



# Dynamic System Level Simulations in faster than realtime

**Presentation at ITG Workshop, UMIC Aachen, 14 July 2011**

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# The Why and How

- We want to observe what ‘the system’ does.
- Therefore we build a mathematical model.
- We write a program in accordance with that and equip it with reasonable parameters (or just sweep) and observe ‘the system’.
- For a nearer definition of ‘the system’:
  - A set of basestations
  - A (larger) set of UEs
  - An radio interface between them
- Dynamic: We expect changes over time OR expect interactions within ‘the system’.
- Changes over time: service/traffic, user position, basestation parameters etc.

# Remember: We need a model

- In Radio Simulations there are two classical paths:
  1. Drop the interaction and work with constant signals.
  2. Model in detail.
- For the 2nd approach, the question: Which level of detail?

# So let's say, you want to look at a LTE DL system

- The level of detail (for our model) is (seems) to be defined by the details of the system.
- As LTE DL is an OFDMA system, we need to look at OFDM symbols ?
- ... or resource blocks i.e. symbols by set of subcarriers?
- ... or transport blocks i.e. a set of resource blocks scheduled together?
  
- The answer lies somewhere in the middle, but what we need to cover is
- RRM (radio resource management) aka scheduling (+link adaptation)

# And the interaction?

- To make a long story short: It's Interference (the I in SINR)
- Interference usually (at least in this LTE DL sense) is an uncoordinated, unpredictable, non-controllable term in the SINR calculation
- AND: it's a sum
- Nice thing: It depends on the load in other cells and only on that.
- First Idea:  
Formulate user specific SINR as function of Signal, other cells Signal and load

# Back to RRM

- Scheduling and Link Adaptation is the modern tooling to approach the boundary of channel capacity: Shannon bound
- So turn it around: Can we use a channel capacity to derive the load?
- -> in every time step, from the user SINR and a certain expected throughput (think packet-size) we can calculate the needed resources
- Simplification: fix the expected throughput (CBR, GBR service), assume QoS scheduling
- Second idea:  
In every time step calculate a cell load based on user SINR and a look at capacity

## ... so closing the loop

- SINR = function(load)
- Load = function(SINR) ?
- We use an estimate of the load by looking at the previous time step.

## What's this time step all about?

- Our (main) idea is to keep the (simulation) time step short enough to be able to look at all dynamic effects, but (way) longer than the real RRM granularity.
- Also to make a long story short: 1s to 50ms

# Program performance, simple MATLAB implementation

**Simulation setup:**  
**600s ( = 600 steps)**  
**800 users (~15u / cell)**  
**57 cells**

MATLAB profiler

<u>Function Name</u>	<u>Calls</u>	<u>Total Time</u>	<u>Self Time*</u>
<u>cart2sph</u>	600	10.841 s	10.841 s
<u>pathloss and beampatterns2</u>	600	23.786 s	8.761 s
<u>distance subroutine</u>	600	8.674 s	8.487 s
<u>channel and sinr log</u>	600	35.320 s	6.801 s
<u>son</u>	1	56.417 s	4.947 s
<u>inpolygon&gt;vec inpolygon</u>	1202	4.120 s	4.120 s
<u>log10</u>	1803	3.888 s	3.888 s
<u>logSum</u>	600	3.092 s	3.013 s

Angle in hor/ver

Guess what...

Wrap-around in channel

SINR calc.

main

Wrap-around in mobility

Interference calc.

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# The steps for simplifications

- Abstract the RRM by a channel capacity (average)
- Calculate the user SINR by estimated cell loads
- Calculate the cell load by user SINR, a scheduling assumption and user traffic.
- Does it work?
- OK, so when does it not work?

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# Contacts and references

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Paper:

ICC09

„A mathematical perspective of self-optimizing wireless networks“  
Viering, Döttling, Lobinger

EURASIP Journal on Wireless Communications and Networking (online)

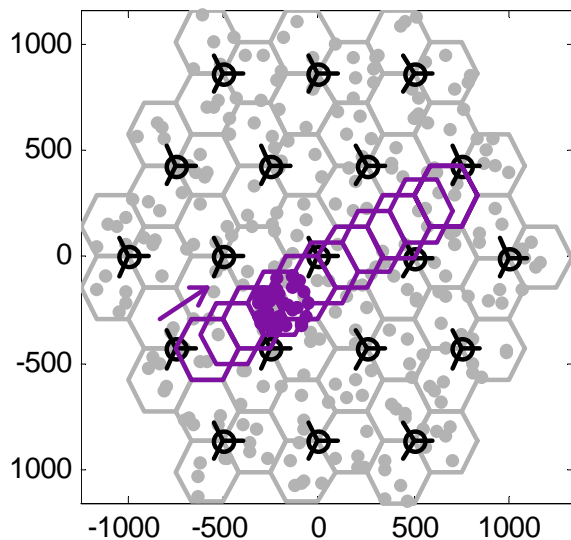
“Efficient Uplink Modeling for Dynamic System-Level Simulations of Cellular and Mobile Networks” Viering, Lobinger, Stefanski

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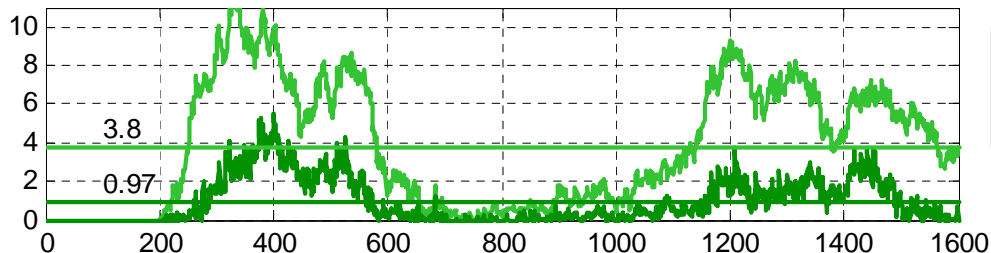
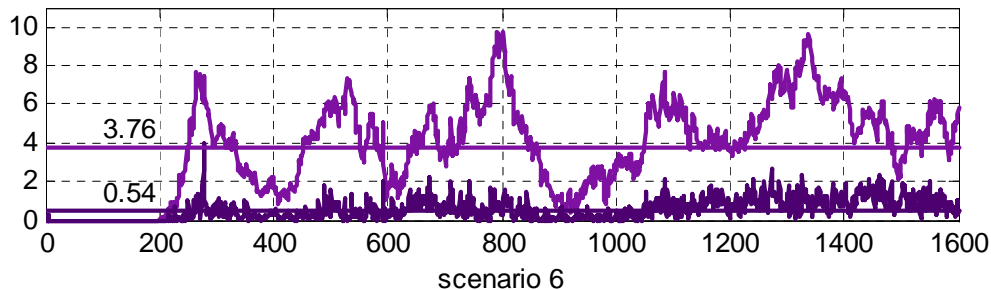
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# Usecase : SON -> load balancing with moving load

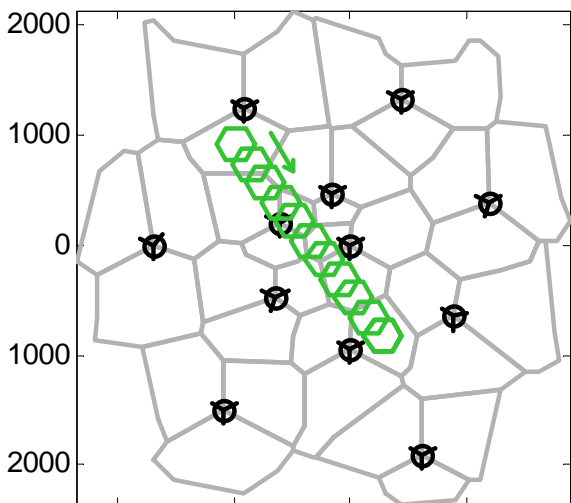
scenario 1, network picture



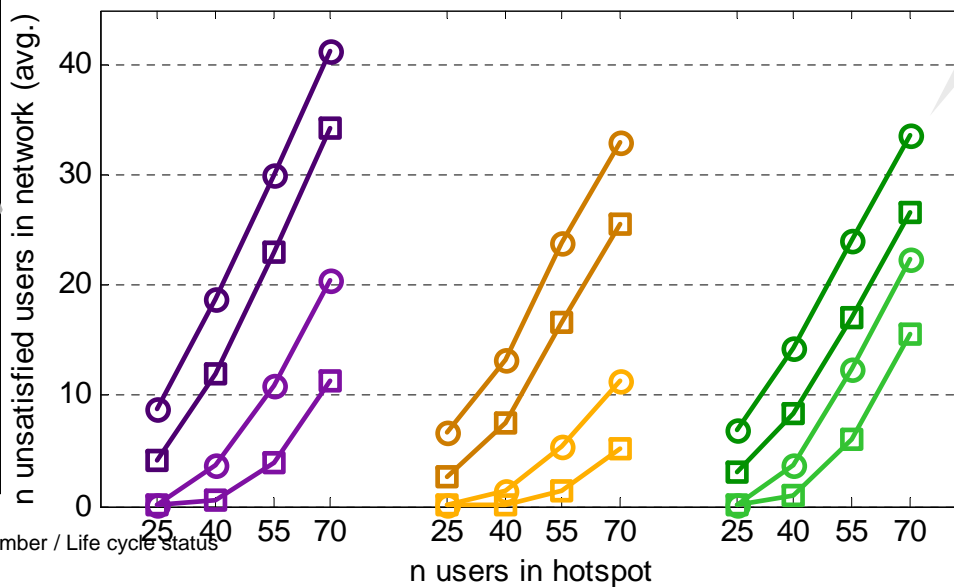
scenario 1, load over time, 40 users in hotspot, 5 users equal load



scenario 6, network picture



scenario 1 | 2 | 6 overall comparison



10 experiments per point

3 x 16 = 48 settings

48 x 10 x 1600s  
-> **210h**  
**realtime**



# Another Simulator example

**SEASON System Experience of Advanced SON**

Simulation Windows Options Help

**Simulation**

Adjustable simulation speed (factor of realtime)

**Energy & Traffic Management**

Handover Mode

- Full Knowledge Handover
- (A3 Event Trigger)-based Handover
- (Trigger + Hysteresis)-based Handover

Energy Consumption

Macro Cells => A = 100,00 W B = 2,00

Micro Cells => A = 20,00 W B = 0,00

Traffic Steering

Traffic Policy: NORMAL

Energy Control

- Activate Energy Saving (Cell Load Mode)
- Macro Cell Load above: 0,95
- Micro Cell load below: 0,05

**UE Reporting Configuration**

Intra-RAT Trigger Events

- A3
- Neighbour RSRP is 2,5 dB better than serving cell.
- Time To Trigger: 1,0 seconds
- Trigger Periodicity: Infinity seconds
- A4
- Neighbour RSRQ above: -10,0 dB
- Time To Trigger: 1,0 seconds
- Trigger Periodicity: Infinity seconds

**Network Configuration**

Visuals Network: 1

- Switch Entire Network OFF
- Antenna Tx Power is: 25 dBm
- Network Technology: HSPA
- Network Frequency: 2,1 GHz
- Bandwidth: 10 MHz
- Downlink Scheduler: CBR
- Maximum PRBs per UE: No Limit
- Orthogonality Factor: 0,60
- Noise Figure @ UE: 7,00 dB
- Handover Hysteresis: 3,0 dB
- RFL Threshold (SINR): -8,0 dB
- RFL Threshold (RSRP): -106,0 dBm

5.29 1.96 0.21 0.39 0.65 2.21 4.20 6.98 5.73 3.43

Pico Cell switched off (energy savings)

Pico Cell

Cell-specific information, e.g. cell throughput

Network Statistics, e.g. total energy consumption

**Aggregate KPI Plots**

Plot KPI: Energy Consumption

Energy Consumption (W)

Time/seconds

— KPI data (odd runs) — KPI data (even runs)

Camera mode