

**Tuesday, July 11, 2017,**  
**Thessaloniki, Greece!**

## **Network Slices toward 5G Communications: Slicing the LTE Network**



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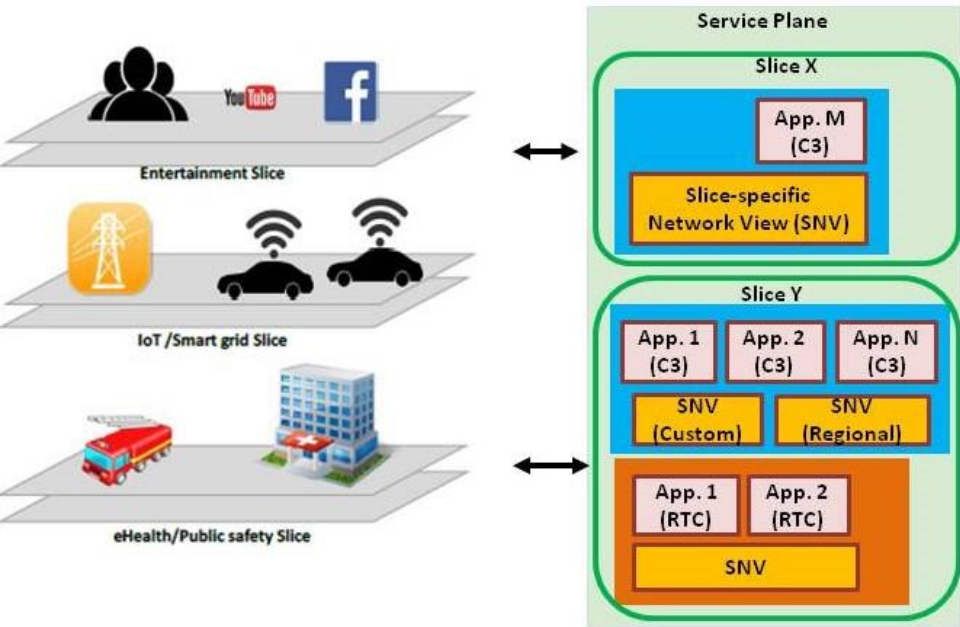
\* Paper: K.Katsalis, N. Nikaiein, E. Schiller, A. Ksentini, and T. Braun, "Network Slices toward 5G Communications: Slicing the LTE Network" IEEE Communications Magazine, Special issue: Network Slicing in 5G Systems, 2017

# Network Slicing: Definitions and Concepts

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- **5G network of the future will involve the integration of several cross-domain networks.**
- **5G systems will be built to enable logical network slices across multiple domains and technologies.**
- **A 5G network slice is a bundle of network services, functions, configurations, network applications, resources, and accoutrements.**
- **The foundation of 5G network slices is built around:**
  - cloud computing and virtualization technologies
  - multi-tenancy and multi-service support
  - integrated network programmability
  - adoption of the SDN/NFV design paradigms

# Network Slicing: Definitions and Concepts

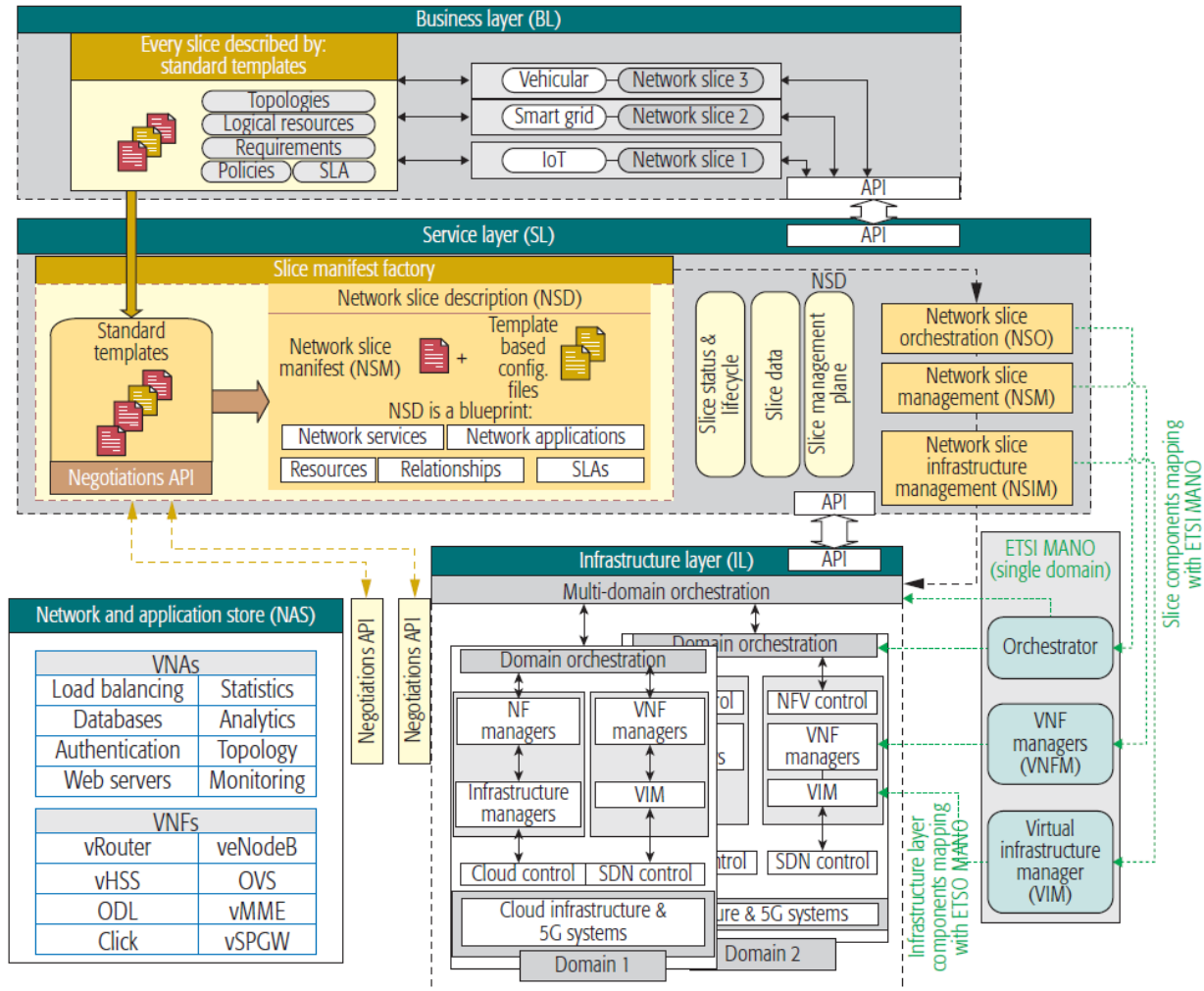


**A network slice is instantiated on a common shared infrastructure**

- Chain and compose adequately configured network functions, network applications, and underlying cloud infrastructures
- Map and place them onto the infrastructure resources and assign target performance metrics
- Program and scale them according to a particular business application scenario

# Network Slicing Architecture

- ❑ Business Layer
- ❑ Network Slice Service Layer
- ❑ Infrastructure Layer
- ❑ Network and Application Store



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# Network Slicing Architecture

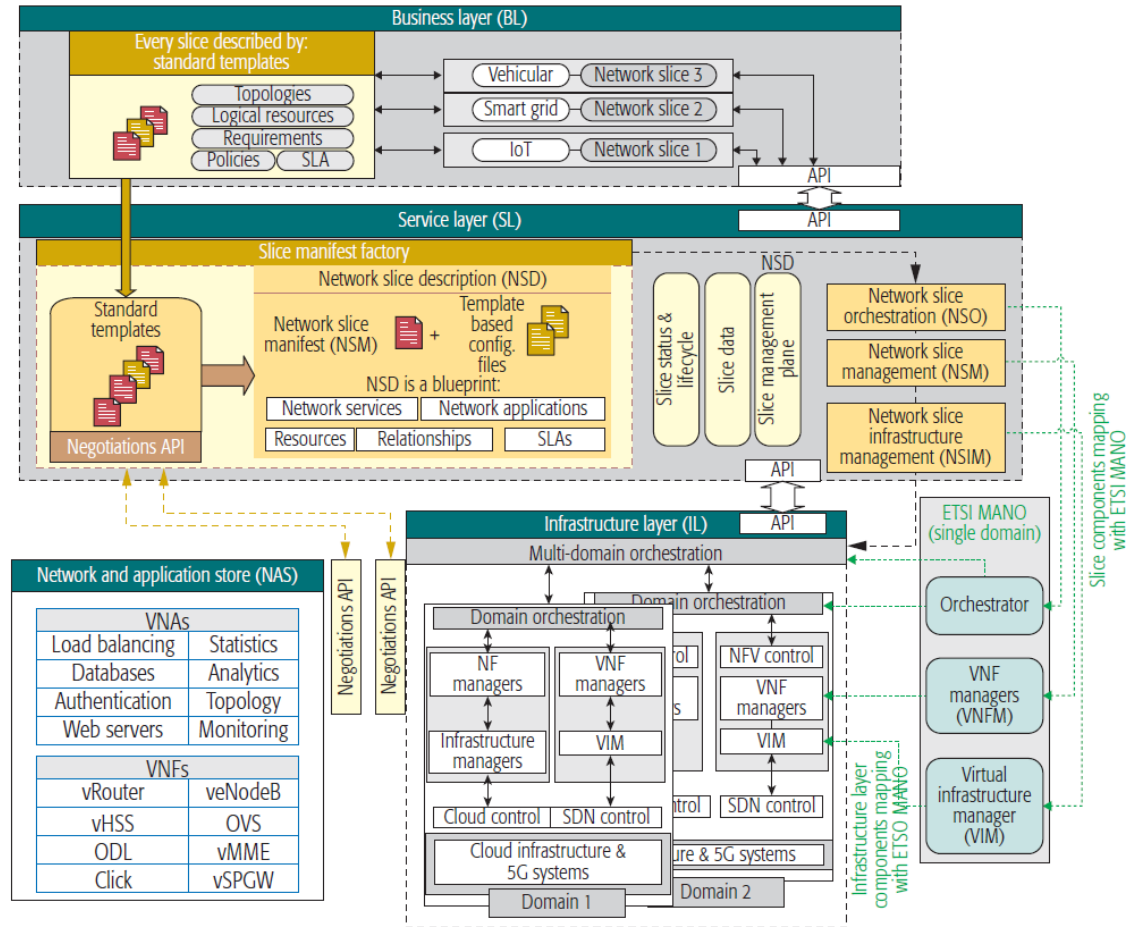
## Business Layer

- 5G use cases span from public safety, high mobility, and business-critical applications, to IoT and high-speed broadband vehicular access.
- The slice owner on top of the business layer creates the desired use case (e.g., IoT) and is the one that actually triggers the building of the network slice.

## Network Slice Service Layer

## Infrastructure Layer

## Network and Application Store



# Network Slicing Architecture

## ❑ Business Layer

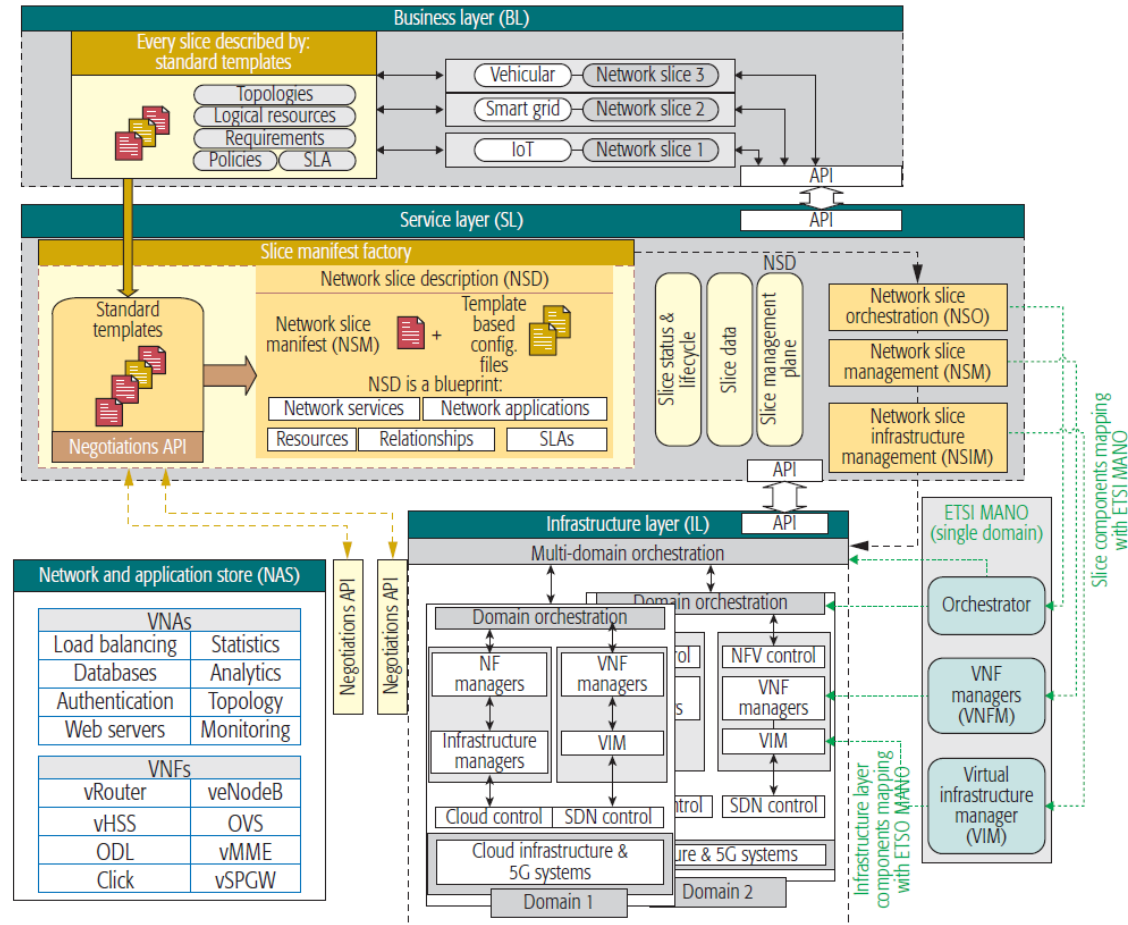
## ❑ Network Slice Service Layer

❑ Life-cycle management of each network slice, related to the deployment, instantiation, management, control, scaling and termination of the network slices.

❑ the transformation of network slice templates to an operational bundle of resources and services.

## ❑ Infrastructure Layer

## ❑ Network and Application Store



# Network Slicing Architecture

## ❑ Business Layer

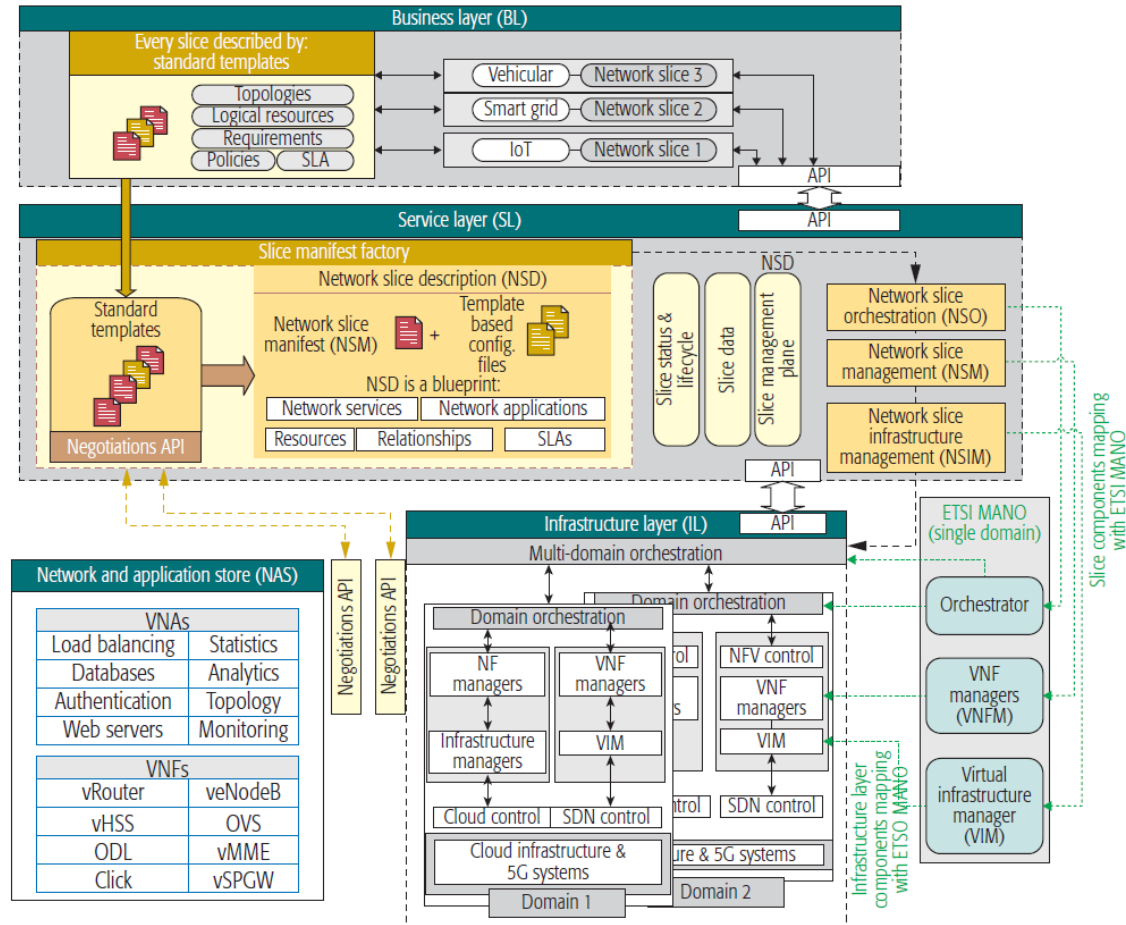
## ❑ Network Slice Service Layer

## ❑ Infrastructure Layer

❑ This layer shall support a real-time reconfigurable cloud ecosystem and virtualization for fast and ultra-fast services.

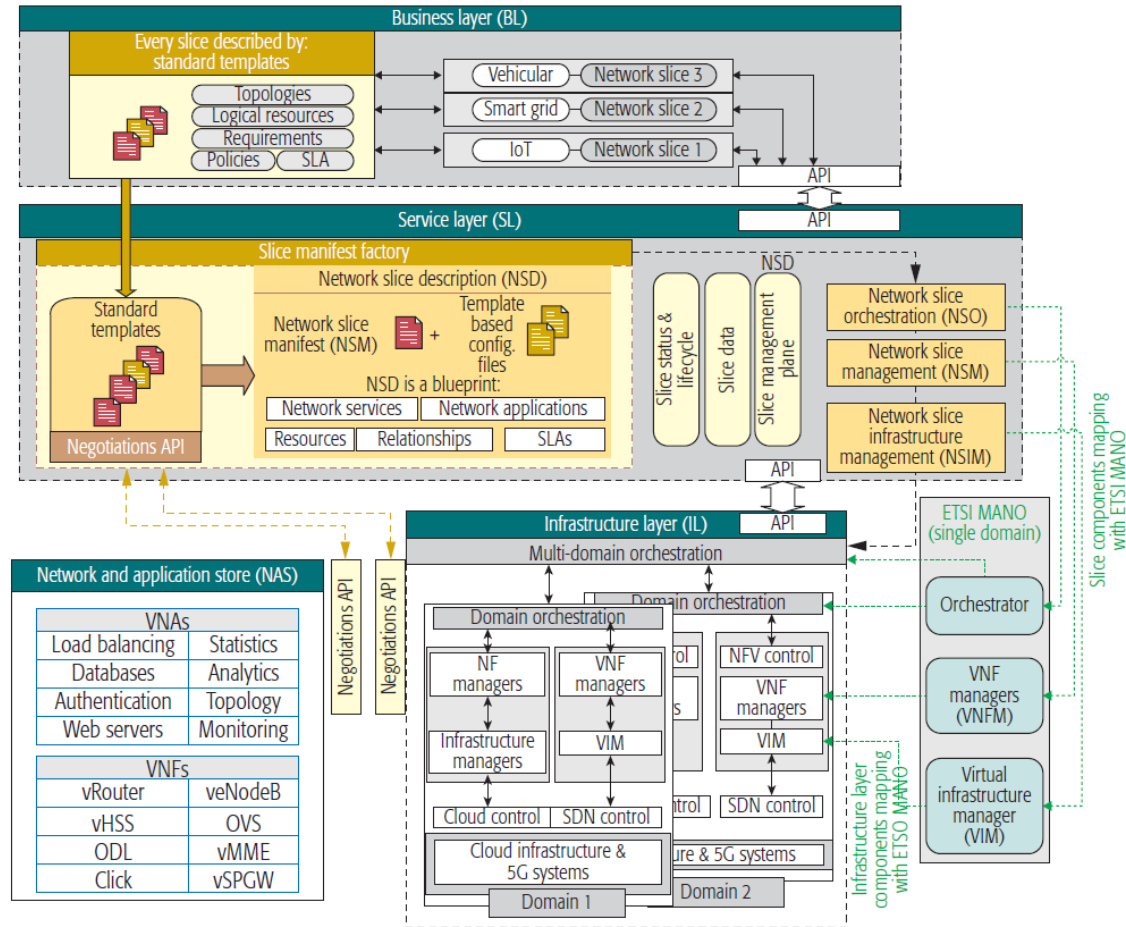
❑ it supports connectivity as a service and delivers the resulted bundle of network services.

## ❑ Network and Application Store

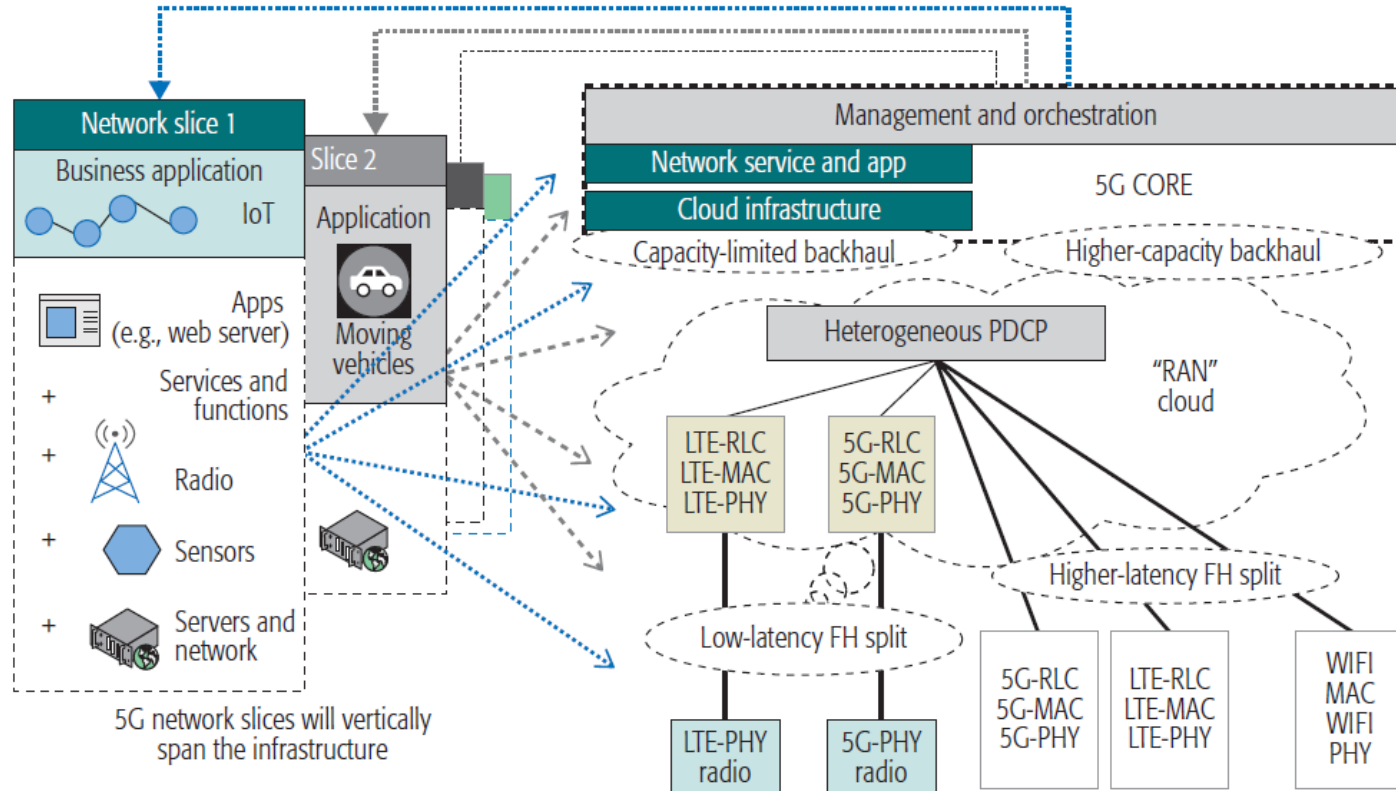


# Network Slicing Architecture

- ❑ Business Layer
- ❑ Network Slice Service Layer
- ❑ Infrastructure Layer
- ❑ Network and Application Store
  - ❑ Allows creation of a slice for each virtual network through digital distribution platforms
  - ❑ Network functions and network applications



# Network Slicing at the 5G RAN

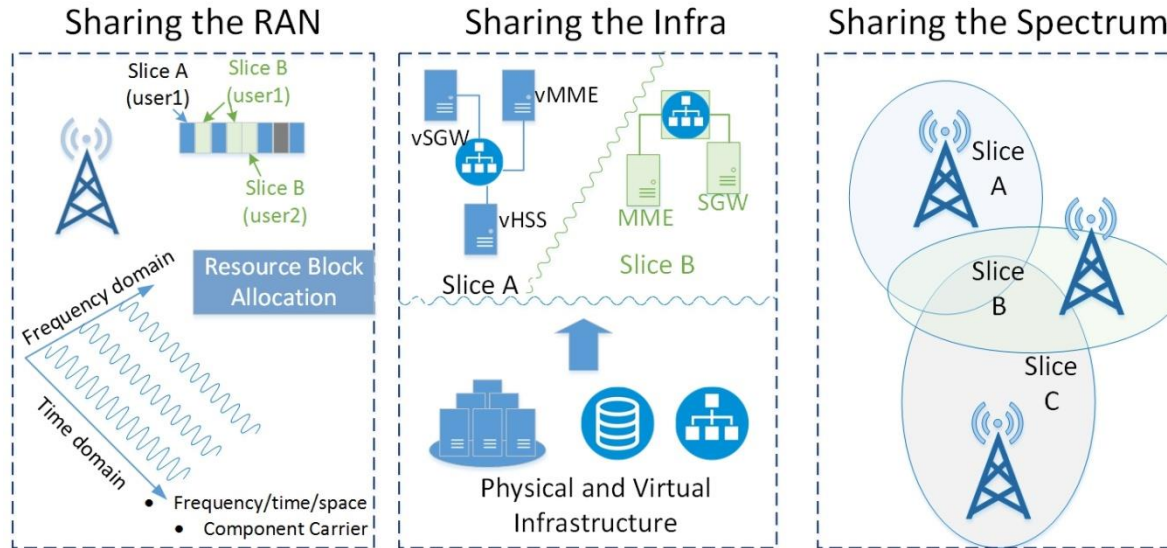


# Technology landscape for Network Slicing

Layer	Technology drivers
SL	SL (NSO, NSM, NSIM): nothing available. NSD/NSM: TOSCAN [12], IBM's Blueprint, rSLA
NAS	FP7-TNOVA ( <a href="http://www.t-nova.eu">www.t-nova.eu</a> ): developers can sell their PNFs and VNF software through auctioning EU FP7-UNIFY ( <a href="http://www.fp7-unify.eu">www.fp7-unify.eu</a> ): information base, where the resource characteristics of PNFs can be stored FP7-MCN ( <a href="https://www.mobile-cloud-networking.eu/">https://www.mobile-cloud-networking.eu/</a> ): a service catalog lists network services composed of multiple network functions EU H2020 SONATA ( <a href="http://www.sonata-nfv.eu">www.sonata-nfv.eu</a> ): emulation platform to support network service developers to locally prototype and test complete network service chains <b>Open Source JUJU Charm Catalog (<a href="https://jujucharms.com">https://jujucharms.com</a>)</b>
IL	<ul style="list-style-type: none"><li>• <b>Orchestration:</b> Openstack Tacker, Rift IO, Hurtle, Open-O, Open-Baton, Cisco's Network Services Orchestrator (NSO), Huawei CloudOpera</li><li>• <b>VNFM:</b> Canonical JUJU, Cloudify, Nokia CloudBand Application Manager, Cisco Elastic Services Controller (ESC) VNFM, Ericsson Network Manager (ENM), Huawei CloudOpera</li><li>• <b>VIM:</b> OpenStack, CloudStack by Citrix, Cloudify, Ericsson Cloud Manager (ECM), Microsoft Azure, Google and Amazon clouds, Hypervisor Technologies (KVM, DOCKER, LCX/LXD, XEN, ESCi, etc.)</li></ul>

# Network Slicing and RAN Sharing

- In the evolved LTE, network slicing is closely related to the concept of RAN sharing for multi-service offering. 3GPP (3GPP TS 23.251, TR.22.852 etc.)
- By means of mobile network resource sharing, actually three dimensions of the problem exist:



# When Slicing the LTE Network

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- ❑ **Running LTE Components in VMs**
  - ❑ **LTE Components as VNFs**
  - ❑ **SDN Control and Programmable RAN Elements**
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## **Questions that arise:**

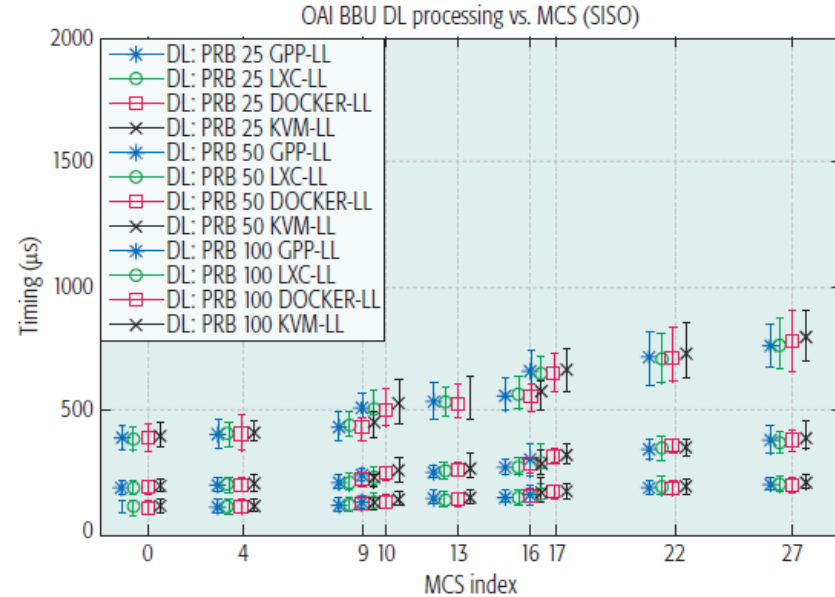
- Is the explosion of LTE elements as VNFs feasible?
- What is the cost of deploying LTE services as VNFs on top of virtualized environments?
- Will there be performance degradation?
- What about the VIM and orchestration efficiency in the case of LTE networks?

# When Slicing the LTE Network

## ❑ Running LTE Components in VMs

❑ the performance degradation can be negligible when running the LTE services over a virtualized environment.

❑ However, these results depict the performance assuming no multi-tenancy and no multi-user transmission.



# When Slicing the LTE Network

## LTE Components as VNFs

✓ **OAI:** OAI offers a software implementation of the whole LTE protocol stack and can operate over commodity hardware for the deployment of the eNodeB and the core network (CN).

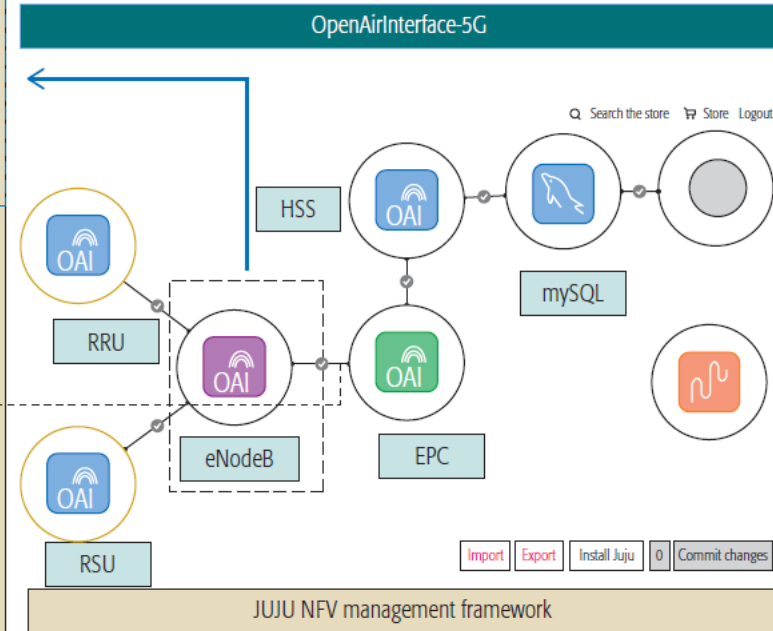
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✓ **JUJU Framework:** an open source VNFM provided by Canonical

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✓ **The first open source LTE VNF solution!!**

```
Service definition
Services:
"oai-enb":
  charm:"cs:~navid-nikaein/trusty/oai-enb"
  num_units: 2
  options:
    N_RB_DL:50
    downlink_frequency: 2680000000L
    eutra_band: 7
    rrh_active:"yes"
    uplink_frequency_offset:
      "12000000"
  to:
    -"o:0"
"oai-epc":
  charm:"cs:~navid-nikaein/trusty/oai-epc"
  num_units: 1
  to:
    -"kvm:0:0"
  relations:
    -"oai-enb:epc"
    -"oai-epc:epc"
    -"oai-hss:db"
  ...
domain:
  "o":
    provider:aws
    machines:
      "o":
        series: trusty
        constraints:"arch=amd64
        cpu-cores=4
        mem=15951 root-disk=8192"
```



# When Slicing the LTE Network

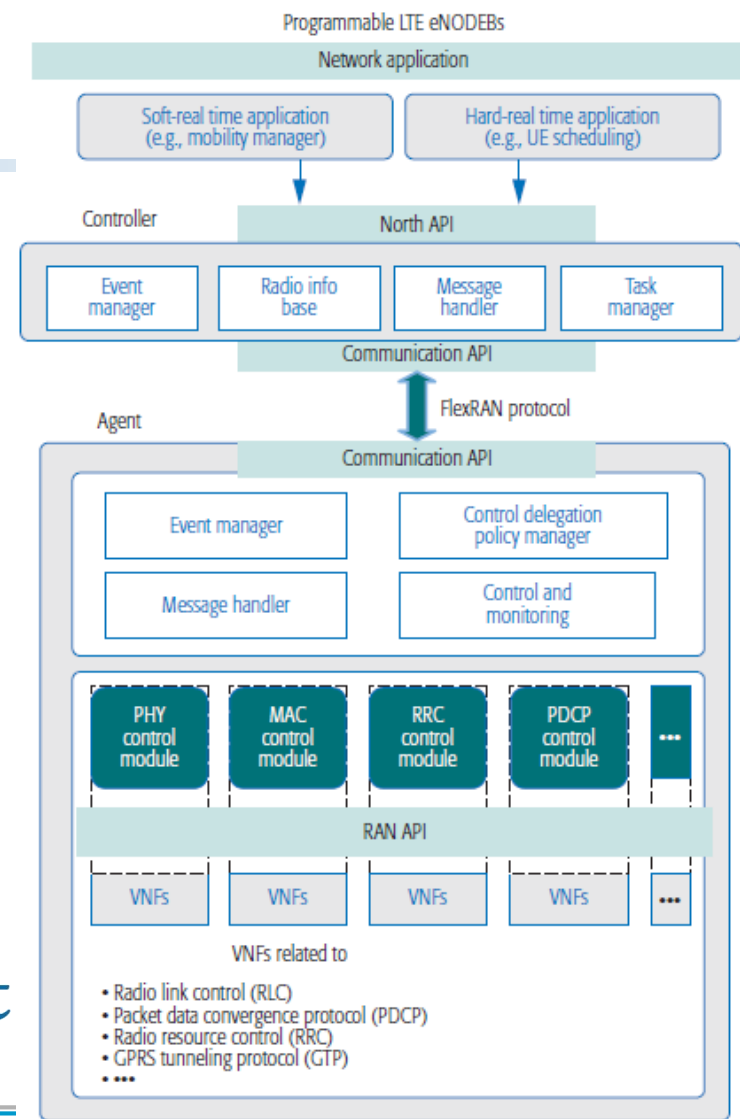
## SDN Control and Programmable RAN Element

### SDN control on the switch fabric:

- Openflow etc.

### SDN control on the eNodeB:

- FlexRAN



<http://networks.inf.ed.ac.uk/flexran/index.html>



# Key issues – Open Questions

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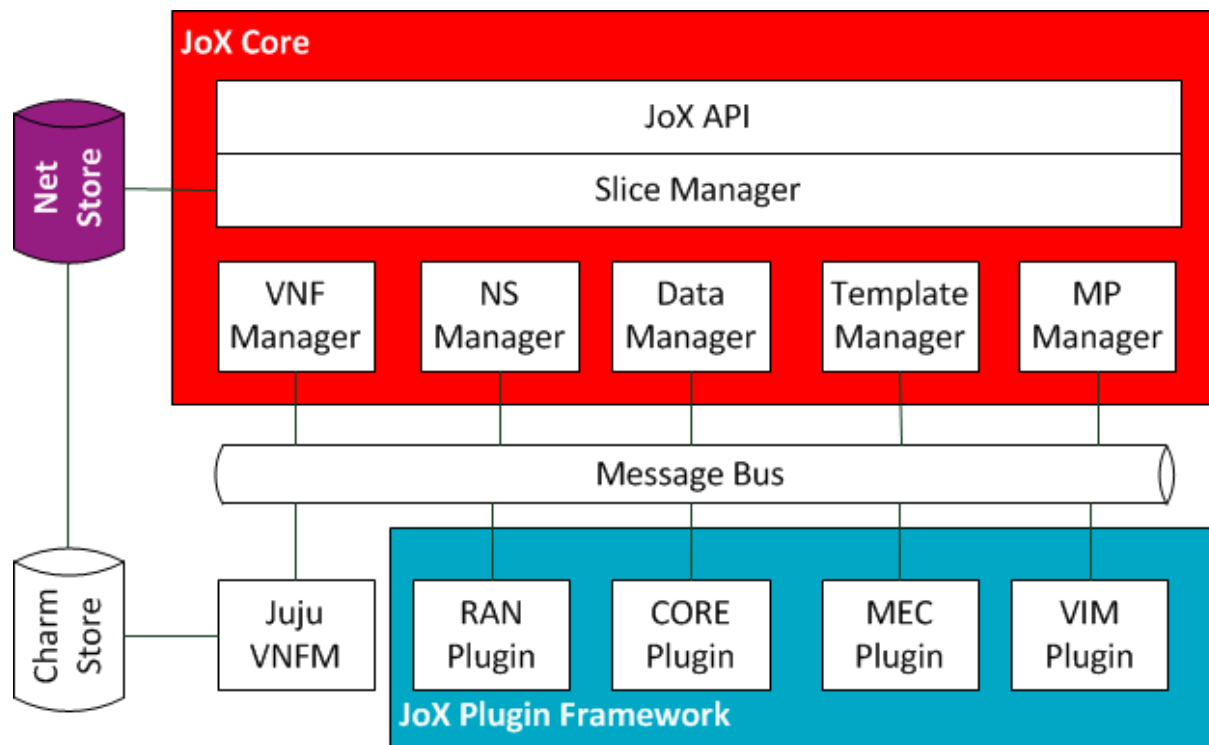
- 1. Network Slice Service Layer: For the actual implementation of the SL, there is no framework that could even partially cover the functionalities required.**
  - This shortcoming is JOX trying to meet
  - effort must be made on the interfaces and APIs' definition among all the architecture layers.
2. NFV management and ETSI NFV MANO equivalence and the role of network slicing and the way it actually can be realized in the wireless domain remain open.
3. LTE control plane designs that can potentially support slice-based SLA-driven RAN designs are missing.
- 4. Slice manifest describes the business application across Business, Service, Infrastructure planes:**
  - Regarding the NSD/NSM files, recent activities are around the TOSCAN model, while IBM's Blueprint and custom solutions are proposed. **However, there is still no mature solution available.**

# JOX: Open source Orchestrator for Network Slicing

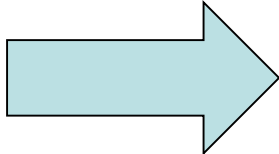
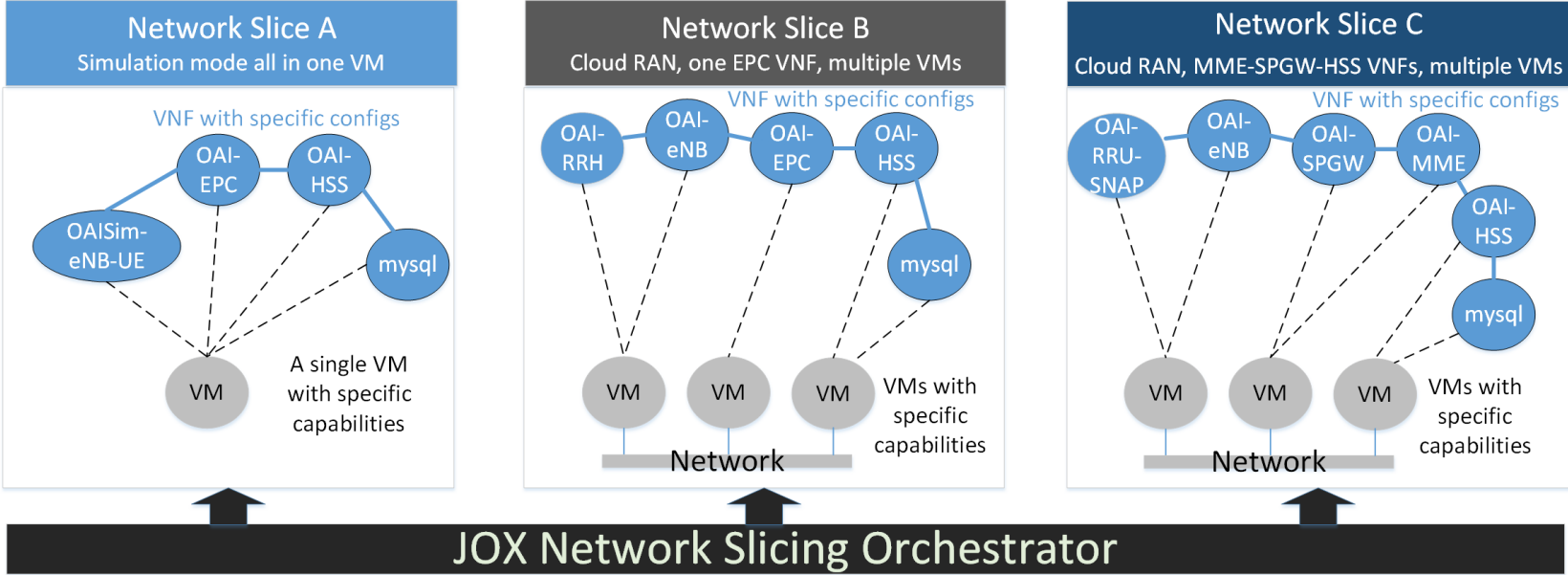
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- **Provide a simple and reusable Juju orchestrator core across different orchestrator**
  - Easy integration with other orchestration frameworks
  - ETSI MANO Compatible
- **Support plugin architecture for fast reaction to the underlying network and infrastructure**
  - Juju passthru
- **Support natively network slicing**
- **Offers a dual network store**
  - Dedicated : repository of templates, network application/algorithm, and models/tools
  - Shared : juju charmstore

# JOX Architecture



# JOX Network Slices Examples



Info about JOX will be publicly available under MOSAIC-5G open source initiative by Eurecom at end of July.

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Thank you for your attention!



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