5G NORMA

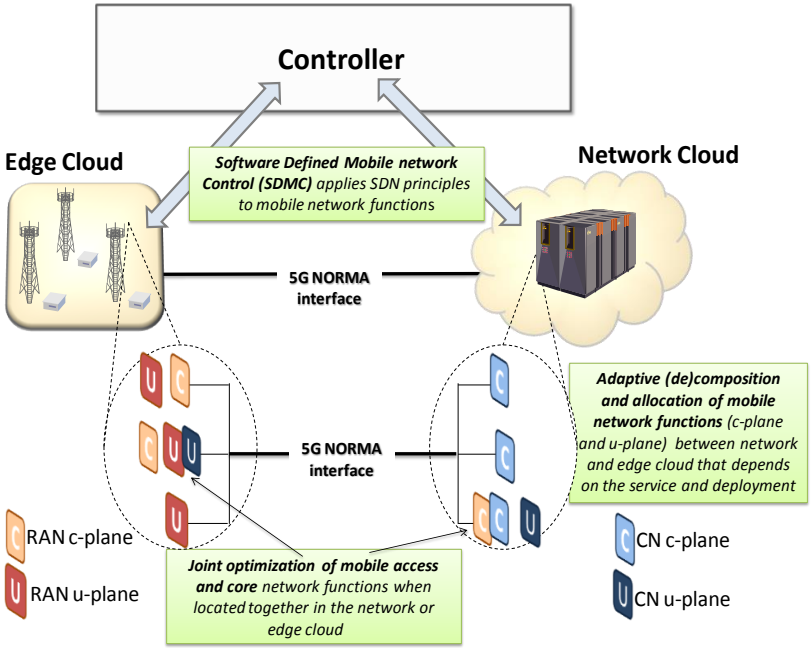
A NOvel Radio Multiservice adaptive network Architecture for the 5G era

This set of slides provides a general overview of the 5G NORMA project

Date: 07 April 2017

MOTIVATION AND OBJECTIVES

3 Innovations Enabling Flexibility



Adaptive (de)composition and allocation of NFs

Joint optimization of RAN and CN

SW-defined Mobile Control

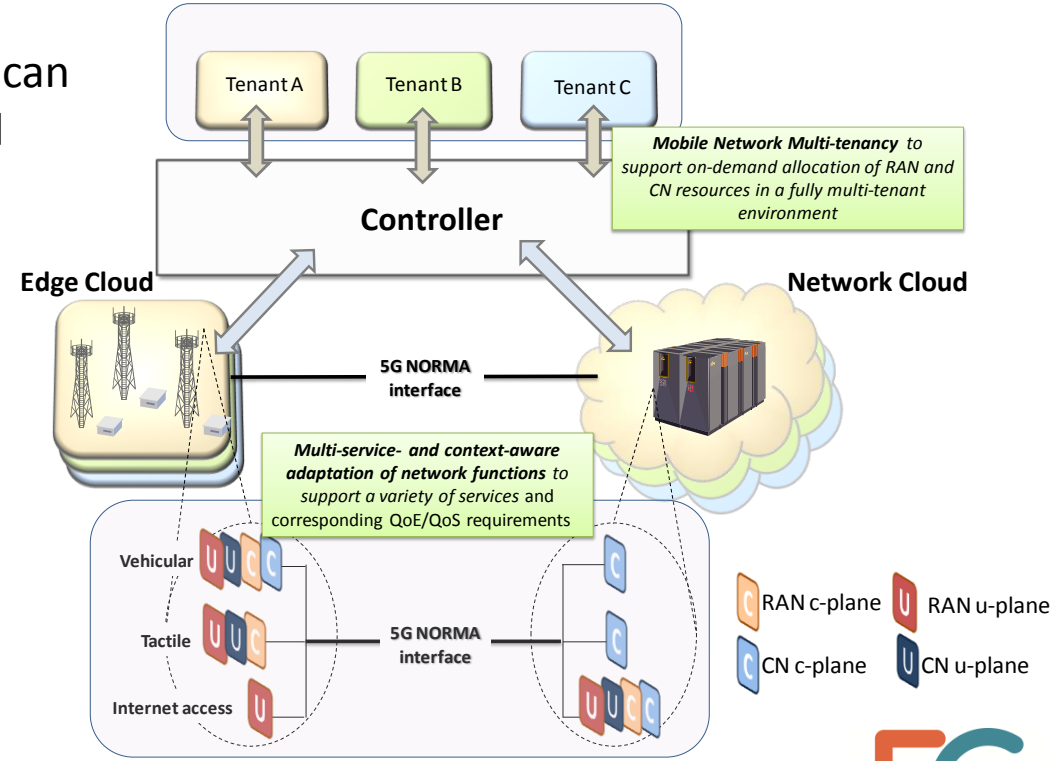
create the flexibility to

- adapt dynamically to daily fluctuations in traffic demand
- adapt to rapid load variations in small cells
- introduce new services and business models quickly

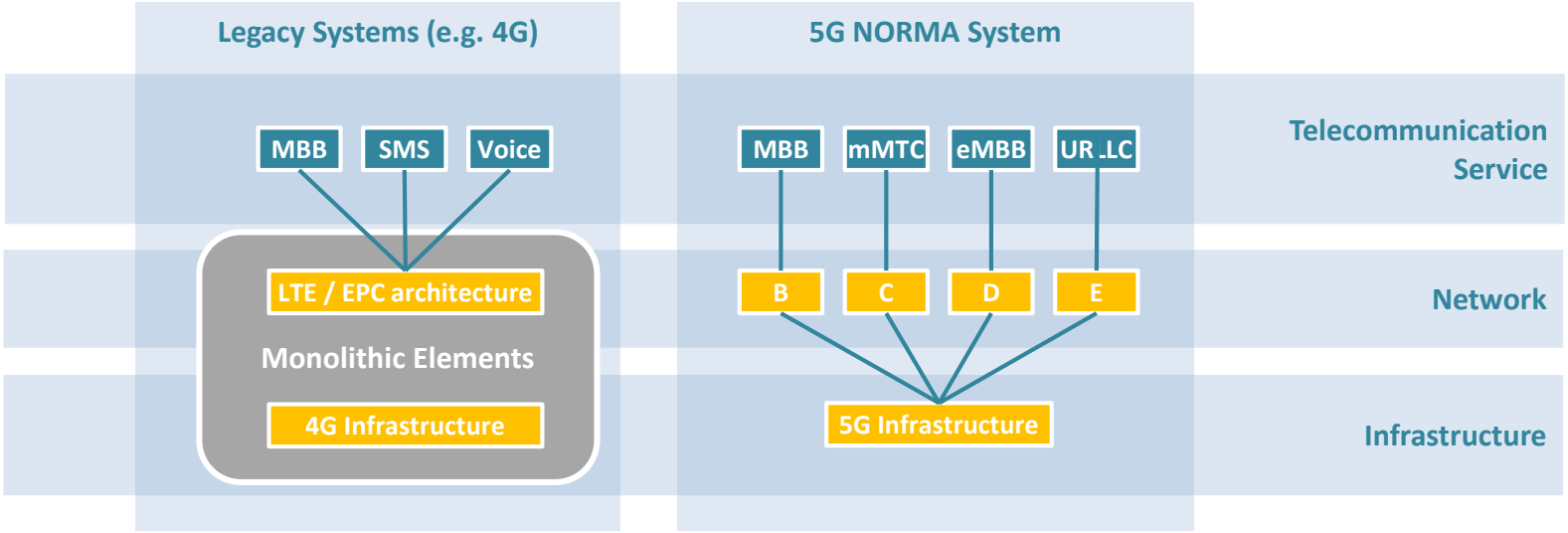
Multi-Service and Multi-Tenancy

Dedicated networks contained in slices can meet the need of different services and tenants:

- Service quality and performance
- Service-specific functionality
- Adaptation to available infrastructure



Multi-service networks – 5G vs. legacy systems



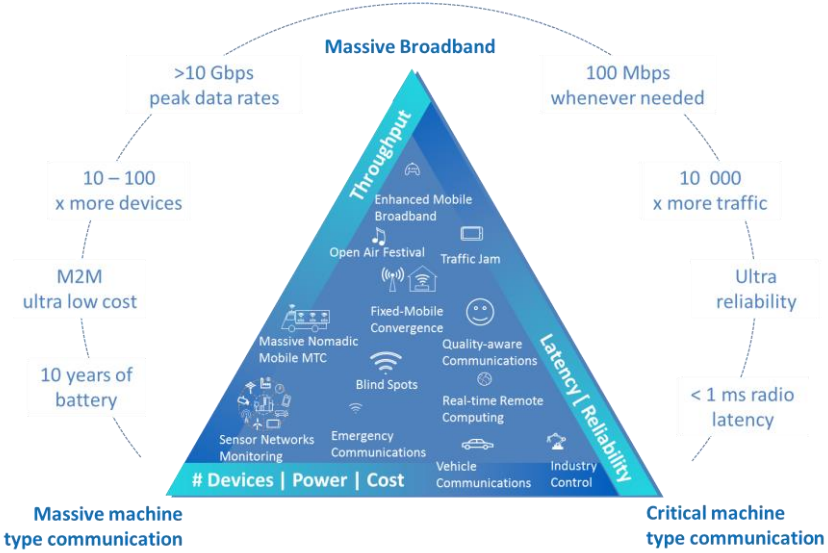
- Multiple telco services 1, 2, 3 (e.g., Internet access, voice, SMS) are delivered using the same network
- Network A (network functionality) is closely bound to the infrastructure
- Network and infrastructure are a compromise to host all services according to their priorities

- Each telco service (e.g., eMBB, V2X, URLLC, mMTC) is delivered using a dedicated, customized mobile network instance (network slice)
- Multiple slices are executed in the same infrastructure
- Infrastructure has capabilities (SDMC, flexible RAN, NFV, etc.) to accommodate performance requirements of different slices

USE CASES

Use cases and requirements

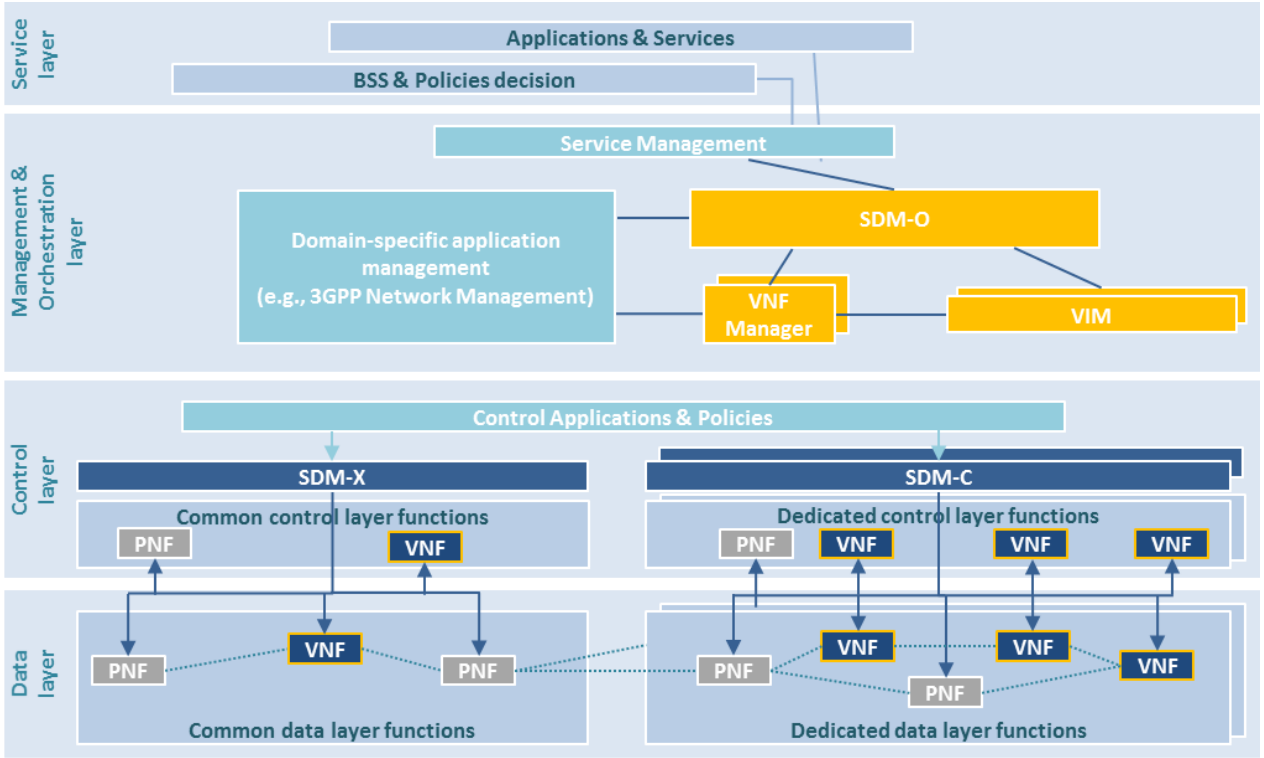
- 5G NORMA has analysed a total of **12 use cases** building on those developed by NGMN, METIS and 3GPP, among other sources
- Based on the analysis of the use cases, a set of **functional and performance requirements** associated to each one have been identified
- In order to facilitate their consideration, the functional requirements have been collected into a set of **eleven groups of requirements**



- Performance requirements have been grouped around three axes: **very low latency and reliability** for critical machine type communications; **high throughput** (compared to legacy networks) for massive broadband communication and the ability to support **high volumes of devices** for massive machine type communication
- 5G NORMA has also identified a set of **design principles** in terms of network architecture and operation design, which are expected to help in the transition from requirements into network architecture

ARCHITECTURE

Preliminary 5G NORMA architecture (functional view)



Exposure of control

- Service management
- Mapping of customer-facing services and procedures to resource-facing services and procedures
- Access control and integrity

Network slicing

- SDM-O: Service and Resource Orchestration
- Inter-slice and intra-slice

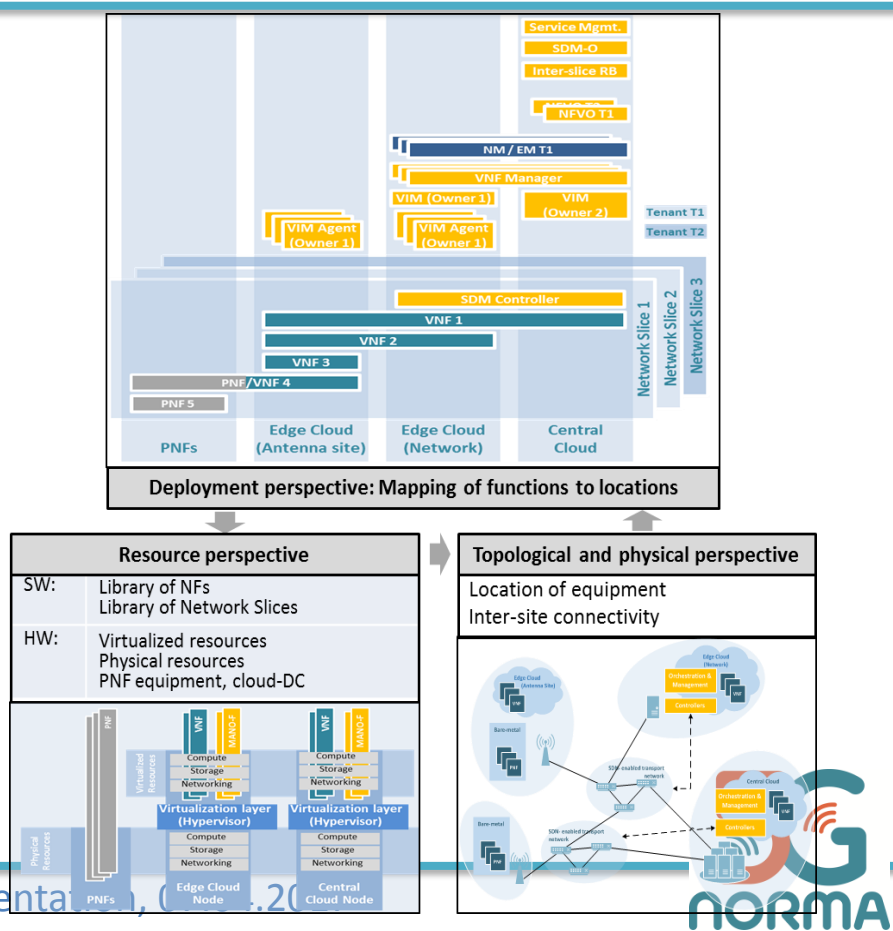
Network programmability

- Differentiation into common and dedicated functions
- SDM-X and SDM-C

5G NORMA architecture innovations and views

Covering all layers: Control and Data Layer, Management & Orchestration Layer, and Service Layer

- The “5 Innovations” of 5G NORMA
  1. Adaptive function (de)composition and flexible placement
  2. Joint optimization of access/core functions
  3. Software defined mobile network control, orchestration and management
  4. Multi-service and context-aware adaptation of network functions
  5. Mobile network multi-tenancy
- Different architectural views for clarity
  - each highlighting specific capabilities of 5G NORMA architecture and innovations



Layers of the 5G NORMA functional architecture

- Service layer
  - comprises Business Support Systems (BSSs) and business-level Policy and Decision functions as well as applications and services operated by the tenant
- Management & orchestration layer
  - 5G NORMA's MANO functions: VIM, VNF Manager and the SDM-O,
  - SDM-O is further split: Inter-slice Resource Broker for cross-slice resource allocation and slice-specific NFV Orchestrator(s)
  - Domain-specific application management functions
  - E.g., in case of 3GPP, this comprises Element Managers (EM) and Network Management (NM) functions
  - EM/NM also implement ETSI NFV MANO interfaces to VNFM and NFVO
  - Service Management: intermediary function between the service layer and the SDM-O that transforms tenant-facing service descriptions into resource-facing service descriptions (and vice versa)
- Control layer:
  - accommodates the two main controllers, SDM-X and SDM-C, control applications, and distributed control NFs
  - SDM-X and SDM-C translate decisions of the control applications into commands to VNFs and PNFs
  - SDM-X and SDM-C as well as other control applications can be executed as VNFs or PNFs themselves
- Data layer
  - comprises the VNFs and PNFs needed to carry and process the user data traffic

Novel capabilities of the 5G NORMA architecture

1) Management and orchestration

a) Tenant-driven network slice blueprint on-boarding and customization
b) Tenant-driven network slice deployment / instantiation
c) Cross-domain resource discovery and orchestration

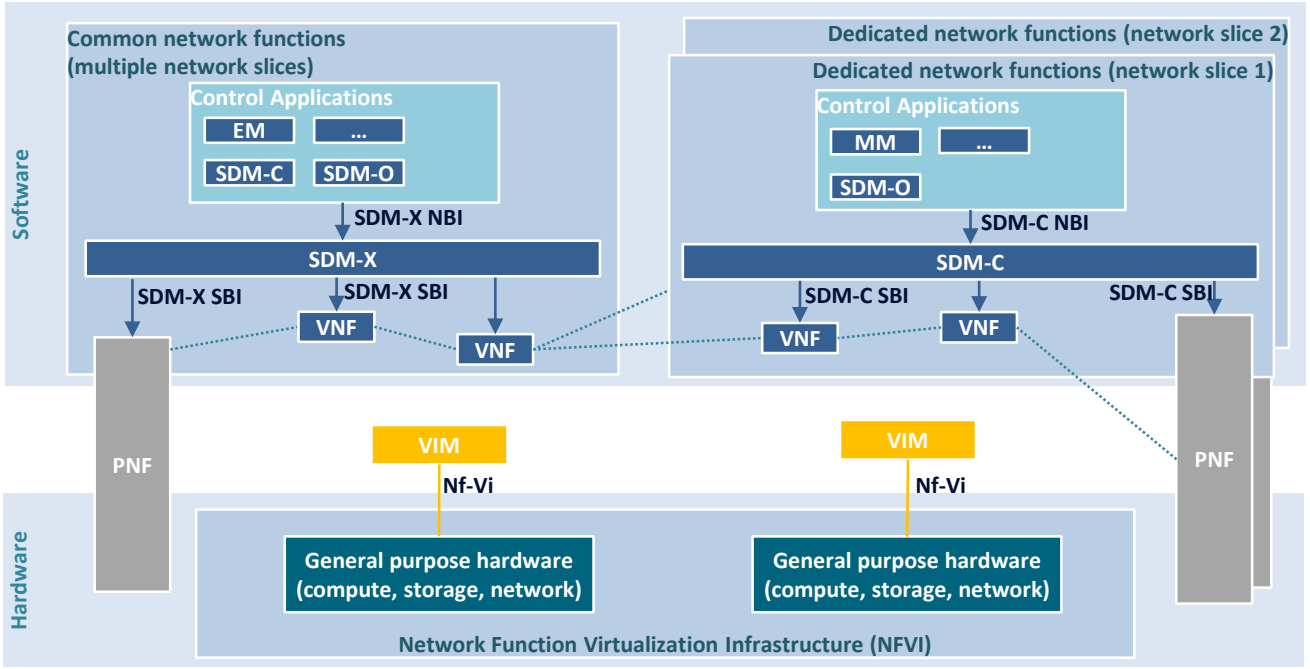
2) Network programmability

a) Handover and mobility management
b) Network slice re-orchestration
   - QoS-triggered
   - Resource-triggered
c) Cross-domain resource sharing

3) Control and data layer

a) Flexible addition/removal of inter-RAT links → programmable MC
b) User-centric connection area setup and best cell update
c) Network slice selection

Extending SDMC for network slicing

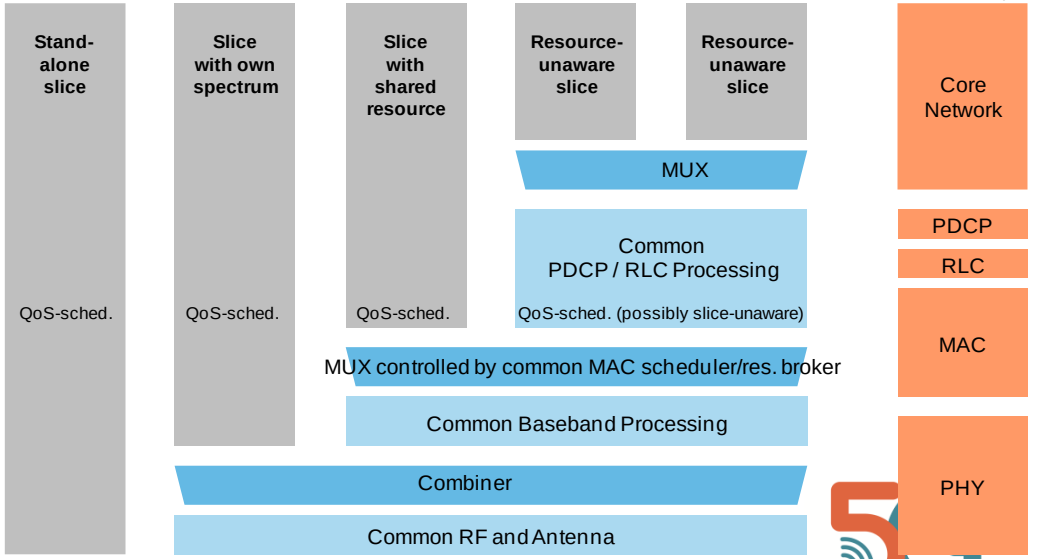


- **SDM-C and SDM-X**: SDM-C for dedicated functions, coordinator (SDM-X) for functions that are **shared by multiple network slices**
- follows the SDN hierarchy as outlined by ONF

  → extending software-defined mobile networking towards network slicing

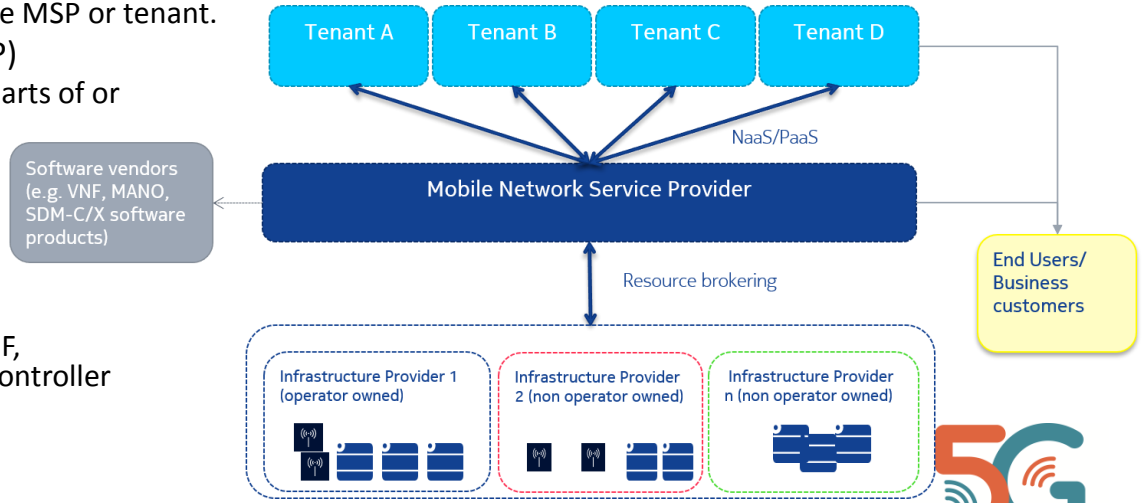
End-to-end network slicing

- Multiple abstraction technologies available
- Virtualisation, multitasking and multiplexing enable the sharing of resources between multiple users by
  - decoupling the functionality from the resources needed to execute this functionality, and
  - partitioning of resources into isolated execution environments.

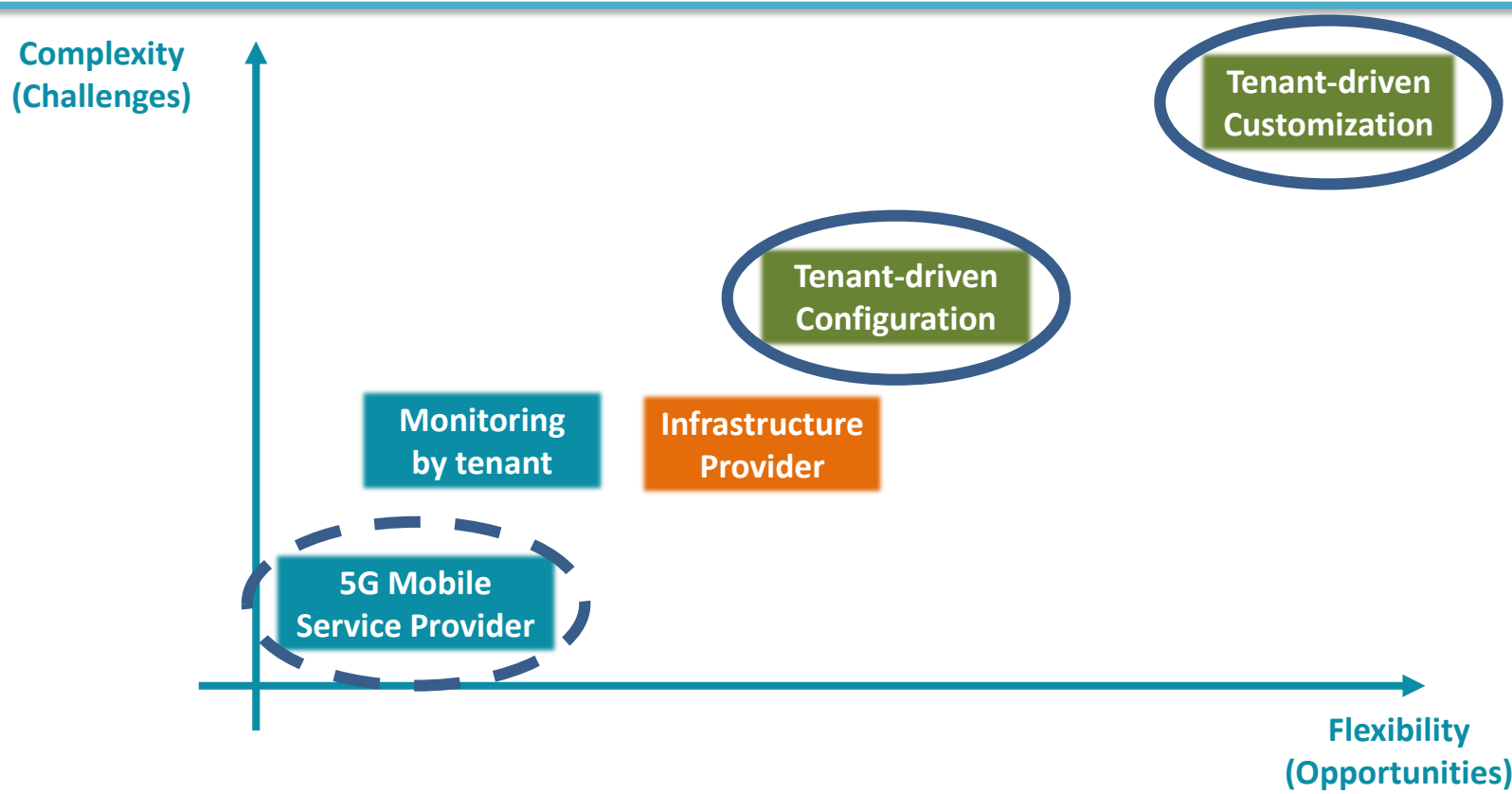


Major stakeholders of the ecosystem

- The 5G NORMA mobile service provider (MSP)
  - is the entity/company that provides Internet connectivity and telecommunication services to subscribers.
  - MSP offers dedicated mobile network instances (i.e., network slices) to 5G NORMA tenants
- The 5G NORMA tenant
  - usually a business entity, buys and leverages on 5G NORMA network slice services provided by the MSP.
  - Mobile Virtual Network Operator (MVNO) or an enterprise (e.g. a vertical) requiring a telecommunications service for their operations
- The 5G NORMA mobile subscriber
  - individual who consumes services from the MSP or tenant.
- The 5G NORMA infrastructure provider (InP)
  - entity/company that owns and manages parts of or all infrastructure of the network.
- The mobile network operator (MNO)
  - entity that operates and owns the mobile network (merges the roles of MSP and InP into a single stakeholder)
- The software vendors
  - companies that develop and distribute VNF, management and orchestration, or SDM controller software

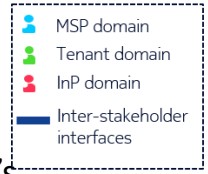


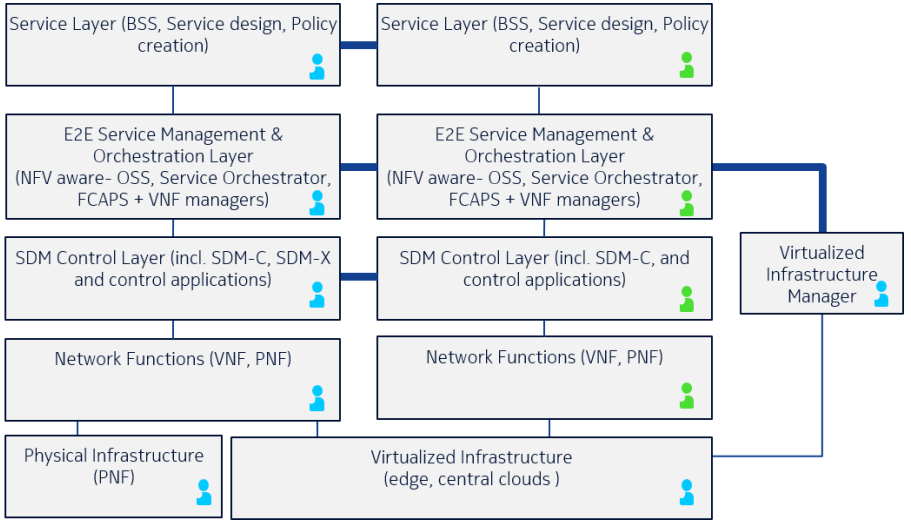
Ecosystem opportunities and challenges



Offer Type 3 – Extended slice configuration & control

- Tenant has a rather wide control over deployed network functions, including
  - Onboarding own NFs for selected areas, e.g., mobility or session management
  - Possibly contributing own infrastructure
- Operating a part of the network slice independent of the MSP (or MNO)
- NFs onboarded to the MSP's or MNO's systems have to be certified
- Tenant has direct relationship/contract with subscriber



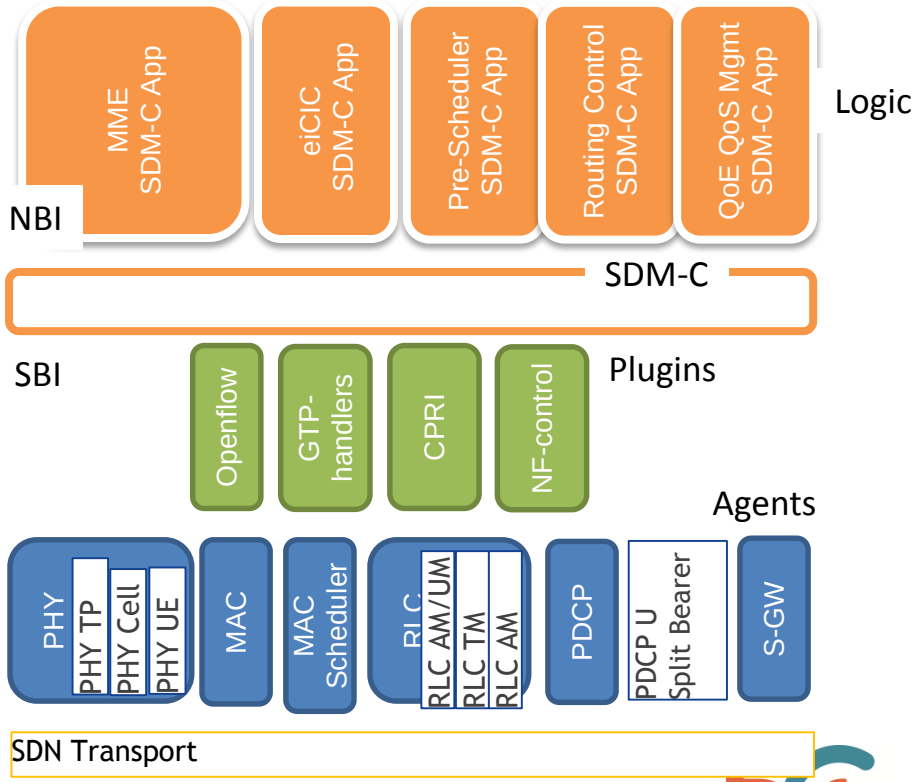


Actor providing the service	Actor purchasing the service	Service	Typical SLA
Mobile Service Provider	Tenant	IaaS + PaaS	Network functionality repository, API to MANO-F and control function, monitoring key performance indicators, virtual resource availability, commitment of MSP-owned infrastructure resources
Tenant	Subscriber	Communication services	Data amount, voice hours duration,..

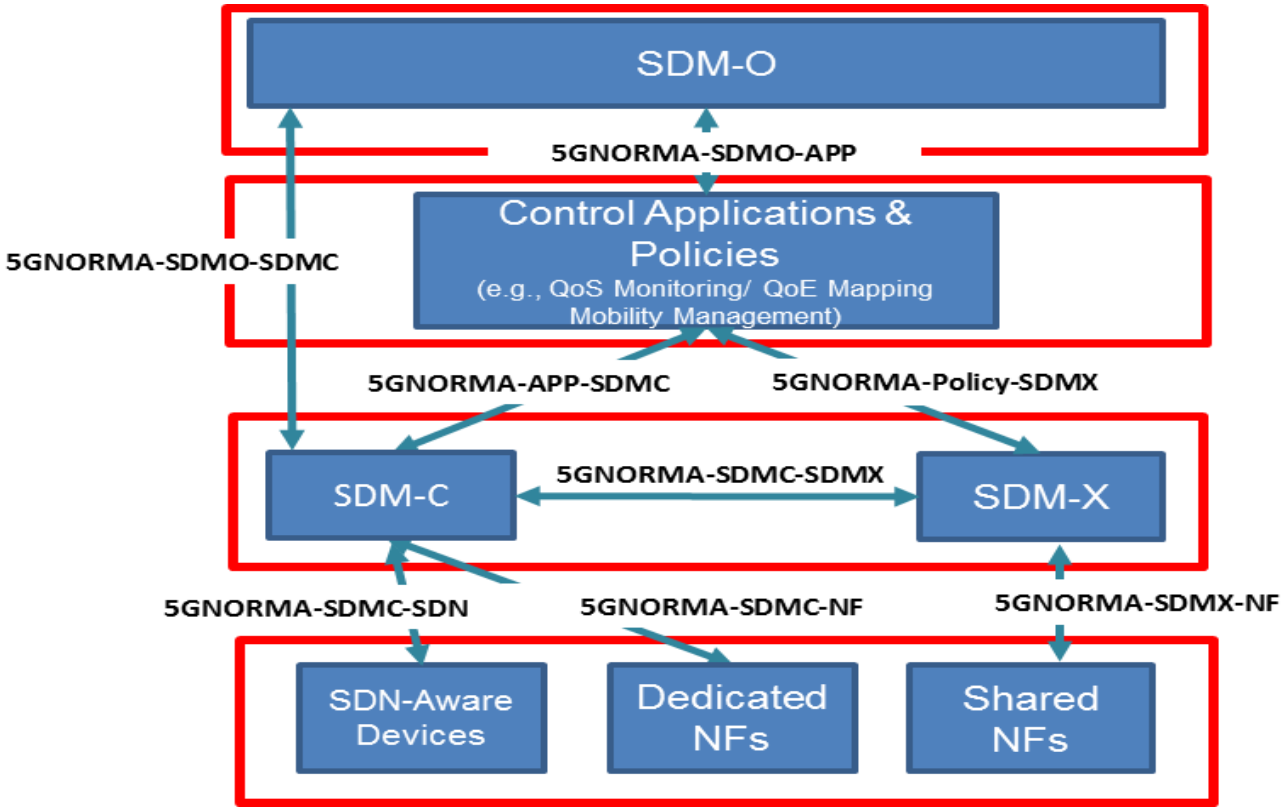
SOFTWARE DEFINED MOBILE NETWORK CONTROL

SDM-C: Software-Define Mobile Network Controller

- Apply the network programmability concept beyond SDN to mobile network functions
- Split network functions into *control applications* (logic) and *controlled functions* (agents)
- Logic (SDM-C Apps) use the NBI of SDM-C
- Agents are controlled through the SBI



SDM-C Interfaces



Benefits of SDM-C

Tailored operation through open, standardized interfaces

- The logic of the network operation is ruled by SDM-C Apps running on top of the NBI
- Operators can gain control of the operation of their network by deploying SDM-C Apps

- The logic of network functionality is implemented in software at SDM-C
- Software-based solutions allow for flexible evolution as compared to Hardware ones

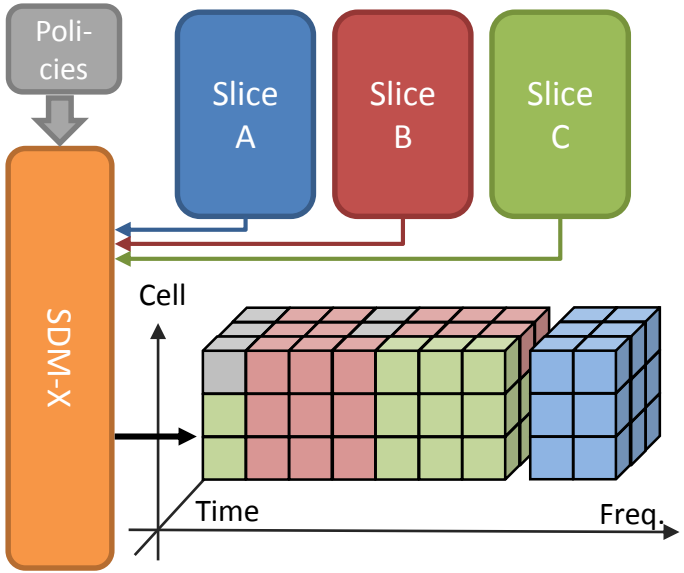
Flexible evolution of network functionality

Performance gains resulting from centralized control

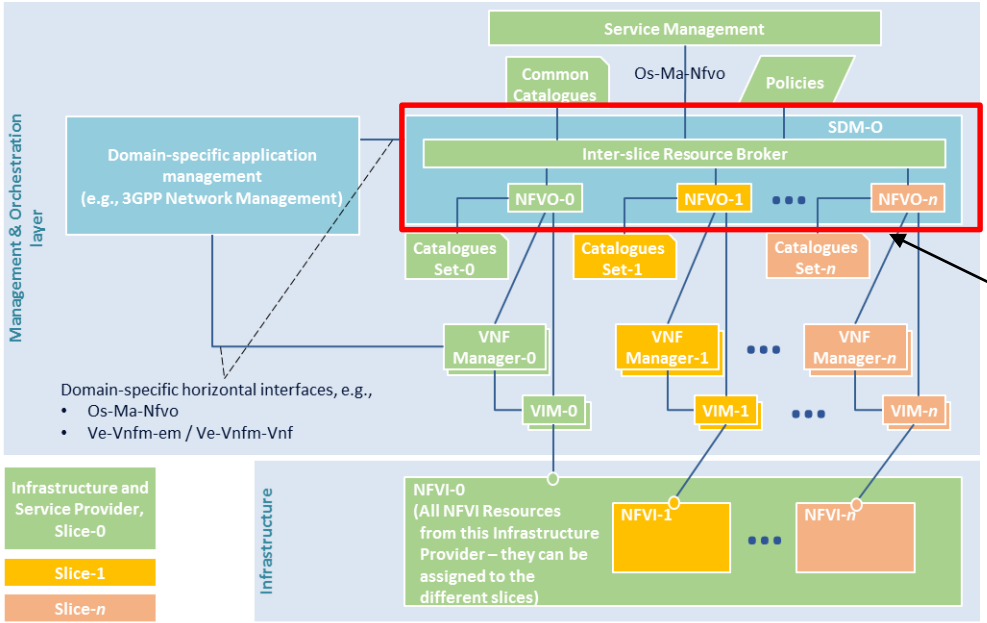
- Centralizing global information at the SDM-C allows for more optimized performance
- Examples: joint optimization of handover and scheduling, re-orchestration triggered by user mobility

SDM-X: Multi-slice network control

- Achieve efficient resource sharing among different slices
- Some functions have to be explicitly shared (i.e., spectrum)
- Other functions may need to be included (i.e. HSS, low layer scheduler)



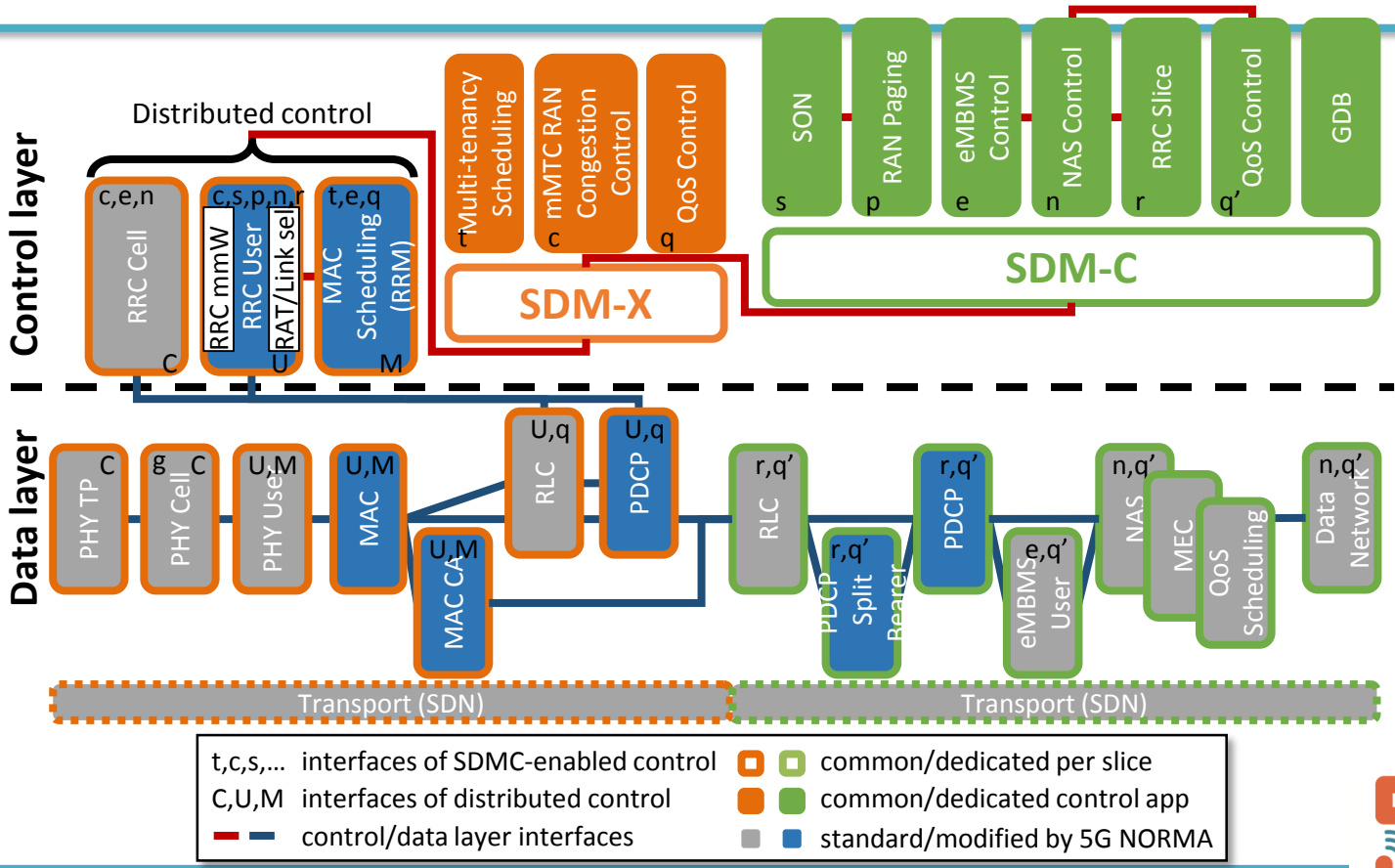
SDM-O and MANO stack



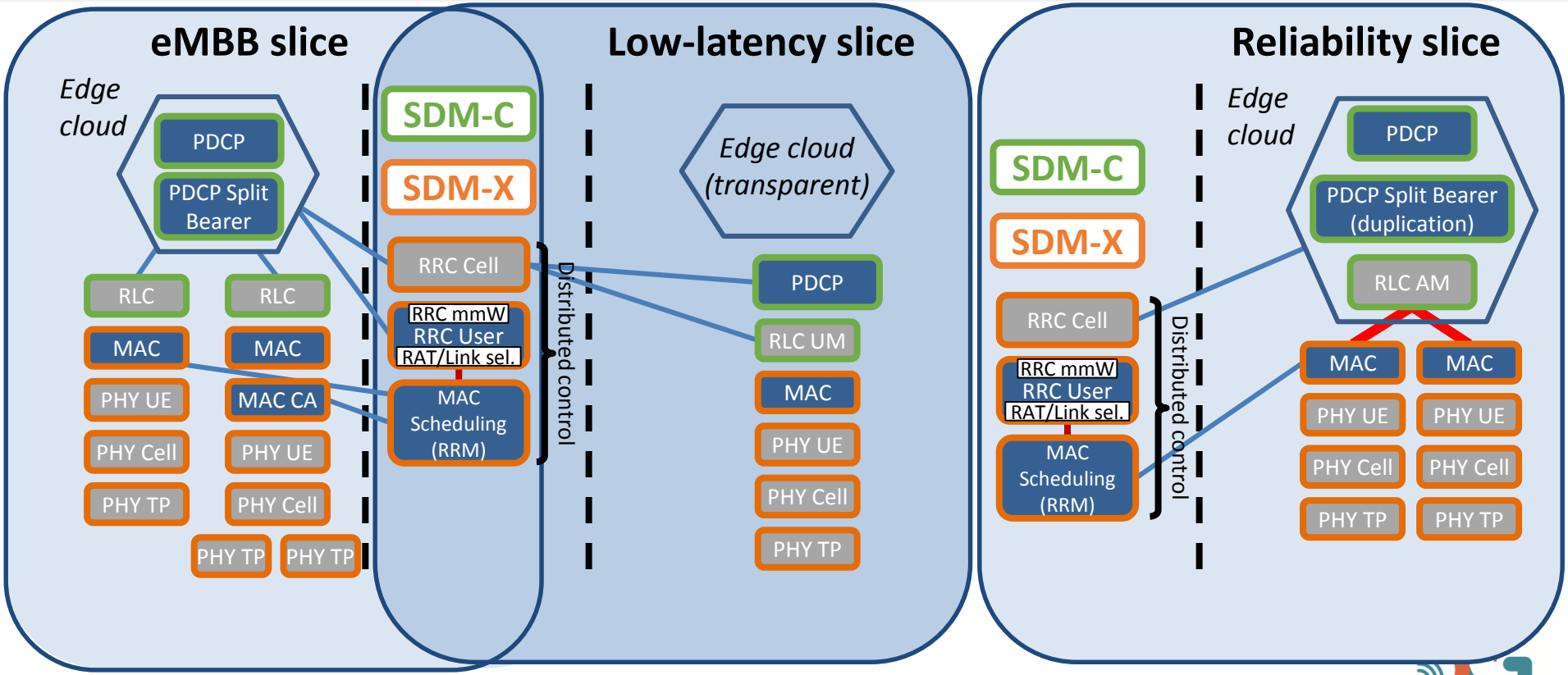
Intra and inter network slice orchestration algorithms

FLEXIBLE RAN

Functional Architecture

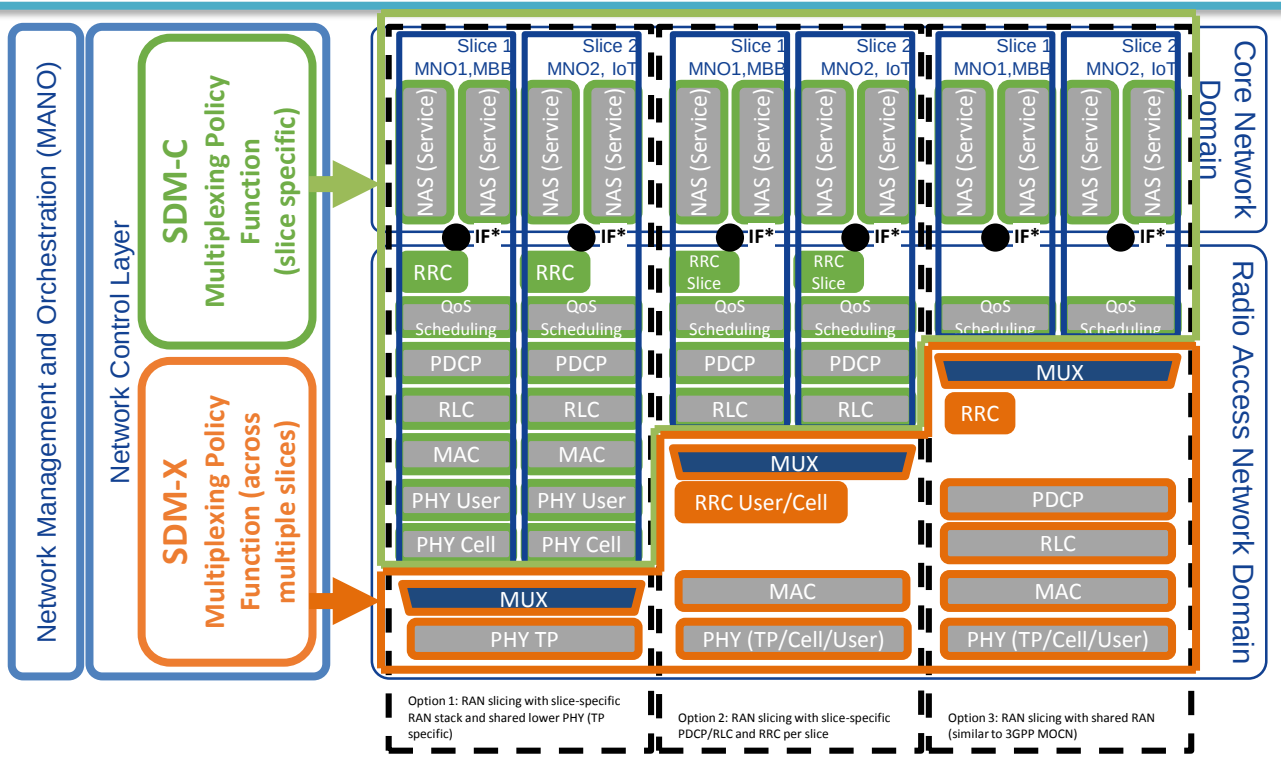


Service-dependent function selection and placement



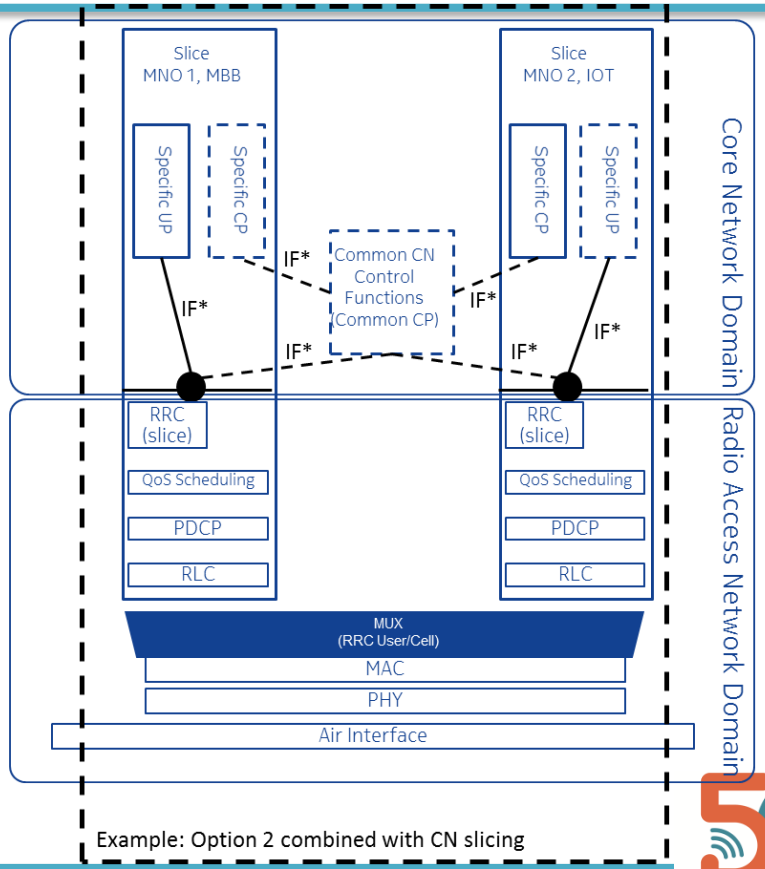
RAN slicing options

- Shared lower PHY
  - Option 1: RAN slicing with slice-specific RAN stack and shared lower PHY (TP specific)
- Shared up to MAC
  - Option 2: RAN slicing with slice-specific PDCP/RLC and RRC per slice
- Fully shared RAN
  - Option 3: RAN slicing with shared RAN (similar to 3GPP MOCN)



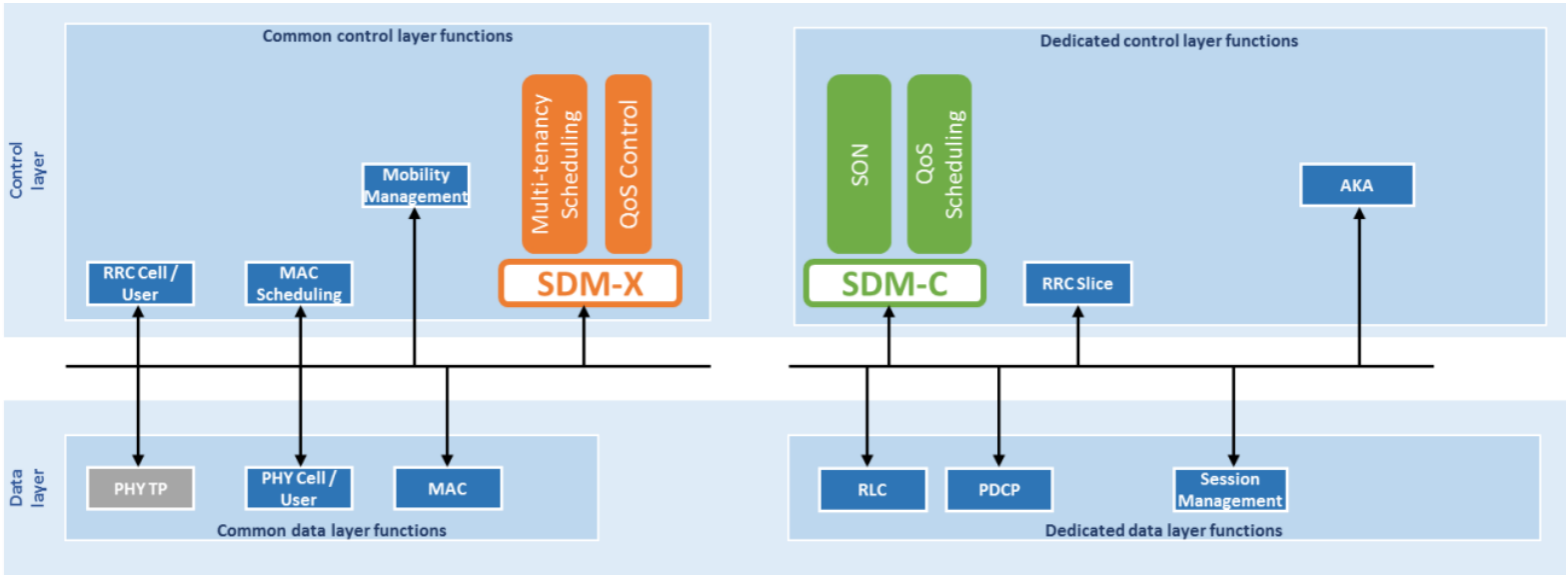
Integration of RAN slicing and CN slicing

- Control layer split
  - cell related functions common to all slices
  - session or user specific RRC



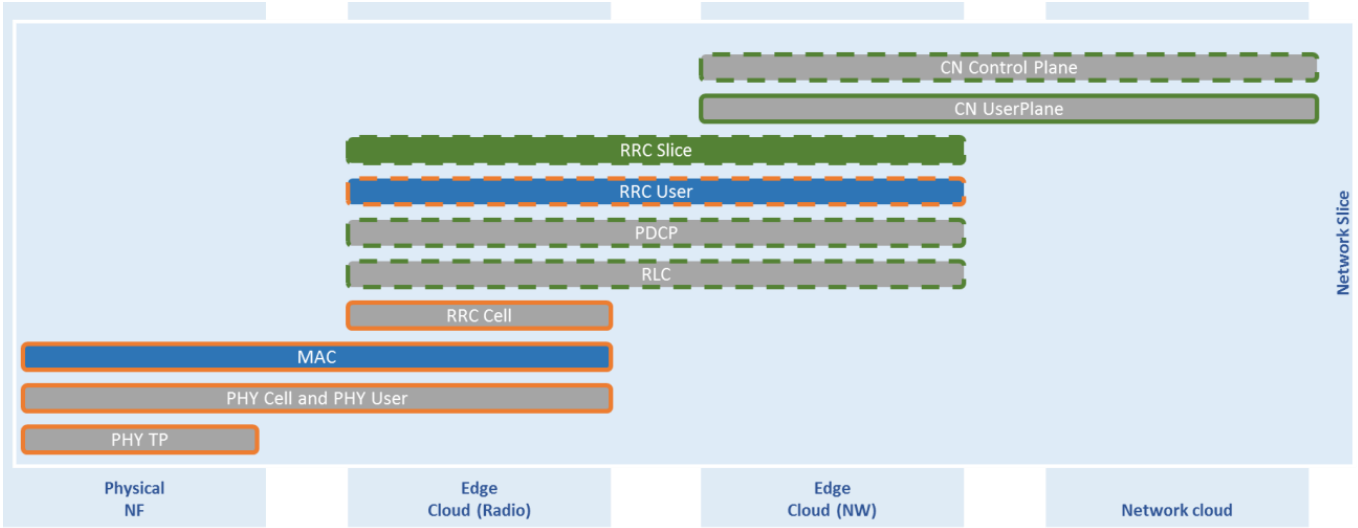
Architecture logical view

- RAN slicing Option 2 functional architecture applied to the architecture logical view



Architecture deployment view

- RAN slicing Option 2 functional architecture applied to the architecture deployment view



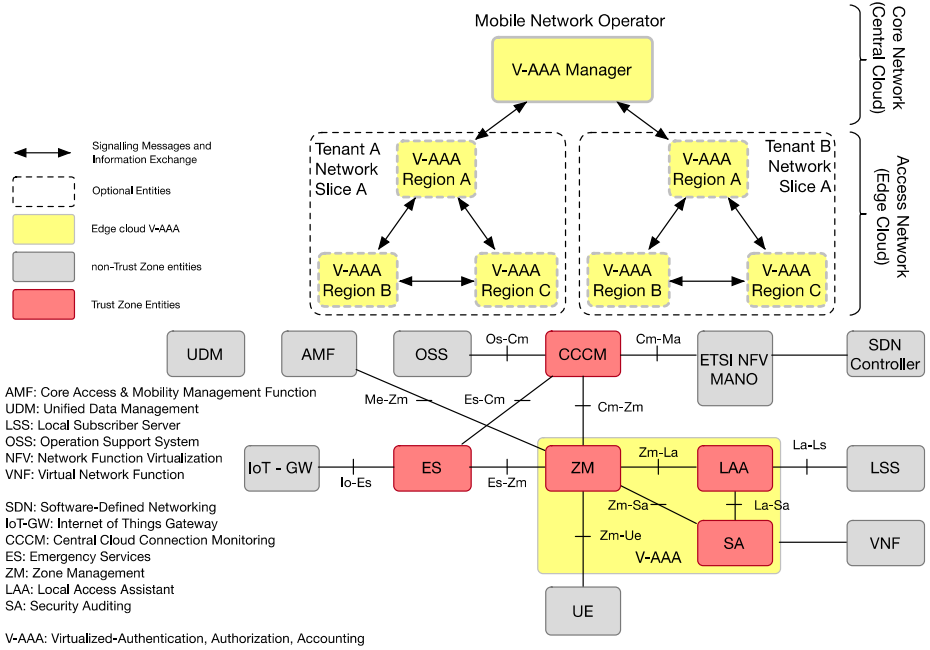
SECURITY ASPECTS

5G NORMA features and related security aspects

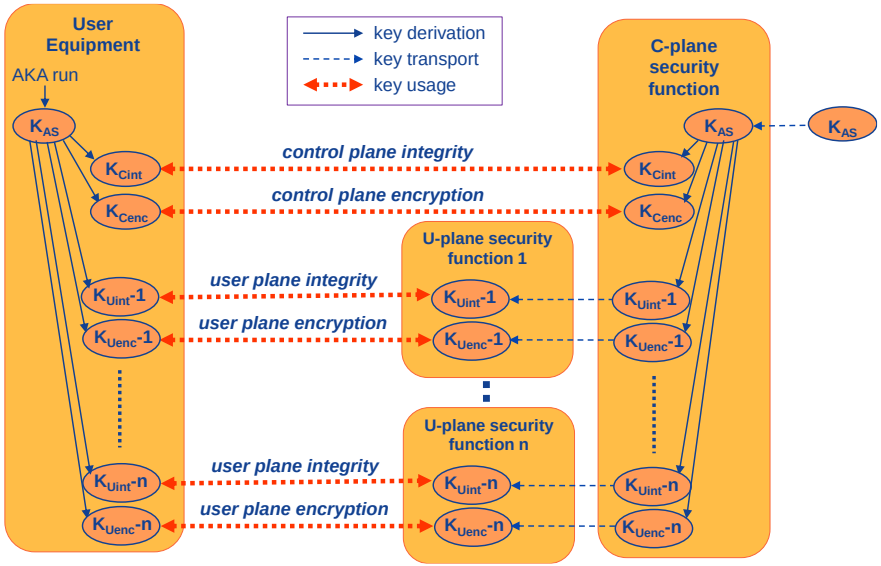
5G NORMA Feature	Related Security
NFV environments for core and RAN functions	NFV security (for central and distributed NFV environments)
Software Defined Mobile Network Control (SDMC)	SDN security, specialized for SDMC
Mobile network multi-tenancy	Tenant isolation, network slicing security
Multi-service awareness	Flexible security approach, e.g. choice of crypto-algorithms
Adaptive allocation of functions, joint optimization of RAN and core	Flexible security approach, e.g. support for flexible allocation of security functions

- New networking paradigms require new security concepts

Innovative 5G NORMA security concepts: Examples



Virtual AAA and Trust Zone

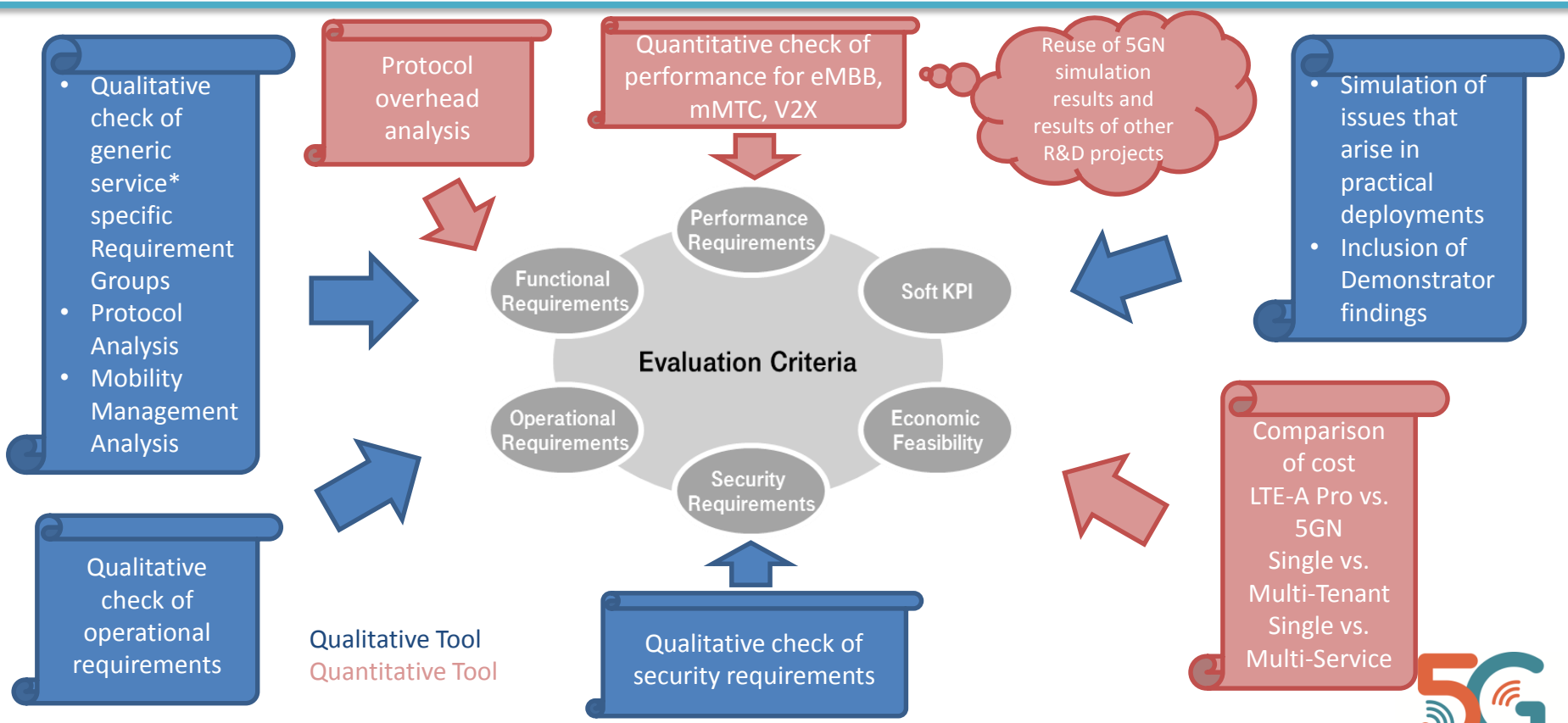


5G NORMA RAN Security Architecture

- 5G NORMA security concepts enabling highly secure networks

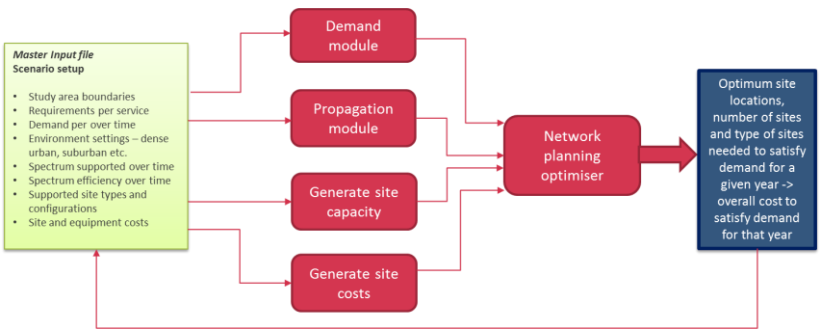
EVALUATION FRAMEWORK

Evaluation criteria & tools



Techno-economic evaluation

- For the techno-economic evaluation of 5G NORMA, a **network cost model** is being developed, which will be evaluated using the **CAPSice tool d**eveloped by Real wireless, that must be adapted for 5G



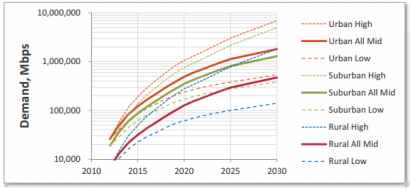


Figure 1-9: Demand growth across scenarios for urban, suburban and rural study areas

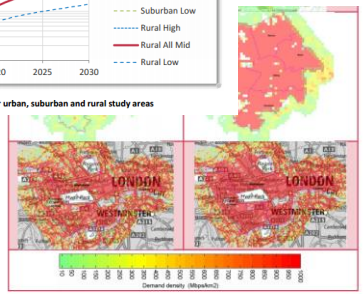


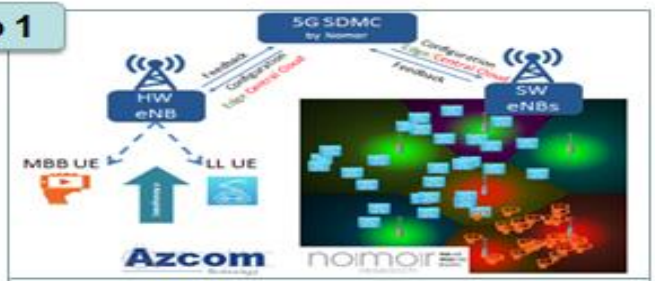
Figure 1-7: Illustrative peak demand density maps for study regions, mid demand scenario

- WP2 has produced the first results on the modelling process, that have been collected in IR2.1:
  - The WP has produced the first assumptions on the **metrics that will be used for the evaluation**, how the scenarios will be used and the baseline or "counterfactual" against which the 5G NORMA architecture will be assessed
  - Also, the **methodology for deriving the costs** associated with the different components of the architecture, both hardware and software, have been produced, as well as the network design rules – the relationship between service demands, network capabilities and equipment capacities at different points in the network
  - WP2 has also started to work on **modelling revenues and identifying socio economic benefits**

DEMO ACTIVITIES

5G NORMA Demos

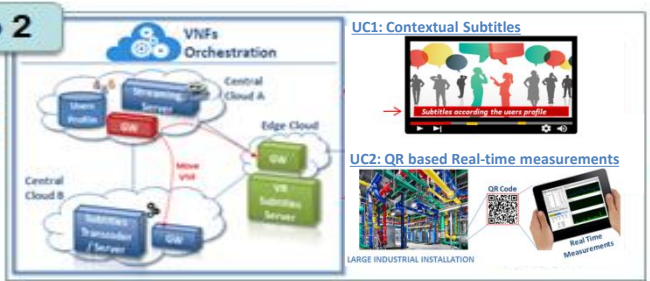
Demo 1



Native Multi-Service Architecture

Adaptive (de)composition and allocation of mobile Network Functions.

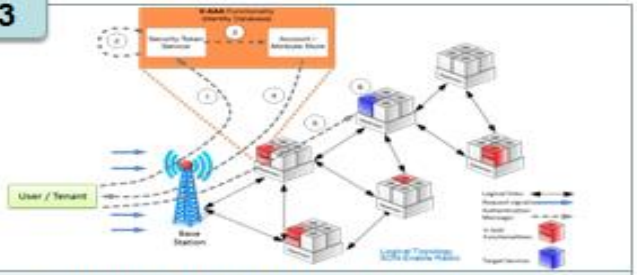
Demo 2



Service-aware QoE/QoS Control

Network Slicing and Virtualization Infrastructure.

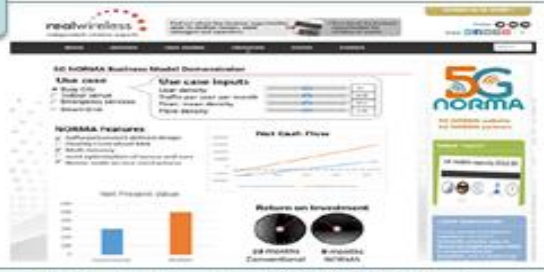
Demo 3



Secured Multi-Tenancy Virtual Network Resources Provisioning via V-AAA

Basic AAA showcase for 5G-NORMA

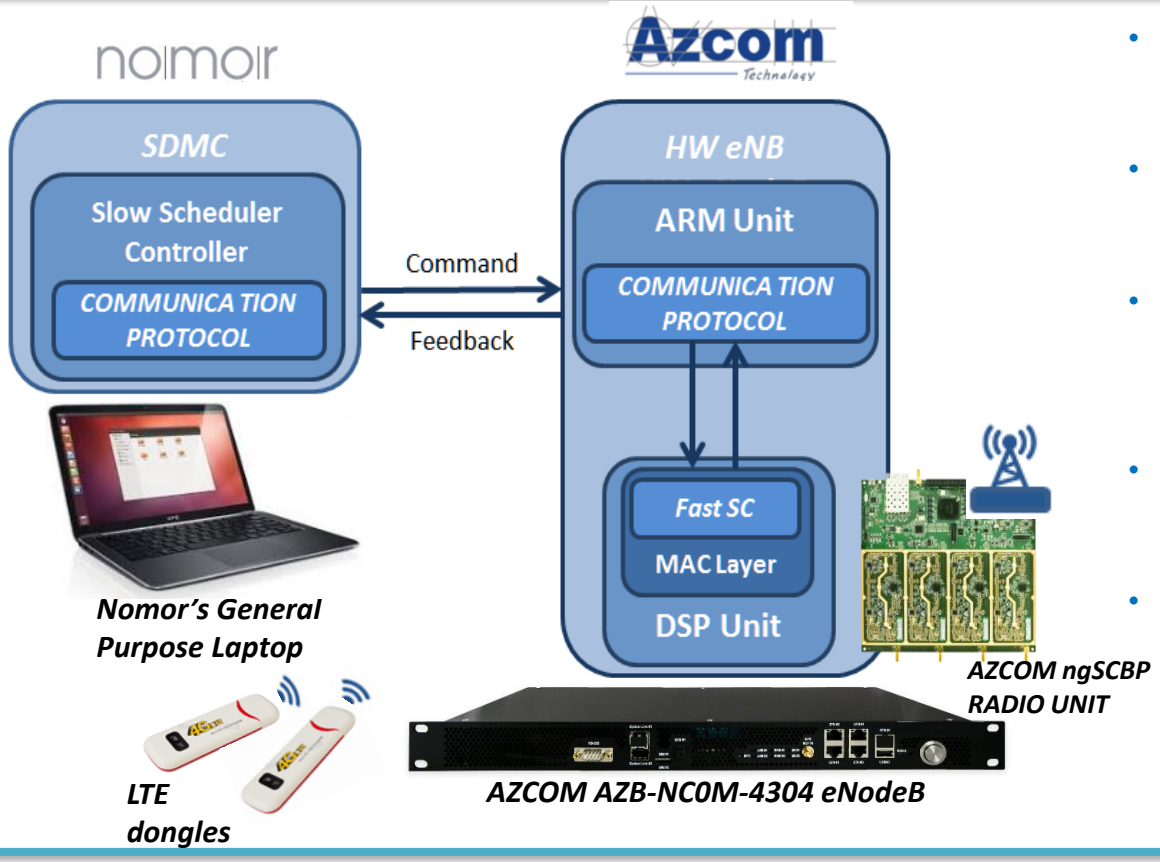
Demo 4



Online Interactive 5G NORMA Business Cases Evaluation Tool

5G NORMA economic model showcase

Demo #1: Native Multi-service Architecture.



- The key elements are:
  - The HW eNodeB provided by Azcom.
  - The SDMC component developed by Nomor.
- Users (LTE dongles) using two different services:
  - A low latency (LL) service.
  - A Mobile Broadband (MBB) service.
- The demo is intended to show the effect of the network reconfiguration done by the SDMC to improve user's experience in terms of QoS in different interference conditions.
- When an interference signal reduces QoS, the SDMC reconfigures the network to guarantee the required quality for those services.
- Main objectives:
  - Show that a novel design of the network architecture with SDMC would produce gains over legacy network architectures like LTE.
  - Show that this concept is technically feasible and can be implemented with reasonable effort.

Demo #2. Service-aware QoE/QoS control

MAIN OBJECTIVES

- Show a real-life proof of concept focused on service aware QoS/QoE control.
- Demonstrate how to use service orchestration capabilities based on NFV.

MAIN CHALLENGES

- VNF *Containerization*.
- VNFs Orchestration:
  - Infrastructure to use.
  - Placement (where virtual functions must be placed).
  - VNF-FG update.
- QoS/QoE control mechanisms.

IMPLEMENTATION

The demo will be based on two use cases:

1) MBB: Generate contextual subtitles to streaming media according the user profile and surrounding context.

- Text language.
- Colours.
- Luminosity.
- Font size.
- Text position.
- ….

2) LL: Real-time physical measurements triggered by QR labels:

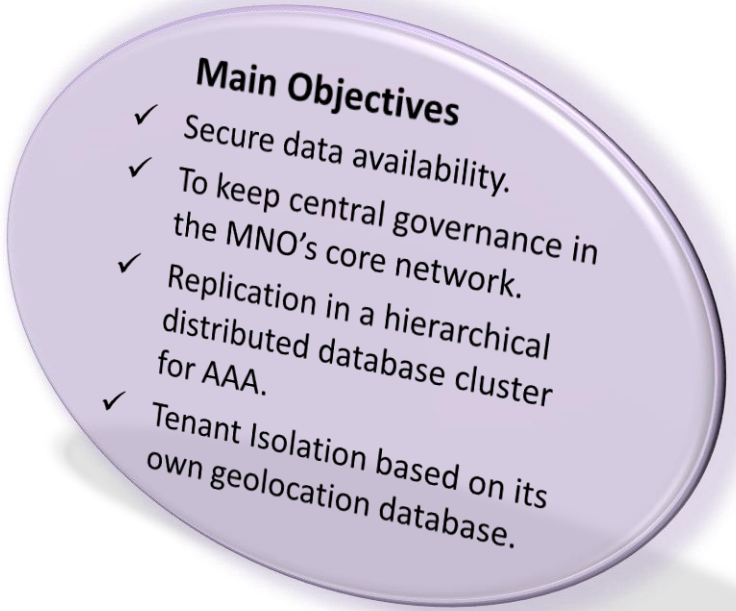
LARGE INDUSTRIAL INSTALLATION

- Augmented Reality.
- Implementation of low-latency monitoring systems.
- Application to large industrial environments.

Demo #3: Secure Billable Multi-tenancy with Virtualized AAA

The whole secured billing system demo consist on:

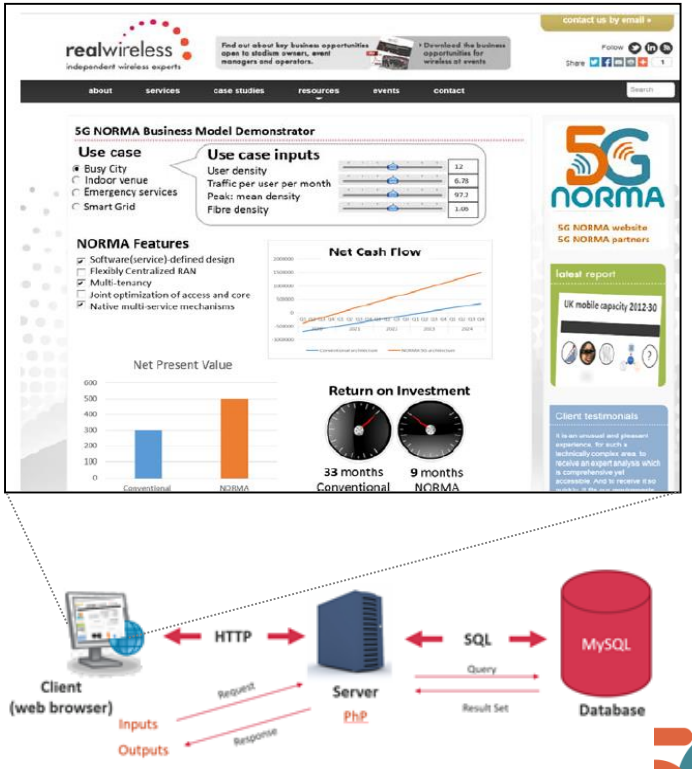
- A basic V-AAA architecture that can be applied on 5G Norma.
- Tenant information isolation based on its own geolocation database.
- A new hierarchical distributed database cluster architecture for multi-tenancy.
- SDN service provisioning and software modules (SDM-C/X) .



Based on commodity hardware (such as Raspberry pi, home Wi-Fi router and switch) to build a testbed in order to validate design and implementation

Demo #4. Online Interactive 5G NORMA Business Case

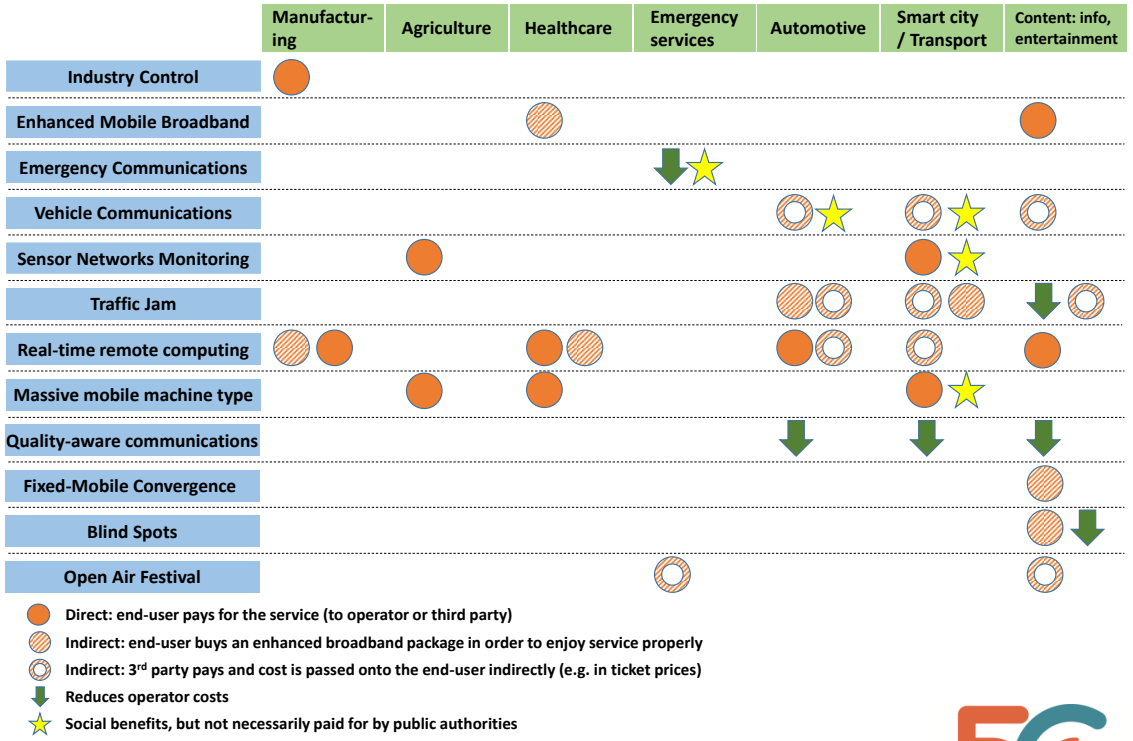
- This demo will showcase the economic model of 5G NORMA.
- **Main purpose**: the economic validation of the 5G NORMA architecture.
- The demonstrator will be a **web-based application** that will allow an on-line assessment of the socio-economic benefit of different 5G NORMA innovations under different input assumptions (e.g. service mix, user density, environment).
- The work will be based on an **abstraction** of the results output from WP2 – hence will be based on the case studies being developed within WP2-6 used to evaluate the 5G NORMA project.



IMPACT

Societal impact of 5G NORMA

- It is important to ascertain that the **use cases** identified are **relevant for the society**
- For this reason, a **mapping of use cases to relevant areas of economic activity** has been carried out
- The **business models for several use cases** have also been developed (four during the period under review – other use cases are being modeled during the second year)



Dissemination Statistics

Impact dimension	Channel	Results
Impact on future products and services	Standards contributions	25 [3GPP 17*); NFV 2;IETF 2; IEEE 2; BBF 1]
	IPRs	7 *)
	Demonstrations (at academic/industrial events)	7
Academic dissemination	Journal papers	14
	Conference papers	30
	Presentations & Talks	34
	Workshops, Panels, Special editions organized	14
Education & Training	Summer School	1 [130 participants, 236 registrations]
Dissemination to the General Public	Web site	
	Social media: YouTube videos + interviews	8
	Press releases	10

*) Status 09/2016

The 5G NORMA consortium: **Enabling 5G business**

(Project Coordinator)
(Technical Manager)

5G NORMA in a nutshell

EU funded R&D project within 5GPPP Initiative, aiming on building consensus on E2E mobile network architecture and rapid implementation

Duration

July 1st, 2015 – Dec 31st, 2017

Connect to 5G NORMA

Webpage: https://5gnorma.5g-ppp.eu/
Twitter: 5G NORMA project @5G_NORMA
5GPPP: https://5g-ppp.eu/
Facebook: facebook.com/5GNORMA
Youtube: https://goo.gl/hGfa8H

Contact 5G NORMA

5G-NORMA-Contact@5g-ppp.eu