Radio Network Design

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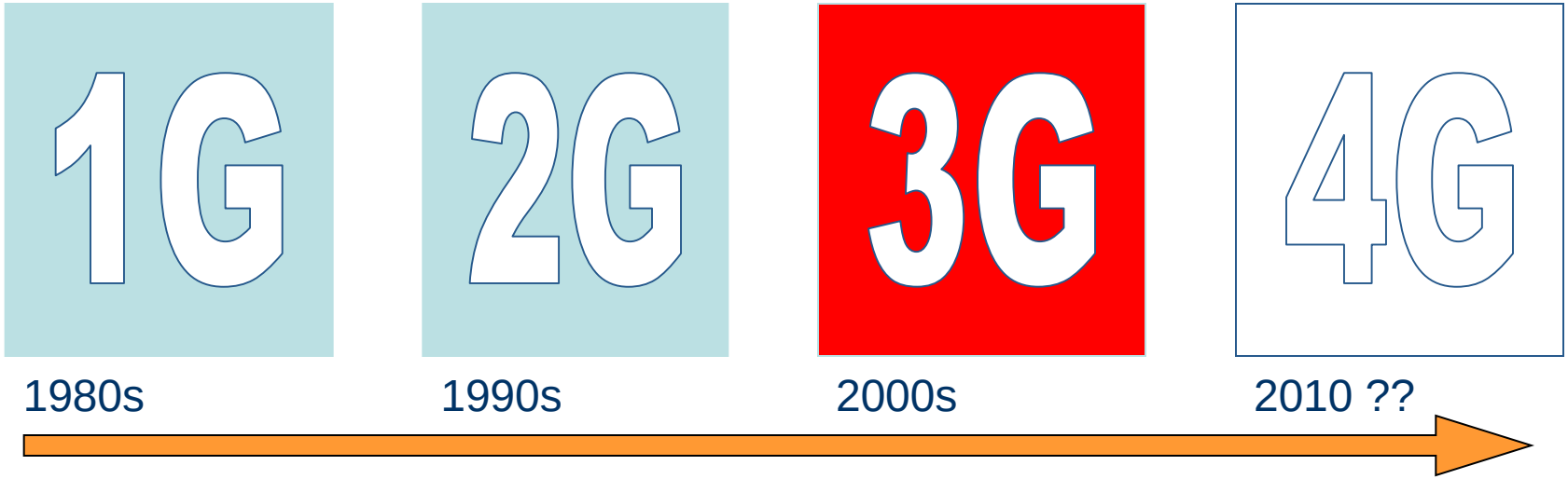
atesio

ZIB

Evolution of Mobile Telecommunications Systems

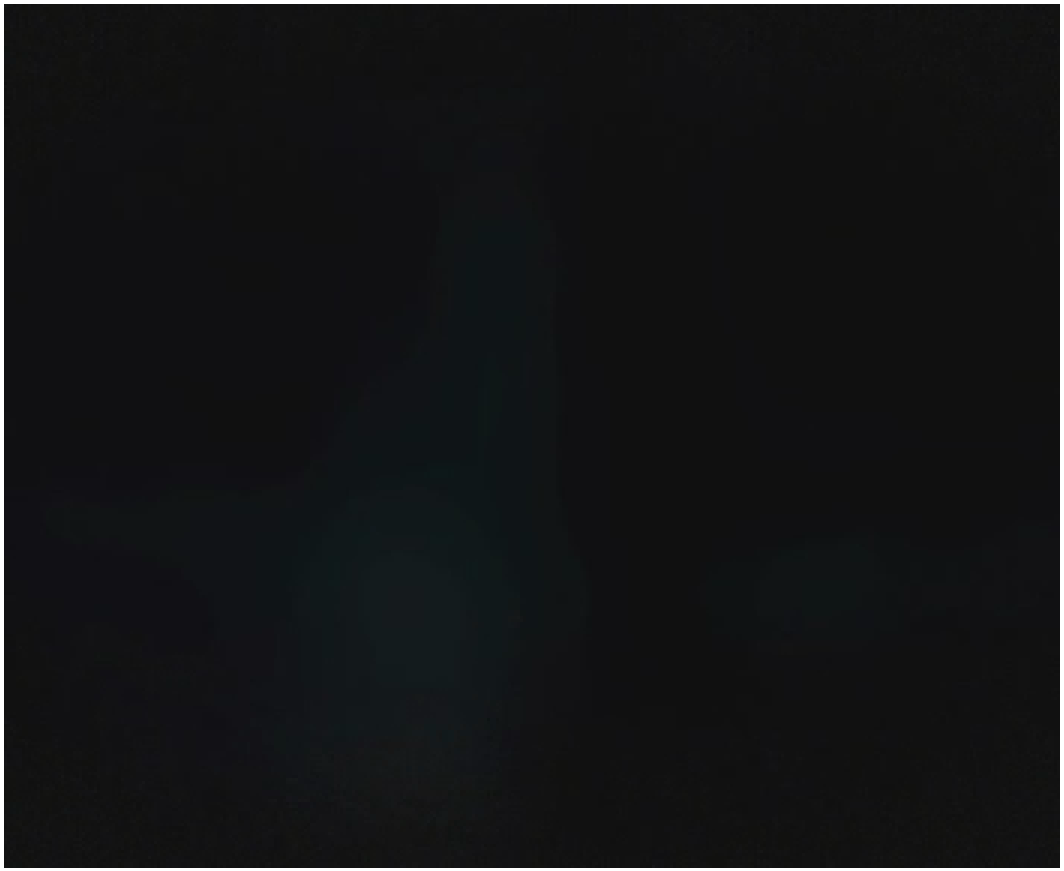


- Analogue
- Voice Only

- Digital
- Voice & Data
- **GSM** mass market
- PCS
- cdmaOne/IS95

- **UMTS**, **WiFi/WLAN**, cdma2000
- Data Rates ≥ 384 kbit/s
- Various Services

- **UMTS LTE**
- WiMAX
- Data Rates ~ 100 Mbit/s
- Mobile Internet
- LTE Advanced

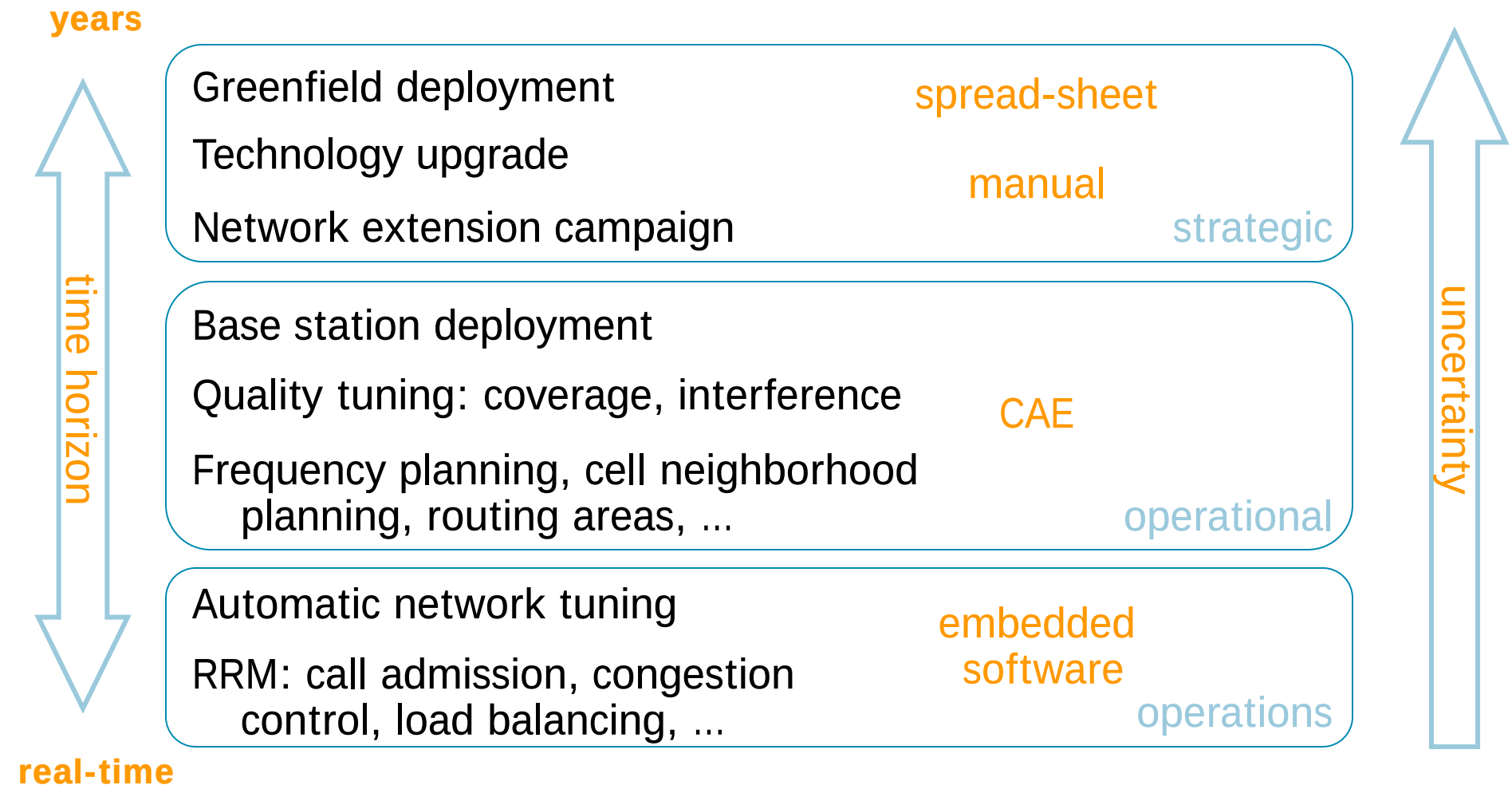


UMTS

Radio Network Optimization

- Radio Networks
- Challenges in Network Planning
- Applications
- Conclusions

Network Planning and Operations



Complex Technologies & Complex Infrastructure

Standards

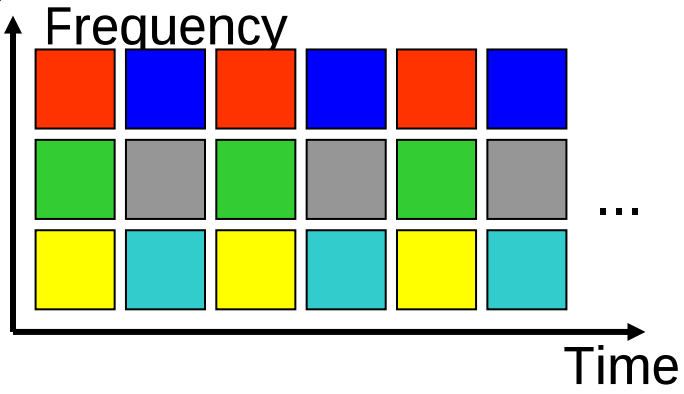
- GSM, GPRS, EDGE
- IS95, cdma-One
- UMTS, HSDPA, CDMA2000
- IEEE 802.11 (W-LAN, Wifi)
- IEEE 802.16 (WiMAX)
- DVB-T
- DAB
- ...

Booming Industry

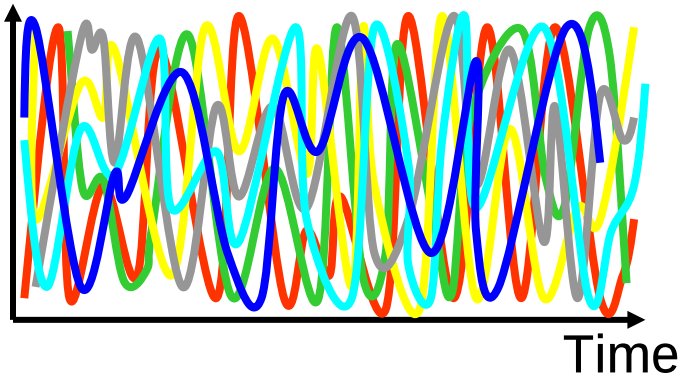
- Large Investments
- Large Revenues

Multiplexing

- TDMA
- FDMA



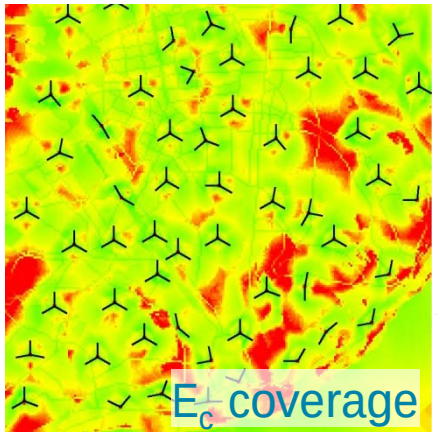
CDMA



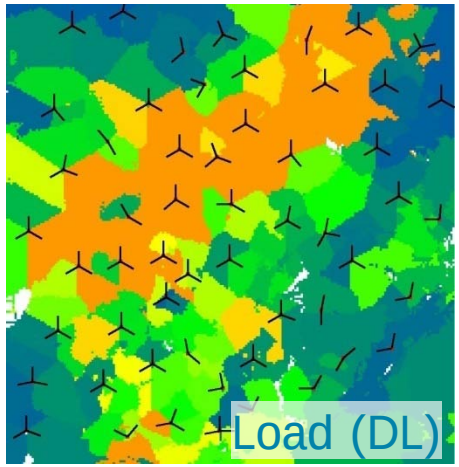
- SDMA (smart antennas)

UMTS network simulation

Coverage
- Quality of pilot signal
- Pilot E_c coverage
- Pilot E_c/I_0 coverage



Load
- How many users served?
- How much capacity left?



→ “Simple” Optimization Models

- Radio Networks
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- Applications
- Conclusions

Challenges in Radio Network Design

coverage

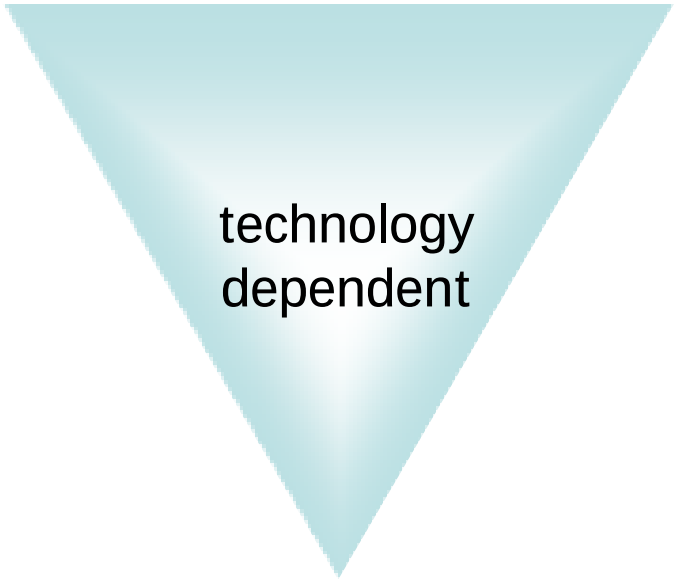
invariant
- GSM

variable
- WLAN
- UMTS

capacity

invariant
- GSM

variable
- GPRS, EDGE
- WLAN
- UMTS

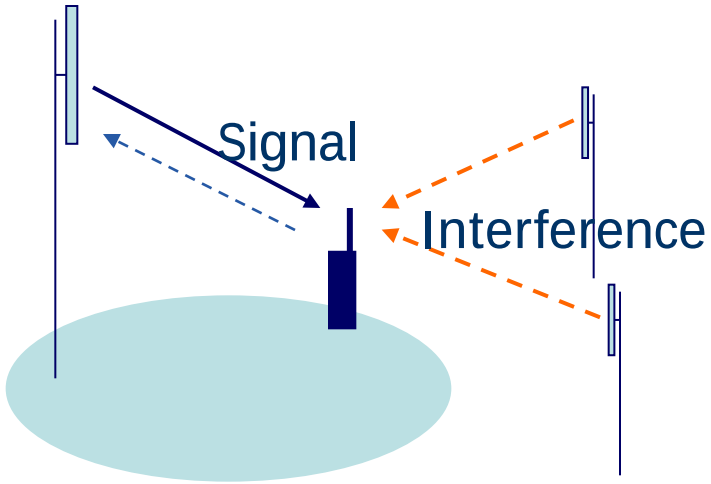


interference

invariant
- GSM on BCCH

variable
- when TX depends on load
- when TX depends on quality

→ may inhibit service and/or reduce capacity



Signal-to-Interference Ratio

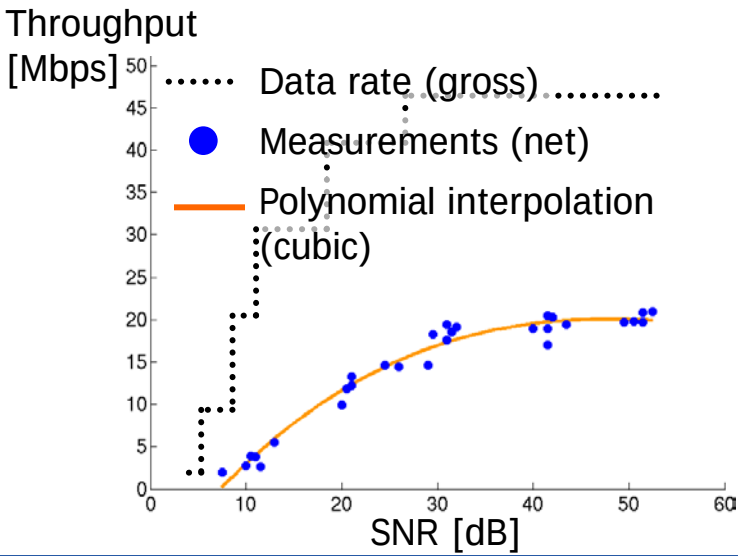
$$\frac{\text{Signal}}{\text{Noise} + \sum \text{Interference}} \geq \text{Threshold}$$

Minimum SIR needed for good transmissions

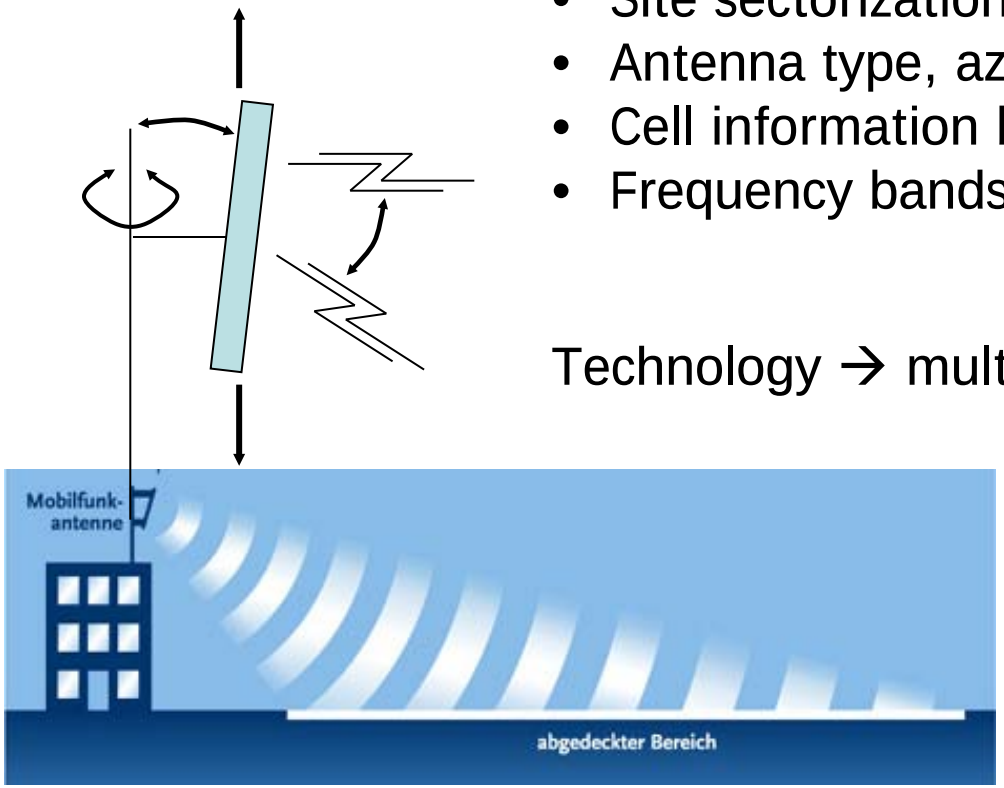
Increase signal strength

Rate adaptation

→ Reduce or eliminate interference



Common Design Parameters

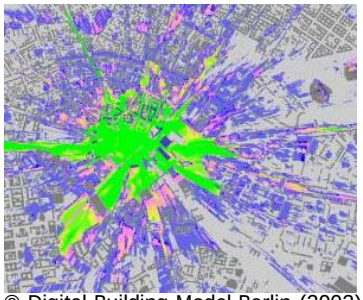


- Location of base stations / access points (including antenna height)
- Site sectorization
- Antenna type, azimuth, mechanical & electrical tilt
- Cell information broadcast power
- Frequency bands

Technology → multi-RAT networks

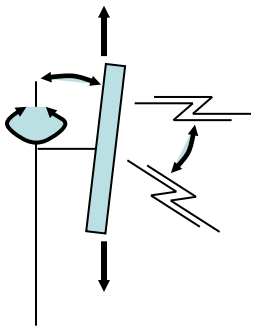
Isotropic Prediction

- Available for each potential antenna location



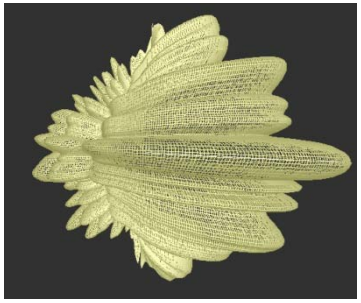
Antenna Configuration

- Azimuth
- Tilt
- Height

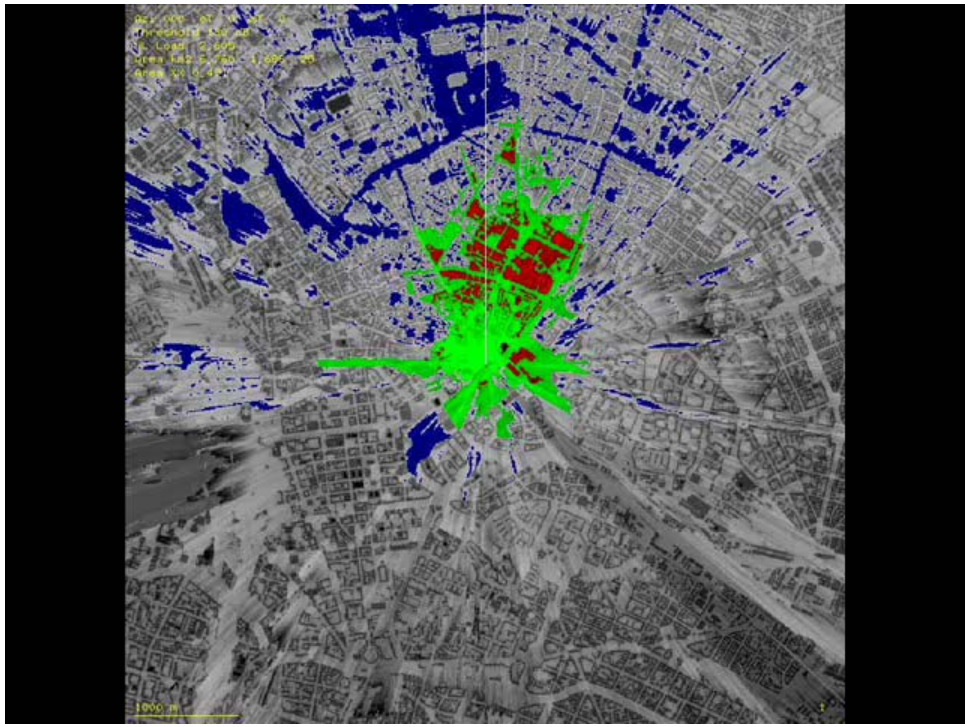


Antenna Diagram

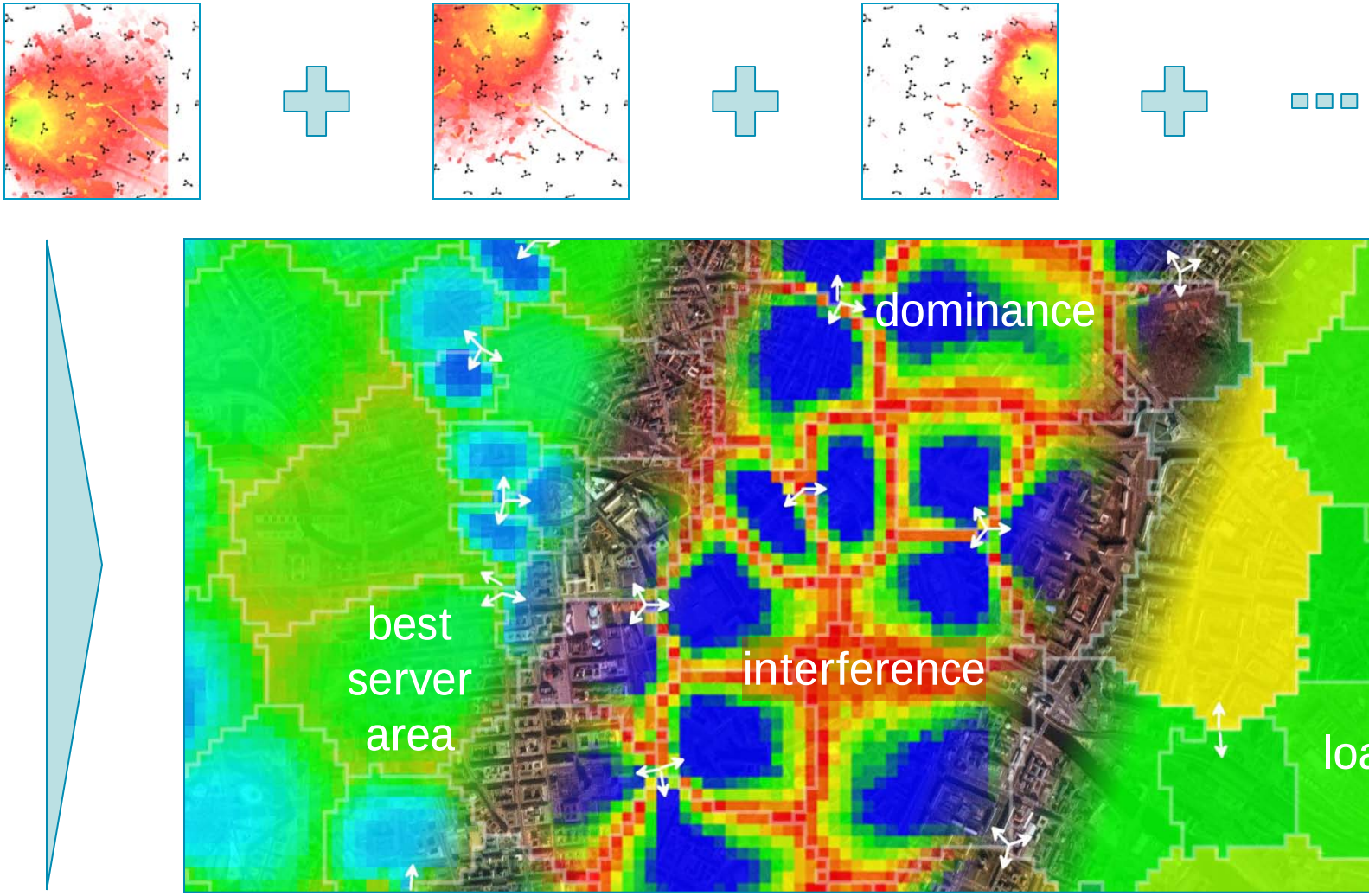
- Signal propagation in different directions



Antenna Prediction



height: 41m, electrical tilt: 0-8°, azimuth 0-120°


dominance
best
server
area
interference
load

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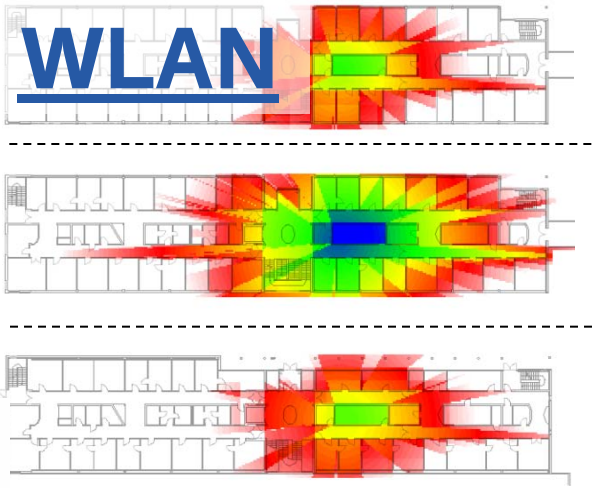
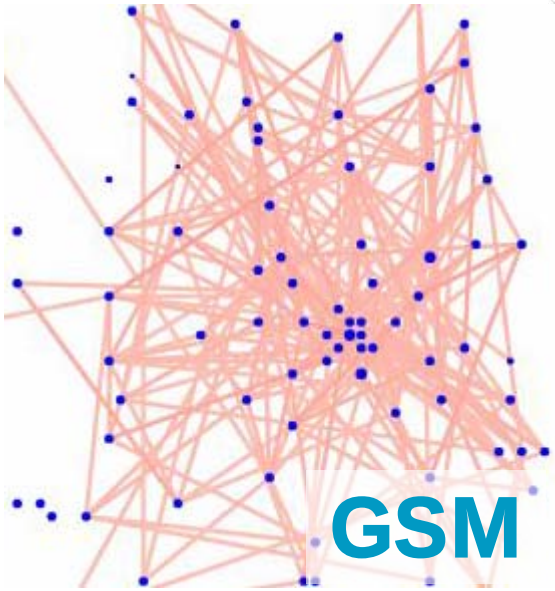
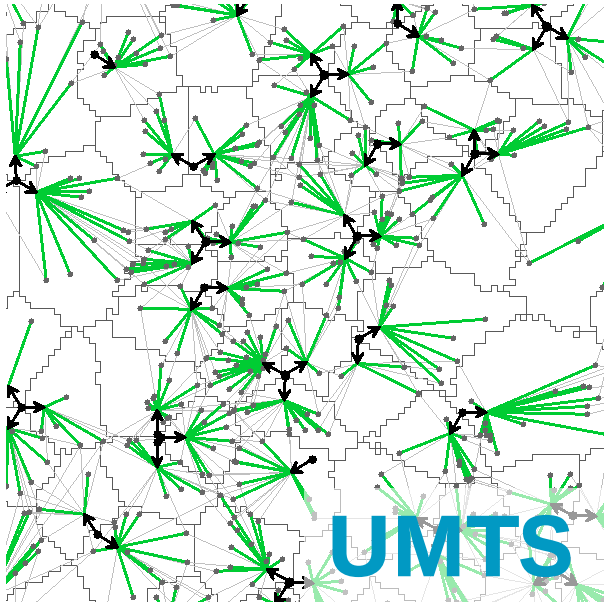
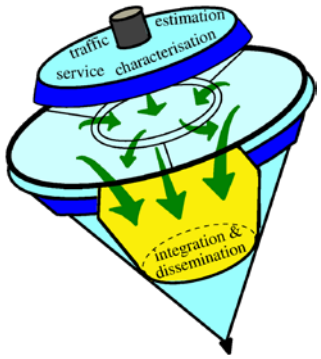
Network Optimization for Different Technologies







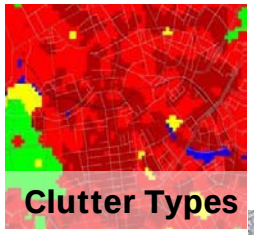
MOMENTUM & MORANS Provide UMTS Data

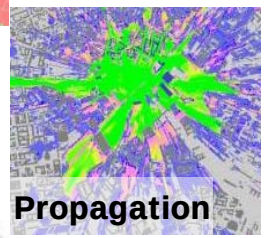


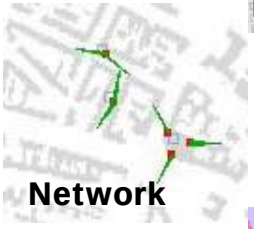
Momentum

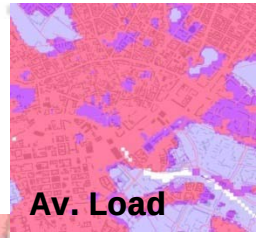
Contains references to all data that constitute the scenario in one file.

- **EnvironmentData**
  Reference to Environment file. The scenario's name is fixed here.
- **EquipmentData**
  Contains references to all equipment and bearer fact sheets.
- **NetworkData**
  Contains references to xml files containing configured networks and RRM settings.
- **TrafficData** (1..∞)
  Contains references to all traffic/demand data, that is, BHCA and average load. Several nodes are possible for different traffic forecasts.
- **ServicesData**
  Contains references to source model and service specifications.









Scope

- Path loss predictions
- Traffic modelling
- Mobility modelling
- Network analysis
- Network optimization

http://momentum.zib.de/data

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Conclusions

Collaboration with Engineers

- indispensable for system modeling and optimization goal

Systems Models & Realistic Data

- very complex
- models often implicit, solution quality from simulations
- models often used as basis (oracle) within local search methods

Mathematical Optimization

- set covering (with bounded overlap)
- k-partition of graph
  (with or without ordered partitions)

Significant Impact

Mostly Unresolved

- robust optimization
- migration planning / multi-stage planning