NFV Slicing Challenges & Impact analysis

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Contents

- Why NFV Network Slicing
- NFV Network Slicing Challenges
- Context, Impact and Q&A

Reference: **"Network Slicing Tutorial" at IEEE NetSoft 2018, Montreal 29th June 2018 - Alex Galis & Kiran Makhijani - http://discovery.ucl.ac.uk/10051374/**

- Key Slicing concepts and history
- Slicing Key Characteristics & Usage scenarios & Value Chain
- Multi-Domain Network Function Virtualisation
- Review of Research projects and results in network and cloud slicing (Projects: SONATA, 5GEX, NECOS, 5G TRANSFORMER, 5G PAGODA, 5G NORMA, 5G SLICENET
- Open Source Orchestrators
- Standard Organization activities & work in progress: NGMN, ITU-T, ONF, 3GPP, ETSI, BBF, IETF.
- Industrial perspective on Network Slicing8. Review of industry Use Cases
- Network Slicing Challenges
- Concluding remarks of Network Slicing
- Acknowledgements & References (SDO's references + additional selected references)

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Network Slicing Concepts

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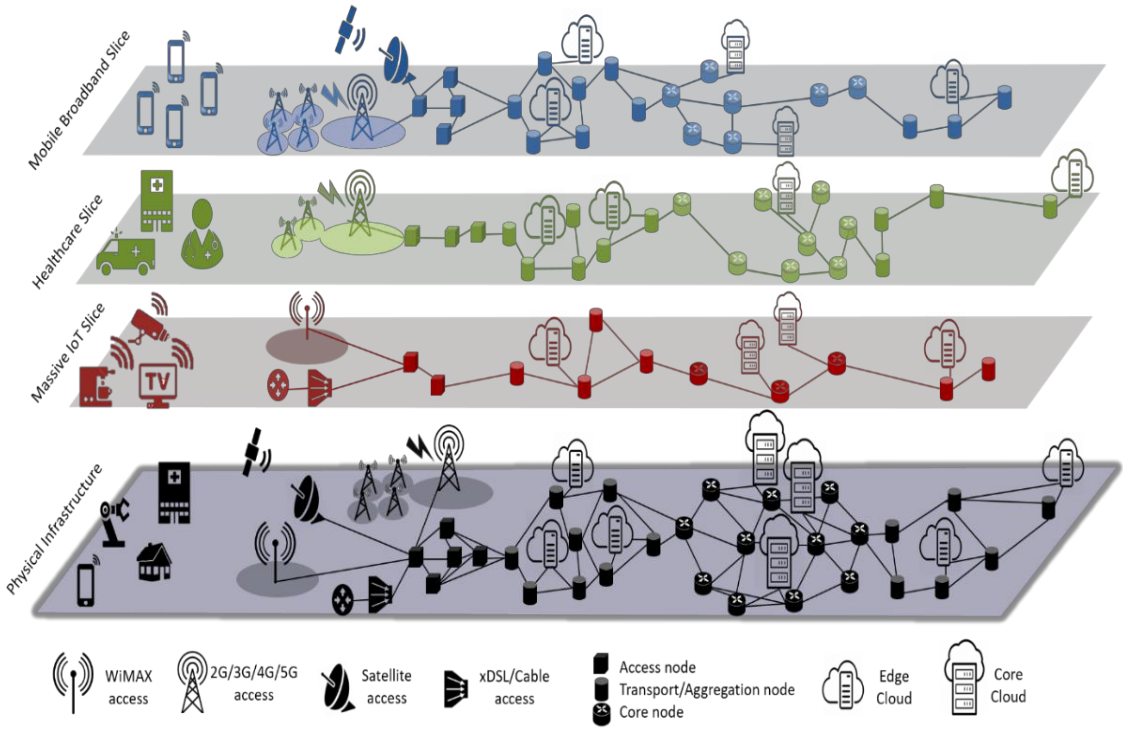
Novel solutions in search of deployability, flexibility, agility, cost efficiency↦ **Network Slicing**

Driving issue: *It is inefficient and expensive to build a separate infrastructure for each service.*

Services & Vertical industries would bring diverging use cases and application scenarios

Network slices are:

- Self-contained
- Mutually isolated
- Manageable & Programmable
- Support for multi-service
- Support for multi-tenancy
- Orthogonal to any infrastructure architecture
- Mainly integration of service+ management+ control planes elements



NS are significantly different from traditional:

- VPNs or a Virtual Network
- Traffic Engineering

Network Slices Usage Scenarios

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- High Precision Networks (i.e. guaranteed QoS)
- Mission-critical Ultra low latency communication
- Massive-connectivity machine communication (e.g. Smart metering, Smart grid and sensor networks)
- Extreme QoS
- Independent QoS isolation design
- Independent operations and management
- Independent autonomic management functionality
- Independent cost and/or energy optimization
- Independent multi-topology routing
- Sharing infrastructure safely and efficiently (Multi-tenants, non-IP architectures)
- Useful in deployment of new protocols

Revisited ETSI NFV Framework

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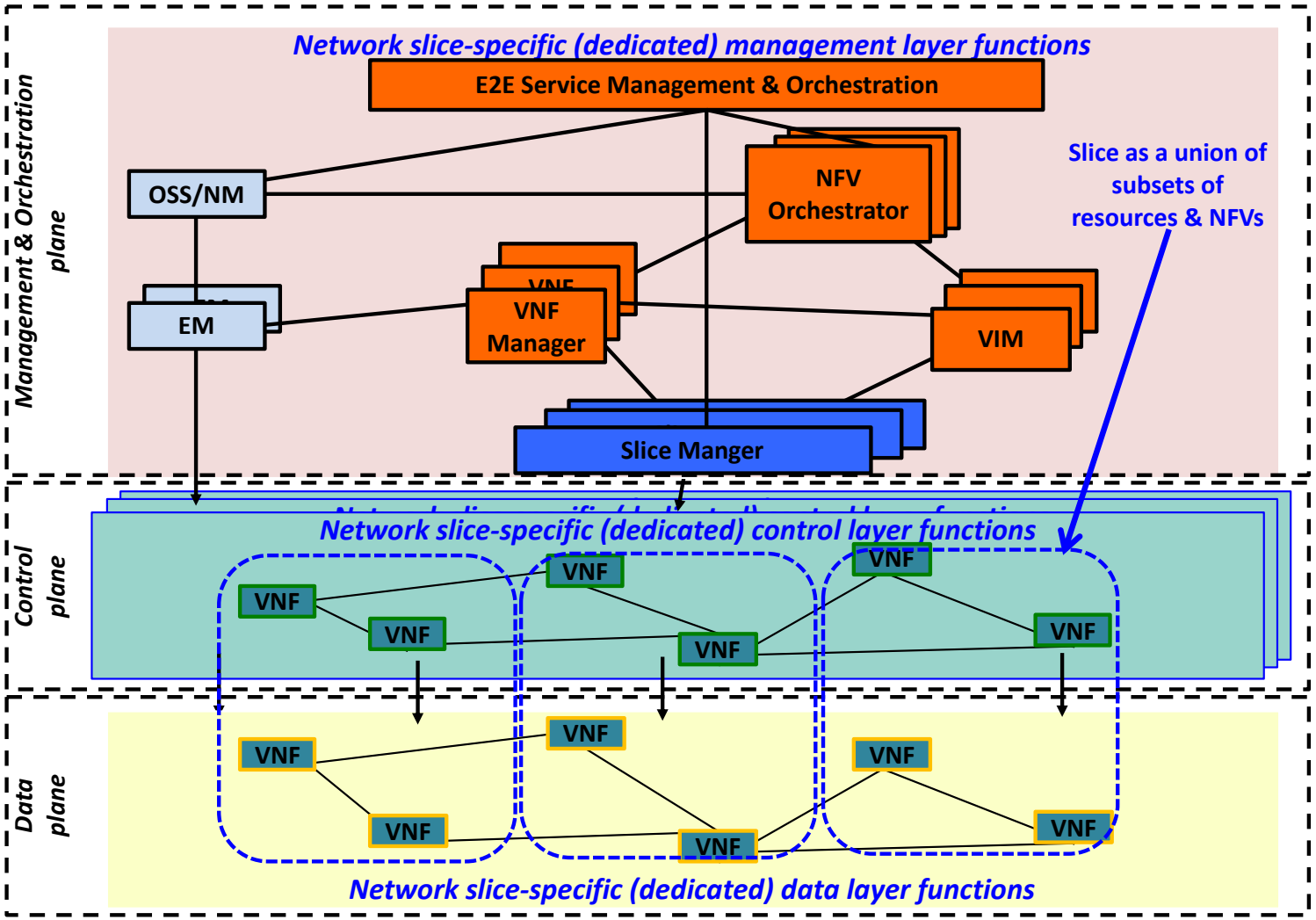
Opportunity to integrate Network Slice across almost all the layers in NFV architecture



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Examples of High Level Architecture & Interfaces Network and Cloud Slicing

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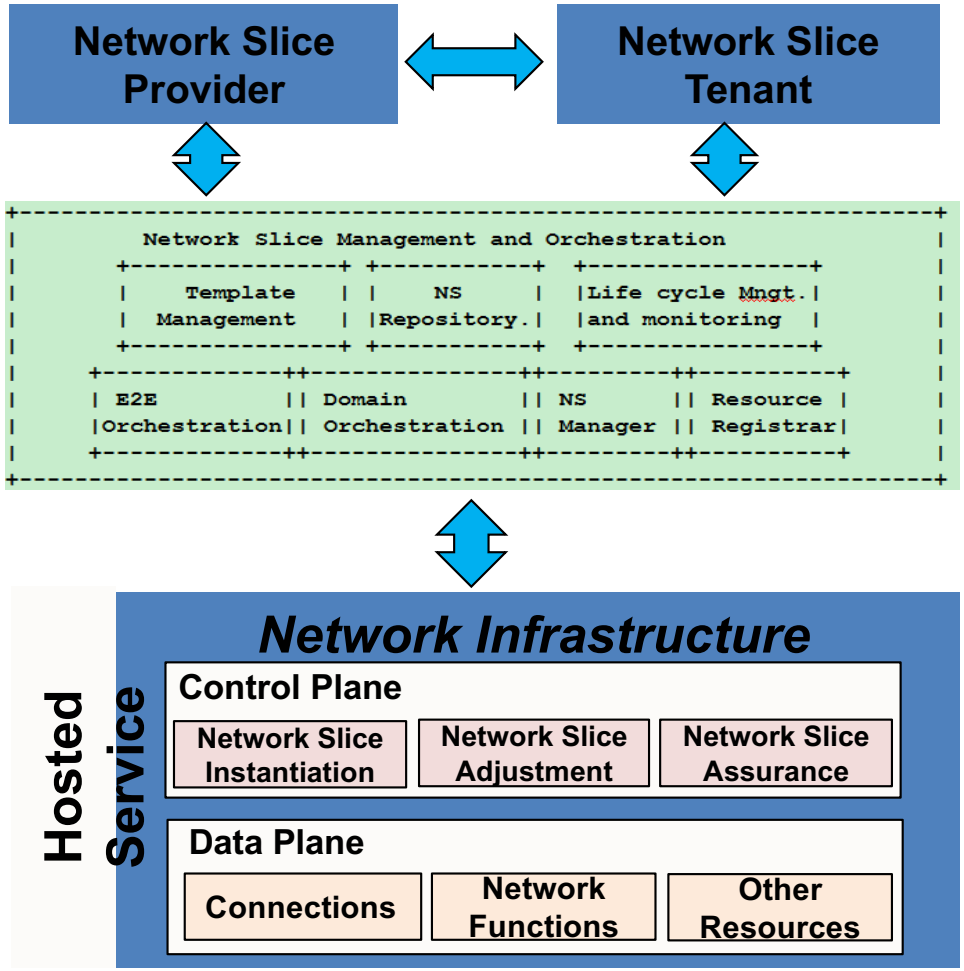
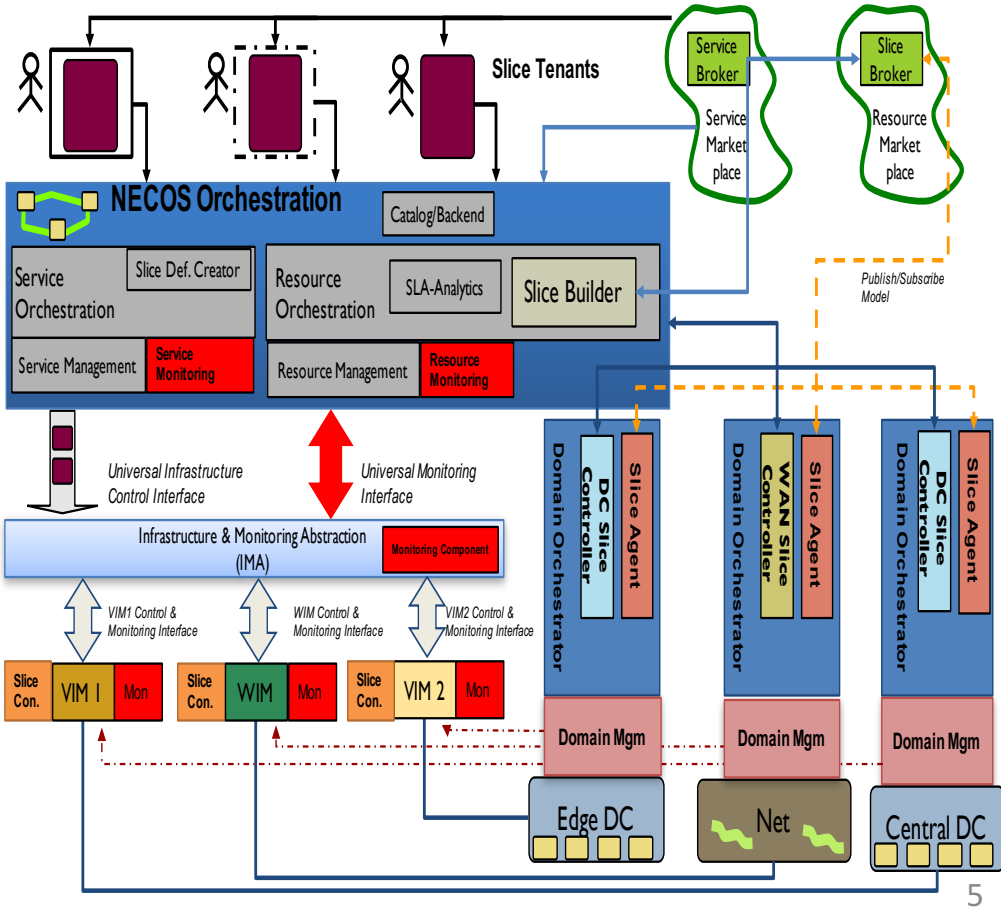
Proposed Framework @ IETF



NECOS Project

http://www.h2020-necos.eu



NFV Slicing Challenges (1)

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Detailed research & scrutiny in all aspects of NFV network slices

Multi-domain NFV network slices:

(1) The **management plane creates the grouping of network resources** (physical, virtual, or a combination thereof), it **connects with the physical and virtual network and service functions**, and it **instantiates all of the network and service functions assigned to the slice.**

(2) Template/NS repository **assists life cycle management;**

(3) Resource Registrar **manages exposed network infrastructure capabilities;**

(4) NS Manager **oversees individual slice** (with capability exposure to NS Tenant).

(5) Coordination of any number of inter-related resources in a number of subordinate domains, and assurance of transactional integrity as part of the triggering process;

(6) Autonomic control of slice life cycle management, including concatenation of slices in each segment of the infrastructure (in data, control, and management planes);

(7) Autonomic coordination and triggering of slice elasticity and placement;

(8) Coordination and (re)-configuration of resources by taking over the control of all the network functions;

(9) Uniform Slice multi-domain lifecycle management : Slice lifecycle management including creation, activation / deactivation, protection, elasticity, extensibility, safety, and sizing of the slicing model per network and per network cloud for slices in multi-domain access, core and transport networks; for slices in data centres/clouds/

NFV Slicing Challenges (2) : Autonomic Slice Management; Cross-Domain; Scalability

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Autonomic slice management:

(1) Network slice is a **dynamic entity with autonomic characteristics** of its lifecycle and operations.

(2) The problem of **allocation of resources between slices combined with real-time optimization** of slice operations in a multi-domain environment can only be solved by continuous autonomic monitoring of slice performance and making continuous autonomic adaptations of the resources allocated to them.

(3) Autonomic control of slice life cycle management, including concatenation of slices in each segment of the infrastructure (in data, control, and management planes);

Slice Element Manager & Capability exposure / Key APIs:

(1) Description of **exclusive control and/or management interfaces and capabilities exposed for a network slice**, enabling the deployment of different logical network slices over shared resources;

(2) Description of the Slice Element Manager which guarantees a level of service, according to a negotiated SLA between the customer and the slice provider.

Service / data model & mapping :

(1) service mapping **enables on-demand processing anywhere in the physically distributed network**, with dynamic and fine granular service (re)-provisioning;

(2) It includes a **slice-aware information** model based on **necessary connectivity, storage, compute resources, network functions, capabilities exposed and service elements;**

(3) Network Function as a Service; (4) Network Slice as a Service.

***Network Slicing Scalability*:** Scalability: In order to partition network resources in a scalable manner, it is required to clearly define to what extent slice customers can be accommodated or not on a given slice. The application of different SLAs on the offered capabilities of management, control and customization of slices will directly impact the scalability issue.

Network Slices with guaranteed QoS / KPIs characteristics - Precision Network Services

What could be NFVRG Next Steps

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NFVRG can be the place for researching and building all aspects and details of network slices in an NFV multi-domain environment.

NFVRG can be the place for research in the involved topics of

- ***NS scalability***
- ***NS as the basis of Precision Network Services (i.e. guarantied QoS / KPIs characteristics like low latency , etc.)***

Feedback is requested on the above!!

Concluding Remarks: Overall Context

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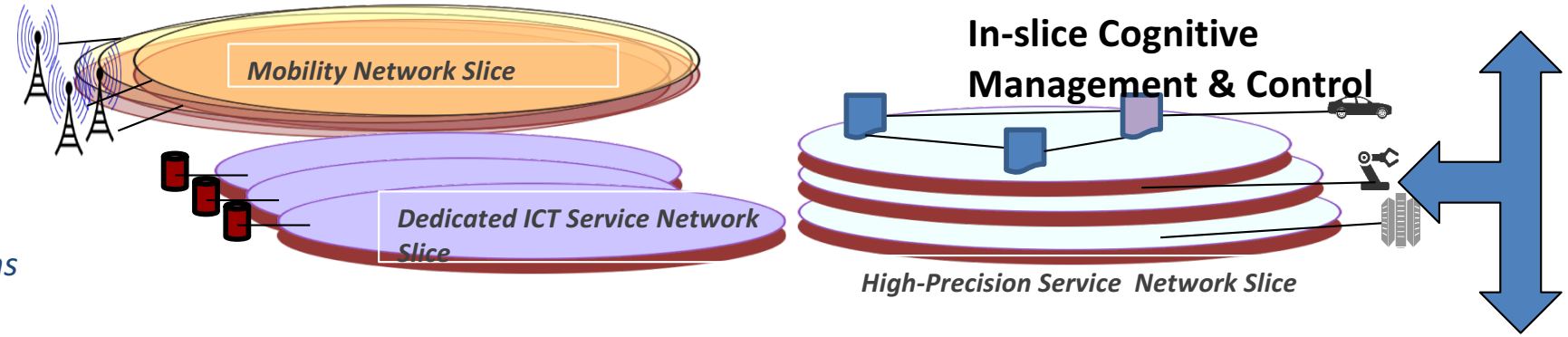
- Transition from network devises to matured network functions and virtual network functions with inbound management
- Dynamically adapting the network to meet future service demands
- Creating the dynamic, configurable, programmable, resilient, safe and cost effective E2E network
- A programmable network fabric with simple interface to the infrastructure (smart network fabric)

E2N Multi-Domain Orchestration
E2E coordination, conflict resolution, multi-domain information exchange

Service Adapted Network Slices *Enabled by Network Functions Including NFV*



Light Weight Smart Network Fabric – Network Abstraction, Allocate (virtual) network resources/ slices, VIM on demand, Maintain network state, Ensure network Reliability in a multi domain environment

Existing Cloud & Network Fabric

Acknowledgement & References

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Projects:

1. 5GEX- H2020 project “Multi-domain Network Service Orchestration - http://www.5gex.eu/

2. NECOS – H2020 project “Novel Enablers for Cloud Slicing” -http://www.h2020-necos.eu

References:

1. “Perspectives on Network Slicing – Towards the New ‘Bread and Butter’ of Networking and Servicing” Alex Galis – January 2018 https://sdn.ieee.org/newsletter/january-2018/perspectives-on-network-slicing-towards-the-new-bread-and-butter-of-networking-and-servicing

2. “Network Slicing Tutorial” at IEEE NetSoft 2018, Montreal 29th June 2018 - Alex Galis & Kiran Makhijani - Download from http://discovery.ucl.ac.uk/10051374/

Spare Slides

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SDOs- References

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ITU-T IMT2010/ SG13 (http://www.itu.int/en/ITU-T/focusgroups/imt-2020/Pages/default.aspx)

- Recommendation: Application of network softwarization to IMT-2020 (O-041) – 150 pp
- Framework for IMT-2020 overall network architecture (O-043) – 20 pp
- Network management framework for IMT-2020 (O-047) – 40 pp
- IMT-2020 network management requirements (O-046) - 25 pp

ETSI

- Network Operator Perspectives on NFV priorities for 5G- https://portal.etsi.org/NFV/NFV_White_Paper_5G.pdf
- Report on Net Slicing Support with ETSI NFV Architecture Framework http://www.etsi.org/deliver/etsi_gr/NFV-EVE/001_099/012/03.01.01_60/gr_NFV-EVE012v030101p.pdf
- ETSI GS NGP 001: "Next Generation Protocol (NGP); Scenario Definitions". http://www.etsi.org/technologies-clusters/technologies/next-generation-protocols

IETF

- NetSlices Architecture draft-geng-netslices-architecture-02
- Network Slicing - Revised Problem Statement draft-galis-netslices-revised-problem-statement-03
- NetSlices Management Architecture draft-geng-coms-architecture-01
- NetSlices Use Cases draft-netslices-usecases-01
- NetSlices Management Use cases draft-qiang-coms-use-cases-00
- NetSlices Information Model draft-qiang-coms-netslicing-information-model-02
- Autonomic NetSlicing draft-galis-anima-autonomic-slice-networking-04
- NetSlices Interconnections https://tools.ietf.org/html/draft-defoy-coms-subnet-interconnection-03

3GPP TR23.799 Study “Network Slicing’ (2016); SA5 TR 28.801 Study Item “Network Slicing” (2017)

ONF Recommendation TR-526 (2017) “Applying SDN architecture to Network Slicing”

NGMN White Paper on 5G 2016) -https://www.ngmn.org/5g-white-paper/5g-white-paper.html

BBF - Requirements / architecture of transport network slicing SD-406: End-to-End Network Slicing **(2017)**

5GPPP Association White Paper Views on 5G Architecture – Mark 2 – January 2018https://5g-ppp.eu/wp-content/uploads/2018/01/5G-PPP-5G-Architecture-White-Paper-Jan-2018-v2.0.pdf

5G Slicing Association - Position Whitepaper :’5G Network Slicing for Cross Industry Digitization’ http://www-file.huawei.com/-/media/CORPORATE/PDF/white%20paper/5G-Network-Slicing-for-Cross-Industry-Digitization-Position-Paper.pdf?source=corp_comm

Roles & Concepts

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Roles

- **Infrastructure Owner** Owns the physical infrastructure (network/cloud/datacentre) and lease them to operators. It becomes an ISP is it lease the infrastructure in network slicing fashion.
- **Infrastructure Slice Provider** – An infrastructure slice provider (ISP), typically a telecommunication service provider, is the owner or tenant of the infrastructures from which network slices can be created.
- **Infrastructure Slice Tenant** – An infrastructure slice tenant (IST) is the user of specific network/cloud/datacentre slice, in which customized services are hosted. Infrastructure slice tenants can make requests of the creation of new infrastructure slice through a service model.

Concepts:

- **Infrastructure Slice** - A set of infrastructure (network, cloud, datacentre) components/network functions, infrastructure resources (i.e. managed connectivity, compute, storage resources) and service functions that has attributes specifically designed to meet the needs of an industry vertical or a service.
- **Infrastructure Slicing** - A management mechanism that Infrastructure Slice Provider can use to allocate dedicated infrastructure resources and service functions to Network Slice Tenant.
- **Partition Types**
  - → Physical separation (e.g., dedicated backbones) → not cost efficient
  - → *A resource only partition is one of the components of a Network Slice, however on its own does not fully represent a Network Slice.*
  - → *Underlays / overlays supporting all services equally ('best effort" support) are not fully representing a Network Slice.*
  - → *Underlays / overlays*, in the form of VPN as overlay solution → not flexible nor agile
  - → Slicing, through network resource allocation → dedicated resources per customer/service to ensure isolation on top of the same infrastructure

Driving issue: *It is inefficient and expensive to build a separate infrastructure for each service.*

Concepts (2)

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Network Slice Types Vs. Management Responsibilities

Network Slice Types

Management Responsibilities

External Tenant Managed Slices

Tenant Manages Slices and Services

External Provider Managed Slices

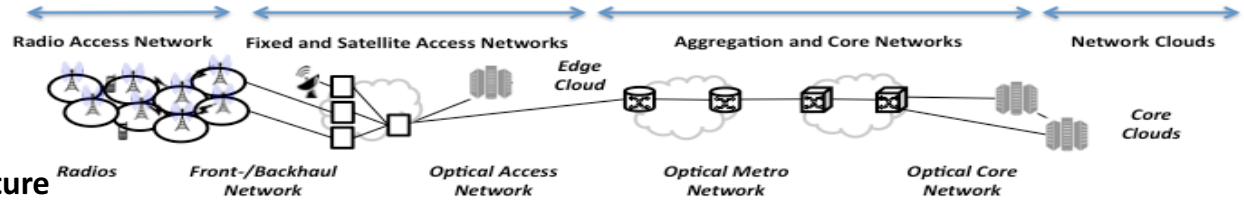
Provider Manages Slices and Tenant Manages Services

Provider Slice As A Service

Provider Manages Slices as a Service

Provider Internal Slices

Provider Manages Slices and Services



Concepts (3)

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Additional viewpoints:

- From **a business point of view, a slice** includes *a combination of all the relevant network resources, functions, and assets required to fulfill a specific business case or service, including OSS, BSS and DevOps processes.*
- From the **infrastructure point of view, infrastructure slice instances** require *the partitioning and assignment of a set of resources that can be used in an isolated, disjunctive or non- disjunctive manner for that slice.*
- From the **tenant point of view, infrastructure slice instance provides** different capabilities, specifically in terms of their management and control capabilities, and how much of them the network service provider hands over to the slice tenant. As such there are two types of slices:
  - (1) **Internal slices**, understood *as the partitions used for internal services of the provider, retaining full control and management of them.*
  - (2) **External slices**, being those *partitions hosting customer services, appearing to the customer as dedicated networks/clouds/datacentres.*
- From the **management plane point of view, infrastructure slices** refers to the managed fully functional *dynamically created partitions of physical and/or virtual network resources, network physical/virtual and service functions that can act as an independent instance of a connectivity network and/or as a network cloud.* Infrastructure resources include connectivity, compute, and storage resources.
- From the **date plane point of view, infrastructure slices** refers to *dynamically created partitions of network forwarding devices with guarantees for isolation and security*.

Concepts (4)

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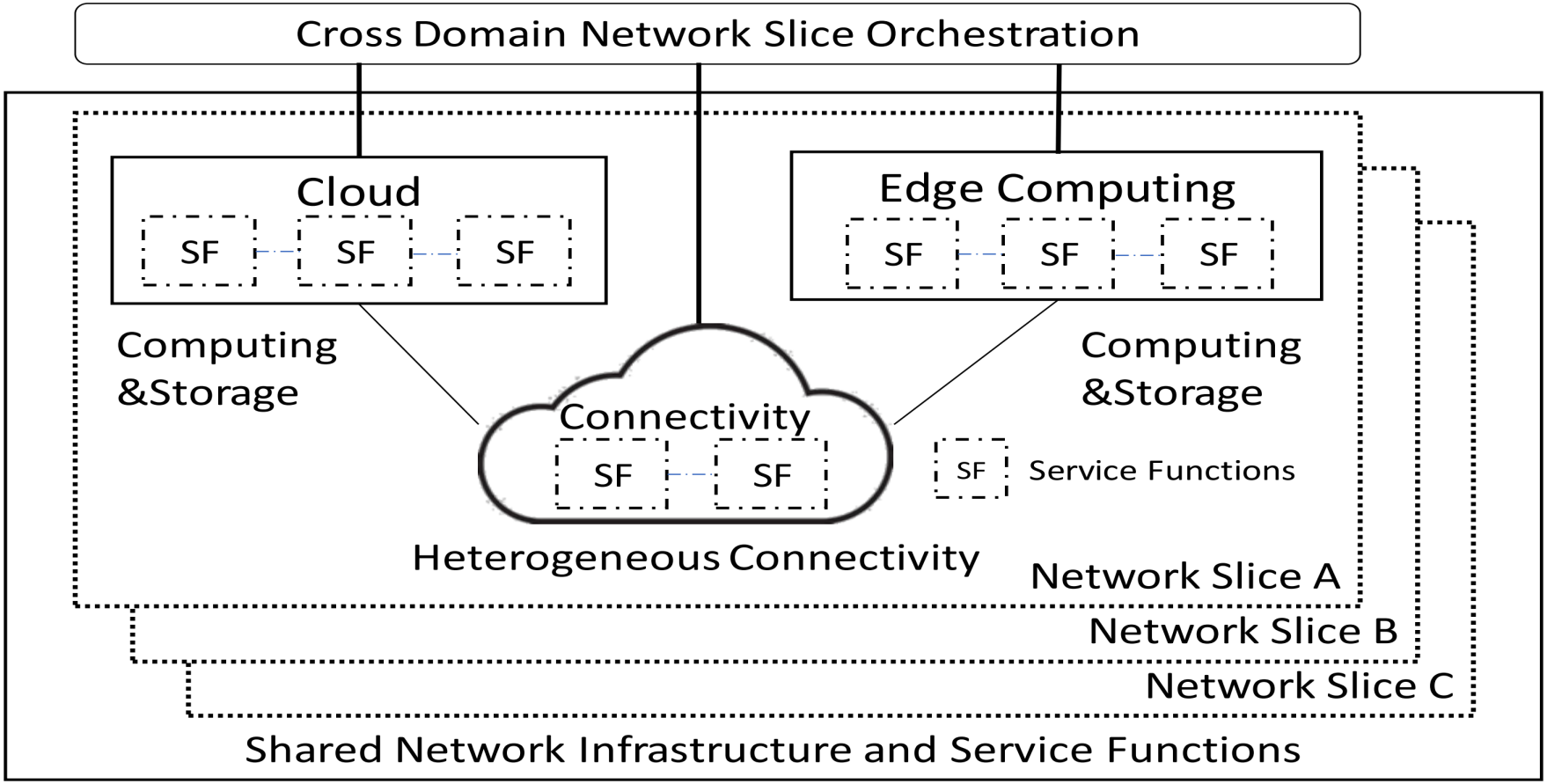
Cross-domain management of network slices in network infrastructure and service functions



Networking Infrastructure Ecosystem

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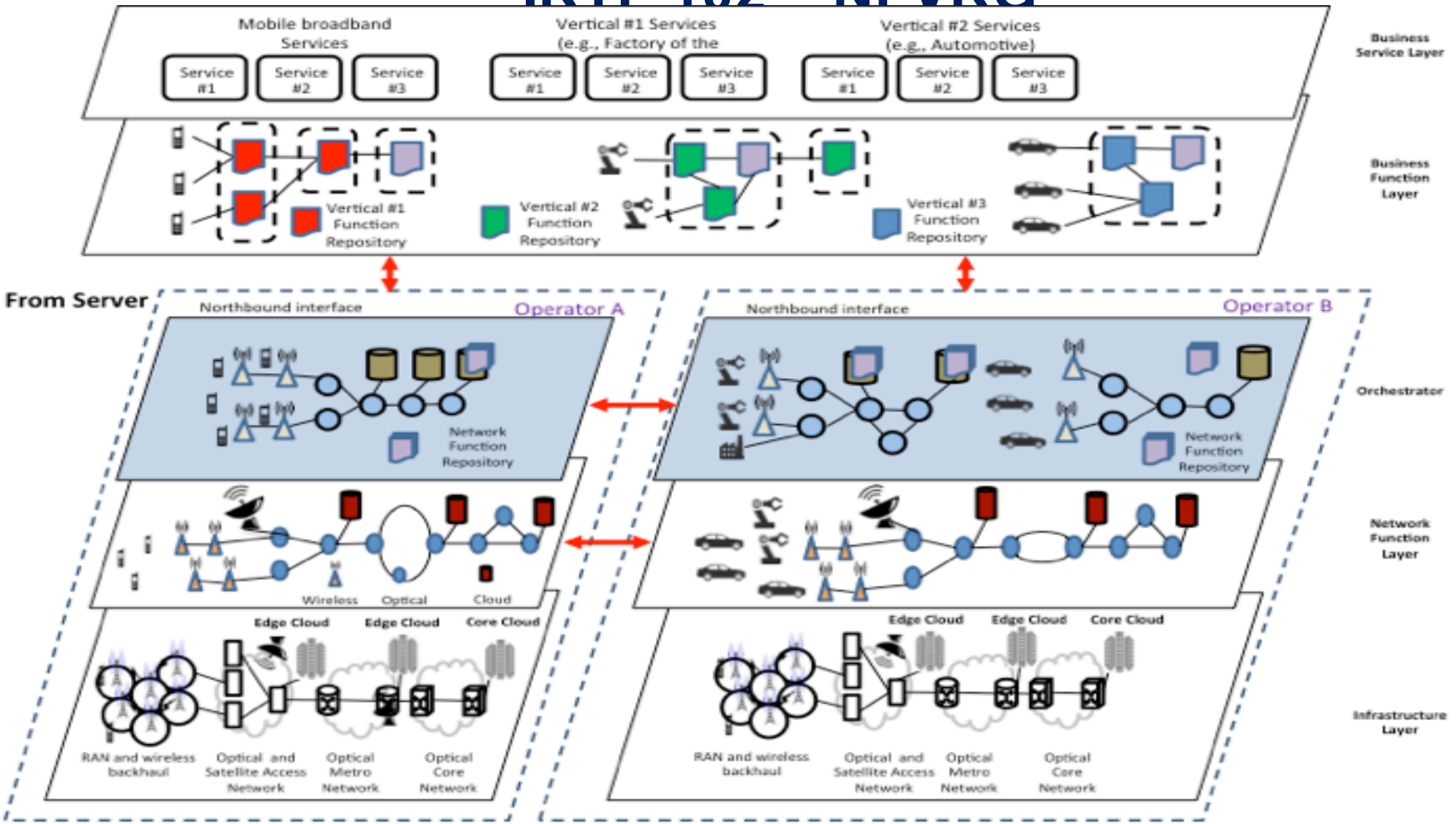

ETSI NGP: Network Slice reference framework

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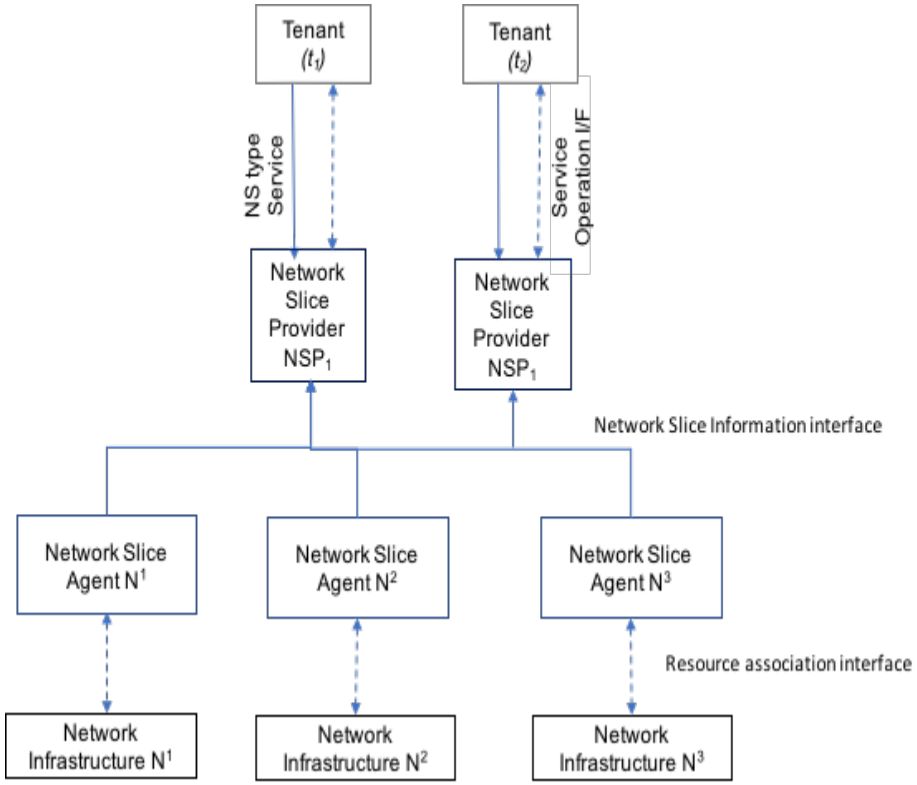
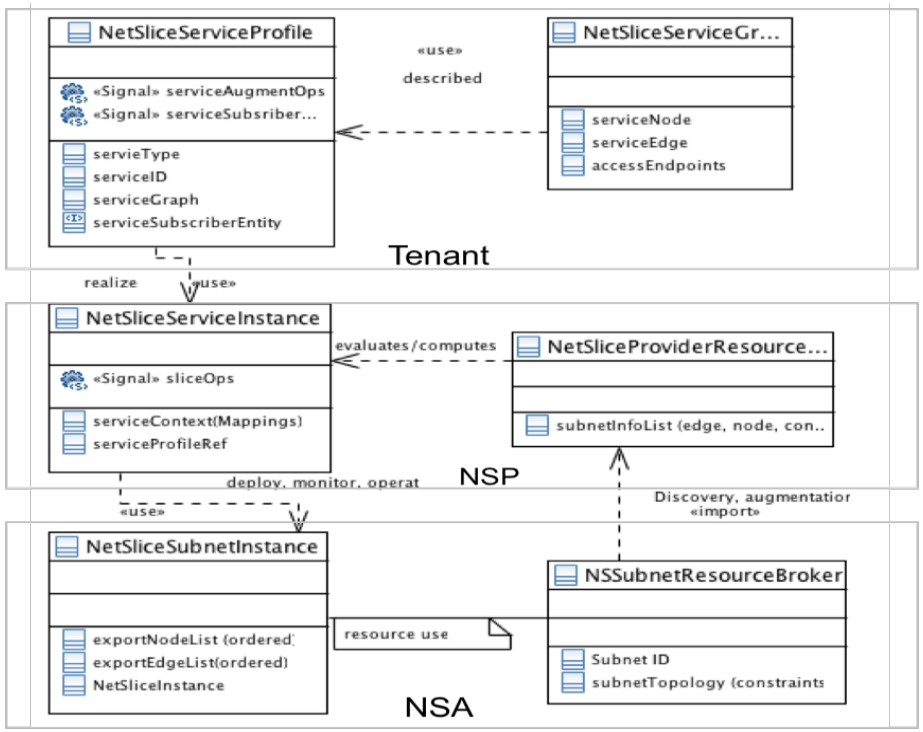


HL Interface Model



HL Data Object Model

Information Model: (a) Reference interfaces in Framework (b) describes the primary data objects, and (c) different functions required to manage end-to-end slices

NGP provides a completely independent of any existing technology existing architecture. It can be used as a guidance, identify your own functional components and/or communications.

Slicing Key Characteristics & Impact

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- **A managed group of infrastructure resources, network functions and services** (e.g. Service Instance component, A Network Slice Instance component, Resources component , Slice Capability exposure component).
- Concurrent deployment of **multiple logical, self-contained and independent, shared or partitioned networks on a common infrastructure platform**.
- **is a dedicated network** part that is built on an infrastructure mainly composed of, but not limited to, connectivity, storage, and computing.
- **it is related to an operator** that sees it as a complete network infrastructure and uses part of the network resources to meet stringent resource requirements.
- Supports **dynamic multi-service support, many/multi-tenancy** and the integration means for vertical market players.
- **NS is programmable and has the ability to expose its capabilities**. The behavior of the network slice realized via network slice instance(s).
- **Service customized Network Slices (enabled by NFV) + Smart Network Fabric for coordinating/orchestration, control of network resource**
- **Guaranteeing service level for end to end across multiple (administrative) domains**
- **Flexible customizability**
  - automation as the way for simplifying the provisioning

Slicing Key Characteristics & Impact (2)

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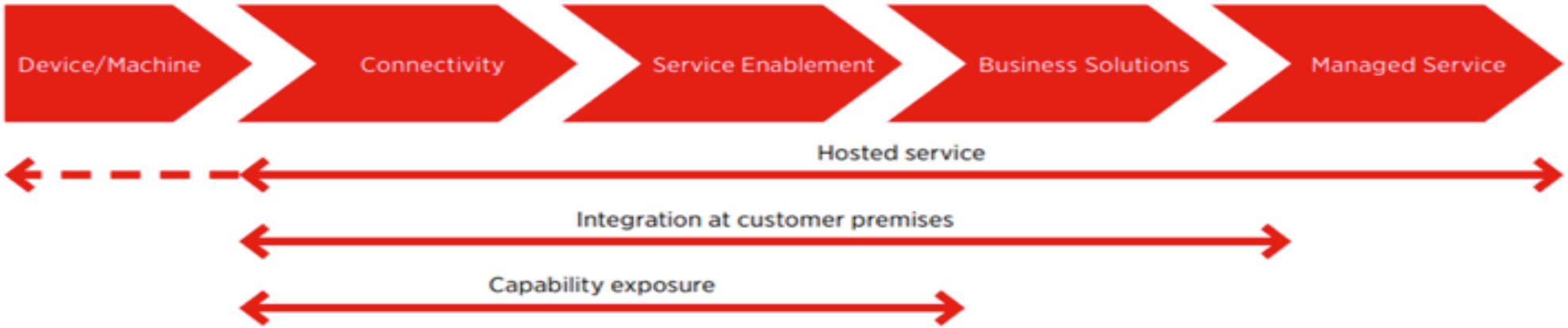
- **Network operators/ ISP can exploit network slicing**
  - Enabling other industrial companies to use networks as a part of their own services (e.g. vertical players: connected car with high reliable network, online game with ultra-low latency, video streaming with guaranteed bandwidth, etc.)
  - reducing significantly operations expenditures, allowing also programmability necessary to enrich the offered tailored services.
  - means for network programmability to OTT providers and other market players without changing the physical infrastructure.
- **NS** simplifies the provisioning of services, manageability of networks and integration and operational challenges especially for supporting communication services.
- **Expecting realization of E2E network slices and creation of new business model**
- **introduces an additional layer of abstraction** by the creation of logically or physically isolated groups of network resources and (virtual) network functions configurations.
- **Considerably transform the networking perspective** by
  - abstracting, isolating, orchestrating and separating logical network behaviors from the underlying physical network resources.

Network Slicing Value Chain



- **Capability exposure**: trough this utilization model, the providers can offer Application Programming Interfaces (APIs) to the vertical business customers for granting the capability of managing their own slices. Such management actions can include e.g. dimensioning, configuration, etc.
- **Integration at customer premises**: complementary network segments, in some cases pertaining to the vertical business customer, become an integral part of the solution, requiring a truly convergent network including the integration in existing business processes as defined by the vertical customer.
- **Hosting applications**: the provider offer the capability of hosting virtualized versions of network functions or applications, including the activation of the necessary monitoring information for those functions.
- **Hosting on-demand 3rd parties /OTTs**: empower partners (3rd parties / OTTs) to directly make offers to the end customers augmenting operator network or other value creation capabilities.

Key Values in Slicing

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Key Values:

- Concurrent deployment of **multiple parallel, logical, self-contained and independent, shared or partitioned networks on a common infrastructure platform**. **Network Slicing has the ability to expose its capabilities**.
- Enable **dynamic multi-service support, many/multi-tenancy** and the integration means for vertical market players.
- **Network Slicing** simplifies the provisioning of services, manageability of networks and integration and operational challenges especially for supporting communication services.
- **Network operators/ ISP can exploit network slicing** for
  - reducing significantly operations expenditures, allowing also programmability necessary to enrich the offered tailored services.
  - means for network programmability to OTT providers and other market players without changing the physical infrastructure.
- **Considerably transform the networking perspective** by
  - abstracting, isolating, orchestrating and separating logical network behaviors from the underlying physical network resources.