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5G Network and Service Management Including Orchestration v3.14.0

5G Network and Service Management including Orchestration

by NGMN Alliance

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Abstract

This document describes requirements for 5G Network and Service Management including Orchestration. The Document includes requirements covering all potential parts of future networks, i.e., fixed-, mobile-, cloud, virtualized technologies from a Network and Service Management including Orchestration perspective.

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2019-02-17	3.14.0	DT Cisco	Resolution of comments by the NGMN Board: Added Definition of Orchestration provided by Michael Klotz DTAG 13022019 Added 2019-02_Cisco and DT revision 1 - Proposed resolution of the Board's comment 2_Vladimir Yanover_08022019 revised by Michael Klotz 13022019 Added Requirements for NW Slice management and orchestration in a roaming case Michael Klotz 13022019

Contents

1 INTRODUCTION

The NGMN 5G White Paper Version 1.0 published in February 2015 has positioned the demands and business requirements beyond 2020.

The enhancement of performance, support of modular network functions by the architecture, scalability, automation of network operations functions, self-healing capabilities are all requested in the White Paper. In addition, along with 5G networks the number of devices will increase dramatically with wide scale introduction and deployment of IoT and M2M communication.

It is expected that the 5G will be deployed, operated in a heterogeneous environment with multi-vendor solutions. The 5G system is foreseen to be software based with a split between hardware and software. Therefore, Cloud and virtualized Telecommunication Technology, SDN, Industry 4.0 (Internet of Things), etc. will be taken into consideration for the 5G deployment.

All that has impact on the Network Management and Operations. The classical FCAPS (Fault, Configuration, Accounting, Performance, and Security) functions are still needed, but some of the processes and implementations will change. The potential increase in complexity would require a higher grade of automation for OAM functions. The network will run more autonomously, and the production of services will be more automated. The production will be done increasingly in real-time, for example, within seconds time-scale. It is expected that the management or changes of VNFs or Clouds will be more dynamic than the management of legacy network elements.

In 2G/3G/4G, Network Management was based on Element Management supported by intelligent strategies like alarm filtering and correlation. The new approach should be more focused on Service Management and based on real-time Network Management (e.g. within seconds).

It is expected that e.g. the NW slicing concept will have an impact on Service and Network Management including Orchestration. All of that will trigger a complete paradigm shift of Service and Network Management.

2 REFERENCES

[1] NGMN 5G White Paper 17.02.2015
[2] ETSI GS AFI 002 V1.1.1 (2013-04)
[3] ETSI GS NFV-MAN 001 V1.1.1 (2014-12)
[4] NGCOR NEXT GENERATION CONVERGED OPERATIONS REQUIREMENTS V.1.4 2013-07-22
[5] TM Forum TR229, Release 14.5.0 October 2014, Frameworx Exploratory Report ZOOM/NFV User Stories
[6] NGMN Description of Network Slicing Concept v1.0.8, September 2016.
[7] NGMN 5G End-to-End Architecture Framework v2.0, 2018-02-26

3 Terminology

3.1 Network Management

In this document it means Fault Management, Configuration Management, Accounting Management, Performance Management, and Security Management (FCAPS)

3.2 Orchestration

Orchestration is the automated execution of operational and functional actions concerning the coordination, combination including configuration, and management of resources and services in the design, creation, delivering, and operations phases of an end-to-end service.

Note: There are several types of orchestration, for example service orchestration, application orchestration, cloud orchestration, and container orchestration.

3.3 Service Management and Orchestration

In this document it means management and orchestration of the services provided to Service Providers' customers.
Note: It is different from "network services" defined by ETSI NFV

3.4 Network infrastructure

In this document network infrastructure means totality of the 5G system which is object for management.
Note: It is different from "virtualization infrastructure" defined by ETSI NFV

3.5 Service Instance

It is a run-time instance of a service that may be realized within or by a Network Slice.

3.6 Network Slice Instance

A set of run-time network functions, and resources to run these network functions, forming a complete instantiated logical network to meet the network characteristics required by the Service Instance(s), OLA(s) (Operation Level Agreement) and SLA(s).

- A Network Slice Instance is complete in the sense that it includes all functionalities and resources necessary to support the set of communication services required by certain business objective(s).

- A Network Slice Instance may be fully or partly, logically and/or physically, isolated from another Network Slice Instance (s).
- The resources used by the Network Slice Instance comprise physical and logical resources.
- A Network Slice Instance may be composed of Network Slice Subnet Instance(s), which as a special case may be shared by multiple Network Slice Instances.
- Instance-specific policies and configurations are required when creating a Network Slice Instance.
- Network characteristics examples are ultra-low-latency, ultra-reliability, quality, security etc.

See [6].

3.7 Network Slice Subnet Instance

A Network Slice Subnet Instance is a run-time construct and comprises of a set of Network Functions and the resources for these Network Functions.

- A Network Slice Subnet Instance is not required to form a complete logical network.
- A Network Slice Subnet Instance may be shared by two or more Network Slice Instances.

The resources comprise physical and logical resources; see [6].

4 LIST OF ABBREVIATIONS

AI	Artificial Intelligence
API	Application Programming Interface
BBA	BroadBand Access
BSS	Business Support System
CEM	Customer Experience Management
CFS	Customer Facing Service
CN	Core Network
CRM	Customer Relationship Management
EPC	Evolved Packet Core
E2E	End-to-End
HW	Hardware
IoT	Internet of Things
MANO	Management and Orchestration
MEC	Mobile Edge Computing
M2M	Machine to Machine
MVNO	Mobile Virtual Network Operator
NEM	Network Element Management
NGMN	Next Generation Mobile Networks
NFV	Network Functions Virtualization
NFVO	NFV Orchestrator
NMS	Network Management System
NSI	Network Slice Instance
NSSI	Network Slice Subnet Instance
NWMO	Network and Service Management including Orchestration
OoE	Quality of Experience
OSS	Operations Support System
RFS	Resource Facing Service
QoS	Quality of Service
RAN	Radio Access Network
RAT	Radio Access Technologies
SDN	Software Defined Networking
SDO	Standards Development Organization
SLA	Service Level Agreement

SM	Service Management
SON	Self Organizing Networks
SOF	Self-Organizing Functions
SW	Software
UE	User Equipment
VNF	Virtual Network Function
VIM	Virtualized Infrastructure Manager

5 Objectives of this document

- The target is to provide key requirements and high level architecture principles of Network and Service Management including Orchestration for 5G.
- This document is based on the NGMN "5G White Paper" [1] with the target to take the requirements and architecture to the next level of details, extending the analysis to cover also Service Management and Orchestration. The document is also based on the inputs from other NGMN groups, particularly from the NGMN E2E Architecture group.
- The goal was to take a comprehensive view on the new needs for Network and Service Management concepts and requirements arising from the infrastructure evolution to 5G as well as from a vast amount of various new service scenarios/possibilities enabled by new 5G technologies.
- Objectives that were set for 5G Network and Service management including orchestration document
    - Define key requirements and high level architecture principles for network management and orchestration
        - Taking into account in a holistic way the network infrastructure evolution towards 5G (e.g. volumes, speed, capacity, virtualization, and dynamics).
        - Driving continuous improvement of operations efficiency via enhanced concepts and solutions.
        - Identifying the needed network management and orchestration functionalities and evolution of them.
    - On high level, the target network management and orchestration needs can be characterized for example by: (*not an exhaustive list*)
        - Enabler for high degree of production process automation supported by policy-controlled autonomic/self-management functions in the network infrastructure.
        - Policy controlled real-time Network management and orchestration to enable flexibility and elasticity in rapid scaling of the network infrastructure capacity when needed.
        - Capabilities to expose open network management interfaces to enable exchange of management information with partners in the value chain.
        - Aggregating E2E network management information across networks consisting of virtualized and non-virtualized network functions.
        - Feeding the information to the service management and orchestration layer and acting on control coming from that layer.
        - Utilizing (real-time) data to enable decision making and optimization based on massive information collection from the network infrastructure.
        - Open and/or standardized interfaces throughout the network, facilitating multi-vendor network infrastructure implementations.
        - NGMN to develop recommendations about which interfaces should be standardized.
        - NGMN to develop recommendations on what information should be included into the information and data models.

- Relations to the requirements on Network Management of the underlying infrastructure (such as backhaul and transport) were studied.

- Objectives that were set for Service management and orchestration
  - Define key requirements and high level architecture principles for service management and orchestration
    - Taking into account in a holistic way service evolution possibilities enabled by 5G (refer to NGMN 5G white paper).
    - Create capabilities for improved time to market of versatile services for end customers and service production partners.
    - Guarantee and improve customer experience of the products and services offered.
    - Identifying and determining the needed service management and orchestration functionalities and their evolution.
  - On high level the service management and orchestration can be characterized for example by; (not an exhaustive list)
    - Environment for service creation and implementation enables fast service introduction; service componentization, parameterization and personalization.
    - Provide E2E information of quality and health of services and how SLA and customer experience targets are fulfilled.
    - Tight interaction with network management and orchestration for optimized utilization of network infrastructure for different service needs.
    - Capabilities to expose open service management APIs to allow to exchange management information with partners in the value chain
    - Using (real-time) analytics to enable decision making, business intelligence and optimization based on massive information collection from the network and service infrastructure as well as the services themselves.
    - Open and standardized interfaces throughout, facilitating multi-vendor infrastructure implementations.
  - Objectives that were set for operations automation and autonomic functions in the network infrastructure.
    - Provide a clear evolution path from current 4G SON solutions to 5G network automation solution.
      - Automation evolution in 4G non-virtualized network towards better coordination between network layers, between RATs and between Radio Access Network (RAN) and Core Network CN.

        Note: This part is needed to align SON capabilities between evolved 4G and 5G network components.
      - 4G Automation evolution driven by virtualization
      - Automation evolution driven by 5G technology advance.
      - Automation should allow receiving input from various data sources that would enable innovation.
  - The objectives set for 5G automation concept were to provide for the following
    - The automation architecture should allow for easy integration with Network and Service Management including Orchestration.
    - The automation architecture should allow for easy integration of RAN, CN and UE automation functions, between centralized and distributed SON components.
    - Convergence of technologies (e.g. multiple 5G RATs) and network slicing should be addressed

- The architecture should provide for scalable solution in view of expected rise in the number of Network Elements in HetNet and the number of subscribers in combined BBA and IoT (M2M) networks.
- The architecture should allow for resolution of network problems in real- time (e.g. in seconds) where relevant.
- Due to the expected high volume and high velocity of data and variety of data due to multiple data sources, the automation architecture should allow support for big data and data analytics.

The scope of the NWMO sub-project did not include

- Customer management
- Product management

6 Input Documents

The following documents were taken into consideration:

- "NGMN 5G White Paper" [6] for the scoping and objective definitions
- ETSI GS AFI 002 V1.1.1 (2013-04)
- ETSI GS NFV-MAN 001 V1.1.1 (2014-12) [2]
- NGCOR Next Generation Converged Operations Requirements V.1.4 2013-07-22 [4]
- TM Forum TR229, Release 14.5.0 October 2014, Frameworx Exploratory Report ZOOM/NFV User Stories [5]
- NGMN 5G End-to-End Architecture Framework v2.0, 2018-02-26 [7]

7 METHODOLOGY APPLIED

NWMO used NGMN 5G white paper [1] as its main basis for continued architecture and requirements work. The 5G white paper addresses on high level 5G system deployment, operations and management requirements as well as high level E2E management and orchestration technology and architecture principles. The working assumption as described by the NWMO objectives is, that those requirements and architecture principles will be derived to next level of details during the course of NWMO work, possibly delivered as series of packages containing increasing granularity and level of details over the years.

The key viewpoint to note was, that NGMN NWMO's task is to drive operator's common concerns and requirements for E2E Network and Service Management including Orchestration for guiding further work conducted by SDOs and industry in developing needed solutions and systems on the 5G evolution journey.

For taking as much as possible holistic view on future development, implementation and operation challenges of 5G, NWMO addressed E2E Network and Service Management including Orchestration problem space via 5G system lifecycle model framework depicted in the Figure 7-1.

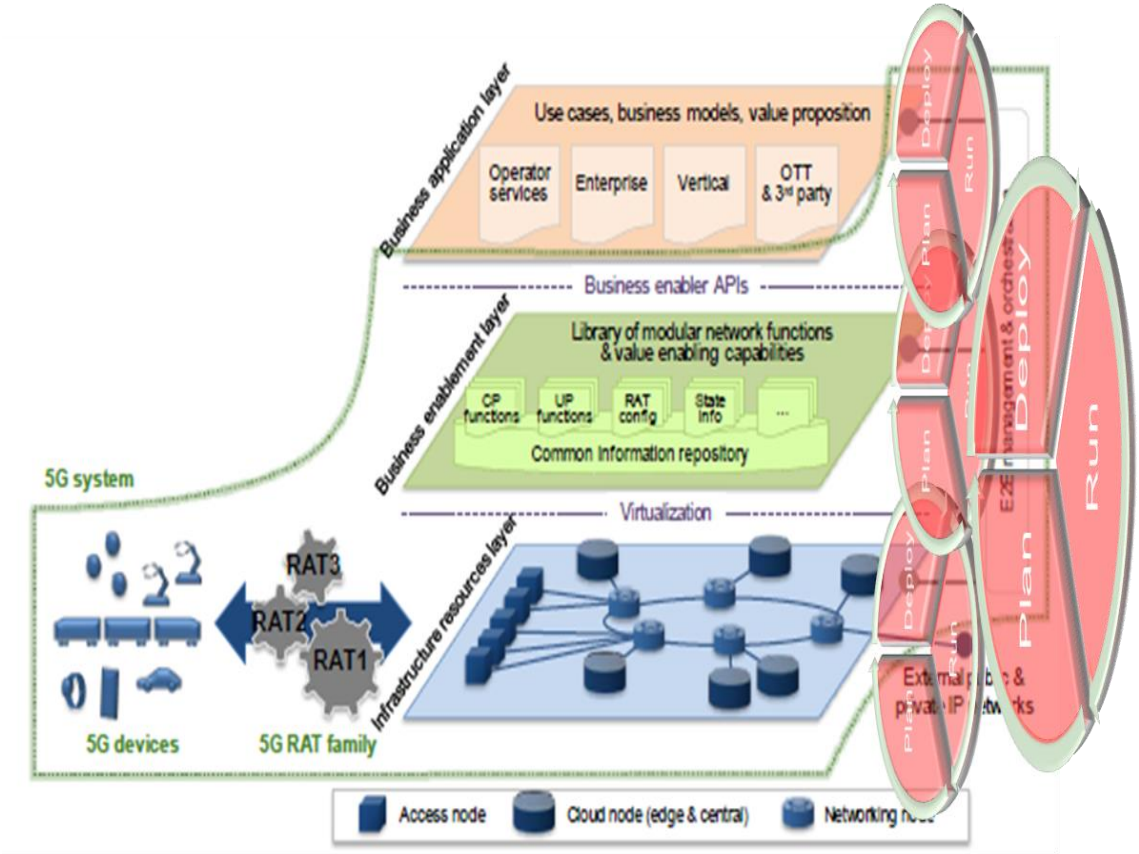

Figure 7-1: 5G system lifecycle model framework

In the 5G system lifecycle model, the development, implementation and operational phases can be viewed via three main phases

- Plan
- Deploy
- Run

Within each of the main phases, the emphasis is to analyse the needed activities and tasks to be executed by defined actors and within the operator organization. This was used to identify capabilities, tools etc. that are necessary in order to conduct E2E Network and Service Management including Orchestration actions. i.e., as it depicted in the original 5G system architecture picture, E2E Network and Service Management including Orchestration is interfaced towards each layer.. This information and understanding can further assist in guiding the definition of E2E Network and Service Management including Orchestration requirements and architecture, reaching technical levels.

The intention of the NWMO was to address the full lifecycle of 5G system environment to analyse the needed requirements and capabilities that operator's will need in E2E management and orchestration when 5G system is developed and evolving. There was no intention to dig in details of technical planning of 5G system

architecture itself. On the other hand, the lifecycle model can be also applied to E2E Network and Service Management including Orchestration entity itself for analysis of the needed development, evolution and possible transformation path from the current OSS and management systems environment.

The analysis of E2E Network and Service Management aspects was based on selected **User Stories** [5].

- Considerations regarding the main phases
    - Plan: Planning can be seen in very wide scope, 5G system needs to provide extreme flexibility so that different visions in terms of 5G use cases, business models and value creation opportunities are met. E2E Network and Service Management including Orchestration capabilities come into relevant role in planning so that 5G system can have assured and controlled user experience, system performance, user device management, availability, integration with partners etc.
    - Deploy: Deployment is basically concerned of implementation, updates, roll-outs, expansions etc. of the 5G ecosystem. The 5G ecosystem consists of virtualized and non-virtualized components. Virtualization and software based components getting a growing role. E2E Network and Service Management including Orchestration capabilities are needed in deployment so that the 5G ecosystem can be rapidly changed and updated as much as possible as well as automated provisioning and delivery of new features are possible.
    - Run: Running or operation phase of the 5G ecosystem is most regarding traditional OSS and management aspects where all typical fulfilment, assurance and billing features are provided by the E2E Network and Service Management including Orchestration. Also understanding that a 5G ecosystem is to a great extent a virtual environment and thus requiring dynamic and real-time/near real-time control as well as Network and Service Management including Orchestration
- Lifecycle analysis may focus on dedicated layer/entity of the 5G system or a combination of them, e.g.
    - Infrastructure resource layer
    - Business enablement layer
    - Both two above together/jointly
    - E2E Network and Service Management including Orchestration entity itself
    - Business application layer can be generally be understood to represent the product and offering layer for operators. It is also depicted to have an interface to E2E Network and Service Management including Orchestration to enable applications to be mapped and implemented by the two lower layers.
    - Within the main phases following actors/roles can be identified:
        - Plan: Planners/designers on different layers of the 5G system; 5G Infrastructure resource planners/designers, 5G Service component/business enabler component planners/designers, 5G XaaS service planners, Product managers, Partner managers, Architects,..
        - Deploy: 5G infrastructure resource deployment managers, 5G service component/business enabler component deployment managers, Testing managers, Release managers, Partner component deployment managers.
        - Run: Operations managers, Quality managers, Incident/problem managers, Capacity managers, Change managers, Policy administrators, Partner managers, Security managers.

8 User Stories

8.1 Network Slice Instance Creation

As a 5G Operator, I want to

design a 5G Network and Service Management including Orchestration Architecture to be able to manage and control my multi-domain network infrastructure, which can be, for example, 5G vs Non-5G, NFV vs Non-NFV composed of 5G RATs, 4G RAT, maybe 2G / 3G RAT, Fixed Access, Non-3GPP RATs, Backhaul, EPC Core, 5G Core

So that I can

Create, deliver, manage and orchestrate Network Slices Instances to fulfil various kinds of customers' needs (end users and enterprises e.g. MVNO) and guarantee autonomic service assurance, autonomic dynamic service delivery and provide proactive CEM dashboard

To do this I need

1. Pre-conditions

- Deploy a multi-domain network infrastructure,
- Expose via network APIs the capabilities of this multi-domain network infrastructure
- Deploy Network and Service Management including Orchestration system which includes:
    - Editors for various items and definitions, including high-level network objectives/goals, policy generators that generate policies from high-level network objectives/goals and policy validators against conflicts (goals conflict resolution, policy conflict resolution, etc.),
    - ETSI MANO components (NFVO, VNF Manager, VIM),
    - SDN Controllers,
    - Legacy OSS (NMS / EMS),
    - E2E Service orchestration.

2. To create a NW slice

E2E Service Orchestration interprets and translates service definition / service design[1] into configuration of resources (virtualized and non-virtualized) needed for service establishment. The configuration of resources may be for actual amount of resources or the policy of their allocation at later time, when the service is activated.
The E2E Service orchestration further triggers the components of the Network and Service Management including Orchestration system (ETSI NFVO, VNF Manager, VIM, SDN Controller, and legacy OSS) to apply the configuration of the required resources, which for some resources may result in their actual allocation.
Note: In case when the needed resources were not allocated at the previous step, they will be actually allocated at the time of service activation, according to the configuration / policies.
Make available a self-service Portal and self-ordering APIs to my customers (residential and enterprises) to allow them for self-ordering their slices with SLAs and update them dynamically when needed.

8.2 Real-time product change / provisioning

As a 5G Customer / Customer Agent I want to

be able to change products in real-time within a multi-domain network infrastructure, which can be, for example, 5G vs non-5G, NFV and non-NFV, composed of 5G RATs, 4G RAT, possibly 2G / 3G RAT, fixed access, Non-3GPP RATs, backhaul, EPC, and 5G core.

[1] The service design may include e.g. description of service chaining

So that I can
be able to change products in real time to benefit from my newly booked products and start using them based on the real time requirements.

To do this I need

1. Pre-conditions
   - Deploy a multi-domain network infrastructure.
   - Expose via Network APIs the capabilities of this multi-domain network infrastructure.
   - Deploy Network and Service Management including Orchestration system which includes:
     - ETSI MANO components (NFVO, VNFM, VIM),
     - SDN Controller,
     - Legacy OSS (NMS / EMS)
     - E2E Service orchestration.
   - Deploy a self-service portal and self-ordering APIs for self-ordering their services with selection of QoS profiles and updating them dynamically when needed.

2. To change in real-time, the product
   - Invoke editors for various items and definitions, including high level network objectives/goals, policy generators that generate policies from high-level network objectives/goals and policy validators against conflicts (goals conflict resolution, policy conflict resolution).
   - Invoke E2E Service orchestration to interpret and translate service definitions / service designs into configuration of resources (virtualized and non-virtualized) needed for service establishment. The configuration of resources may be for actual amount of resources or the policy of their allocation at later time, when the service is activated.
   - Invoke the orchestration to trigger the components of the Network and Service Management including Orchestration system (ETSI NFVO, VNF Manager, VIM, SDN Controller, and legacy OSS) to apply the configuration of the required resources, which for some resources may result in their actual allocation.

Note: In case when the needed resources were not allocated at the previous step, they will be actually allocated at the time of service activation, according to the configuration / policies.

   - Individual customers may use a self-service portal and self-ordering APIs for self-ordering their services with selection of QoS profiles and updating them dynamically when needed.

8.3 Catalogue driven product introduction / modification

As a 5G Operator I want to
be able to simply create new/modify product/service models and put them into the service catalogue.

So that I can
quickly introduce new products. There should be no/minimal programming necessary. The service lifecycle shall potentially be days from idea to production.

To do this I need

- Pre-conditions
  - Deploy a multi-domain infrastructure.
  - Expose via network APIs the capabilities of this infrastructure.
  - Deploy Network and Service Management including Orchestration system which includes:
    - ETSI MANO components (NFVO, VNF Manager, VIM),
    - SDN Controller,
    - E2E Service orchestration.

- Deploy a self-service portal and self-ordering APIs for self-ordering their services with selection of profiles providing for certain service quality and experience and updating them dynamically when needed.

- To introduce new product,
  - Invoke editors for various items and definitions, including high-level network objectives/goals, policy generators that generate policies from high-level network objectives/goals and policy validators against conflicts (goals conflict resolution, policy conflict resolution
  - Invoke E2E Service orchestration to interpret and translate service definitions / service designs into configuration of resources (virtualized and non-virtualized) needed for service establishment. The configuration of resources may be for actual amount of resources or the policy of their allocation at later time, when the service is activated.

Note: Actual activation of the service will be triggered by network events like for example user attach to the network or explicit request from the enterprise user.

8.4 Progressive Deployment of 5G Network

As a 5G Operator, I want to

manage and orchestrate highly dynamic network infrastructures so that service can be offered progressively and seamlessly. Specifically, operators want to adapt and/or align E2E Network and Service Management including Orchestration to the business need of gradually expanding roll-out and deployment of 5G network, avoiding transition failures in the architecture and impact on legacy services, and ensuring scalability of the network and service management system.
The operation may involve fully virtualized (NFV) networks, hybrid (PNFs and VNFs) networks, and fully converged network, which can have different types of access, backhaul and core nodes.

So that I can

Progressively create, deploy, grow (with customers' needs) and orchestrate E2E Network and Service Management of 5G networks and services smoothly within architecture that allows such business strategy at minimum cost.
The ultimate objective is to save on Network Management efforts which may include rapid (a) introduction, (b) scaling, (c) healing, and (d) migrations of network slices, services and functions without significantly impacting performance and customer expectations and service experience.

A migration may include both the transport network and the core network. For migration to SDN controlled transport networks, a number of pre-migration, migration, and post-migration best practices have been developed[2]. For instance, a likely scenario is to start with a geographical segment market, where 5G (NFV) is implemented in a small part of the network first, that is often standalone. After successful trial and operation, the necessary best practices can be developed, and the same 5G (NFV) NWMO function can be integrated with and/or extended to cover another part of the network.

Thus, progressive deployment of 5G (NFV) NWMO could be advanced to the entire network. The partitions of the network that are upgraded to 5G (NFV), could be organized by geography, technology, business, administration, or strategy.

To do this I need

In order to support gradual deployment of 5G E2E NWMO, open and flexible orchestration capabilities are required.

[2] Migration Use Cases and Methods, https://www.opennetworking.org/images/stories/downloads/sdn-resources/use-cases/Migration-WG-Use-Cases.pdf, 2015.

One of such capabilities is agile multi-domain E2E Network and Service Management including Orchestration, that allows for a progressive transition from legacy technologies to 5G supporting technologies including SDN-based control/management, legacy and emerging MANO (NFVO, VNFM, and VIM) for virtualization. For example, MANO architecture uses descriptor/template mechanisms to enable orchestration. When the number of the independent domains increases, the orchestrator needs to support increased flexibility and scalability in order to facilitate a growing number of descriptors and information management modules regarding the added number of network services and VNFs.

In specifics, a gradual network migration can be achieved through centralized and/or federated orchestration. To this end, aligned and coordinated management of descriptors and their information elements between different levels of orchestrators is needed.

8.5 5G end-to-end Service Management

As a 5G operator and service provider, I want to
Design and develop an end-to-end (E2E) Service Management (SM) to be able to manage the whole chain of a service also to support the customer point of view amongst other things, e.g. regarding a Customer Facing Service (CFS).
Several areas should be considered and covered on demand as e.g.:

- Converged networks (fixed and mobile, hybrid networks)
- RAN and Core
- Virtualized and non-virtualized networks as well as applications/services and/or parts of them
- Cloud based services/applications and infrastructure
- One and/or several administrative domains within the entire service chain.
- Legacy and non-legacy parts

The E2E SM should be able to cooperate with the Network Management in an efficient and effective manner. Furthermore, it should be flexible, robust, automated as much as possible, etc.
In addition, it shall support e.g.:

- Proactive Network and Service Management and associated monitoring
- Self-healing of services
- Self-optimization of services
- Self-Service Management by users as e.g. MVNOs and end customers
- Big data handling
- Artificial intelligence (AI) methods/mechanisms and solutions
- Model driven approach
- DevOps approach
- Modular approach of the SM
- Easy extensibility and reduction of functionalities on demand
- No single point of failure
- Multi tenancy
- Cooperation with other SMs and relevant components as e.g. BSS
- NW Slicing
- Combination of service design and execution framework
- Real-time handling.

So that I can
flexibly manage and orchestrate including optimize etc. the E2E services based on several technologies and demands.

Furthermore, support the common handling together with the BSS, and other user and customer owned SM components and systems, if requested.
Build flexibly an SM on demand based on a "core SM" and additional SM modules to cover several needs.
Improve the customer experience, to increase the degree of automation and QoS (Quality of Service) with reduced costs.
Easily integrate and/or remove services or service extensions on demand.
Provide a high degree of a self-service management at the user and end costumer sides.
Deliver an SM that acts proactive.

To do this I need
Standardized, at least open[3] and extensible interfaces and APIs that allow the E2E service handling in a multivendor management environment and in an efficient and effective way.
In addition, the architectural framework(s), necessary functionalities, mechanisms etc. should be standardized widely as well.
It is needed a timely provision of the prerequisites (standards, appropriate solutions, etc.) and the quick coverage of the handling of new challenges as e.g. new technologies and functionalities/capabilities.
This requires a close cooperation of the SDOs and open source communities (e.g. ETSI NFV, 3GPP SA5 and SA2, ONF, TMF, BBF, MEF, and NGMN) as well as the key players on the market in order to avoid a lot of silos and proprietary solutions amongst other things.
The entire E2E chain has to be improved with all the SW/HW components, realization methods and mechanisms as well as processes applied, etc.

8.6 5G ultra low latency and real-time challenges concerning the end-to-end Service Management

As a 5G operator and service provider, I want to
Design and develop a flexible end-to-end (E2E) Service Management (SM) that can handle application and services based ultra-low latency/real-time requirements.
It should be able to cover several areas and technologies e.g. in the telecommunication area, automotive industry, healthcare sector, energy sector, for augmented reality applications/services as well as within the computer gaming industry.

So that I can
Handle applications/services that require ultra-low latency/real-time management in an E2E view with a flexible appropriate ultra-low latency/real-time E2E SM on demand at reasonable costs.

To do this I need
To know whether and which ultra-low latency/real-time requirements are needed concerning the corresponding E2E SM.

To keep 5G architecture simple and to reduce the heterogeneity.
Flat architectures with reduced amount of reference points and interfaces.
Less components, reduction of layers and functionalities. Only functionalities which are really needed shall be provided.

Usage of lightweight protocols and functionalities.

Standardization as far as possible to support the automation of the SM handling and the corresponding actions.

[3] For interfaces, being open means that the interface details are available to public so that any manufacturer will be able to implement them.

This requires a close cooperation of the SDOs as well as the key players on the market.
The entire E2E chain has to be improved with all the SW/HW components, realization methods and mechanisms as well as processes applied, etc.

Use case
The use case describes a scenario where several objects/persons will hand over equipment in a drone environment. In this case the following assumptions and activities have to be considered and realized amongst other things:

- It is assumed that no direct communication between the objects/persons is possible, that means there is no point-to-point communication between the drone and the lorry.
- For that reason, data will be exchanged to getting closer and to make some optimization between the drone and the lorry e.g. in the performance field. The sensor information will be sent concerning e.g. speed, acceleration behavior of the objects and the distance between them to the network/service and orchestration components.
  The Network and Service Management including Orchestration components manage/control the behavior of the objects in such a way that the equipment will be handed over in a correct manner. Therefore it will be realized an analysis of the data by the corresponding Network and Service Management including Orchestration components.
- Based on this analysis, the Network and Service Management including Orchestration component(s) send the necessary information to the objects to manage/control them and to configure as well as orchestrate the objects respectively on demand.
- Ultra-low latency requirements have to be fulfilled to realize the activities within the requested time
- Network and Service Management including Orchestration tasks have to be realized for the management of corresponding virtualized resources and services on demand.

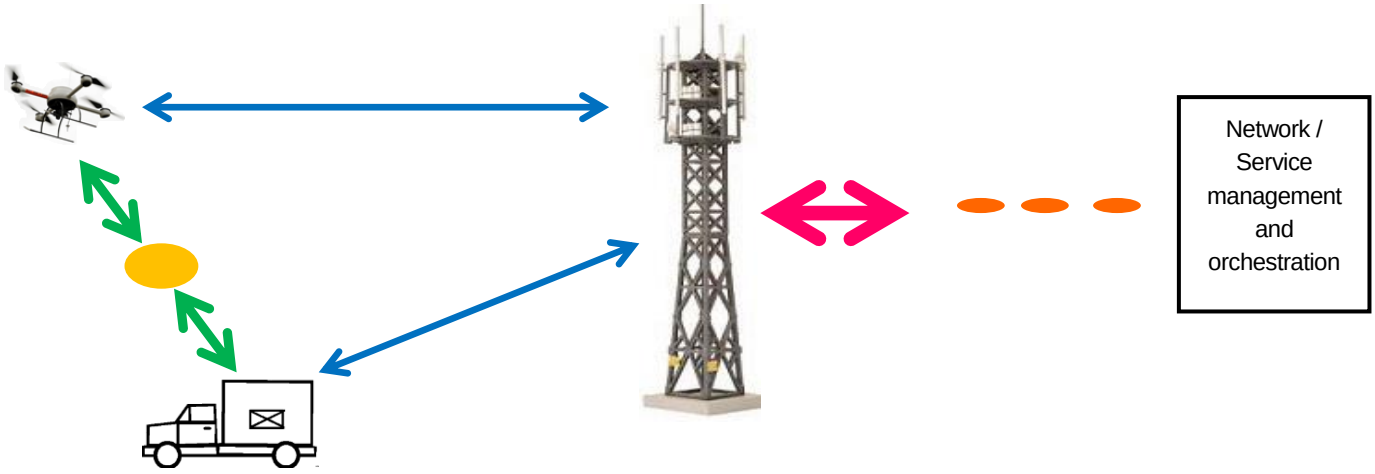

Figure 8.6-1 Use case for a drone environment

8.7 Optimization

As a 5G Operator, I want to

be able to automate optimization of my multi-domain network infrastructure, which can be, for example, 5G vs Non-5G, NFV vs Non-NFV composed of 5G RATs, 4G RAT, maybe 2G / 3G RAT, Non-3GPP RATs, fixed access network, Backhaul, EPC Core, 5G Core

So that I can

Optimize

- utilization of the network infrastructure, virtualized and non-virtualized as determined by certain KPIs
- user experience as determined by appropriate metrics of user experience, where needed, per slice
- business service and application performance (as determined by certain metrics and KPIs), where needed, per slice

To do this, I need

- Deploy a multi-domain network infrastructure,
- Expose via Network APIs the capabilities of this multi-domain network infrastructure
- Deploy Management and Orchestration Functions which includes:
    - ETSI MANO components (NFVO, VNF Manager, VIM) in case when some network nodes are virtualized,
    - SDN Controllers
    - Legacy OSS (Network Management / Element Management functions)
    - E2E Service orchestration

The Management and Orchestration Functions may include domain specific elements.

- The assumption is that Data Collectors are available at the network nodes to collect the network and service data for example performance data which can be delivered to the entities subscribed to the data such as Analytics software and Optimization Applications
- Deploy Analytics software for processing of the network performance data, such as statistics computation and pattern recognition
- Deploy Optimization Applications that receive and analyse the network performance data and provide (re)configuration of the network nodes and/or network policies to achieve the optimization targets defined by the operator
    - The optimization targets (metrics) may be set in terms of
        - utilization of the network infrastructure
        - user experience such as video quality
        - E2E application / service performance

      The targets may be set per NW slice where needed.
    - The (re)configuration of the network nodes and/or policies is executed via management, orchestration and control system
- Activate
    - Collection, storage and processing of network and service data for example performance data which can be delivered to the entities subscribed to the data such as Analytics software and Optimization Applications
    - Delivery network and service data for example performance data to the subscribed entities such as Analytics software and Optimization Applications. The data may include
    - Utilization of the infrastructure such as usage of Radio resources
        - Metrics reflecting user experience
        - E2E application / service performance
    - Optimization Applications to process the network and service data for example performance data and outcome from the Analytics software, with optimization target(s) configured by the network operator. The possible target(s) are

        - Utilization of the infrastructure such as usage of Radio resources
        - user experience
        - E2E application / service performance
    - Optimization applications to dynamically (re)configure the network and service functions via Management, Orchestration and Control System, using Network APIs, to effect appropriate network components such as
        - E2E Service orchestration
        - ETSI MANO components
        - SDN Controllers
        - Legacy OSS (Network Management / Element Management functions)

8.8 Network management and orchestration for mixed networks

As a 5G Operator, I want to
Use management and orchestration functionalities to manage both 5G and non-5G network elements

Note: mixed network in the context of this user story refers to networks that are composed of both 5G network elements and non-5G network elements

So that I can
Enhance the existing management functionalities to manage both 5G and non-5G network elements (e.g. Fault Management function, Performance Management function etc.), or build some new management functionalities (e.g. needed for Slicing management etc.) to manage both 5G and non-5G network elements.

To do this, I need
Check the existing management interfaces that could be potentially enhanced or new management interfaces that are needed to satisfy the operator's needs.

8.9 End-to-end network management and orchestration with network slices

As a 5G Operator, I want to
Configure network slices to support multiple end user services

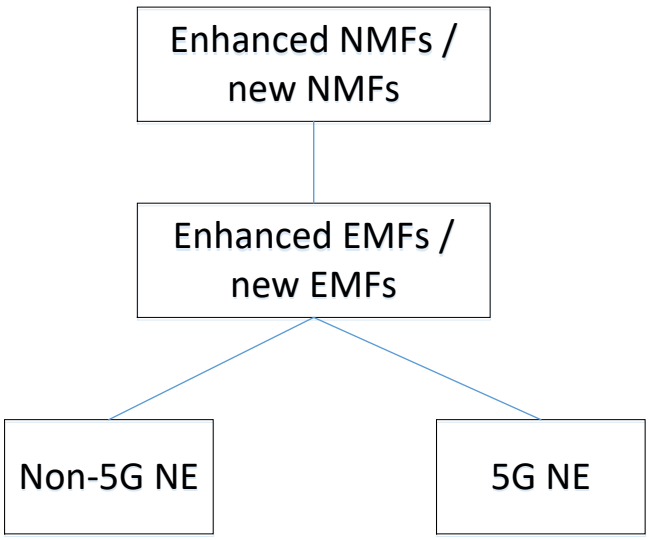

Figure 18.9-1

So that I can
Deploy the end user services with different requirements for the network.

To do this, I need

- Analyse the end user service and determine the requirements for the network.
- Prepare and configure the corresponding network slices. This includes either creating a dedicated network slice for the end user service or selecting an existing network slice, which the end user service shares with other services.
- If a new network slice is created, arrange appropriate network functions to be included into the network slice. The arrangement could include PNFs or VNFs or both. VNFs can be created in a virtualization scenario if needed.
- If an existing network slice is selected, also modify the slice if needed to satisfy the end user services.
- Monitor the service performance of the created slices, some modifications to the network slices are needed if the performance is not as desired

8.10 Network slicing applied to multi-operator roaming

As a 5G Operator, I want to
Offer services to enterprise customers that include global access with a set of features and characteristics where the features set, capabilities and quality in the roaming scenario is consistent with the features set, capabilities and quality in a non-roaming scenario.

So that I can
In a (lead) time and cost-efficient manner offer services that extend into the geographical domains of other 5G operators.

To do this I need

- To be able to request resources and services from other 5G operators.
- Keep control of the configuration of the network functions and life cycle management of the VNFs and Network Services that implement the capabilities needed for the service delivery to the end-user
- Get these network functions configured and integrated into the other 5G operators' network, so that they can provide the service

- Create (and life cycle manage) network slices that “extend” into other 5G operator network using the approach described above
- Assure the service end-to-end, including the portion provided through the other 5G operator.

Description
In this user story, a customer can request a service from operator A that is realized by network slicing. In order to get global reach, operator A may request services/resources from operator B (C, D…) that allow A to have network functions deployed within operator B network, using the infrastructure of operator B, yet fully managing these network functions and how they consume resources. Furthermore, operator B would allow operator A to get network functions configured and integrated into its network, such that “roamers” can get service through them.
To facilitate this, inter-operator interfaces will be required between the management/orchestration systems of operator A and B. These need to be able to scale to global operations.

8.11 Collection of E2E service quality information

As a 5G Operator, I want to
Arrange collection of the E2E service quality information.

So that I can
- Monitor the quality of particular services to provide my customers with communications services of sufficient quality.

To do this I need
- At least one of the following:
    - To have deployed at the UEs service quality measurement functions capable of delivery of the measurement results to the network’s management system
    - To have deployed at the Application Servers the service quality measurement functions capable of delivery of the measurement results to the network’s management system
- Arrangements in the management system to store the quality information and make it available to authorized consumers

Description
The process starts from a request for provisioning of the collection of the E2E service quality information. Such request can be generated by any authorized entity such as management or optimization application. The configuration may include for example one or more of the following parameters:
- The trigger for launching the session, such as activation of the corresponding service
- the UEs’ location area where the measurements should be performed
- the application type (end user service type)
- identification of the network slice instances, in which the measurements should be collected
- the set of measurements
- where and in which format the collected information should be stored
- the categories of the UEs

The management system delivers this configuration information to one of the following elements:
- Application Server (AS)
- Application level of the UEs in which the corresponding service may be activated

During the session, the E2E service quality information is generated and collected by one of the named entities:

- Case of the Application Server (AS). This option is possible in case when the network operator has access to the Application Server either directly (in case when the AS is operated by the network operator) or via proper Exposure function. The measurement session is configured by the network operator via the management and orchestration system. The session includes collection of quality measurements simultaneously for multiple UEs in parallel. The collected information is delivered to the management system for storage and further processing.
- Case of the UE. The E2E service quality information is generated and collected by the UE when the end user service of the requested type is active. The session is pre-configured by the management system; actual data collection starts when the service is activated. After sufficient amount of the information is collected, the UE delivers this information to the management system at proper occasion.

8.11 Network Slice allocation

As a 5G Operator, I have to

Provide a network slice instance that fits the requested network requirements. The allocation process is to use an existing network slice instance (NSI) or to create a new NSI.

So that I can

Provide a communication service that meets the defined requirements.

To do this I need

To use the 5G management system to verify if other existing NSIs support the requested communication service. An identified existing NSI has to satisfy the network requirements, overall performance, capacity and lifecycle management requirements for all the communication services it has to provide. If no existing NSI can be used I have to create a new one, if possible.

Description

The 5G Operator receives the request to provide a new communication service.
The 5G Operator uses the 5G management system to provide an NSI to satisfy the request.
The 5G management system performs the following steps:

- Verify if there is an NSI that will satisfy the request
- If no such NSI exists, create a new NSI and associate the requested communication service with it
- If any compatible NSI exists, verify if the network management policies (e.g. related to sharing) allow using it.
- If the policies don't allow using any of the identified NSIs, create a new NSI and associate the requested communication service to it.
- If the 5G management system finds an existing NSI that can be used, verify if the identified NSI supports the overall performance, capacity and lifecycle requirements for the communication services it has to serve.
- If yes, use it to satisfy the current communication service request.
- If none of the identified NSIs support the overall performance, capacity and lifecycle management requirements for the communication services, verify the network management policies to decide whether one of the identified NSIs can be used, possibly with reconfiguration.
- In case the network management policies don't allow to reconfigure any of the identified NSIs, create a new NSI and associate the requested communication service to it.
- In case the network management policies allow reconfiguring one of the identified NSIs, identify the new requirements for the NSI according to the overall performance, capacity and lifecycle management requirements for all communication services to be supported by the NSI.
- Verify if the new overall requirement for the NSI are compatible with the network management policies.
- If yes, associate the requested communication service with the NSI, otherwise create a new NSI.

- In the case of creating a new NSI, verify if the network requirements are compatible with the network management policies and the resource availability.
- If yes, the new NSI can be created otherwise the provisioning request is denied.

8.12 Network Slice creation using existing NSSIs

As a 5G Operator, I have to

Create a new network slice instance (NSI) that meets the requested network requirements. I would like to use existing network slice subnet instances (NSSIs), sharing them, to optimize the network resource usage.

So that I can

Provide communication service by creating a new NSI where some of its constituent NSSIs are shared with existing network slice instances.

To do this I need

To use the 5G management system to provide the constituent network slice subnets that will be used for the network slice. The allocation process verifies, for each requested network slice subnet, if there are sharable NSSIs available that support the requirements, otherwise I have to create a new one.

Description

The 5G management system has already identified that the requested communication service cannot be established on any of the existing NSIs, so it proceeds to create a new NSI.

As part of a new NSI creation process, the 5G management system derives network slice subnet requirements from the network slice requirements.

The 5G management system allocates the network slice subnets by using existing NSSIs or creating new ones, if possible. The 5G management system verifies if there are already deployed NSSIs that can be shared in terms of network management policies and that are compatible in terms of requirements.

To provide each requested NSSI, the 5G management system performs the following steps:

- Verify if there is an NSSI that satisfies the network subnet requirements. Otherwise, create a new NSSI.
- If there is a suitable NSSI, verify if the network management policies (e.g. related to sharing) allow to use the NSSI. If the network management policies don't allow use of any of the identified NSSIs, create a new NSSI.
- If any suitable NSSI exists, verify if it satisfies the overall performance, capacity and lifecycle management requirements for all the NSIs it has to serve.
- If yes, use it to satisfy the current request for network slice subnet allocation.

- If none of the identified NSSIs satisfies the overall performance, capacity and lifecycle management requirements needed for all the NSIs, verify the network management policies (e.g. related to an NSSI maximum capacity) to choose between decide reconfiguration one of the identified NSSIs, and creation of a new NSSI.
- In case the network management policies allow reuse of one of the identified NSSIs, identify the new overall requirements for the NSSI according to the overall performance, lifecycle management and capacity requirements for all the NSIs it has to serve.
- Verify if this new overall requirements for the NSSI are still compatible with the network management policies.
- If the verification is positive, reconfigure the NSSI, otherwise create a new NSSI.
- In the case of creating a new NSSI, verify if the original updated network requirements are compatible with the network management policies and the resource availability.
- If yes, the new NSSI can be created otherwise the NSI allocation request is denied.

8.13 Requirements update when the NSI is shared among services

As a 5G Operator, I have to

Modify a network slice instance (NSI) according to the modified network requirements.

So that I can

Provide a communication service that meets the updated requirements, optimizing the network resources usage.

To do this I need

To use the 5G management system to verify if the current NSI already supports the new requirements and if it still supports the new overall performance, capacity and lifecycle management requirements for all services. If needed and if it is allowed by the network management policies (e.g. related to an NSI maximum capacity), the 5G management system reconfigures the NSI, otherwise the management system creates a new network slice instance to support the communication service.

Description

The 5G management system receives the request with modified network requirements for a communication service provided by an NSI.

The 5G management system performs the following steps:

- Verify if the current NSI still can satisfy the new network requirements
- If yes, verify if the new overall performance, capacity and lifecycle requirements for all the services can still be satisfied by the NSI.
- If yes, use the NSI to satisfy the current communication service request.
- If no (no compatibility with the network requirements or with the overall performance, capacity and lifecycle requirements), evaluate, according to the network management policies and to the requirements of the other services, if the current NSI can be modified or allocation of a new NSI is needed.
- To update the current NSI, identify the new requirements according to the overall performance, capacity and lifecycle requirements for all the communication services.
- Verify if these new overall requirements are compatible with network management policies.
- If yes, reconfigure the NSI.
- Otherwise, proceed allocate a new NSI to support the communication service.
- If the 5G management system has provided a new NSI to fulfill the new requirements, evaluate the network requirement and the performance, and lifecycle capacity requirements for the remaining communication services that are still using the old NSI (if any) to decide if that NSI has to be reconfigured.

8.14 Requirements update when some NSSI is shared among NSIs

As a 5G Operator, I have to

Modify an existing NSI according to a request of network requirements update. Alternatively, if there is another NSI which could support the new network requirements, the operator may decide to use the alternative NSI

So that I can

Provide a communication service that fits the updated requirements, optimizing the network resources usage.

To do this I need

To use the 5G management system to verify if the current NSI already supports the new requirements. If the NSI doesn't fit the new requirements, the 5G management system considers reconfiguring the current NSI or reusing some other existing NSI that fits the new requirement.

Description

The 5G management system receives the request to update the requirements of an NSI. This NSI is not shared with other communication services but some NSSIs are shared with other NSIs.

The 5G management system performs the following steps:

- Verify if the current NSI satisfies the new network requirements and if the shared NSSIs are capable to provide the overall performance, and lifecycle capacity requirements for all the NSIs they are supporting.
- If the current NSI and shared NSSIs are capable of that, continue using them.
- If not, verify, according to the new requirements and to the network management policies (e.g. related to sharing or NSI capacity), if reconfiguring the current NSI or using some existing NSI already capable of satisfying the new requirements for the communication service.
- If the 5G management system decides to use an existing NSI, the chosen NSI has to be:
    - Sharable according to the network management policies.
    - Capable of satisfying the new requirements.
    - Capable of meeting the requirements for the overall performance, capacity and lifecycle requirements for all the communication it has to serve.
- If the 5G management system decides to reconfigure the current NSI, it has to update the subnets requirements and to verify if it is possible to update the current NSSIs or creation of the new NSSIs is needed.
- For each requested subnet, the 5G management system has to verify if the current NSSI is capable of supporting the new network requirements
- If yes, and if the NSSI is shared, verify if it is capable of supporting the new overall performance, capacity and lifecycle requirements for all the NSIs it has to serve.
- If yes, use it to satisfy the current update request.
- If no evaluate, according to the network management policies and to the requirements of the other NSIs using it, if update of the current NSSI or allocation of a new one is needed.
- To update the current NSSI, define the new requirements according to the overall performance, and lifecycle capacity requirements for all the NSSIs that are using it.
- Verify if these new overall requirements match the network management policies.
- If yes, reconfigure the NSSI.
- Otherwise, proceed allocating a new NSSI to support the updated communication service.
- If the 5G management system has provided a new NSSI to fulfill the new requirements, evaluate the network requirement and the performance, capacity and lifecycle requirements for the remaining services that are using the old NSSI (if any) to decide if the NSSI has to be reconfigured.
- If the 5G management system decides use an existing NSI, the old NSI has to be dissociated from the communication service.

8.15 Configuration of the RAN Network Functions shared between Network Slice Instances

As a 5G Operator, I want to

- Arrange configuration of the RAN Network Functions (NFs) shared between the Network Slice Instances (NSIs), in the process of creation or modification of their constituent RAN NSSIs

So that I can

- Achieve shared RAN NF support with QoS differentiation between the Network Slice Instances (NSIs)

To do this I need

- Deploy RAN NFs capable of receiving and executing the RRM Policy that provides a guide for sharing of the Radio resources between the RAN NSSIs corresponding to the NSIs

- Deploy the network management and orchestration system capable of setting the RRM Policy to the shared RAN NSSIs and individual shared RAN NFs

Description
The process starts from the request to the network management and orchestration system for creation or modification of the NSIs, which are to share certain RAN NFs. The request contains QoS requirements for the NSIs.
The network management and orchestration system derives the requirements for the RAN NSSI to be created or modified, from the NSIs' QoS requirements.
In case when certain RAN NF (and the corresponding cells) should be shared between multiple RAN NSSIs, the network management and orchestration system derives the RRM Policy for every such cell, from the QoS requirements. The RRM Policy guides partitioning of the cell Radio resources between the involved NSSIs
The network management and orchestration system configures the RRM Policy to the target cells.

8.16 Optimization of the RAN NFs shared between the Network Slice Instances

As a 5G Operator, I want to
- Optimize configuration of the RAN Network Functions (NFs) shared between the Network Slice Instances (NSIs)

So that I can
- Achieve maximum performance of the shared RAN NFs, while keeping QoS differentiation between the NSIs and within every NSI.

To do this I need
- Deploy RAN NFs capable of receiving and executing the RRM Policy that guides sharing of the Radio resources between the RAN NSSIs corresponding to the NSIs
- Deploy the network management and orchestration system capable of setting the RRM Policy to the shared RAN NSSIs and individual shared RAN NFs according to the QoS requirements
- Deploy facilities for the collection of the E2E service quality information

Description
Before the process starts, the network should be configured as described in the User Story "Configuration of the RAN NFs shared between Network Slice Instances"
The process starts when the collection of the NSI specific E2E service quality information in the network starts as described in the user story "Collection of E2E service quality information". Collection of the E2E service quality information may be initiated by the Network Slice Optimizer. In addition, regular performance measurements may be collected.
The Network Slice Optimizer function receives the NSI specific E2E service quality information and may receive regular performance measurements. Based on this data, the NSS Optimizer estimates whether the QoS level targeted for the active NSIs is maintained. In case it's not, the cause is identified. If the cause is in the RAN, the Network Slice Optimizer issues commands that modify the RRM Policy and / or RAN configuration parameters in the affected RAN NFs. This modification may be followed by modification in Core Network configuration and policies. In case when degradation is caused by Core Network operations, the RAN policy modification may be skipped. If the modification improves the situation in the relevant cells, the modified policy and configuration stays; otherwise the Network Slice Optimizer may command to restore the original RRM Policy and the configuration.

Network Slice Optimizer can be standalone (Figure 8.16-1) or constitute a part of the network management and orchestration system (Figure 8.16-2). In both cases, the interfaces used by the Network Slice Optimizer should be open interfaces, preferably standardized.

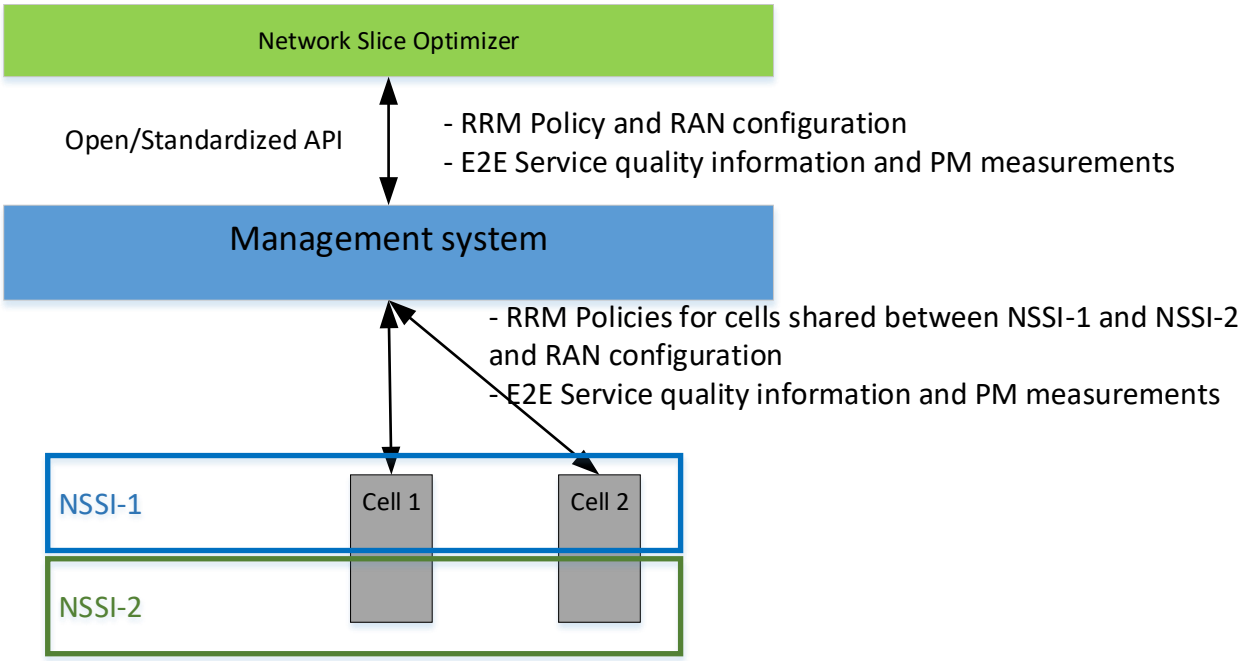

Figure 8.16-1. Modification of the RRM policies to reach the optimization goals; the optimizer is located outside of the management system.

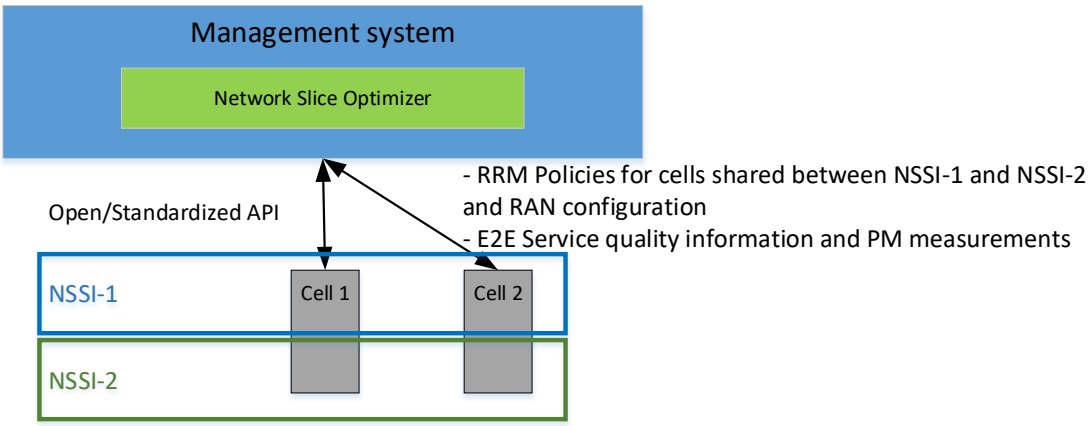

Figure 8.16-2. Modification of the RRM policies to reach the optimization goals; the optimizer is located in the management system.

8.17 E2E service via several administrative domains and their orchestrators

As a 5G Operator, I want to
create, deploy, manage and orchestrate a flexible E2E service via several domains, based on network slicing, where each domain has its own orchestrator. The orchestrators can communicate via standardized interface(s). In addition, the domains, especially the network slices, can be also adapted by the customers based e.g. on SLAs and OLAs, if needed. Therefore the appropriate management and orchestration capabilities have to be provided. The individual administrative domains can be owned for example by several companies and/or different divisions of a company.

So that I can
offer to my customers E2E services - e.g. communication service(s) - that use resources and management as well as orchestration capabilities from different administrative domains. This means that management capabilities provided as a service could be used by the customers to manage the E2E service(s) within the boundaries of for example an SLA/OLA. Create, deploy, manage and orchestrate an E2E service including network slices which spans over several administrative domains with their own orchestrators and where the domains contain network slices, to fulfil several operators', service providers' and in general customers' needs on demand (e.g. based on several rules, policies, SLAs, OLAs, etc.).

To do this I need
to take the following steps:

- Create and deploy a multi-domain network and service infrastructure
- Create and deploy the Network and Service Management including Orchestration functionalities which can support and handle automatically e.g.:
    - E2E network and service management including orchestration via several administrative domains
    - Network slice management and orchestration
    - Several policies and rules
    - Several SLAs and OLAs
    - Conflict resolutions mechanism for example several policies and rules
    - Communication between several orchestrator functionalities located in several administrative domains
    - Etc.
- Provide standardized interface(s) between the orchestration functionalities of several administrative domains which support the necessary orchestration functionalities
- Expose via interfaces/APIs the capabilities of this network and service environment
- Provide a self-ordering portal for customers' needs for configuration and orchestration of the services and network slices based e.g. on SLAs and OLAs (could be e.g. companies such as operators, service providers, and several area organizations within the companies, for example Operations and IT, and inhabitants)
- Create and deploy network slices via a multi-domain network and service infrastructure to provide E2E service(s). The network slices can cover one and/or multiple administrative domains.

Description
In this user story an Operator/Service provider facilitates e2e services across multiple administrative domains addressing E2E service, network slice, domain and customer requirements that need to be taken into account.

Note: A possible necessary conflict resolution between domains and inside domains as well as a resolution responsibility topic are not in the scope of this user scenario.

8.18 Dedicated Management data repository

As a 5G Operator, Service Provider or consumer of network and service management including orchestration framework, I want to;
Design and provide a flexible, fully automated and efficient Management System capable of providing end-to-end (E2E) Network management and Service orchestration.

So that I can
Facilitate delivery of the 5G diversity of services to support the requirements of different category of customers including verticals.
The network management for 5G and future generation of networks can become increasingly complex and demanding, especially with rising expectations to support and maintain high level of automation and zero-touch network management and service orchestration. The dedicated centralised/common data repository service/functionality for the Management system serves to facilitate maintenance (e.g. storage, retrieval, update, etc.) while allowing shared access of management data/information among OAM entities/services.

To do this I need
Management system capable of supporting a dedicated data repository function/service which can be utilised to enhance overall Management system functionality by facilitating maintenance (e.g. storage, retrieval, update, etc.) of management data/information relating to the following;

- Data/information to support automation/SON-related and management data analytics,
- Data/information to support management of network slicing (slice, subnet and/or network function level),
- Management data (e.g. performance, configuration, alarms related, policy related, etc..), KPIs and QoE related data/information
- Dedicated management service specific (OAM) data,
- Data/information to support tracing management and MDT (Minimisation of Drive Test) functionalities/services,
- Data/information to support management service exposure/discovery services/functionalities,
- Data/information to support management of Communication services,

The list above is not exhaustive and can include other data/information to support other services and functionalities.

8.19 Management data analytics

As a 5G Operator, Service Provider or other consumer of network and service management including orchestration framework , I want to;

Design and provide a flexible, fully automated and efficient Management System capable of providing end-to-end (E2E) Network management and Service orchestration.

So that I can
Facilitate delivery of the 5G diversity of services to support the requirements of different category of customers including verticals.
The network management for 5G and future generation of networks can become increasingly complex and demanding, especially with rising expectations to support and maintain high level of automation and zero-touch network management and service orchestration. The management data analytics service/functionality for the management framework serves to facilitate optimum operation and performance of management services/functionalities.

To do this I need
Management framework capable of supporting management data analytics functionality/service which can be utilised to enhance overall management framework functionality, specifically addressing the requirements for automation and zero-touch network management and service orchestration. Supporting the capability of analytics in order to facilitate the following;

- Analytics service as enabler and to support automation and SON functions/algorithms,
- Analytics service to support network slicing management (e.g. lifecycle management and resource allocations),
- Analytics service to support management of Communication services and service assurance (performance, KPI, etc.),

The list above is not exhaustive and can include other aspects where elements of management data analytics can be utilised.

9 Requirements

9.1 Standardized network management protocols

5G NWMO 9.1.1:
Standardized network management protocols

9.2 Self-Healing

5G NWMO 9.2.1:
Provision and support of self-healing functionalities for E2E services.

9.3 Scalability

5G NWMO 9.3.1:
Support the scalability of network and service functions.

5G NWMO 9.3.2:
Support the scalability of E2E services.

5G NWMO 9.3.3:
Support the scalability of network and service management including orchestration functionalities and component(s).

9.4 Testing and automation

5G NWMO 9.4.1:
Provision of automated “active” and “passive” testing functionalities for networks and E2E services.

5G NWMO 9.4.2:
Provision and support of automated testing capabilities to validate the QoS in connection with corresponding SLAs.
Delivery of the outcome of the test(s) to the corresponding network and service management including orchestration functionalities and component(s).

5G NWMO 9.4.3:
Provision and support of automated testing functionalities to test an E2E service after the self-healing of the service to check whether the service is working properly before this service will be activated within the network.
Delivery of the outcome of the test(s) to the corresponding network and service management including orchestration functionalities and component(s).

5G NWMO 9.4.4:
Support of capabilities for automated testing in test and production networks with Artificial Intelligence (AI) and Machine Learning (ML) functionalities to improve and optimize NW and customer facing services based on corresponding requirements.

9.5 Analysis

5G NWMO 9.5.1:
The network and service management shall include predictive and trend analysis functionalities such as statistics computation and pattern recognition e.g. to ensure the necessary E2E QoS and QoE as well as to support the capacity planning for networks and services.

5G NWMO 9.5.2:
Provision and support of processing and evaluation functionalities of several data sources.

5G NWMO 9.5.3:
Provision and support of functionalities to use big data approaches in the context of network and service management including orchestration functionalities and component(s).

5G NWMO 9.5.4:
Management framework shall be capable of supporting management data analytics service/functionality to facilitate enhancements of automation and zero-touch network management and service orchestration.

9.6 Optimization, real-time and ultra-low latency aspects

5G NWMO 9.6.1:
Provision of network and service management including orchestration functionalities to support network and E2E service optimization in real-time in consideration of ultra-low latency aspects.

9.7 Proactive monitoring

5G NWMO 9.7.1:
Provision and support of proactive monitoring capabilities regarding network(s) and E2E services.

9.8 Simulation

5G NWMO 9.8.1:
Provision and support of simulation capabilities to analyse an E2E service as well as the network behaviour. Delivery of the outcome of this simulation to the network and service management including orchestration functionalities and component(s).

9.9 Capacity planning

5G NWMO 9.9.1:
Provision and support of functionalities to facilitate the capacity planning for network elements, network functions, virtualised and non-virtualised, and networks as well as E2E services.

9.10 Modelling

5G NWMO 9.10.1:
Provision and support of network and service modelling.

5G NWMO 9.10.2:
Support of the usage of network and service model(s) in connection with the network and service management including orchestration functionalities and component(s).

9.11 Installation and uninstallation of services

5G NWMO 9.11.1:
Provision of functionalities to easily install and uninstall services and / or make changes concerning services e.g. to extend or reduce service functionalities.

9.12 Reliability of E2E services

5G NWMO 9.12.1:
Provision of network and service management including orchestration functionalities to support and to ensure the reliability of E2E services. It includes the QoS and QoE of the service as well.

9.13 Customer self-installation and configuration of services

5G NWMO 9.13.1:
Support of customer self-installation and configuration of services.

9.14 Fraud detection

Support management of fraud detection concerning networks and services.

9.15 Billing and accounting

5G NWMO 9.15.1:
Support of billing and accounting functionalities. For example, to deliver the necessary data for it.

9.16 Standardized and open management interfaces

5G NWMO 9.16.1:
Provisioning and use of standardized and open network and service management including orchestration interfaces.

9.17 Real-time and ultra-low latency aspects

5G NWMO 9.17.1:
Provision and support of functionalities to facilitate the realization of real-time/ultra-low latency services.

5G NWMO 9.17.2:
Provision and support of real-time network and service management including orchestration functionalities for ultra-low latency services.

9.18 Optimization Requirements

5G NWMO 9.18.1:
Support automated optimization of multi-domain network infrastructure, which may include, for example, 5G vs Non-5G, NFV vs Non-NFV composed of 5G RATs, 4G RAT, maybe 2G / 3G RAT, Non-3GPP RATs, fixed access network, Backhaul, EPC Core, 5G Core

5G NWMO 9.18.2:
For automated optimization, the multi-domain network infrastructure should expose its capabilities via interfaces.
Note. In case when the interfaces are not exposed in certain network domains, automated optimization system may not be able to mitigate performance degradation in these domains, which may result in degradation of the QoE of certain services.

5G NWMO 9.18.3:
For automated optimization, the multi-domain network infrastructure should be equipped with Management and Orchestration Functions as appropriate including

- ETSI MANO components (NFVO, VNF Manager, VIM) in case when some network nodes are virtualized,
- SDN Controllers
- Legacy OSS (Network Management / Element Management functions)
- E2E Service orchestration

The Management and Orchestration Functions may be domain specific.

5G NWMO 9.18.4:
Support optimization for the following target functions:

- utilization of the network infrastructure, virtualized and non-virtualized as determined by certain KPIs
- user experience as determined by appropriate metrics of user experience, where needed, per slice
- business service and application performance (as determined by certain metrics and KPIs), where needed, per slice

5G NWMO 9.18.5:
The network infrastructure and management system should support Data Collectors at the network nodes to collect the network and service data for example performance data which can be delivered to the entities subscribed to the data such as Analytics software and Optimization Applications

5G NWMO 9.18.6:
The management system should include Analytics software for processing of the network performance data, such as statistics computation and pattern recognition

5G NWMO 9.18.7:
The network should include Optimization Applications that receive and analyse the network performance data and provide (re)configuration of the network nodes and/or network policies to achieve the optimization targets defined by the operator. The optimization targets (metrics) may be set in terms of

- utilization of the network infrastructure
- user experience such as video quality

- E2E application / service performance

The targets may be set per slice where needed.
To achieve the optimization goals, the Optimization Applications should be able to execute (re)configuration of the network nodes and/or policies via network APIs and Management and Orchestration Functions.

5G NWMO 9.18.8:
An efficient optimization pre-requisites that each domain can act locally and do self-optimization.
At the same time each domain can receive policy/control instructions from higher domain or multi-domain orchestrator. This implies that each domain can provide capability such as data and insights to policy or orchestrator

9.19 NW Slice Management Requirements

5G NWMO 9.19.1:
Support NW slice management in multi-domain network infrastructure, which may include, for example, 5G vs Non-5G, NFV vs Non-NFV composed of 5G RATs, 4G RAT, maybe 2G / 3G RAT, Non-3GPP RATs, fixed access network, Backhaul, EPC Core, 5G Core

5G NWMO 9.19.2:
For NW slice management support, the multi-domain network infrastructure shall expose its capabilities via standardized or at least open, interfaces.
Note. In case when the interfaces are not exposed in certain network domains, slicing management in such domains may not be possible therefore affecting differentiation between slices that in some cases may result in degradation of the QoE of certain services.

5G NWMO 9.19.3:
For NW slice management support, the multi-domain network infrastructure should be equipped with Management and Orchestration Functions as appropriate that can be realized through for example

- ETSI MANO components (NFVO, VNF Manager, VIM) in case when some network nodes are virtualized,
- SDN Controllers
- Legacy OSS (Network Management / Element Management functions)
- E2E Service orchestration

The Management and Orchestration Functions may be domain specific.

5G NWMO 9.19.4:
For NW slice management support, the network infrastructure and service management should support Data Collectors at the network nodes to collect the network and service data (e.g. service performance metrics) restricted to specific network slice. For example, performance data which can be delivered to the entities subscribed to the data such as analytics software and optimization applications.

5G NWMO 9.19.5:
Support of management and orchestration services and functions for NW slices in a multi operator roaming case.

5G NWMO 9.19.6
Support of services and functions to manage and orchestrate NW slices in multi domain - orchestrator environments in a roaming case.

5G NWMO 9.19.7:

Support of management and orchestration services and functions in roaming environments to operate e2e services based on one or more NW slices.

5G NWMO 9.19.8:
Support of management and orchestration interfaces to use management and orchestration services and functions concerning NW slices from other operators and service providers in a roaming case.

5G NWMO 9.19.9:
Support the integration of management and orchestration services and functions from other operators and service providers into the own management and orchestration environment to manage and orchestrate NW slices in a roaming case.

5G NWMO 9.19.10:
Support of management and orchestration interfaces to use own management and orchestration services and functions concerning NW slices within management and orchestration environments from other operators and service providers in a roaming case.

5G NWMO 9.19.11
Support of management services and functions to facilitate the fulfillment of requested security and data privacy requirements concerning NW slices in multi operator and service provider environments in a roaming case.

9.20 Data collection

5G NWMO 9.20.1:

- Network Slice Monitoring
    - E2E collection of fault management data of network functions / network slices which are involved in delivery of an E2E service.

5G NWMO 9.20.2:

- Collection of E2E service quality information
    - Collection of E2E service quality information generated by the UE application or by the Application Server (when available). The service may be supplied via certain network slice instance.

9.21 Domain aspects

5G NWMO 9.21.1:

- Provision and support of standardized or open management interfaces for an orchestrator.

5G NWMO 9.21.2:

- Provision and support of functionalities to enable the management of different types of network slices for an e2e service.

5G NWMO 9.21.3:

- Provision and support of functionalities to enable the vertical and horizontal management of network slices for an e2e service.

5G NWMO 9.21.4:
- Provision and support of capabilities to enable the integration of the network and service management including orchestration of network slices provided by other parties (e.g., third parties and verticals).

5G NWMO 9.21.5:
- Provision and support of functionalities to enable the handling of the network and service management including orchestration of network slices provided by other parties (e.g., third parties and verticals).

5G NWMO 9.21.6:
- Support of capabilities to manage an end-to-end service automatically based on AI and ML functionalities over several domains which are in the responsibility of one or more operators and/or service providers as well as provided by different suppliers.

9.22 Edge computing related management aspects

5G NWMO 9.22.1:
- Provision and support of functionalities to enable the management including orchestration of edge computing functionalities.

5G NWMO 9.22.2:
- Provision and support of functionalities to enable the management including orchestration of edge computing functionalities in case when the operator's network provides Multi-Access in combination with Edge Computing.

5G NWMO 9.22.3:
- Provision and support of functionalities to automate the management including orchestration of edge computing functionalities, and the application of them.

5G NWMO 9.22.4:
- Provision and support of functionalities to automate the management including orchestration of edge computing functionalities, their applications and services in case when the operator's network provides Multi-Access in combination with Edge Computing.

9.23 NW and Service Management including Orchestration Framework

5G NWMO 9.23.1:
The NW and Service Management including Orchestration Framework shall be modular with capabilities to add and remove components.

9.24 Tracing

5G NWMO 9.24.1:
Support of capabilities to trace NW and customer facing services to provide data for the support of making NW and Service management including orchestration decisions and associated actions automatically, in targeted and law compliant way.

9.25 Coordination and Control

5G NWMO 9.25.1:
Support of capabilities to coordinate and to control in a management sense automatically end-to-end NW and customer facing services over one or several domains in vertical and/or horizontal ways based on AI and ML functionalities.

5G NWMO 9.25.2:
The NW and Service Management including Orchestration Framework shall cover the design and running phases.

9.26 Security and Data Privacy

5G NWMO 9.26.1:
The network and service management including orchestration framework shall support capabilities to fulfil security and data privacy requirements.

5G NWMO 9.26.2:
The network and service management including orchestration framework shall support capabilities to be compliant with regulatory requirements for data privacy in target jurisdictions.

5G NWMO 9.26.3:
Support of capabilities to monitor and trace NW and customer facing services to provide data to support or facilitate cybersecurity by automated cyber-attack detection, prevention, and mitigation, in a targeted and law compliant way.

9.27 Management data repository

5G NWMO 9.27.1:
Management system shall be capable of supporting a dedicated data repository service/functionality to facilitate common access and usage of management data.

9.28 Self-organizing in 5G: Requirements to architecture of the self-organizing functionality

For 5G, self-organization functionality is expected to continue the evolution path started at 4G, so requirements set in 10.1.3.2 will be applicable. On top of that, the 5G Self-organization concept will provide for the following, as required by 5G technology advances

5G NWMO 9.28.1:

5G self-organizing functionality should be a coherent solution that integrates all self-organization functions across the network (i.e. RAN and CN), across network / management layers and across RATs. In particular new 5G technology elements such as the elements mentioned in [1], sec. 5.5, should be addressed

5G NWMO 9.28.2:
The self-organization architecture should be adapted to a virtualized network; above considerations for 4G virtualization are applicable

5G NWMO 9.28.3:
5G self-organization should provide for efficient collection of comprehensive information of the state of the network including RAN, CN and UE

5G NWMO 9.28.4:
The self-organization architecture should allow for easy integration with management (OAM) and service orchestration

5G NWMO 9.28.5:
The self-organization architecture should allow for easy integration between RAN, CN and UE functions, between centralized and distributed components supplied by different vendors

5G NWMO 9.28.6:
The self-organization architecture should allow for application aware optimization

5G NWMO 9.28.7:
The self-organization architecture should be able to address interoperation of multiple technologies in 5G, such as multiple Radio Access Technologies (RATs)

5G NWMO 9.28.8:
The self-organization architecture should address network slicing

5G NWMO 9.28.9:
The self-organization architecture should provide for scalable solution in view of expected raise in the number of Network Elements in HetNet

5G NWMO 9.28.10:
The self-organization architecture should provide for scalable solution in view of expected raise in the number of subscribers in combined Broadband Access and Internet of Things networks

5G NWMO 9.28.11:
5G self-organization functions should be adaptable to work over a range of ideal and non-ideal backhaul and/or fronthaul, which may use fixed or wireless links.

9.29 Architectural requirements of E2E network and service management including orchestration

The requirement of end-to-end network and service management including orchestration is to support the following

5G NWMO 9.29.1:Support of Intent-based interfaces using abstraction model without tightly coupling the interface resources with any specific interface type, configuration, protocol, etc.

5G NWMO 9.29.2:
Support of the highest-level of granularity and modularity of physical and virtual resources

5G NWMO 9.29.3:
Support of cloud-native and platform as a service (PaaS) capability

5G NWMO 9.29.4:
Support of logically centralized and physically distributed architecture to enable different implementation options for seamless management and orchestration of end-to-end services

9.30 Requirements to the management, orchestration, and optimization architecture

5G NWMO 9.30.1:
The E2E 5G network and service management including orchestration architecture and functionalities shall support easy integration and /or reduction of Network and Service Management (NSM) functionalities on demand in connection with an existing NSM ecosystem or an NSM ecosystem that shall be generated. This shall be done via necessary standardized, or at least open interface(s).

5G NWMO 9.30.2:The E2E 5G network and service management including orchestration architecture and functionalities shall reuse common NSM architecture components and functionalities to the greatest possible extent. The examples of telecommunication scenarios where this can be applied, could be in connection with automotive, energy and healthcare sectors.

5G NWMO 9.30.3:
The E2E 5G network and service management including orchestration architecture and functionalities shall support management of different network / service domains (e.g. MANO domain, non-MANO domain, etc.) and different administrative domains.

5G NWMO 9.30.4:
The E2E 5G network and service management including orchestration architecture and functionalities shall support the management of shared NW slices also in the scenario with 3rd parties that provision and / or use the slice.

5G NWMO 9.30.5:
The E2E 5G network and service management including orchestration architecture and functionalities shall include provisions for centralized, distributed and hybrid centralized/distributed modes of operations.

5G NWMO 9.30.6:
The E2E 5G network and service management including orchestration architecture and functionalities shall include provisions for cloud based implementation.

5G NWMO 9.30.7:
E2E 5G network and service management including orchestration architecture and functionalities shall support LCM of SW

5G NWMO 9.30.8:
E2E 5G network and service management including orchestration architecture and functionalities shall support testing (e.g. in the context of self-healing of services)

5G NWMO 9.30.9:
E2E 5G network and service management including orchestration architecture and functionalities shall support active and passive monitoring.

5G NWMO 9.30.10:
Integration of necessary self-organizing functionality into the E2E 5G network and service management including orchestration architecture.

5G NWMO 9.30.11:
The E2E 5G network and service management including orchestration architecture and functionalities shall support the easy integration of methods and functionalities of

- Artificial Intelligence
- Machine Learning algorithms
- Self learning algorithms
- Pattern recognition

5G NWMO 9.30.12:
The E2E 5G network and service management including orchestration architecture and functionalities shall support and handle the management of all involved technologies.

5G NWMO 9.30.13:
The E2E 5G network and service management including orchestration architecture and functionalities shall support the various phases of services and applications (e.g. Demand, Develop, Integrate and Operate).

5G NWMO 9.30.14:
The E2E 5G network and service management including orchestration architecture and functionalities shall support seamless integration and management of application functions which delivers additional functionalities in this context (e.g. analytic functionalities).

5G NWMO 9.30.15:
The E2E 5G network and service management including orchestration architecture and functionalities shall provide for easy integration and the handling of MEC solutions including their management to support real-time and ultra low latency aspects.

5G NWMO 9.30.16:
The E2E 5G network and service management including orchestration architecture and functionalities shall support optimization loops at various levels such as network functions and services as well as applications, with automatic triggering the necessary subsequent activities.

5G NWMO 9.30.17:
The E2E 5G network and service management including orchestration architecture and functionalities shall support and facilitate integration of management functionalities as well as management systems of customers / 3rd parties such as verticals (e. g. the automotive industry, the healthcare and the industry sector).

5G NWMO 9.30.18:
The E2E 5G network and service management including orchestration architecture and functionalities shall support the integration and flexible intelligent usage of PM and FM data which may include prediction, and self-optimization based on self-learning which is assisted by a profile framework.

5G NWMO 9.30.19:
Concerning the real-time and ultra low latency aspects in connection with the E2E 5G network and service management including orchestration architecture and functionalities there shall be supported a flexible

- Flat architecture
- Lightweight architecture

- Lightweight interfaces and
- Lightweight functionalities

10 Automation

In order to enable operators to deploy, engineer and operate a 5G network, it will be essential to automate many of the network functions.
As stated in the 5G white paper [1], section 4.6.4: "The 5G system should reduce the complexity of the tasks of planning, configuration and optimization of the whole system. In particular, the 5G system should allow for easy deployment and management of massive small cells with features, like plug and play, self-configuration, optimization and healing."

10.1 Self-organizing functionality in 5G

This section outlines the self-organization functionality in 5G.
One of aspects of self-organizing functionality is to provide for efficient automatic network optimization to boost network quality and cut OPEX and CAPEX.

In 4G, RAN SON functions were introduced (see Annex A).

In addition, 4G technology includes some self-organizing capabilities involving both Radio Access Network (RAN) and Core Network (CN) entities.
For 5G it's preferable to apply a systematic approach which would combine self-organizing functionalities of RAN, CN, backhaul and underlying infrastructure in a coherent integrated end-to-end solution.

10.1.1 Status of self-organizing technology in 4G

In 4G, the self-organizing technology is represented mostly by Radio Access Network (RAN) SON functions such as Mobility Load Balancing (MLB), Coverage and Capacity Optimization (CCO), … etc., running at two different network layers: some belong to Distributed SON and some to Centralized SON, potentially with coordination between the two layers. Such coordination however is not specified in 4G SON standards. There are also network self-organizing functions running in Core Network (CN) with certain means of coordination with RAN SON[4].

10.1.2 General direction of self-organizing evolution towards 5G

In 5G, self-organizing is expected to be a coherent functionality that integrates all self-organizing functions, across the network (i.e. RAN and CN), across the network layers and across Radio Access Technologies (RATs), with efficient coordination between the centralized and distributed components. Such solutions should be adapted to allow for virtualized network components.

10.1.3 Aspects of Evolution of 4G self-organizing functionality

As noted in [1], sec. 5.1, 4G technology, including self-organization functionality, is continuously evolving in terms of standardization, implementation and deployment. In addition, integration of the evolved 4G system (further denoted e4G) into the 5G system is foreseen per [1], sec. 5.5.
One of important aspects of 4G evolution is virtualization [1], sec. 5.1. Virtualization is significant factor influencing the architecture of self-organizing functionality, so it needs special attention
The following aspects are addressed in the following sections:

- The evolution aspects not related to virtualization
- The evolution aspects driven by virtualization

[4] For example, User Plane CONgestion management (UPCON)

10.1.3.1 4G self-organizing functionality evolution aspects not related to virtualization

The following requirements can be put forward for 4G self-organizing functionality evolution:

- Provide for sufficient coordination capabilities between Centralized SON and Distributed SON with the goal to improve efficiency of combined (Hybrid) SON
- Provide for sufficient coordination between Distributed SON implementations provided by different vendors
- Provide for joint operations of RAN SON and self-organization functions in the Core Network
- Provide for efficient coordination between RATs: Evolved LTE and 5G
- Provide for efficient collection of comprehensive information of the state of the network including RAN, CN and UE

10.1.3.2 4G Self-organizing functionality evolution aspects driven by virtualization

10.1.3.2.1 Use Case description

In a virtualized network, Virtual Network Functions (VNFs) may be running in different Network Virtual Function Infrastructure (NFVI) domains e.g. for different levels of RAN centralization. For example, CN VNFs may be running in the central data centre of the network operator while RAN VNFs may be running in regional or local data centres to provide for lower latency. It is expected that the virtualized network will include VNFs supplied by different vendors.
The following Figure 10-1 provides graphic expression for the Use Case.

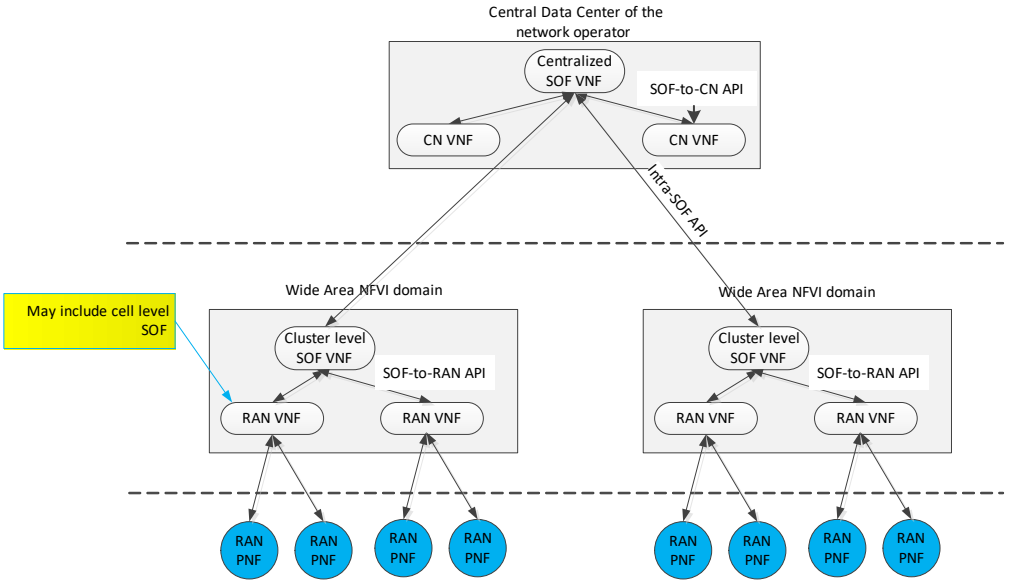

Figure 10-1. Use Case with more than one level of centralization

10.1.3.2.2 Requirements associated with the Use Case

In view of this Use Case, the following requirements can be put forward for evolution of 4G self-organizing functionality driven by virtualization

- In virtualized networks with different levels of centralization, allocation of self-organizing functions to different NFVI domains should follow the levels of CN / RAN centralization
- The components of self-organizing functionality hosted by the corresponding NFVI domains should be interfacing to RAN and CN VNFs via standardized APIs to support multiple RAN VNF vendors[5]
- Coordination between the components of self-organizing functionality located in same NFVI domain or different domains and / or in different network layers should be implemented via standardized APIs.

  Note. The SON API of Small Cell Forum can be considered an example and prototype of such interface

11 MANAGEMENT, ORCHESTRATION AND OPTIMIZATION ARCHITECTURE SOLUTIONS

11.1 Assumptions on the 5G network

The network of the mobile operator is based on multi-domain network infrastructure, which may include the following domains:

- 5G RAT (New Radio) based Access Network
- Non-5G RAT based Access Network
- Virtualization (NFV) domain with corresponding NFVI

Note. One or several parts of the network can be virtualized and one or several parts of the network can be non-virtualized

- Fixed Access
- Transport / Backhaul
- 5G Core Network
- 4G (EPC) Core Network

Note: Above list of domains is not exhaustive.
The capabilities of this multi-domain network infrastructure are exposed through certain interfaces / APIs

11.2 Functional components of the management, orchestration and optimization architecture

The following are components of the management, orchestration and optimization architecture:

- Policy management
- MANO components (NFVO, VNF Manager, VIM),
- Domain controllers such as SDN Controllers,
- Legacy OSS (Network and Service management),

[5] ETSI's Mobile Edge Computing (MEC) project provides an example of similar approach. The White Paper "Mobile-Edge Computing" outlines Radio Network Information Services (RNIS) interface between the 3rd party software running at the Base Station MEC platform and the BS software to collect information on the status of the cell. In this approach the role of the MEC platform is similar to NFVI

- E2E Service orchestration.

11.3 Functional description of the E2E Service Orchestration

- E2E Service Orchestration interprets and translates service definition / service design6 into configuration of resources (virtualized and non-virtualized) needed for establishment of certain service. The configuration of resources may be for actual amount of resources or the policy of their allocation at later time, when the service is activated.
- The E2E Service orchestration triggers the components of the Network and Service Management including Orchestration system (ETSI NFVO, VNF Manager, VIM, SDN Controller, and legacy OSS) to apply the configuration of the required resources, which for some resources may result in their actual allocation. This action may be a part of the life cycle operation applied to certain network slice instance, which is supposed to carry the service. This operation may result in creation of a new network slice instance, or modification of the existing network slice instance

11.4 Relationship between service instance and network slice instance

A service instance can be supported by a Network Slice Instance (NSI). The NSI may exist or be created just for a single service instance or it may exist or be created to support multiple service instances

[6] The service design may include e.g. description of service chaining

ANNEX A. Self-Organization in 4G

In 3GPP, RAN SON functions were introduced in Rel. 8 – 11.

In addition, 3GPP developed specifications that provide network with additional self-organizing capabilities involving both Radio Access Network (RAN) and Core Network (CN) entities. The User Plane Congestion management (UPCON) started in Rel. 12 is an example of such capability.

SON features were introduced in 3GPP as follows:

Release 8

- Automatic Inventory
- Automatic Software Download
- Automatic Neighbour Relation
- Automatic Physical Cell ID (PCI) assignment

Release 9

- Mobility Robustness/Hand Over optimization
- RACH optimization
- Load balancing optimization
- Inter-Cell Interference Coordination

Release 10

- Coverage and Capacity optimization
- Enhanced Inter-Cell Interference Coordination
- Cell Outage Detection and Compensation
- Self-healing functions
- Minimization of Drive Testing
- Energy Savings

Release 11

- Automatic Neighbour Relations
- Load Balancing Optimization
- Handover Optimization
- Coverage and Capacity Optimization
- Energy Savings
- Coordination between various SON Functions
- Minimization of Drive Tests