Reliable Operation of Heterogeneous Wireless Networks with SON (Self-Organizing Networks)

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Nokia Siemens Networks
- Research

Tutorial DRCN 9th International Conference on Design of Reliable Communication Networks

Nokia Siemens Networks

Overview

09.00-09.10 Intro

09.10-09.30 LTE / HetNet / Network Management Basics (Szabolcs)

09.30-10.00 SON Basics (Henning)

10.00-10.30 Self-Configuration (Henning)

- Auto-connectivity and –commissioning
- Dynamic Radio Configuration: (Multi-vendor) Physical Cell ID (PCI) allocation

10.30-11.00 Coffee break

11.00-12.15 Self-Healing, incl. Demo (Szabolcs)

12.15-12.45 SON coordination / Integrated Demo (Henning)

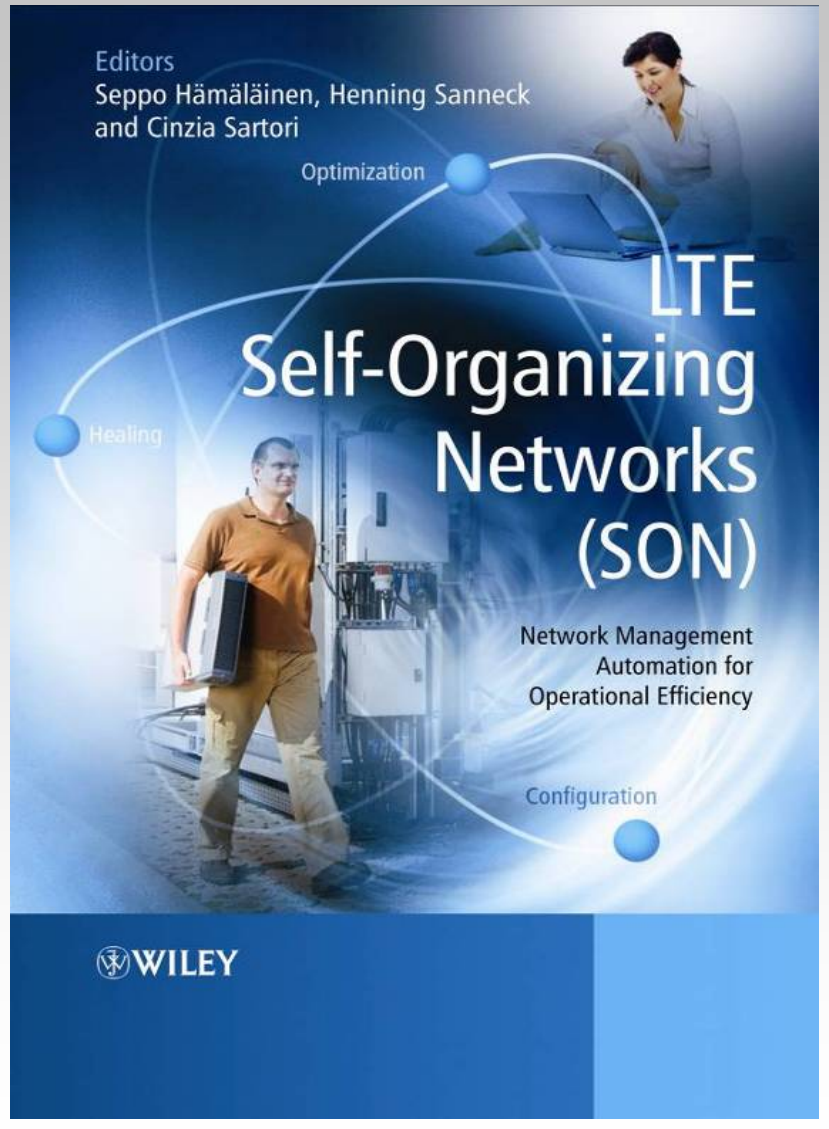
- LTE radio network simulation, centralized self-optimization, SON coordination

12.45-13.00 Conclusions

Mobility Robustness Optimization: included in materials

SON coordination: included in materials

Commercial break



1. Introduction
2. *LTE Overview*
3. **Self-Organising Networks (SON)**
4. **Self-Configuration ('Plug-and-Play')**
5. *Self-Optimisation*
6. **Self-Healing**
7. Supporting Function: MDT
8. SON for Core Networks
9. **SON Operation**
10. **SON for Heterogeneous Networks (HetNet)**
11. Future Research Topics

Overview

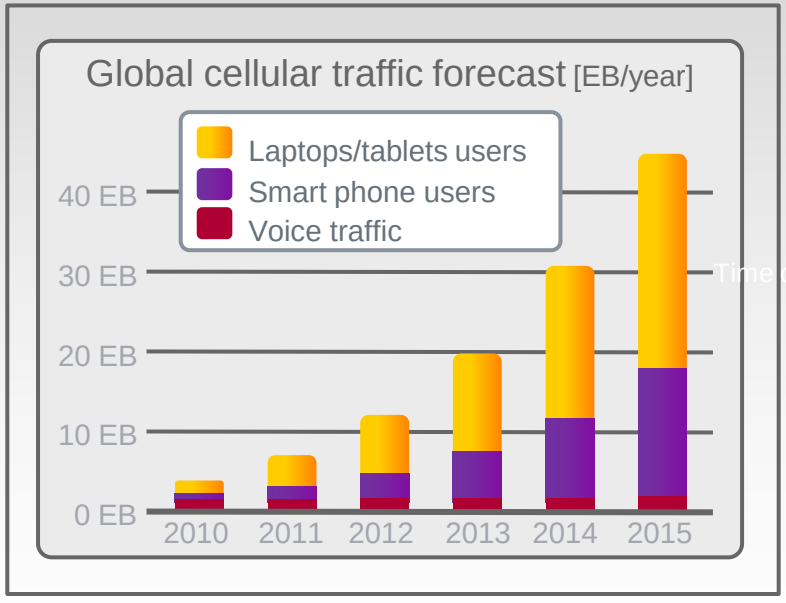
- **Background**
- **LTE basics**
- **LTE system architecture**
- **LTE – Advanced**
- **3GPP Management Architecture**

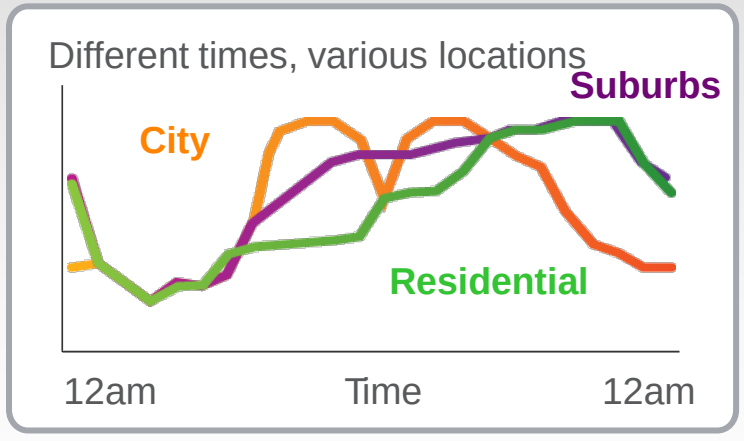
Mobile data traffic explosion

People use increasingly their smart phones, tablets and net books for daily tasks

- Browsing the Internet, email, music and video, navigation, communities, business on the move etc.

When accessing to services, people expect ease of use, speed and responsiveness, everywhere / everytime





→ **How can mobile network operators cope in terms of their infrastructure and its operation (OPEX) while assuring best Customer Experience ?**

Key requirements for network infrastructure towards 2020

Support up to 1000 times more traffic

Manage up to 10 times more users

Enable Gbps peak speeds

Reduce latency to milliseconds

Improve energy efficiency

Make networks self-aware, self-adaptable, and intelligent

Deliver safe superior customer experience

We cannot predict all the use cases
so flexibility is a key requirement

Support of up to 1000 times more capacity in wireless access

10x Performance

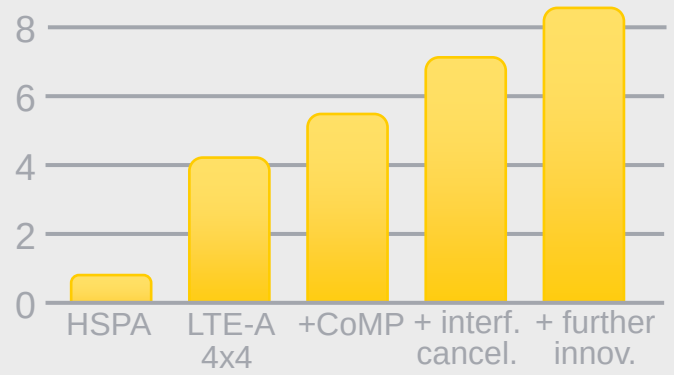
10x Spectrum

10x Base stations

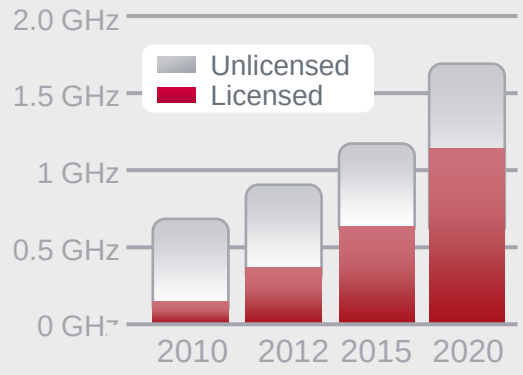
=

1000x Capacity

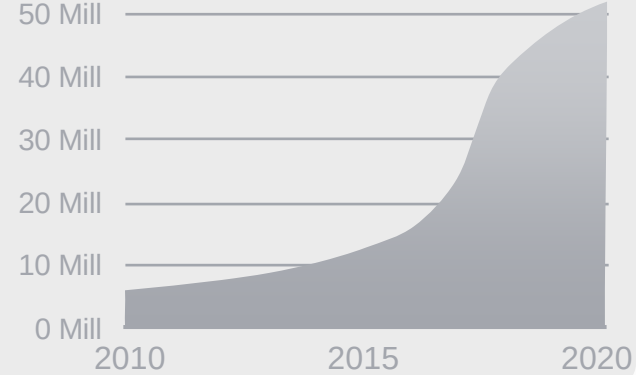
Spectral efficiency [bps/Hz/cell]



Available radio spectrum



Global base station forecast

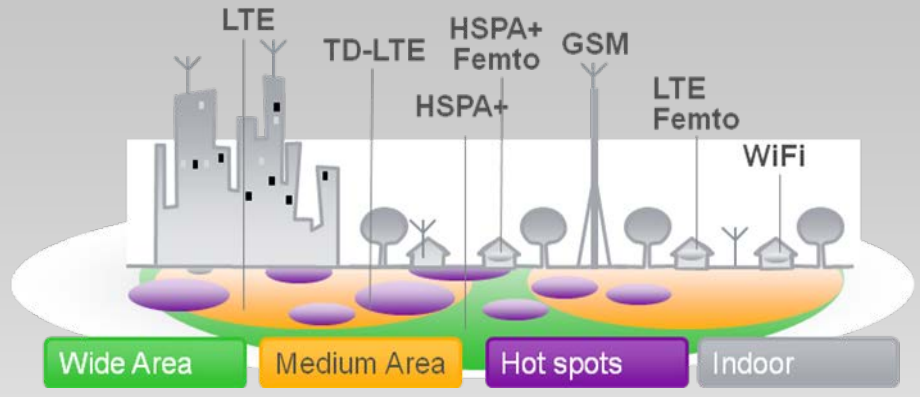


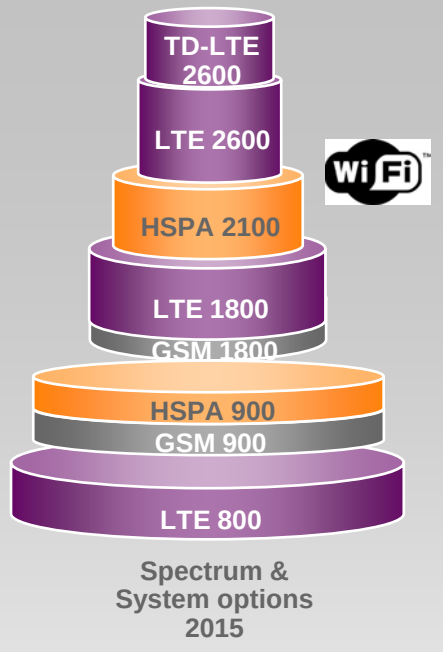
Most of these will be small cells

In addition over 500M WiFi APs

Heterogeneous Networks providing “unlimited” capacity and “ubiquitous” coverage

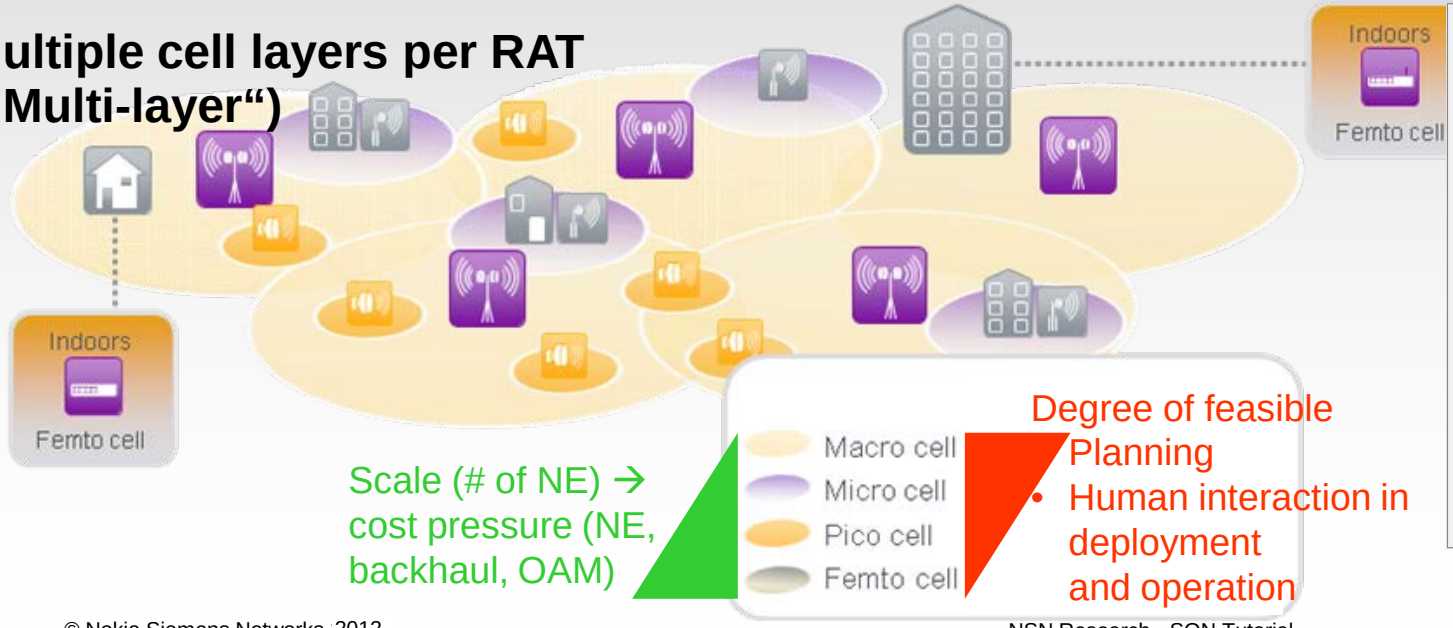
Multiple Radio Access Technologies („Multi-RAT“)

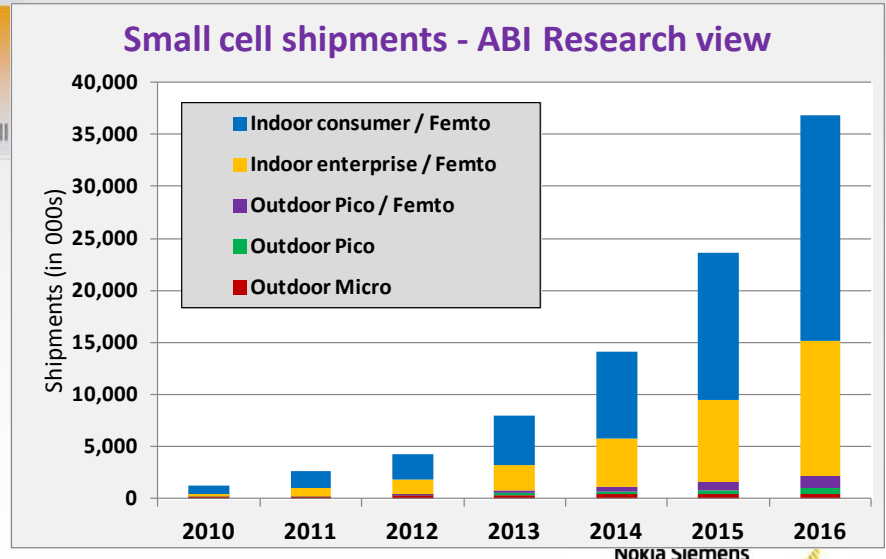




Spectrum & System options 2015

Multiple cell layers per RAT („Multi-layer“)





LTE principles, radio performance

- LTE peak data rate increases by a factor of ~100x compared to HSPA+ . Spectral efficiency also increases significantly while there are no substantial improvements in coverage

Requirement	LTE	HSPA+
Peak transmission rate At 20MHz BW	DL: 150-300 Mb/s UL: 75 Mb/s	DL: 42-168 Mb/s UL: 11-54 Mb/s
Spectral efficiency (average) 4-rx mobile	1.7 – 2.7 bps/Hz/cell	1.21 - 1.9 bps/Hz/cell
Coverage	162dB	162dB

- LTE-related research & standardization has been the framework for work on SON (due to the offered window of opportunity), yet SON features are now increasingly considered for other RATs as well

LTE principles

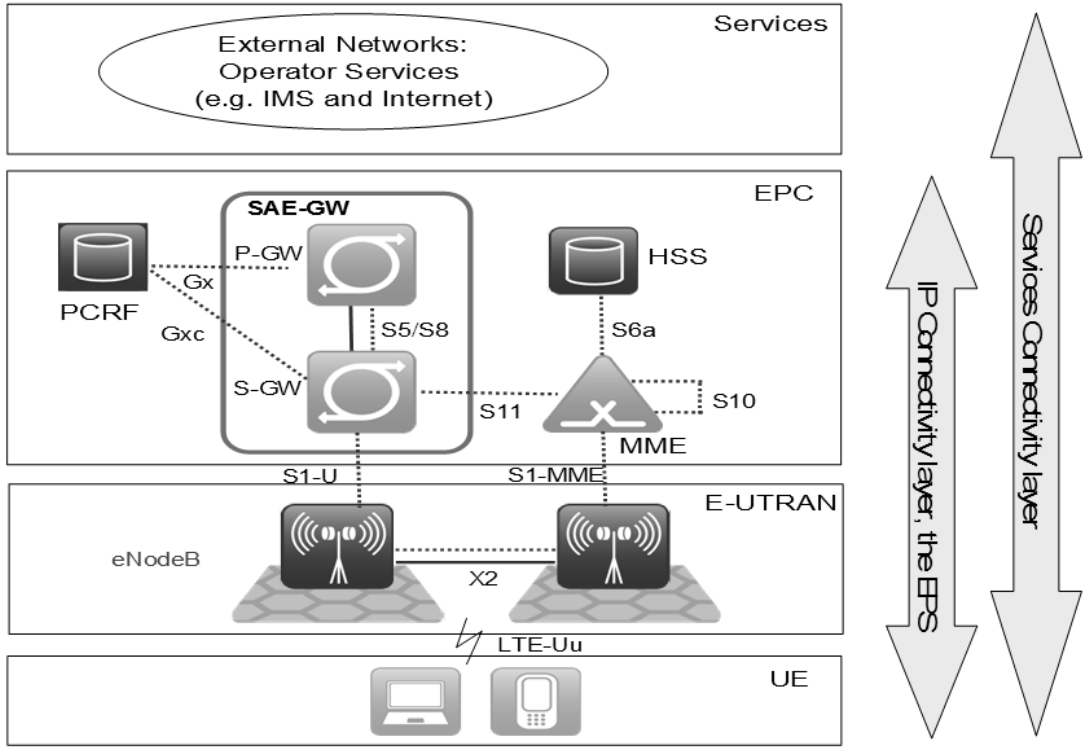
Evolved UTRAN

- LTE downlink is based on Orthogonal Frequency Division Multiplexing (OFDM) in which data are carried simultaneously by narrow-band subcarriers
- LTE uplink is based on Single Carrier FDMA to minimise UE power consumption
- The signal is organised into sub-frames of 1ms each
  - 1ms subframe and the flat network architecture enable very short latency for both data and signaling
- LTE is scalable with system bandwidth ranging from 1.4MHz up to 20MHz
- Both paired (FDD) and unpaired (TDD) spectrum allocation are supported with the same downlink subframe structure
- All LTE UEs support at least two receive antennas, allowing downlink receive diversity
  - More advanced techniques, such as Transmit diversity, spatial multiplexing (Single-User and Multi-Users MIMO) and beam-forming are also supported

LTE principles

System architecture

- Evolved Packet System (EPS) consists of
  - Evolved UTRAN
  - Evolved Packet Core
  - Connectivity to 3GPP and non-3GPP access systems
- In EPS architecture only the radio access and core network are new
  - UE and Services remain unchanged
- EPS provides IP connectivity and protocol layers for optimised IP connectivity
- EPS key aspects are:
  - Reduced number of network elements on the data path
  - Streamlined RAN functionality provided with a single node
  - Separation of the control and user plane network elements (MME and S-GW)
- EPS applies flat architecture in which radio functionalities collapse to one element only - eNB

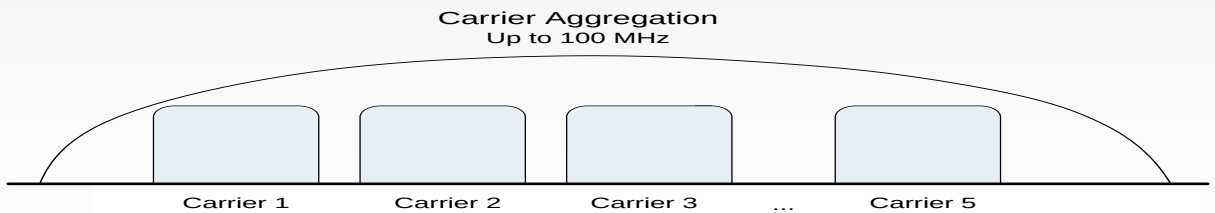


TS23.402: Architecture enhancements for non-3GPP access

LTE principles

LTE-Advanced (Rel.10 … Rel.12 ff)

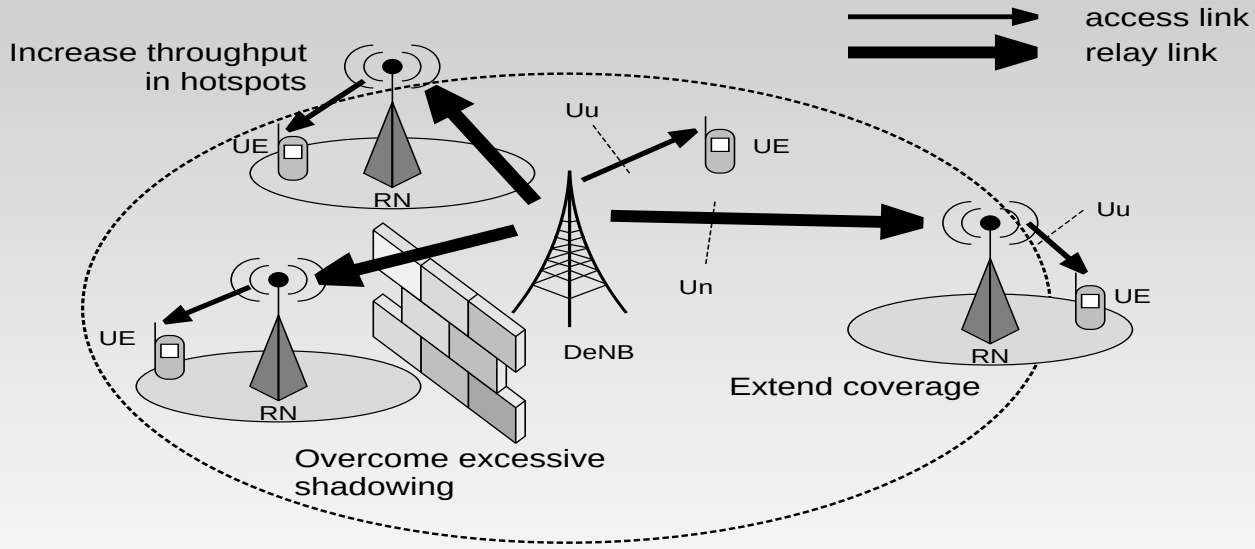
- LTE-A is defined in 3GPP Rel.10 and is targeting to requirements as defined by ITU-R
- LTE-A maintains backwards compatibility with previous LTE versions
- Technology components included in LTE-A are
  - Improved MIMO schemes
    - Rel. 10 extends downlink MIMO to support 8 RX/TX antennas in DL and 4 TX and 8 RX antennas in UL
  - Coordinated Multipoint Transmission and Reception (CoMP)
    - A number of geographically separated base station cooperate by providing joint scheduling and transmission in DL and joint processing of signal in UL
  - Carrier Aggregation (CA)
    - CA targets to data rates of 1Gpbs in DL and 500Mbps in UL by means of bandwidth extensions. Up to 5 component carriers can be used



LTE principles

LTE-Advanced

- Relay node (RN)
  - Demanding LTE-A targets require short distance between transmitters and receivers
  - In order to reach cell-edge users, multi-hop Relay Nodes (RN) have been introduced
  - RN's are served by Donor-eNB that allocates part of air-interface capacity to provide backhaul link for RN

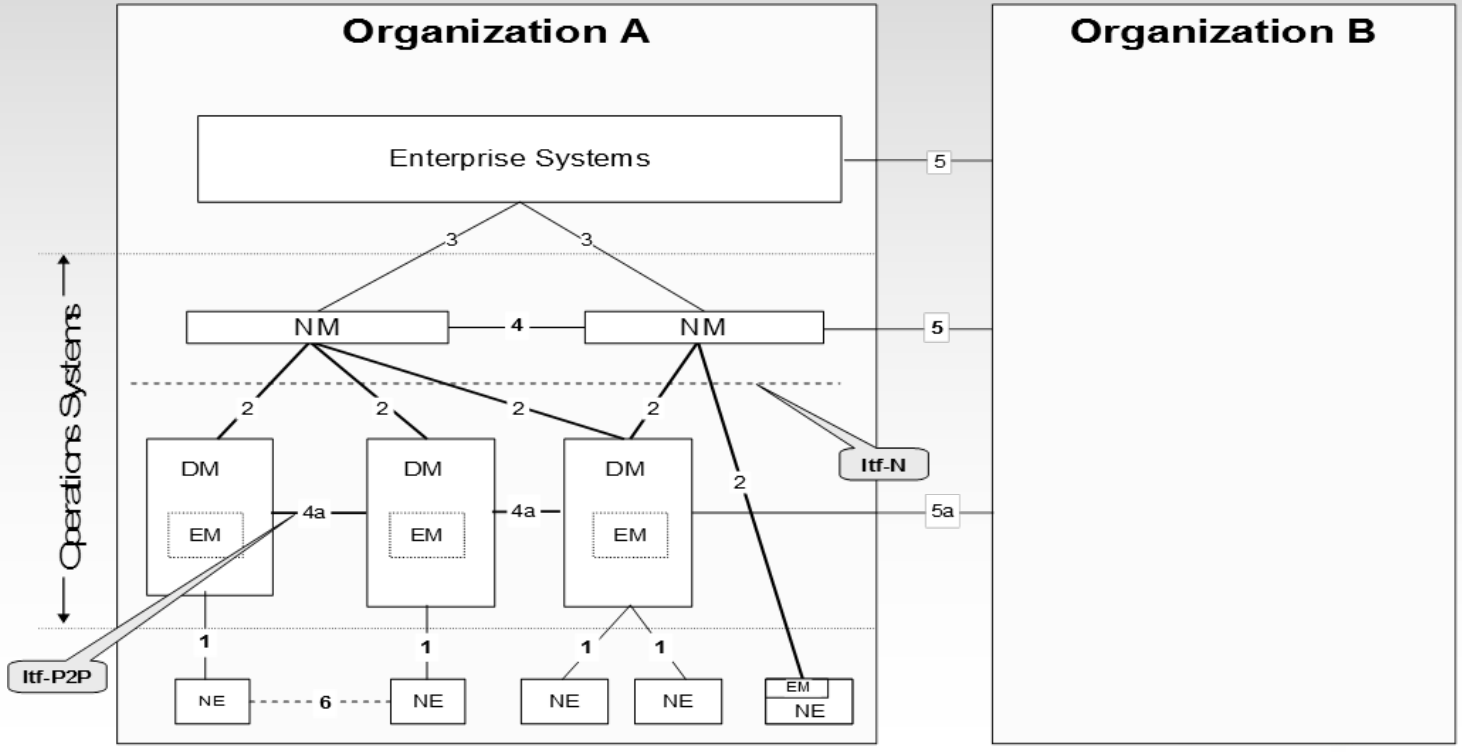


Heterogeneous Networks (HetNet)

- In HetNets different types of base stations co-exist: macrocells provide wide area coverage, and low powered base stations in small cells hotspot capacity
  - Small cells are micro, pico, femto, HeNB
- Micro, pico and Enterprise-femto cells are operated by operator, while residential-femto is operated by the end-user
- HeNB operating modes are Open Subscriber Group, Closed Subscriber Group and hybrid
- One of the key problems for SON to solve is inter-cell interference between macro and small cells. This is addressed by enhanced Inter Cell Interference Cancellatio (eICIC)

3GPP management architecture

- LTE follows the same 3GPP management reference model as 3G as specified by 3GPP
- Several interfaces from operations systems to NEs are introduced
  - **Itf-S (“Type 1”)**: Interface between the Network Element (NE) and the Domain Manager (DM). This interface is vendor specific.
  - **Itf-N (“Type 2”)**: Interface between the Domain Manager (DM) and the Network Manager (NM). This is a standardised open interface and thus facilitates multi-vendor management
  - **Itf-P2P („Type 4a“):** interface between the Domain Managers (DMs) as well as the Element Manager (EM) embedded into the Network Element. Itf-P2P interfaces have been not used in real deployments.

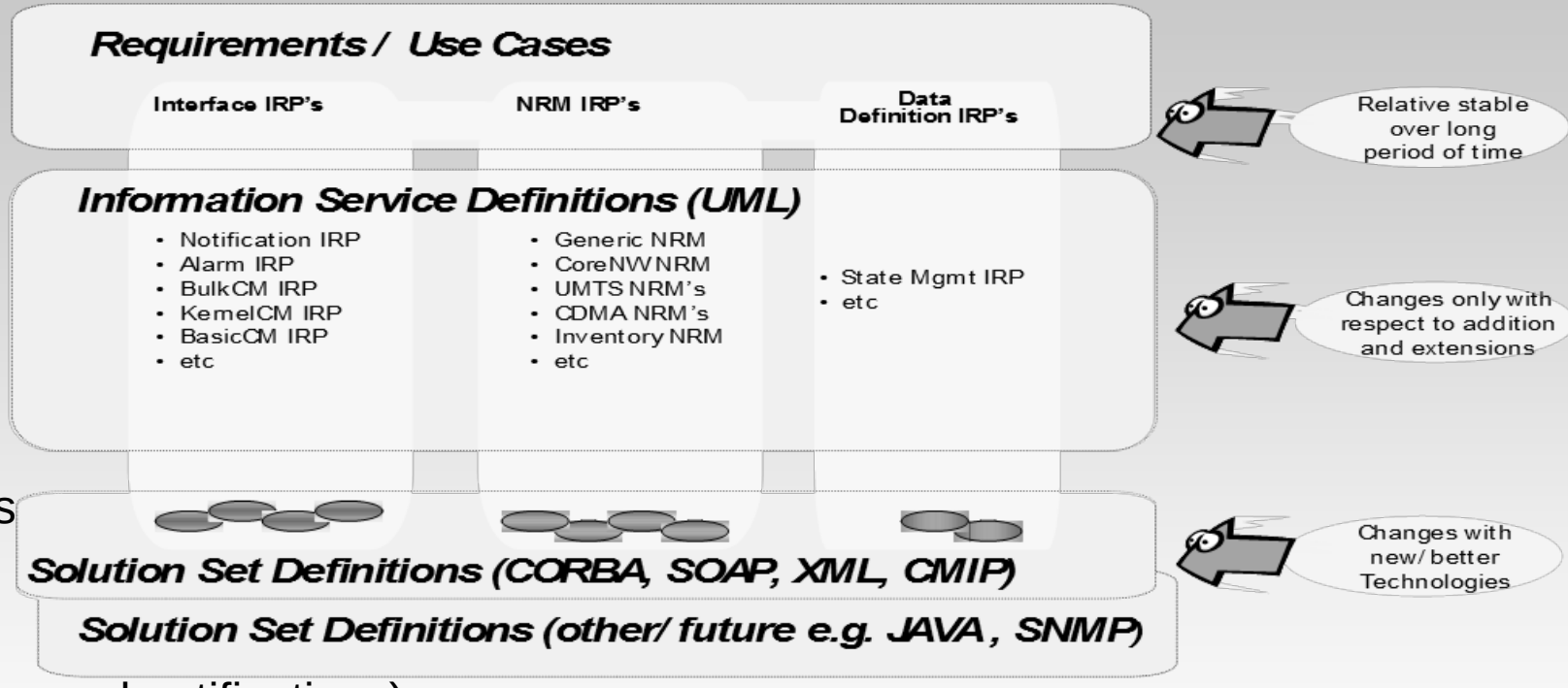


TS32.101: Telecommunication management; Principles and high level requirements

3GPP management architecture

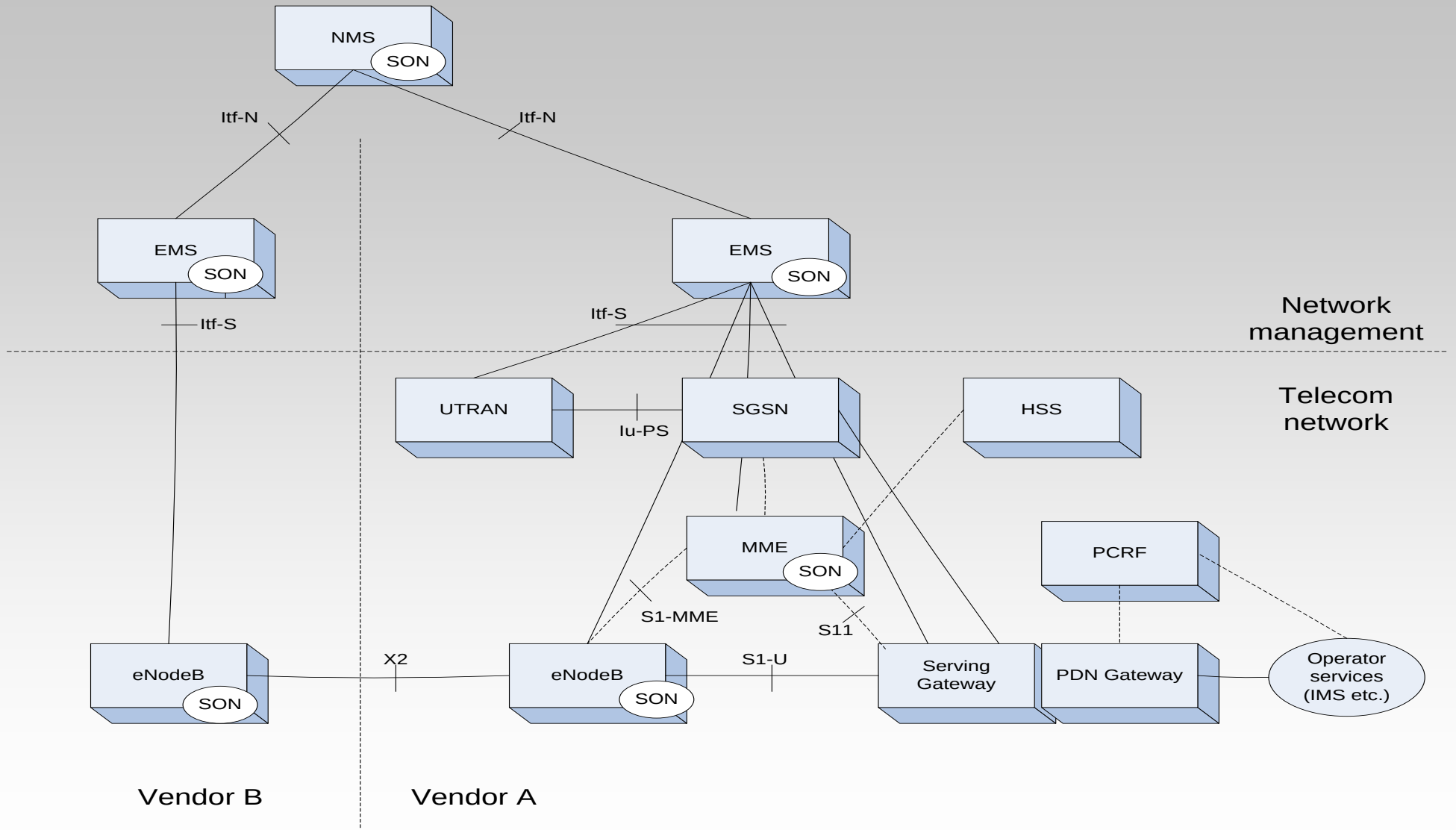
3GPP's management is based on an interface concept known as Integration Reference Point (IRP).

- IRP "levels" are
  - Requirements / use cases
  - Information Service (IS) providing technology (protocol) -independent definitions
  - Protocol-specific (CORBA, SOAP/XML) Solutions Sets (SS) : mapping of IS definitions
- IRP types are:
  - Interface IRPs define how information is shared (operations and notifications)
  - NRM (Network Resource Model) IRP defines what can be managed
  - Data Definition IRP – abstract data definitions to be used in NRM IRPs

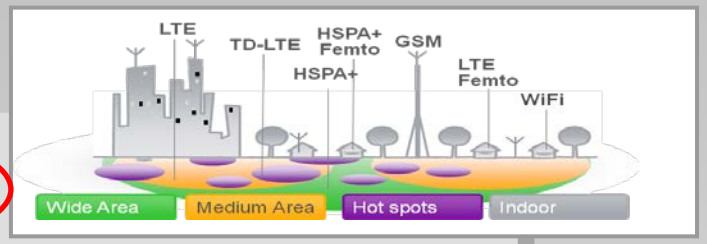


TS32.103: Telecommunication management; Integration Reference Point (IRP) overview and usage guide

Overall architecture

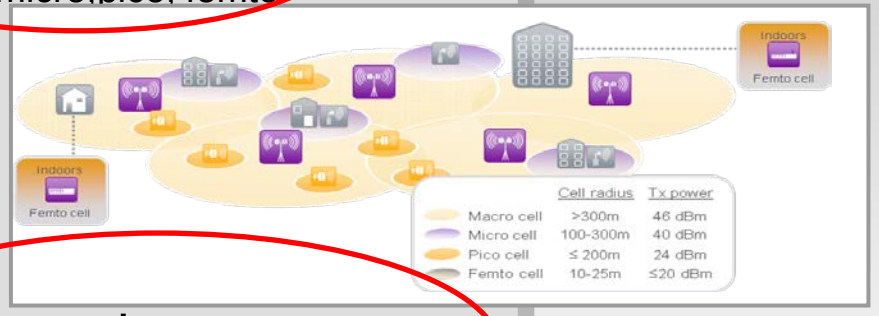


Multi-RAT, Multi-Layer, Multi-vendor Heterogeneous Networks



Multi-RAT
LTE, LTE-A, WCDMA, HSPA+, WiFi

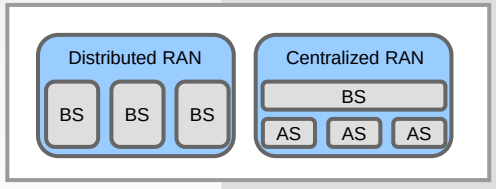
Multi-Layer
Macro, micro,pico, femto



Multi-xyz

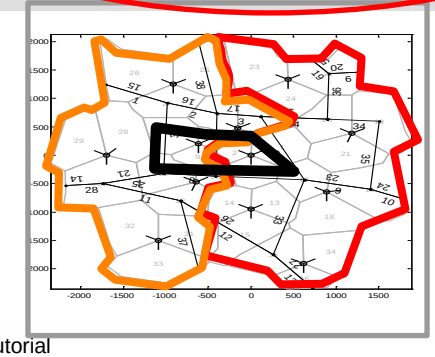
time

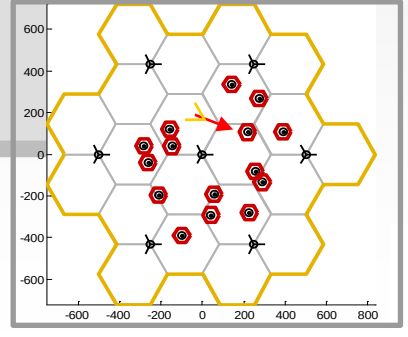
Multi-Arch.
Distributed, Centralized ("CloudRAN")



Multi-vendor
Different vendors providing different RATs / cell layers

Multi-operator
Network sharing / virtualization





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Outlook and conclusions

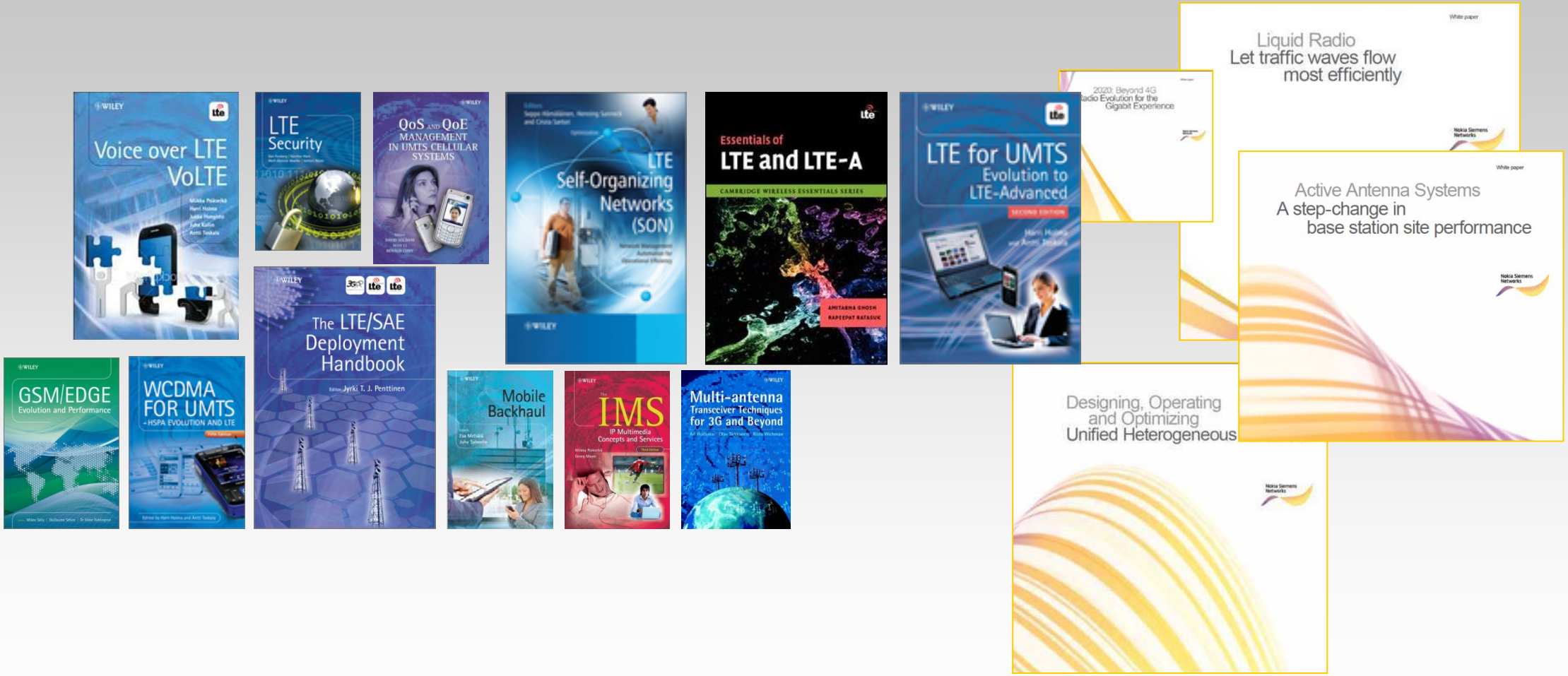
Conclusions

- The strong user demand / mobile data traffic explosion requires that operators „densify“ their network increasing capacity and assuring coverage → **Heterogeneous Networks (HetNets)**
- The decreasing revenue per user forces operators to reduce costs to remain profitable; HetNets increase complexity and thus Operational Expenses (OPEX), however → **dilemma**

- **Self Organizing Networks (SON)** concepts aim at managing complexity and thus drive down costs for **infrastructure** networks
  - For infra networks, SON concepts have to be carefully evaluated (business value, legacy / standardization requirements, complexity)

- **For HetNets, SON becomes imperative**
  - Existing concepts need to be extended, new concepts are required to address Multi-layer, Multi-RAT
  - Time horizon: from combination of available features into a solution (cf. WiFi offload) to long-term research agenda (Cognitive Networks)
- Self-configuration: *“zero touch” dynamic* deployment, reduced degree of radio planning
- Self-optimization: improved performance with *fast, local, autonomous* optimizations
- Self-healing: *detect all relevant* problems, support operator in *diagnosis*
- SON operation (management & coordination): supporting multi-vendor system integration and operation

Related Nokia Siemens Networks whitepapers and books with NSN authors



Topic areas:

- SON in macro cells and HetNets
- SON management and coordination
- SON in the field
- SON evolution

Co-organized by Alcatel-Lucent, Ericsson, Nokia Siemens Networks, Actix, Orange, TU Braunschweig, University of Piraeus