Network Slicing – Research Management Challenges

‎UCL

IRTF 102 – NMRG

Contents

- **Network Slicing Usage Scenarios**
- **Network Slicing Management Research Challenges**
- **Concluding Remarks**

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 - 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)**

Prof. Alex Galis

University College London, UK

a.galis@ucl.ac.uk

Concepts
(Driving Issue: It is inefficient and expensive to build a separate infrastructure for each service)
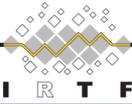
IRTF 102 – NMRG

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. It is substantially different to traditional VPNs , Virtual Networks or traffic engineering approaches. It focusses mainly on service, management and control panes with a footprint in the data pane
- **Infrastructure Slicing** - A management mechanism that Infrastructure Slice Provider can use to allocate dedicated infrastructure resources and service functions to Network Slice Tenant.
- **NS are significantly different from traditional: VPNs or a Virtual Network or Traffic Engineering**
- **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

# Slices Usage Scenarios

IRTF 102 – NMRG

- High Precision Networks (i.e. guaranteed KPIs, 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)

3

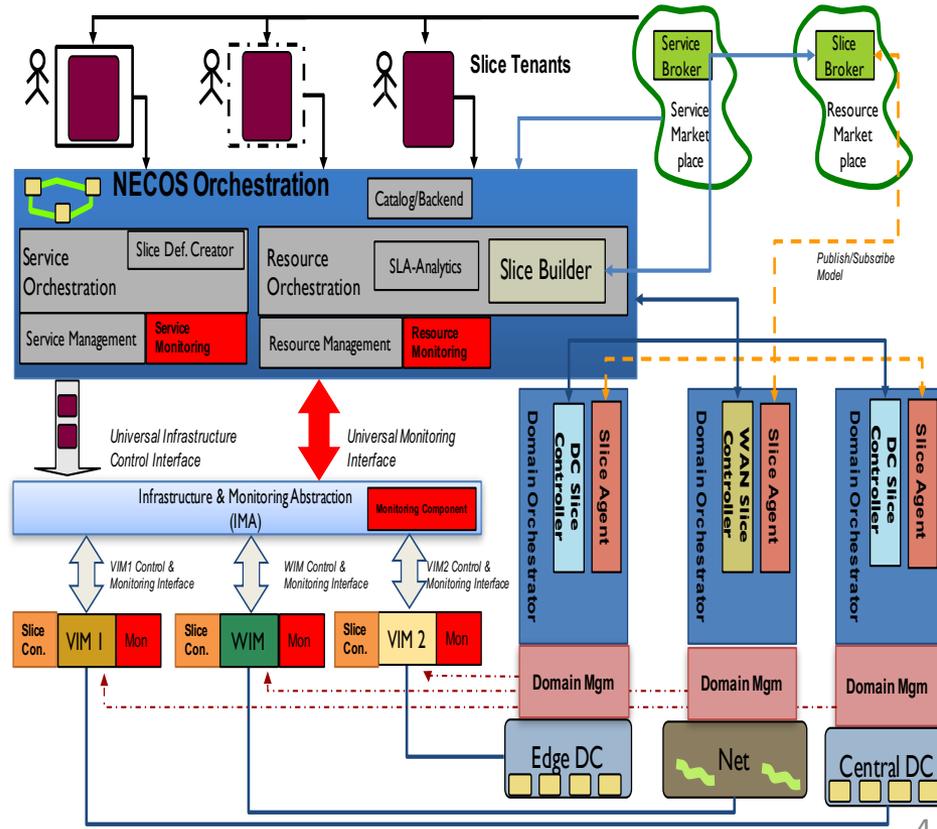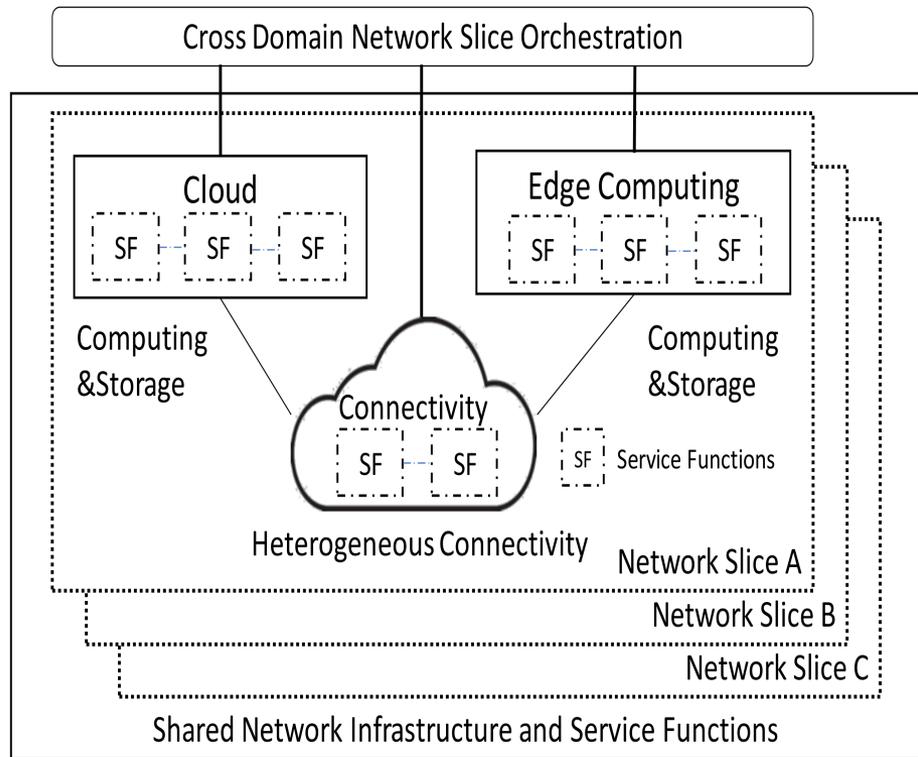# Examples of High Level Architecture & Interfaces Network and Cloud Slicing
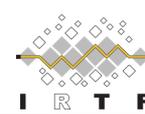
IRTF 102 – NMRG

Proposed Framework @ IETF
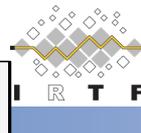
NECOS Project

http://www.h2020-necos.eu

Research Challenges (1): E2E Network Slice Management and Orchestration

IRTF 102

Comprehensively study all management aspects and APIs of network slices.

NS Life Cycle Management: (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) **Uniform Slice 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 access, core and transport networks; for slices in data centres/clouds/

E2E multi-domain Orchestration (1) **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; (2) **Autonomic control of slice life cycle management**, including concatenation of slices in each segment of the infrastructure (in data, control, and management planes); (3) **Autonomic coordination and triggering of slice elasticity and placement**; (4) **Coordination and (re)-configuration of resources** by taking over the control of all the network functions.

5

IRTF 102 – NMRG

Full NS FCAPS: (1) Fault, Configuration, Accounting, Performance, Security; (2) Monitoring Subsystem is responsible for **monitoring continuously the state all components of a NS;** Monitoring Subsystem receives the detailed service monitoring requests with references to resource allocation and Network functions instances in a NS. (3) **Discovery and monitoring probes are needed of all NS components** and NS itself and for dynamic discovery of service with function instances and their capability.

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 can only be solved by continuous autonomic monitoring of slice performance and making continuous autonomic adaptations of the resources allocated to them.

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.**

Slice composition / decomposition : The stitching of slices is an operation that **modifies functionality of an existing slice by adding and merging functions of another slice** (i.e. enhancing control plane properties be functions defined in another slice template). Stitching of slices is used to enrich slice services: (1) Slice stitching operations are supported by uniform slice descriptors; (2) Efficient stitching/ decomposition (vertically, horizontally, vertically + horizontally).

# Research Challenges (3) Key Network Slicing Capabilities
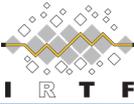
IRTF 102 – NMRG

E2E 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 management scalability issue.

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

Concluding Remarks: Overall Context
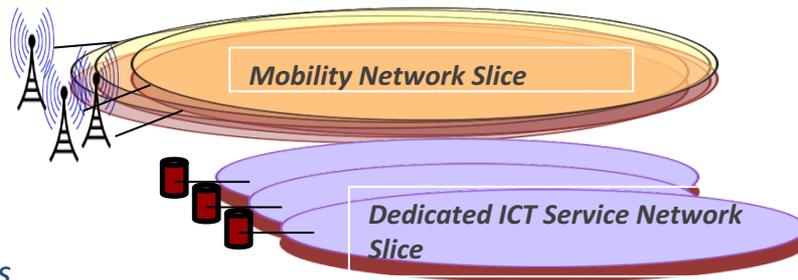# www.clayfour.ee.ucl.ac.uk
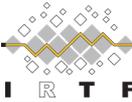
IRTF 102 – NMRG

- Transition from network devises to integrated network & service 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 system with simple interface to the infrastructure (smart network fabric)

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

In-slice Cognitive Management & Control

Mobility Network Slice

Service Adapted Network Slices
Enabled by Network Functions Including NFV

Dedicated ICT Service Network Slice

High-Precision Service Network Slice
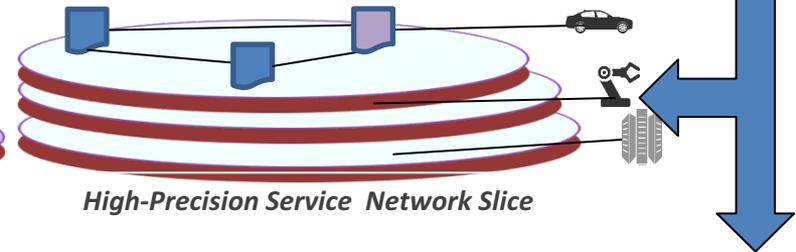
Light Weight Smart Network Fabric –Network Abstraction, Allocate (virtual) network resources/ slices, Maintain network state, Ensure network Reliability in a multi domain environment

Existing Cloud & Network Fabric

RADIO ACCESS

FIXED ACCESS

METRO

CORE

EDGE

EDGE

EDGE

EDGE

EDGE

EDGE

What could be the NMRG next Steps

IRTF 102 – NMRG

- *While its scope and definition continue to evolve, there is reasonable level common understanding of the key central role Network Slicing will play in future network and service management scenarios.*

- *NMRG can be the place for researching all details including E2E frameworks, e2e orchestration functions and APIs of e2e management of network slices.*

- *Feedback is requested on the above!*

Acknowledgement & References
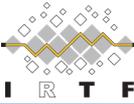
IRTF 102 – NMRG

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/

SDOs- References

IRTF 102 – NMRG

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

Q&A

IRTF 102 – NMRG