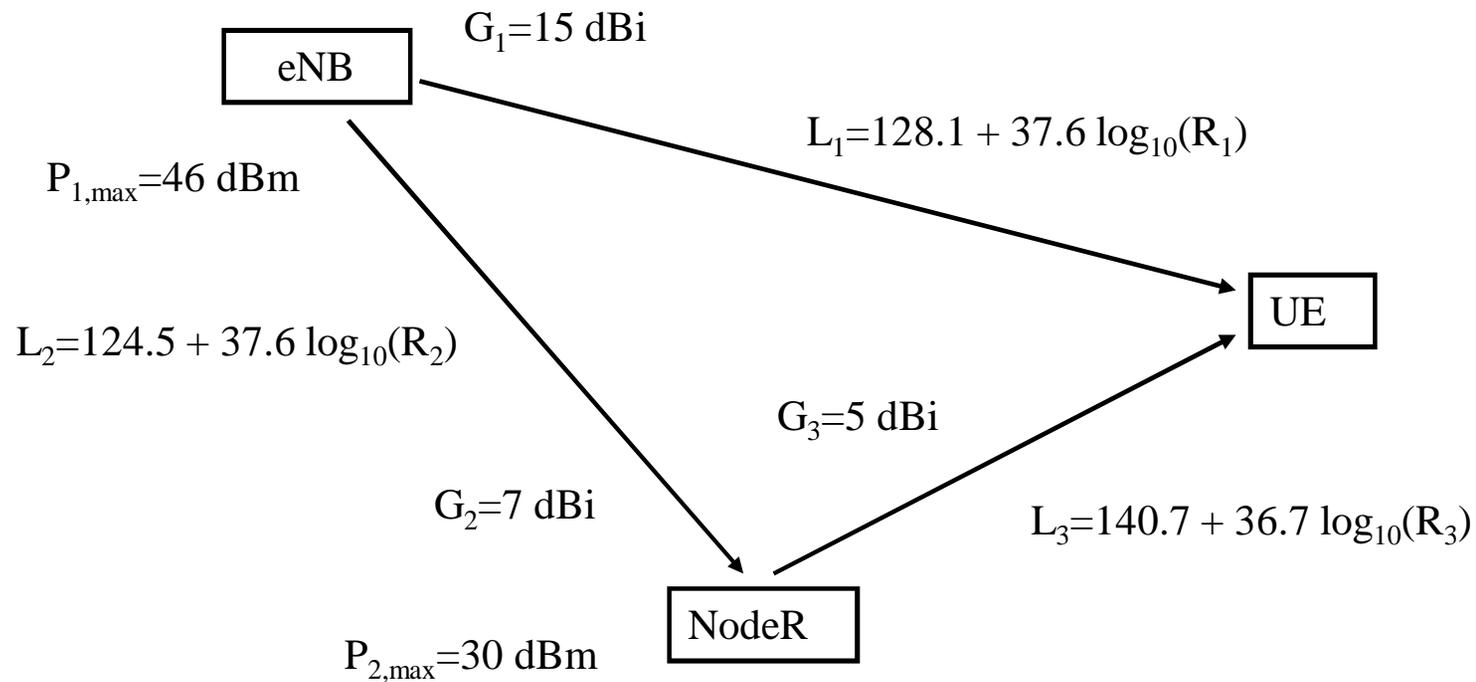
R1-090072

# Simulation Methodology Update for Relay Study

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## Relay Settings in R1-084017



When  $R_1 = R_3$ , NodeR-UE connection is weaker than eNB-UE by:

$$(L_3 - L_1) + (G_1 - G_3) + (P_{1,\max} - P_{2,\max}) = 12 + 10 + 16 = \mathbf{38} \text{ dB}$$

## Implied Coverage Area per NodeR (DL Example)

### ■ Assuming

- Use relay only if NodeR-UE link is stronger than eNB-UE
- Same penetration loss applied to both connections
- Same antenna pattern for NodeR-UE and eNB-UE
- Shadow fading ignored
- 50% of areas to be improved by relay

### ■ Covered area of a NodeR roughly estimated as

- The distance ratio  $R_1/R_3 = 10^{(38/37.6)} = 10$
- Area percentage =  $(1/10)^2 = 1\%$  of a cell area

### ■ Number of NodeRs per cell is in the range of ~50

- Potential high cost of operation
- Significant interference caused by crowded NodeRs
- Frequent relay switching for moving UEs

## Implied Link Quality of eNB-NodeR Connection (DL)

- Little pathloss advantage over eNB-UE link:  
 $\Delta = L_1 - L_2 = 3.6 \text{ dB}$
- Modest gain over UE antenna:  
 $G_2 = 7 \text{ dBi}$
- Modest channel rate of backhaul connection:  
Achievable SINR is about 4~5 dB for NodeRs at cell edges

## Targeted Relay Scenario in R1-084017

- A large number of relay nodes in a cell
- Limited field optimization for each relay node
- Stationary mobiles with semi-static UE-relay associations
- Moderate effective data rate

## Another Relay Scenario of Potential Interest

- Optimized fixed location of relay to achieve high data rate of backhaul connection
- Relay antenna is over the rooftop
- Relay has enough transmit power and antenna gain
- Limited number of relay nodes to reduce deployment cost and relay induced interference
- Graceful handling of UE mobility

## Selecting Sensible Pathloss Models

- Too many models proposed, often quite confusing
- Let's consider only the most popular models and make simple and sensible derivations
- Widely used for LTE study:  
eNB-UE:  $L \text{ (dB)} = 128.1 + 37.6 \log_{10}(R)$ , R in kilometers
- Prevailing model: COST-231 Hata

## COST-231 Model

### ■ COST-231 Hata:

$$L \text{ (dB)} = 46.3 + 33.9\log_{10}(f) - 13.82\log_{10}(h_b) - a(h_m) \\ + [44.9 - 6.55\log_{10}(h_b)]\log_{10}(R) + C_m$$

where:

- $f$  – center frequency in MHz (1500~2000)
- $h_b$  – effective height of the base station antenna in meters
- $h_m$  – height of the mobile antenna in meters (1~10)
- $a(h_m) = [1.1\log_{10}(f) - 0.7] h_m - [1.56 \log_{10}(f) - 0.8]$
- $C_m$  – 0 dB for medium-sized cities or suburban centers, 3 dB for metropolitan centers

## Assumptions and Pathloss Equations

- Relay antenna height is half of eNB antenna height and at most 10 meters
- Carrier frequency  $f = 2000$  MHz
- NodeR-UE vs. eNB-UE:

$$\begin{aligned}\Delta_1 &= -13.82\log_{10}(0.5) + [44.9 - 6.55\log_{10}(0.5)]\log_{10}(R) \\ &= 4.16 + 1.97\log_{10}(R)\end{aligned}$$

- eNB-NodeR vs. eNB-UE:

$$\Delta_2 = -[1.1\log_{10}(2000) - 0.7](10 - 1.5) = -24.9$$

- Proposed models:

$$\text{NodeR-UE: } L = 132.3 + 39.6\log_{10}(R)$$

$$\text{eNB-NodeR: } L = 103.2 + 37.6\log_{10}(R) \text{ (pessimistic if strong LOS)}$$

## NodeR Antenna Gains

- Antennas are passive devices and popular models are of reasonable sizes and inexpensive
- For eNB-NodeR connection:
  - Directional antenna preferred
    - Fixed location allows direction optimization of over-the-rooftop antenna
    - Reduce the other cell interference
    - Good channel quality helps to improve the effective channel rate
    - Reliable connection minimizes HARQ retransmissions, reducing total delays
  - 70 degree antenna (\*) with gain of 17 dBi assumed
- For NodeR-UE connection
  - Moderate beamwidth antenna preferred:
    - To cover multiple moving UEs
    - Limit the interference caused by NodeR in DL and by UEs in other cells in UL
  - 70 degree antenna (\*) with gain of 17 dBi assumed

\* On horizontal pattern only. Vertical pattern may need to be associated with area topography

## NodeR Transmit Power

- Each NodeR can have moderate amplifier power if there are not many per cell
- High enough to cover users within reasonable distance
- High enough to compensate “duplex loss”
- Directional antenna allows moderate transmit power without causing significant interference to other cells
- Reasonable level: 6~12 dB below eNB transmit power

## Conclusions

- Simulation parameters in R1-084017 reflect only one type of relay scenario
- Propose a relay scenario that allows small number of relay nodes and readily supports UE mobility
- Propose to add the following parameter values for relay simulation study:
  - Pathloss models: NodeR-UE:  $L = 132.3 + 39.6 \log_{10}(R)$   
eNB-NodeR:  $L = 103.2 + 37.6 \log_{10}(R)$
  - Antenna beamwidth and gain (to eNB/UE): horizontal 70 degree, 17 dBi excluding cable loss
  - NodeR transmit power: 34~40 dBm in 10 MHz

## References

- [1] R1-082975 “Application scenarios for LTE-Advanced relay”, China Mobile (CMCC), Vodafone, Huawei
- [2] R1-084017 “Text proposal for evaluation methodology”
- [3] R1-084354 “Considerations on the relay maximum transmit power”, Huawei
- [4] R1-083778 “System simulation evaluation for link from eNode-B to RN”, Fujitsu

# Thanks

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