5Growth

Network architectures for 5G and beyond

Josep Mangues-Bafalluy

Abstract

5Growth sets a solid and tangible ground towards beyond 5G network architectures

5Growth Vertical pilots

Industry 4.0

Industry 4.0

Vertical premises

Vertical premises

Transportation

Energy

3

Implications to the network architecture

Trends

Vertical-orientation

Disaggregated network equipment / Softwarization
- Increasing number of interfaces
- Increasing number of stakeholders

Ubiquitous computing
- Distribution/Decentralization in general brings heterogeneity

Deployment heterogeneity
- Different nature of verticals
- Access and transport network variety
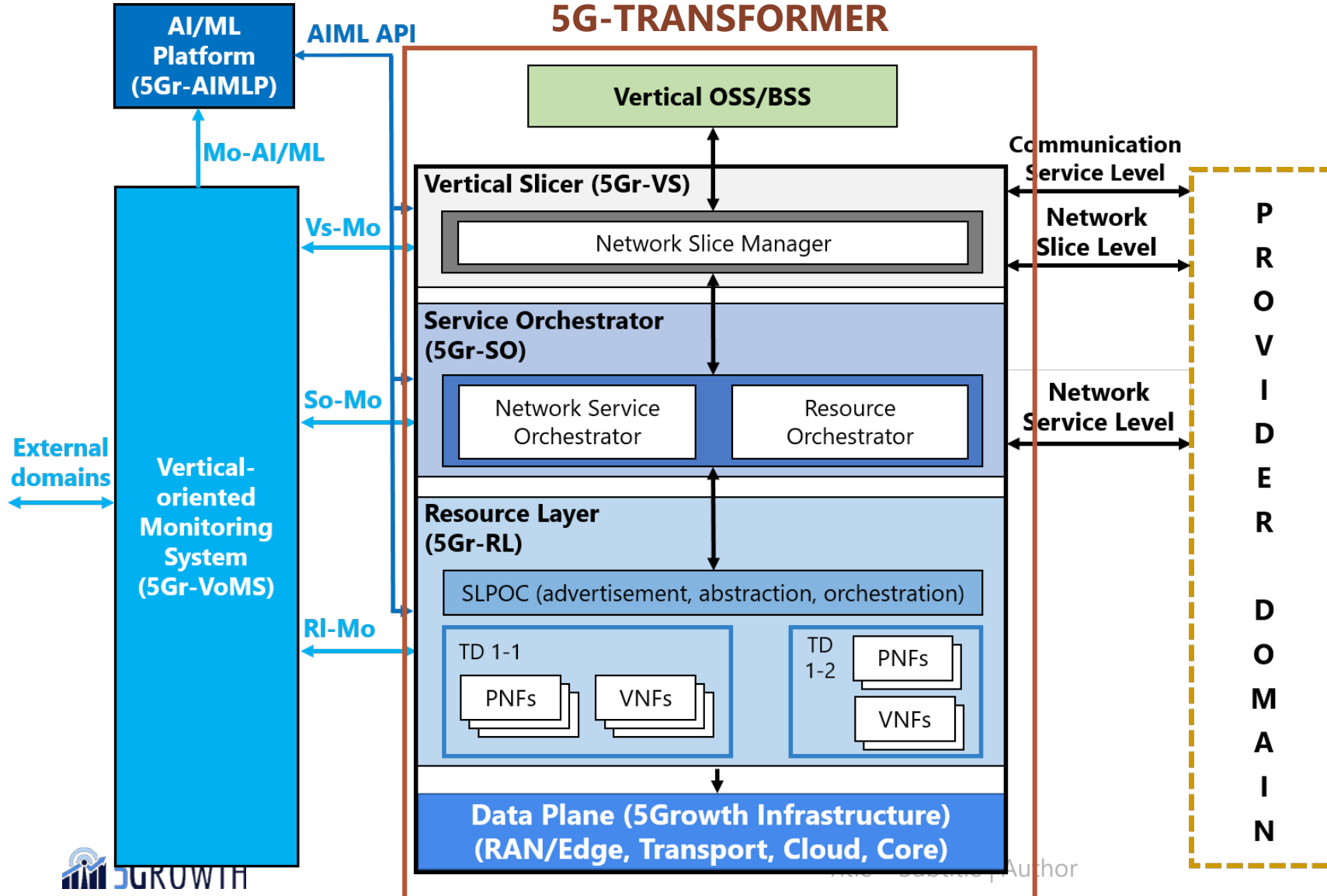
Result

Complex network
- Multiple administrative domains (incl. NPN-PN integration)
- Multiple providers
- Multiple technology domains (incl. RAN)

Dynamic adaptation to varying demands and network conditions
- AIML-based SLA management
  - AIML platform
  - Monitoring platform

5GROWTH

Extending Baseline Architecture

Baseline Architecture Leveraging on 5G-TRANSFORMER

AI/ML Platform (5Gr-AIMLP)

AIML API

Mo-AI/ML

Vs-Mo

External domains

Vertical-oriented Monitoring System (5Gr-VoMS)

So-Mo

Rl-Mo

Vertical OSS/BSS

Vertical Slicer (5Gr-VS)
Network Slice Manager

Service Orchestrator (5Gr-SO)
Network Service Orchestrator | Resource Orchestrator

Resource Layer (5Gr-RL)
SLPOC (advertisement, abstraction, orchestration)

TD 1-1
PNFs | VNFs

TD 1-2
PNFs
VNFs

Data Plane (5Growth Infrastructure) (RAN/Edge, Transport, Cloud, Core)

Communication Service Level

Network Slice Level

Network Service Level

PROVIDER DOMAIN

Vertical Slicer (5Gr-VS)
- Common entry point for all verticals
- Definition of vertical services and SLAs
- Network Slice (NS) to NFV Network Service mapping (NFV-NS)
- Arbitration

Service Orchestrator (5Gr-SO)
- End-to-End (E2E) service & resource orchestration
- NFV Network Service Management
  - Creation, instantiation, scaling, termination, update, query
- Federation and Inter-domain

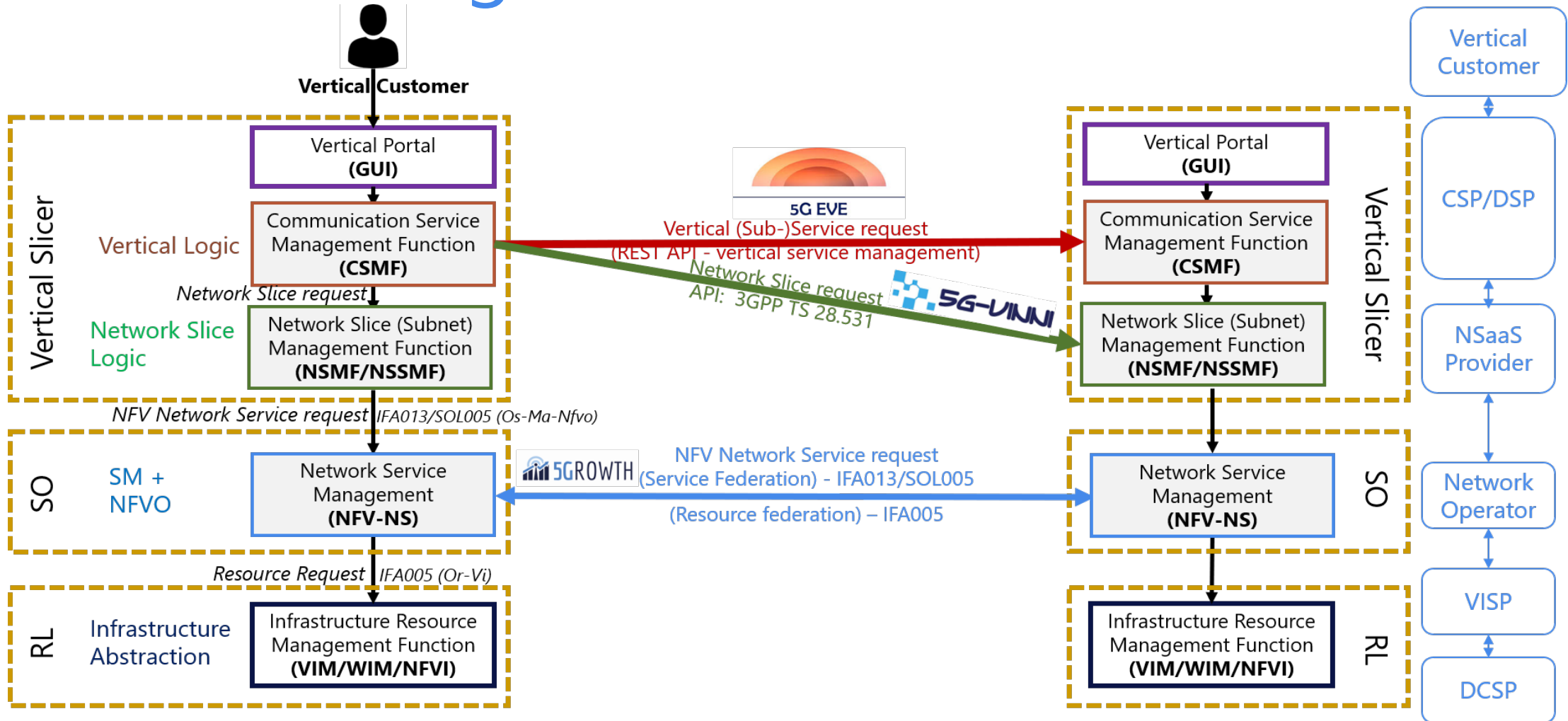**Resource Layer (5Gr-RL)**
- Resource abstraction

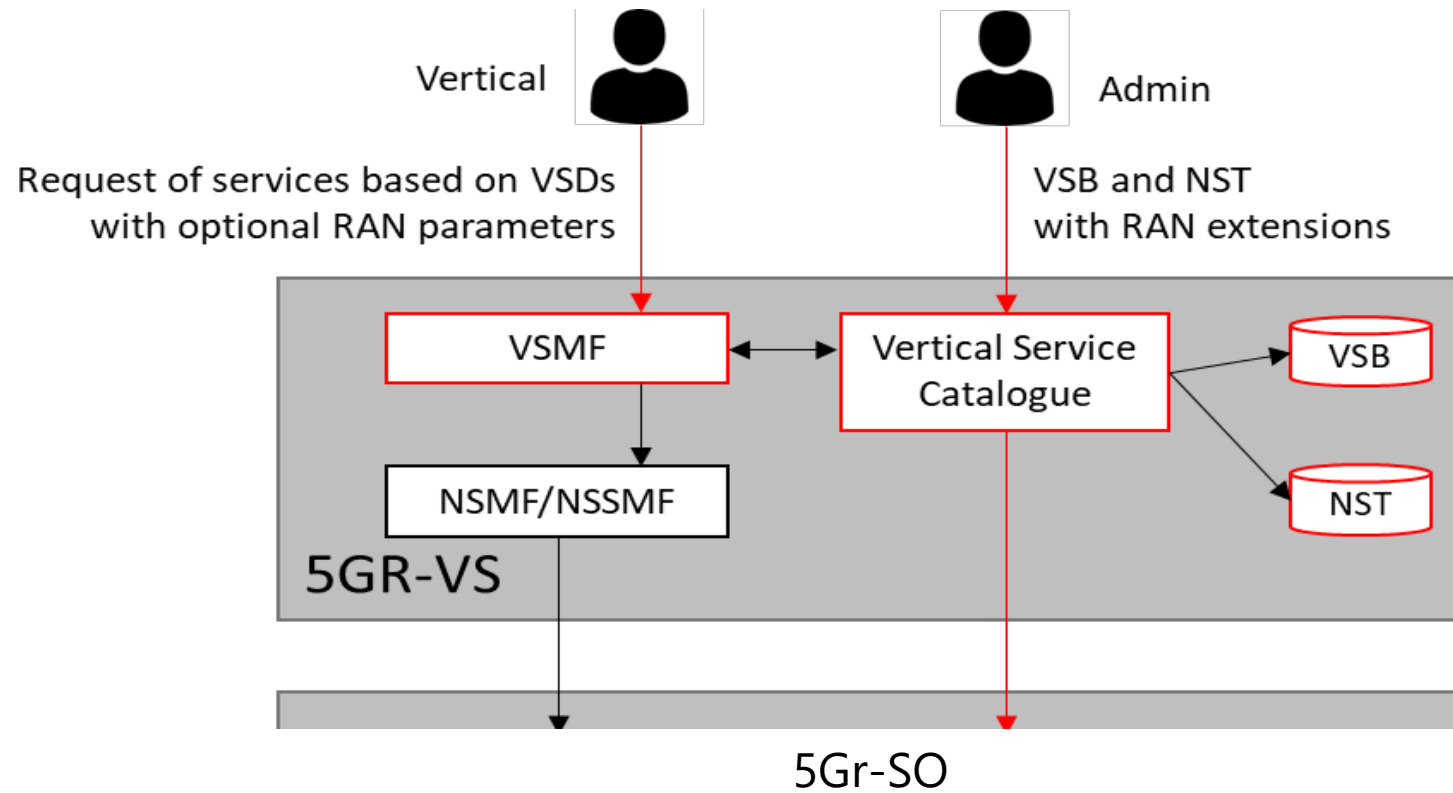**Monitoring Platform (5Gr-VoMS)**
- Centralized Monitoring Engine

AI/ML Platform (5Gr-AIMLP)
- Centralized AI/ML model management

5GROWTH
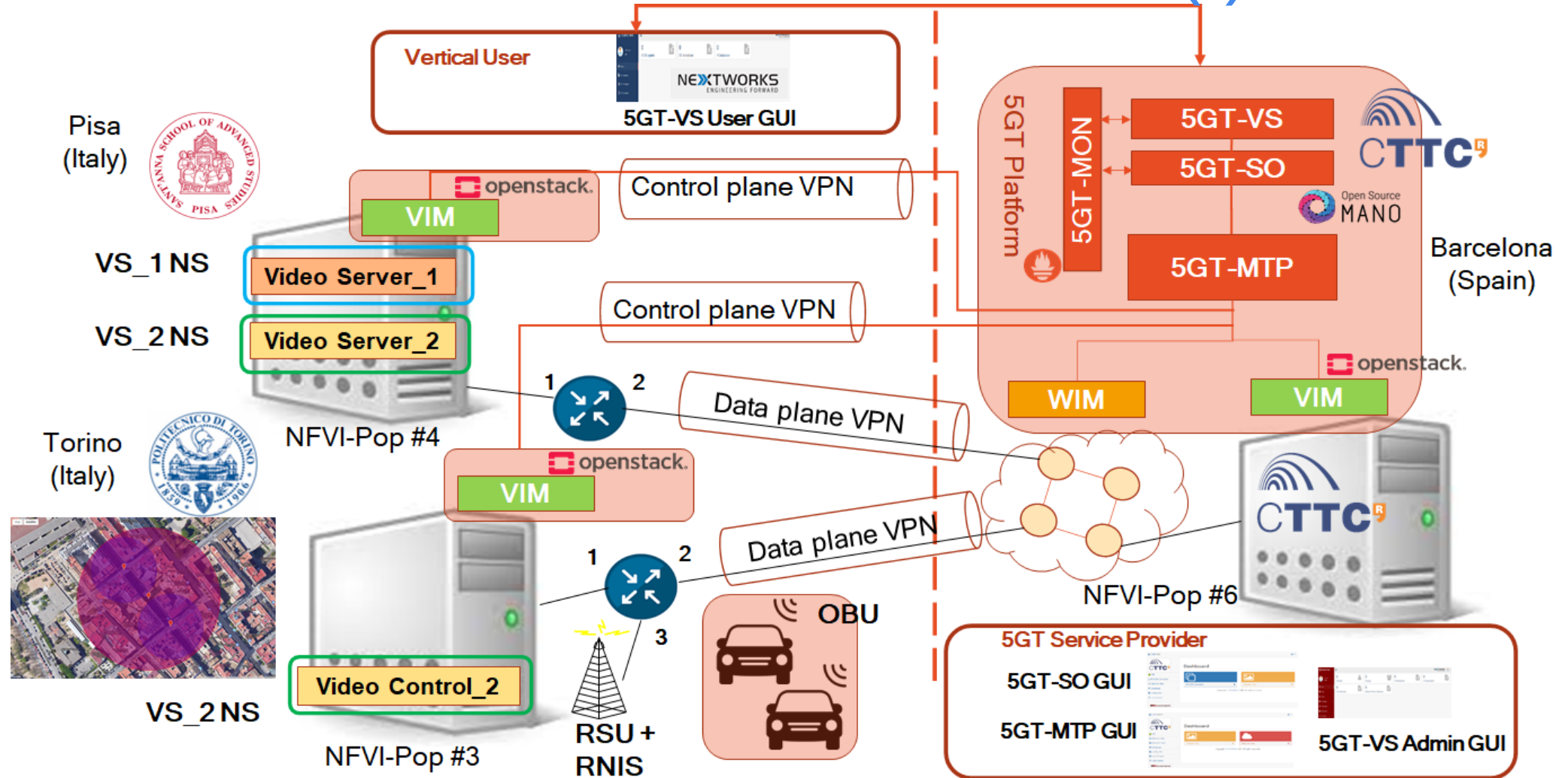
Support for Multiple domains
NPN-PN integration

5Gr-Vertical Slicer

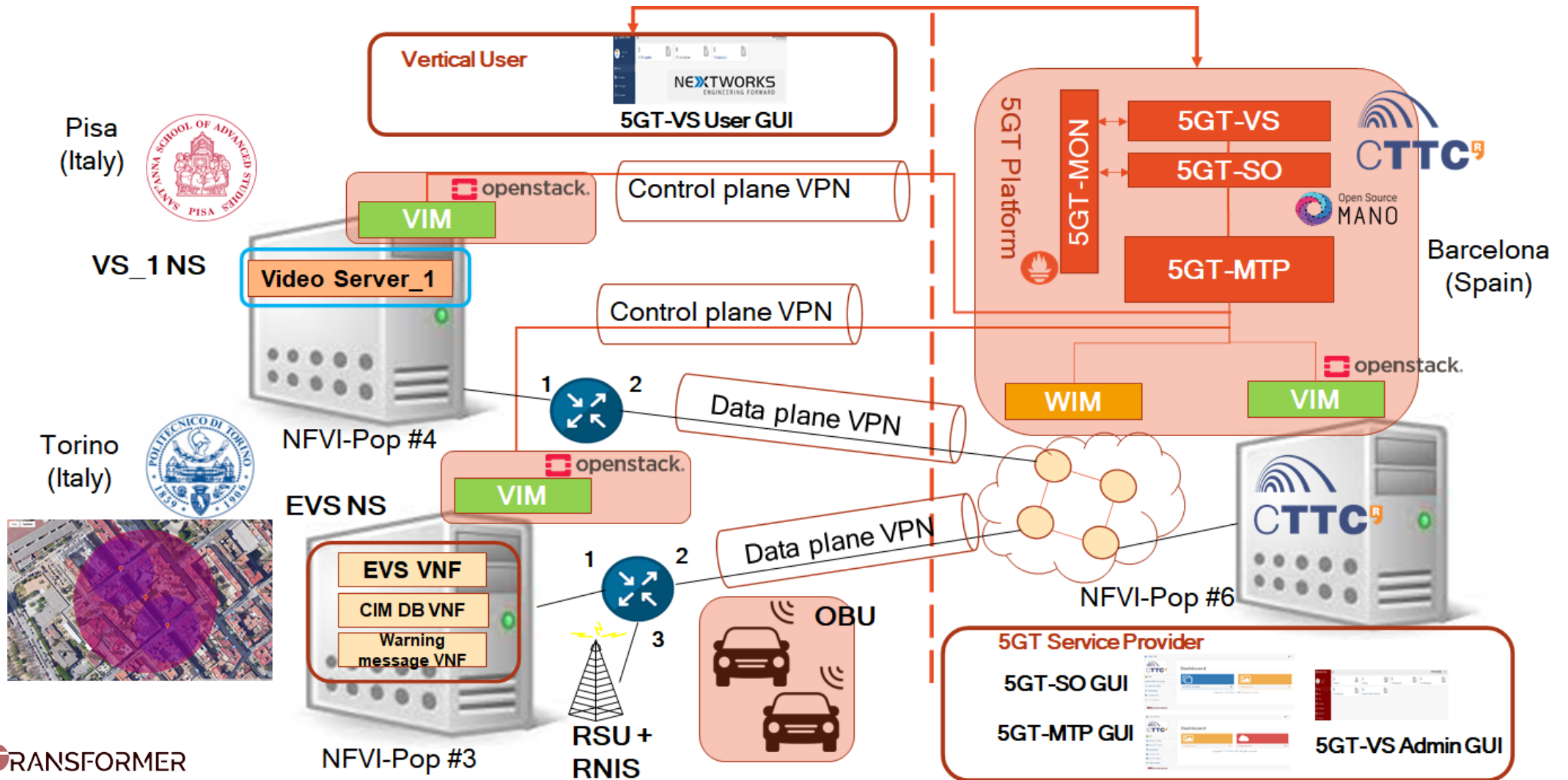# Service heterogeneity
Inter-service arbitration at the VS (I)

10

Service heterogeneity
Inter-service arbitration at the VS (II)

What's next?

Putting more intelligence in intra-slice interaction handling (i.e., services inside the same slice)
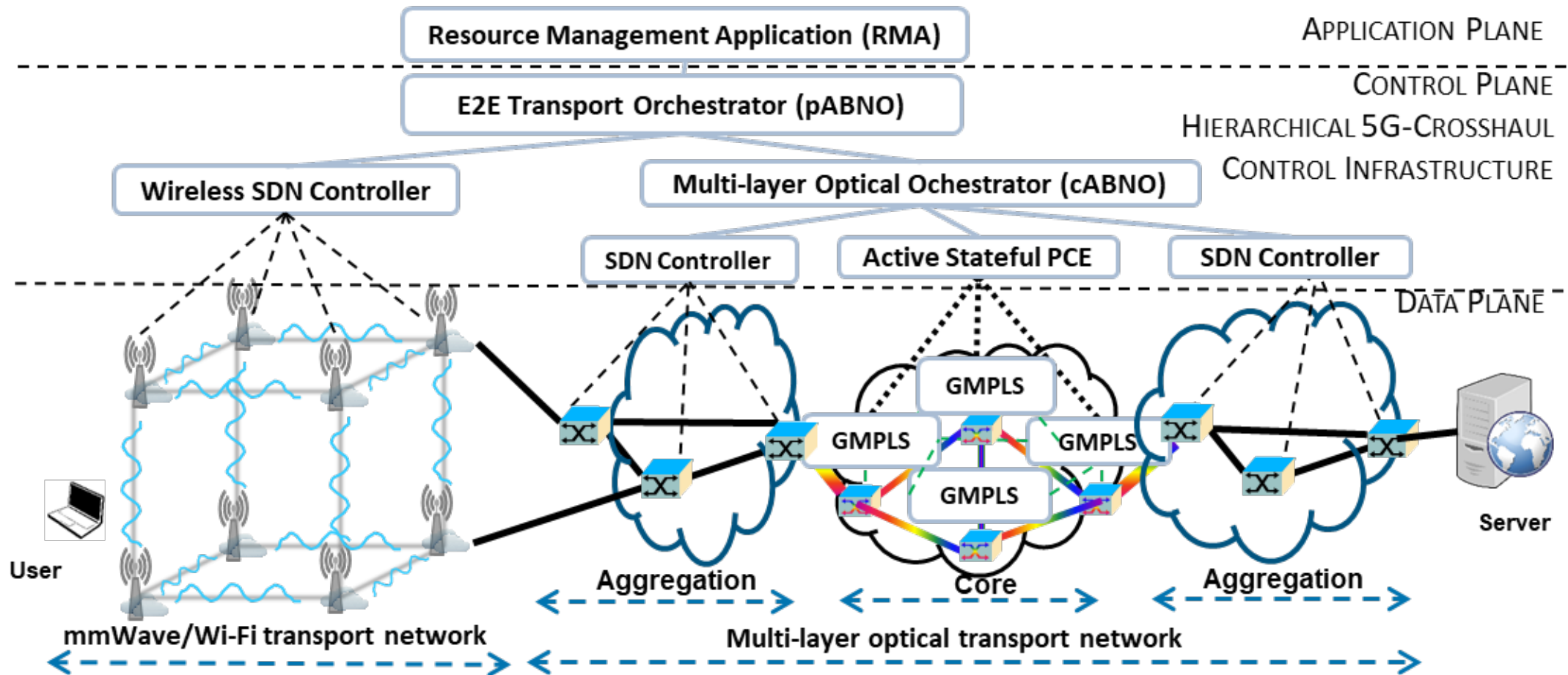
- Including decision-making based on vertical application metrics

Putting more intelligence in inter-slice handling (from the same vertical customer of between customers)
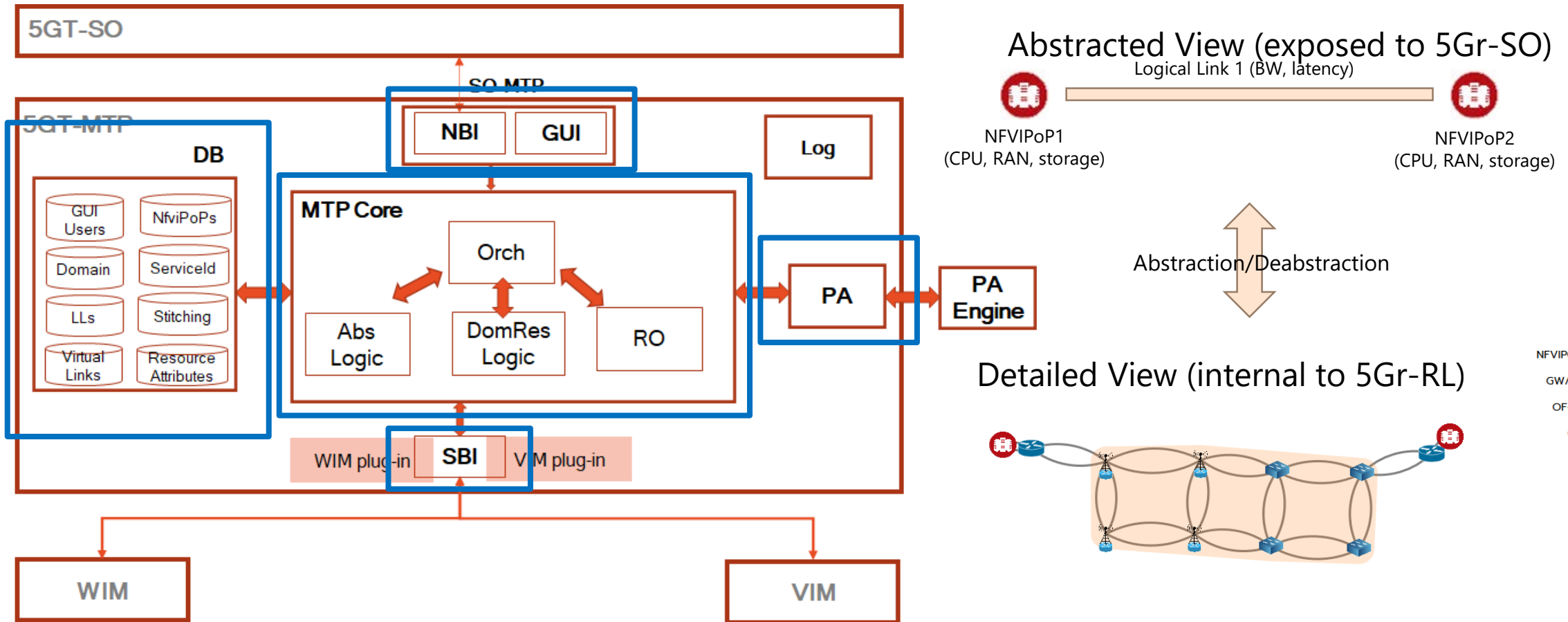
Dynamic slice composition

5GROWTH

Technological heterogeneity
Resource abstraction

J. Mangues, J. Baranda, G. Landi, J. Núñez, R. Casellas, S. Bilal Chundrigar, A. de la Oliva, A. Mourad, S. T. Talat, C. F. Chiasserini, J. X. Salvat, Experimental framework and evaluation of the 5G-Crosshaul Control Infrastructure , Elsevier Computer Standards & Interfaces, January 2019.

13

Technological heterogeneity Resource abstraction (II)

J. Baranda, L. Vettori, R. Martínez, J. Mangues, A Mobile Transport Platform Interconnecting VNFs over a Multi-Domain Optical/Wireless Network: Design and Implementation, in Proceedings of the 24TH International Conference on Optical Network Design and Modelling (ONDM'20), 14-18 May 2020, Castelldefels (Spain).

What's next?

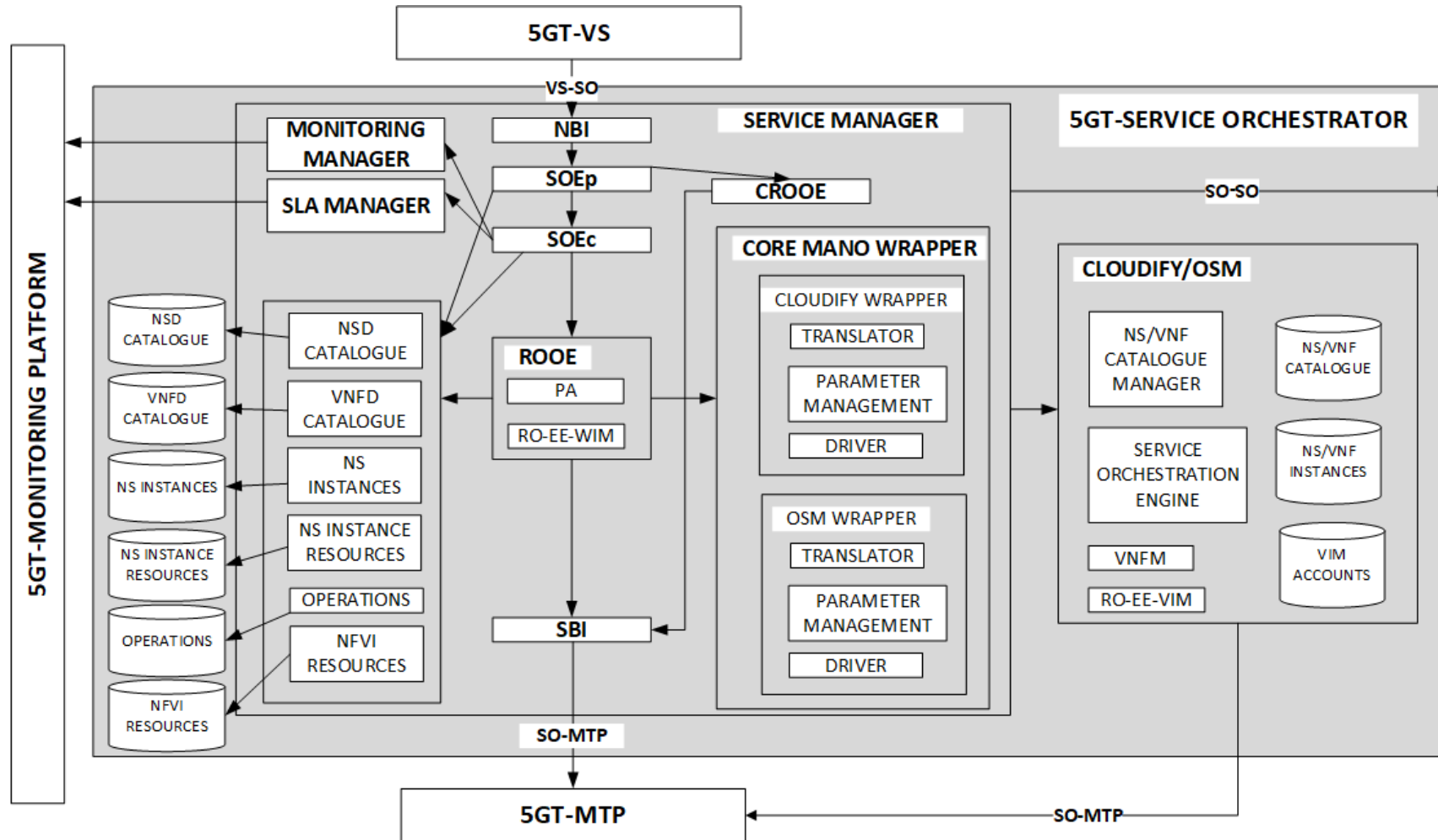AIML-based virtual infrastructure provider optimizations

Joint access and backhaul optimizations

Towards RAN integration and abstraction
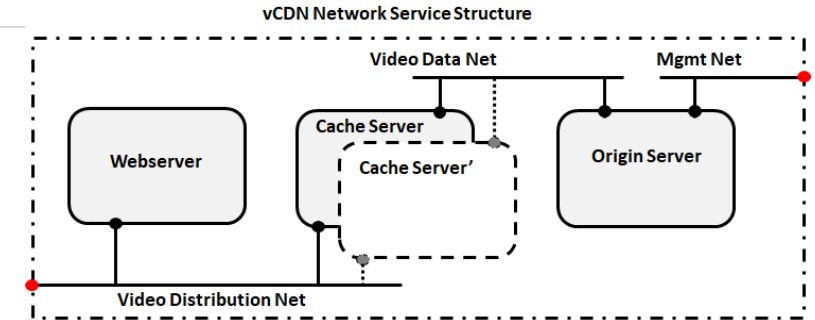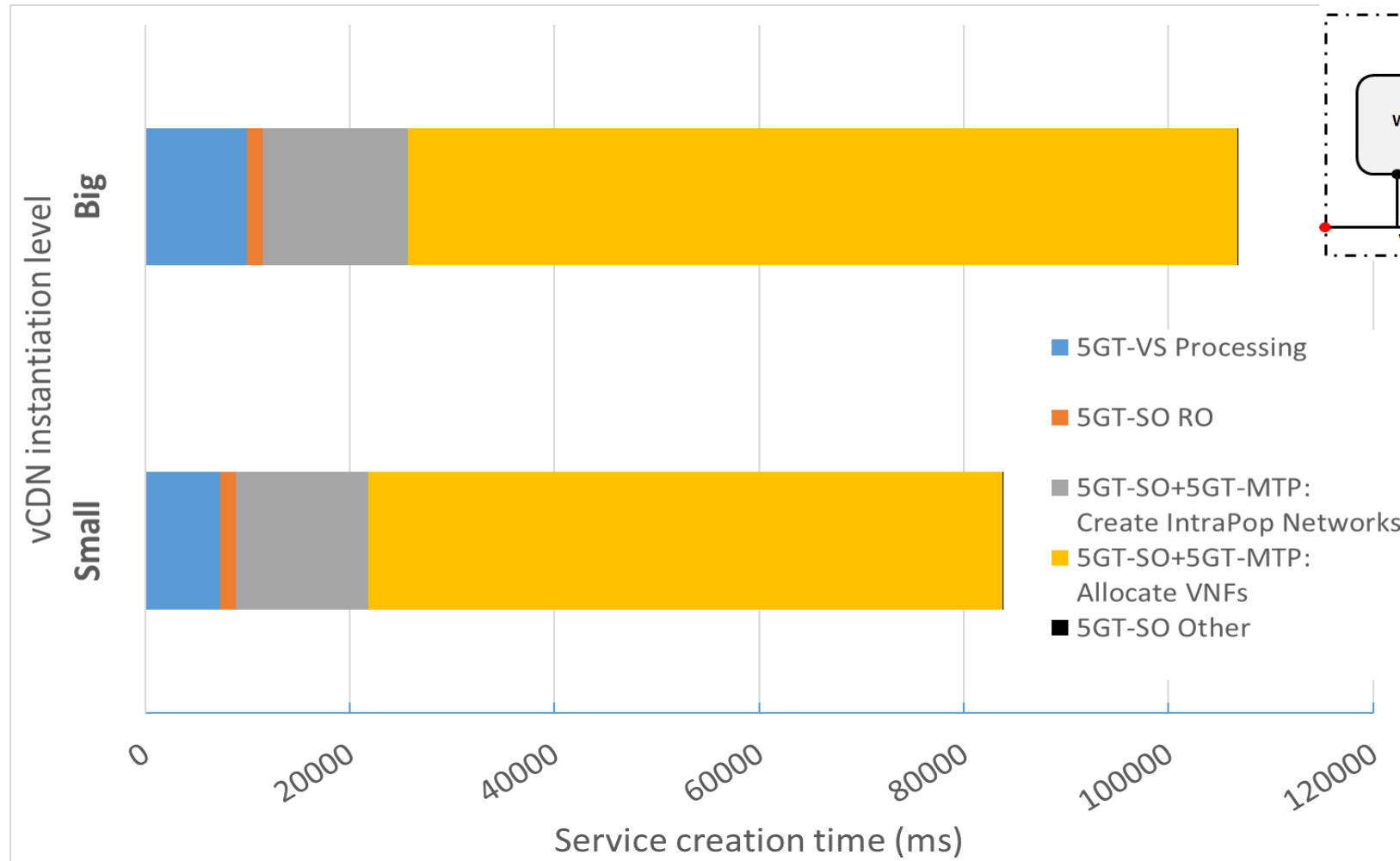- Smooth integration of O-RAN-like based approaches

Handling of CUPS and cell-less architectures
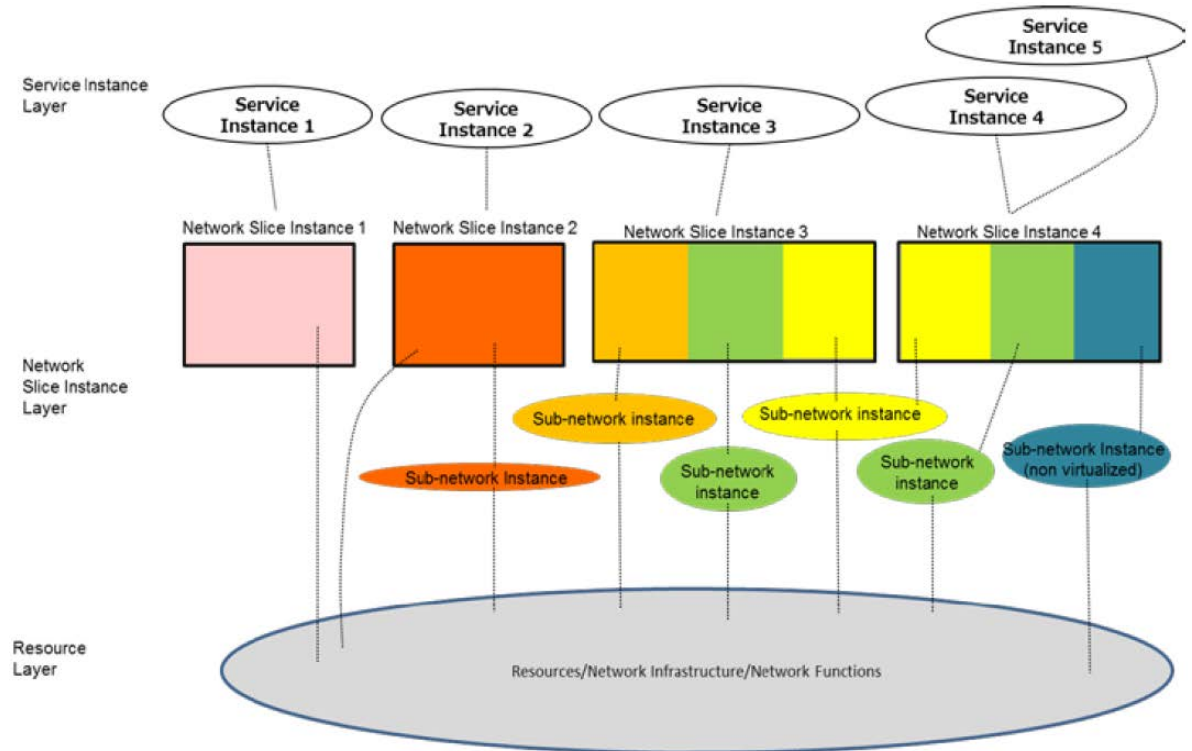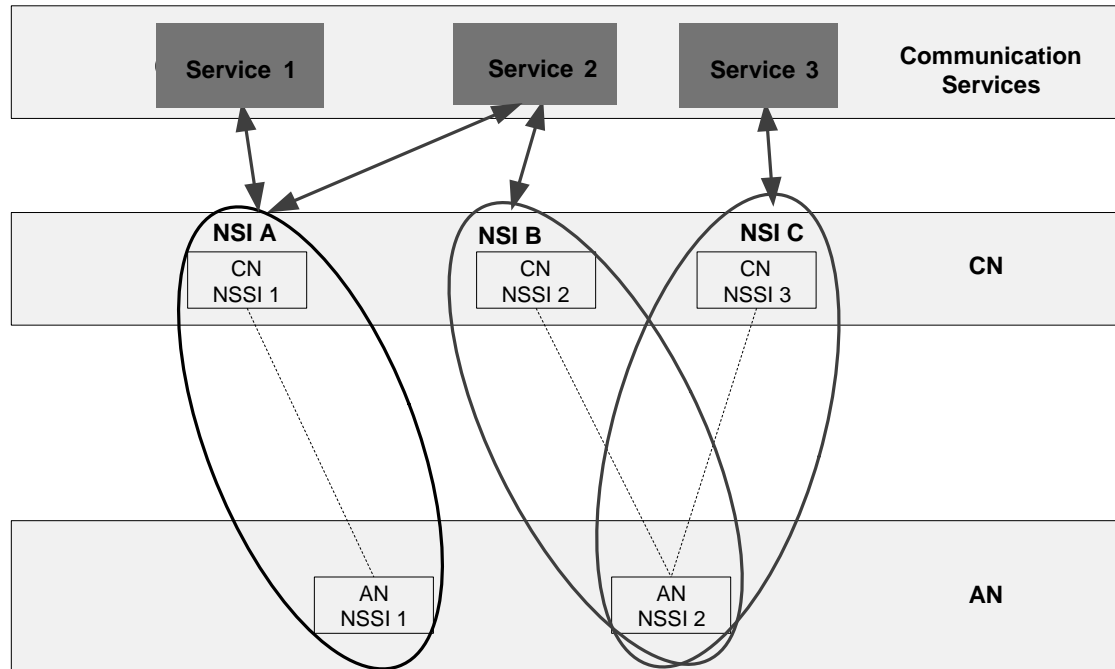
5GROWTH

Service Orchestration

J. Mangues, J. Baranda, I. Pascual, R. Martínez, L. Vettori, G. Landi, A. Zurita, D. Salama, K. Antevski, J. Martín-Pérez, D. Andrushko, K. Tomakh, B. Martini, X. Li, J. X. Salvat, 5G-TRANSFORMER Service Orchestrator: Design Implementation and Evaluation , in Proceedings of the 28th edition of the European Conference on Networks and Communications (EUCNC'19), 18-21 June 2019, Valencia (Spain).

Dynamic deployment of vertical services

X. Li, T. Deiss, J. Mangues, J. Baranda, X. Costa-Pérez, G. Landi, C. J. Bernardos, P. Iovanna, A. Zurita, P. Bertin, Automating Vertical Services Deployments over the 5GT Platform , IEEE Communications Magazine, Telecom Software, Network Virtualization, and Software Defined Networks series, July 2020.
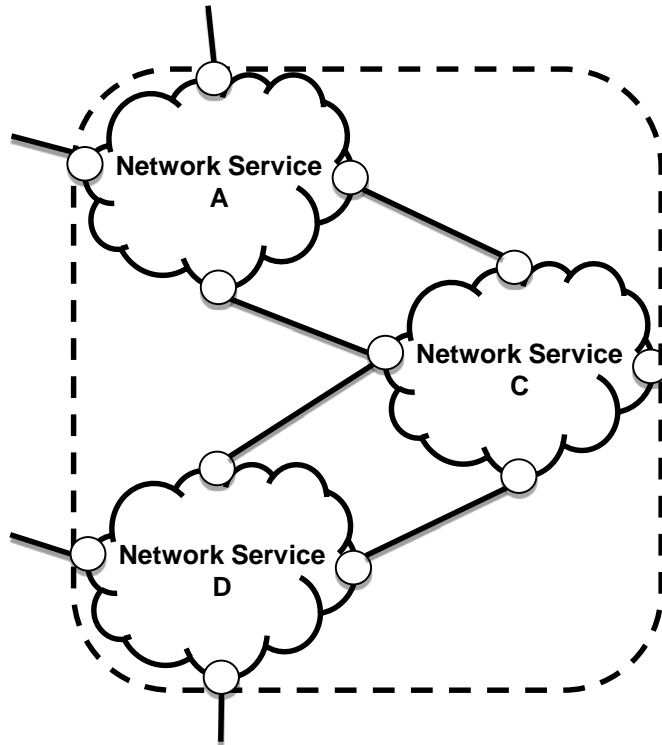
17

Slicing support

3GPP TR28.801. Study on management and orchestration of network slicing for next generation network

NGMN. Description of the network slicing concept.

Slicing support
Composite Network Service
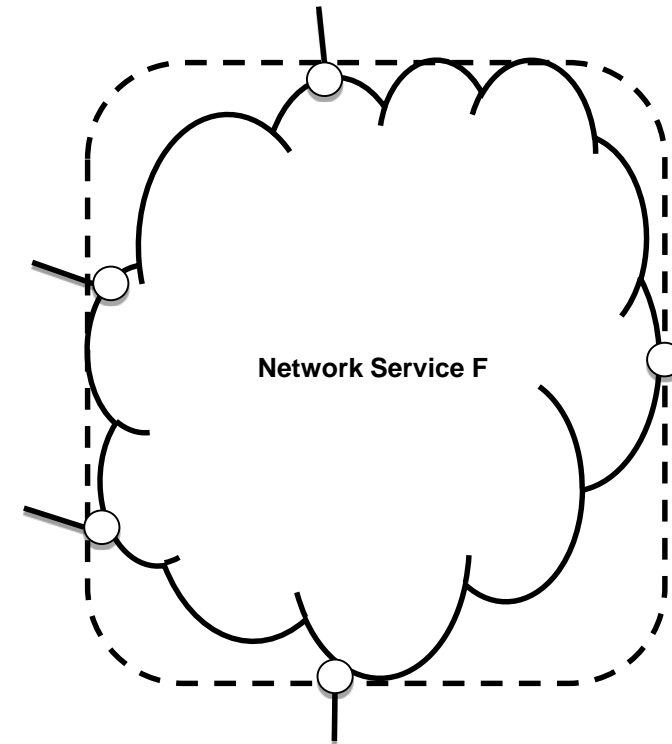
ETSI NFV IFA012. Report on Os-Ma-Nfvo reference point - application and service management use cases and recommendations

J. Baranda, J. Mangues, L. Vettori, R. Martínez, G. Landi, K. Antevski, Demo: Composing Services in 5G-TRANSFORMER ,
in Proceedings of The Twentieth ACM International Symposium on Mobile Ad Hoc Networking and Computing, 2-5 July 2019. Catania (Italy).

5GROWTH

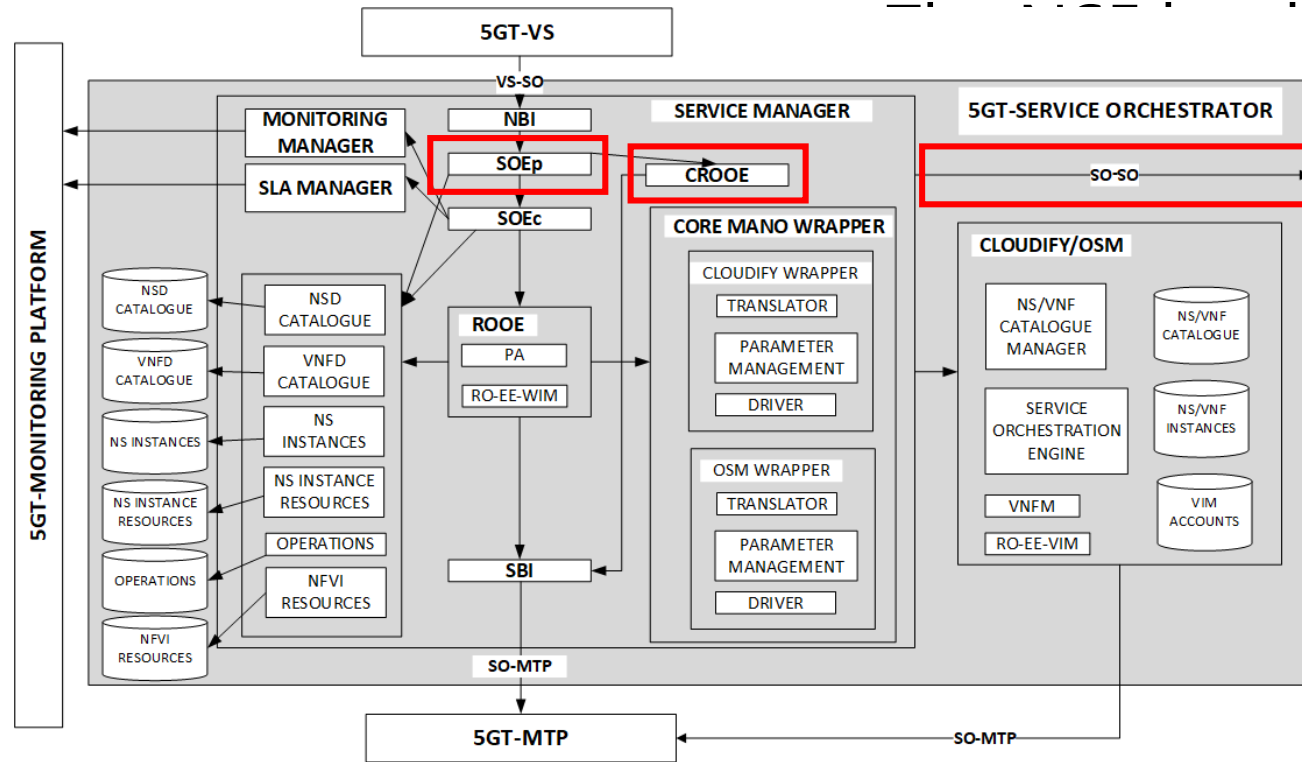# Network service federation (NSF) in 5Growth

E2E network service catalog

Built through composite network services

5Gr-SO as the central component because

- E2E service view
  - Integrated nested NSs from other domains
- Resource view
  - Local
  - Remote (partially)
- Enables federation of domains with heterogeneous MANO platforms (e.g., Cloudify, OSM)

J. Baranda, J. Mangues, R. Martínez, L. Vettori, K. Antevski, C. J. Bernardos, X. Li, Realising the Network Service Federation vision , IEEE Vehicular Technology Magazine, Future Networks Initiative Special Issue on 5G Technologies and Applications, June 2020.

NSF: Workflow (I)

The NSF has been included on top of the single-domain [1] thanks to two SOEp and CROOE

NSF is inspired in 30 work but to deal with resource operations enabling connection between different ADs

in the NSF process, we distinguish between consumer domain (CD) and the provider domain/s (PD/s)

J. Baranda, J. Mangues, R. Martínez, L. Vettori, K. Antevski, C. J. Bernardos, X. Li, 5G-TRANSFORMER meets Network Service Federation: design, implementation and evaluation , in Proceedings of the 6th IEEE International Conference on Network Softwarization (NetSoft'20), 29-3 July 2020, Ghent (Belgium).

[1] J. Mangues et al., "5G-TRANSFORMER Service Orchestrator: Design, Implementation and Evaluation", EUCNC'19

Federation in action
eHealth use case
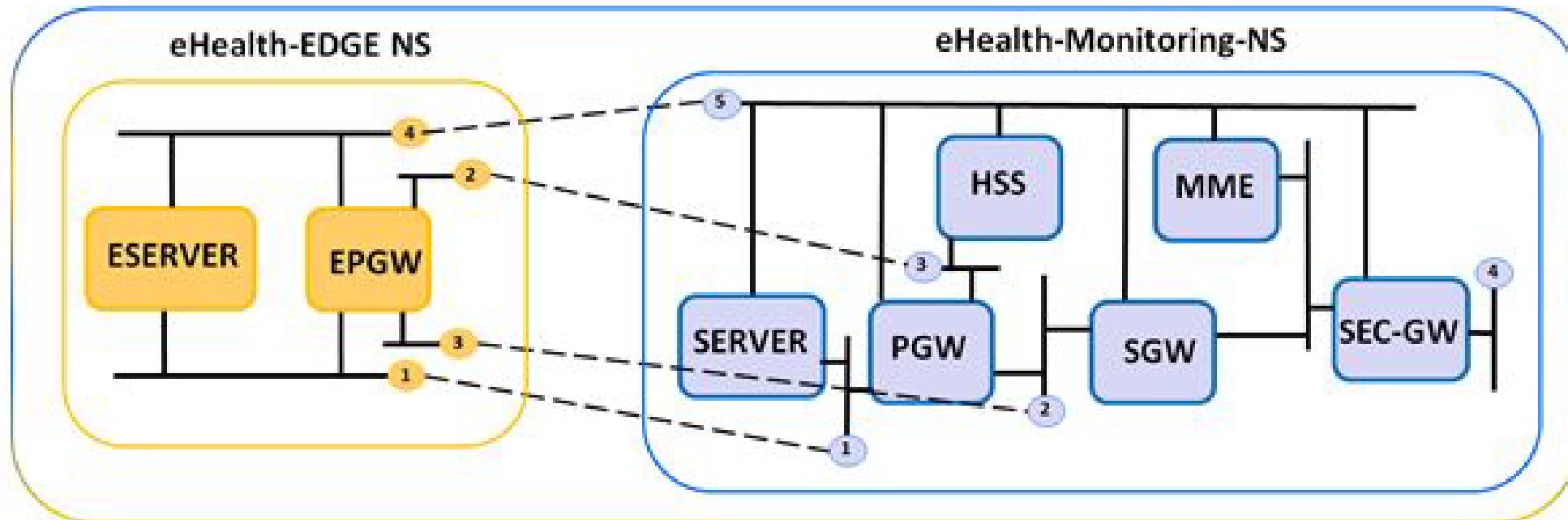
J. Baranda, J. Mangues, L. Vettori, R. Martínez, K. Antevski, L. Girletti, C.J. Bernardos, K. Tomakh, D. Kucherenko, G. Landi, J. Brenes, X. Li, X. Costa-Pérez, F. Ubaldi, G. Imbarlina, M. Gharbaoui, NFV Service Federation: enabling Multi-Provider eHealth Emergency Services , in Proceedings of the International Conference on Computer Communications (INFOCOM'20), 6-9 July 2020, Toronto (Canada).

eHealth Monitoring service

eHealth Monitoring Service

eHealth Emergency Service
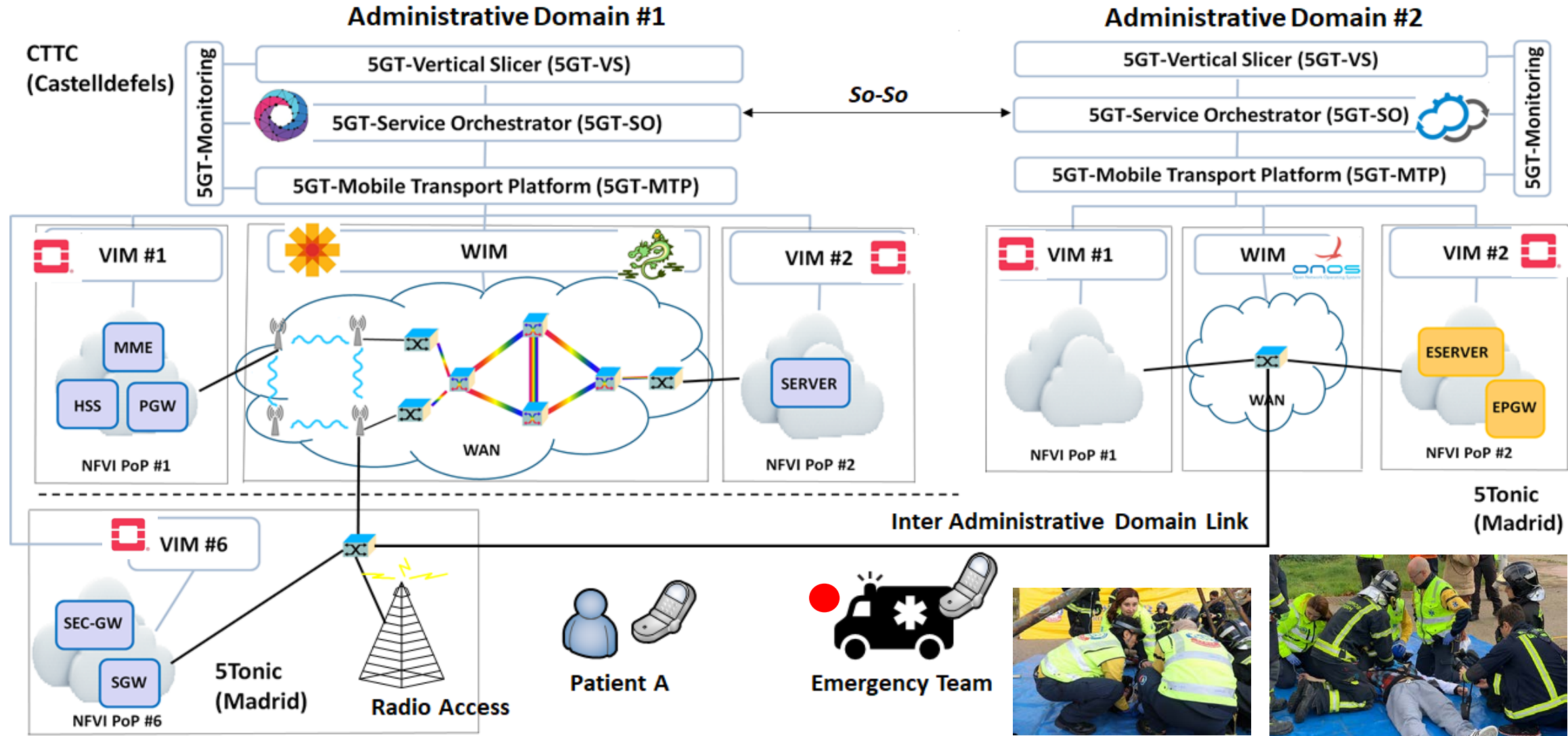
Service Creation Time Profiling

The biggest contribution to SCT comes from resource allocation operations:

- VNF allocation (yellow), configuration of LL (blue), creation of IntraPoP Network (green)
- 98.5% for Composite Multi-Pop (245s)
- 92% for Federation (257s)

A polling operation (grey) impacts in the SCT of Federation

- 7% of total SCT
- Time to process, decompose, interaction between sub-modules and ADs is on the order of ms
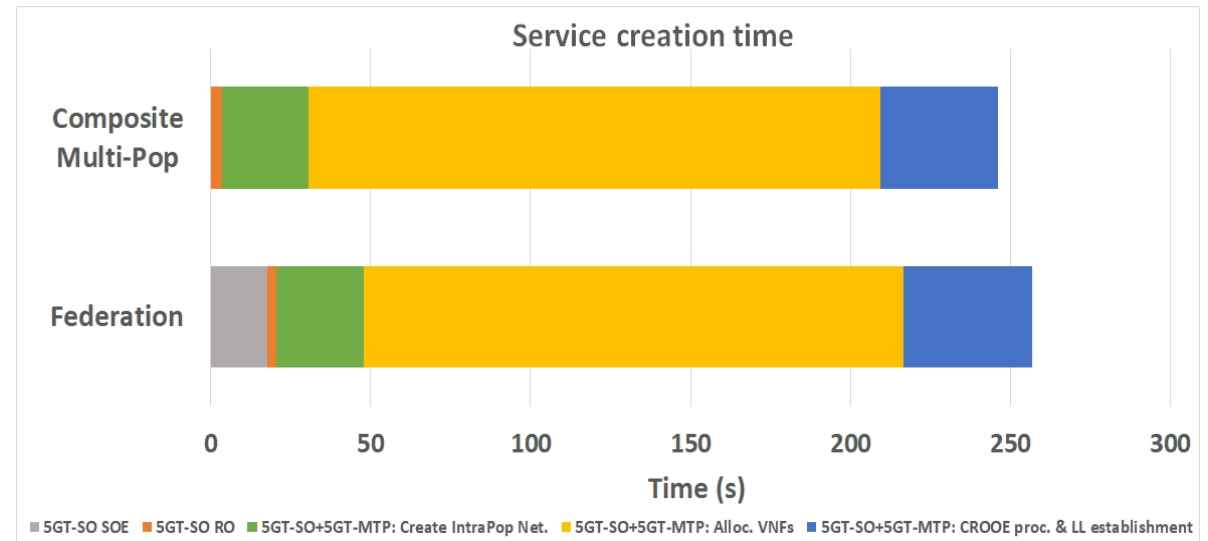
J. Baranda, J. Mangues, R. Martínez, L. Vettori, K. Antevski, C. J. Bernardos, X. Li, 5G-TRANSFORMER meets Network Service Federation: design, implementation and evaluation , in Proceedings of the 6th IEEE International Conference on Network Softwarization (NetSoft'20), 29-3 July 2020, Ghent (Belgium).
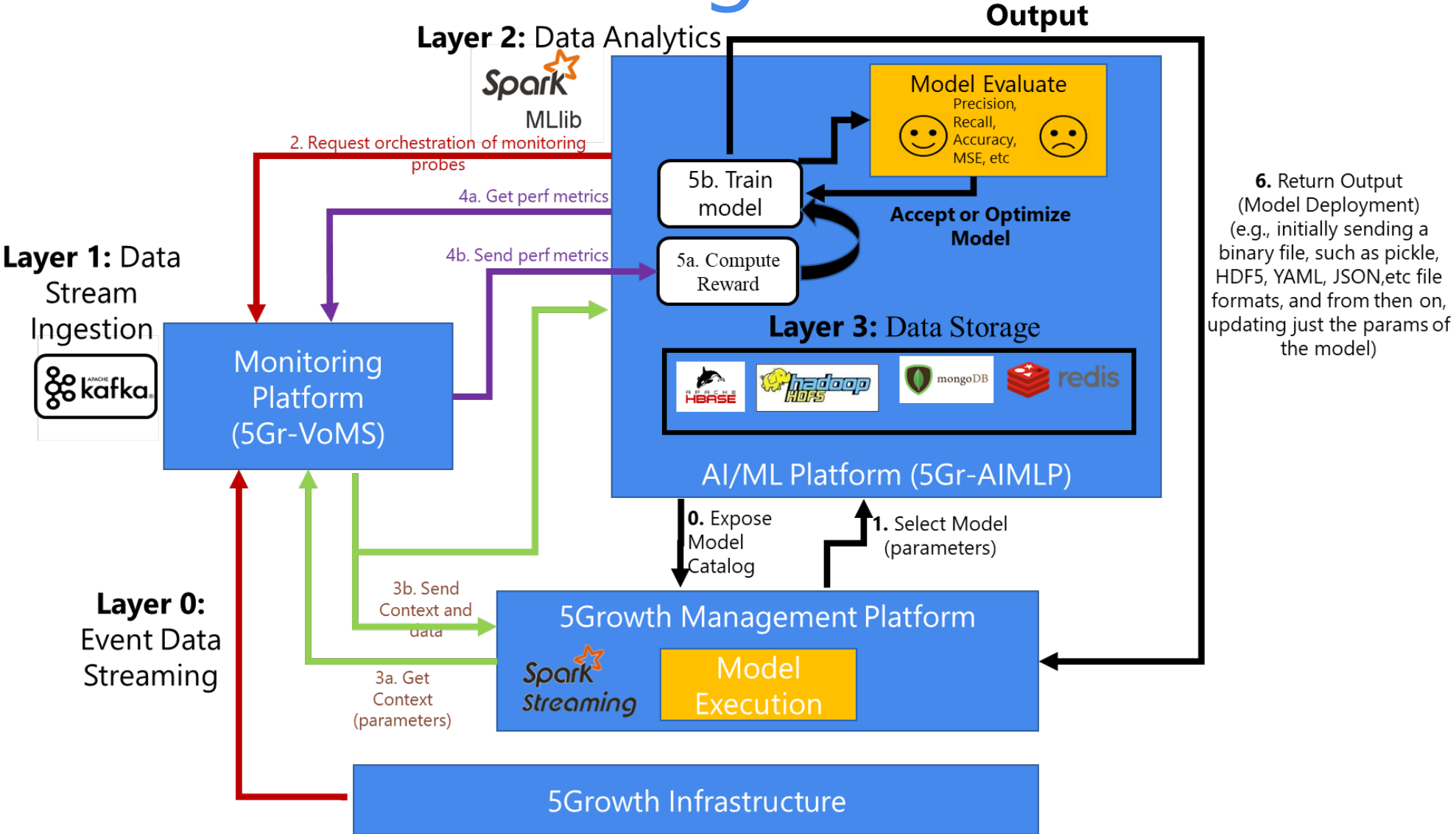
What's next?

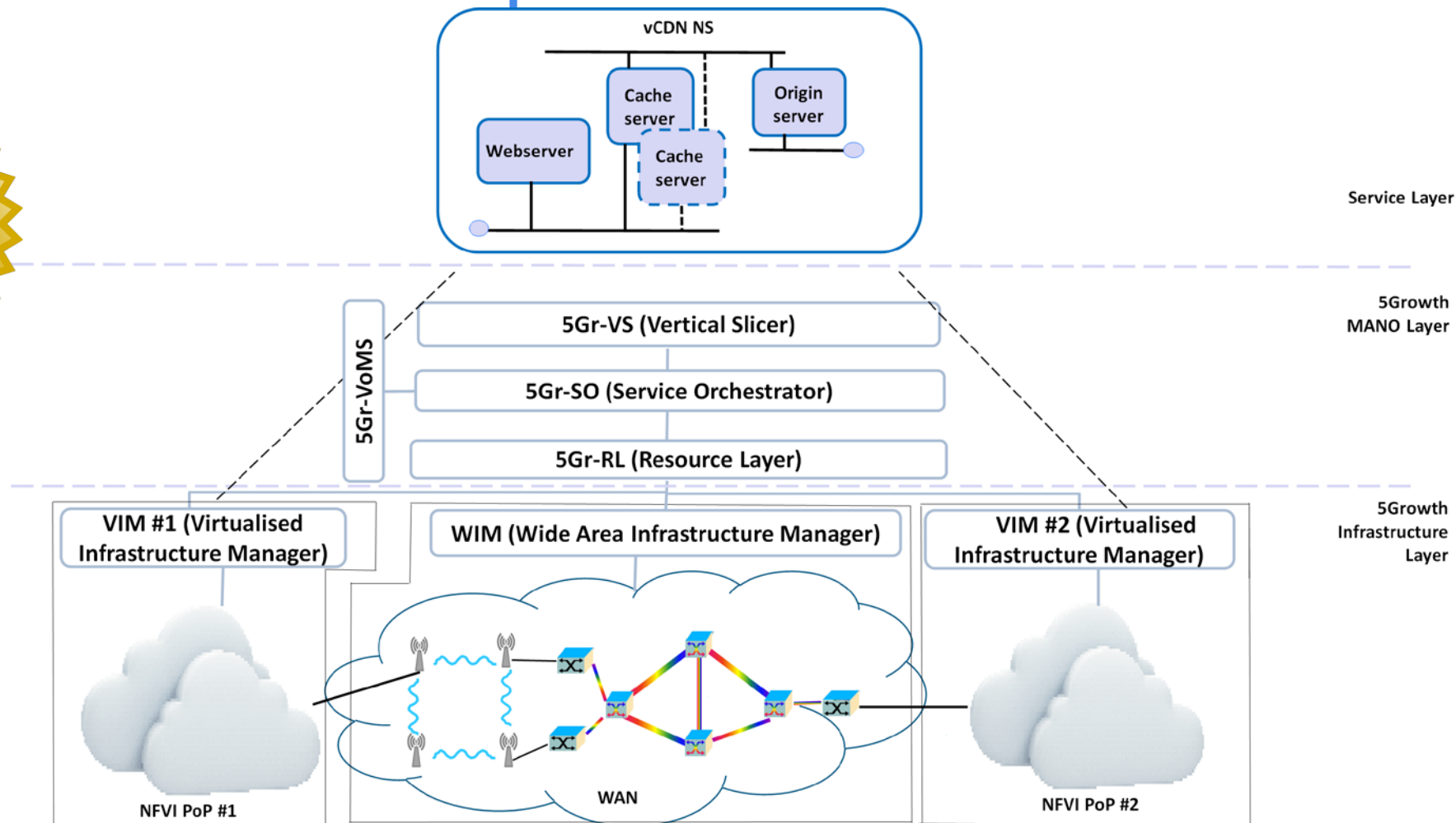Enabling all sorts of multi-stakeholder interaction

Dynamic service composition

Dynamicity and trust in multi-stakeholder service discovery

Intelligence in selection of provider of discovered services

5GROWTH

Dynamic SLA management

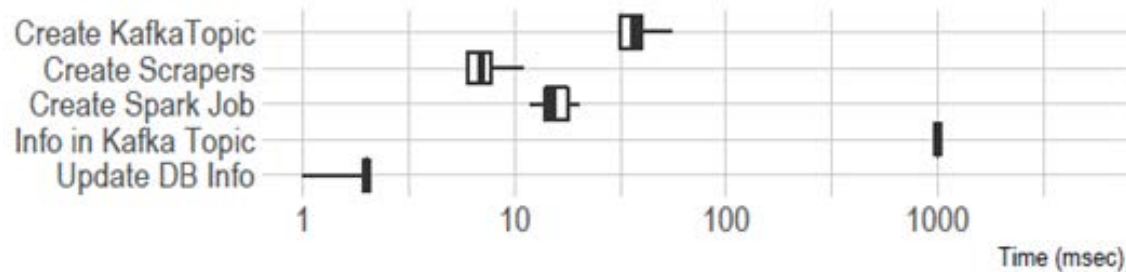C. Papagiani, J. Mangues, P. Bermúdez, S. Barmpounakis, D. de Vleeschauwer, J. Brenes, E. Zeydan, C. Casetti, C. Guimaraes, P. Murillo, A. Garcia-Saavedra, D. Corujo, T.Pepe. "5Growth: AI-driven 5G for Automation in Vertical Industries." EUCNC 2020.

AIML-based SLA management Experimental Setup

J. Baranda , J. Mangues-Bafalluy , Engin Zeydan , L. Vettori , R. Martínez , Xi Li, A. Garcia-Saavedra, C.F. Chiasserini, C. Casetti, K. Tomakh, O. Kolodiazhnyi, C. J. Bernardos. "On the Integration of AI/ML-based scaling operations in the 5Growth platform." IEEE NFVSDN 2020.

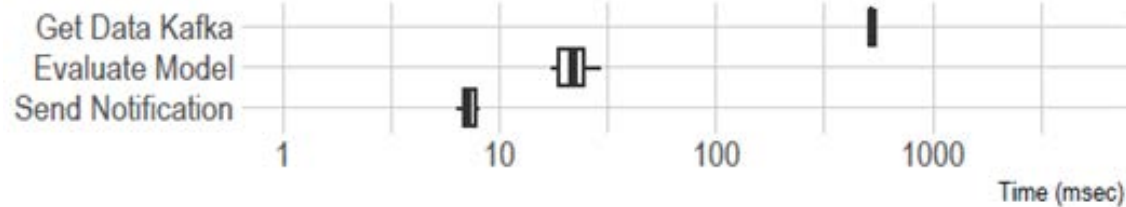# AIML-based SLA management
Time Profiling

Instantiation time is increased by ≈ 1s. (much lower than resource-oriented deployment)

Interaction with kafka is the most time consuming step in instantiation and at runtime

Spark job deletion is long if running when deletion requested

What's next?

AIMLaaS

- Generic model definition and management
- Real-time model updates
- Smooth integration with monitoring platforms and data engineering pipeline in general

5GROWTH

In brief

Future networks come with demanding requirements

- Support for diverse virtualized services with stringent requirements
- Shared and diverse infrastructure
- Multi-technology
- Multi-stakeholder
- NPN-PN integration

Modularized and adaptable architecture with clear demarcation of functionalities

5Growth sets a solid ground for 5G (and beyond) network architectures

5GROWTH

5Growth+

Periodically revisit "What's next" slides considering the implications of:

- Much higher data rates
- Much higher densification
- Cell-less architectures
- Much higher technological diversity
- New coverage areas (e.g., sky, underwater)
- Energy efficiency requirements

5GROWTH

34

http://5growth.eu/   5growth-project   5Growth

@5growth_eu   5growth_h2020

Open Source code available @ GitHub   https://github.com/5growth

35