Fraunhofer FOKUS

From past to future: Research & Development Thoughts on Telecommunication Networks for Smart Cities

Invited Keynote

Research Symposium on Future Internet Architectures and Technologies, in conjunction with COMPSAC 2013, July 26, 2013, Kyoto, Japan

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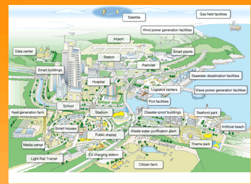
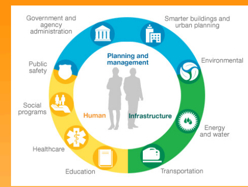
The smart city challenge for telecommunication

By 2040, more than 70 % of the world‘s population will live in „mega cities“, putting unprecedented demand on infrastructure, energy consumption and services

[United Nations’ State of the World Population 2011 report]





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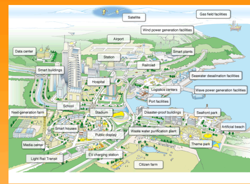

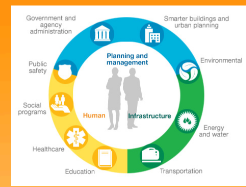

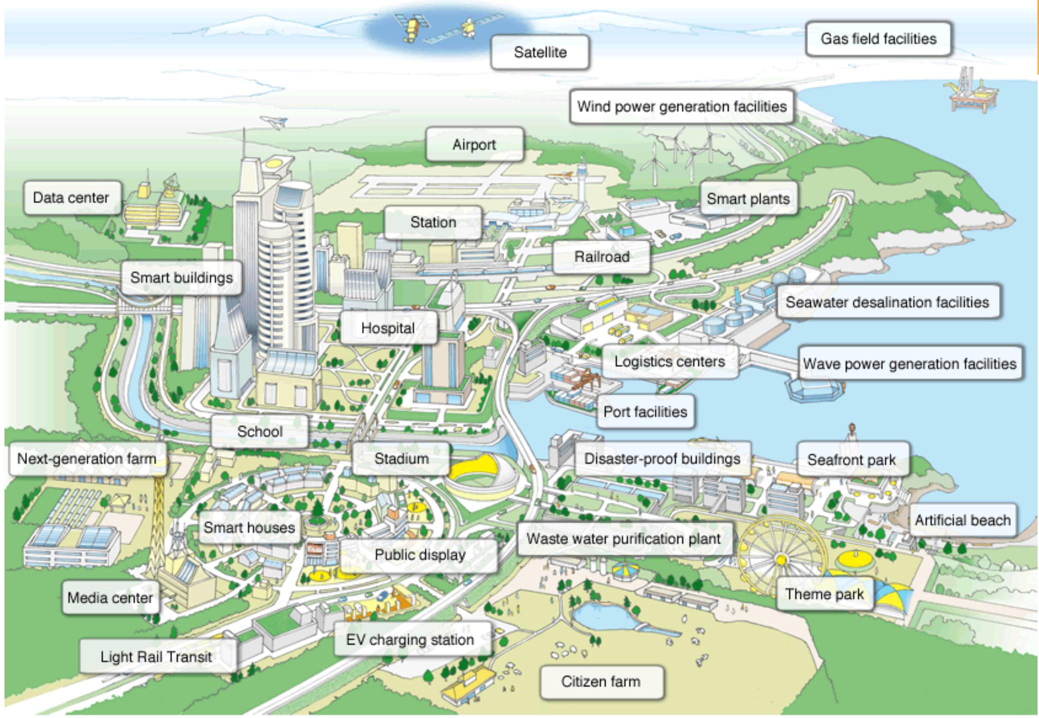

NEC’s vision of a smart city:
on a micro scale, a smart city has dedicated “functional areas”, e.g. living, recreational, work

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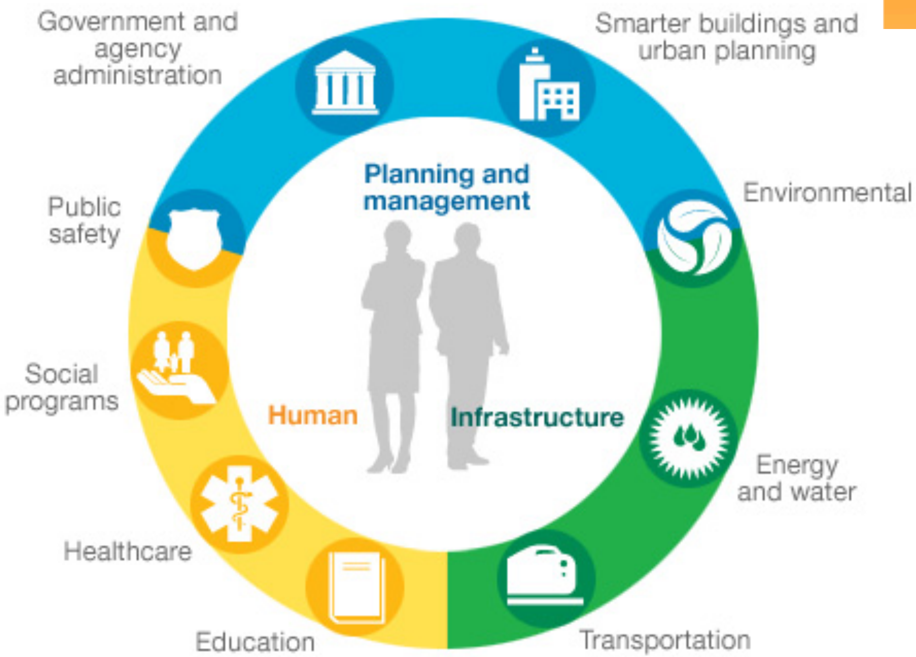

Three cornerstones of smart cities (IBM):
Planning & Management
Infrastructure
Human

Fraunhofer FOKUS addresses all three parts and **NGNI** provides the telecommunication-related research, development, and test-beds to industry and other research institutions

Marc Emmelmann -- emmelmann@ieee.org

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What does this mean for telecommunication?

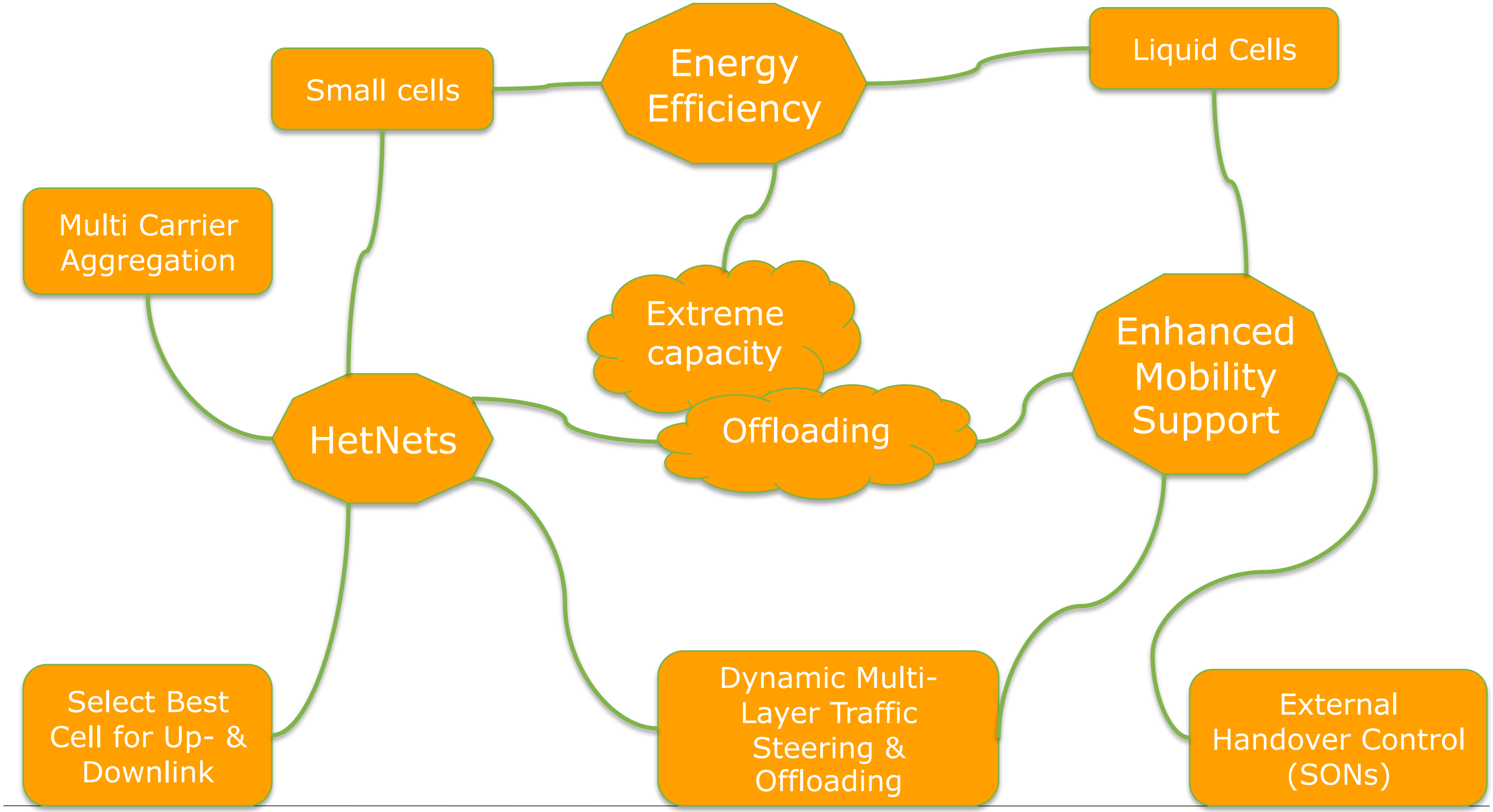
- Time- and location-based optimization of primary and secondary resources for telecommunication
  - Time- & location-based:
    - on a micro scale, population density changes over the day (business districts vs. recreational / living areas)
    - On a pico scale, current QoS constrains or user behavior can impact the choice of "right resources"
  - Primary: spectrum, link capacity
  - Secondary: energy (consumption)
- Extreme complexity in terms of
  - Resource demands towards the telecommunication network
  - Managing the networks

Research topics demanded by industry:
Who's in the Think-Tank ?

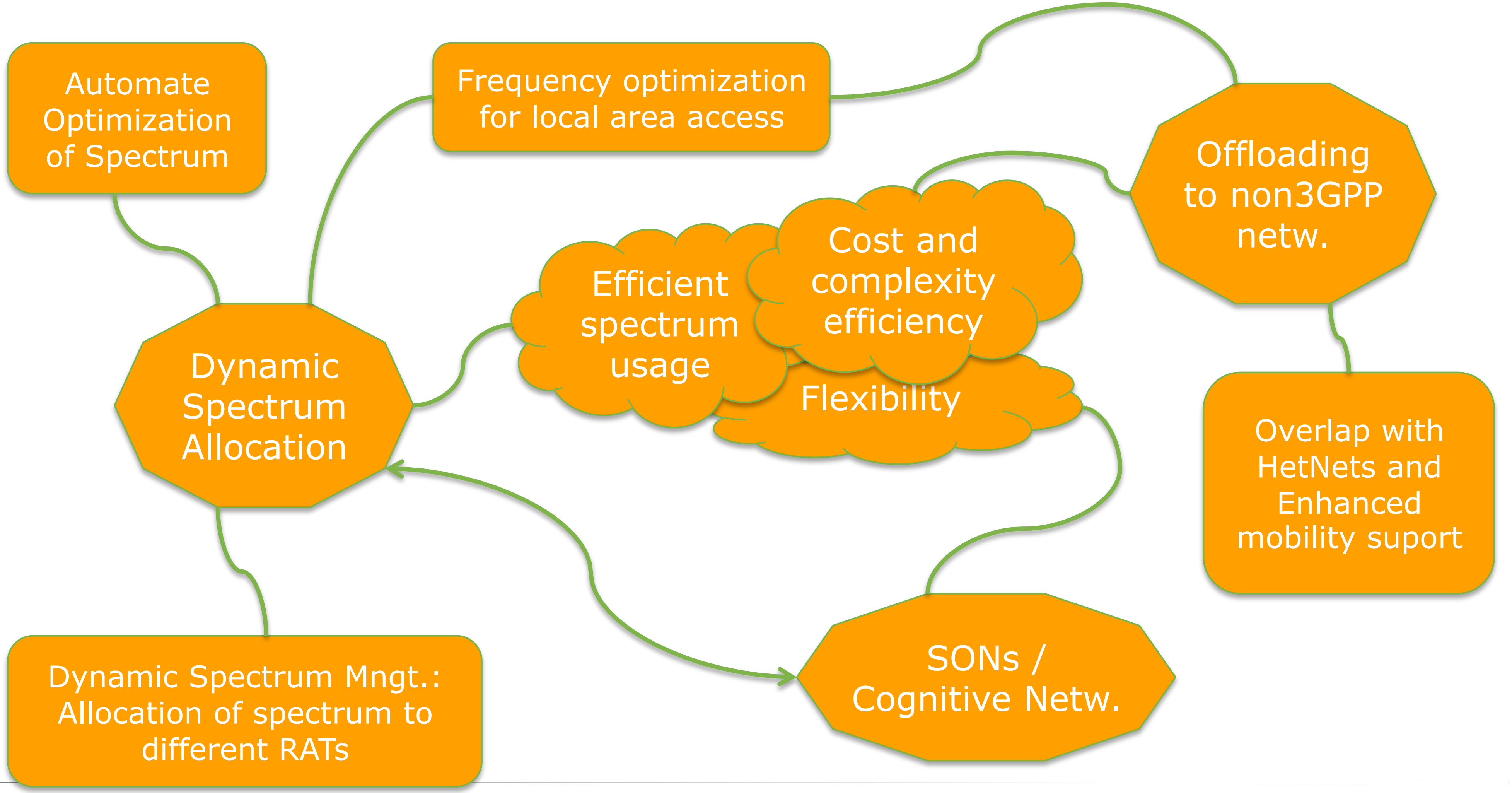
NGNI's R&D Vision maps to industry demands:
3GPP Workshop on 'Future Radio in 3GPP'

Requirements from the Industry's Perspective
"Location aware resource optimization"

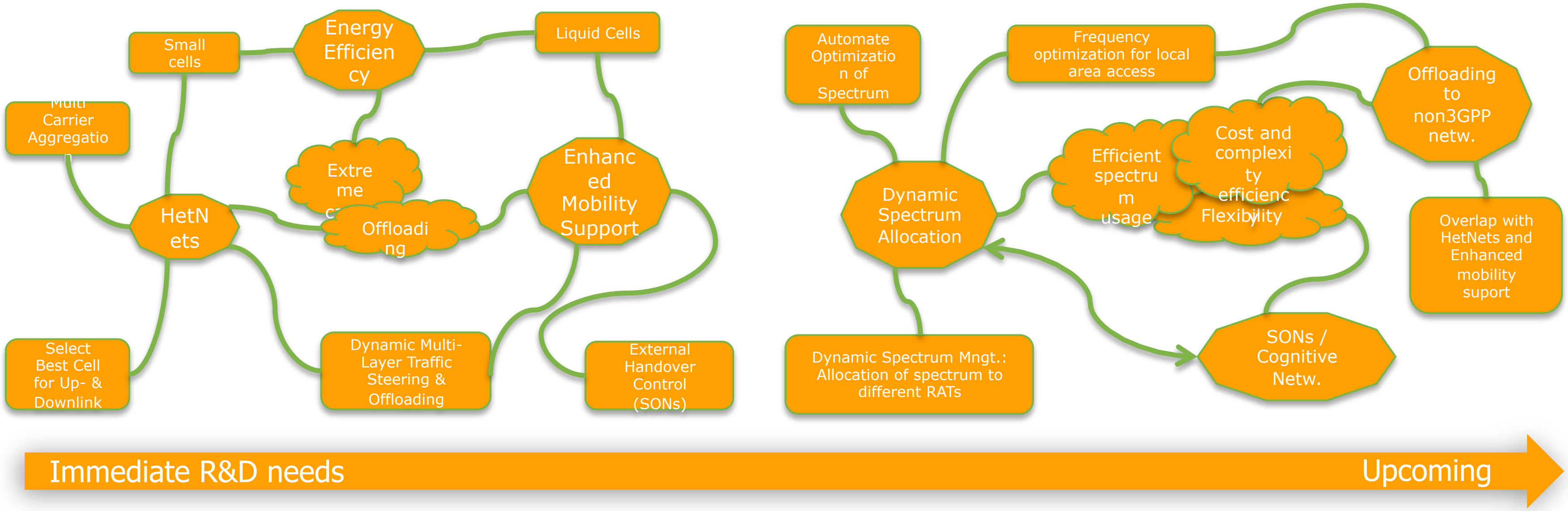
Location Aware Resource Optimization (1/2)
Short-Term R&D topics



Location Aware Resource Optimization (2/2)
Mid- & Long-Term R&D Topics



Selected R&D Highlights
NGNI's Tools & Testbeds for Smart City ICT



Offloading: Fast Initial Link Set-Up for 802.11

Extreme Capacity & Dynamic Multi Layer Traffic Steering: Network Virtualization Functions & Software Defined Networks

Dynamic Spectrum Access: Resource and Spectrum Manager

SONs & Network Management: Self-Growing Networks

Increasing Trust in orchestrated, self-managed network optimization

OpenMTC

OpenEPC

OpenSDNCore

OpenCTK

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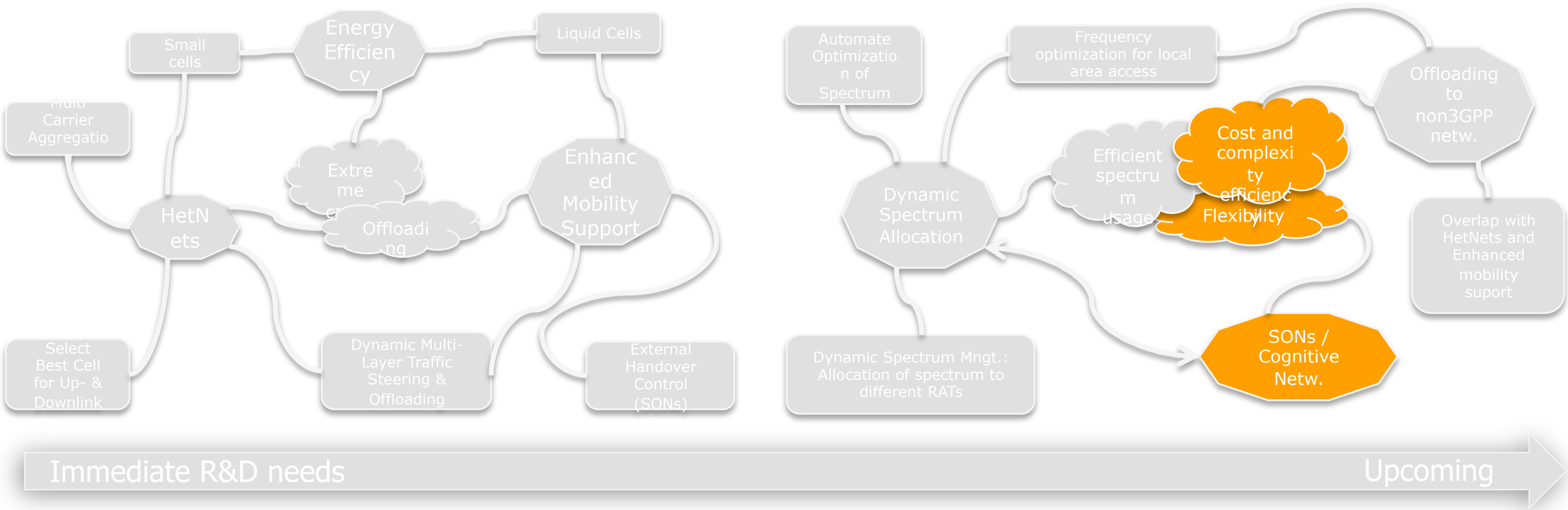

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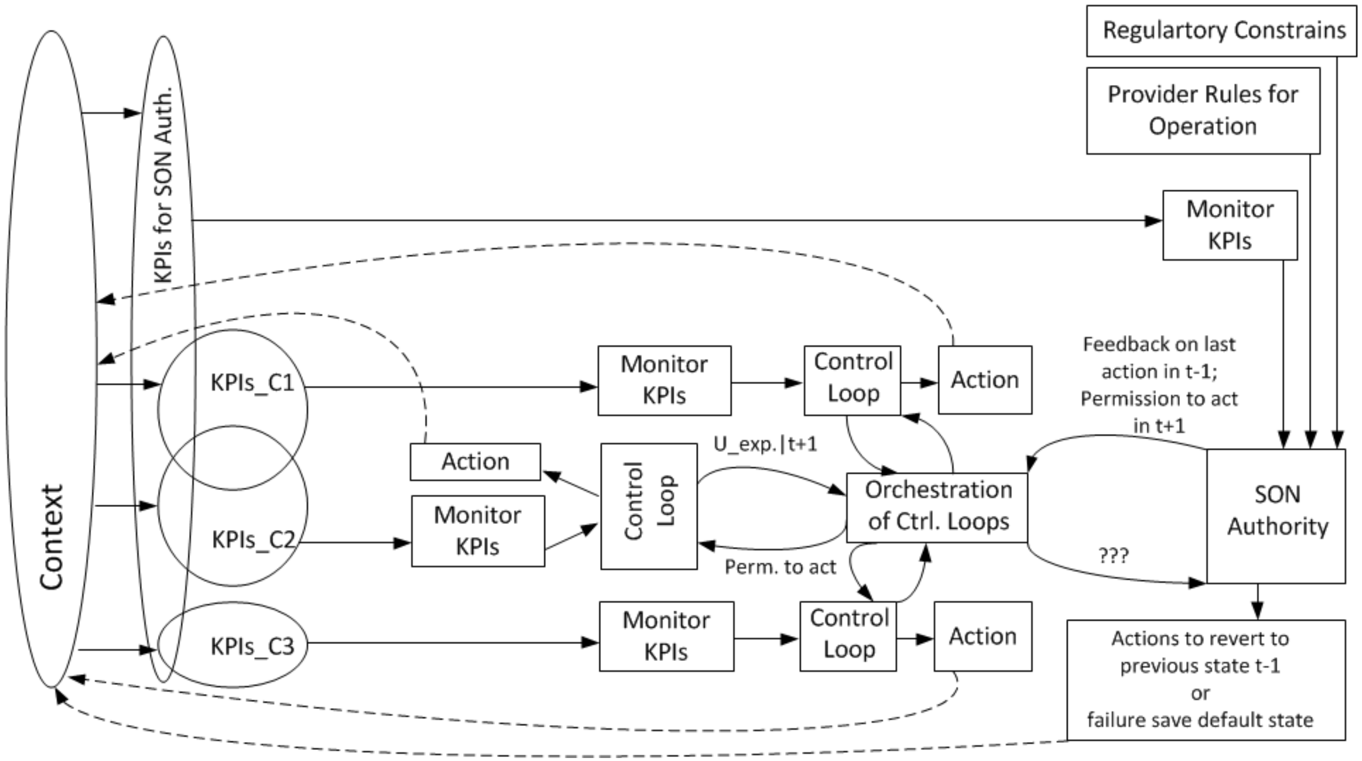
Increasing Trust in Self-Managed, Orchestrated Network Optimization

- One of the biggest issues we face when talking to network operators is that they do not trust automated / self-organized network optimization. Even though they know they need “artificial intelligence” to handle the complexity in network management, they still whised to handle network management by an (human) employee who can push the read button in case the network misbehaves. [R&D Vision exchange between Fred Backer (Cisco) and Marc Emmelmann and Julius Müller (FOKUS), July 2013]

- Way forward? SON Authority
  - interacts with Orchestration Ctrl. Loop
  - Ability to reestablish well behaving state (go back to nth previous configuration)
  - Failure-safe default set of configuration

- Driven by:
  - Regulatory Policies
  - Provider Policies



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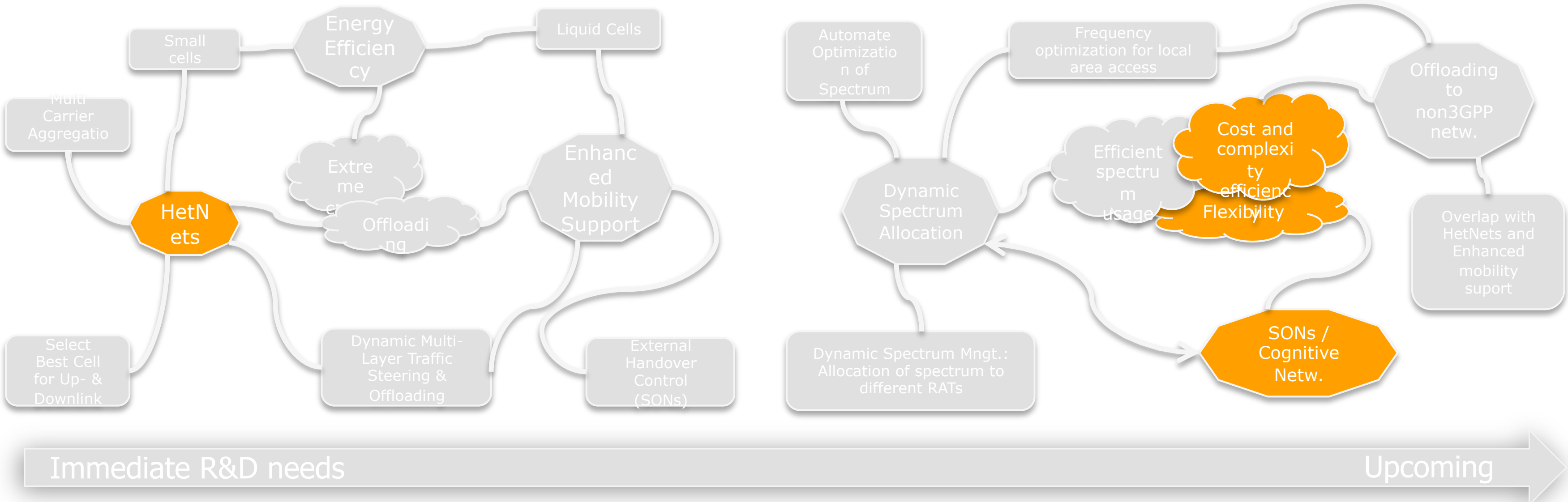

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SONs & Network Management:
Self-Growing Networks (Life-Cycle based network managing and repurposing)

A 'self-growing network' is considered a novel type of network composed of (heterogeneous) network nodes and sub-networks that can cooperate and utilize their reconfiguration capacity to optimize on-demand for a dedicated (temporary) purpose, also augmenting capacity by associating with additional nodes, networks, services and functions in that. In contrast to conventional self-organizing networks, a self-growing network is purpose-driven and is following a predetermined or dynamically adjusted life cycle.

- All life cycle components included:
  - Purposes: defined by network capabilities required to fulfill it
  - Transition points: intermediate, transient purposes enabling the activation of purposes
  - Transition rules
- Facts / context acquired by parsing received messages
- Evaluation of rules create facts that result in actions being trigged

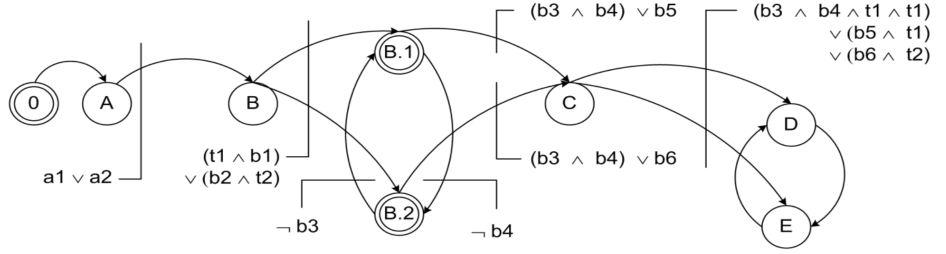
Purposes:
A: Facility Managment
B: Low confidence Fire Detection
C: High confidence Fire Detection
D: Notification of emergency responders
E: Triggering Evacuation of building

Progression Points:
0: Initialization
B1: Increase accuracy of temperature_reading_1
B2: Increase accuracy of temperature_reading_2

Facts:
t1: temperature_reading_1 > t_threshold
t1: temperature_reading_2 > t_threshold

a1: temperature_reading_1 available
a2: temperature_reading_2 available

b1: conf(temperature_reading_1) > conf_thr_low
b2: conf(temperature_reading_2) > conf_thr_low
b3: conf(temperature_reading_1) > conf_thr_mid
b4: conf(temperature_reading_2) > conf_thr_mid
b5: conf(temperature_reading_1) > conf_thr_high
b6: conf(temperature_reading_2) > conf_thr_high



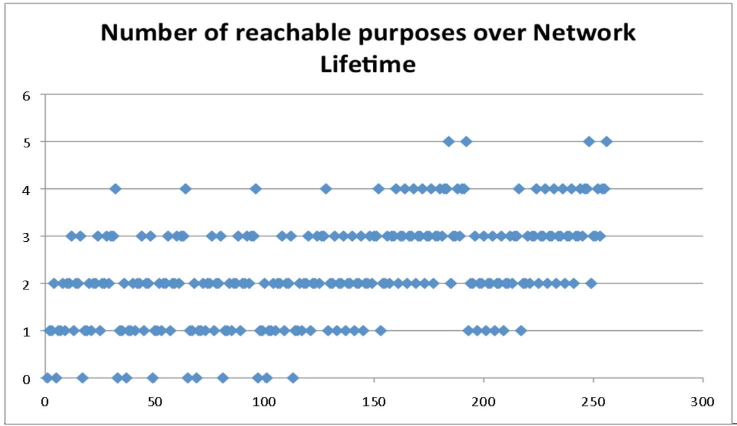
0 → A
A ∧ (a1 ∨ a2) → B

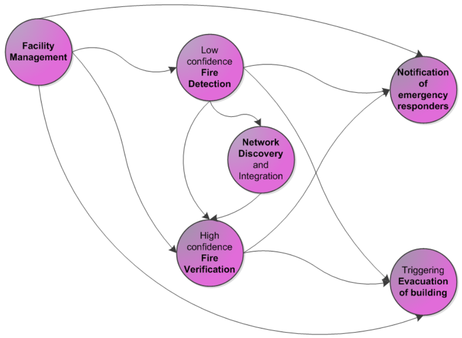
B ∧ ((t1 ∧ b1) ∨ (b2 ∧ t2)) → B.1
B ∧ ((t1 ∧ b1) ∨ (b2 ∧ t2)) → B.2
B.1 ∧ ¬ b4 → B.2
B.1 ∧ ((b3 ∧ b4) ∨ b5) → C
B.2 ∧ ¬ b3 → B.1
B.2 ∧ ((b3 ∧ b4) ∨ b6) → C
C ∧ ((b3 ∧ b4 ∧ t1 ∧ t1) ∨ (b5 ∧ t1) ∨ (b6 ∧ t2)) → D
C ∧ ((b3 ∧ b4 ∧ t1 ∧ t1) ∨ (b5 ∧ t1) ∨ (b6 ∧ t2)) → E

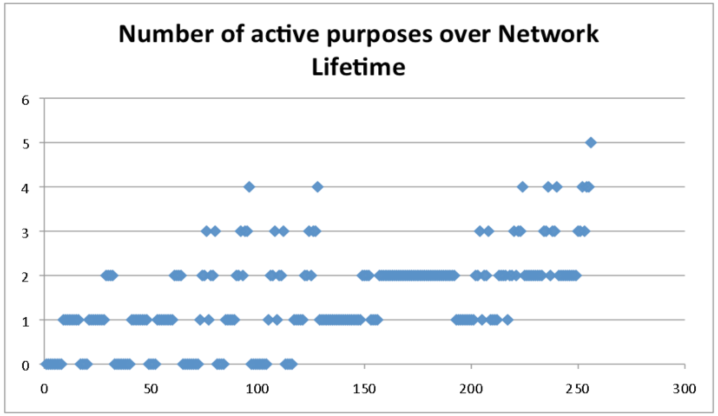
D → E
E → D

Verification of Self-Growing:
Realization of incident-driven purpose change

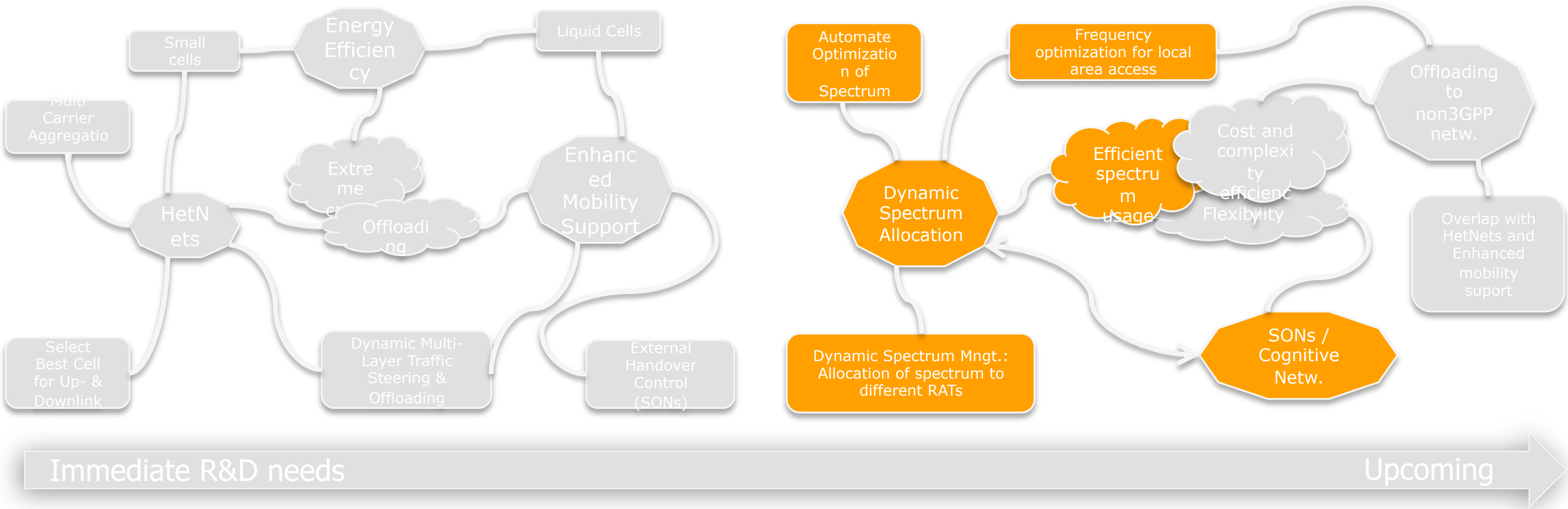
- Dynamically merge existing networks (cellular network, sensor networks, etc.) to handle an incident situation; here: detection of fire and building evacuation
  - Number of reachable purposes correlate with the self-growing process
  - The number of active purposes relates to the number of purpose changes of the network's life time
  - Considering all possible combinations of context evaluated by the life-cycle's rule set, we experience 67 purpose changes.
- Use of OpenCTK Toolkit







Selected R&D Highlights
NGNI's Tools & Testbeds for Smart City ICT



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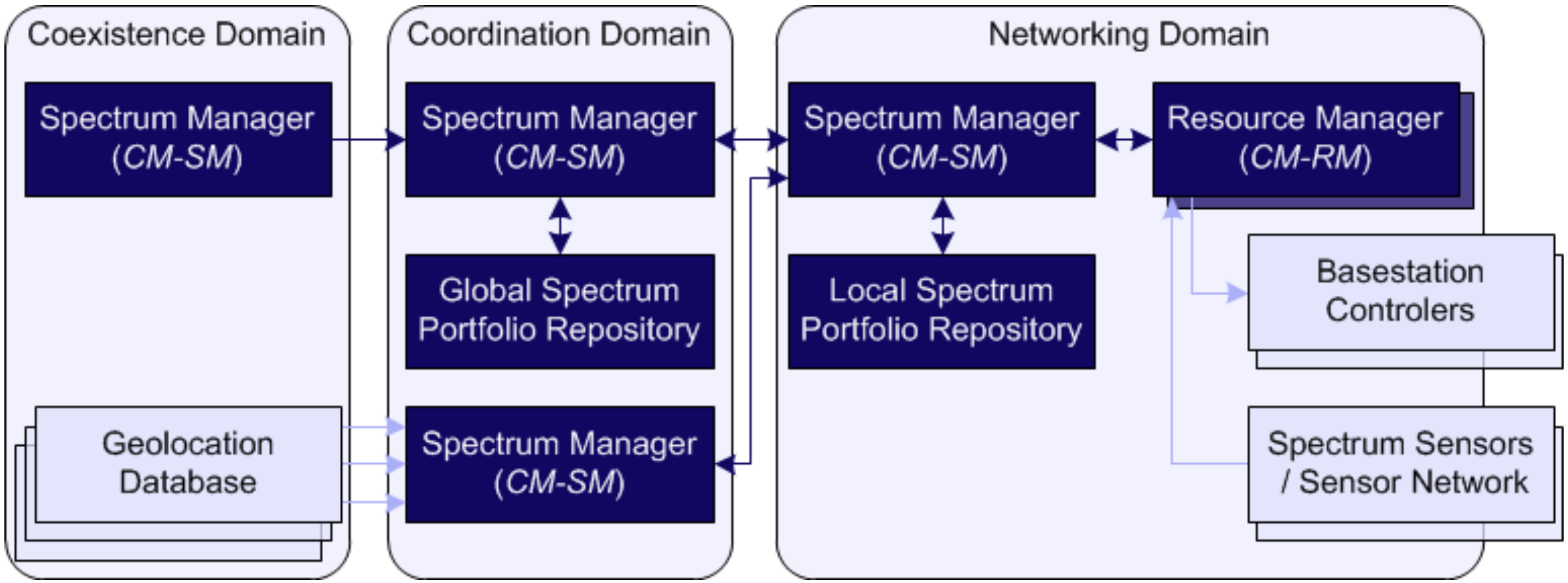
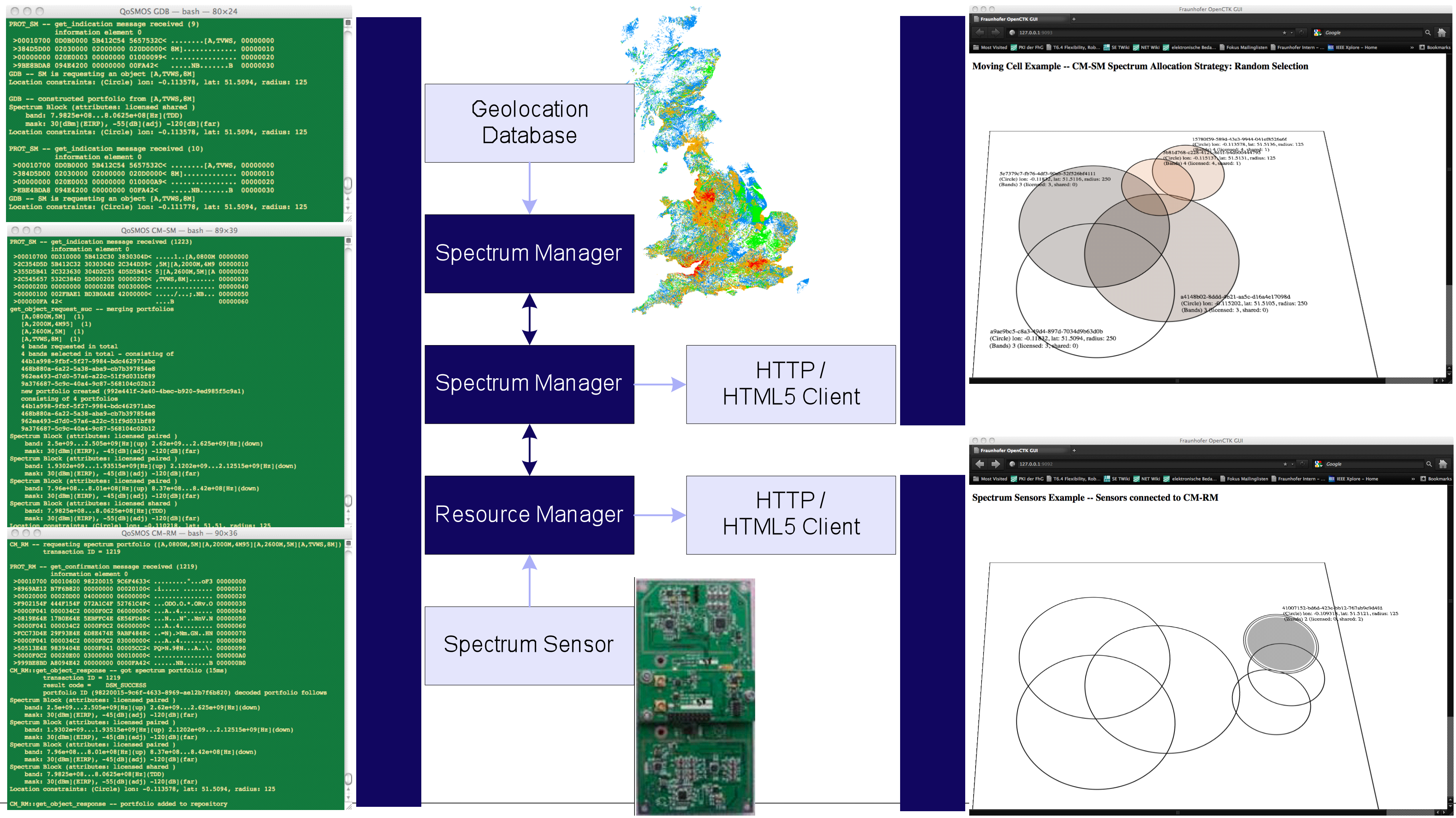
Dynamic Spectrum Access:
Managing Application

- Hierarchical spectrum managers including
  - Communication protocols and data structures (incl. spectrum database access);
  - Spectrum portfolios and portfolio repositories (incl. optimization strategies);
  - Spectral, spatial and temporal constraints for portfolios (i.e. policies).
- Utilizing the QoSMOS domain concept, implemented on top of OpenCTK.



DSA: Proof-of-Concept Implementation



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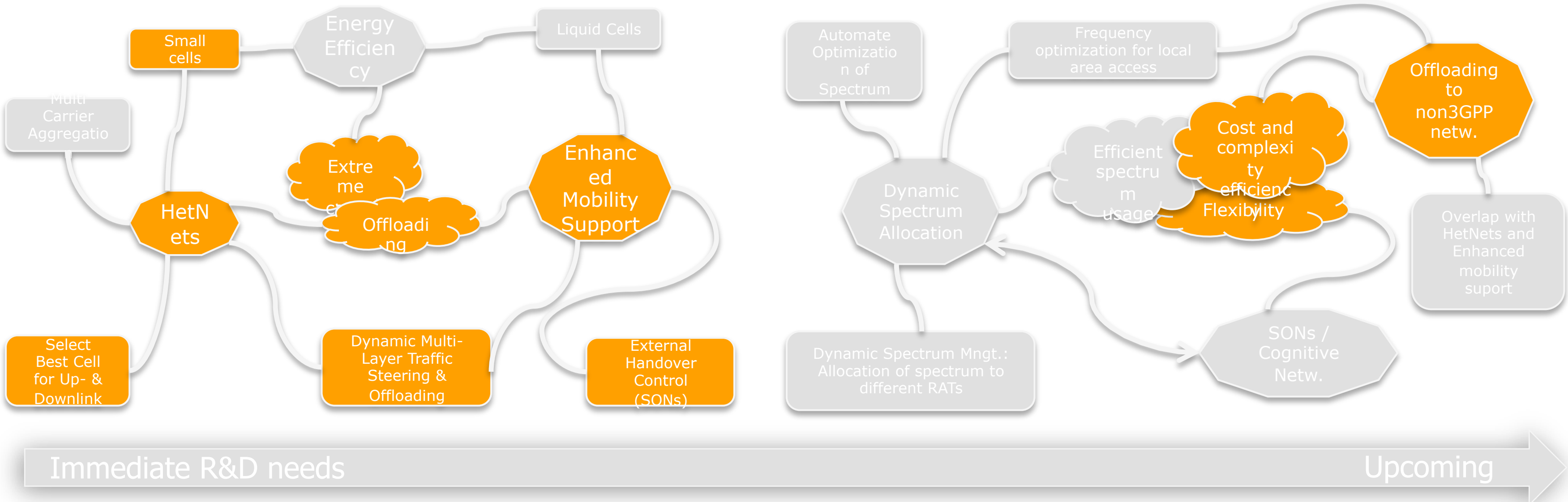

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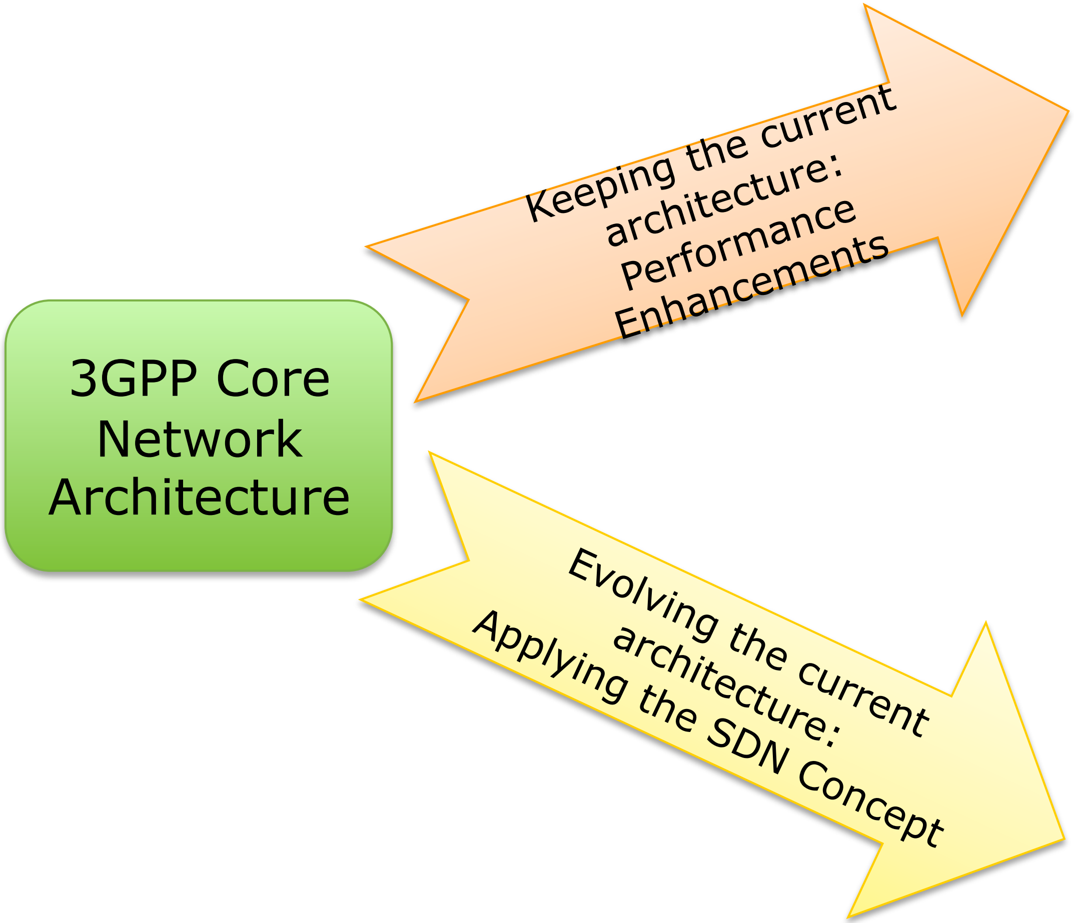
Extreme Capacity:
Core Network Evolution Strategies

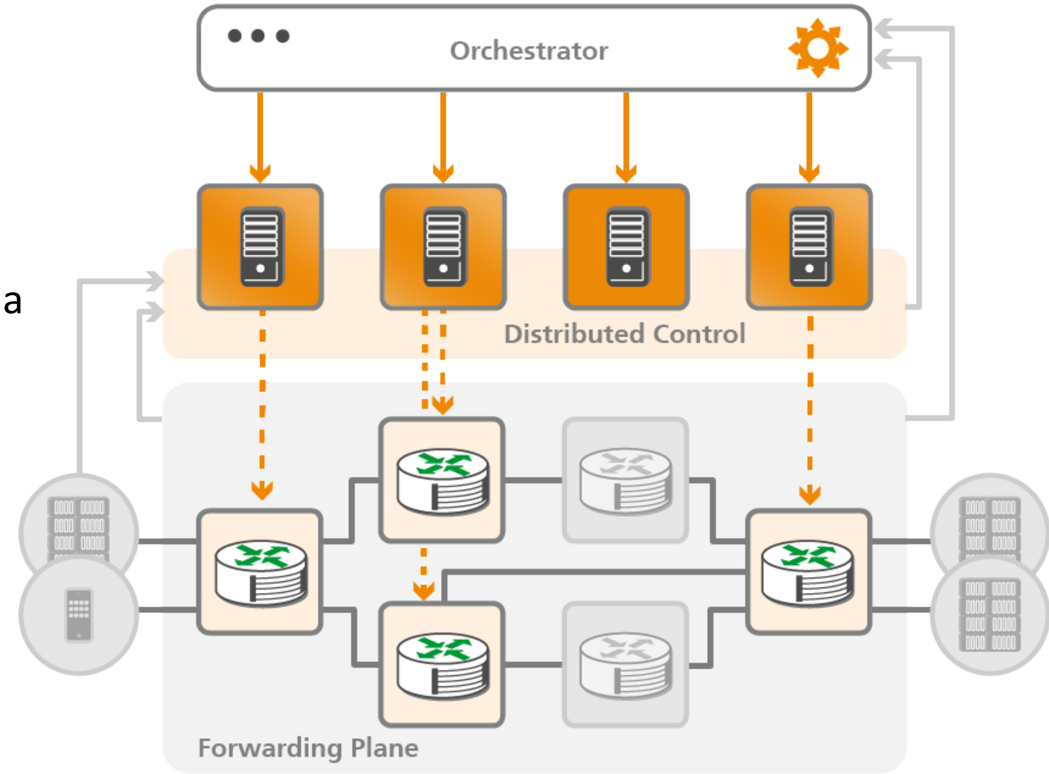


- Short term optimizations
- Enhancing capacity through improving system performance
- Overprovisioning: Adding additional redundant components for
- 3GPP Access- and core network congestion handling approaches

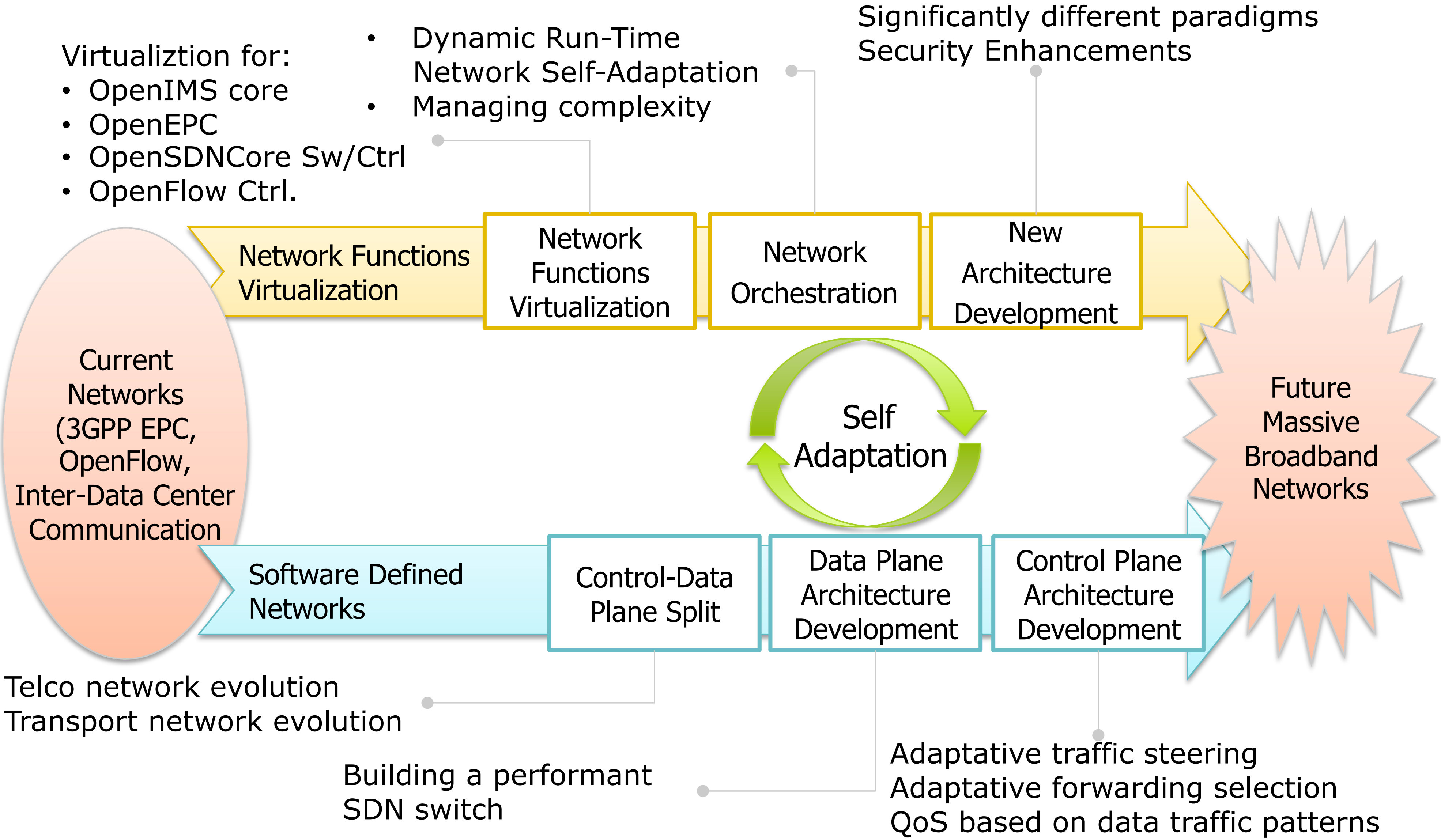
- SDN: Separation of data- and control-path
- Flexibility in controlling architecture components
- Elasticity in data- and control-path
- Smart usage of network resources

OpenSDNCore Scope

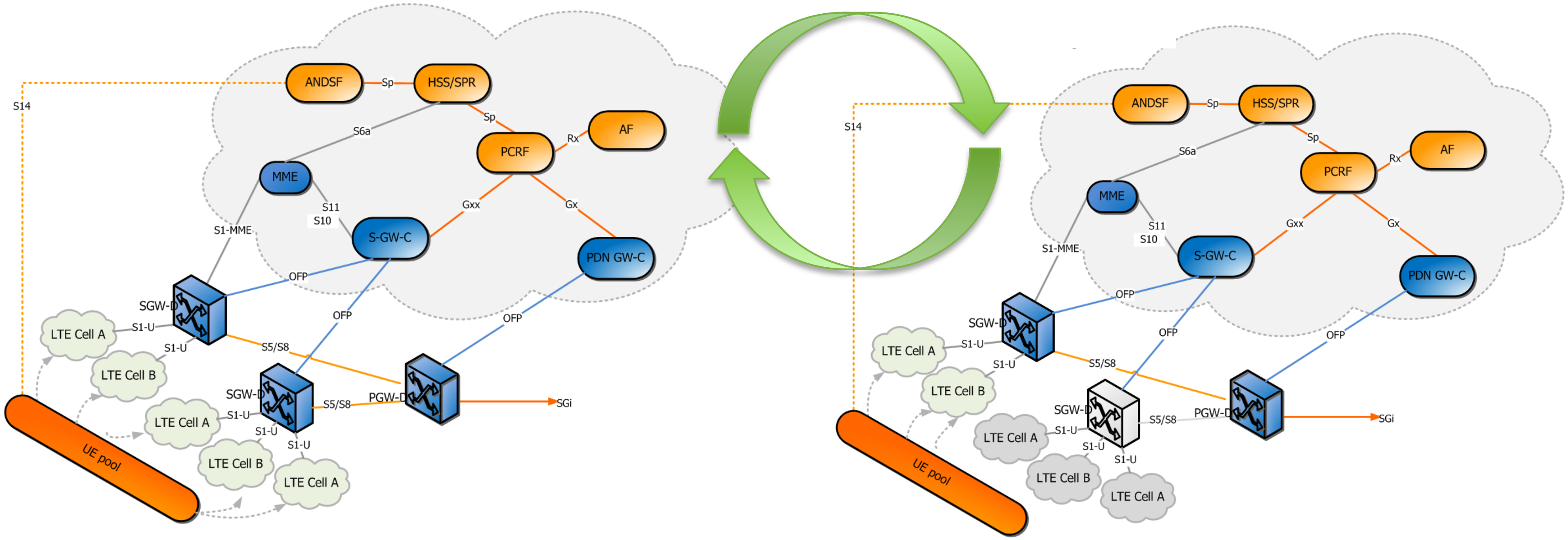
- To provide self-adaptable connectivity at the following levels
  - Data Path – providing the basis for developing novel forwarding mechanisms
  - Control Plane – integrating novel Internet and Telecom principles in a simplified modular manner
  - Orchestrator – self-adaptable network deployments



OpenSDNCore R&D Directions



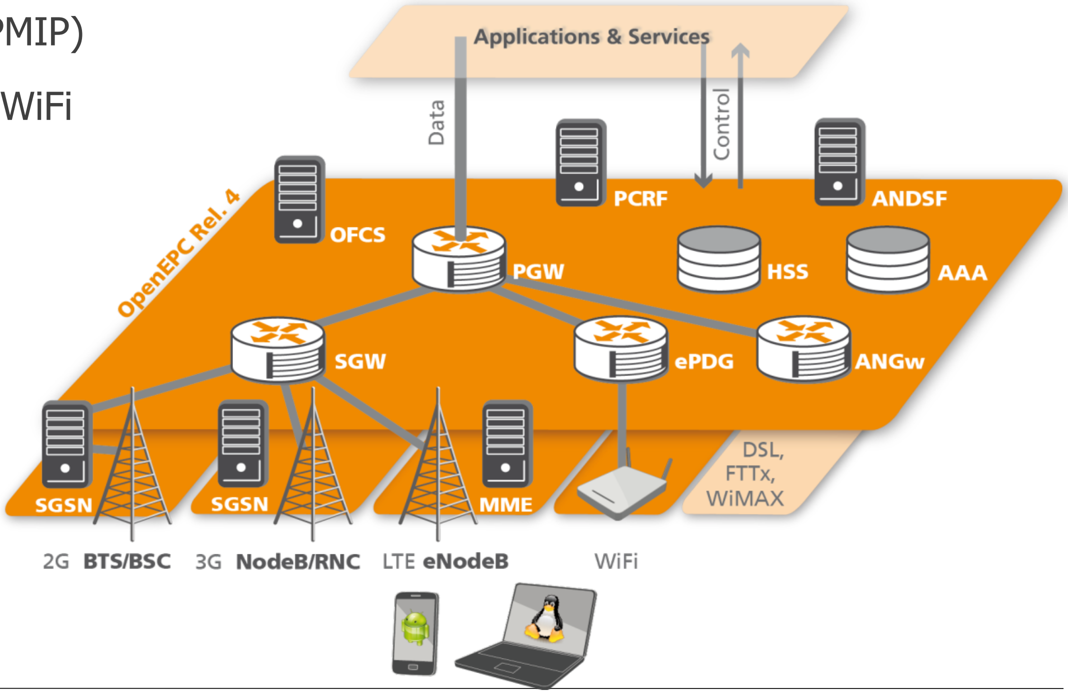
OpenSDNCore Control Use Case
Adapting data traffic paths to the flexible network topology



- Elastic data flow placement aligned on real-time network topology and network load situations
- Optimized data delivery through optimized data paths
  - Bandwidth availability and end-to-end delay
  - Flexibility due to outstanding functionality (Maintenance, failover, etc.)
  - Service location
  - Energy consumption of the access- and core-network

Building upon Existing Test Bed Experience
OpenEPC Rel. 4: Mirroring the Future Operator Core Network

- OpenEPC includes the main functions of 3GPP Evolved Packet Core (Release 8,9, 10, 11,...)
- The principles of standard alignment, configurability and extensibility have been respected in the overall architecture and in the specific components implemented
- OpenEPC Rel. 4 enables the establishment of small operator network testbeds including:
  - Core network mobility support (GTP, PMIP)
  - Integration with real LTE, 3G, 2G and WiFi
  - AAA for 3GPP and non-3GPP accesses
  - Policy and Charging Control
  - Access network selection
  - Common mobile equipment support



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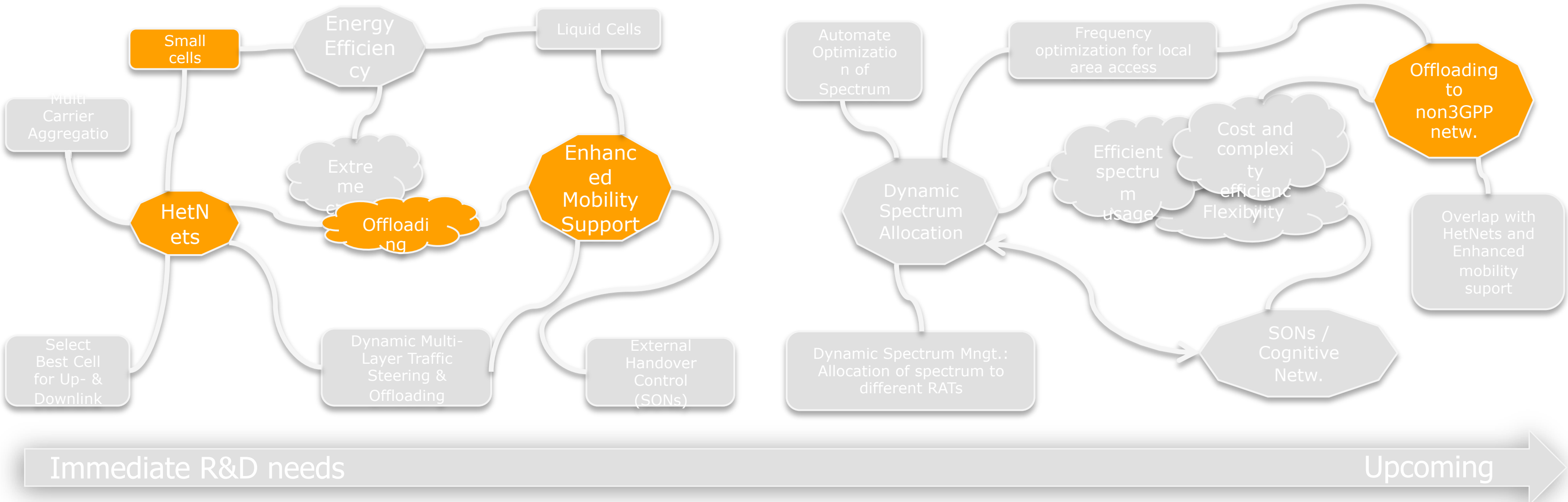

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Offloading: Standardizing past research on Fast Initial Link Set-Up

- Problem with 802.11 Link Set-UP
  - Discovery of networks as well as the association takes too long (up to several seconds)
  - Lots of users cross AP coverage area in short time

- Initial Research started more than 10 years ago
  - Parallel activities in Europe & Japan
  - Presented to IEEE 802.11

- New IEEE 802.11 Project to standardize solutions

- ➔ more informtion in the dedicated talk on TGai in the afternoon.

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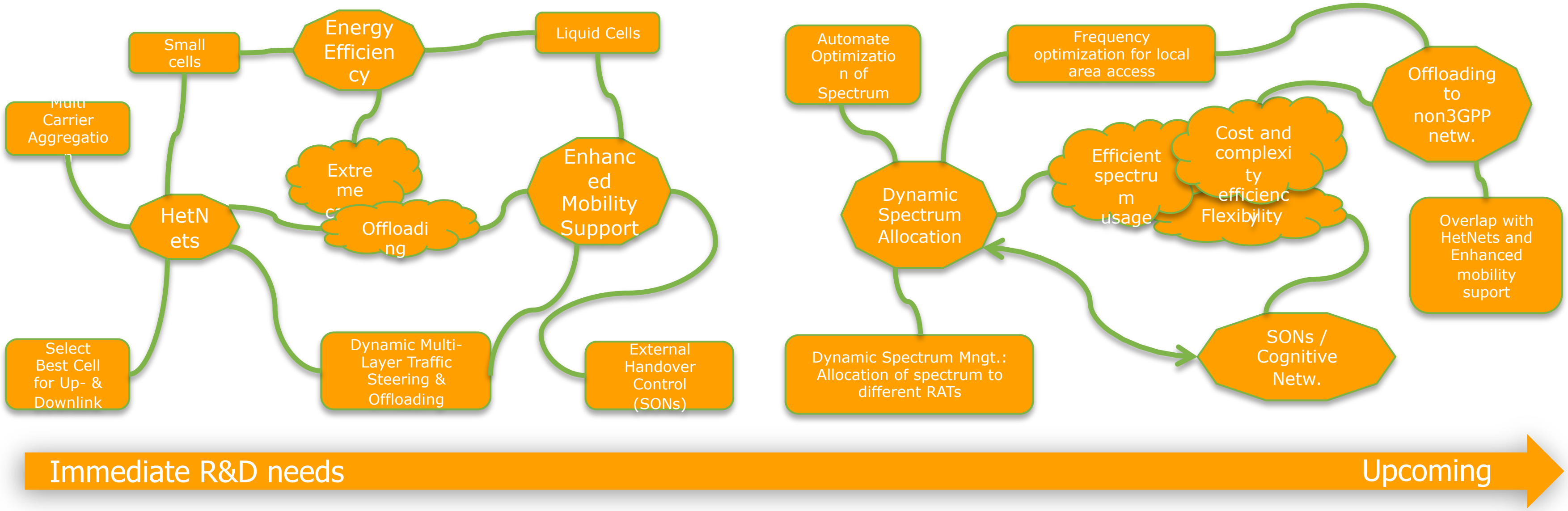

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Summary
A discussion statement at the end

Even when working on single-topic solutions, keep in mind that they have to be managed / orchestrated eventually.

Handling the complexity – on a large and small scale – is the biggest challenge for upcoming telecommunication networks

Further Questions?
Contact & Further Information

Marc Emmelmann – emmelmann@ieee.org

- Download this presentation at: http://emmelmann.org/Pages/Publications.html
- Self-Growing in Incident-Driven Purpose Change (video documentation of proof-of-concept implementation and demonstration), http://goo.gl/as89wl
- Testbed & Toolkits
  - OpenEPC, http://www.openepc.net/
  - OpenSDNCore, www.opensdncore.org
  - OpenIMSCore, www.openimscore.org/
  - FOKUS Open SOA Telco Playground, www.opensoaplayground.org/
  - NGN to Future Internet Evolution, NGN2FI, www.ngn2fi.org/
  - Fraunhofer FOKUS – NGNI, www.fokus.fraunhofer.de/go/ngni/

4th FOKUS „Future Seamless Communication“ Forum (FFF)
Berlin, Germany, November 28-29, 2013

FUSECO Forum 2013
FUTURE SEAMLESS COMMUNICATION

- **Theme: „Smart Communications Platforms for Seamless Smart City Applications – Fixed and Mobile Next Generation Networks Evolution towards virtualized network control and service platforms and Seamless Cloud-based H2H and M2M Applications“**

- FUSECO FORUM is the successor of the famous FOKUS IMS Workshop series (2004-09)
  - FFF 2010 attracted 150 experts from 21 nations
  - FFF 2011 was attended by around 200 experts from 30 nations
  - FFF 2012 was attended again by around 200 experts from 30 nations

- See **www.fuseco-forum.org**

Workshop 3:

"Evolution of the Operator Networks beyond EPC: SDN and NFV"

References

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