



Orchestrating Service Automation

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2023 Internet2 Community Exchange

May 8-11, Atlanta, Ga, USA

Public (PU)

Agenda

- Environment
- More than just a Theory: Network eAcademy
- Practice: Operational Services and TechLab
- Bringing it all together

The GÉANT Project



GÉANT's vision is to ensure equal network access for all scientists across Europe to the research infrastructures and the e-infrastructure resources



The GÉANT Project is a part of the European Union's Horizon Europe research and innovation programme under the seven-year Framework Partnership Agreement (FPA)



500 contributors from 37 partners - European R&E Institutions



50 M users

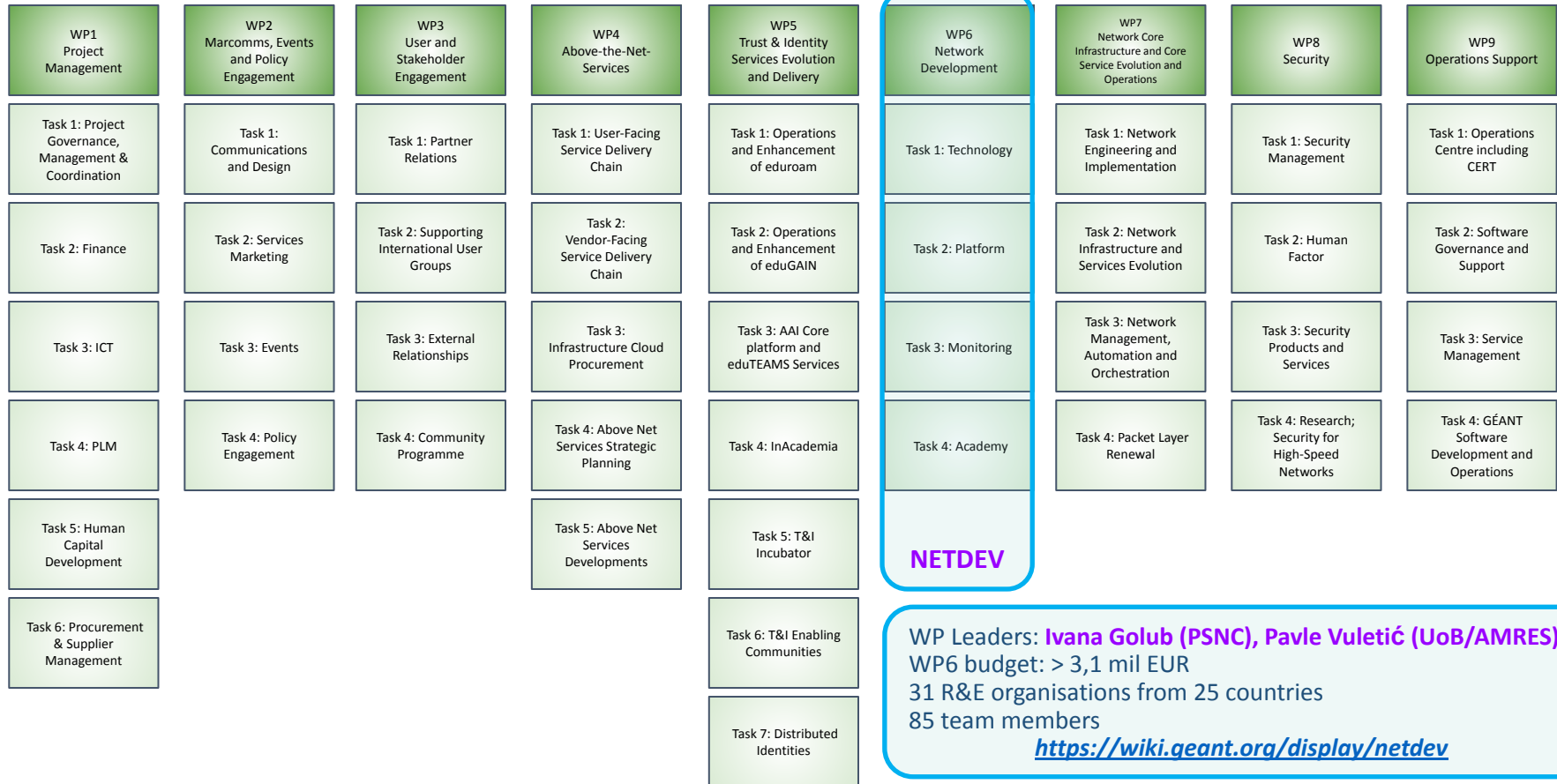


GÉANT 5-1 (GN5-1) Project duration: 1 Jan 2023 – 31 December 2024

The GÉANT 5-1 Project Structure

WP1 Project Management	WP2 Marcomms, Events and Policy Engagement	WP3 User and Stakeholder Engagement	WP4 Above-the-Net-Services	WP5 Trust & Identity Services Evolution and Delivery	WP6 Network Development	WP7 Network Core Infrastructure and Core Service Evolution and Operations	WP8 Security	WP9 Operations Support
Task 1: Project Governance, Management & Coordination	Task 1: Communications and Design	Task 1: Partner Relations	Task 1: User-Facing Service Delivery Chain	Task 1: Operations and Enhancement of euroam	Task 1: Technology	Task 1: Network Engineering and Implementation	Task 1: Security Management	Task 1: Operations Centre including CERT
Task 2: Finance	Task 2: Services Marketing	Task 2: Supporting International User Groups	Task 2: Vendor-Facing Service Delivery Chain	Task 2: Operations and Enhancement of eduGAIN	Task 2: Platform	Task 2: Network Infrastructure and Services Evolution	Task 2: Human Factor	Task 2: Software Governance and Support
Task 3: ICT	Task 3: Events	Task 3: External Relationships	Task 3: Infrastructure Cloud Procurement	Task 3: AAI Core platform and eduTEAMS Services	Task 3: Monitoring	Task 3: Network Management, Automation and Orchestration	Task 3: Security Products and Services	Task 3: Service Management
Task 4: PLM	Task 4: Policy Engagement	Task 4: Community Programme	Task 4: Above Net Services Strategic Planning	Task 4: InAcademia	Task 4: Academy	Task 4: Packet Layer Renewal	Task 4: Research; Security for High-Speed Networks	Task 4: GÉANT Software Development and Operations
Task 5: Human Capital Development			Task 5: Above Net Services Developments	Task 5: T&I Incubator				
Task 6: Procurement & Supplier Management				Task 6: T&I Enabling Communities				
				Task 7: Distributed Identities				

The GÉANT Project Structure



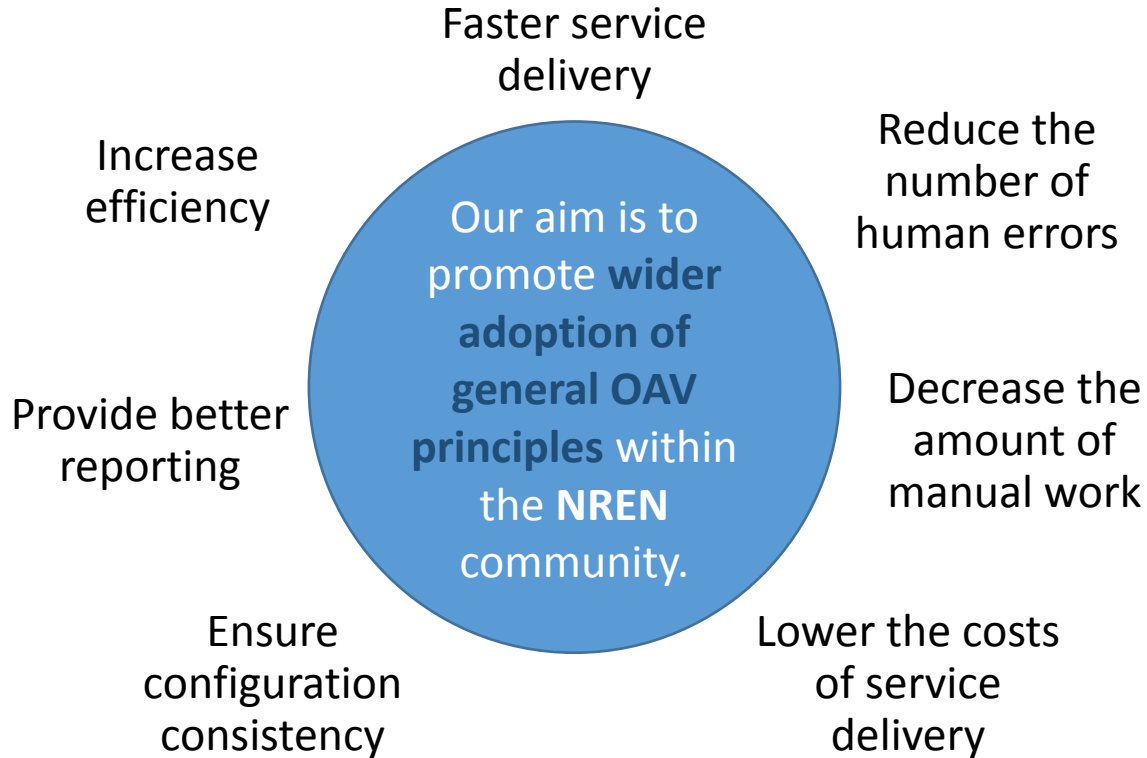
Network eAcademy



Agenda: Network eAcademy

- Introduction: Orchestration, Automation and Virtualisation
- Architecture/Mapping
- Training
- Terminology
- Maturity Model
- Promoting Orchestration, Automation and Virtualisation

OAV: Orchestration, Automation and Virtualisation



Why Architecture, Training, Terminology, Maturity Model...?

- OAV Survey to the NRENs (published in Sep 19):
https://www.geant.org/Projects/GEANT_Project_GN4-3/GN43_deliverables/D6-2_Automation-and-Orchestration-of-Services-in-the-GEANT-Community.pdf
- Several discussions and workshops around the topic:
 - [GN4-3 Future Service Strategy Workshop, May 19](#)
 - [BoF session at TNC, June 19](#)
 - [STF17, July 2019](#)
 - [Network Management and Monitoring Workshop \(NEMMO\), Oct 19](#)

Collaborative approach to OAV in the GÉANT Community



Strong need for collaboration and exchange of knowledge and expertise



Knowledge as a gap



We speak different languages



A generally accepted architecture blueprint needed

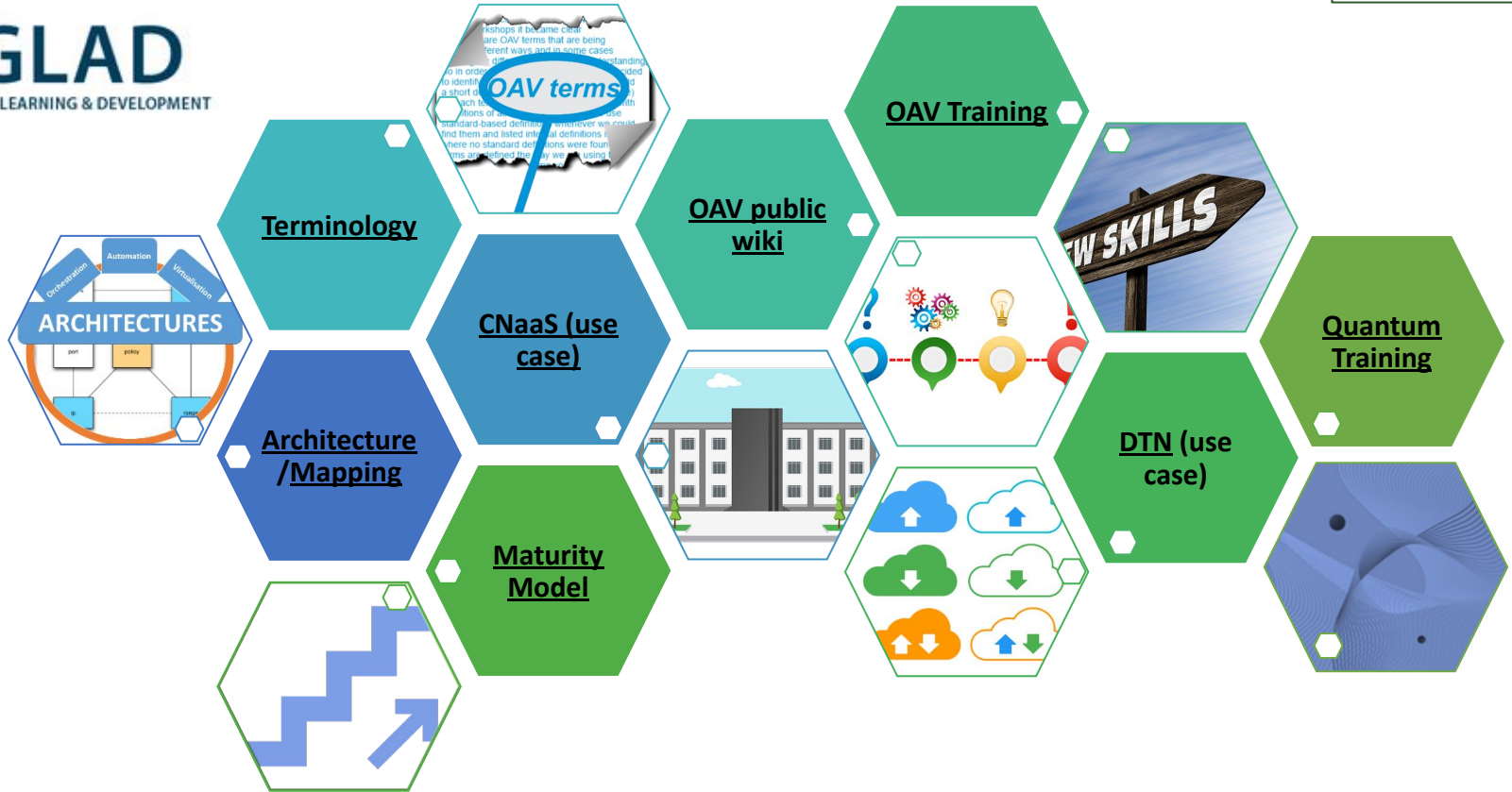


NRENs are willing to share experiences and learn from others

Network eAcademy

Network eAcademy

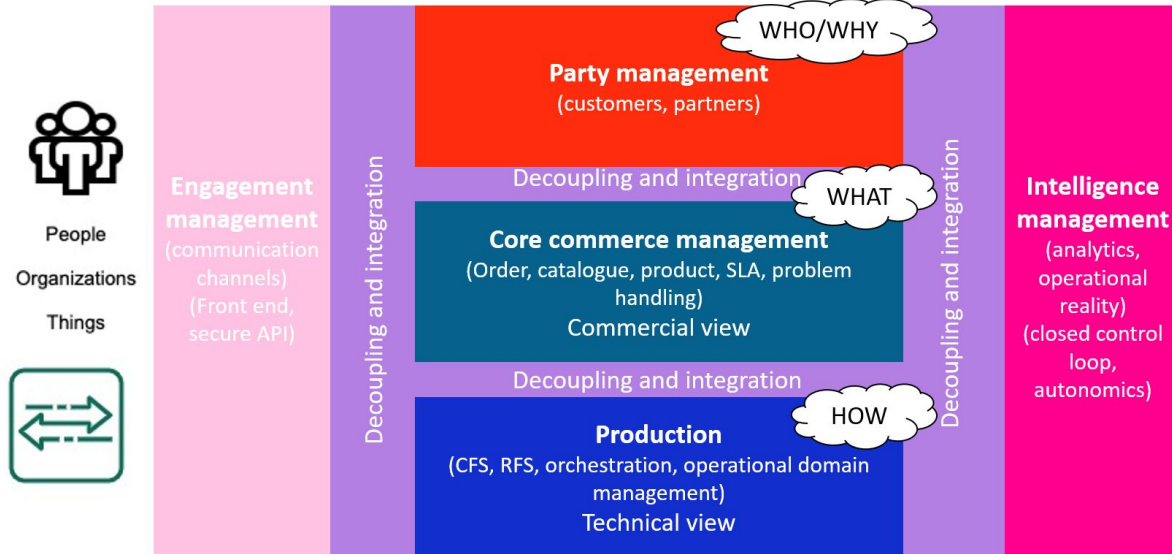
Powered by:



Architecture & Mappings

Architecture

- Mapping NREN & use cases architectures to a common blueprint, the TM Forum Open Digital Architecture (functional architecture).



NREN mappings to date:

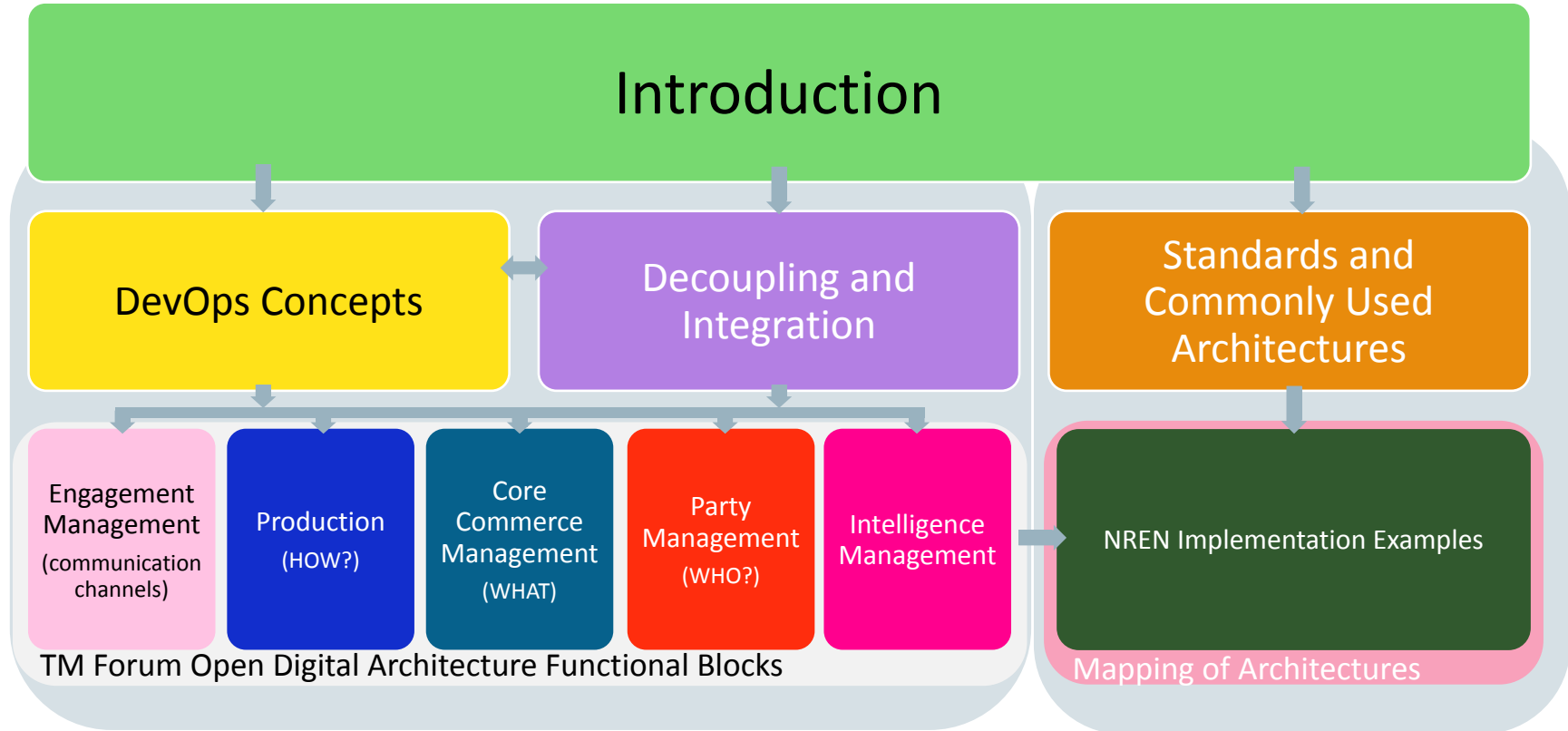
- [CARNET](#)
- [CYNET](#)
- [GÉANT](#)
- [GRNET](#)
- [HEAnet](#)
- [PIONIER](#)
- [SURFNET](#)

Platform mappings:

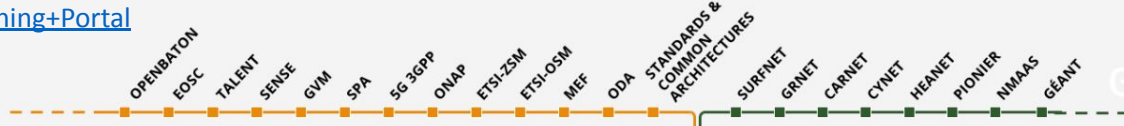
- [NMaaS](#)

Knowledge Map for the Training

Training



Network Automation eAcademy



- Legend**
- Unit / Document
 - Released / Not released

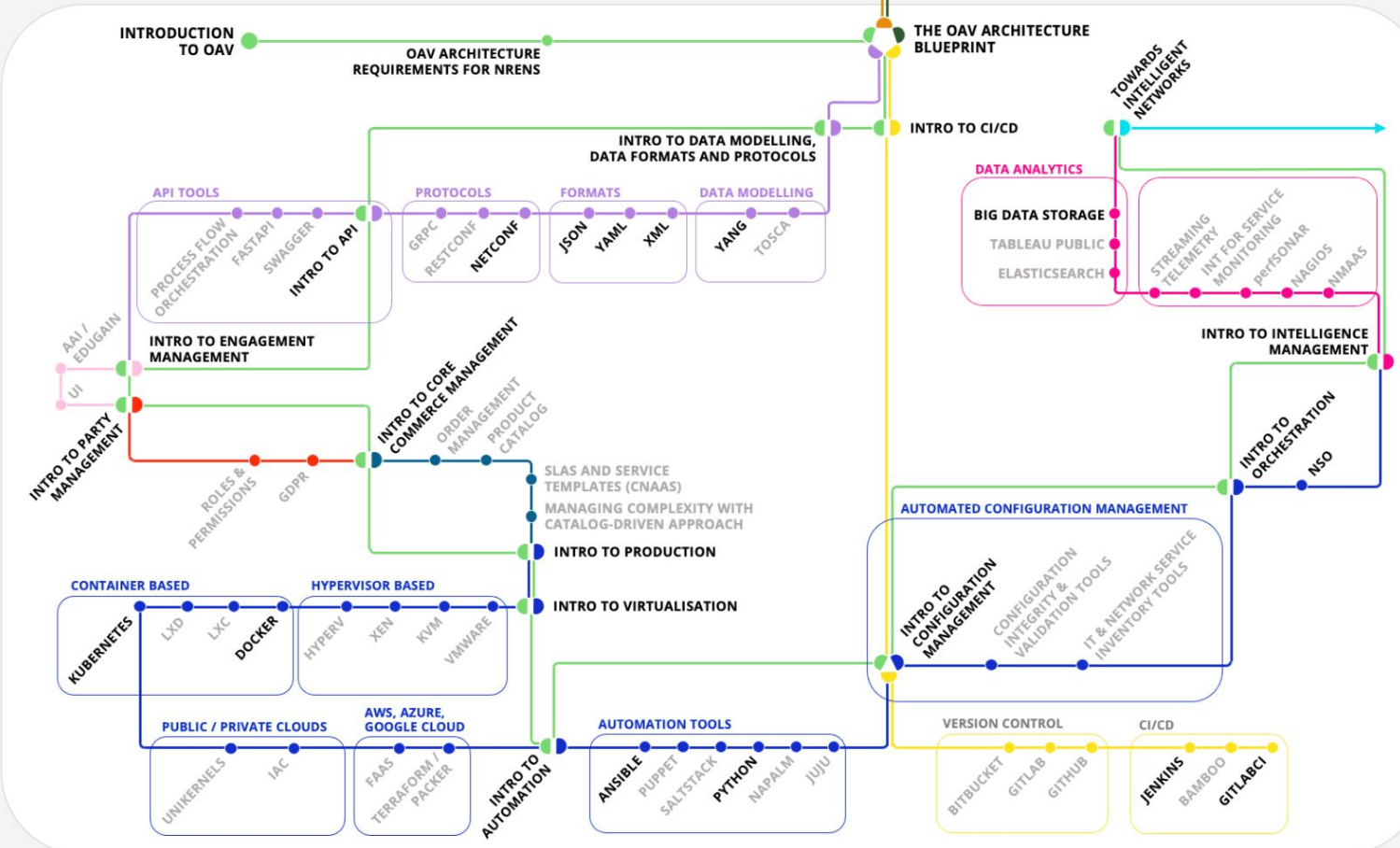
Exchange point

You can jump back and forth between this station and all exchange points at any time

Tracks

- GENERAL INTRODUCTION
- AGILE, DevOps, CI/CD
- DECOUPLING & INTEGRATION
- PRODUCTION
- ENGAGEMENT MANAGEMENT
- PARTY MANAGEMENT
- CORE COMMERCE MANAGEMENT
- INTELLIGENCE MANAGEMENT
- OAV REALISATION
- USE CASES AND EXAMPLES
- ARCHITECTURE

Functional Blocks in the TM Forum OPEN DIGITAL ARCHITECTURE (ODA)



General Introduction Line

Training

Network Automation Academy
INTRODUCTION TO OAV

General

30'

Network Automation Academy
OAV ARCHITECTURE REQUIREMENTS FOR NRENs

General

10'

Network Automation Academy
THE OAV ARCHITECTURE BLUEPRINT

General
Open Digital Architecture

30'

Network Automation Academy
INTRODUCTION TO CI/CD

General
Applo, DevOps, CI/CD

15'

Network Automation Academy
INTRODUCTION TO DATA MODELLING, DATA FORMATS AND PROTOCOLS

General
Open Digital Architecture
Decoupling & Integration

30'

Network Automation Academy
APIs: INTRODUCTION TO API

General
Open Digital Architecture
Decoupling & Integration

45'

Network Automation Academy
INTRODUCTION TO ENGAGEMENT MANAGEMENT

General
Open Digital Architecture
Engagement Management

15'

Network Automation Academy
INTRODUCTION TO PARTY MANAGEMENT

General
Open Digital Architecture
Party Management

15'

Network Automation Academy
INTRODUCTION TO CORE COMMERCE MANAGEMENT

General
Open Digital Architecture
Open Commerce Management

15'

Network Automation Academy
INTRODUCTION TO PRODUCTION

General
Open Digital Architecture
Production

30'

Network Automation Academy
INTRODUCTION TO VIRTUALISATION

General
Open Digital Architecture
Production Virtualisation

30'

Network Automation Academy
INTRODUCTION TO AUTOMATION

General
Open Digital Architecture
Production Automation

30'

Network Automation Academy
AUTOMATED CONFIGURATION MANAGEMENT: INTRODUCTION TO CONFIGURATION MANAGEMENT

General
Open Digital Architecture
Production Automation

30'

Network Automation Academy
INTRODUCTION TO ORCHESTRATION

General
Open Digital Architecture
Production Orchestration

30'

Network Automation Academy
INTRODUCTION TO INTELLIGENCE MANAGEMENT

General
Open Digital Architecture
Intelligence Management

15'

<https://wiki.geant.org/display/NETDEV/OAV>

+Training+Portal

Decoupling and Integration (Data Models, Formats, Protocols, APIs)

Training

Network Automation Academy

INTRODUCTION TO DATA MODELLING, DATA FORMATS AND PROTOCOLS

General
Open Digital Architecture
Decoupling & Integration

30'

Network Automation Academy

DATA MODELLING: YANG

Open Digital Architecture
Decoupling & Integration

10'

Network Automation Academy

DATA FORMATS: XML

Open Digital Architecture
Decoupling & Integration

60'

Network Automation Academy

DATA FORMATS: YAML

Open Digital Architecture
Decoupling & Integration

30'

Network Automation Academy

DATA FORMATS: JSON

Open Digital Architecture
Decoupling & Integration

45'

Network Automation Academy

PROTOCOLS: NETCONF

Open Digital Architecture
Decoupling & Integration

4h (including installation)

Network Automation Academy

PROTOCOLS: RESTCONF

Open Digital Architecture
Decoupling & Integration

45'

Network Automation Academy

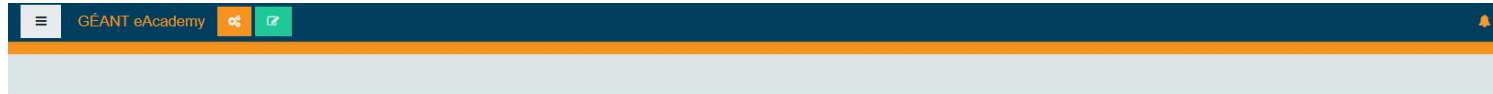
APIs: INTRODUCTION TO API

General
Open Digital Architecture
Decoupling & Integration

<https://wiki.geant.org/display/NETDEV/OAV+Training+Portal>

Ansible

Training



Ansible

Home > My courses > Technical skills > Network > Network Automation eAcademy > Ansible

OVERVIEW | I - Settings, Inventory, Module Basics | II - Playbooks, Variables and Modules | III - How people use Ansible, Loops, Jinja2 | IV - Playbook Validation, Vault, Roles, Sharing content | Test environments and Useful Links | Feedback and Completion Certificate

Welcome to the Course: Ansible



COURSE DATE: On Demand	DURATION: 60 minutes	COMMITMENT: 60 minutes + lab time
REQUIREMENT: YAML Learning Module	COURSE TYPE: Self-paced	CREDENTIAL: Certificate

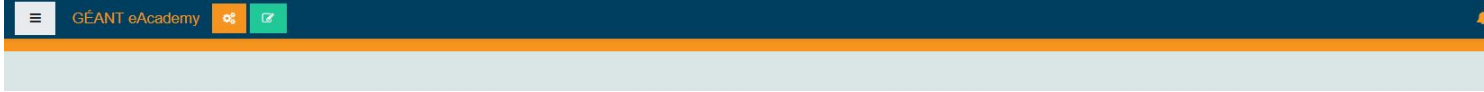
Learning path:	OAV Training Portal
Prerequisite:	Formats: YAML
Preceded by:	Introduction to Automation
Followed by:	Puppet (not yet published)
Next available:	Configuration Management

Course summary

Ansible is an automation framework which allows users to manage services, the servers on which they run and the network devices which interconnect them. This course has several sections which should be taken in order,

<https://e-academy.geant.org/moodle/course/view.php?id=120>

Ansible Requirement: YAML, YAML Requirement?



Formats: YAML

Home > My courses > Technical skills > Network > Network Automation eAcademy > Formats: YAML

OVERVIEW Main Goals Formats: YAML Useful Links Quiz Feedback & Certicate

Welcome to the Course: Formats: YAML



From September 2021



20 min



30 min



Introduction to Data Models, Data
Formats, and Protocols (recommended)



Selfpaced



Certificate of completion

Learning path:	OAV Training Portal
Preceded by:	Formats: XML
Followed by:	Formats: JSON

Course summary

YAML is a human-friendly data serialisation standard broadly used in Orchestration, Automation and Virtualisation (OAV). This course offers a quick overview of the YAML syntax and some examples from the real world in a single video, with useful tips and references and a quiz.

In more detail, the learning unit discusses the following topics:

<https://e-academy.geant.org/moodle/course/view.php?id=129>

Ansible □ YAML □ Data models, Data Formats, and Protocols

☰
GÉANT eAcademy

Data modelling, data formats and protocols - Introduction

Home
My courses
Technical skills
Network
Network Automation eAcademy
Introduction to data modelling, data formats and protocols

OVERVIEW Main Goals Course Materials Definitions Data Modelling Data Formats Protocols Links Quiz Feedback Form & Certificate of Completion

Welcome to the Introduction to Data Modelling, Data Formats and Protocols learning unit

Network Automation eAcademy

INTRODUCTION TO DATA MODELLING, DATA FORMATS AND PROTOCOLS

General
Open Digital Architecture
Designing & Integration

COURSE DATE:

From January 2021

DURATION:

20 minutes

COMMITMENT:

30 minutes

REQUIREMENT:

None

COURSE TYPE:

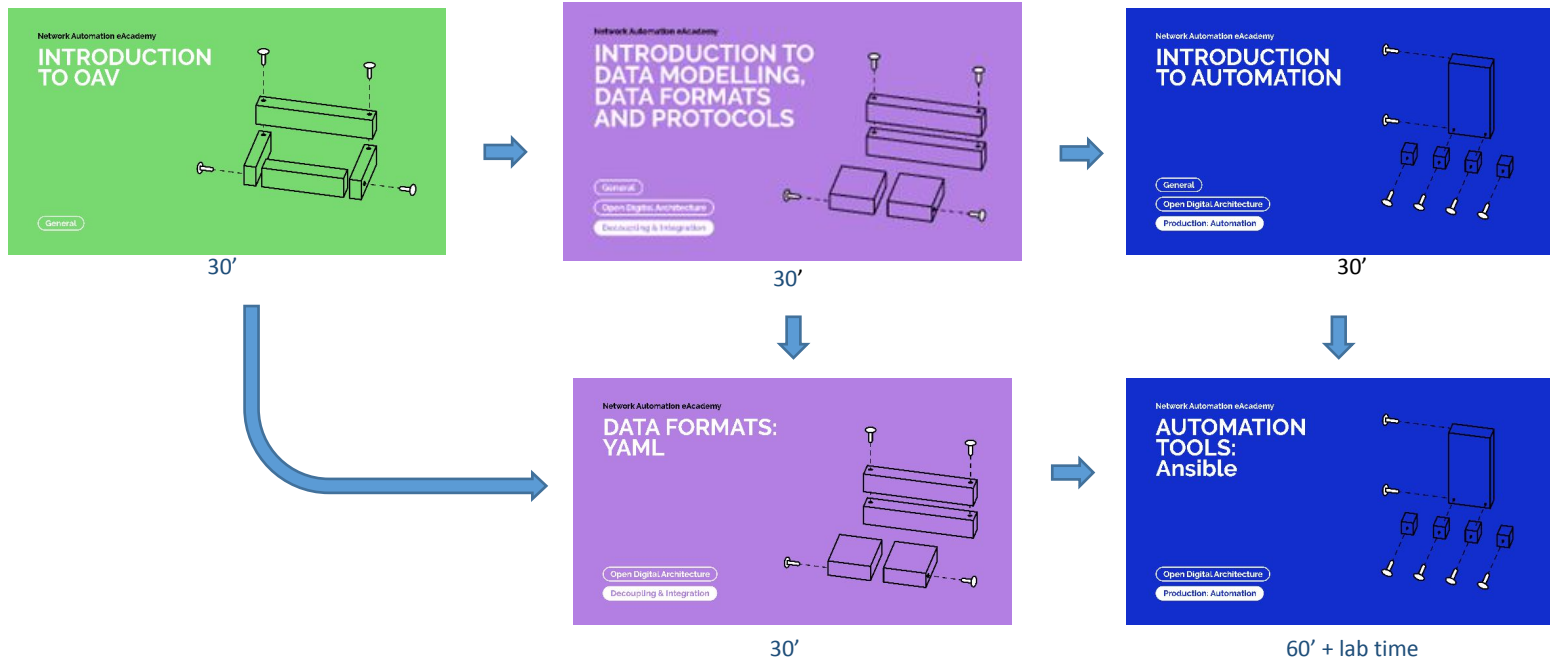
Self-paced

CREDENTIAL:

Certificate of Completion

<https://e-academy.geant.org/moodle/course/view.php?id=61>

Ansible



<https://wiki.geant.org/display/NETDEV/OAV+Training+Portal>

Ansible: Video with Subtitles

GEANT eAcademy

Ansible

Home > My courses > Technical skills > Network > Network Automation eAcademy > Ansible > II - Playbooks, Variables and Modules

OVERVIEW I - Settings, Inventory, Module Basics II - Playbooks, Variables and Modules III - How people use Ansible, Loops, Jinja2 IV - Playbook Validation, Vault, Roles, Sharing content Test environments and Useful Links Fee

Please watch the video below to continue your Ansible learning journey.

At the end of this section you will be able to

- Run playbooks and parse their outputs
- Use ssh troubleshooting to identify problems which Ansible may hide from you
- Understand Ansible's use of variables and how to reference their value
- Understand Ansible's host_vars/group_vars directory structure
- Understand what modules do and how to use them in playbooks


```

---
- name: Install mod_rewrite on all webservers
  hosts: webservers
  become: true
  tasks:
    - name: Install Apache
      apt: pkg=apache2 state=latest

    - name: enable mod_rewrite
      apache2_module: name=rewrite state=present
      notify:
        - restart_apache2

  handlers:
    - name: restart_apache2
      service: name=apache2 state=restarted
  
```

20 section2/playbooks/install_Apache_with_handlers.yaml www.geant.org

 [Ansible section II - slides and speaker notes](#) PDF document

Ansible: Slides with Speaker Notes

GEANT eAcademy

Ansible

Home > My courses > Technical skills > Network > Ansible

OVERVIEW | I - Settings, Inventory, Module Basics | II - Playbooks

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- Understand Ansible's `host_vars/group_vars` directory structure
- Understand what modules do and how to use them in playbooks

Playbooks

```

---
# Oh look, a comment...
# ...spread out over multiple lines

- name: Set up Apache           # Or nginx, or Mongoose
  hosts: webservers
  tasks:
    - name: install Apache
    - name: generate Apache config file
    - name: download Web content to relevant directory
    - name: restart Apache
    - name: eat cake
  
```

5

www.geant.org



Most ansible users gather their Ansible work in YAML files called **Playbooks** – which start with three dashes. Playbook **comments** start with hashes, and are one per line. Playbooks contain a list of plays, or groups of tasks. In a playbook, look for the dashes in column one to see the list of plays. In the example shown here, there is one play (**Set up Apache**).

Playbooks can also contain the hosts or groups which the tasks should influence; these

Ansible section II - slides and speaker notes PDF document

Current Courses in the Network eAcademy – Automation

Introduction

- **OAV - Introduction** (30')
- **OAV Architecture Requirements for NRENS** (10')
- **The OAV Architecture Blueprint** (30')

DevOps

- **Introduction to CI/CD** (15')
- **CI/CD: Jenkins** (5h)
- **CI/CD: GitlabCI** (40')

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TM Forum Open Digital Architecture

Decoupling & Integration

- **Introduction to Data Modelling, Data Formats, and Protocols** (30')
- **Data Modelling: YANG** (10')
- **Formats: XML** (60')
- **Formats: YAML** (30')
- **Formats: JSON** (45')
- **Protocols: NETCONF** (4 h - including installation)
- **Introduction to API** (45')

Engagement Management

- **Introduction to Engagement Management** (15')

Party Management

- **Introduction to Party Management** (15')

Core Commerce Management

- **Introduction to Core Commerce Management** (15')

Production

- **Introduction to Production** (30')
- **Introduction to Virtualisation** (30')
- **Container-Based Virtualisation: Docker / Swarm** (3h)
- **Container-Based Virtualisation: Kubernetes** (4h - including lab)
- **Introduction to Automation** (30')
- **Automation Tools: Ansible** (60'+lab time)
- **Automation Tools: Python** (90')
- **Introduction to Configuration Management** (20')
- **Introduction to Orchestration** (30')
- **Orchestration: NSO** (6h - including lab)

Intelligence Management

- **Introduction to Intelligence Management** (15')
- **Big Data Storage** (1,5h)

OAV Realisation

- **Towards Intelligent Networks** (30')

<https://wiki.geant.org/display/NETDEV/OAV+Training+Portal>

ADDITIONAL READING

Architecture Mappings

NREN use cases

- CARNET
- CYNET
- GÉANT
- GRNET
- HEAnet
- PIONIER
- SURFNET
- GÉANT

other use cases

- NMaaS

Architectures

- **Standards & Common Architectures**
- TM Forum ODA
- SPA
- MEF
- ETSI-OSM
- ETSI-ZSM
- ONAP
- 5G 3GPP
- GVM
- SENSE
- TALENT
- EOSC
- OpenBaton

Practical Examples

- Ansible:
 - Git repository with the examples in the unit.
 - Mini-Lab: Vagrant testing environment with a Unix server and a JunOS box.
- NETCONF:
 - Installation guide with a virtual environment in GNS3.
 - Adding a static route to a router, step-by-step.
- NSO:
 - Installation of free trial version.
 - Implementing a Radius server configuration over multiple devices.
 - Deploying an ACL on multiple devices, and/or interfaces on a device.

Network Automation eAcademy in progress



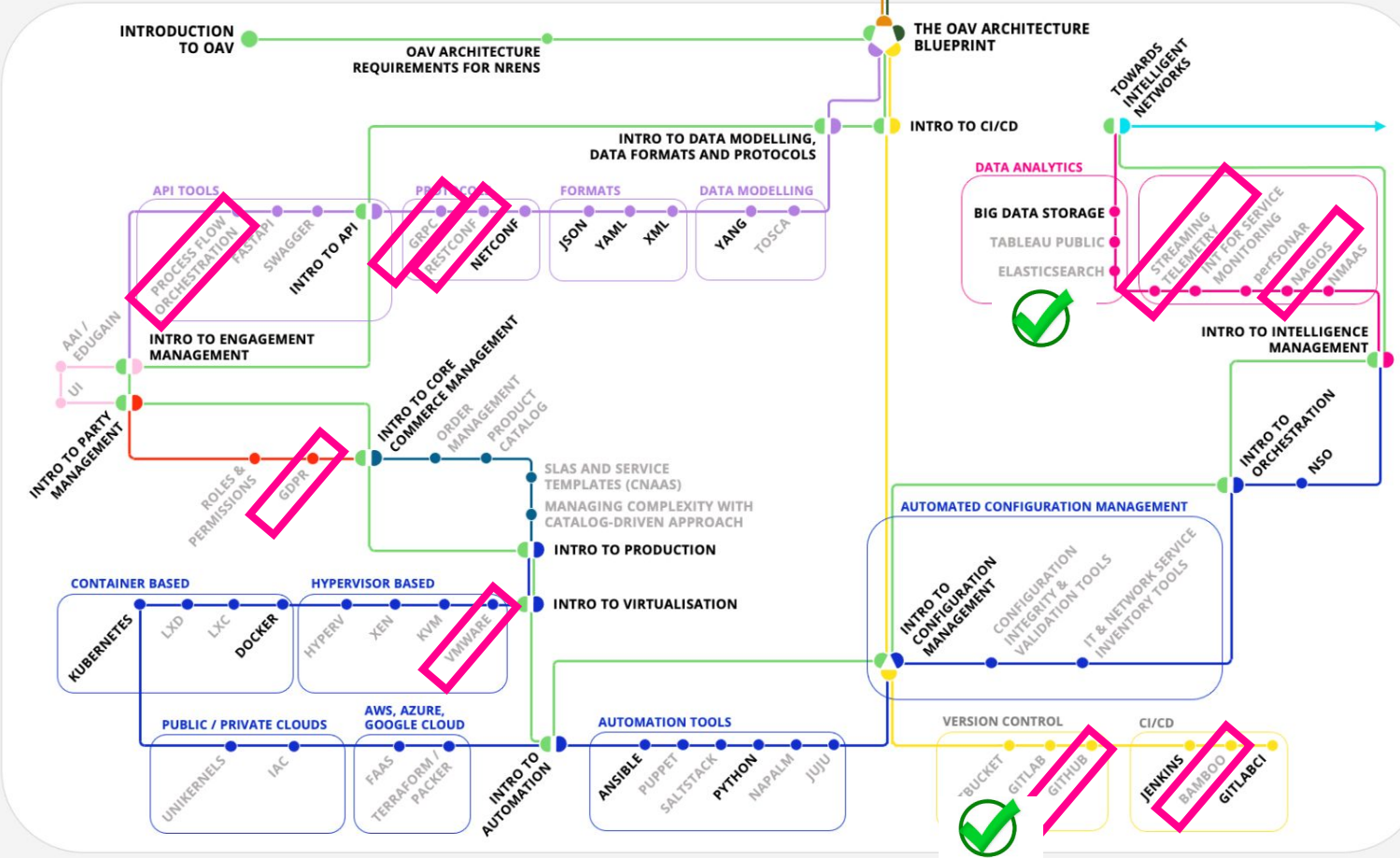
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- CORE COMMERCE MANAGEMENT
- INTELLIGENCE MANAGEMENT
- OAV REALISATION
- USE CASES AND EXAMPLES
- ARCHITECTURE

Functional Blocks in the TM Forum OPEN DIGITAL ARCHITECTURE (ODA)



PROCESS FLOW ORCHESTRATION

RESTCONF

GDPR

VMWARE

INTRO TO CONFIGURATION MANAGEMENT

"BUCKET"

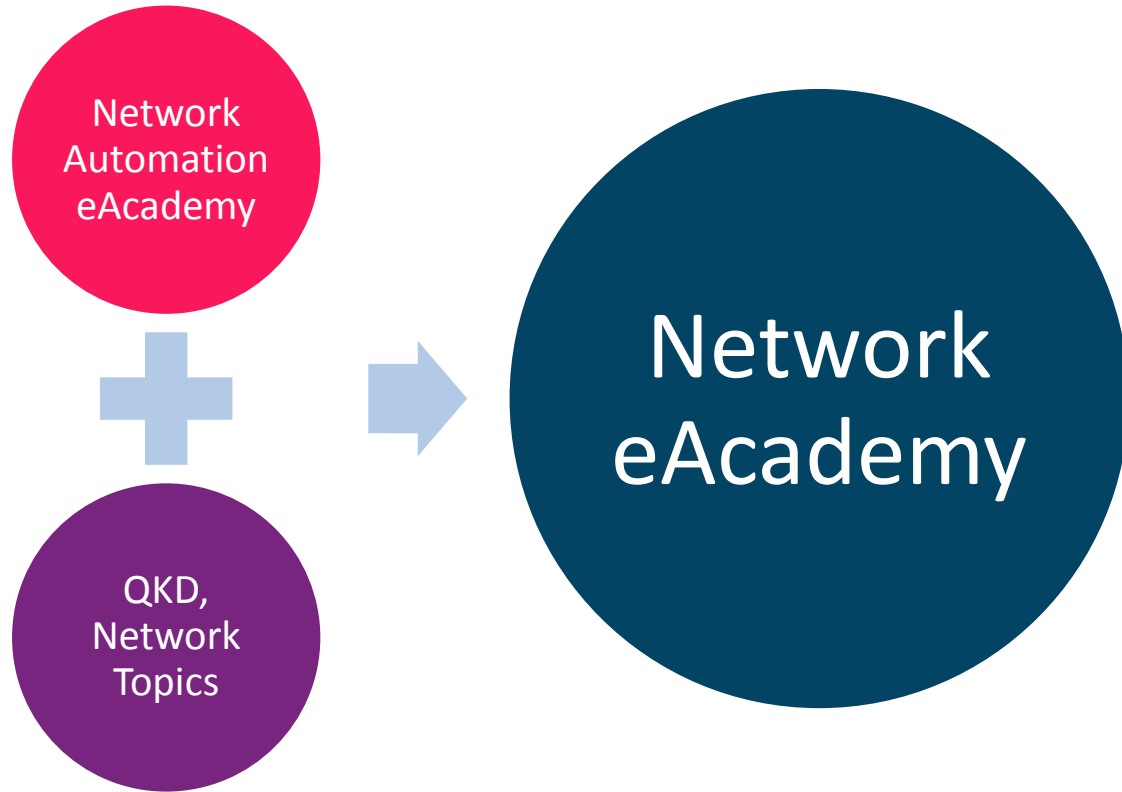
JENKINS

GITLABCI



The Network eAcademy

Network
eAcademy



Current Courses in the Network eAcademy – Quantum

Training



Quantum Algebra: Bloch Sphere

Course creator: Peter Kaufmann



Quantum Algebra: Entanglement Swapping

Course creator: Peter Kaufmann



Quantum Algebra: Mathematical Operators

Course creator: Peter Kaufmann



Quantum Algebra: Operator Multiplication: Variants

Course creator: Peter Kaufmann



Quantum Algebra: Qubit Entanglement

Course creator: Peter Kaufmann



Quantum Algebra: Qubits

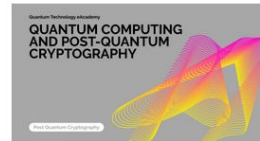
Course creator: Peter Kaufmann



Quantum Algebra: Teleportation




Quantum Computers



Quantum Computing and Post-Quantum Cryptography


Currently working on – Quantum **in progress**

Training




Quantum Algebra: Bloch Sphere

Course creator: Peter Kaufmann



Quantum Algebra: Entanglement Swapping

Course creator: Peter Kaufmann




Quantum Algebra: Mathematical Operators

Course creator: Peter Kaufmann



Quantum Algebra: Operator Multiplication Variants

Course creator: Peter Kaufmann



Quantum Algebra: Qubit Entanglement

Course creator: Peter Kaufmann



Quantum Algebra: Qubits

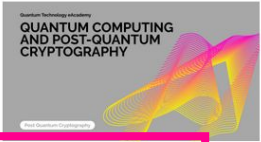
Course creator: Peter Kaufmann



Quantum Algebra: Teleportation



Quantum Computers



Quantum Computing and Post-Quantum Cryptography

Terminology and Glossary of OAV Terms

- Need for an agreement on common terminology.
- The idea is to have a common ground of understanding.
- Published [version](#) 2.0 with additional terms about **AI** and **Maturity Model**
- Accepted by the GNA-G Automation Working Group

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Glossary

OAV Terms	Definition and reference
AIOps	<p><i>AIOps is (the usage of) Artificial Intelligence for IT Operations. It combines big data and machine learning to automate IT operations processes, including event correlation, anomaly detection and causality determination.</i></p> <ul style="list-style-type: none"> • https://www.gartner.com/en/information-technology/glossary/aiops-artificial-intelligence-operations
AI-powered Virtual Agent (AIVA)	<p><i>An AI-powered Virtual Agent is an animated virtual character, more complex than a chatbot, that makes use of technologies like machine learning and natural language processing (NLP). This allows it to actively participate in a conversation, acting more like a human.</i></p> <ul style="list-style-type: none"> • Reference(s): based on https://www.ringcentral.com/virtual-agent.html and TM Forum AI Fundamentals course [TMF_AIF] and TM Forum "AI and its pivotal role in transforming operations" report and webinar [TMF_AI]
API (Application Programming Interface)	<p><i>An API is a set of commands, functions, protocols, and objects that programmers can use to create software or interact with an external system. Any data can be shared with an application program interface.</i></p>



<https://wiki.geant.org/display/NETDEV/OAV+Terminology>

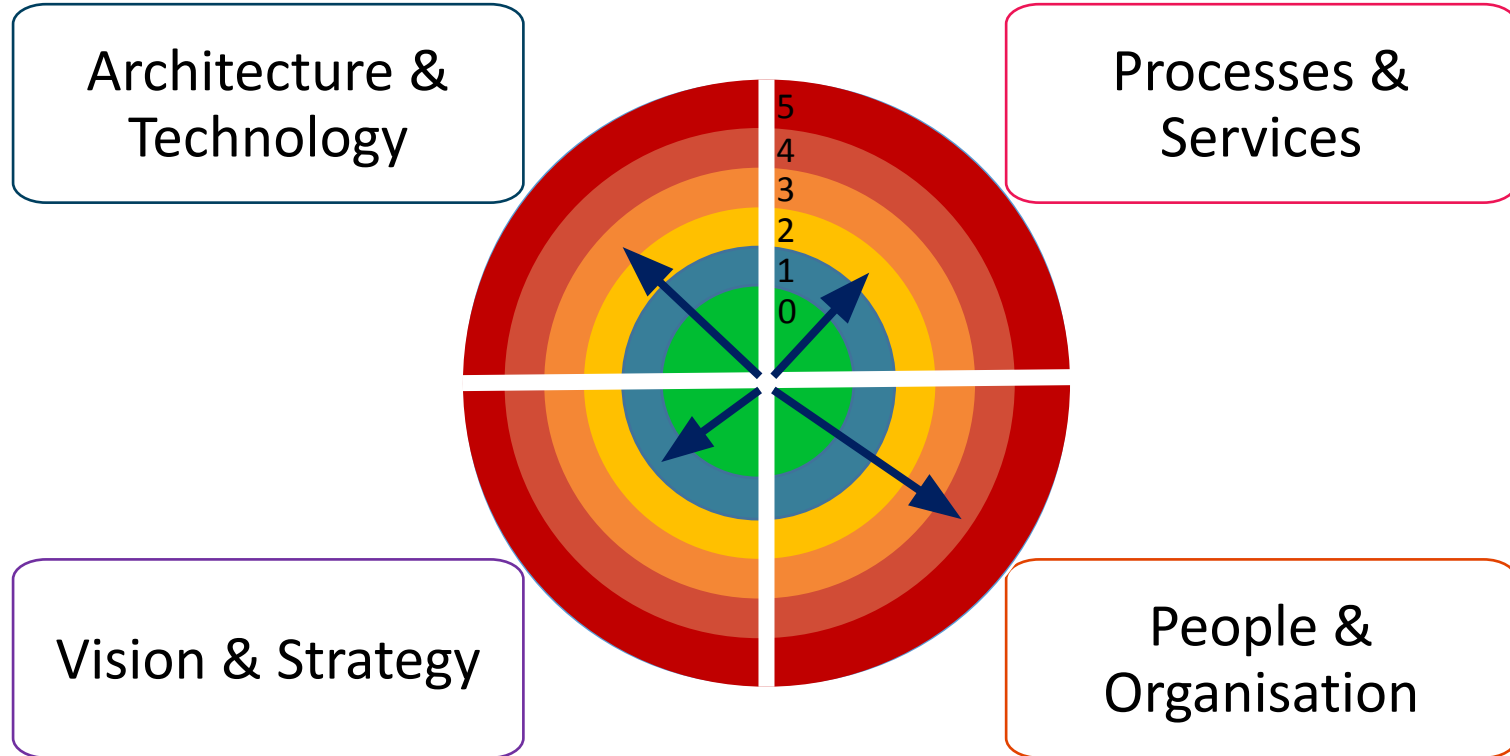
OAV Maturity Model

Maturity Model

Measure	Measure the current OAV capabilities in a meaningful way
Identify	Enable clear identification of strengths and improvement points, be aware of threats and opportunities
Prioritise	Help prioritise what to do in order to advance and improve
Journey	Identify gaps between the current and future state and how to get there

OAV Maturity Model - Dimensions

Maturity Model



OAV Maturity Model - Stages

Maturity Model

Level 0

Sit

None



created by Valerie Lamm

Level 1

Crawl

Ad Hoc



© 2010-2011

Level 2

Walk

Use Case /
Project-based /
Reactive



© 2010-2011

Level 3

Run

Integrated



© 2010-2011

Level 4

Fly

Proactive



© 2010-2011

Level 5

Energise

Self-*



© 2010-2011

The Maturity Model

Maturity Model

Survey (31 questions)*:

<https://www.surveymonkey.com/r/SPYDQVB>

Information to help you check your progress through stages and dimensions:

<https://wiki.geant.org/display/NETDEV/OAV+Maturity+Model>

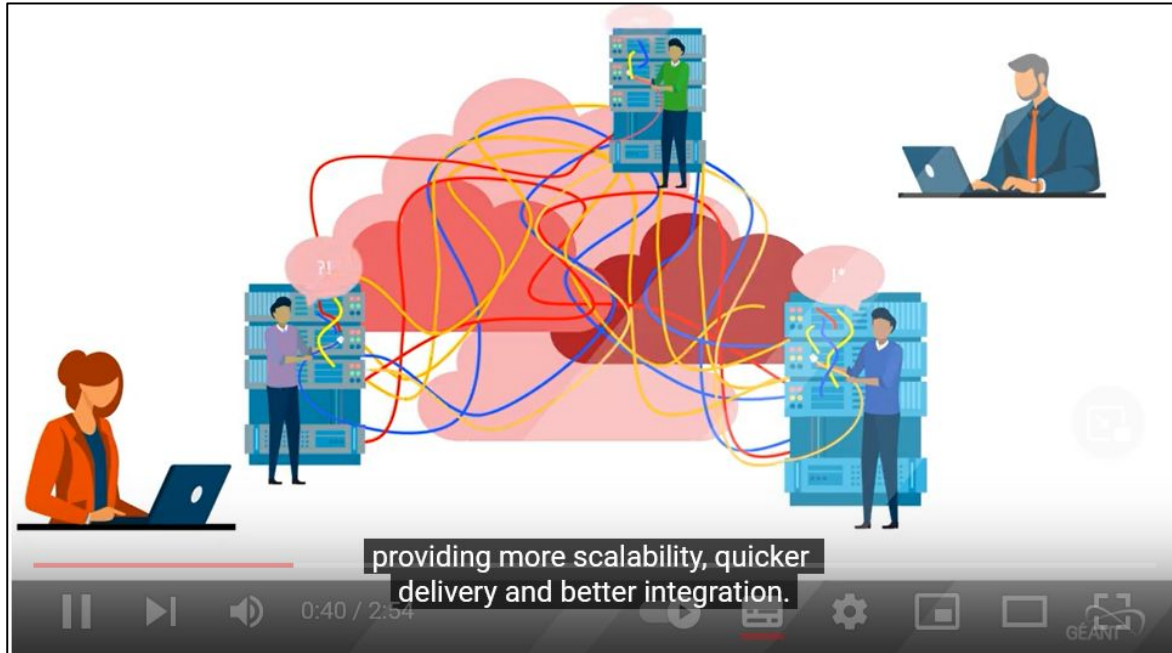
Presentations of the OAV MM Infoshare:

<https://events.geant.org/e/OAV-MM>

* Data is used for analytical purposes only (we don't publish data for individual institutions)
The report is sent to the person defined in the survey

Promoting Orchestration, Automation and Virtualisation (I)

Promotion



Towards Service Automation for Research and Education

Video in the GÉANT TV channel:

<https://youtu.be/Q5Wg1Qnqybg>

Promotion

Promoting Orchestration, Automation and Virtualisation (II)

Digital Platform Concepts
and Principles*

* based on the TMForum Open Digital Architecture

Architecture building blocks

De-couple functionalities into separate components.
Use the single source of truth approach to data storage.
Implement DevOps to develop/maintain each component.

open APIs

Promote a multi-vendor environment where each component has a well-defined API.
Ensure interoperability with open API specifications.
Same APIs for intra- and inter-domain integration.

Orchestration and Automation

Start incrementally: automate repetitive daily tasks first.
Orchestrate multiple components using processes.
Innovate: don't improve existing manual processes or compromise - invent new, more efficient workflows.

Service abstraction

Define abstracted service representations.
Describe services and resources using catalogues.
Re-use components for all services.

THE AUTOMATION, ORCHESTRATION
AND VIRTUALISATION
JOURNEY

The WP6 T2 team can help you on your OAV journey.



WHERE TO START?

Map your NREN architecture to the Open Digital Architecture* to start analysing the current situation



FROM A TRADITIONAL OSS/BSS

Analyse components and functionalities
De-couple & de-duplicate
Expose components via APIs
Automate manual tasks per component
Use orchestrators to implement complex processes spanning multiple components

VIA A DIGITAL PLATFORM

Agree on common terminology to understand each other
Common service abstraction definition
Interoperable interfacing via common Open APIs
Federate with other NRENs or commercial providers

TO AN INTEROPERABLE
COMMUNITY

On-demand provisioning of multi-domain services using common APIs and data models

Leveraging ODA to build interoperable (multi-domain) digital services

The ODA modular architecture supports efficient automation, data integrity and a streamlined approach to workflows with a template- and catalogue-based "single source of truth".

Within the GEANT community, the federated approach of supporting interoperable discrete functional building blocks translates to agreeing to a minimum set of common APIs - used both internally and externally - and a common description of composable abstract services and resources in the corresponding catalogues. In this way, the NRENs are able to implement the Vegas rule ("what happens in the domain stays in the domain"), meaning that each NREN remains in control of how it implements its platform, and decides what and how much information (or level of abstraction) is exposed to other parties or systems via open APIs.

ODA Benefits

- Agile development of new services
- Independent evolution of components
- Multi-domain and federated services via standardised patterns
- Technology agnostic blueprint
- Integrates related standards
- Faster support and troubleshooting
- Change management support
- Zero-touch orchestration
- Multi-vendor interoperability
- Stepwise evolution
- Model-driven service management
- Support for autonomous networks
- AI/ML ready

OAV Wiki Knowledge Base

Terminology	https://wiki.geant.org/display/NETDEV/OAV+Terminology
Community Portal	https://wiki.geant.org/display/NETDEV/OAV+Community+Portal
White paper	https://wiki.geant.org/display/NETDEV/OAV+Architectures



- o Want to align your architecture with ODA?
- o Have an OAV use case you would like to share and work on with us?
- o Looking for a particular component or an open API specification?
- o Seeking/offering to provide OAV training?

Contact us at oav@lists.geant.org

Networks - Services - People

www.geant.org

TOWARDS COLLABORATIVE DIGITAL SERVICES

The delivery of modern network services is evolving from services that were traditionally provisioned via heavily manual processes that were based on classic OSS/BSS platforms. Today's users demand self-service environments where they can make changes at a time that suits them. NRENs and their clients are reacting to this demand by embracing a digital transformation process - seeking to use digital platforms in an agile way - where that process mandates automation, modularity and flexibility. The drivers for automation are clear, including more efficient provisioning, and configuration consistency. It is also important to consider how a collaborative approach for the GEANT community can bring additional benefits.

As NRENs and R&E organisations embrace their digital transformation, it is important to foster such collaboration through the sharing of knowledge and experience within the GEANT community. Agreeing to implement Orchestration, Automation and Virtualisation (OAV) using a shared vocabulary and a common high-level architecture blueprint helps to ensure interoperability and, potentially, facilitates future inter-domain services as NRENs converge towards a shared objective for their users: the provision of true on-demand, self-service environments.

The search for such a blueprint led to the selection of the TM Forum's Open Digital Architecture (ODA), adopted by and driving the digital transformation of most communication providers. ODA is a reference framework which provides a common understanding and generality in an environment where each NREN is free to choose its own path towards OAV - including architecture, design and implementation.

Fostering collaboration and interoperability via common principles and guidelines

Modular architecture approach	Loosely coupled components that work together in an orchestrated manner.
Discrete, functional building blocks	Each component exposes well-defined functional capabilities.
Open APIs	Each component is accessed via an Open API that fosters interoperability, supports multi-vendor environments, and is the basis for automation and orchestration.

© GEANT Association on behalf of the ODA-3 and ODA-2b Projects. As part of the GEANT 2020 Framework Partnership Agreement (FPA), the project received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 101017626 (ODA-3) and Grant Agreement 101017626 (ODA-2b).

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Towards Collaborative Digital Services

Pamphlet and Infographic:

https://www.geant.org/Resources/Documents/OAV_Arch_text_and_infographics_new_links.pdf

Wiki

- [Community Portal](#)
- Sections for OAV:
 - [Architecture](#)
 - [Training](#)
 - [Maturity Model](#)
 - [Terminology](#)
 - [Literature](#)
 - Examples of usage: [CNaas](#), [DTN](#)
 - [Dissemination](#): Deliverables, Infoshares, Presentations, Articles...

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z																						
																								OAV Examples by Country																							
AARNET, Australia																								<ul style="list-style-type: none"> • https://www.aarnet.edu.au/ • Hindrik Buining, David Jericho, Orchestration, Automation and Virtualisation, BOF, TNC19, Tallinn, Estonia, June 20, 2019 (pdf) 																							
ARNES																								<ul style="list-style-type: none"> • https://www.arnes.si/ • ARNES is working on the project WLAN-2020 to offer wireless connection within the schools in the country, hiring consultants during the deployment phase. They are using Automator as the middleware and doing ZTP (Zero Touch Provisioning). • They have built the ARNES network service orchestration stack, automation based on Ansible. • https://geant.app.box.com/s/46892sqzqkbc9683j8tybg6l5du7jhtz 																							
CARNET																								<ul style="list-style-type: none"> • https://www.carnet.hr/ • Damir Regvart, Lidija Jakovčić, Silvija Mišić, CARNET OAV, BOF, TNC19, Tallinn, Estonia, June 20, 2019 (pdf) • CARNET is also working on a national project to offer wireless connection within the schools in the country (https://www.e-skole.hr/en/results/adequate-ict-infrastructure-in-pilot-schools/), with a network management system built by them (Management system for the educational system). CARNET does the network provisioning and monitoring through an API: https://geant.app.box.com/s/7f5t6tbv2dho3fed13767m906mm16 • See the lightning talk during the Network Management and Monitoring Workshop. 																							
CSUC																								<ul style="list-style-type: none"> • https://www.csuc.cat • CSUC has automated the provisioning of new circuits in the L2 and L3 devices using Rundeck, Python scripts and Ansible modules for Anella Científica (Regional Research and Education Network in Catalonia). • For the Internet Exchange, CATNIX, CSUC has an internal portal where customers can add their new MAC addresses and the filters are updated in the switches through Python scripts. 																							
CyNet																								<ul style="list-style-type: none"> • http://www.cynet.ac.cy/ • saorai@geant.org: CYNET OAV Architecture Analysis, https://www.geant.org/Resources/Documents/GN4-3_White-Paper_CYNET_OAV_Architecture_Analysis.pdf • Iacovos Ioannou, Active member of OAV working group of WP6-T2. 																							
ESnet, USA																								<ul style="list-style-type: none"> • http://es.net/ • John MacAuley, Service orchestration in ESnet6, BOF, TNC19, Tallinn, Estonia, June 20, 2019 (pdf) 																							
FUNET																								<ul style="list-style-type: none"> • https://www.csc.fi/funet-kalkki-palvelut • Aapo Hakala, Workshop on Network Management and Monitoring, Copenhagen, October 2019: https://wiki.geant.org/download/attachments/131629403/Funet%20Kampus%20Service.pdf?version=1&modificationDate=1571047057236&api=v2. • Kampus Service Project. All new customer provisioning is automated, with no manual configuration (only physical installation). • Everything automated using Ansible, configuration stored in YAML files. 																							
GEANT																								<ul style="list-style-type: none"> • https://www.geant.org/ • Bram Peeters, Orchestration, Automation and Virtualisation (OAV) in GEANT, GN4-3 Future Service Strategy Workshop, Amsterdam, May 9, 2019 (pdf) • Mian Usman, Orchestration and Automation, BOF, TNC19, Tallinn, Estonia, June 20, 2019 (pdf) • Tony Barber, 10th SIG-NOC meeting presentation 																							

With Many Thanks to our Trainers!

Aristos Anastasiou (MARNET)	Iacovos Ioannou (CyNet)
Jasone Astorga (RedIRIS / UPV/EHU)	Hamzeh Khalili (RedIRIS / i2CAT)
Estela Carmona (RedIRIS / i2CAT)	Roman Łapacz (PSNC)
Dónal Cunningham (HEAnet)	Eldis Mujarić (CARNET)
Yuri Demchenko (SURFnet / UvA)	Anastas Mishev (MARNET / UKIM)
Aleksandra Dedinec (MARNET/UKIM)	Susanne Naegele-Jackson (DFN / FAU)
Sonja Filiposka (MARNET / UKIM)	Simone Spinelli (GÉANT)
Maria Isabel Gandia (RedIRIS / CSUC)	Kostas Stamos (GRNET / CTI)
Eduardo Jacob (RedIRIS / UPV/EHU)	Your name here?
Nicolai Iliuha (RENAM)	



Contact us at network-eacademy@lists.geant.org

For any questions, the R&E community can join us once a month.

And the WPL, the GLAD team and the Communications team at GÉANT!

Orchestrated Services in Practice

Operational Services and TechLab

Agenda: Orchestrated Services in Practice



- Description
- Architecture
- Usage
- More info

NMaaS



GÉANT

Network Management as a Service

NMaaS is an effective and efficient **network and service management platform**:

- Simplifies intra-domain network management by providing the **infrastructure and tools** via a **cloud-based** network management system.
- Enables **management and monitoring of client networks** through **on-demand deployment** of network management tools in the cloud infrastructure.
- Uses a **multi-tenant approach** - each organisation has private access to their network and services from a highly available cloud based platform.



Network Management as a Service

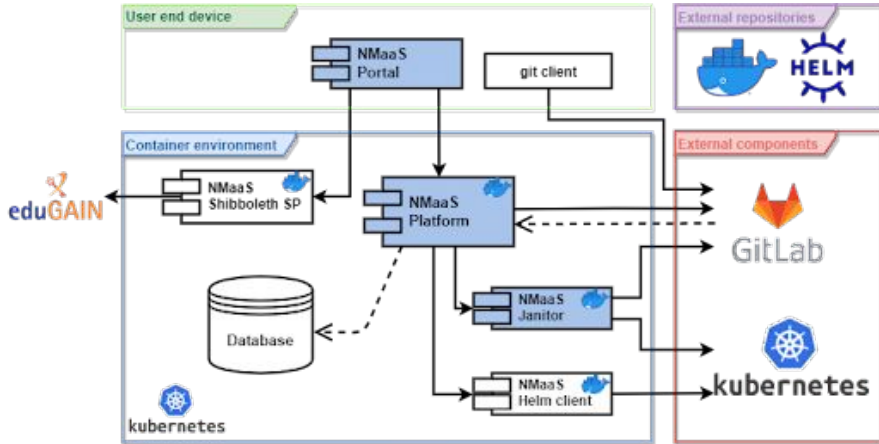
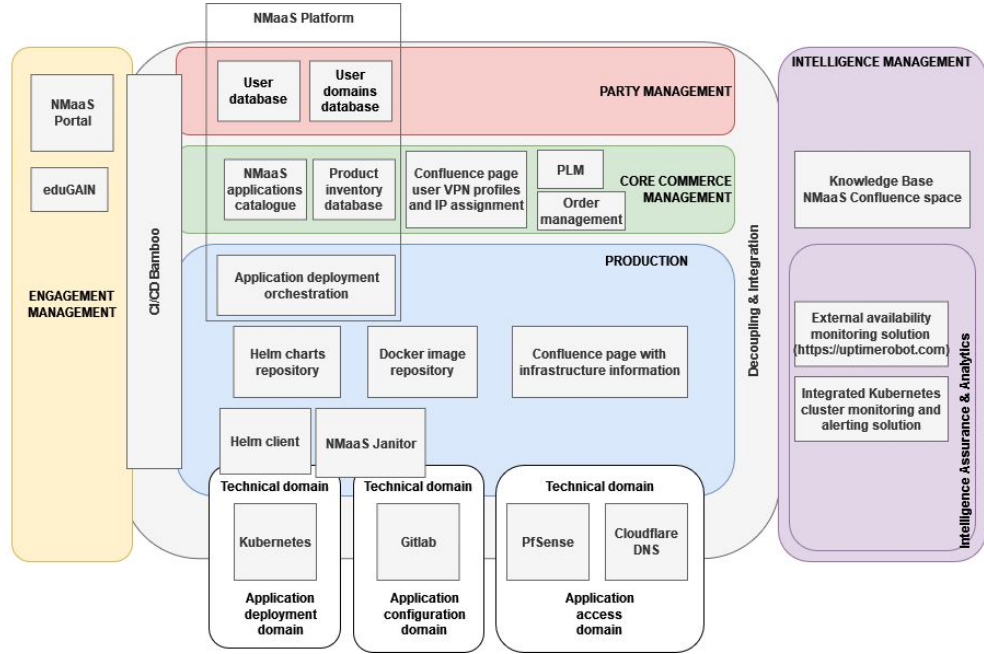
Contact: nmaas@lists.geant.org

Portal: <https://nmaas.eu>

NMaaS Architecture



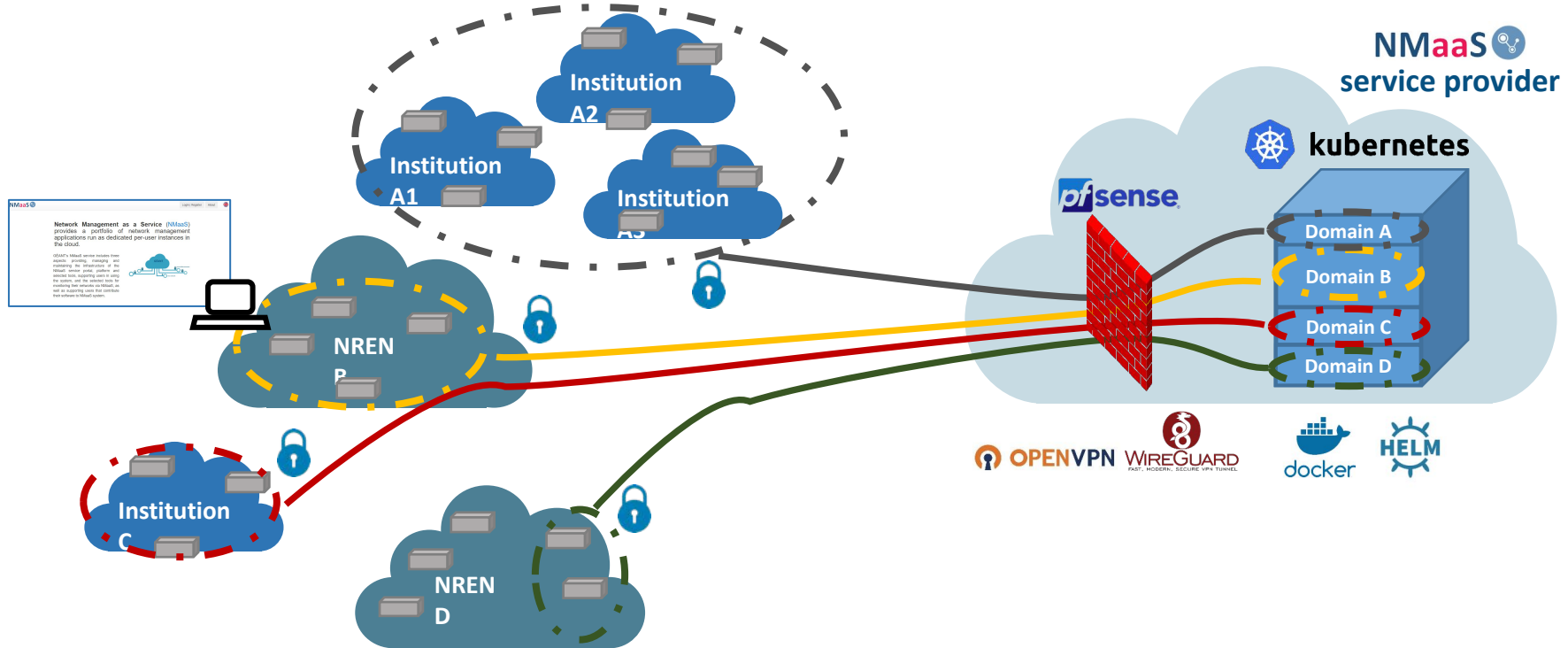
Users
Network operators



[NMaaS-OAV-Architecture-Analysis](#)



NMaaS service deployment



NMaaS tools

28 applications available in the portfolio

Oxidized

NAV

Prometheus

Grafana

Booked

Bastion

Debian repo

Routinator

NetBox

Icinga2

CodiMD

Synapse

InfluxDB

ELK Stack

Jenkins

Zabbix

LibreNMS

SPA & Inventory

perfSONAR Central

Management

WiFiMon

Uptime Kuma

Victoria Metrics

WebDAV Server

Healthchecks



Adding new tools require:



Docker image(s)

Helm chart

Metadata and info about the application



NMaaS Use Cases

Network / Equipment Management

- Small / medium size networks / institutions
- Project-owned equipment

NMaaS Virtual Lab



NEW

- Aimed for education
- Using on-demand application deployment in a learning context
- Creating personalised and portable development environments

Examples:

- Deploying black-box containers to study software vulnerabilities
- Shared domains between multiple users for where teamwork scenarios
- Personalised catalog of applications for each user through domain groups
- Bulk application deployment
- ...



How to use NMaaS?

MANAGED SERVICE

Production NMaaS instance for operational network management i maintenance (*secure, fully supported*)

<https://nmaas.eu>

A **sandbox NMaaS instance** to explore NMaaS features and offered applications (*no configuration overhead, demo apps already deployed*)

<https://nmaas.geant.org>

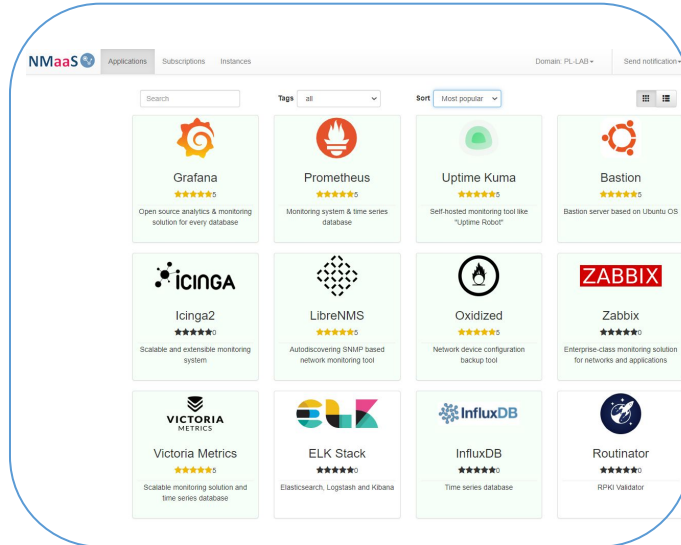
SELF-HOSTED

Run your own NMaaS instance (Kubernetes cluster required) visit NMaaS **Installation Guide**:

<https://docs.nmaas.eu/install-guide>

Run Kubernetes cluster and NMaaS on a local machine visit **local NMaaS Testing Environment Installation Guide**:

<https://docs.nmaas.eu/local-vm>



<https://network.geant.org/nmaas/>

nmaas@lists.geant.org

<https://github.com/nmaas-platform>

Service Provider Architecture Platform



Service Provider Architecture

Enables and supports transformation from traditional OSS/BSS environments towards the Digital Business Platform

SPA is a modular blueprint guide for designers and developers that want to build a next generation service management platform by integrating functionalities in a flexible and uniform way.



spa@lists.geant.org

gn4-3-wp6-t2-dev@lists.geant.org

<https://wiki.geant.org/display/NETDEV/SPA>

Service Provider Architecture Platform



SPA platform is the implementation of the SPA to orchestrate and automate network services in the GÉANT and NREN network infrastructures.

Design a LEGO® type of service architecture

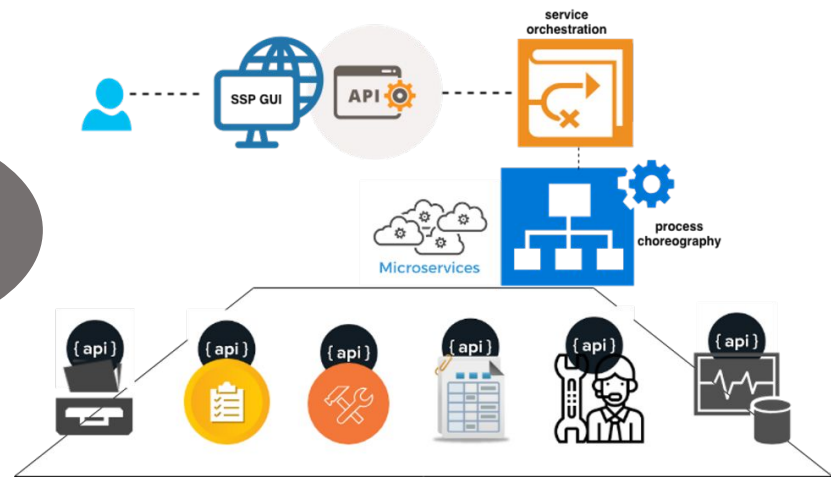
Support the service lifecycle of all network services

Common information model

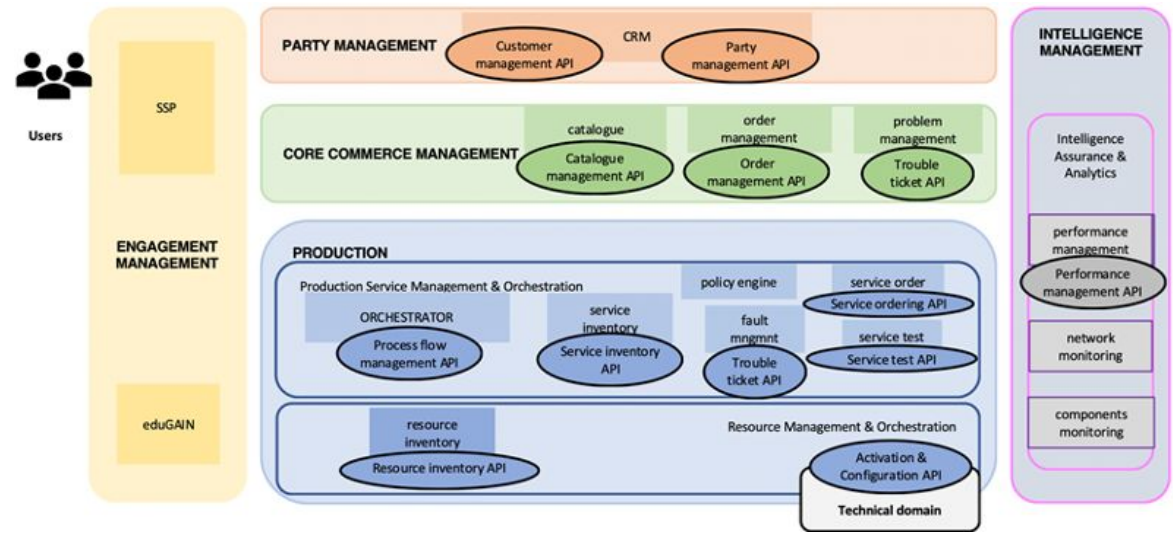
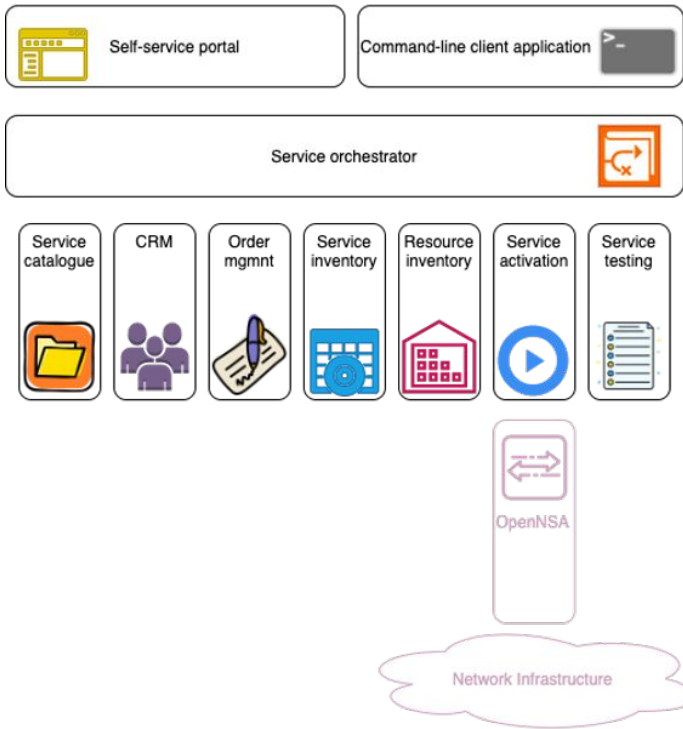
TMF Framework compliant

Orchestration for complex workflows


Use automation wherever possible



Service Provider Architecture



Single Point of Truth for the orchestration and automation framework

- **Resource and Service Inventory** version 3 
- OpenAPI 3.0 schema validation for the REST API
 - Any data model described by the schema can be supported
- REST API compliant with TMF OpenAPI specs (verified with the TMF test suites)
- Flexible for data model extensions and updates (NoSQL database)
- REST API OAuth 2.0 Authentication with Keycloak
- Upcoming: a series of tests in the PIONIER network
 - SPoT - one of the key components for the work on automation of resource and service configuration



Services based on SPA



GÉANT Connection
Service

E-Line Service
in NMaaS

GÉANT Connection Service (GCS)



- Microsoft ExpressRoute point-to-point L2 circuits in the GÉANT infrastructure
- Production service for GÉANT OC
- OpenNSA as the activation component (topology abstraction, access to the infrastructure)
- Continuous improvements
 - New requirements from the GÉANT OC
 - UAT (User Acceptance Test) environment for pre-production tests

36
STPs

44
routers

24 active
circuits

707
automated
workflows

665
terminated
circuits

GEANT HOME SERVICES INVENTORY HELP IMPADMIN -

GEANT SSP Admin Portal

Create circuit List circuits Debug Logs

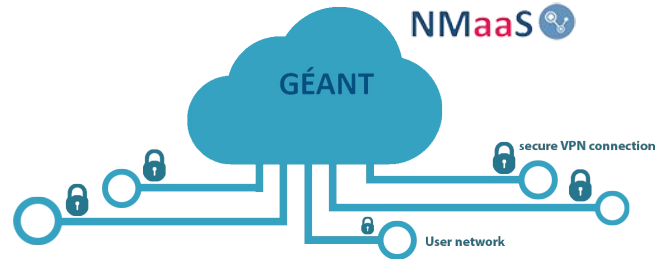
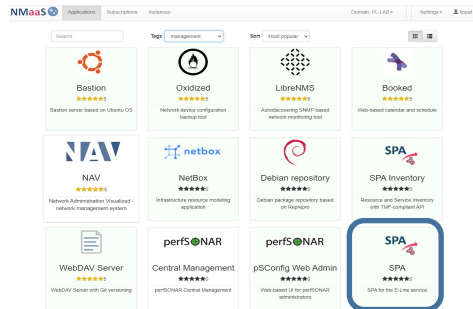
First ← Prev Page 1 of 1 All ↓ Next → Last Status Ack+Act+Inact ↓ Start Date From 2018-08-23 Start Date To 2020-02-26 Text Q ON

Request Details				Service Details									
Service Type	User	Time(UTC)	Status	Conn. ID	Name	3rd party ID	Start(UTC)	End(UTC)	Capacity	Src. STP	Src. VLAN	Dest. STP	Dest. VLAN
Geant E-line	Operations Centre	2019-12-02 10:31:58	active	GC-0f2428874	BELNET_ExpressRoute_Vlan4080	SKEY:c34e3b9c-b79f-44ef-958b-b8c0354e1115	2019-12-02 10:30:58	None	0	1-ams-nl.gcs.geant.net_2019_topology:belnet-ap3-expressroutes	4080	1-fra-de.gcs.geant.net_2019_topology:rms_expres_route_1	2
Geant E-line	Operations Centre	2019-12-02 10:30:47	active	GC-7b6b96a6f5	BELNET_ExpressRoute_Vlan4081	SKEY:c34e3b9c-b79f-44ef-958b-b8c0354e1115	2019-12-02 10:29:11	None	0	1-lon-uk.gcs.geant.net_2019_topology:belnet-ap2-expressroutes	4081	1-fra-de.gcs.geant.net_2019_topology:rms_expres_route_2	2



E-Line Service in NMaaS

- Sandbox for testing L2 point-to-point connection service
 - All SPA components with default test settings
 - OpenNSA with simple emulated network topology
 - All service lifecycle actions
- No need to deploy the service on your own resources
 - Only an account in NMaaS is needed
 - User creates an instance of the service for testing
- SPA in NMaaS may help to familiarise with the OAV concept and the available SPA implementation (start of the orchestration and automation journey)



GP4L



GP4L - GÉANT P4Lab

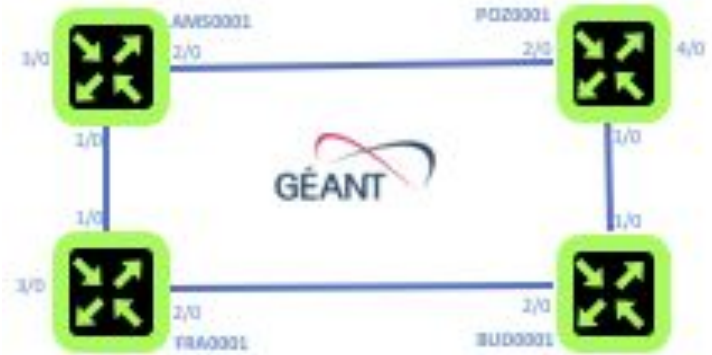
P4 switch-based lab infrastructure interconnected through the GÉANT network

- 4 switches in Europe: AMS, POZ, FRA, BUD

Initially aimed to **validate the RARE/FreeRtr** open source routing stack software

With growing interest, offering **experimental dataplane programming facilities to researchers** to perform geographically distributed network experiments:

- With the usage of RARE/FreeRtr NOS
- Using a clean slate environment (i.e use exclusively GP4L without RARE/FreeRtr dataplane & control plane)



GP4L
GÉANT P4 LAB

Router for Academia, Research and Education (RARE)

RARE is an open source routing platform, used to create a network operating system (NOS) on commodity hardware (a white box switch).



RARE uses FreeRtr as a control plane software and is thus often referred to as RARE/FreeRtr



More information:

<https://wiki.geant.org/display/rare>

P4 Programmable Switches

EdgeCore Wedge100BF-32QS:

100GbE Data Center Switch

- Bare-Metal Hardware
- L2/L3 Switching
- 32xQSFP28 Ports

Data-Plane Programmability

- Intel Tofino Switch Silicon
- Barefoot Networks

Quad-Pipe Programmable Packet Processing Pipeline

- 6.4 Tbps Total Bandwidth

CPU: Intelx86 Xeon 2.0GHz

- 8-core/48GB/2TB SSD



RARE IPv4/IPv6 Features

Include, but not limited to:

- Interior Routing Protocol
- Dataplane forwarding
- External Routing Protocol
- Link local protocol
- Network management

Supported platforms:

- BMv2, TOFINO, DPDK, XDP

List updated regularly:

- <https://wiki.geant.org/display/rare>

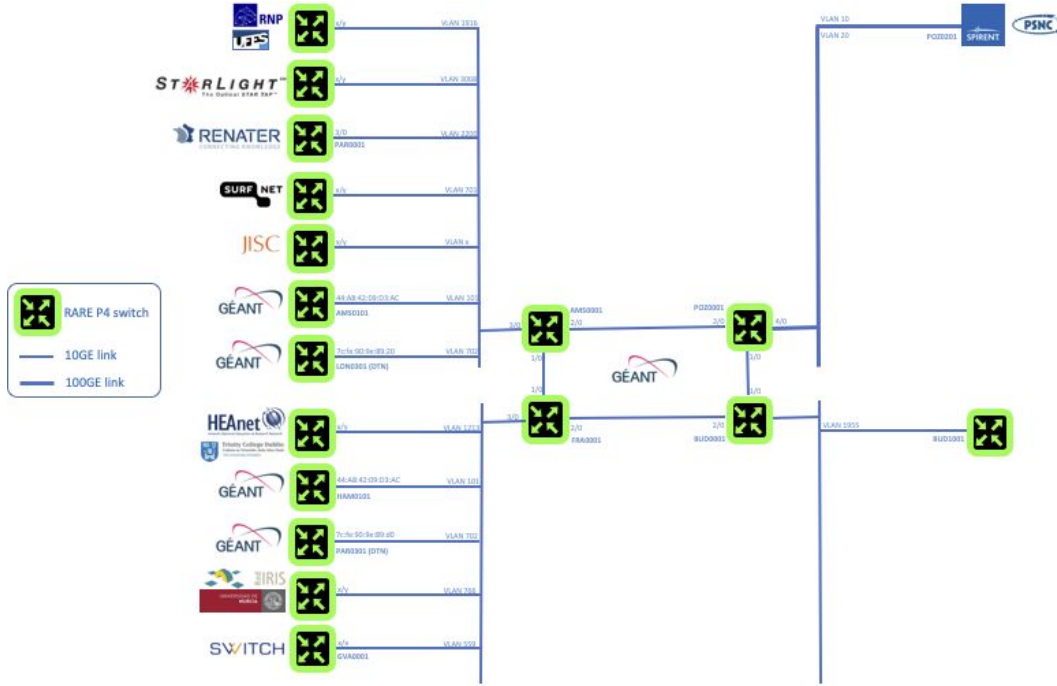
For more features or details, contact:

- rare-users@lists.geant.org

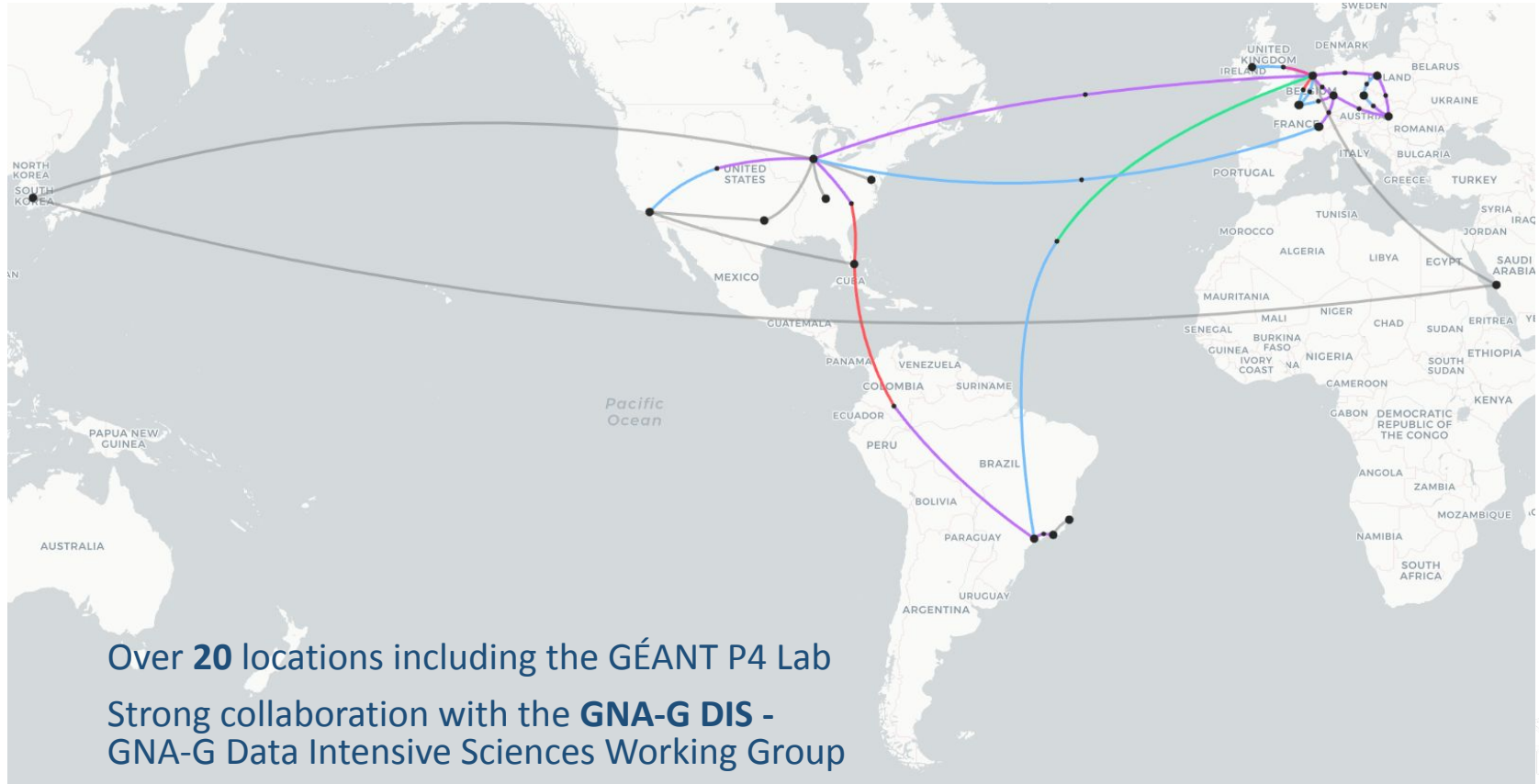
Complete feature list

Type	Test #	Name				
acl	01 ^a	copp	✓	✓	✓	✗
acl	02 ^a	ingress access list	✓	✓	✓	✗
acl	03 ^a	egress access list	✓	✓	✓	✗
acl	04 ^a	nat	✓	✓	✓	✗
acl	05 ^a	vlan ingress access list	✓	✓	✓	✗
acl	06 ^a	vlan egress access list	✓	✓	✓	✗
acl	07 ^a	bundle ingress access list	✓	✓	✓	✗
acl	08 ^a	bundle egress access list	✓	✓	✓	✗
acl	09 ^a	bundle vlan ingress access list	✓	✓	✓	✗
acl	10 ^a	bundle vlan egress access list	✓	✓	✓	✗
acl	11 ^a	bridge ingress access list	✓	✓	✓	✗
acl	12 ^a	bridge egress access list	✓	✓	✓	✗
acl	13 ^a	vlan bridge ingress access list	✓	✓	✓	✗
acl	14 ^a	vlan bridge egress access list	✓	✓	✓	✗
acl	15 ^a	ingress pppoe access list	✓	✓	✓	✗
acl	16 ^a	egress pppoe access list	✓	✓	✓	✗
acl	17 ^a	ingress vlan pppoe access list	✓	✓	✓	✗
acl	18 ^a	egress vlan pppoe access list	✓	✓	✓	✗
acl	19 ^a	hairpin ingress access list	✓	✓	✓	✗
acl	20 ^a	hairpin egress access list	✓	✓	✓	✗
acl	21 ^a	hairpin vlan ingress access list	✓	✓	✓	✗
acl	22 ^a	hairpin vlan egress access list	✓	✓	✓	✗
acl	23 ^a	hairpin pppoe ingress access list	✓	✓	✓	✗
acl	24 ^a	hairpin pppoe egress access list	✓	✓	✓	✗
acl	25 ^a	hairpin vlan pppoe ingress access list	✓	✓	✓	✗
acl	26 ^a	hairpin vlan pppoe egress access list	✓	✓	✓	✗
acl	27 ^a	ingress gre access list	✓	✓	✓	✗
acl	28 ^a	egress gre access list	✓	✓	✓	✗
acl	29 ^a	ingress vlan gre access list	✓	✓	✓	✗

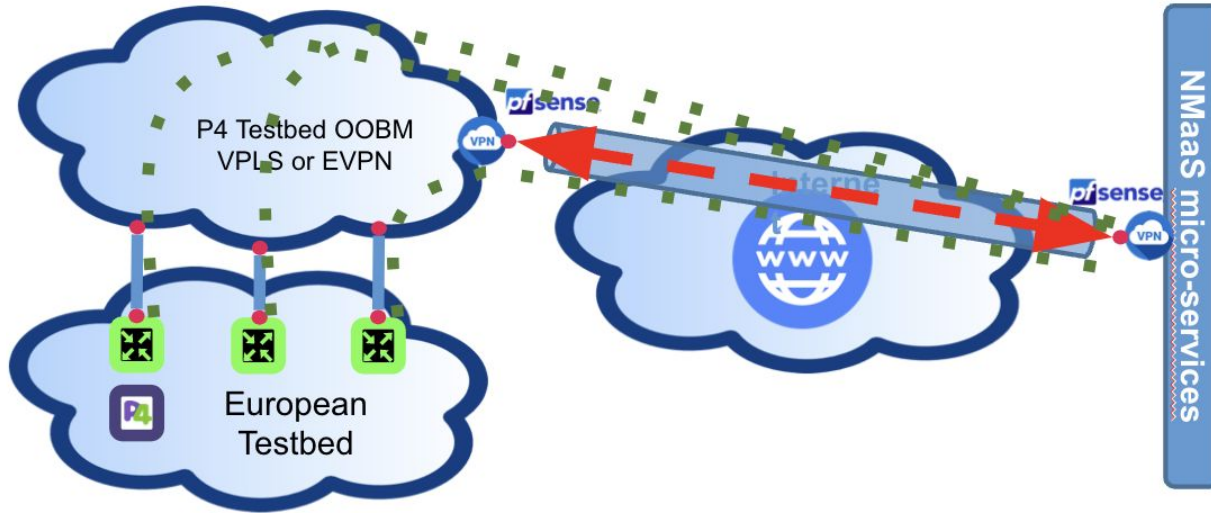
GP4L Going Global



Global P4L October 2022



NMaaS Tools Portfolio for GP4L Monitoring and Management



Network Management as a Service:

<https://nmaas.eu>

<https://wiki.geant.org/display/NMaaS>

Search	Tags	Sort	None
NAV	LibreNMS	Oxidized	Booked
Bastion	Victoria Metrics	perfsONAR Central Manager	perfsONAR emond
ELK Stack	matrix	perfsONAR MaDDash	perfsONAR pSConfig Web A
Jenkins	InfluxDB	InfluxDB	CodiMD
Grafana	Prometheus	Icinga2	SPA
Routinator	WebDAV Server	Uptime Kuma	NetBox
wifimon	ZABBIX	SPA	

GP4L Use cases

- Topology Monitoring with BGP-LS
- Next Generation Multicast with AMT relay/gateway and Unicast to Multicast translator, Juniper and Akamai
- Polka - an innovative source routing paradigm, IFES/UFES
- Packet Marking Specification: IPv6 Flow Label, CERN
- SuperComputing22 Demo, GNA-G DIS

[More information about the use cases](#)

Useful Links

Documentation:

GP4L project: <https://wiki.geant.org/display/GP4L/>

RARE/FreeRtr: <https://wiki.geant.org/display/RARE>

<https://blog.freertr.org>

<https://docs.freertr.org>

<https://blog.freertr.org>

GÉANT NETDEV: <https://wiki.geant.org/display/NETDEV>

Contact:

Users: gp4l-users@lists.geant.org, rare-users@lists.geant.org

Developers: gp4l-dev@lists.geant.org, rare-dev@lists.geant.org

Project: gp4l@lists.geant.org, rare@lists.geant.org

TechLab



TechLab

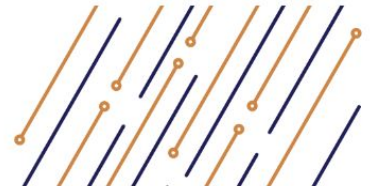
TechLab is an initiative to facilitate access to information on research network infrastructures and services that can be made available to work on modern and innovative solutions.

Brings together specialists and researchers to share knowledge and experience and promote work results

Offers shared resources and services for advanced testing, piloting and research.

Promotes test infrastructures whose owners are open for collaboration

Increases the visibility of test infrastructures and their developed solutions



TechLab - information sharing

Data provided:

- General information
- Current state
- Maintenance
- Access
- Support
- Services
- Resources
- Data
- APIs
- References

perfSONAR in NMaaS

Created by Eldis Mujarić, last modified by Susanne Nägele-Jackson on Dec 20, 2022

General information

perfSONAR is an open-source, modular and flexible architecture for active network performance monitoring that provides a view of network performance across multiple domains, allowing NOC and PERT engineers to seamlessly analyse and diagnose network behaviours across the entire end-to-end path. The tools provided in the perfSONAR suite perform active measurements of throughput, packet loss, delays and jitter, and record network route and path changes.

To promote the perfSONAR software and empower small organisations and teams in its usage, the GÉANT project is providing through the NMaaS platform all the perfSONAR central components. That means that you only need to deploy public perfSONAR measurement points (MP) on your network and you can run all the central components to manage, collect and visualise your network performance measurement data on the GÉANT provided central components.

Current state

Active

Maintenance

WP6T3 perfSONAR sub-task team.

Access

Through regular [NMaaS](#) access, prior registration might be needed for users not already having an account.

Support

- WP6T3 perfSONAR team can be reached at perfsonar@lists.geant.org
- [NMaaS Support](#)

Services

perfSONAR central components:

- [Archive](#): Esmond
- [Dashboard](#): MaDDash
- [Configuration](#): pSConfig Web Admin (PWA)
- perfSONAR Central Management which is the 3 above services together.

Resources

- NMaaS sandbox (link to be added, Edo?)
- perfSONAR documentation:
 - [Esmond](#)
 - [MaDDash](#)
 - [pSConfig Web Admin](#)

Data

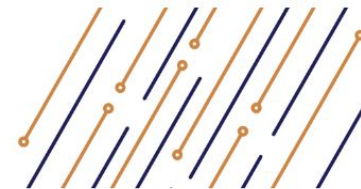
To be useful, you'll need to provide access to your own perfSONAR nodes and configure them to post their measurement results data to the central components provided by NMaaS. Configuration of measurements and archiving can be done through the PWA provided on NMaaS.

APIs

- [Esmond API](#)
- [MaDDash API](#)

References

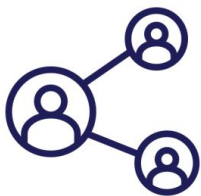
- [perfSONAR project](#)
- [perfSONAR software documentation](#)
- [perfSONAR in the GÉANT project](#)



Brand name for available shared testing facilities

Starting from NETDEV facilities, open for contributions

Available so far:



[GP4Lab](#)



[NMaaS](#)



[perfSONAR
in NMaaS](#)



[SPA/E-Line in
NMaaS](#)



[SPA Inventory2 in
NMaaS](#)



[WiFiMon in
NMaaS](#)

perfSONAR in NMaaS



General information

perfSONAR is an open-source, modular and flexible architecture for active network performance monitoring that provides a view of network performance across multiple domains, allowing NOC and PERT engineers to seamlessly analyse and diagnose network behaviours across the entire end-to-end path. The tools provided in the perfSONAR suite perform active measurements of throughput, packet loss, delays and jitter, and record network route and path changes.

To promote the perfSONAR software and empower small organisations and teams in its usage, the GÉANT project is providing through the NMaaS platform all the perfSONAR central components. That means that you only need to deploy public perfSONAR measurement points (MP) on your network and you can run all the central components to manage, collect and visualise your network performance measurement data on the GÉANT provided central components.

Services

perfSONAR central components:

- Archive: Esmond
- Dashboard: MaDDash
- Configuration: pSConfig Web Admin (PWA)
- perfSONAR Central Management which is the 3 above services together.

<p>perfSONAR</p> <p>Central Management</p> <p>★★★★★</p> <p>perfSONAR Central Management</p>	<p>perfSONAR</p> <p>esmond</p> <p>★★★★★</p> <p>Central Measurement Archive</p>
<p>perfSONAR</p> <p>MaDDash</p> <p>★★★★★</p> <p>Monitoring and Debugging Dashboard</p>	<p>perfSONAR</p> <p>pSConfig Web Admin</p> <p>★★★★★</p> <p>Web-based UI for perfSONAR administrators</p>

WiFiMon in NMaaS

WiFiMon is a WiFi network monitoring and performance verification system. It is capable of detecting performance issues, visualising the achievable throughput of a wireless network for each user, and providing technical information about a WiFi network (e.g., signal strength, link quality, bit rate, etc.). **WiFiMon** leverages well-known performance verification tools (e.g., Akamai **Boomerang** and **Speedtest**) and in addition uses data from the WiFi physical layer in order to gather a comprehensive set of WiFi network performance metrics.

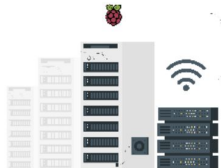
WiFiMon Operation Modes

WiFiMon can operate in two different modes which can be used either separately or together

Software Crowdsourced Measurements



Hardware Probe Measurements



WiFiMon



Technology and vendor agnostic



WiFiMon can be deployed on any WiFi network as it monitors the performance on the network layer. It can also provide additional benefits in 802.1x enabled networks including **eduroam** in which case users can make various performance analyses per access point, per user, etc.

Easy to deploy



WiFiMon is a software image (also available as a Docker Image) and can be easily deployed on an NREN/University network on hardware or software probes.

Fine grained information on network performance



WiFiMon shows the end-user (mobile client) behaviour on a network, its perception about the responsiveness of the network and the speed of web resource downloads, correlation of the performance data with end-user data, and data analysis with an effective query builder.

Active monitoring with low network overhead



WiFiMon active measurements are not significantly invasive and do not use any significant bandwidth. One **WiFiMon** measurement is comparable to one average web-page download (load speed).

TechLab next steps

Collect information about test infrastructures from around the world, built and managed by projects and institutions of all kinds.

Want to join?

Contact us at netdev@lists.geant.org



Collaboration - How can you get involved?

Providing examples for the community portal.

Creating learning units, sharing your knowledge!

Mapping your architecture to the blueprint.

Running the Maturity Model survey.

Using the materials and Techlab and providing feedback.

...

Contact us at network-eacademy@lists.geant.org

More from NETDEV: **Production services**



[Argus - Alarm Aggregation and Correlation Tool](#)



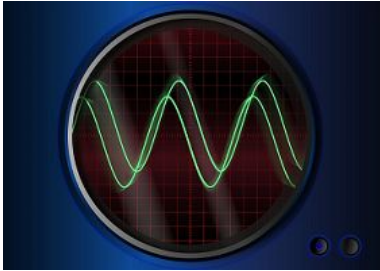
[TimeMap - Open-source Latency/Jitter Measurement Service](#)



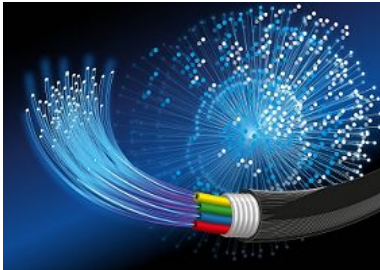
[Performance Measurement Platform \(PMP\)](#)

<https://wiki.geant.org/display/NETDEV/netdev@lists.geant.org>

More from NETDEV: Network development



[Optical Time and Frequency Networks \(OTFN\)](#)



[Quantum Technologies](#)

<https://wiki.geant.org/display/NETDEV>
netdev@lists.geant.org

Future Events

16-17 May, [18th SIG-NOC meeting](#), Stockholm Sweden including **Argus, perfSONAR**

22-26 May, [RIPE86](#), Rotterdam, the Netherlands including **WiFiMon and TimeMap**

02 June, GNA-G automation WG meeting in Utrecht, the Netherlands

05-09 June, [TNC23](#), Tirana, Albania including **Network Development in the GÉANT Project, Network eAcademy and the OAV Maturity Model, Argus, WiFiMon, Quantum Internet Activities in European NRENs**

06 June, [GNA-G side meeting at TNC23](#) Tirana, Albania

21 June, [Quantum Solutions](#), online



Thank You!

<https://wiki.geant.org/display/NETDEV/NeA>
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