Optimum Selection of detachable Base Stations in Low Traffic Scenarios

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Overview

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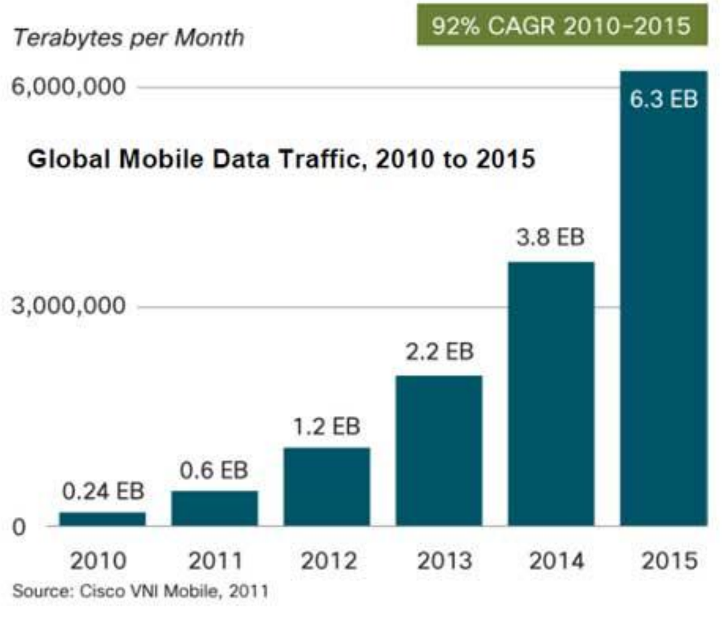
1. Introduction

- In a Mobile Network up to 80% of the overall power is consumed in the cellular access part of the network

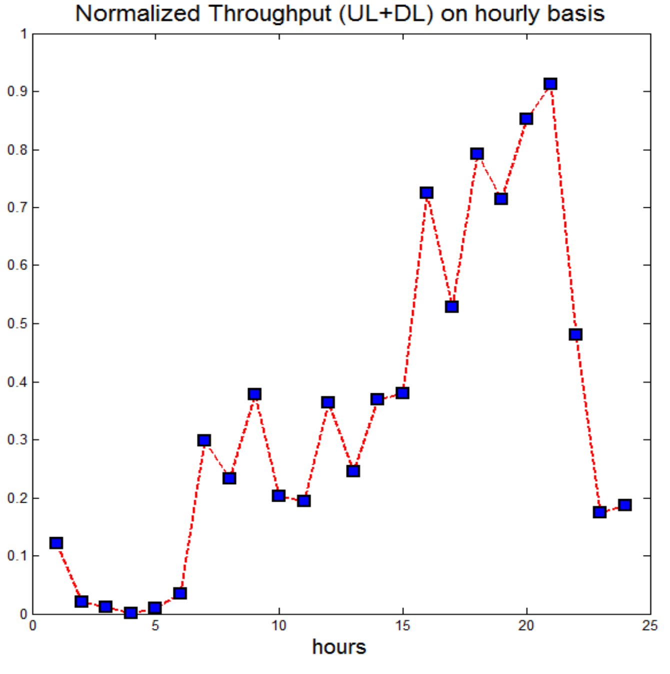
- Rising energy costs and growing traffic demands make energy consumption a major issue for Mobile Network Operators

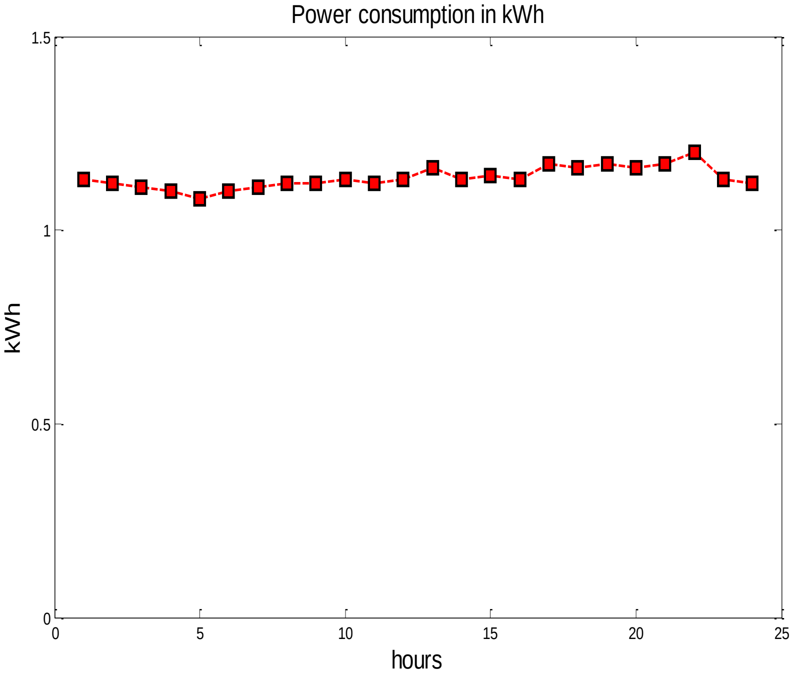


1. Introduction

- Temporal Traffic and Power Consumption Analysis:

Highly varying traffic vs. constant energy consumption over the day





Urban, 3-sector nodeB site (no additional cooling equipment installed); Power Consumption includes RF Backhaul Equipment

1. Introduction

- **Idea**: Adapting the capacity of the access network to the actual traffic load by shutting down Base Stations in low traffic hours to save energy

- Previous Work:
  - „Traffic-Driven Power Saving in Operational 3G Cellular Networks“

    Chunyi Peng, Suk-Bok Lee, Songwu Lu, Haiyun Luo, Hewu Li

    ACM MobiCom 2011

  - „ Toward Dynamic Energy-Efficient Operation of Cellular Network Infrastructure”

    Eunsung Oh, Xin Liu, Zhisheng Niu

    IEEE Communications Magazine, June 2011

1. Introduction

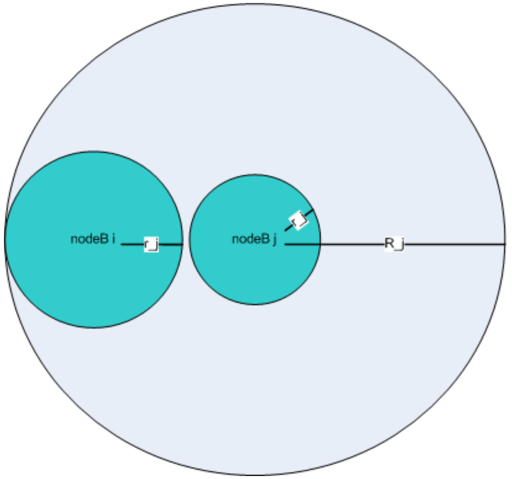
- **Key question:** Which base stations can be shut down in low traffic scenarios without a negative effect on the **network coverage?**
  - Find topological redundancy in the access network related to coverage

- **Existing approach:**

  Grid-based profiling:

  - Starting with a given base station topology, equivalent BS's are grouped into grids; BS i and j are equivalent if:

$$r_i + d(i,j) \leq R_j,$$
$$r_j + d(i,j) \leq R_i$$



with

r_i, r_j normal communication ranges

d(i,j) distance between the base station sites

R_i, R_j maximum possible communication ranges

  - "Northwest rule" and selection of Base stations in low and high traffic hours

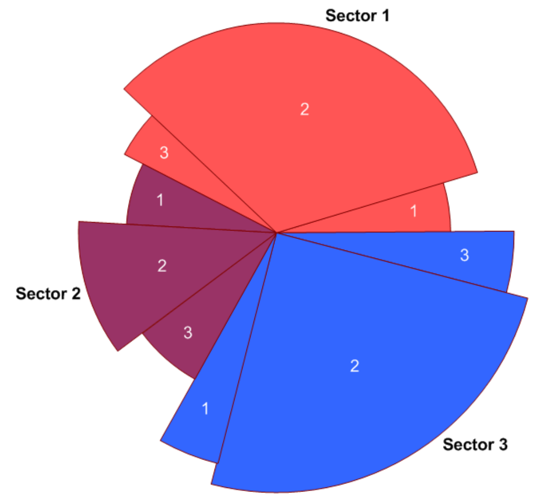
1. Introduction

- **Problems with the existing approaches:**
  - Base station transmission ranges are modeled as circles with the base station sites at the center
  - Base stations with more than one sector cell are not considered
  - Single sector cell shutdowns are not considered
  - Methods are not useful for practical implementation

- **General Problem:**
  - There is no analytic way to calculate the overlapping coverage areas for a given set of base station sites

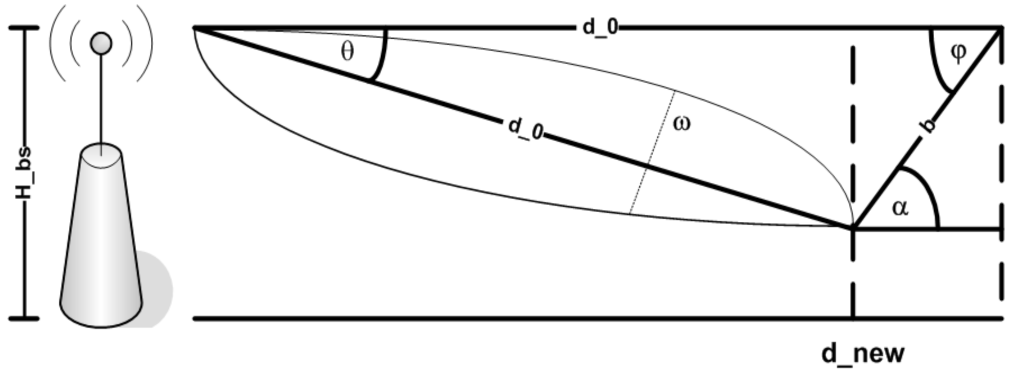
2. New Method

- A **numerical** method to find detachable Base Stations according to the coverage situation with respect to the configuration and location of the base stations within a given base station topology…
  - using equidistant test spots for the calculation of interfering areas of different base stations
  - using COST 231 Hata model to calculate transmission ranges with respect to a given maximum allowed path loss and the actual environment in the cells (urban, suburban,…)
  - using divided circular sectors to model single sector cells and cell edges with different radii according to the site configuration (antenna height, cable loss, antenna gain) and the cell edge attenuation



2. New Method

- assuming RET(Remote Electrical Tilt) for the adaptation of the transmission ranges

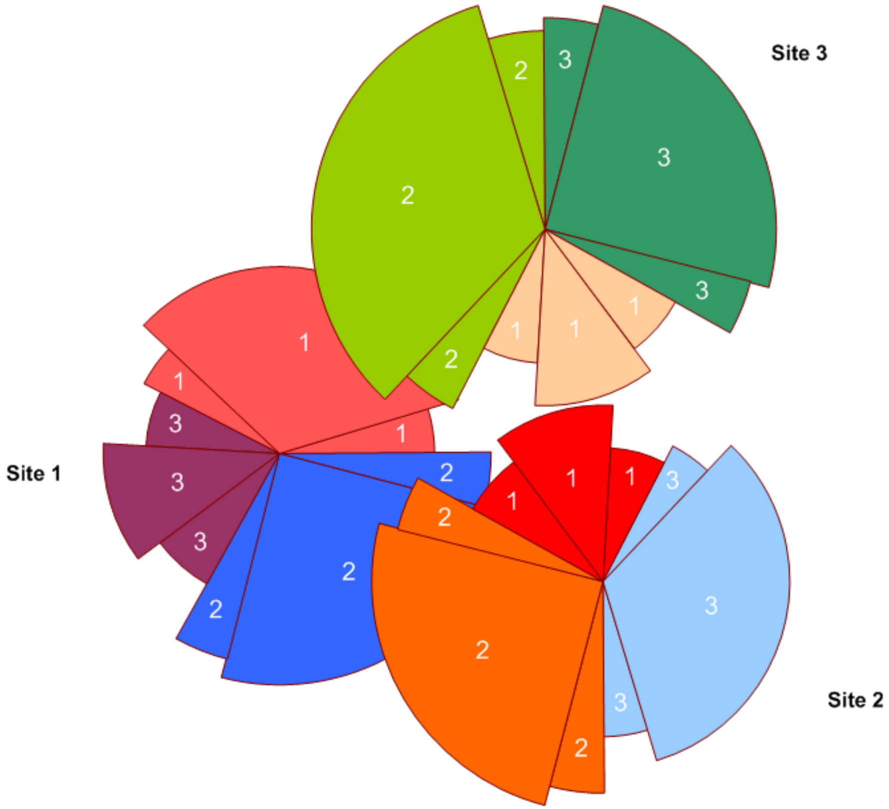


$$d_{new} = d_0 - \cos(\alpha)\, b$$
$$b = (2d_0^2 - 2d_0^2 \cos(\theta))^{\frac{1}{2}}$$
$$\alpha = 180° - \theta - \varphi$$
$$\varphi = \frac{180° - \theta}{2}$$

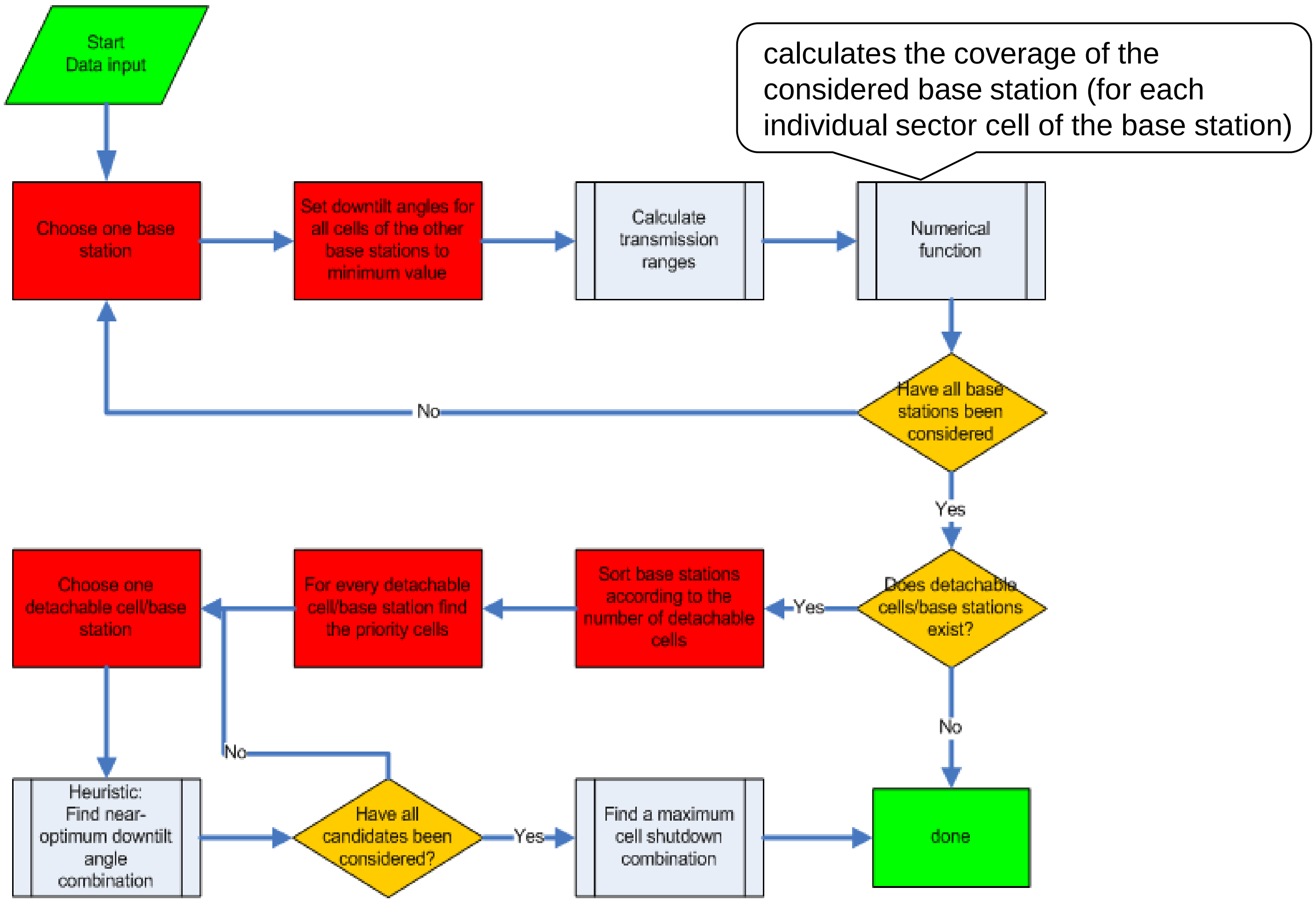
- with:
  - d_0 transmission range according to COST 231 HATA model
  - θ electrical antenna downtilt
  - d_{new} transmission range considering the downtilt angle θ

2. New Method

- For a given set of base station sites the new method finds the detachable base stations or sector cells which can be shut down for energy savings without degrading the **cellular network coverage**
- Required Input data:
  - Set of BS`s with geographic positions of sites
  - For each cell:
    Azimuth, real and minimum possible antenna downtilt angle, antenna heights and gain, feeder-loss, propagation environment in the sector cell
  - Maximum allowed path loss
  - Test spot distance



2. New Method


Start
Data input
Choose one base station
Set downtilt angles for all cells of the other base stations to minimum value
Calculate transmission ranges
Numerical function
calculates the coverage of the considered base station (for each individual sector cell of the base station)
Have all base stations been considered
No
Yes
Does detachable cells/base stations exist?
Yes
Sort base stations according to the number of detachable cells
For every detachable cell/base station find the priority cells
Choose one detachable cell/base station
No
Heuristic: Find near-optimum downtilt angle combination
Have all candidates been considered?
No
Yes
Find a maximum cell shutdown combination
done

2. New Method

- The new method discovers the energy saving potential by shutting down base stations for a given base station topology without negative effects on the network coverage

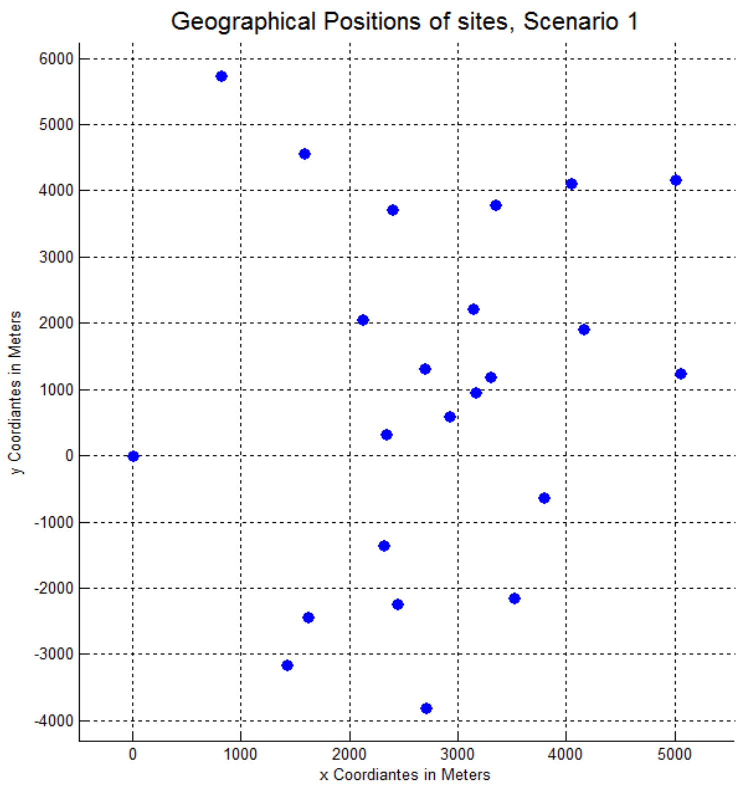
  - Not only whole base stations but also single sector cells are considered

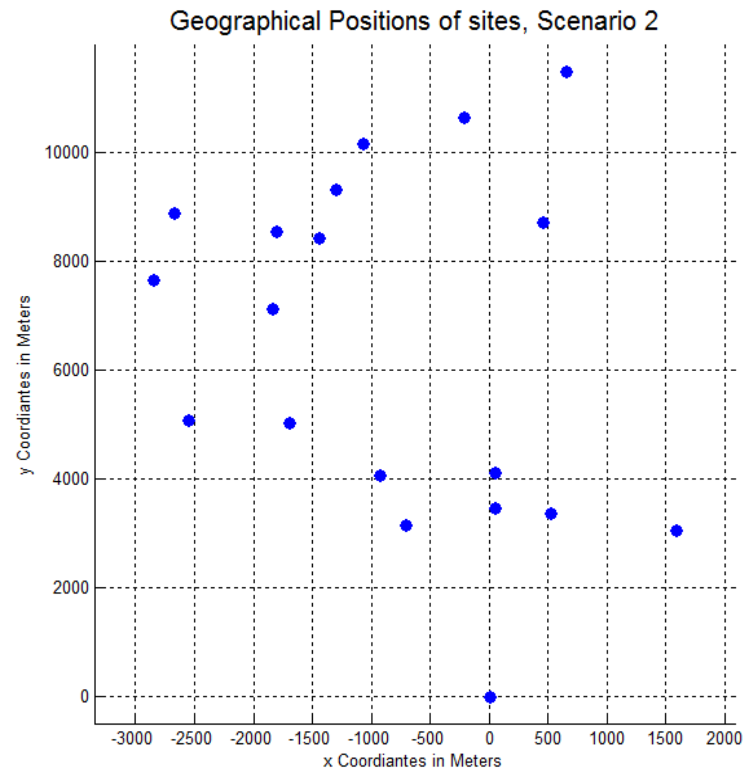
  - Finds the maximum subset of detachable base stations and single sector cells

  - Calculates the minimum required antenna downtilt angle adaptation for the remaining cells to sustain full network coverage

3. Performance Analysis

- Application of the new method to a 3G Mobile network deployment in two German mid-sized city scenarios with 23/19 macro sites respectively:

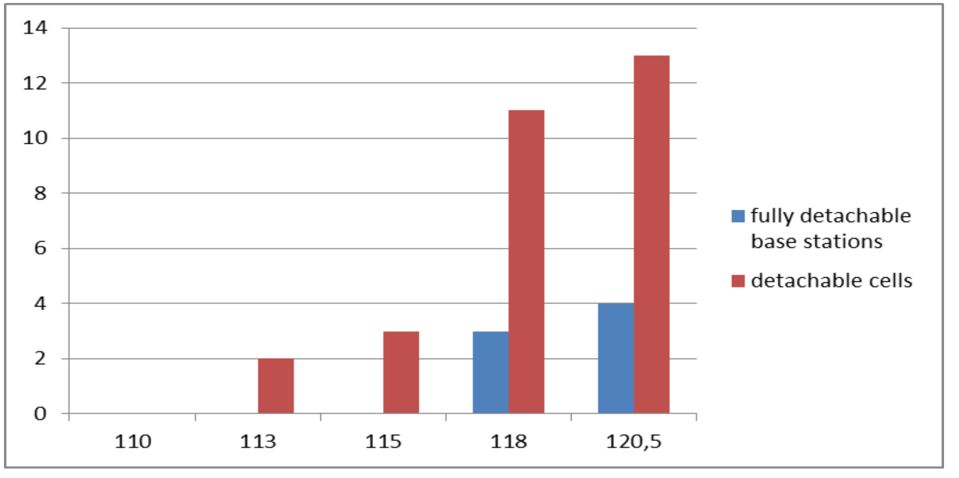




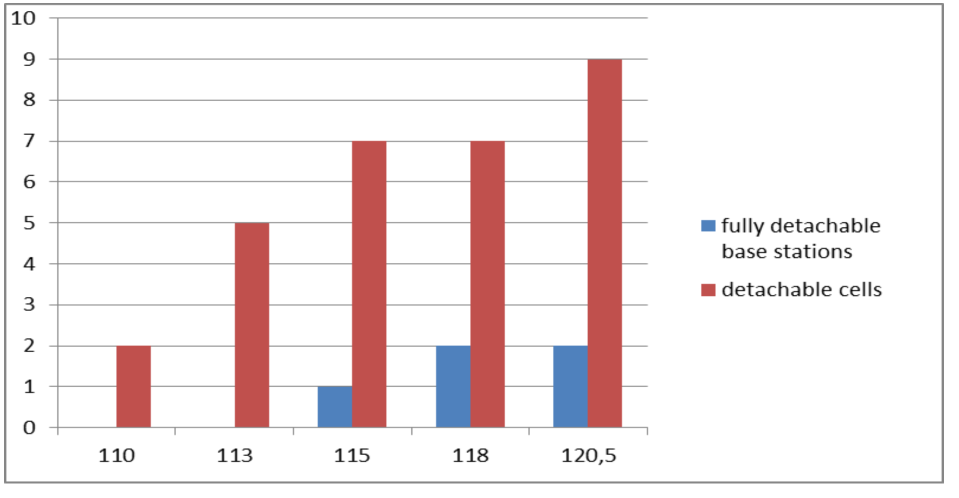
3. Performance Analysis

- Number of detachable sector cells and base stations with respect to the maximum allowed path loss in dB (without antenna gain and feeder loss)

Scenario 1:



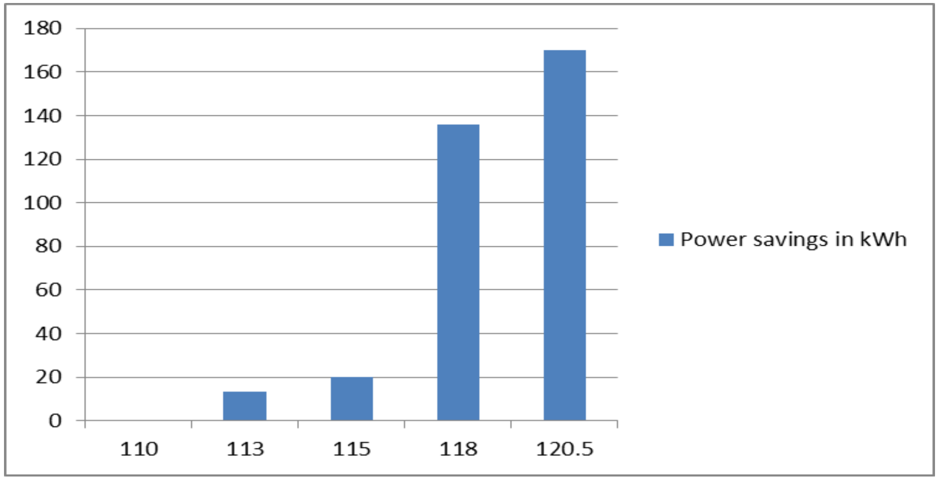
Scenario 2:



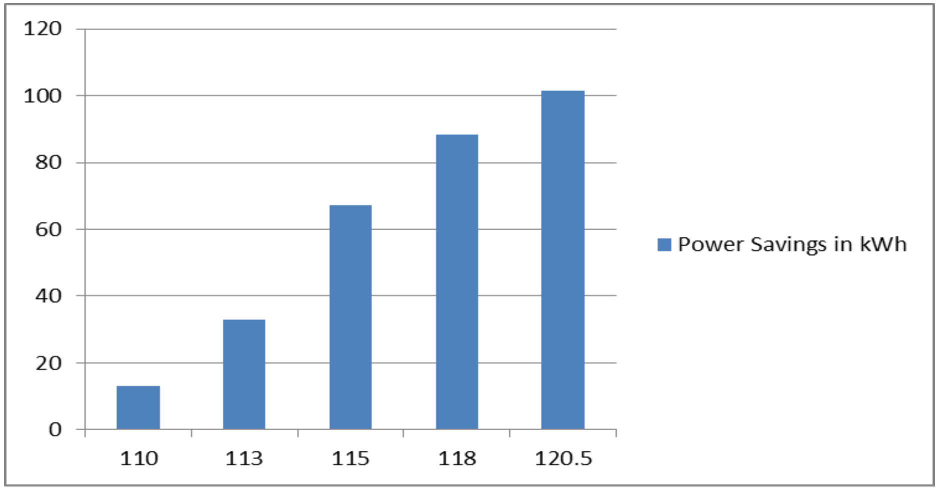
3. Performance Analysis

- Resulting weekly power saving potential with respect to the maximum allowed path loss in dB:

Scenario 1:



Scenario 2:



3. Performance Analysis

- Key results:

  - the energy saving potential depends on the max. allowed path loss

  - significant energy saving potential has been identified in urban and suburban scenarios

  - no energy saving potential in rural areas

4. Summary

- Contrary to existing methods any possible combination of priority cells is considered (to sustain the network coverage)

- The new method provides an advanced modeling of the sector cell transmission ranges with respect to the downtilt angle, the environment and cell specific parameters

- The new method requires quite a long calculation time (hours to days) due to the huge number of test spots (which is required for sufficient accuracy) – however this is not critical as offline calculation is sufficient

4. Summary

- Current work:

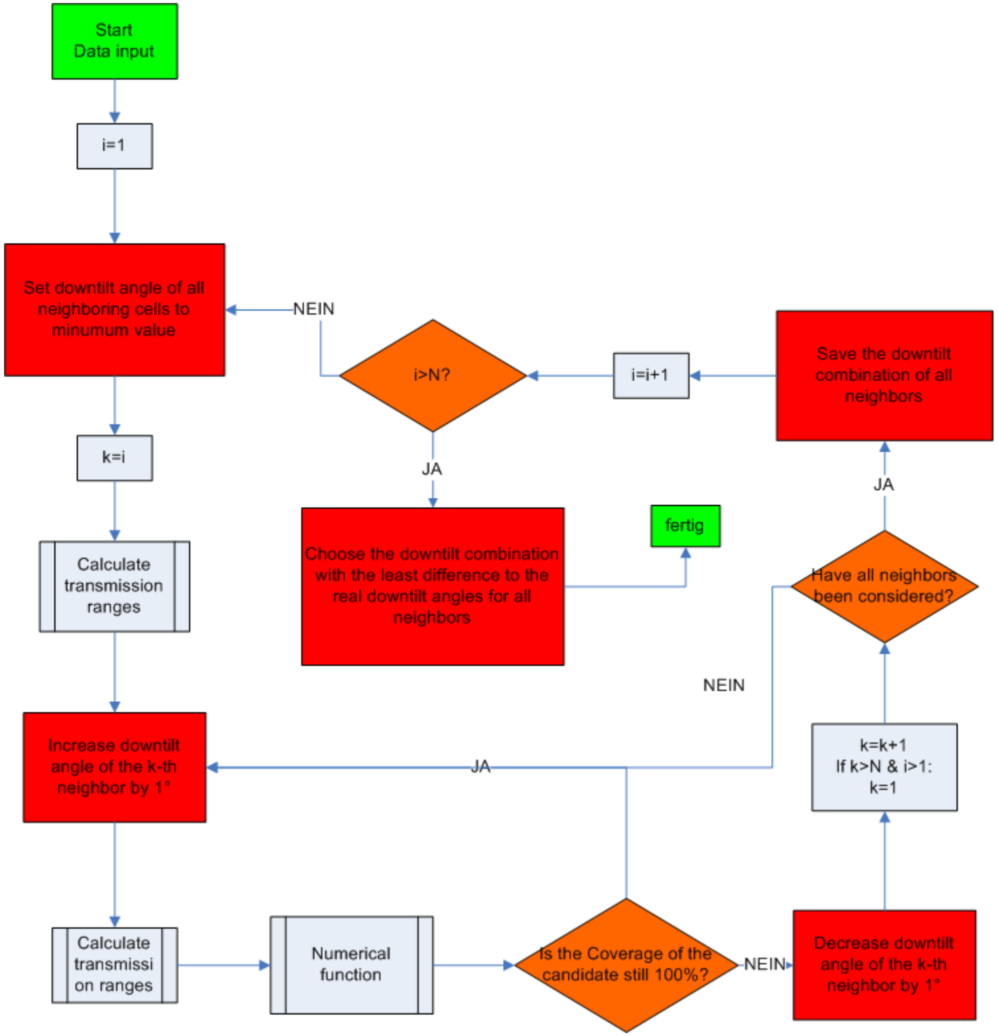
  - Extension of the method to consider the capacity aspect (via „User Snapshot“-based Load Simulation)

  - Deriving threshold values for cell load/ throughput/ number of active users so that no traffic loss occurs in case of a cell shutdown

Thank you

Backup

- Heuristic for near-optimum downtilt angle calculation:



Backup