Self-Organisation in LTE networks: Soft integration of new base stations

Andreas Eisenblätter (atesio)  
Ulrich Türke (atesio)

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Overview

- **LTE**
- **EU ICT-Project Socrates: Self-Organisation in LTE Radio Networks**
- **Use Case: Automatic Generation of Initial Cell Parameters**
- **Outlook & Conclusions**
Motivation for LTE Development

Source: IEEE Spectrum, July 2004
LTE Design Targets

- Improved performance
  - Peak *data rates* of at least 100 Mbps in downlink and 50 Mbps in uplink
  - Support of huge *cell radii* (up to to 100 km, reasonable performance up to 30 km)
  - Reduced IP *latency* of at most 5 ms
  - RAN round-trip times of at most 10 ms
  - OFDMA with sub-frame length of 1ms
  - Extended support of MIMO
  - Flexible *bandwidth allocation*

- Reduced network complexity
  - *IP based* core network
  - Fewer network element types

- Cheaper to deploy and to maintain
  - OPEX reductions, e.g., by means of network *self-organisation*
  - Reduced power consumption
  - Better IPR regime

Source: NGMN
### Radio Spectrum for LTE in Europe

#### Diagram:

- **VHF**
- **UHF**
- **L-Band**
- **GSM 1800**
- **UMTS**
- **S-Band**
- **LTE TDD**
- **LTE FDD**

#### Key Points:

- **Large, but scattered spectrum available**
  - High flexibility in spectrum usage required: 1.4, 3, 5, 10, 15, 20 MHz
  - Low interference with co-existing technologies

- **Low frequencies allow good areal coverage**

- **High frequencies offer sufficient bandwidth for high data-rate services**

- **FDD/TDD bands available**
FP7-Project Socrates

Overview
- Self-Optimisation and self-ConfiguRATion in wirelEss networkS
- Technological focus: 3GPP E-UTRAN (LTE)
- 3-year duration: from 01/01/2008 until 31/12/2010
- Effort: 378 person months, € 4.980.433

Objectives
- Novel concepts, methods & algorithms for effective self-organisation
- Assessment of operational impact
- Validation & demonstration
- Influence 3GPP standardisation & NGMN activities
Self-Organisation in the LTE Radio Network

- **Basis**
  Continuous monitoring and measuring within the operational radio network as embedded functionality

- **Self-optimisation**
  Autonomous optimisation of radio network performance

- **Self-configuration**
  (Largely) Automatic configuration of new network elements

- **Self-healing**
  Autonomous (temporary) adaption of the network configuration in reaction to element failures (compensation)
Self-Configuration: Automatic Generation of Initial Cell Parameters

Observation

Network Quality
Cell Efficiency

Total Network
Area of Interest

Relative Traffic Amount

Day 1
Day 2
Day 3
Time

0:00
0:00
0:00

0
10

0
2
4
6
8
10

0
2
4
6
8
10

0
0.2
0.4
0.6
0.8
1.0

0
1
2

0:00
0:00
0:00

Day 1
Day 2
Day 3
Time
Study Assumptions

- **Network**
  - LTE FDD, 2.6 GHz, 10 MHz bandwidth
  - Realistic network layout
  - Realistic path-loss data (10m/100m resolution)

- **Traffic Profile**
  - Realistic traffic pattern
  - Varying intensity over time (homogeneous scaling of one spatial traffic pattern)

- **Optimisation**
  - Antenna configuration
  - Maximisation of supported traffic

- **Performance Analysis**
  - System-level
  - Large-scale (10 Mio. pixel)
  - User- & cell-based metrics (throughput, load, …)

- Overall setting alike to traditional off-line planning / optimisation
 LTE Performance Analysis & Optimisation

- **Coverage** assessment
  - Based on RxLev and RxQual of pilot signal

- **Capacity**: capability to serve offered traffic
  - Link throughput computed using truncated Shannon capacity of a radio channel
  - Interference determined on the basis of a cell coupling system similar to those known from UMTS / HSDPA / WiMAX

- The optimisation is performed using (adapted) *local search techniques* for UMTS radio network capacity optimisation (see, e.g., Hans-Florian Geerdes: *UMTS Radio Network Planning: Mastering Cell Coupling and Capacity Optimization*, Vieweg+Teubner, 2008)
Network State Stability Study

- Is an off-line setting for planning / optimisation appropriate?

- Related important questions
  - How stable is “optimal network configuration” that is aimed at?
  - How sensitive is performance with respect to network configuration?

- Setup of “robustness” study
  - Consideration of 100 different traffic random realisations (snapshots) of mean traffic map provided by an operator (Poisson sampled)
  - Optimization of network configuration for each of these snapshots
    → 100 network configurations
  - Evaluation of difference between configurations
  - For each snapshot: Comparison of performance of all other 99 network configurations with performance of optimum network configuration for this snapshot
Traffic Degradation: Network Optimized for “Wrong Traffic”

Strong variation in network performance
Traffic Degradation vs. Difference in Network Configuration

Strong variation also in network configuration
Traffic Degradation vs. Mean Traffic Degradation

Optimising w.r.t. averages gives overall OK performance
Challenges ahead

- Investigations on *reasonable control paradigm*
  - Control paradigms: local, distributed, global
  - Need for coordination if non-global control is applied
  - Need for (massive) data exchange if global control is applied
  - Speed of control
  - Very fast control may produce an over-fitting of the configuration

- Online *measurements* need to be taken into account
  - From mobile devices
  - From base stations
  - Measurements (quantify, quality) depend on network usage
  - How to adapt the control mechanisms to the available network feedback

- Inferring *network state*
  - To which extent can a network configuration be considered static?
  - Can data collected at other times or elsewhere complement scarce measurements?
  - ...