Self-Organizing Network functions for handover optimization in LTE Cellular networks

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Agenda

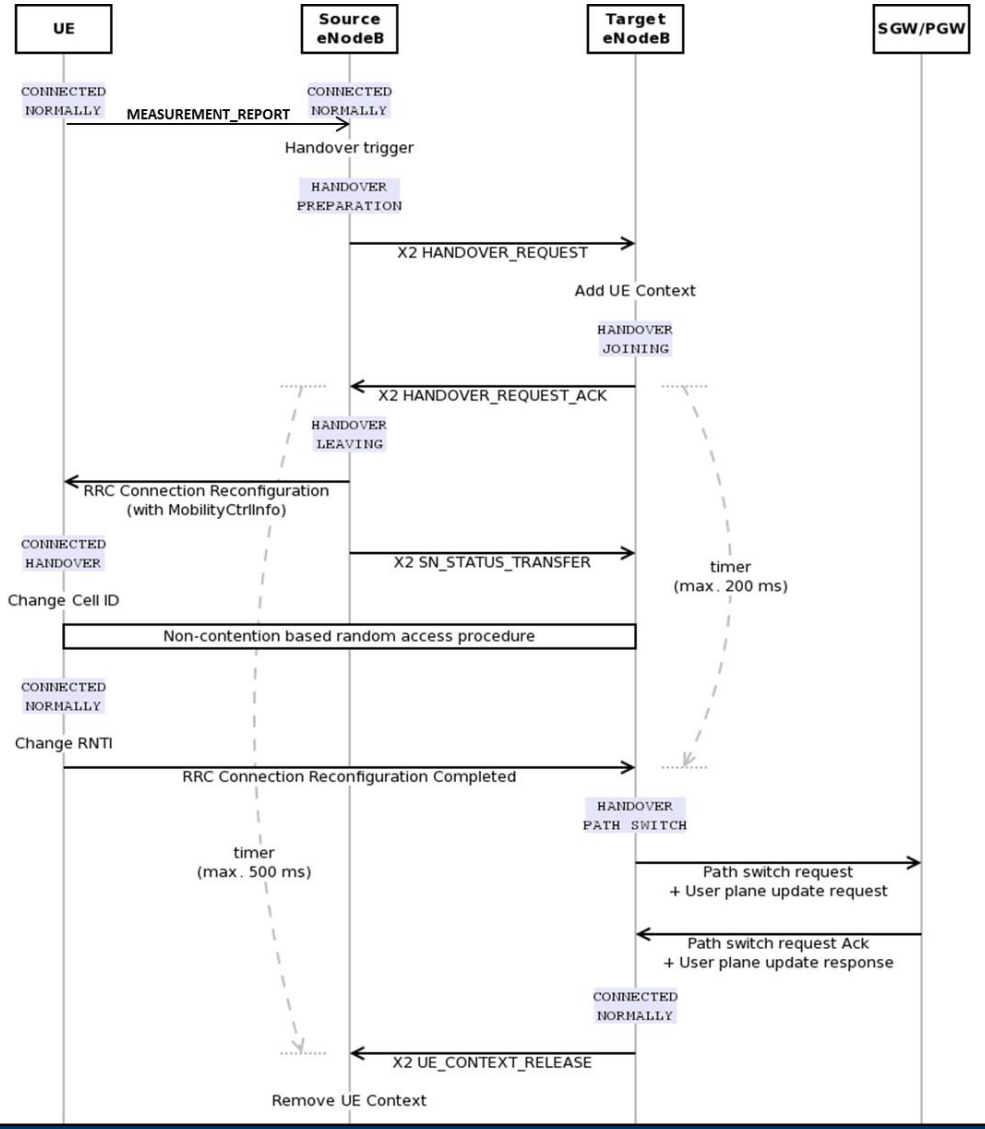
- Introduction
  - SON functionality in LTE
- SON for Handover optimization
  - Mobility Load Balancing (MLB)
  - Mobility Robustness Optimization (MRO)
- Performance evaluation
  - Simulation model and parameters
  - Results on MLB and MRO
- Conclusions / Outlook

Introduction

- Long Term Evolution (LTE) has significantly changed the overall network control approach
  - Most Radio Resource Control (RRC) functionality moved to eNodeB, e.g. for handover decision
  - Decisions mainly based on local information, e.g. UE measurements to support mobility
  - Exchange of some information between eNodeB via X2 interface, e.g. load measurements, handover report, radio link failure indication
- LTE supports from the beginning various Self Organizing Network (SON) functionality
  - Self configuration to ease installation (plug and play)
  - Self healing to overcome critical situations (auto repair)
  - Self optimization to improve overall performance (auto tune)

LTE Handover Procedure

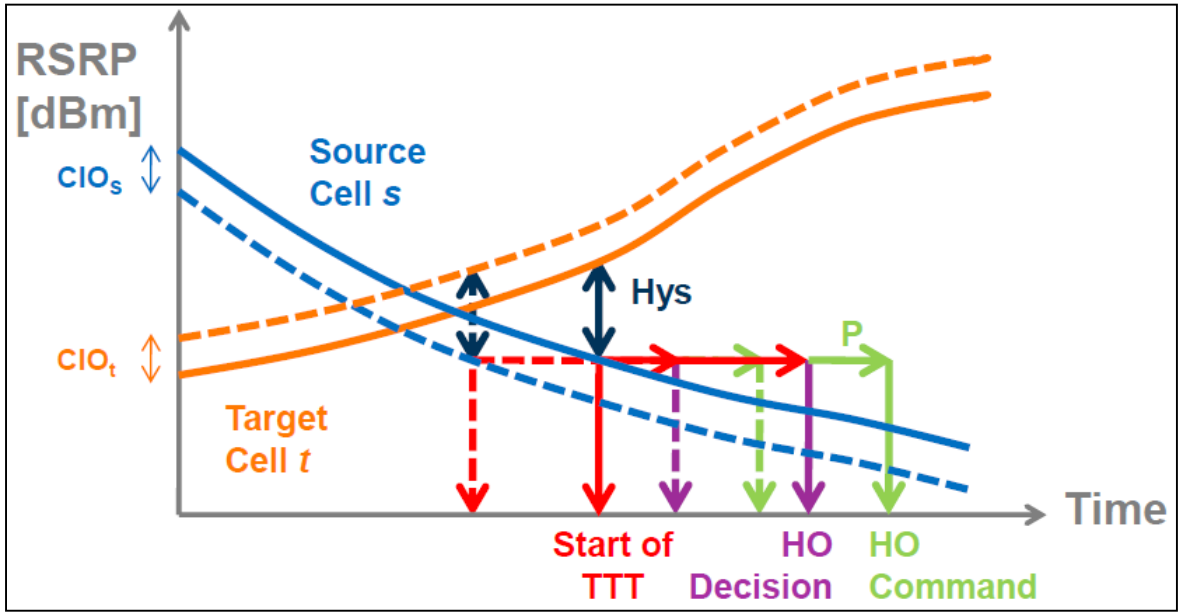
- Hard handover
  - Only one connection to a single eNodeB
  - Data forwarding during handover phase
  - Short interruption of data transfer



[7] ns-3 project, ns-3 model library
Release ns-3.29, Jan 2019

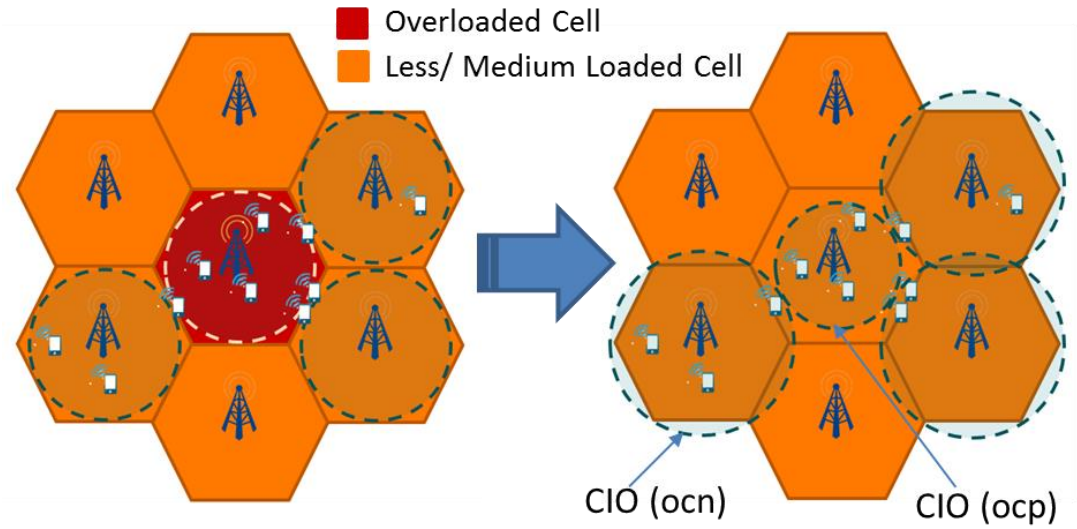
LTE Handover Decision

- Handover event A3
  - Intra- and inter-frequency measurements
  - Neighbor cell with offset better than serving cell
- Handover Parameters
  - Hysteresis
  - Time to Trigger (TTT)
  - Cell Individual Offset (CIO)



Mobility Load Balancing

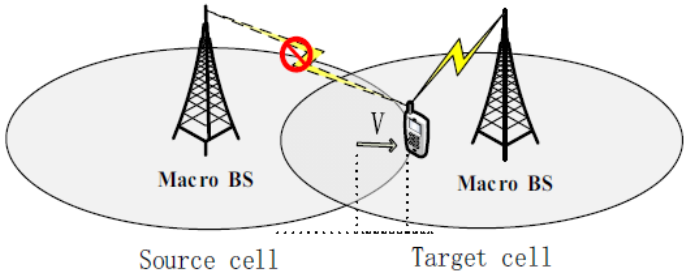
- MLB target: balance the network loading between adjacent cells
  - Reduce localized network congestion and inefficient network utilization
  - Improve the efficiency of resource utilization
- Adjustment of Cell Individual Offsets
  - Force handover to less loaded neighbor cell
  - Move traffic from overloaded cell



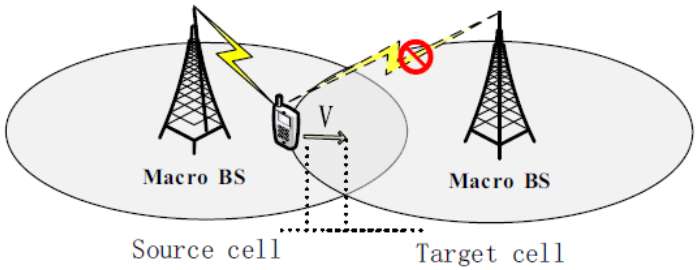
Mobility Robustness Optimization

- MRO aim: improve the overall handover performance
  - Reduce the number of handover related Radio Link Failures (RLFs) and unnecessary handovers
  - Adapt the cell parameters Hysteresis and Time to Trigger

- Radio Link Failures
  - Late Handovers: UE out of cell coverage before HO completed

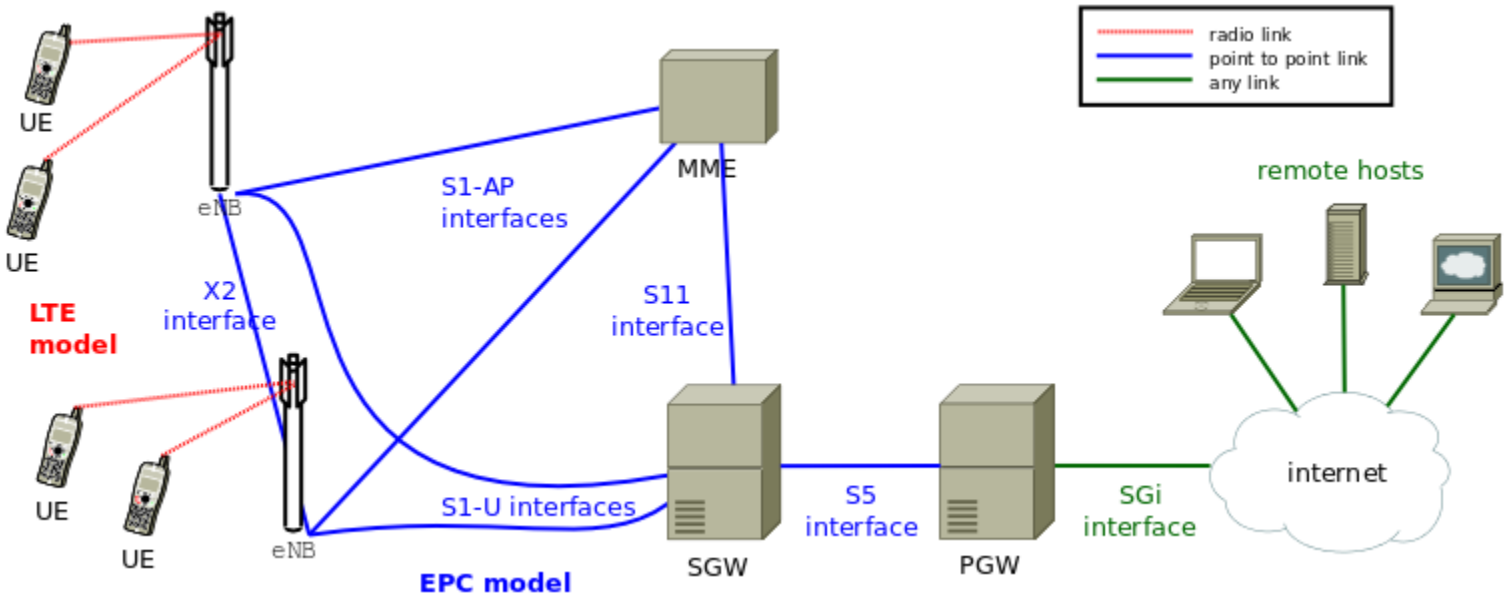


  - Early Handovers: UE handed over before sufficient quality on target cell



LTE System Simulations

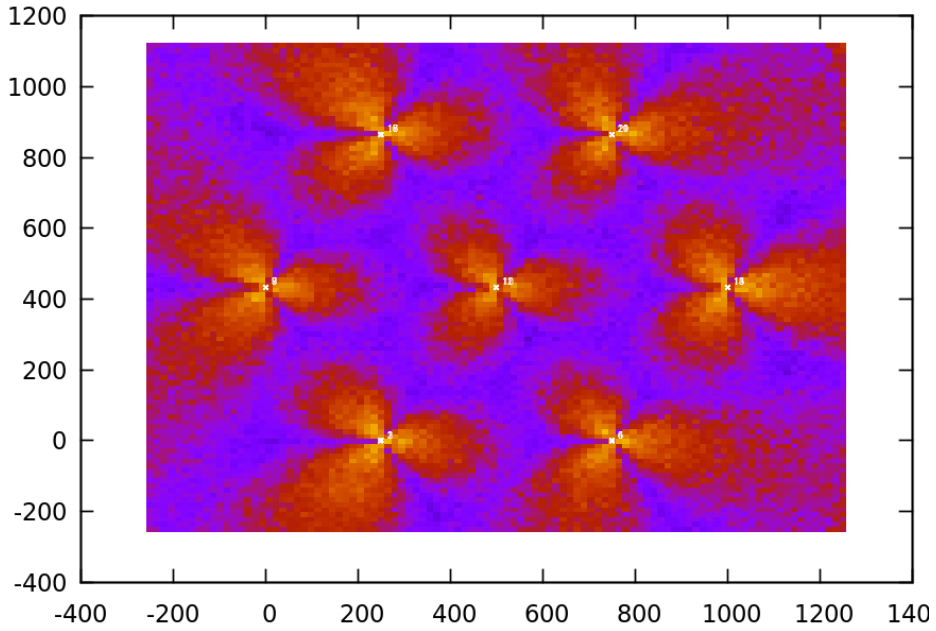
- Usage of LTE model in NS-3 – LENA
  - Radio Resource Control (RRC) modification
  - Radio Link Failure (RLF) Detection
  - Cell load handling, application of CIO



[7] ns-3 project, ns-3 model library Release ns-3.29, Jan 2019

Simulation Setup

Parameter Name	Value
Simulation Time	50 sec
Number Of Macro eNodeB Sites	7 (Hexagonal 2-3-2 formation)
Sectors per Site	3
Inter Site Distance	500 m
Mobile Speed	0 – 3 kmph (MLB) 10, 35, 70 kmph (MRO)
Macro eNodeB Tx Power	46 dBm
UE Tx Power	10 dBm
Number of UEs	12 (MLB) / 164 (MRO)
Macro eNodeB Bandwidth (UL & DL)	5 MHz (25 RBs)
Handover Trigger Event	A3 Event
Hysteresis	3.0 dB / 0 – 3.0 dB
Time to Trigger (TTT)	256 msec / 0 – 5120 msec
eNodeB Antenna	Parabolic Antenna Model
UE Antenna	Isotropic Antenna Model
Channel Propagation Model	Hybrid Building Propagation Loss Model
MLB Activation/ Deactivation Threshold	70% / 40% cell load

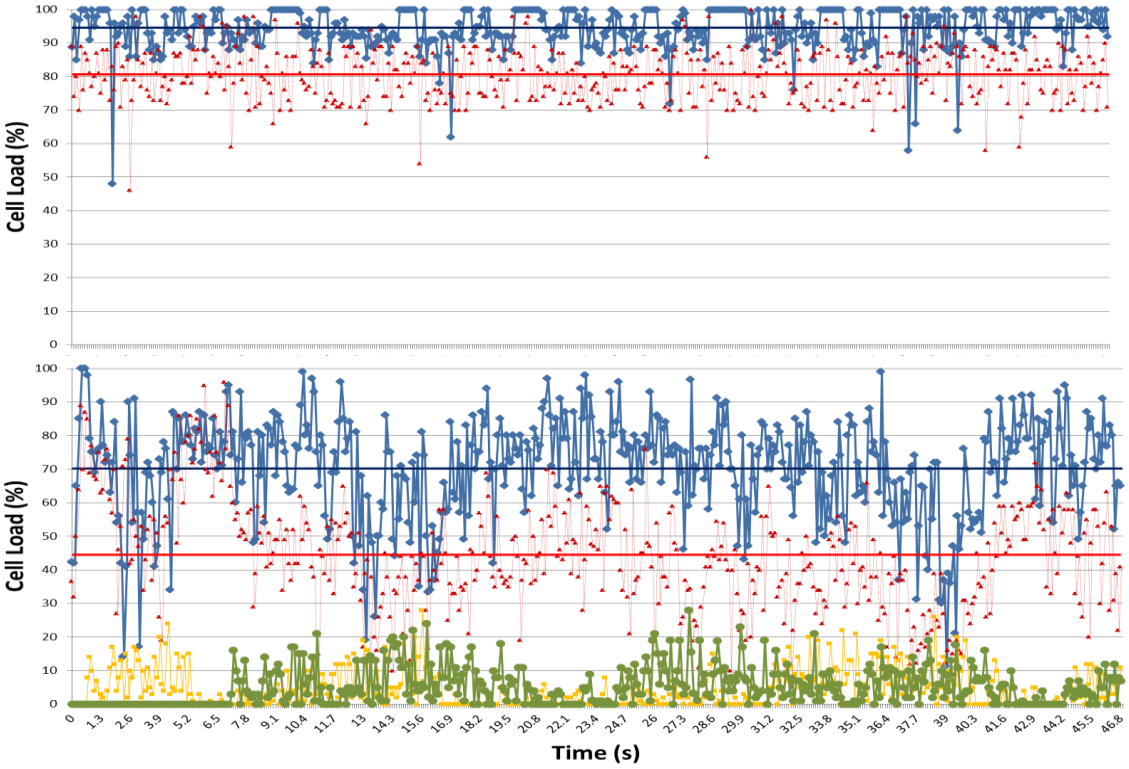


Simulation Results – MLB

MLB can balance the overall network loading between adjacent cells

- Loaded UEs at the cell borders and neighbor cells with sufficient capacity

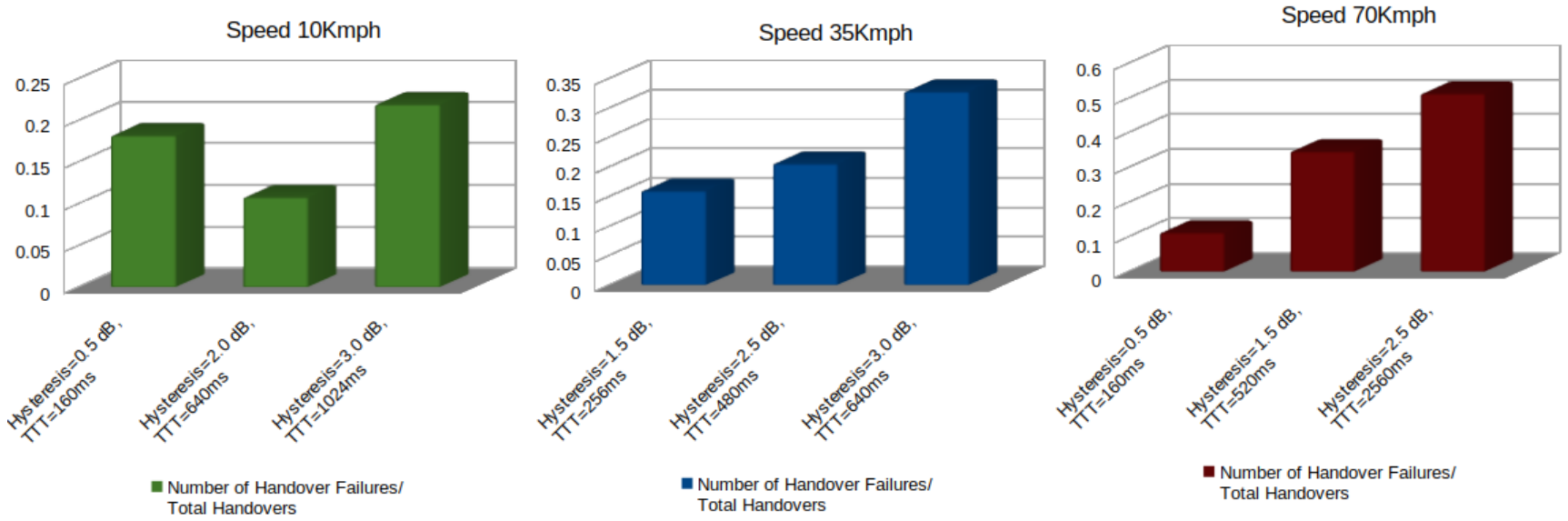
Cell ID	Cell Load (%) MLB inactive	Cell Load (%) MLB active
12	95	70
21	81	44
5	0	4
14	0	5



MLB inactive

MLB active

Simulation Results – MRO



MRO reduces the occurrence of handover failures

- Optimal parameter settings depend on environment (mobile speed)

Speed (Kmph) Range	Hysteresis (dB) Range	TTT (msec) Range
0 – 18	2.0 – 3.0	640 – 5120
20 – 50	1.0 – 2.0	256 – 640
> 50	0.0 – 1.0	160 – 480

Conclusions

- LTE has significantly changed the overall network control approach
  - RRC Functionality mainly based on local decisions in eNodeB
- LTE SON functionality has the potential to optimize e.g. the handover function
  - Adaptation of the handover parameters to the network conditions
  - MLB to balance the network load between adjacent cells
  - MRO to improve the handover failure behavior
- Dynamic system simulations showed the effect of MLB and MRB algorithms
  - Application of LTE simulation module in NS-3
  - MLB significantly reduces loading of overloaded cells
  - MRO showed the potential to reduce handover failures

Outlook

- Interaction between handover related parameter setting would be challenging
  - Change of the handover parameters due to MLB may trigger MRO and vice versa
  - Incoordination between MRO and MLB could result in unstable and oscillating behavior
  - Impact of other settings, e.g. transmit power, antenna tilt, might further complicate SON
- Coordinated approach for SON required
  - Clustering of algorithms affecting the same KPI
  - Application of advanced methods, e.g. based on cognition, machine learning and big-data

Thank You !

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