Evaluation of Self-x Approaches for Mobile Radio Networks using Cell Level Simulations

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Why Self-organising Systems?

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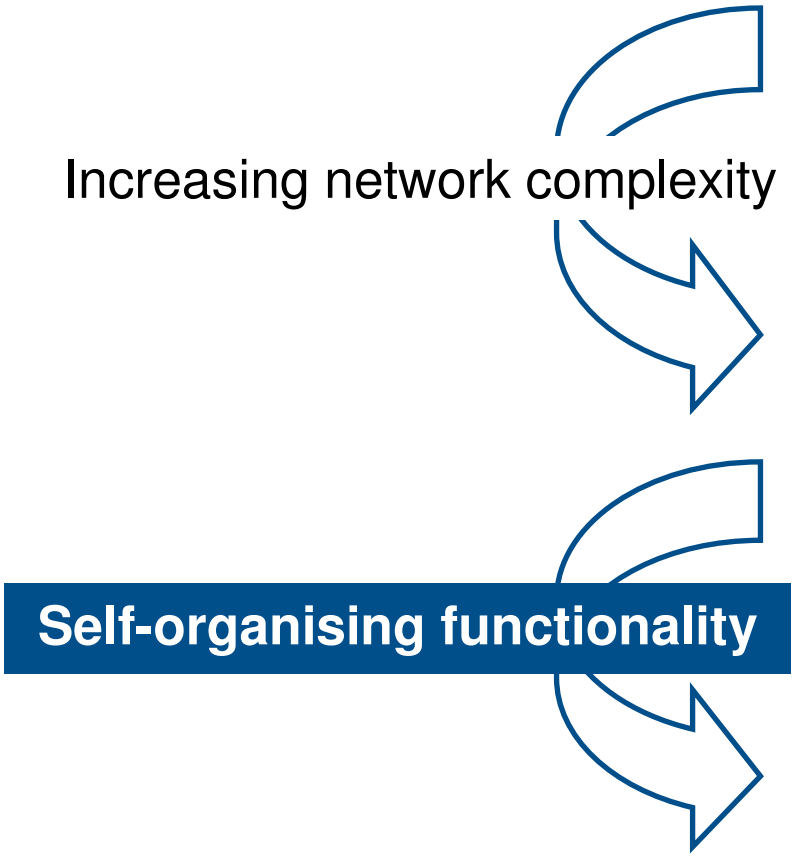

- Future mobile radio networks trends
  - Multiple Radio Access Technologies
  - Increasing variety of services
  - High data rates
- Increased operational effort, complexity, cost
- Automatic network planning, operation, optimisation required
- Ensuring manageability
- Reduction of operational effort
- Increase of resource efficiency

Self-organising Functionality

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Self-x

- **Self-planning**
  - network planning
  - automated
- **Self-configuration**
  - initial operating parameters
  - download/ cognitive/ interactive
  - automated
- **Self-optimisation**
  - parameter adjustment
  - adaptation to changes
  - automated
- **Self-healing**
  - reaction to failures
  - automated

Self-organising Functionality

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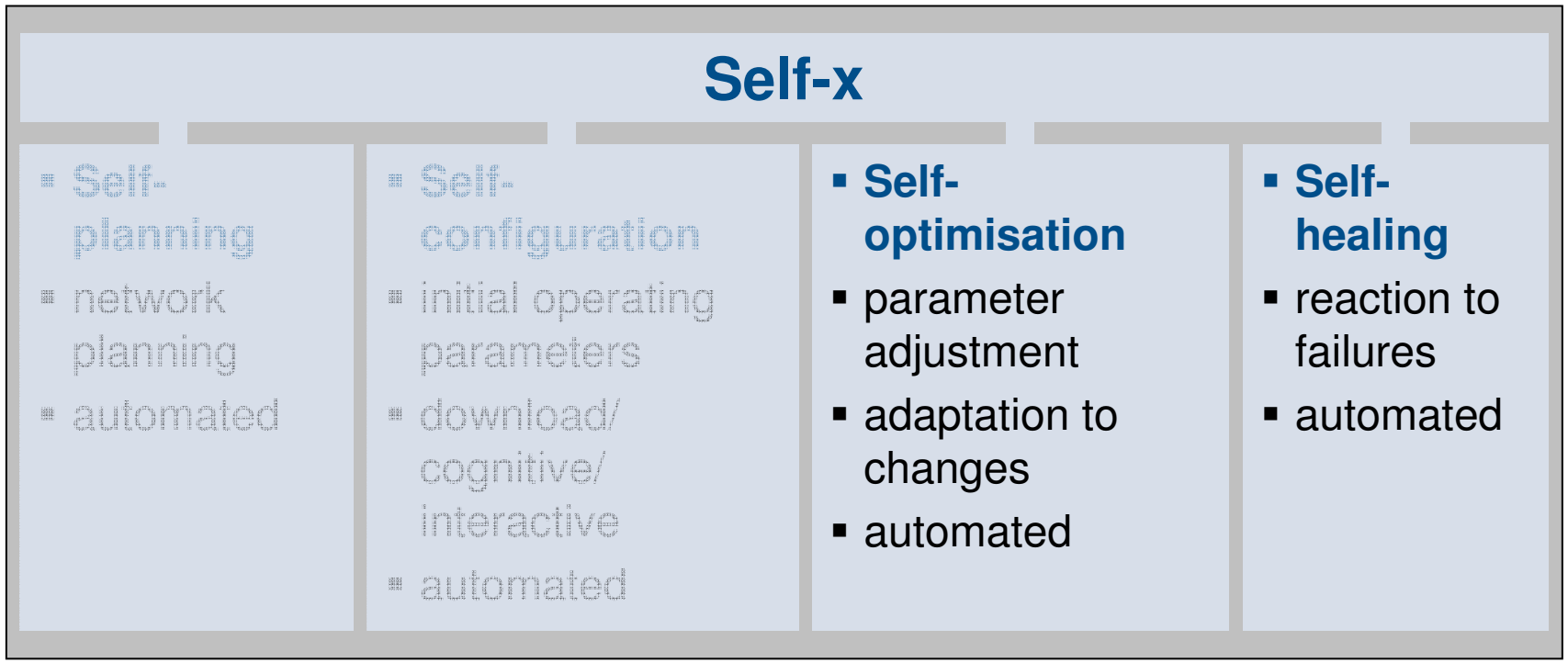

Outline

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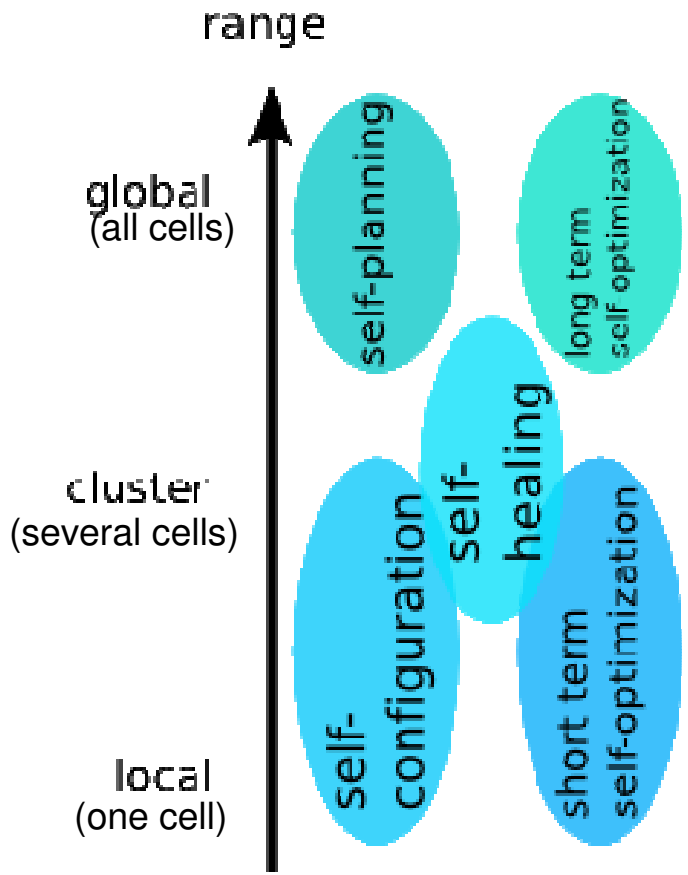
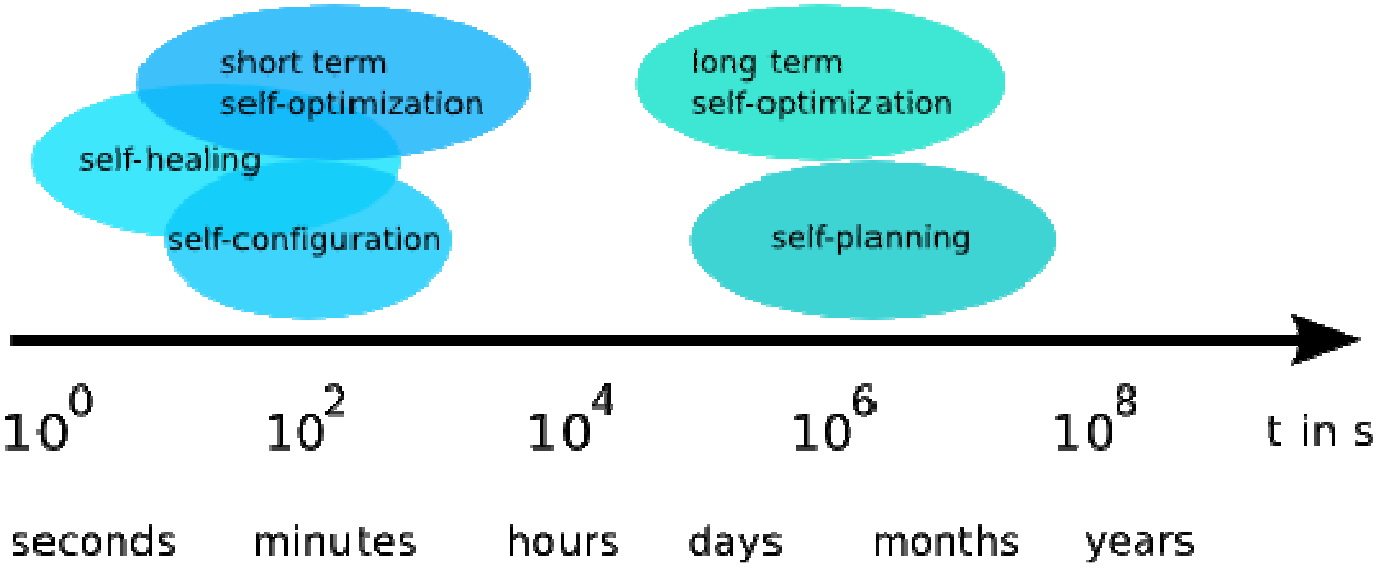
- **Simulation Fundamentals**
- Bandwidth Demand Model and Cell Outage Probability
- Key Data of the Simulative Approach and Simulation Example

Spatial Classification of Self-x



- Cells are in the focus
  - Several, interdependent cells
- Simulation at cell-level

Temporal Classification of Self-x



- Large timescales
  - Duration of minutes, hours, days
  - Time steps of seconds, minutes, hours
- Fast fading averaged out

Scheduler Assumption, QoS

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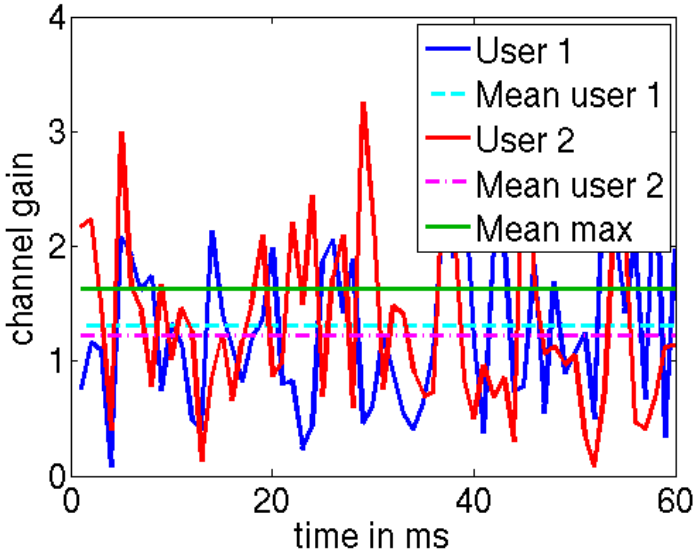
- Scheduling increases average SINR
  - Example: max SINR
  - Decrease in required resources
- Sufficient QoS achievable if sufficient resources available
  - w.r.t. delay, maximum/minimum/average data rate, data rate jitter,…



- Focus on determining and evaluating resource situation
  - Resource demand/resource supply of the cells
- QoS is expressed in terms of average user data rate
  - Further QoS parameters achievable according to scheduler assumption

Bandwidth Averaging

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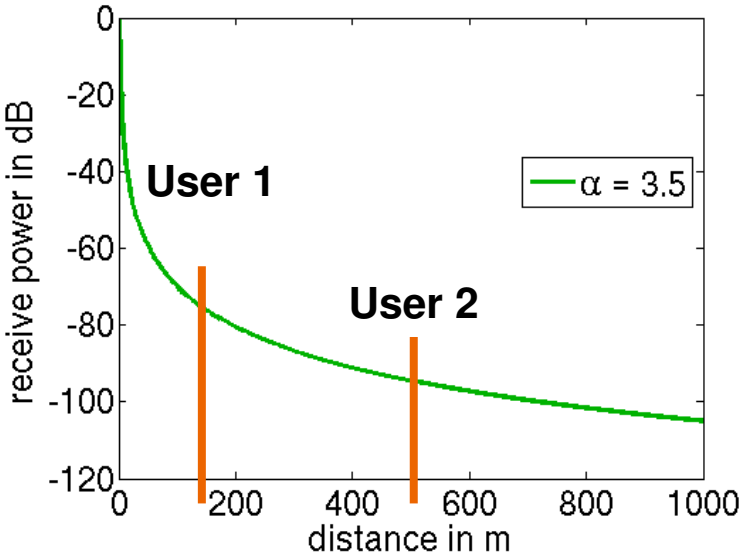
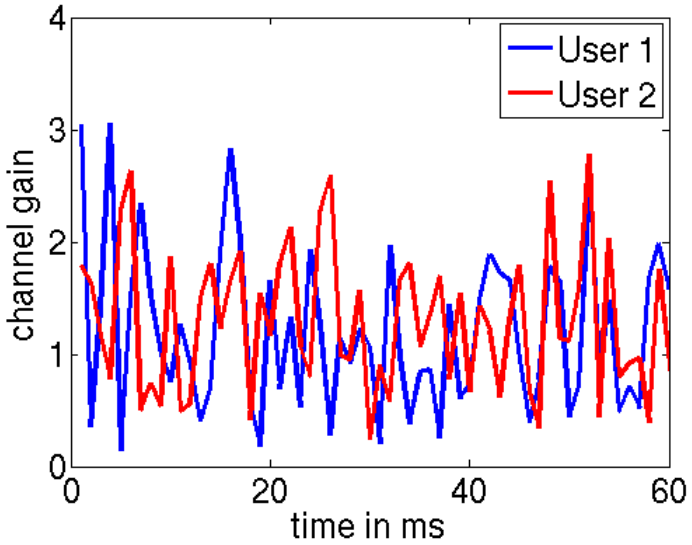
- Cell bandwidth demand = sum of user bandwidth demands
  - All users of one cell considered jointly
- User bandwidth demands depend on service type, channel and user position
  - Fluctuations in user bandwidth demand





- Simulation at cell-level: Bandwidth averaging over all users
  - Influence of service type, fast fading, and user position mitigated
  - Bandwidth demand fluctuations mitigated

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User Bandwidth Demand PDF

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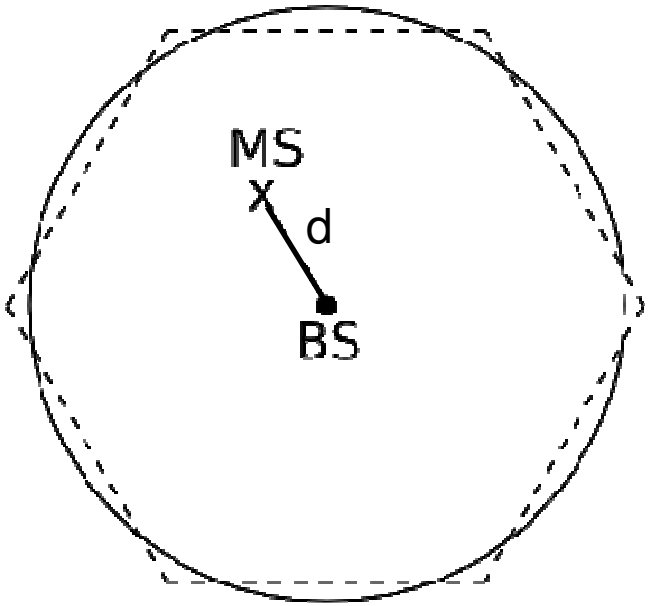
- Single cell scenario



User position PDF

$$f_{r,\varphi}(r,\varphi)$$

$$f_d(d)$$

$$f_{PL}(PL)$$

$$f_{SINR}(SINR)$$

$$f_B(B)$$

Bandwidth demand PDF of a single user

η : user data rate
B : user bandwidth
γ : receiver SINR

- Bandwidth demand of a single user

$$B = \frac{\eta}{\log_2(1+\gamma)}, \quad \gamma = \frac{1}{d^{\alpha}} \cdot \frac{P_{\text{tx}}}{P_{\text{N}} + P_{\text{I}}}$$

Cell Bandwidth Demand PDF

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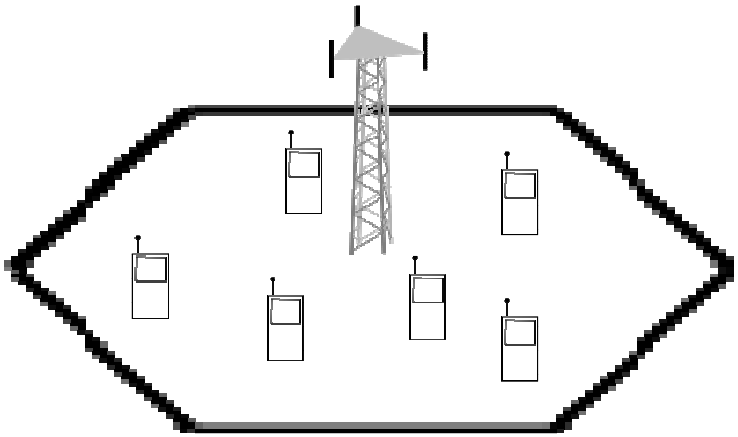
- K independent users



- η_i : data rate requirement of user i
- B_i : bandwidth demand of user i
- Cell bandwidth demand for FDMA

$$B_{\text{cell}} = \sum_{i=1}^{K} B_i$$

For data rates of comparable order:

Central Limit Theorem

$$f_{B_{\text{cell}}}(B_{\text{cell}}) \sim N(\mu_{\text{cell}}, \sigma^2_{\text{cell}})$$

$$\mu_{\text{cell}} = \sum_{i=1}^{K} \mu_i \ , \quad \sigma^2_{\text{cell}} = \sum_{i=1}^{K} \sigma_i^2$$

$$f_{B_i}(B_i) \quad \Rightarrow \quad \mu_i, \sigma_i^2$$

Bandwidth Demand: Examples

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Cell radius $R = 250$ m, $\alpha = 4$

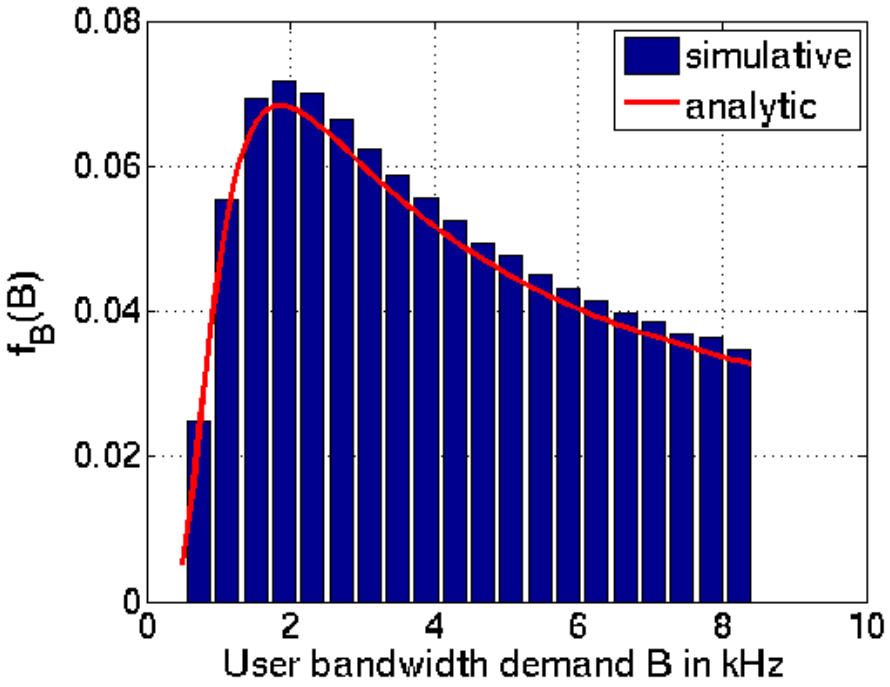
$P_{\text{tx}} = -70$ dBm/Hz

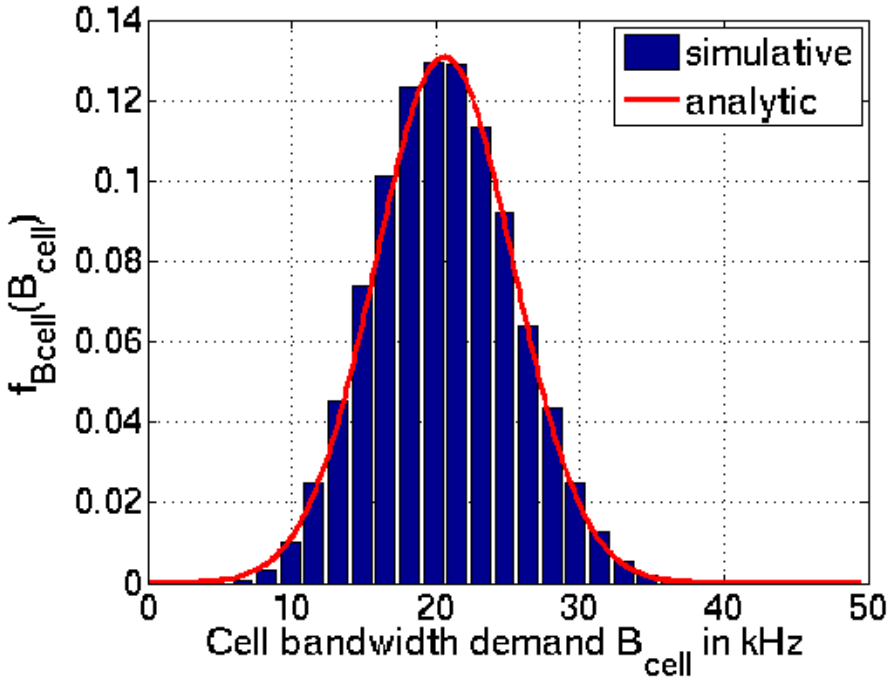
$P_{\text{N}} + P_{\text{I}} = -167$ dBm/Hz

$K = 5$, Uniform user distribution

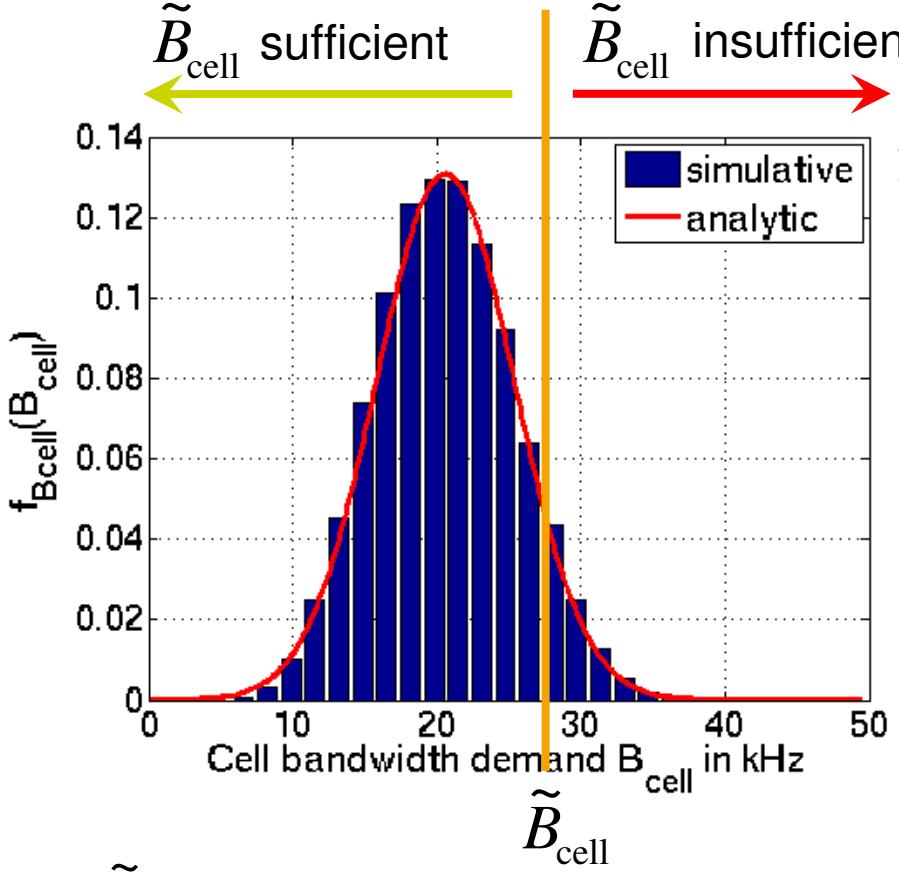
$\eta_i = 10$ kbit/s , $i = 1 \ldots K$

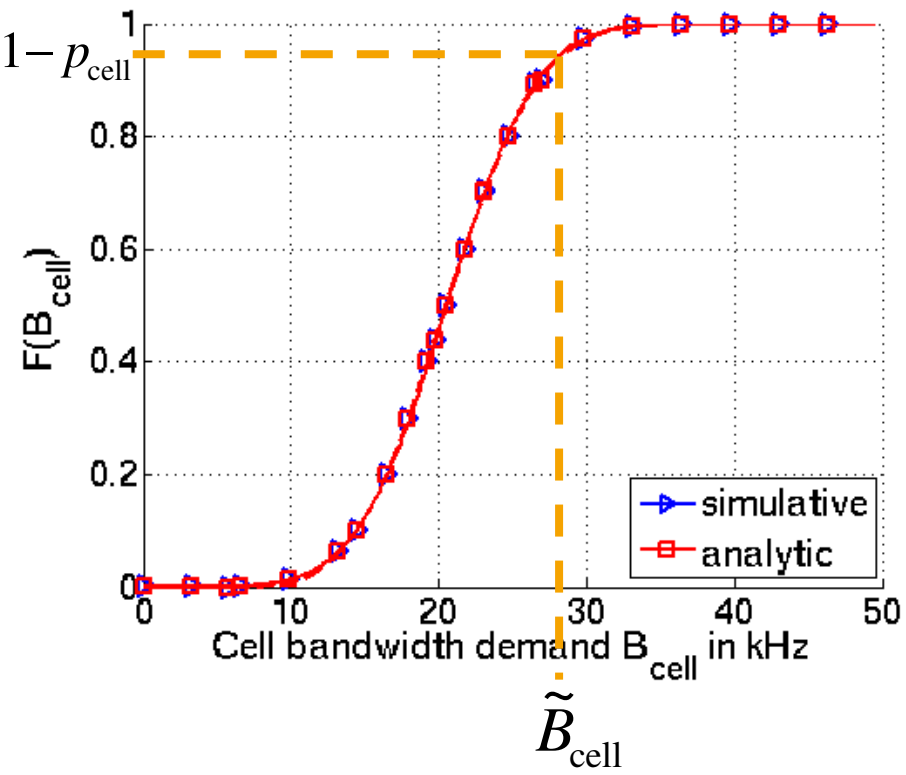
$\eta_{\text{unit}} = 1$ bit/s





Cell Outage Probability





- $\tilde{B}_{\text{cell}}$: assigned cell bandwidth
- p_{cell} : cell outage probability

$$p_{\text{cell}} = 1 - F(\tilde{B}_{\text{cell}})$$

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Simulation Parameters and Flowchart

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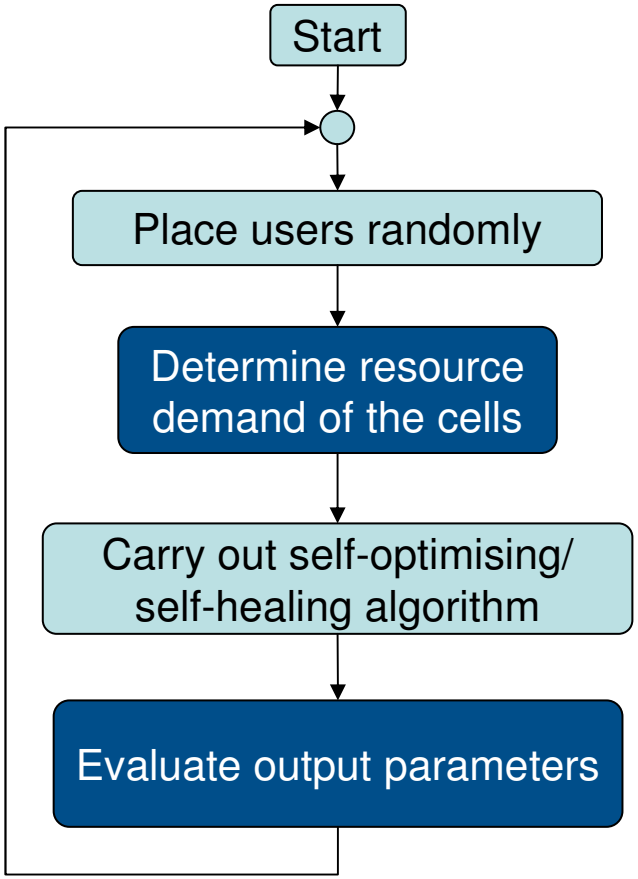
- Input data
  - User distribution
  - Service distributions
  - Traffic models
  - Propagation models
- Output data
  - Allocated cell bandwidth
  - Resource availability
  - Capacity, throughput
  - Outage probability



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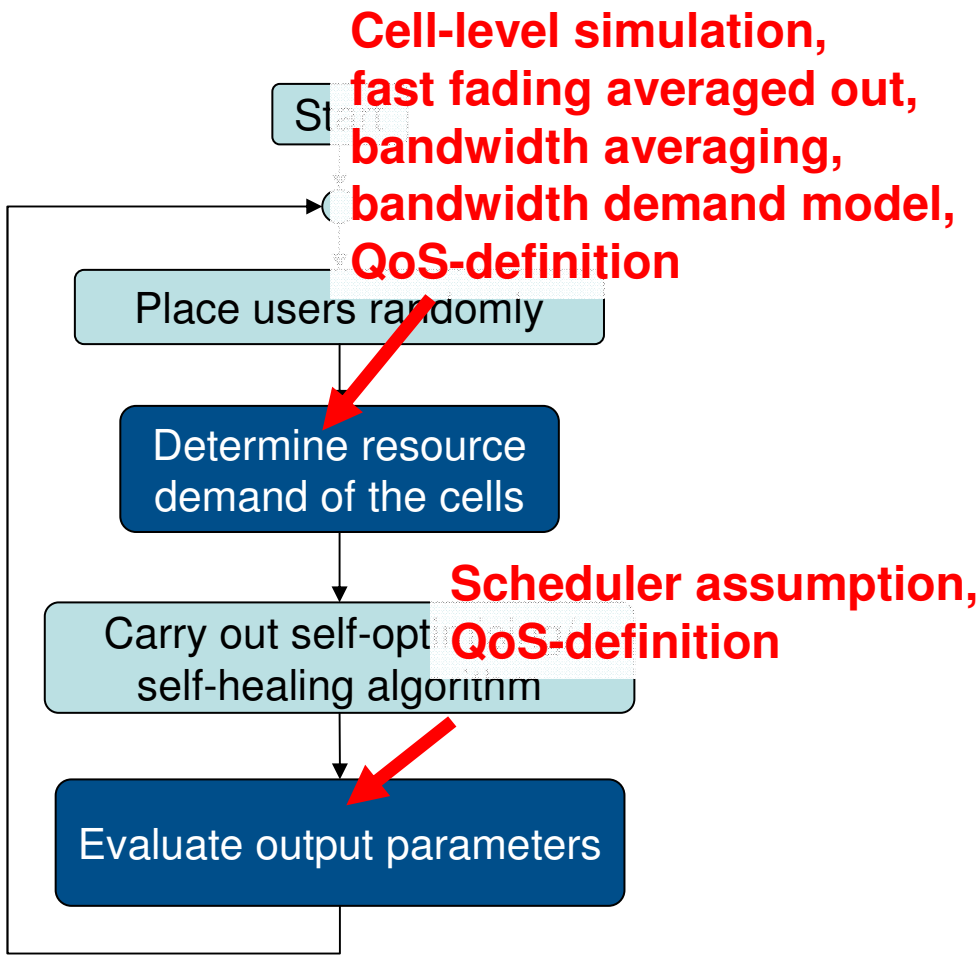

Simulation Example: Scenario

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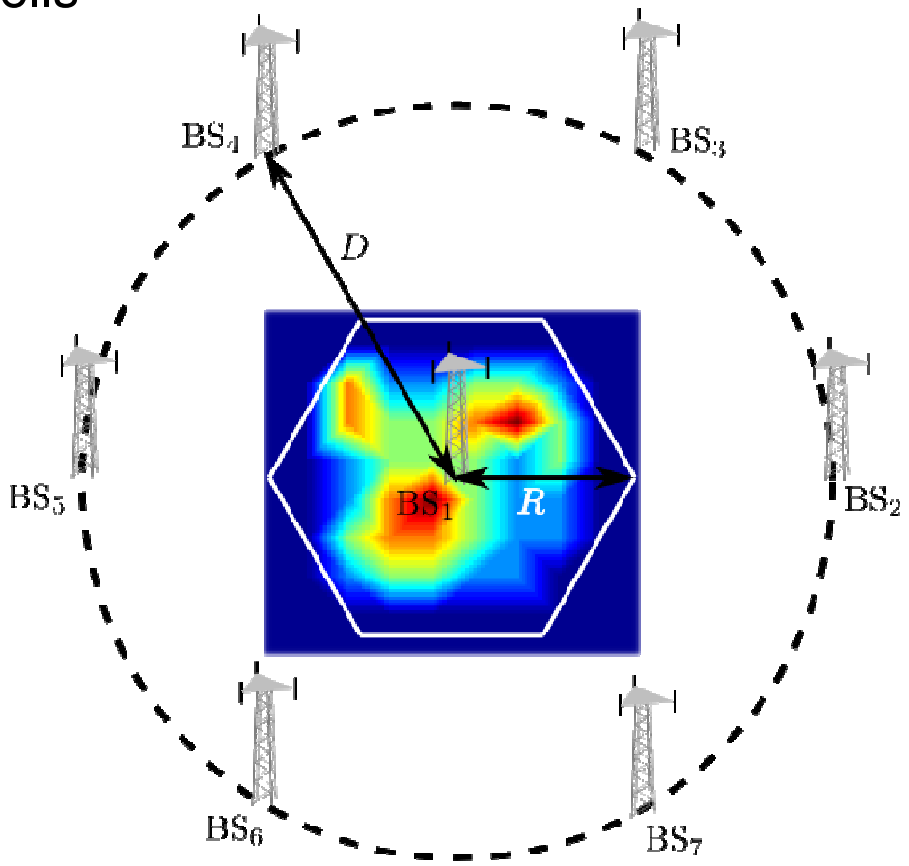
- Evaluation of resource assignment algorithm for joint assignment of transmit power and bandwidth to cells
- Cell outage probability $p_{\text{cell}}^{(\text{BS1})}$ of centre cell evaluated
- Six closest interferers regarded
- User density
  - Red: high
  - Blue: low
- Voice service



Simulation Example: Parameters

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Cell radius R	250m
Height of MSs/BSs	1.5m/32m
Average number of active users K	50
Data rate (QoS) requirement per user	10kbit/s
Data rate unit	1bit/s
Propagation model	3GPP SCM Urban Macro
Pathloss exponent	3.5
Carrier frequency	1.9GHz
Lognormal shadow fading variance	8dB
Shadow fading correlation distance	40m
Noise power spectral density (PSD) P_{N}	-167dBm/Hz
Target cell outage probability $\tilde{p}_{\mathrm{cell}}$	0.05

Simulation Flowchart

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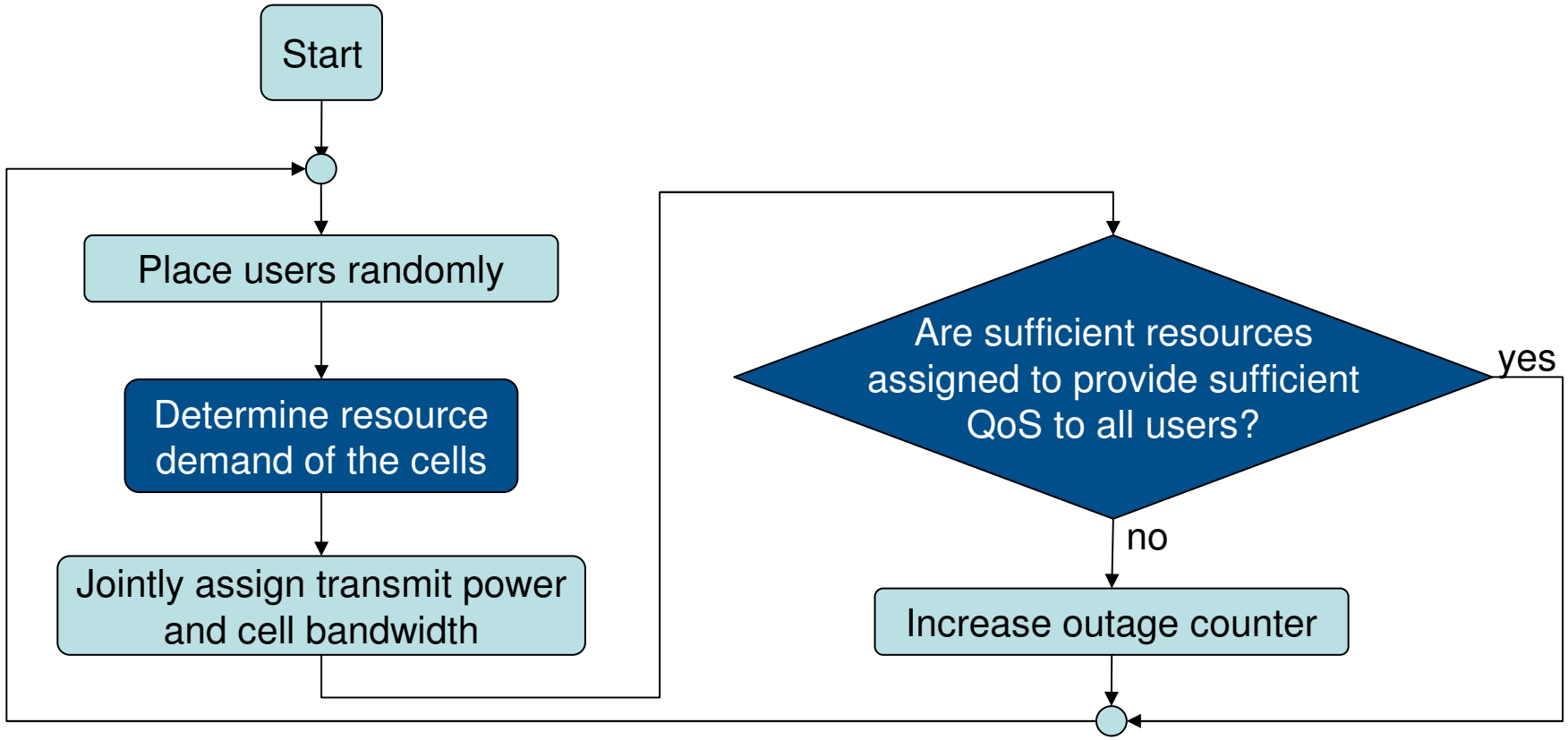
- Goal: evaluation of resource assignment algorithm for joint assignment of transmit power and bandwidth to cells of mobile radio networks



Simulation Example: Results