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5G Network Slicing Management for Challenged Network Scenarios

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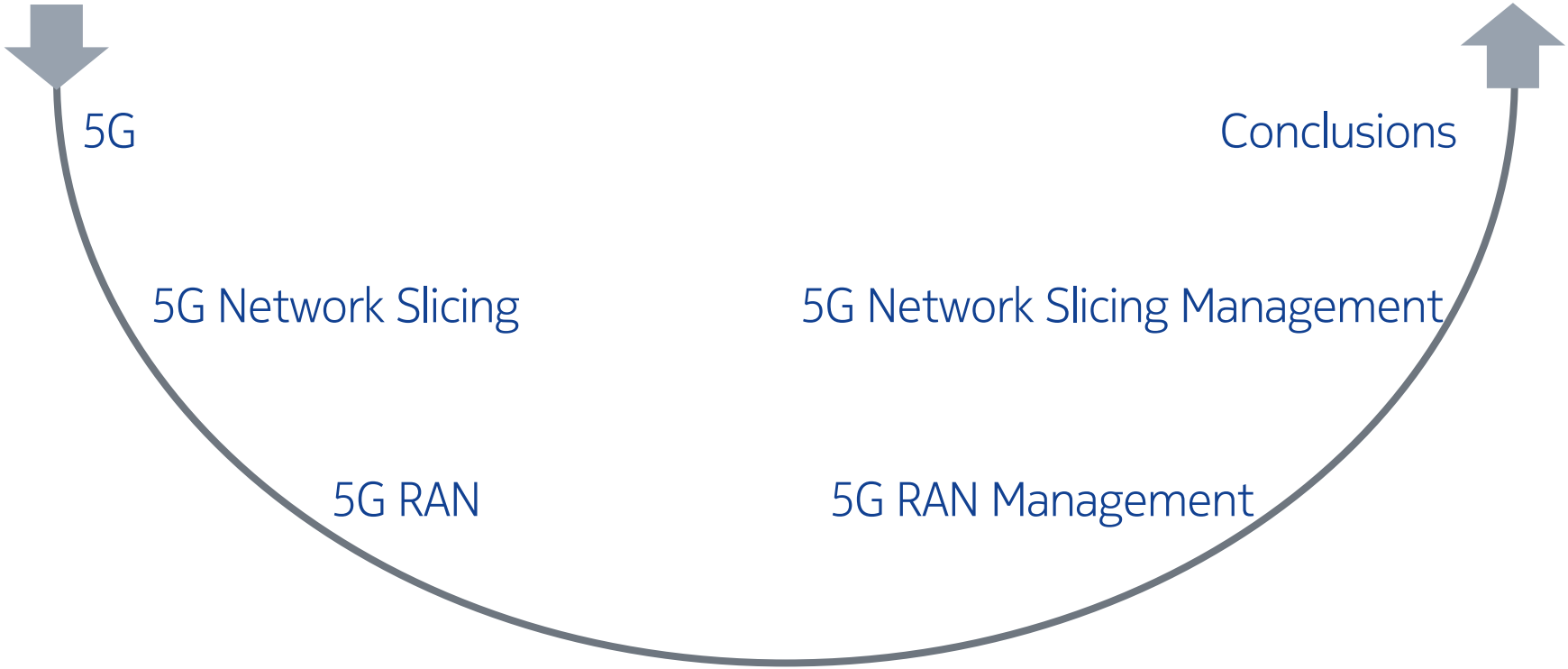
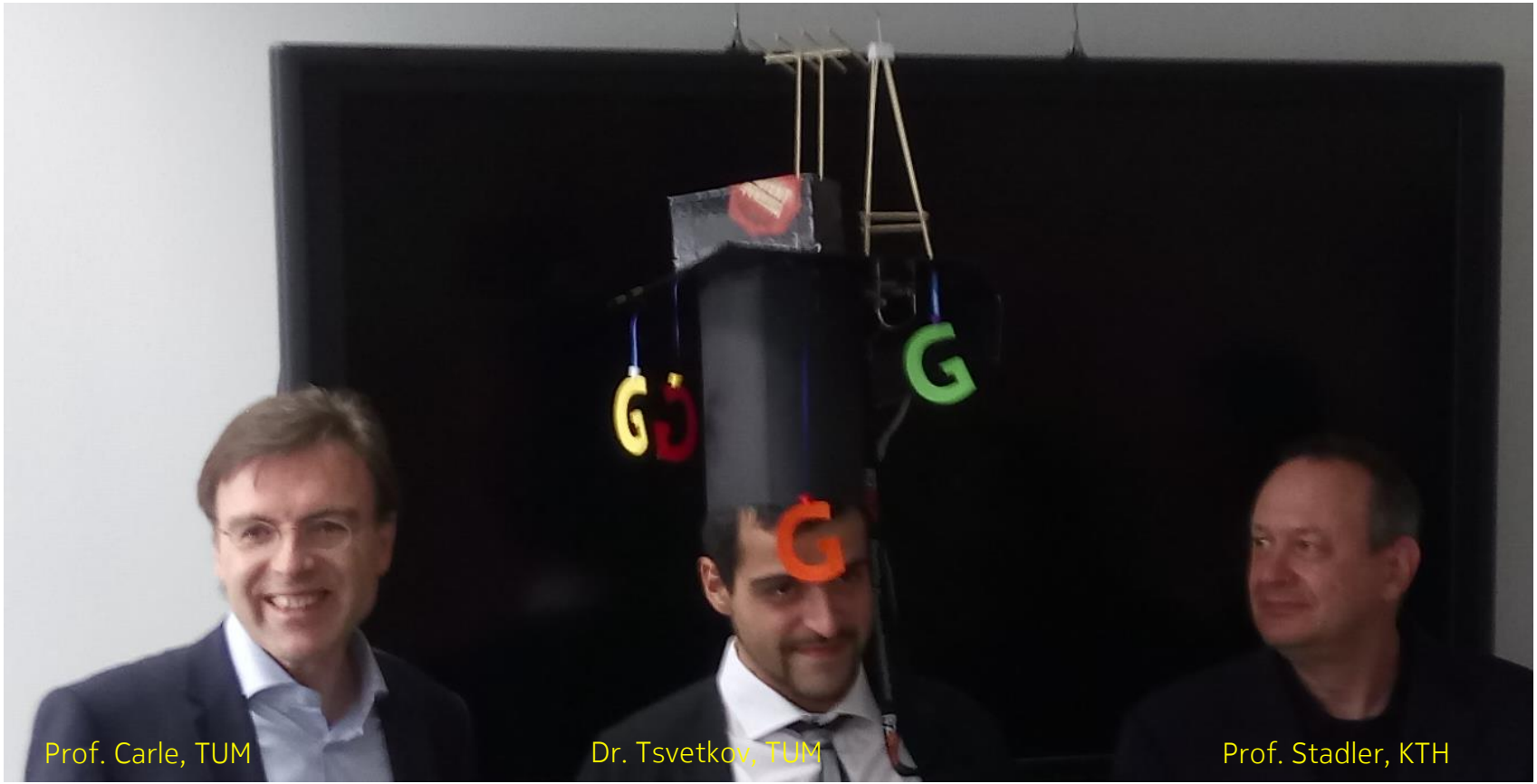
Outline



5G: just yet another “G” ?



5G Cellular Networks

New user demands with extremely diverse requirements

Devices
1.5 GB/day

Smart Factories
1 PB/day

Billions of sensors
connected

Autonomous driving
1ms latency

Capacity

>10 Gbps
peak data rates

100 Mbps
whenever needed

10 000
x more traffic

Latency

1,000,000
devices per km²

<1 ms
radio latency

Ultra low cost
for massive
machine coms.

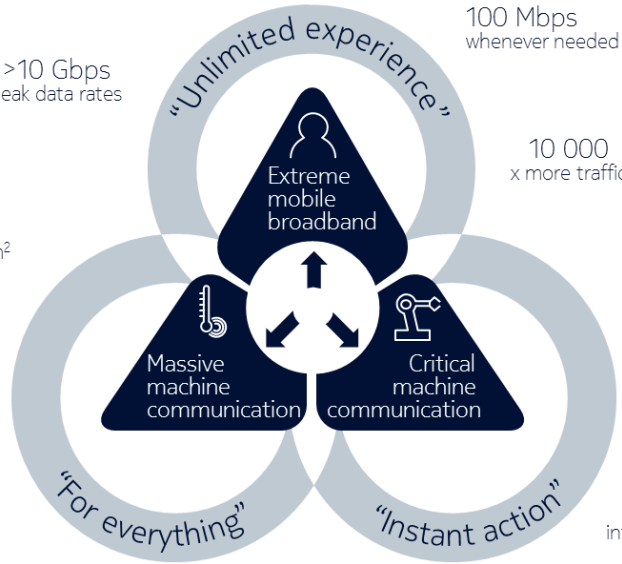
Ultra
reliability
< 10^{-5} E2E outage

Connectivity

10 years
on battery

Zero
mobility
interruption

Reliability



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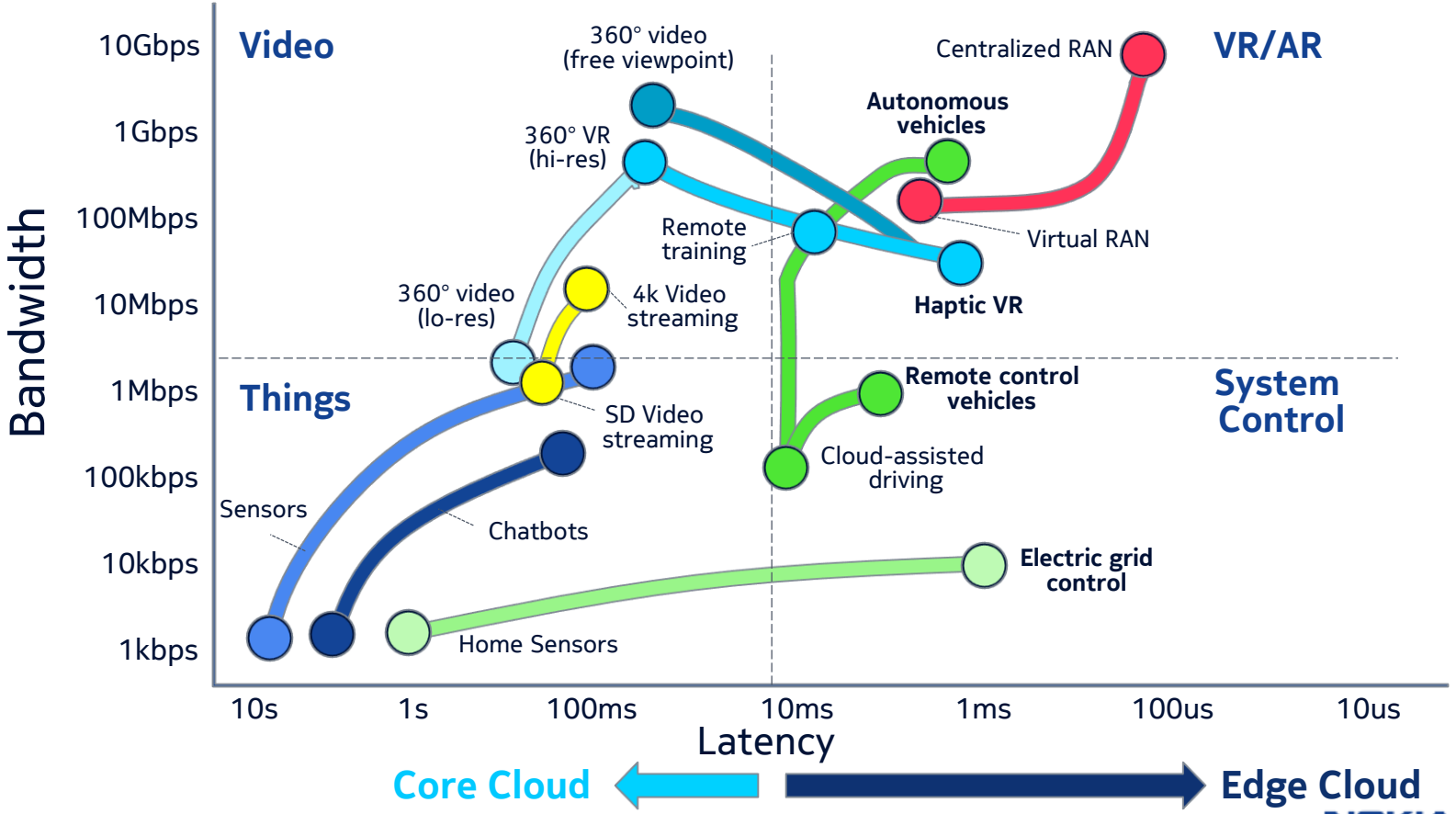
5G: Diversity of Use Cases - The 4 Key Business Value Dimensions



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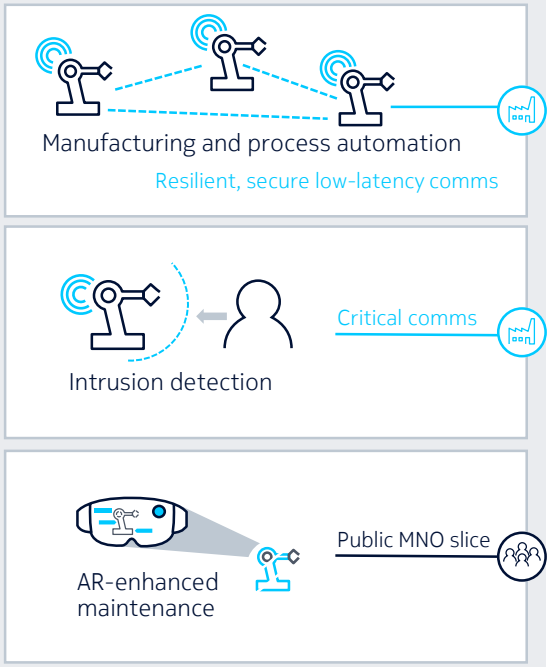
5G challenged network scenario: Industrial Internet / Industry 4.0

Resilient, secure low-latency communication



Wireline connections today

>90%

Low / deterministic latency
<1ms; 99.999% reliability

Inherent security
by dedicated network slices

Single company network
for all kinds of industrial applications

Business case

Overall costs for greenfield
2-5 times lower

# of sensors ↗
=
Payback period ↘

Break even for wireline replacement
1 year

Reconfiguration cycle ↘
=
Payback period ↘

Benefits

Removing cost
of cabling installation and maintenance

Less reconfiguration time

Less production capacity overprovisioning

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Slicing

https://www.pexels.com/photo/wheat-bread-slices-166021/
http://tvtropes.org/pmwiki/pmwiki.php/Main/InventorOfTheMundane
https://www.telekom.com/de/konzern/details/network-slicing-485774

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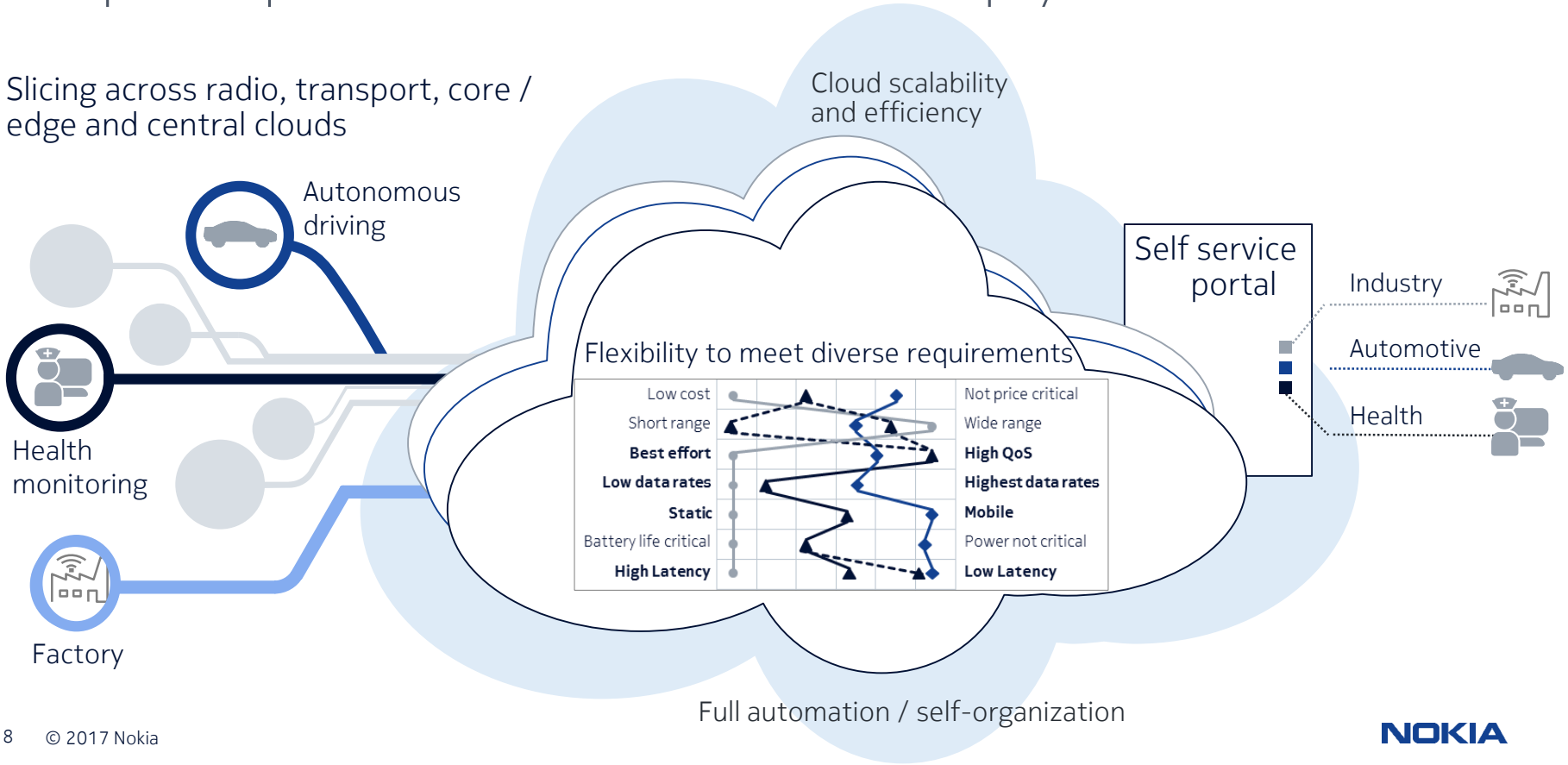
5G Network Slicing | Optimized service delivery for heterogeneous use cases

Multiple independent network instances on one physical network



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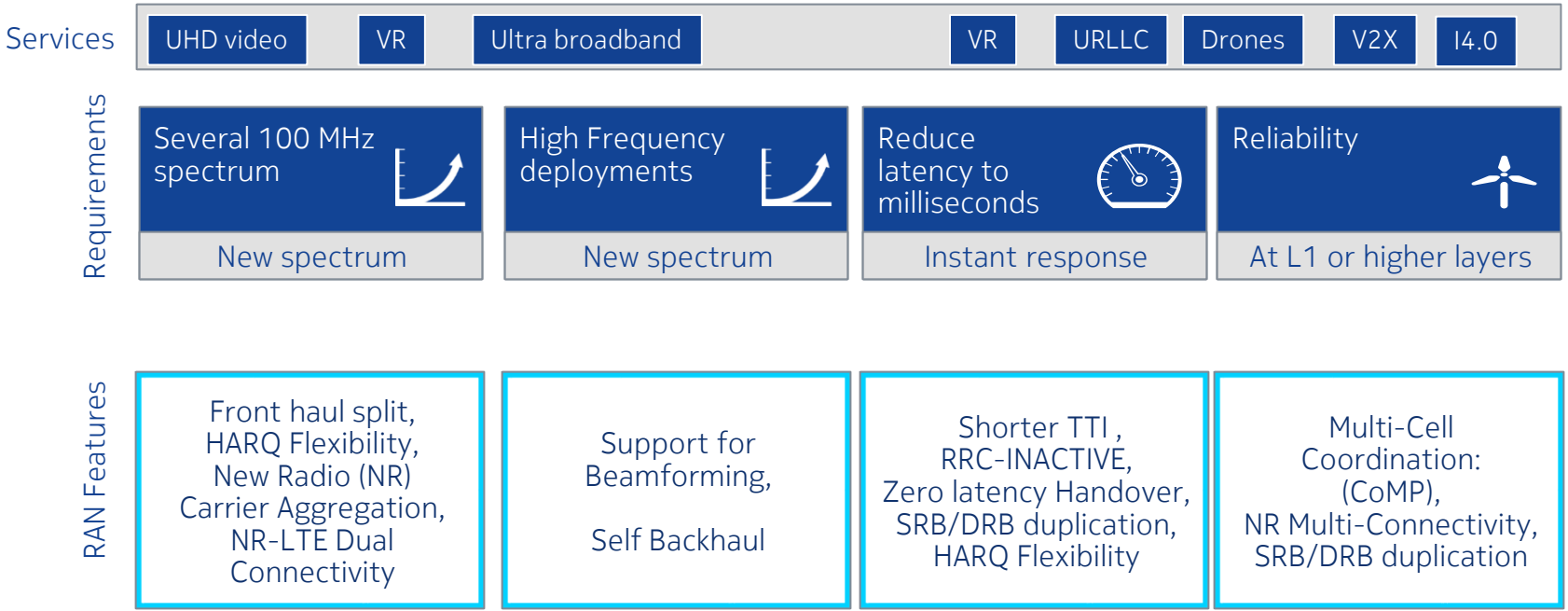
Different use case requirements → different slice characteristics

	SMF/Control Plane Capacity	Mobility Frequency	UPF/ Forwarding Capacity	Latency Challenge	Resiliency need
Smart Meters 	LOW	LOW	LOW	LOW	LOW
Car to Car 	HIGH	HIGH	LOW	HIGH	HIGH
Fixed Wireless 	LOW	LOW/None	Ultra HIGH	MEDIUM	MEDIUM
Mobile Broadband 	MEDIUM	HIGH	MEDIUM	MEDIUM	MEDIUM
Industrial IoT 	LOW	LOW	HIGH	HIGH	HIGH

SMF: Session Management Function

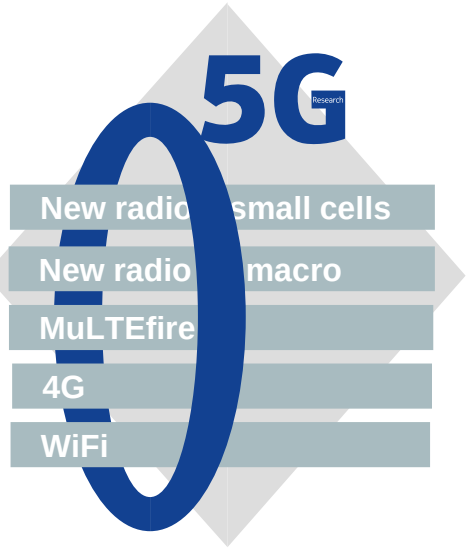
UPF: User Plane Function

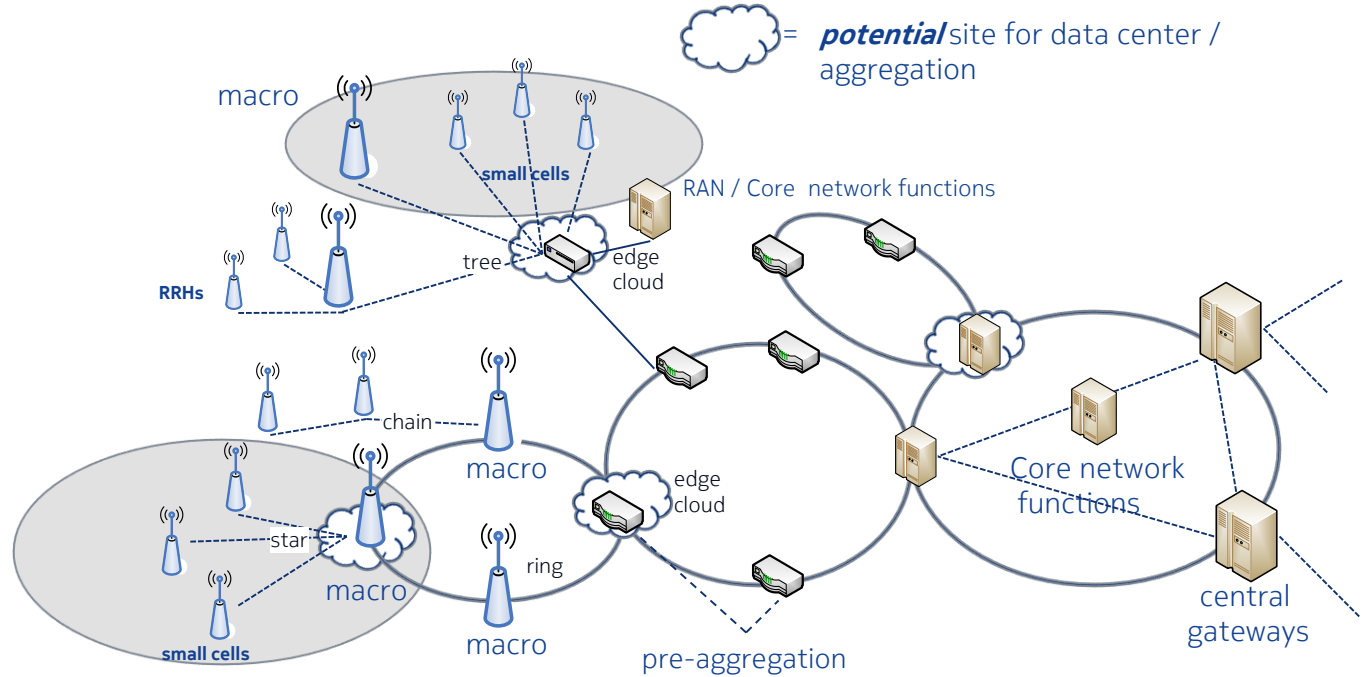
5G RAN: Requirements and Features



SRB/DRB: Signaling / Data Radio Bearer

5G RAN structure





Heterogenous environment:
- Multi-RAT, multi-layer
- Small cell ←→ cloud RAN
- Physical and virtualized Network Functions
- Multi-vendor

Distance and latency to radio access increases

x100.000 small cells	x10.000 macro sites	x1.000 pre-aggregation sites	x100 aggregation sites	x10 central gateways

→ Very flexible, but also very complex RAN structure

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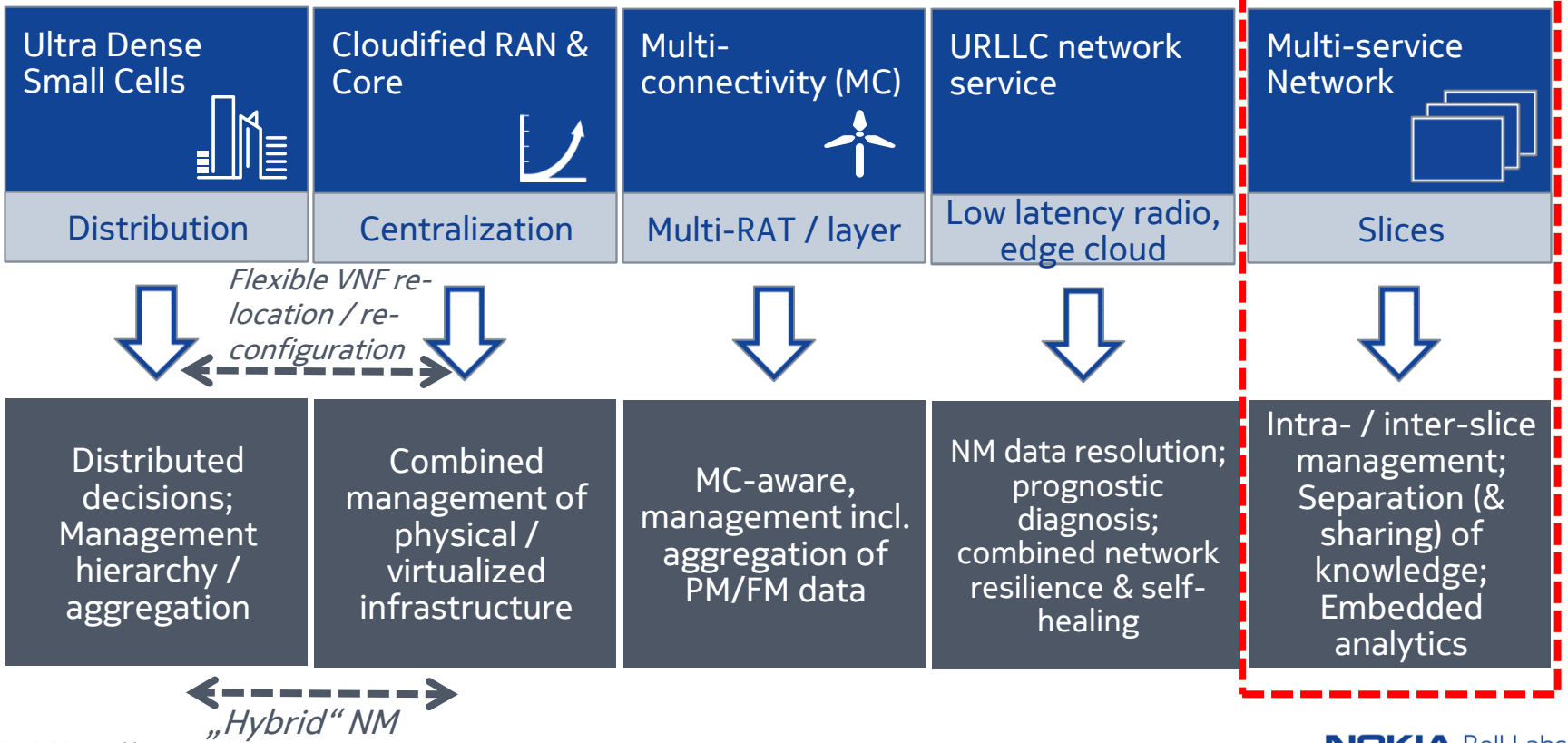
5G RAN Management
Addressing the challenges



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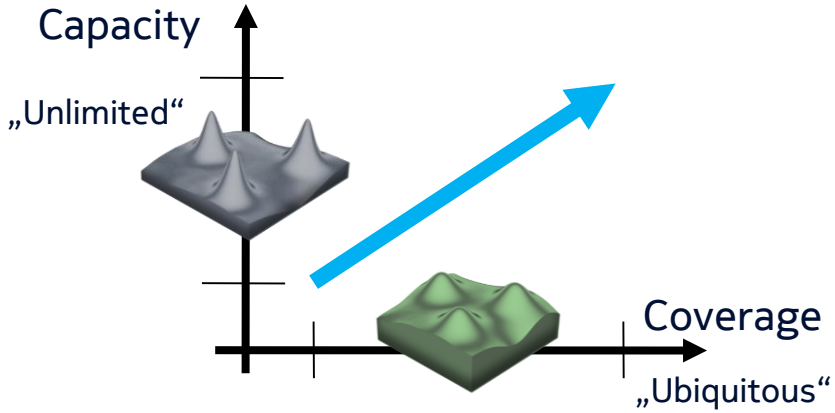
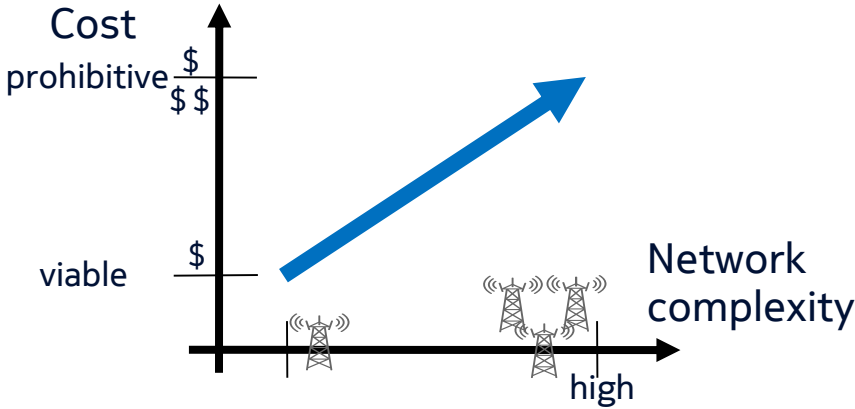
5G RAN Management: Opportunity vs. Risk

Opportunity: ubiquitous, unlimited connectivity for a wide range of services



Risk: complexity of the network infrastructure (dense small cells, mixed physical / virtualized infrastructure)



Characteristic: Scale (# users, # applications)
Manifestation: network usage data

Characteristic: Scale (# cells, # (V)NFs)
Manifestation: network operation data

Cognition: drive opportunity, limit risk by “mastering data” → mastering complexity

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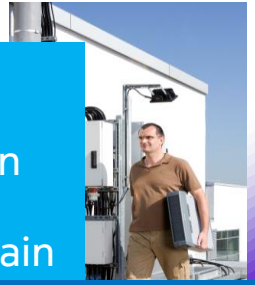
Cognition & Self-Organization

applied to infrastructure networks ?

Cellular macro network
- Tightly planned, infrequent physical topology changes, automated operation
- Single operator
- Single vendor equipment per OAM domain

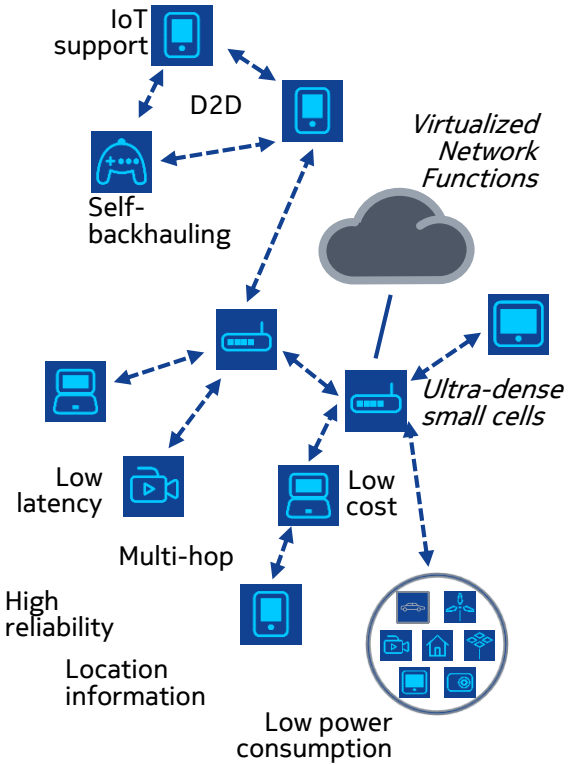


5G Cellular Heterogeneous Network
- Some parts only coarsely planned, frequent virtual topology changes, highly automated operation
- Multi-tenant (shared infra)
- Multi-vendor per domain

Ad-hoc / mesh network
- Uncoordinated deployment, frequent physical topology changes, autonomous operation
- Only node operator
- Open environment, standardized protocols between nodes

"Self-organization is a process where the organization (constraint, redundancy) of a system spontaneously increases, i.e., without this increase being controlled by the environment or an encompassing or otherwise external system." (F. Heylighen, Principia Cybernetica Web, 1997)

5G RAN Management



5G

New radio – small cells

New radio – macro

MuLTEfire

4G

WiFi

verticals

Cognitive Network Management System
(multi-vendor, multi-tenant)

Optimization

Troubleshooting / Healing

Configuration

Analytics

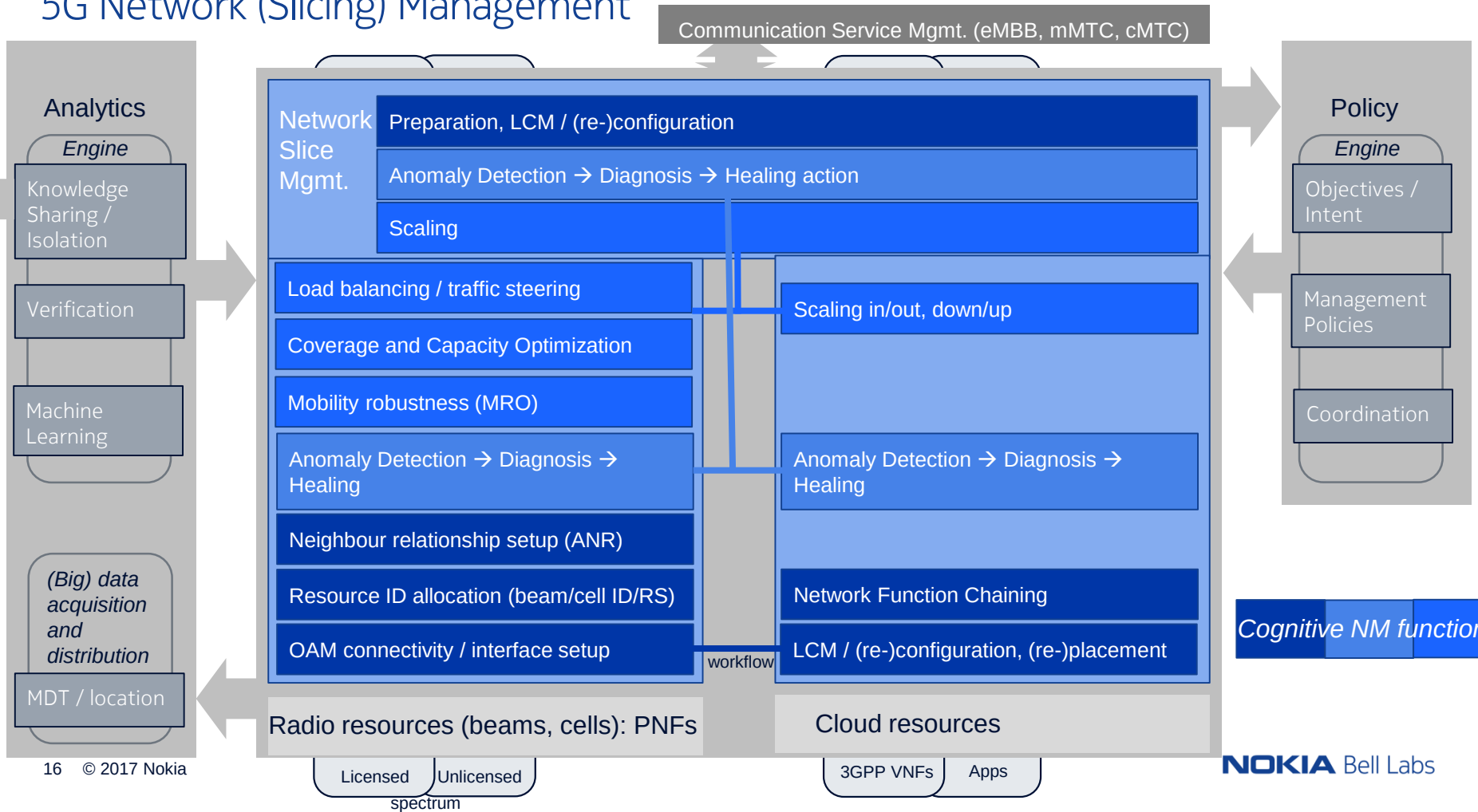
Policy

(Trained) telco-centric knowledge models & context

network data

(challenged) network scenarios

5G Network (Slicing) Management



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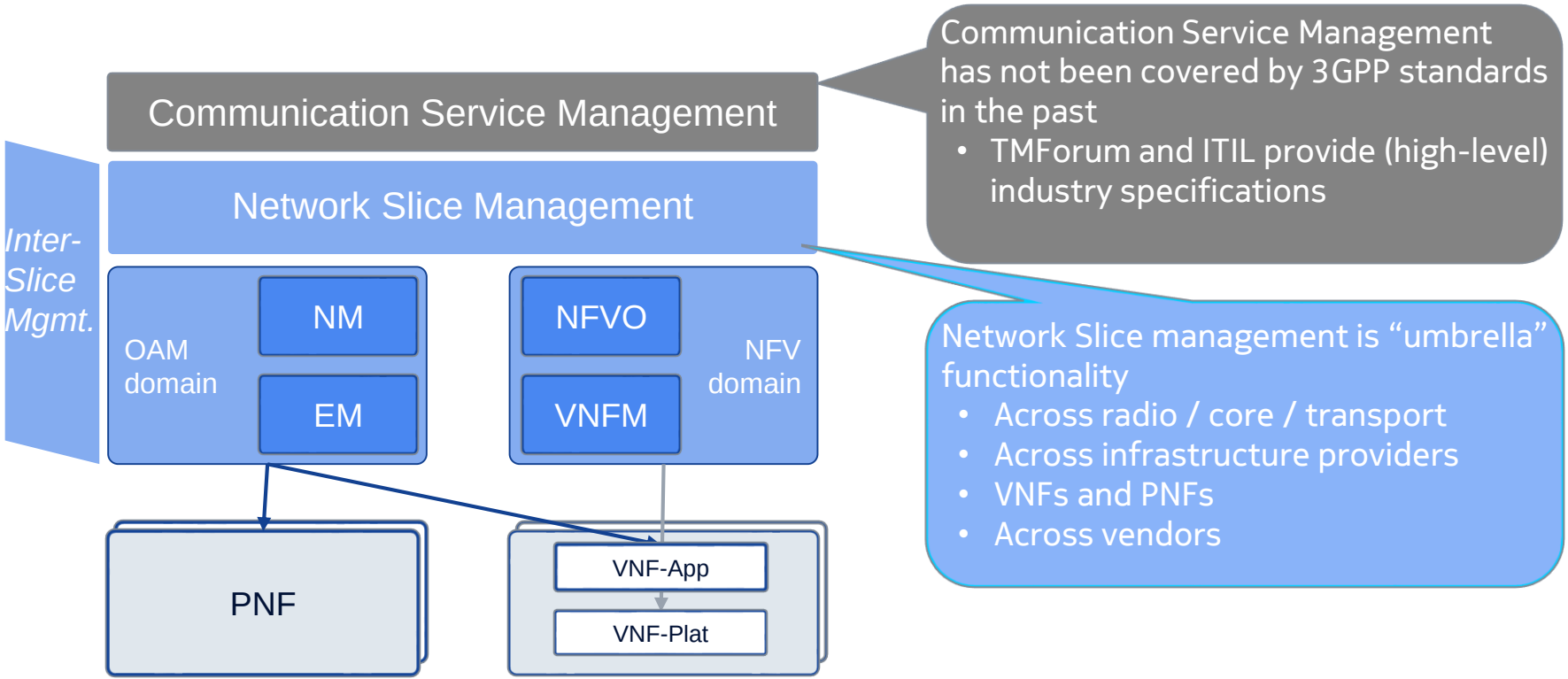
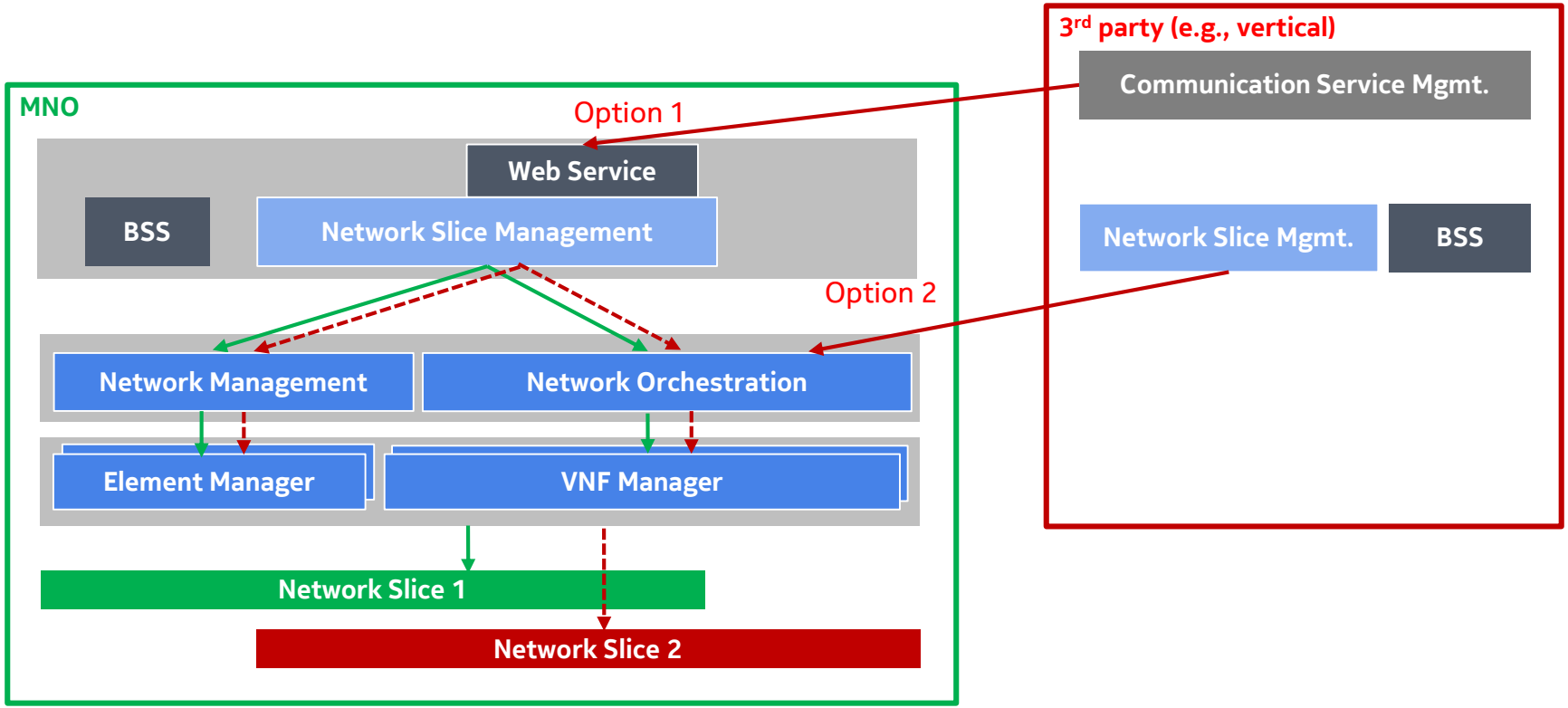
5G Network Slicing Management: system architecture



Depth of control and entry levels of 3rd party



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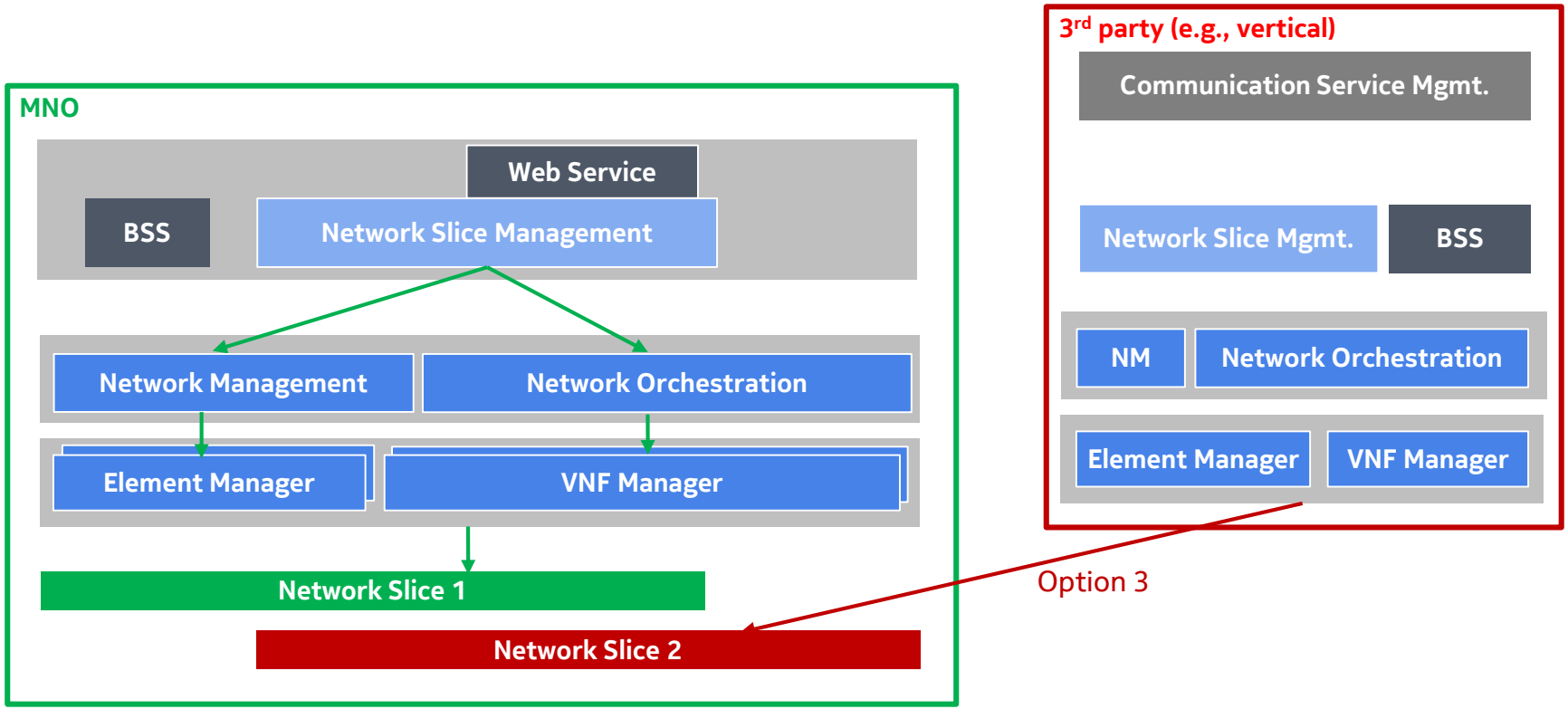
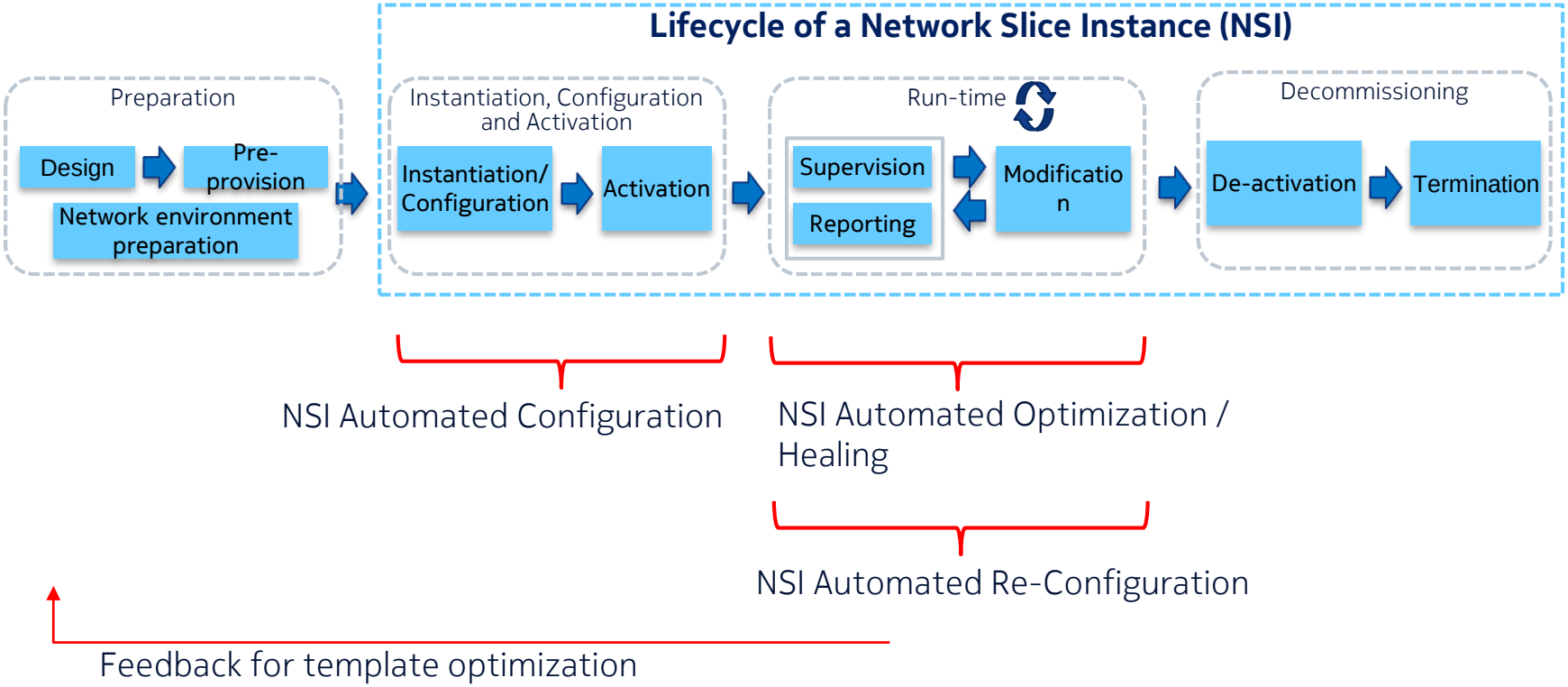
Depth of control and entry levels of 3rd party



Network Slice Lifecycle
3GPP 28.801



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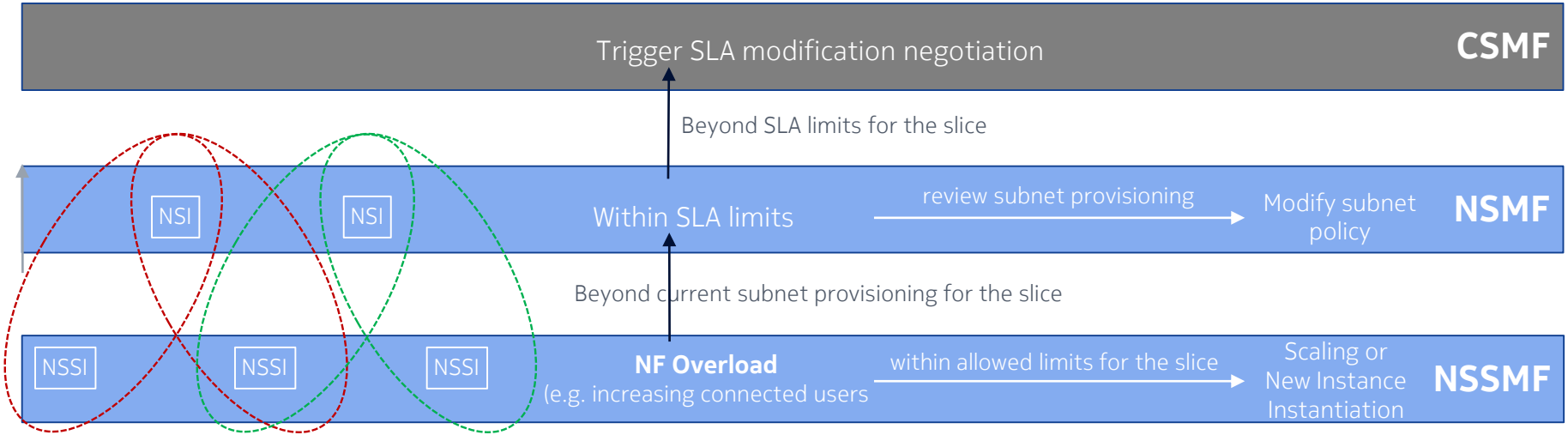
Run-time optimization, reconfiguration
Example of NF Overload detection

CSMF= Communication Service Management Function
NSMF = Network Slice Management Function
NSSMF = Network SubNetwork Slice Management Function



Each layer monitors and checks possible actions within its scope according to SLA.
Otherwise „escalate“ to next higher level

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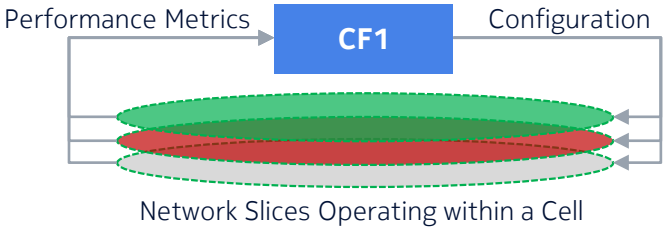
5G Cognitive NM function design
Impacts of Multi-Tenancy and Multi-Service

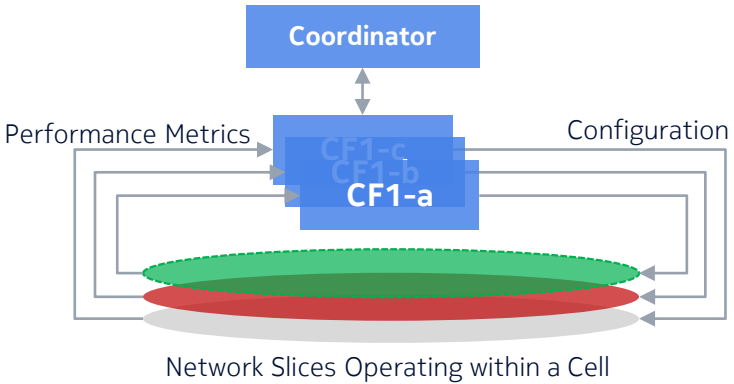
Cell-Specific Function Instance

- Differentiate input (performance metrics) for different slices
- Coordination among requirements of different slices
- Cognitive NM function policy update when slice is (de)activated



Slice-Specific Function Instance

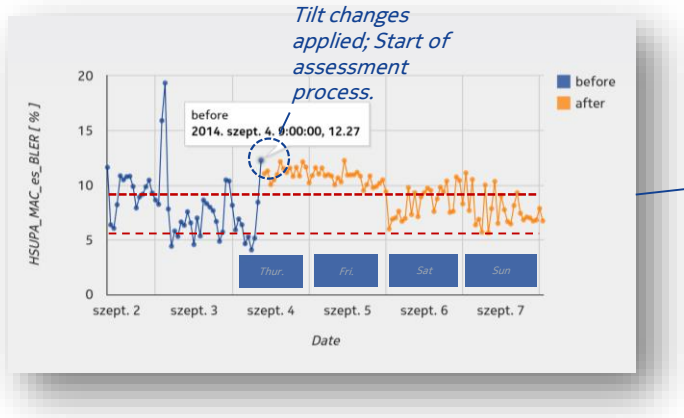
- Multiple instances per cell
- Coordination between different function instances of same type operating on the same cell
  - Parameters adjustable per UE
  - Parameters adjustable only at cell level

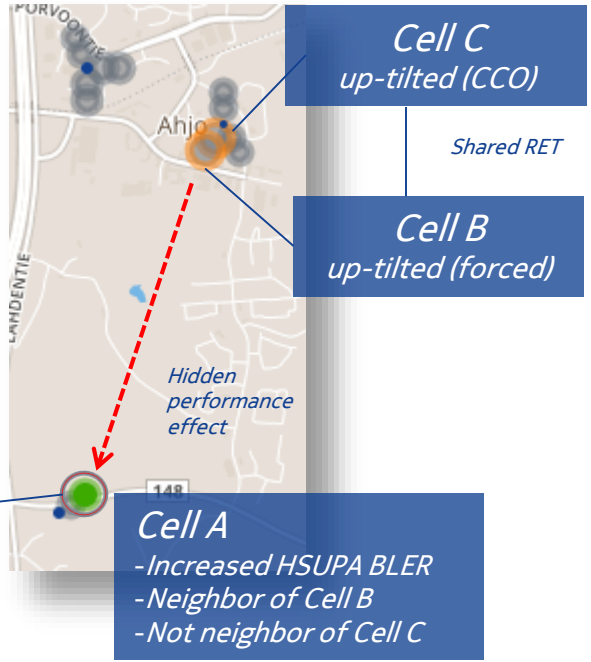


CF: Cognitive Function

5G Cognitive NM functions: example CCO / verification

- Observed effect in real network data:
  Cell B up-tilt 2° → Cell A shows increased values of KPI “BLER in the HSUPA MAC layer”
- Cause: Coverage and Capacity Optimization (CCO) algorithm triggered Cell C up-tilt → Cell B forced to up-tilt due to being on the same RET module as Cell C
- Example case solved with hierarchical „network intelligence“:
  CCO (tilt optimization) function plus
  verification function with wider network view





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5G Network Slicing Management for Challenged Network Scenarios

Conclusions

- **5G addresses some “challenged network” scenarios (factory, UAV, disaster response, V2X)**
- **5G Network characteristics (ultra dense, cloudified, multi-service / -tenant) impose new RAN operability challenges**
    - **Functional:**
        - per service- / tenant- instrumentation and *dynamic* operation (multiplicity of *virtual* network configurations)
        - data: higher resolution of measurements; new external sources / context
        - higher degree of autonomy in management
    - **Architectural:**
        - new building blocks slicing management, analytics & policy engine
        - higher degree of distribution, cooperation / coordination and abstraction

→ Cognitive NM functions to master network data → mastering network complexity

5G Network Slicing Management for Challenged Network Scenarios

Conclusions

- **5G Network Slicing Management**
  - Different levels of control by tenant required (high-level vertical vs. MVNO)
  - Slice run-time optimization / healing → slice-aware Cognitive Functions → managing Physical and Virtual NFs
    - Coordination across different slice's requirements

→ **Enable the management of diverse service types in diverse network scenarios**

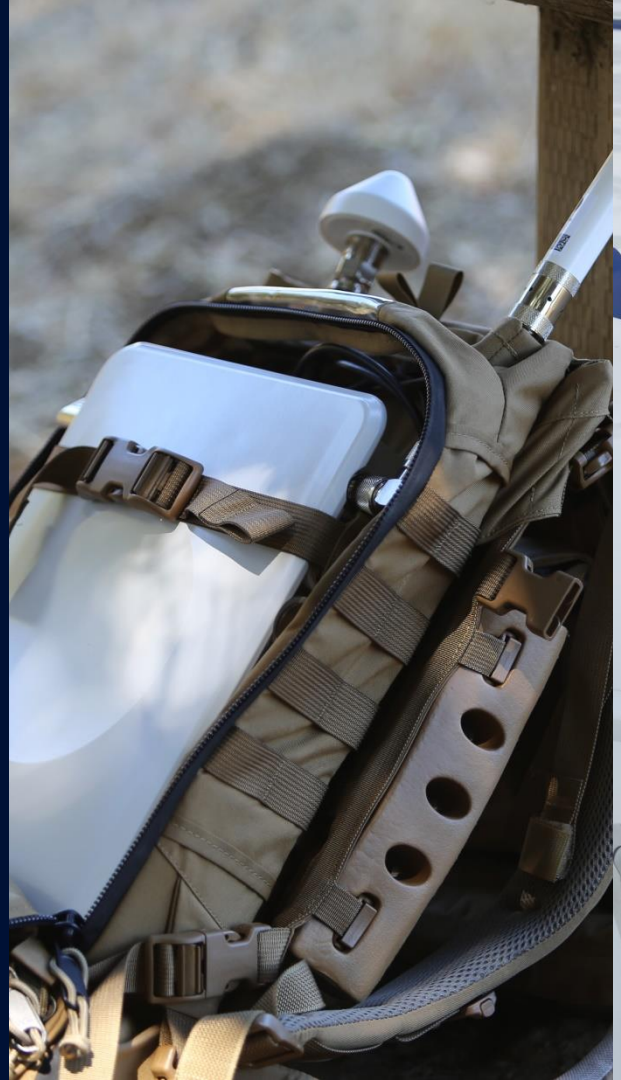
Research challenges

- Dynamic slice instantiation and management (for unpredicted events)
- Slice management knowledge sharing & isolation
- Cognitive Function placement
- 5G URLLC management: instrumentation, prognostic diagnosis

Nokia & Challenged Networks today

Nokia Saving Lives

An Innovation and Non-Profit Initiative



Nokia Saving Lives – https://networks.nokia.com/innovation/nokia-saving-lives

- HD/IR/Thermal Cameras
- Loudspeaker / Microphone
- Gas Sensor
- Delivery System
- LTE data and control connection

Local NGO / International Crisis Management Organization
(Mission Training, Storage, deployment)

Local Operator
(Frequency License)

LTE

Portable LTE
Ultra Compact Network
(on pole, drone, balloon)

LTE

RF
BTS
PaCo

LTE

Handsets

Nokia Operational Team/
Deployment

Portable Control Center

Connectivity / PaCo
Flight management
Rescue Apps
Data Storage

- Video streaming
- 3D map creation
- Object detection/People count
- Flight management automation

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