Handover parameter optimization in LTE self-organizing networks

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Outline

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3. Simulation metrics
4. Controllability and Observability studies
5. Performance of the non-optimised network
6. Handover optimisation SON algorithm
7. Simulation results
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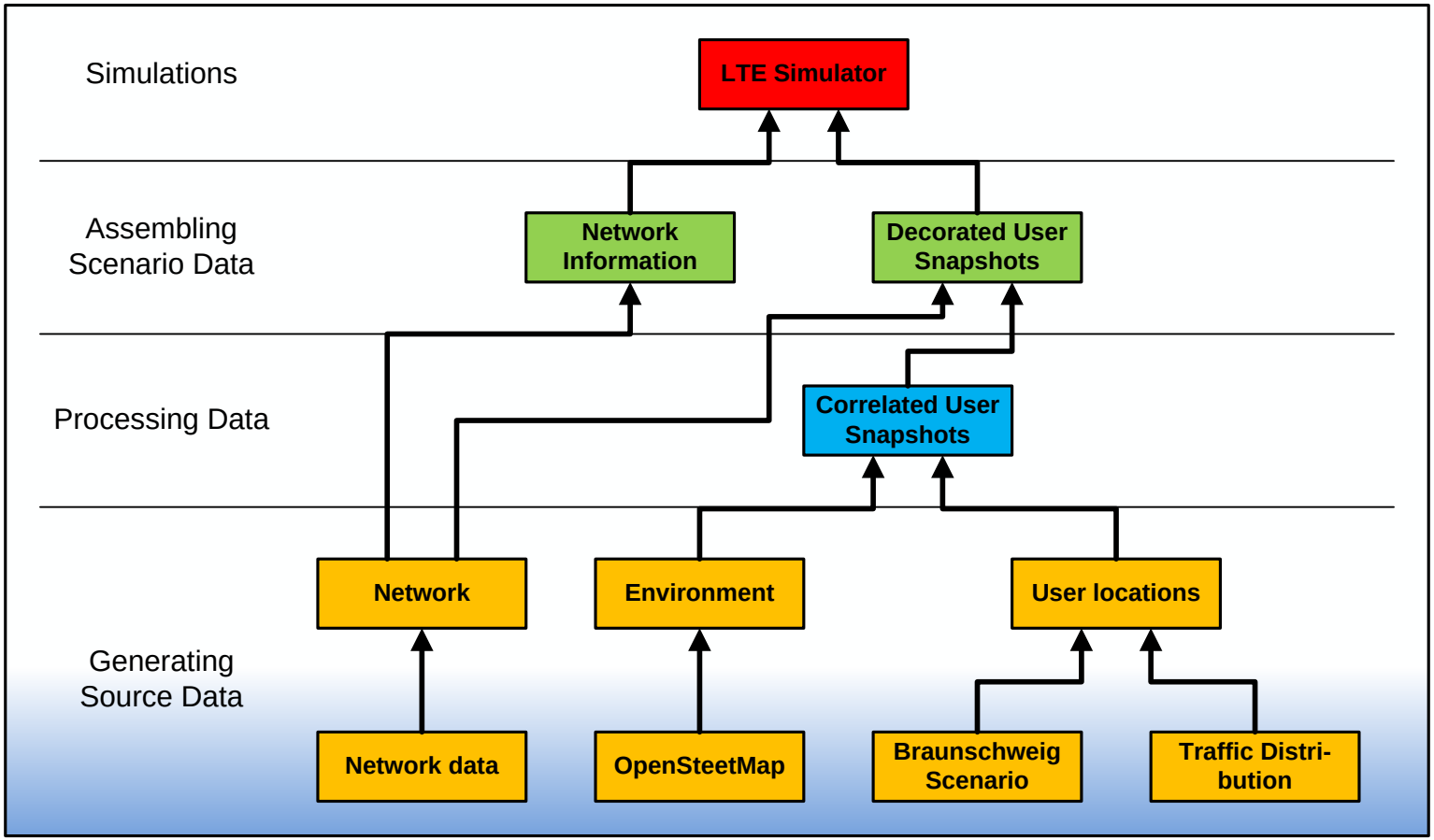
Introduction

- Problem
  - Handover parameter optimisation is done manually
    - high OPEX
    - long optimisation intervals based on error reports
  - Non-optimal handover performance
    - handover failures
    - ping-pong handovers
    - call dropping
- Handover parameter optimisation objective
  - automate the optimisation
  - adapt the handover parameters on a short-term scale
  - optimise the handover performance
- Approach
  - analyse the system behaviour
  - develop handover optimisation algorithm

Realistic SOCRATES Scenario

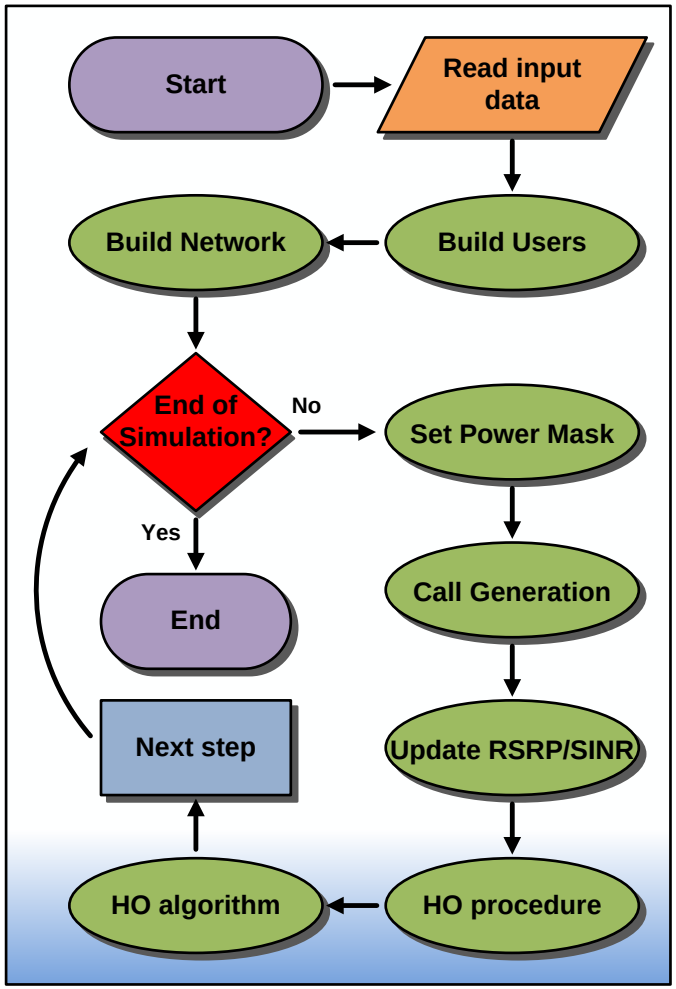


Realistic SOCRATES Scenario

- Computing the landuse information from openstreetmap.org
  - Landuse classes: Road, Building, Water, Street and Railway

MATLAB LTE system-level simulator

- Input data
  - Realistic SOCRATES scenario
- Power mask
  - Soft frequency reuse
- Call generation
  - All users connected
- Update RSRP/SINR
  - Shadow fading maps
- Handover procedure/algorithm



Simulation metrics

- Control parameters
  - Hysteresis
  - Time-to-Trigger
- Assessment metrics
  - Handover failure ratio
  - Ping-Pong handover ratio
  - Call dropping ratio

Control parameter	Values
Hysteresis	(0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 9.5, 10) in [dB]
Time-to-Trigger	(0 0.04 0.064 0.08 0.1 0.128 0.16 0.256 0.32 0.48 0.512 0.64 1.024 1.280 2.56 5.12) in [s]

$$HPI_{HOF} = \frac{N_{HO\_fail}}{N_{HO\_fail} + N_{HO\_succ}}$$

$$HPI_{HPP} = \frac{N_{HO\_pp}}{N_{HO\_pp} + N_{HO\_npp} + N_{HO\_fail}}$$

$$HPI_{DC} = \frac{N_{HO\_dropped}}{N_{HO\_accepted}}$$

Simulation metrics

- System metrics
  - RSRP (Reference Signal Received Power)
    - cell transmit power P_c
    - pathloss L_{ue} to the UE
    - shadow fading L_{fad} with a standard deviation of 3dB

$$RSRP_{c,ue} = P_c - L_{ue} + L_{fad}$$

  - SINR (Signal to Interference Noise Ratio)
    - interfering cells N

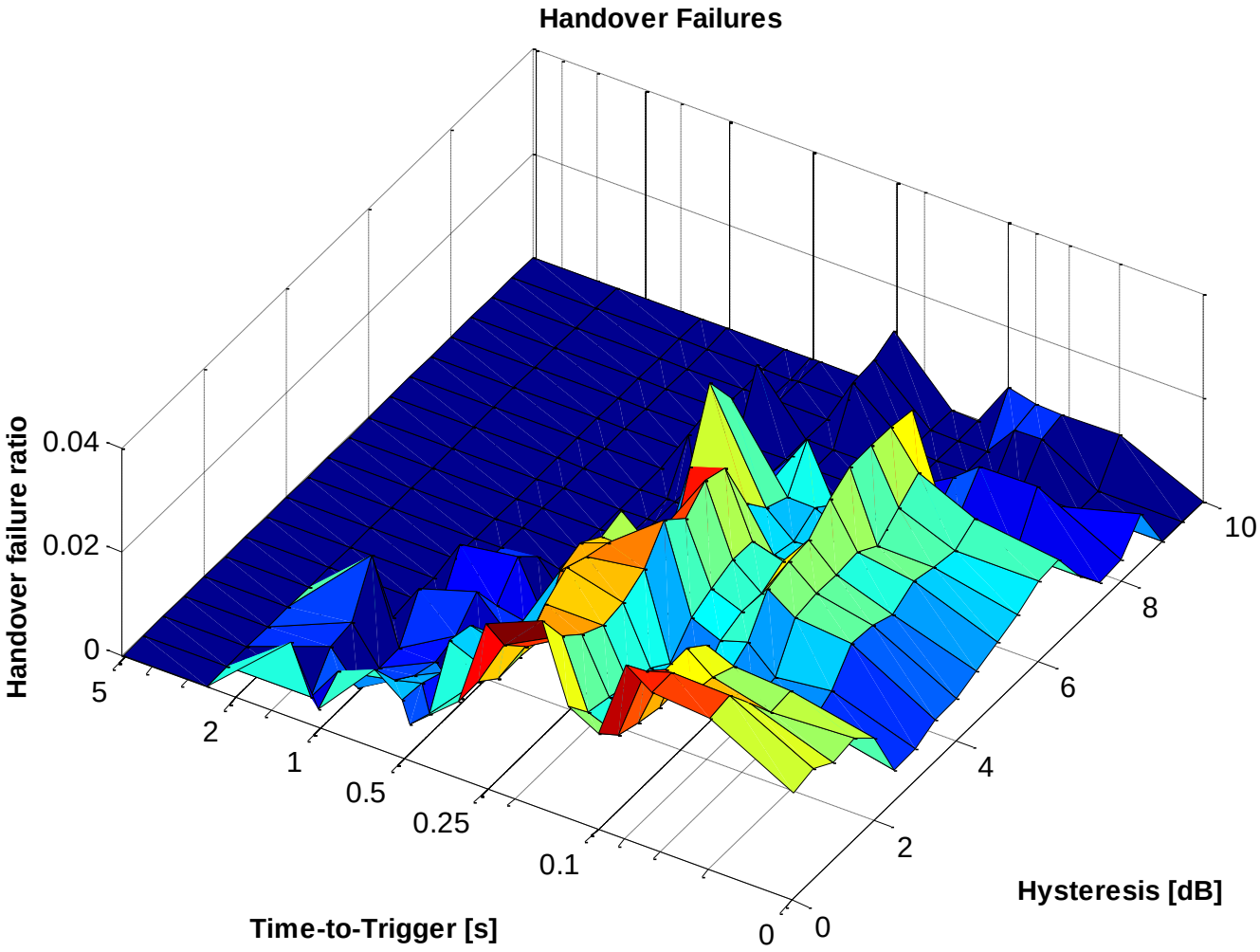
$$SINR_{c,ue} = RSRP_{c,ue} - 10 \cdot \log_{10}\left(\sum_{n=1}^{N} 10^{\frac{RSRP_n,ue}{10}} \right)$$

Controllability and Observability studies

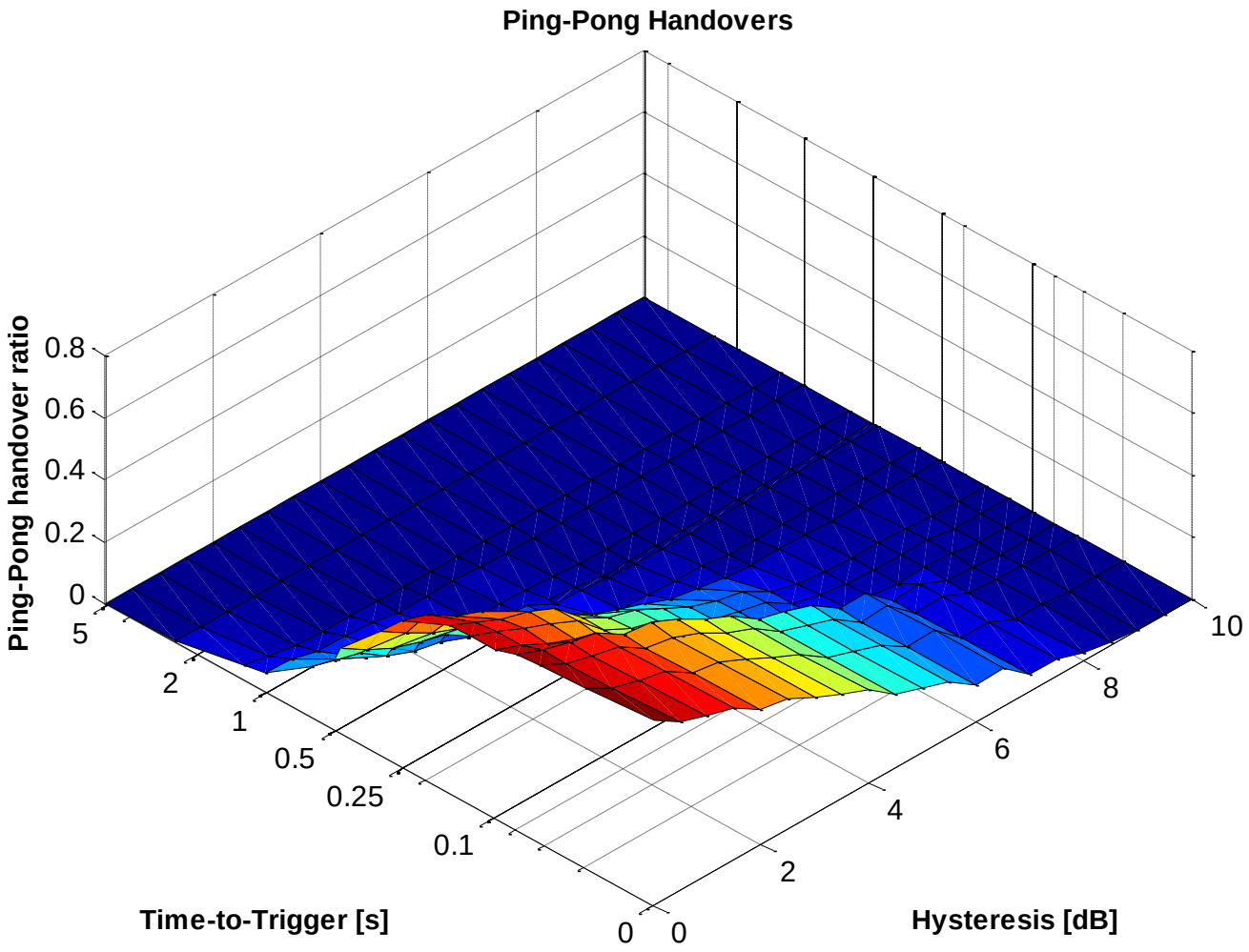
- Objective
  - Analyse the system behaviour and sensitivity
  - Find handover algorithm approach
- Simulation assumptions
  - All resources are used in all cells (maximum interference)
- Simulation approach
  - Perform system simulations for all hysteresis and time-to-trigger value combination (handover operating point)

Simulation parameter	Value
Simulation time	200 [s]
Simulation step time	0.01 [s]
Simulation area (mobile users)	1.5 km * 1.5 km
Number of users	30
eNodeB transmit power	46 [dBm]
Number of considered cells in the scenario	76
Measured cells (N)	21
Considered interfering cells for SINR calculations	20
Critical ping-pong handover time (T_crit)	5 [s]
Handover execution time	0.25 [s]
SINR averaging window	0.1 [s]
Min. SINR threshold	- 6.5 [dB]

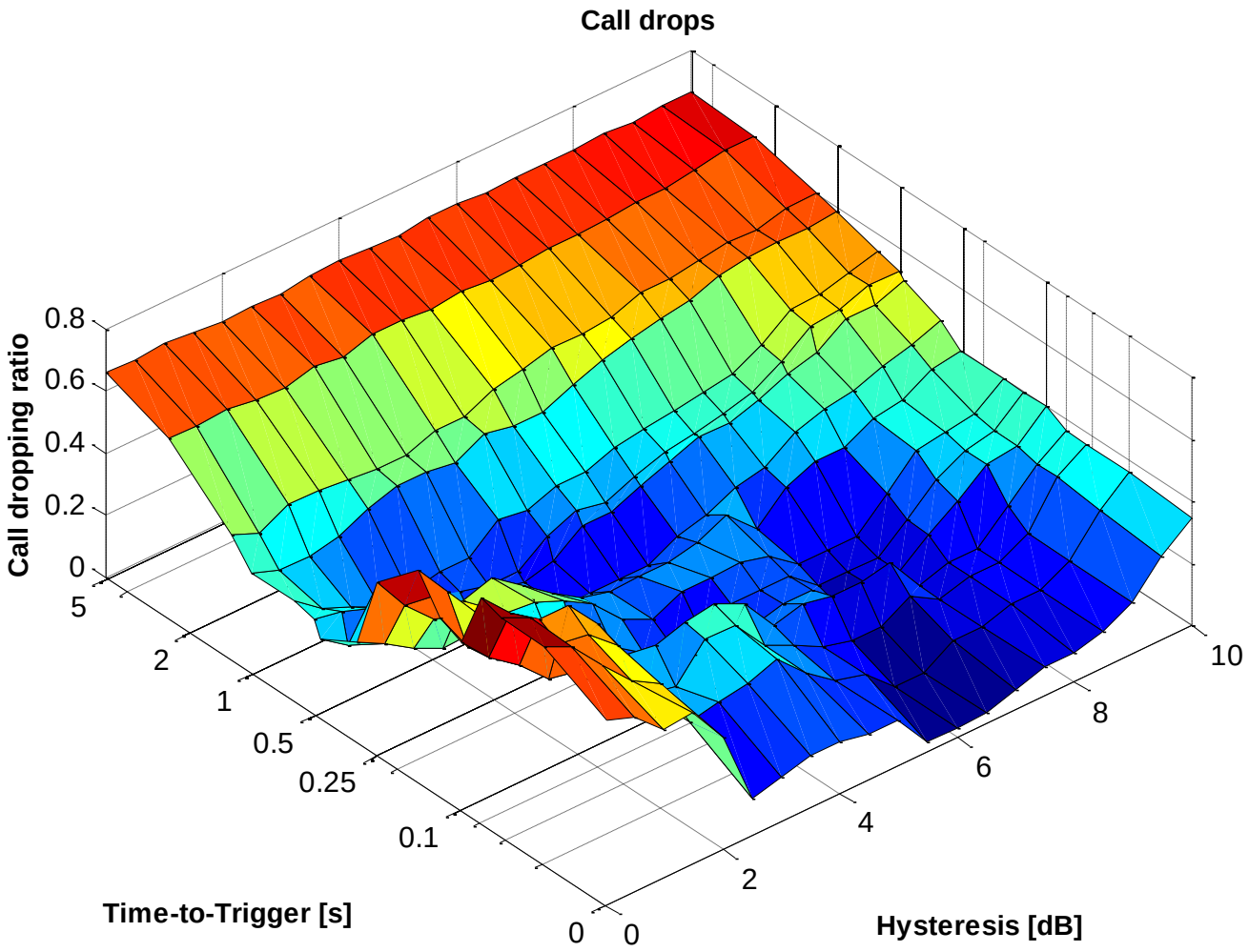
C & O: Handover failures



C & O: Ping-Pong handovers



C & O: Call dropping



Handover performance weighting function

- $HP = w_1 HPI_{HOF} + w_2 HPI_{HPP} + w_3 HPI_{DC}$

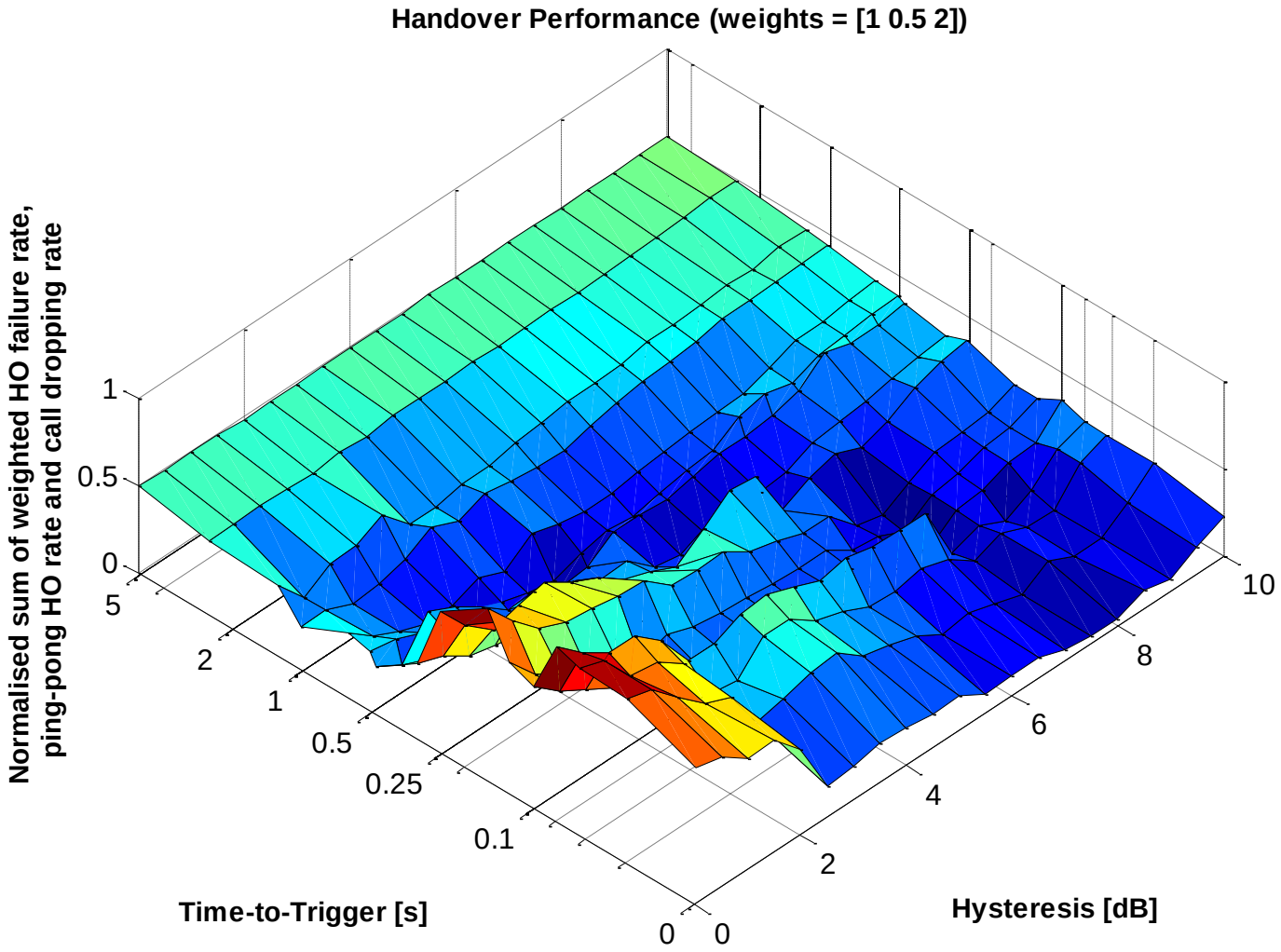
  - w_x is the weight of the individual HPI
  - HPI_{HOF} is the handover failure performance indicator
  - HPI_{HPP} is the ping-pong handover performance indicator
  - HPI_{DC} is the dropped calls performance indicator

Weighting parameter	Value
w_1	0.5, 0.6, …, 2.0
w_2	0.5, 0.6, …, 2.0
w_3	0.5, 0.6, …, 2.0

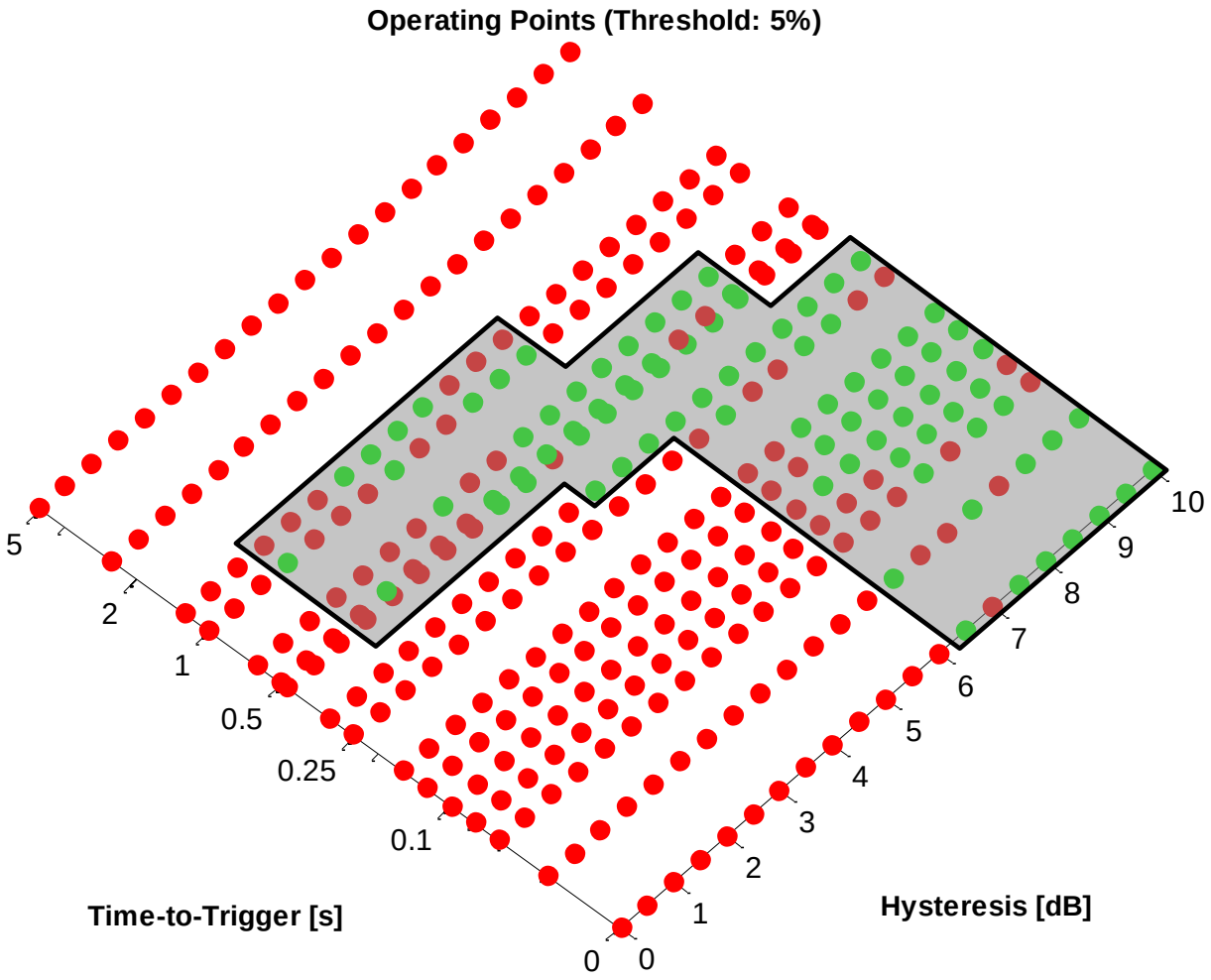
- 4096 valid weighting parameter combinations have been considered

- If (HP<0.05) => “meaningful” handover parameter operating point

Handover performance



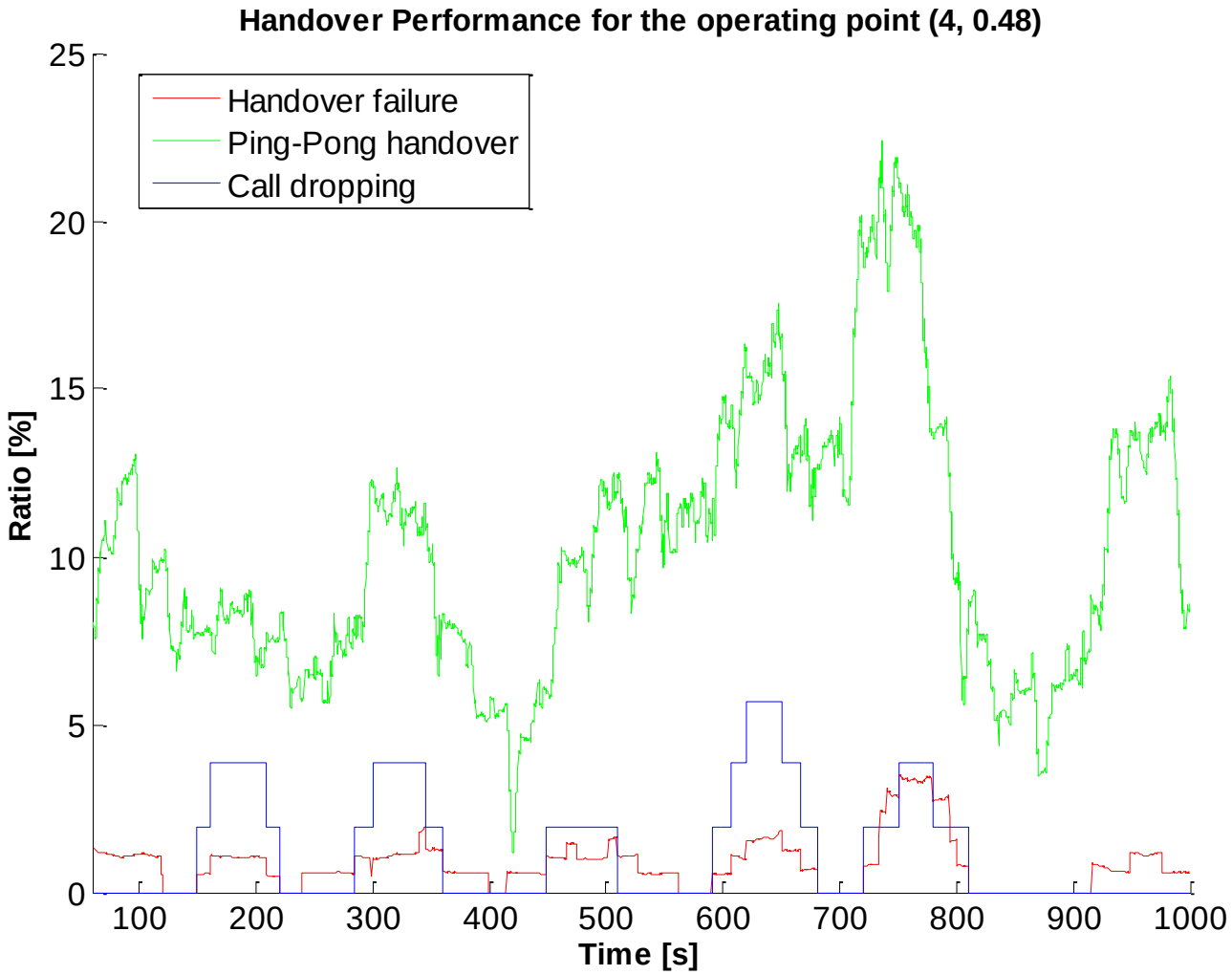
“meaningful” handover operating points



Simulation parameters for the performance analysis

Simulation parameter	Value
Simulation time	1000 [s]
Simulation step time	0.01 [s]
Simulation area (mobile users)	1.5 km * 1.5 km
Number of users	50
eNodeB transmit power	46 [dBm]
Operating points (Hysteresis, Time-to-Trigger)	(4, 0.48), (6, 0.32), (8, 0.1), (9, 0.08) in [dB, s]
Number of considered cells in the scenario	78
Measured cells (N)	21
Considered interfering cells for SINR calculations	20
Handover performance averaging window	60 [s]
Critical ping-pong handover time (T_crit)	5 [s]
Handover execution time	0.25 [s]
SINR averaging window	0.1 [s]
Min. SINR threshold	- 6.5 [dB]

Performance of the non-optimised network



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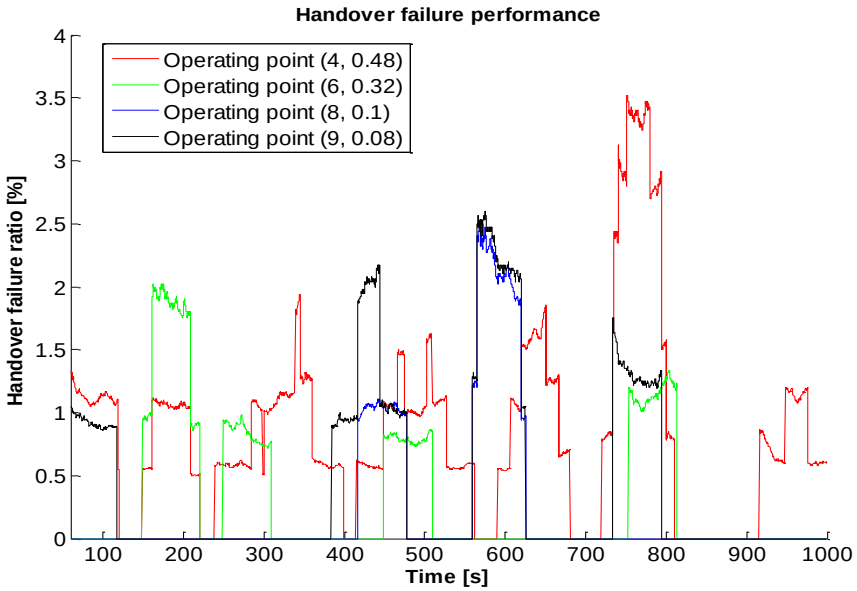
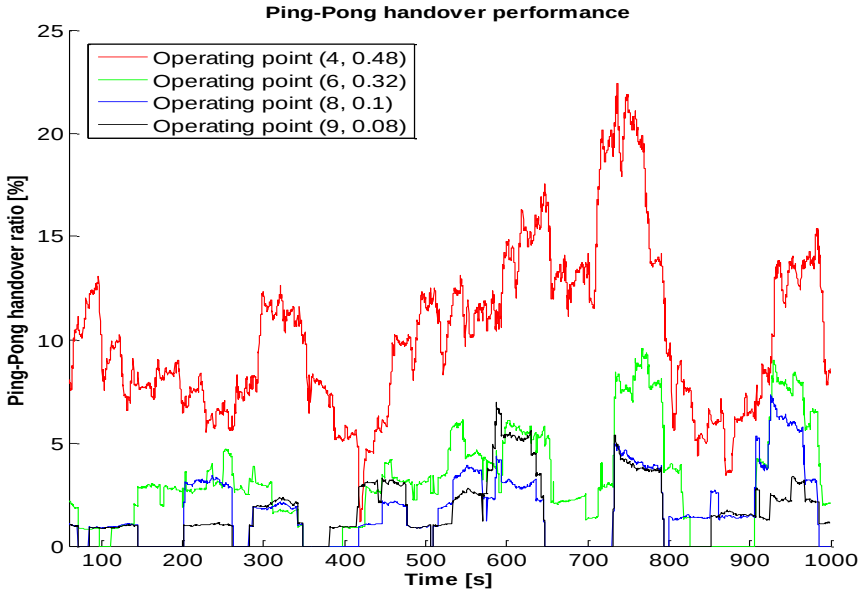
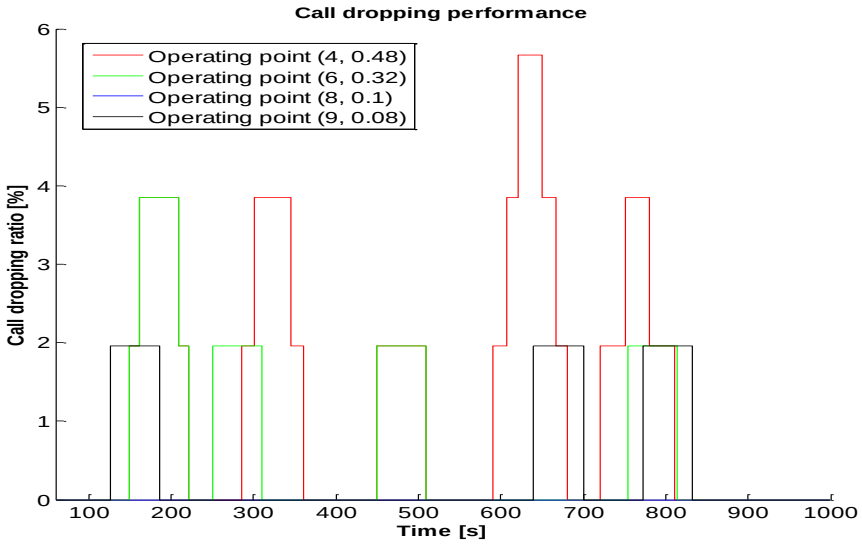
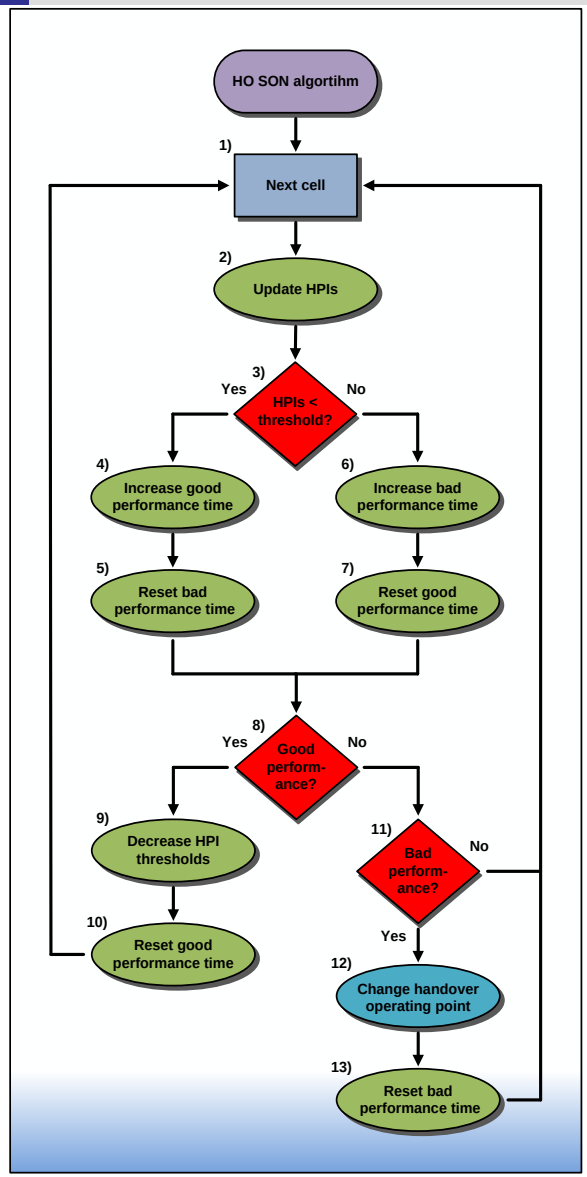






- Comparison of the network performance for four different operating points
  - (4 dB Hys, 0.48 s TTT)
  - (6 dB Hys, 0.32 s TTT)
  - (8 dB Hys, 0.1 s TTT)
  - (9 dB Hys, 0.08 s TTT)

Handover optimisation SON algorithm

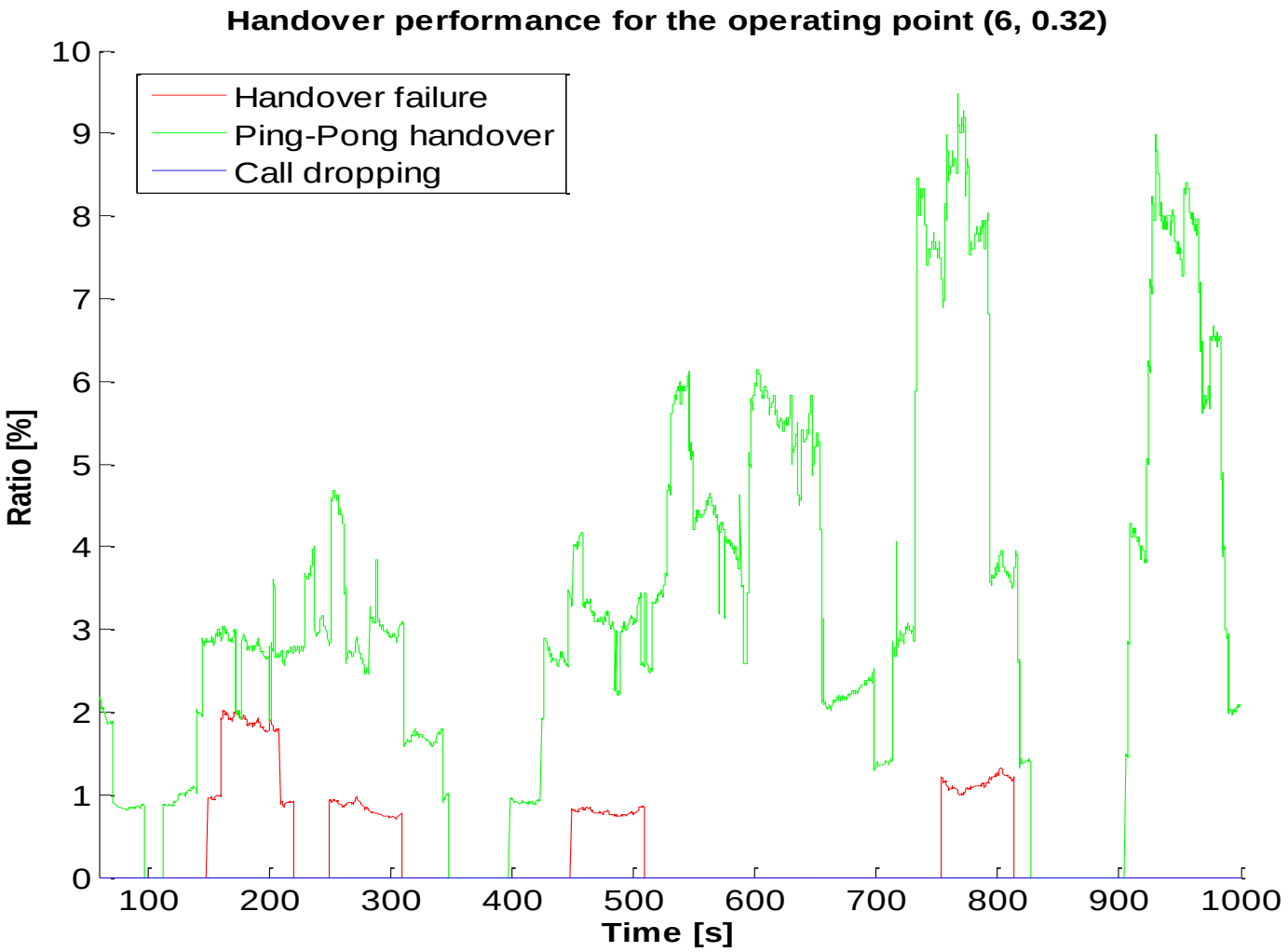


Optimisation criteria for HPIs

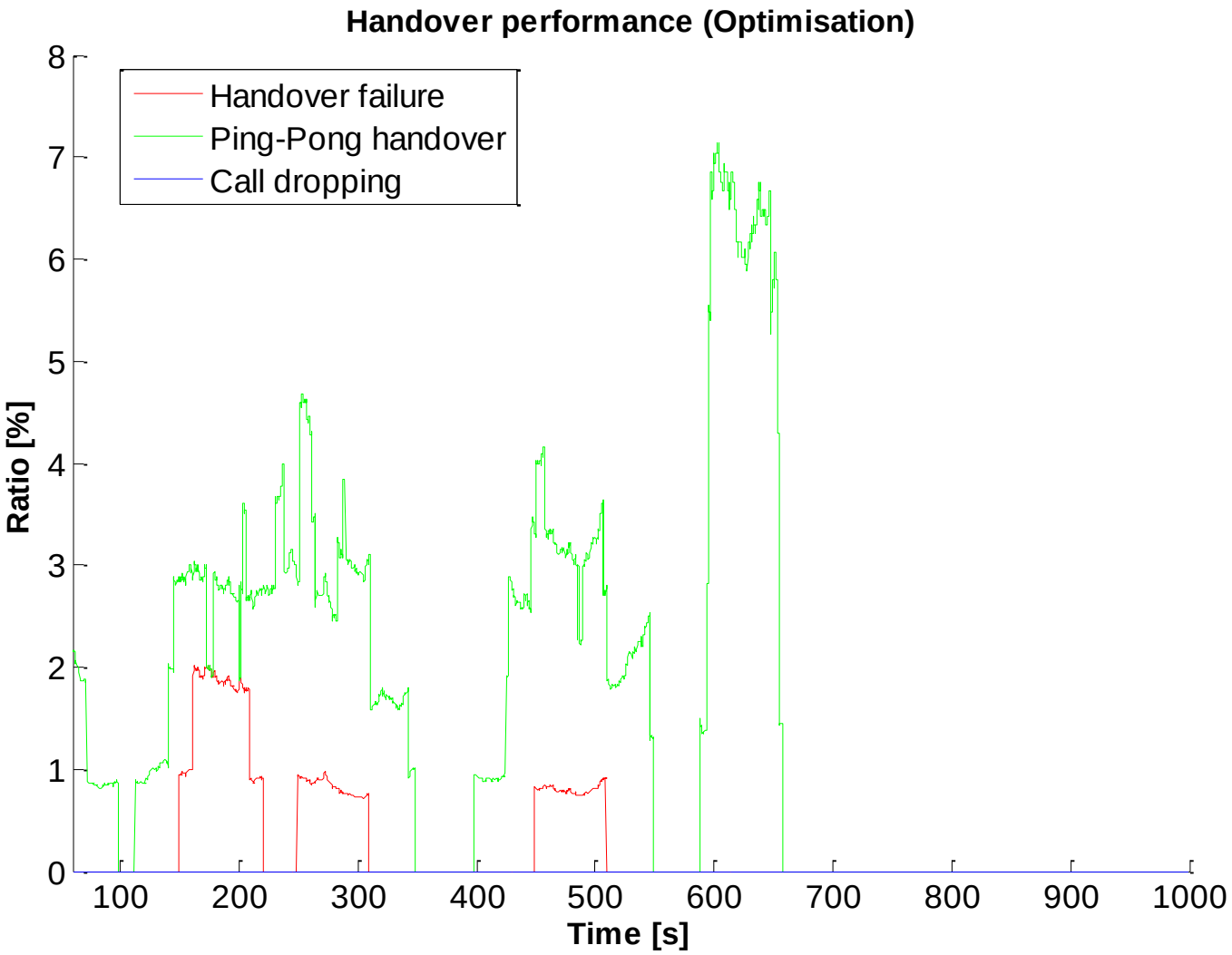
Handover Performance Indicator	Hysteresis	Time-to-Trigger	Optimisation
Handover failure ratio	< 5 dB		↑ TTT
	5 dB – 7 dB		↑ TTT & ↑ HYS
	> 7 dB		↑ HYS
Ping-Pong handover ratio	< 2.5 dB		↑ TTT
	2.5 dB – 5.5 dB		↑ TTT & ↑ HYS
	> 5.5 dB		↑ HYS
Call dropping ratio	> 6 dB	> 0.6 s	↓ TTT & ↓ HYS
	<= 6 dB	> 0.6 s	↓ TTT
	> 7.5 dB	<= 0.6 s	↓ TTT & ↓ HYS
	3.5 dB – 6.5 dB	<= 0.6 s	↑ HYS
	< 3.5 dB	<= 0.6 s	↑ TTT & ↑ HYS

- Optimisation actions are added up
- Hys and TTT are only changed by one step at a time
- The new operating point has to belong to the set of “meaningful operating points”

Handover optimisation simulation results



Handover optimisation simulation results

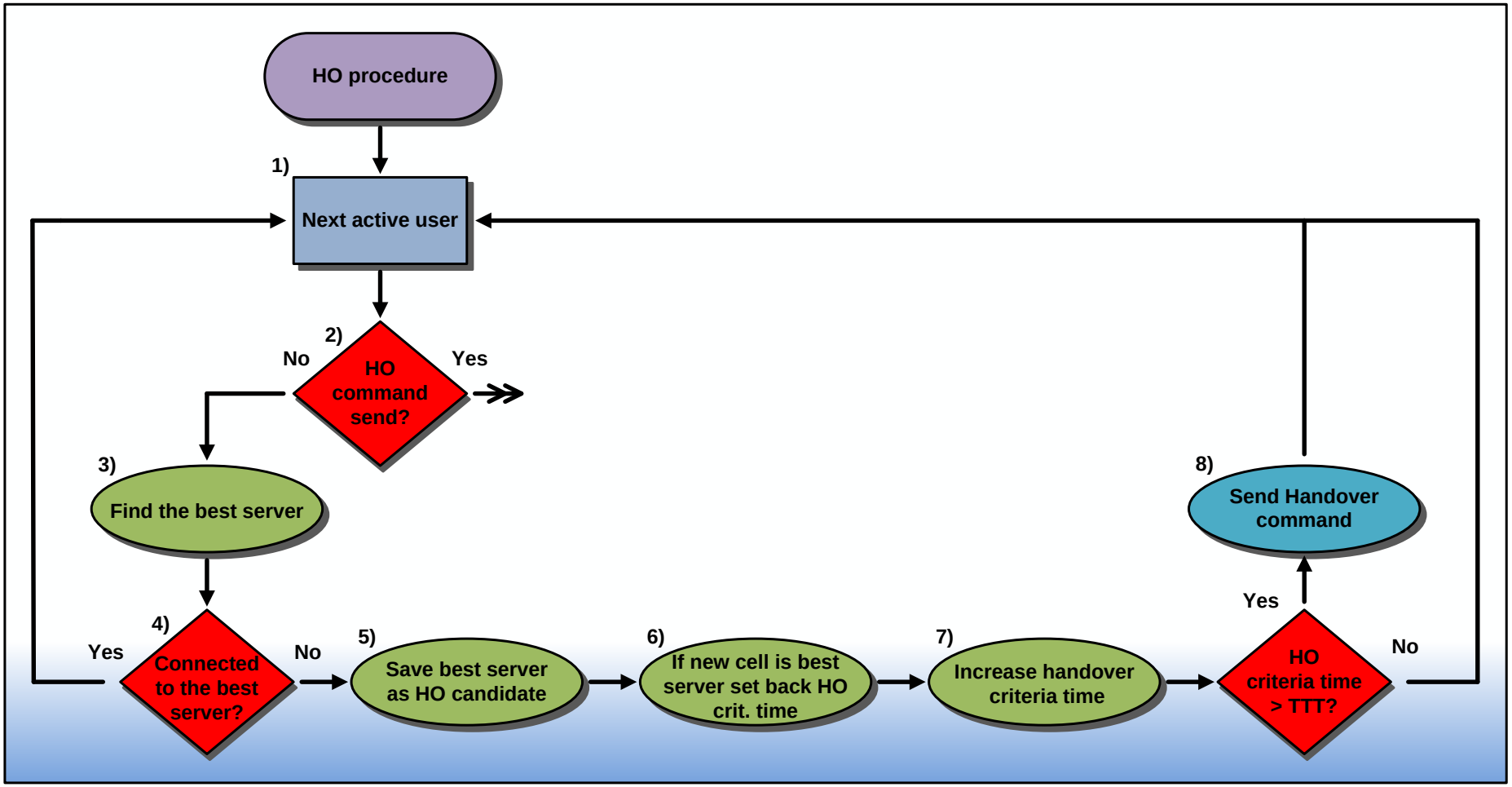


Conclusion

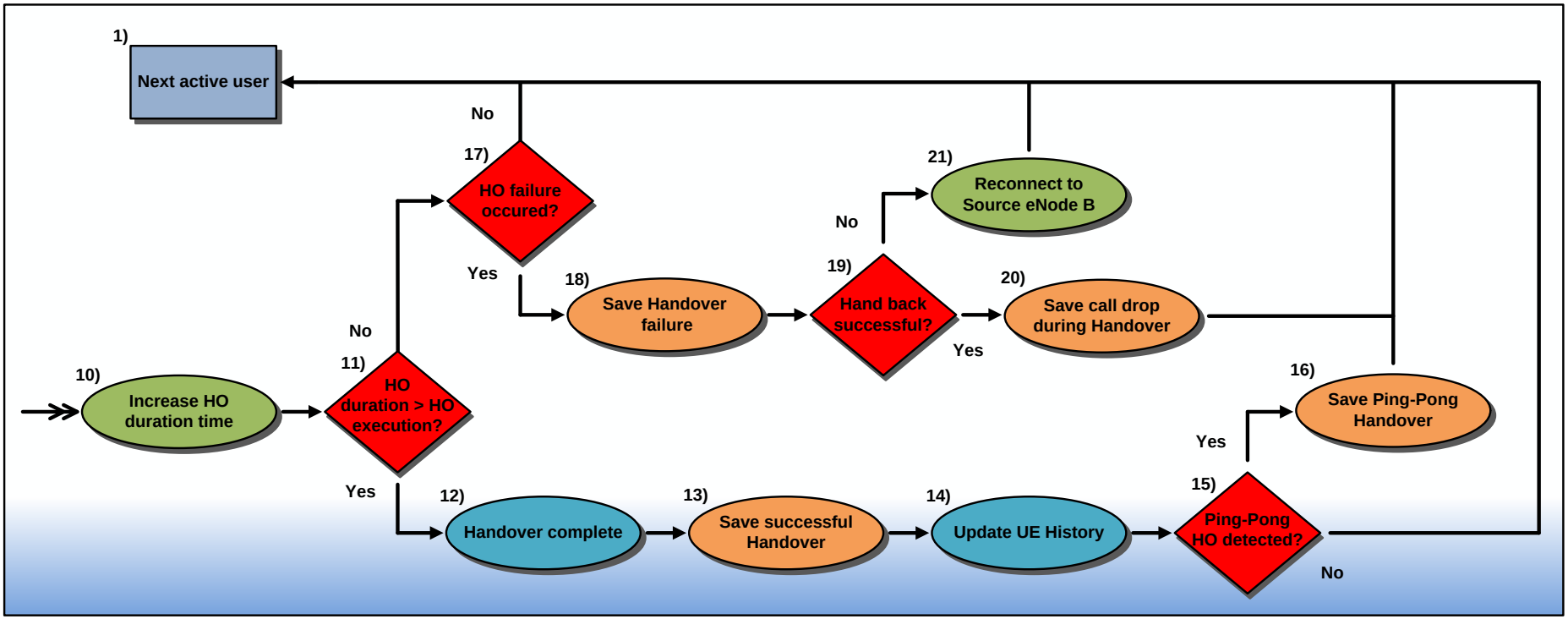
- The system behaviour to different handover operating points has been analysed
- Handover performance can be optimised using the proposed algorithm
- Handover operating points are chosen for every cell individually
- The overall network performance is increased and the handover failure ratio and ping-pong ratio drop to zero in the shown case
- Next steps
  - Run the algorithm in a larger scenario
  - Improve the SINR calculation (scheduling)
  - Introduce background traffic (implication on system throughput)
  - User specific handover parameters

Thank you very much for your attention

Handover procedure I



Handover procedure II



- The handover procedure is executed in every simulation time step
- Handover procedure is independent of the handover algorithm