



# Network eAcademy

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EURO-IX Meeting  
12<sup>th</sup>-14<sup>th</sup> May 2024, Heraklion, Greece

Public (PU)

## Maria Isabel in a *three* Nutshells



# CATNIX

Catalonia Neutral  
Internet Exchange

# ANELLA CIENTÍFICA

# GÉANT

Networks • Services • People

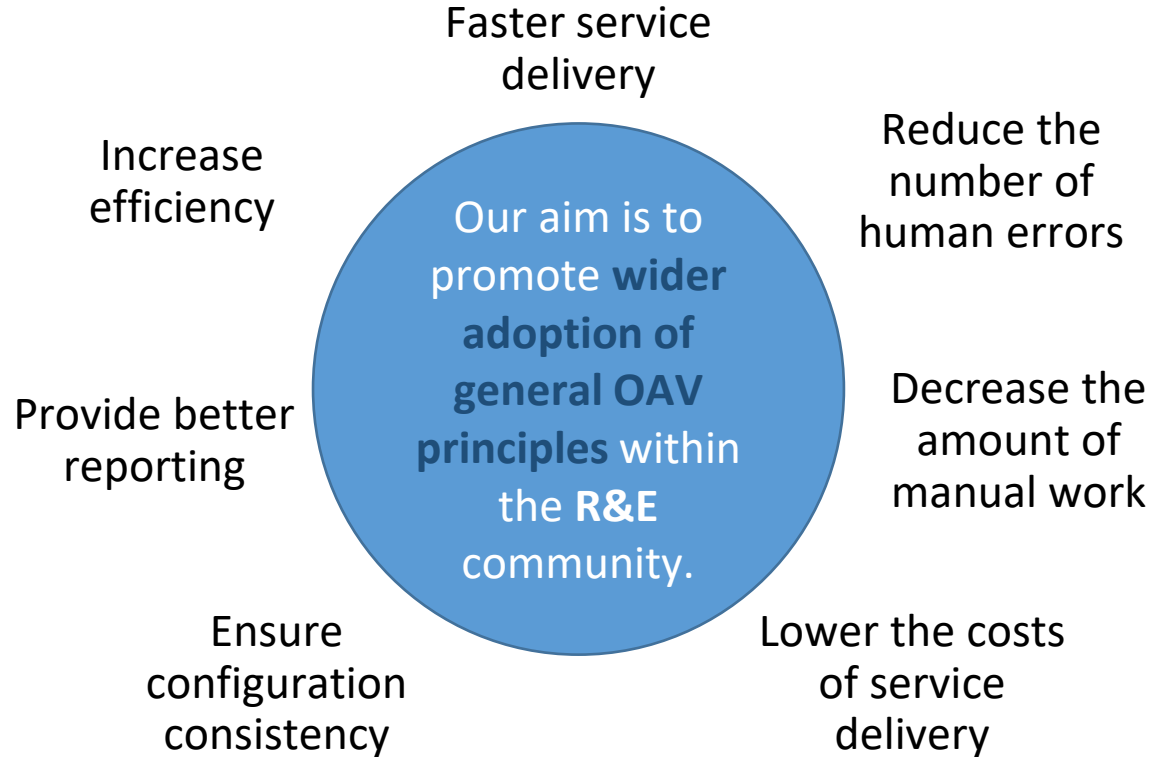
# Introduction - The GÉANT Project

GÉANT is the collaboration of European National Research and Education Networks (NRENs) on delivering an information ecosystem of infrastructure and services to advance research, education and innovation on a global scale:

- 50 million users
- 500 contributors from 37 R&E partners
- 9 projects so far
- Current project generation: GN5-1



## OAV: Orchestration, Automation and Virtualisation



## 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

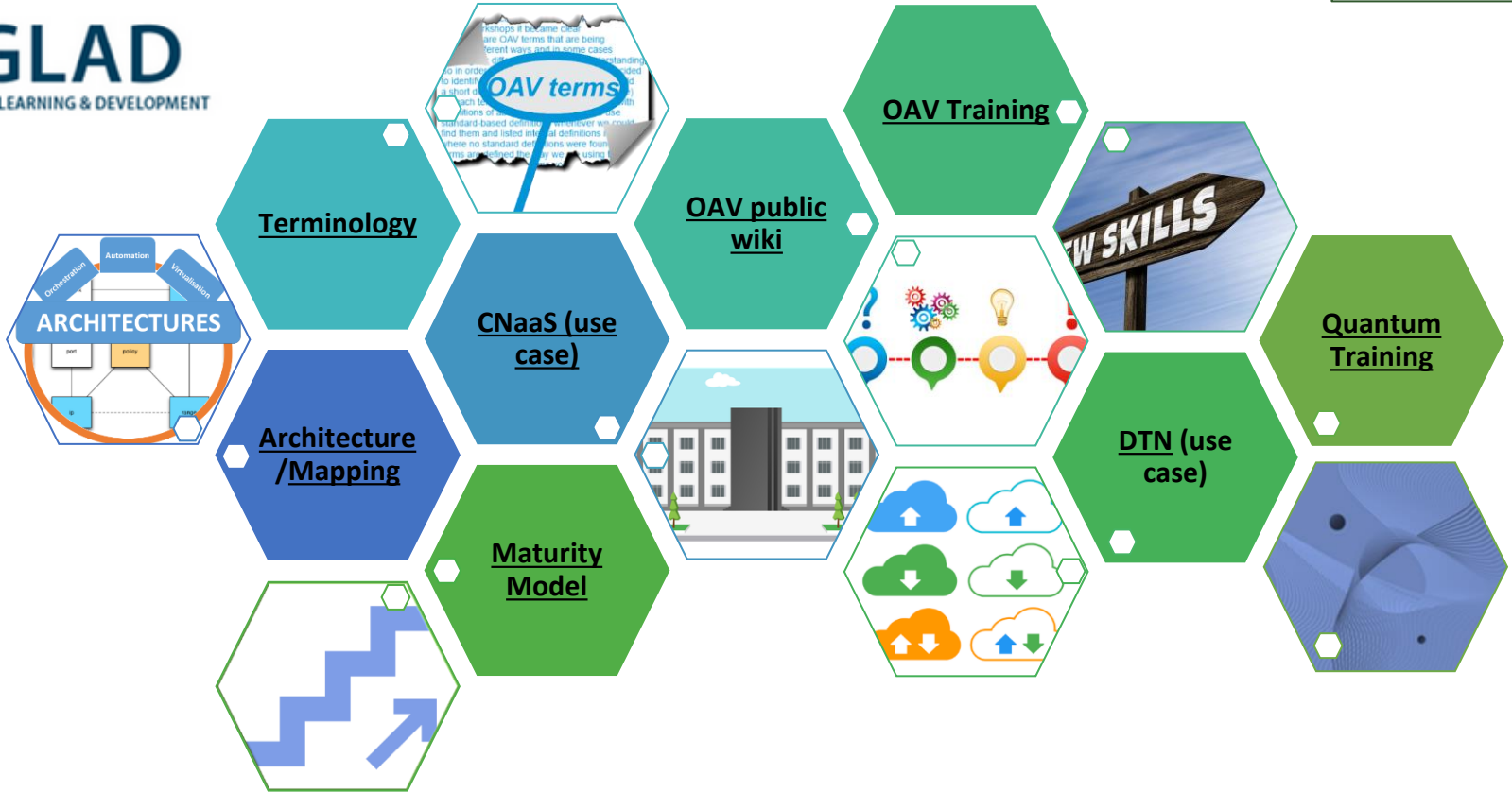
Feedback from the OAV Survey to the NRENs (published in Sep 19):

[https://www.geant.org/Projects/GEANT\\_Project\\_GN4-3/GN43\\_deliverables/D6-2\\_Automation-and-Orchestration-of-Services-in-the-GEANT-Community.pdf](https://www.geant.org/Projects/GEANT_Project_GN4-3/GN43_deliverables/D6-2_Automation-and-Orchestration-of-Services-in-the-GEANT-Community.pdf)

# Network eAcademy

Network eAcademy

Powered by:



## 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   |
|--|--|
| <b>AIOps</b>                                   | <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"> <li>• <a href="https://www.gartner.com/en/information-technology/glossary/aiops-artificial-intelligence-operations">https://www.gartner.com/en/information-technology/glossary/aiops-artificial-intelligence-operations</a></li> </ul>  |
| <b>AI-powered Virtual Agent (AIVA)</b>         | <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"> <li>• <b>Reference(s):</b> based on <a href="https://www.ringcentral.com/virtual-agent.html">https://www.ringcentral.com/virtual-agent.html</a> and TM Forum AI Fundamentals course [TMF_AIF] and TM Forum "AI and its pivotal role in transforming operations" report and webinar [TMF_AI]</li> </ul> |
| <b>API</b> (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                                |

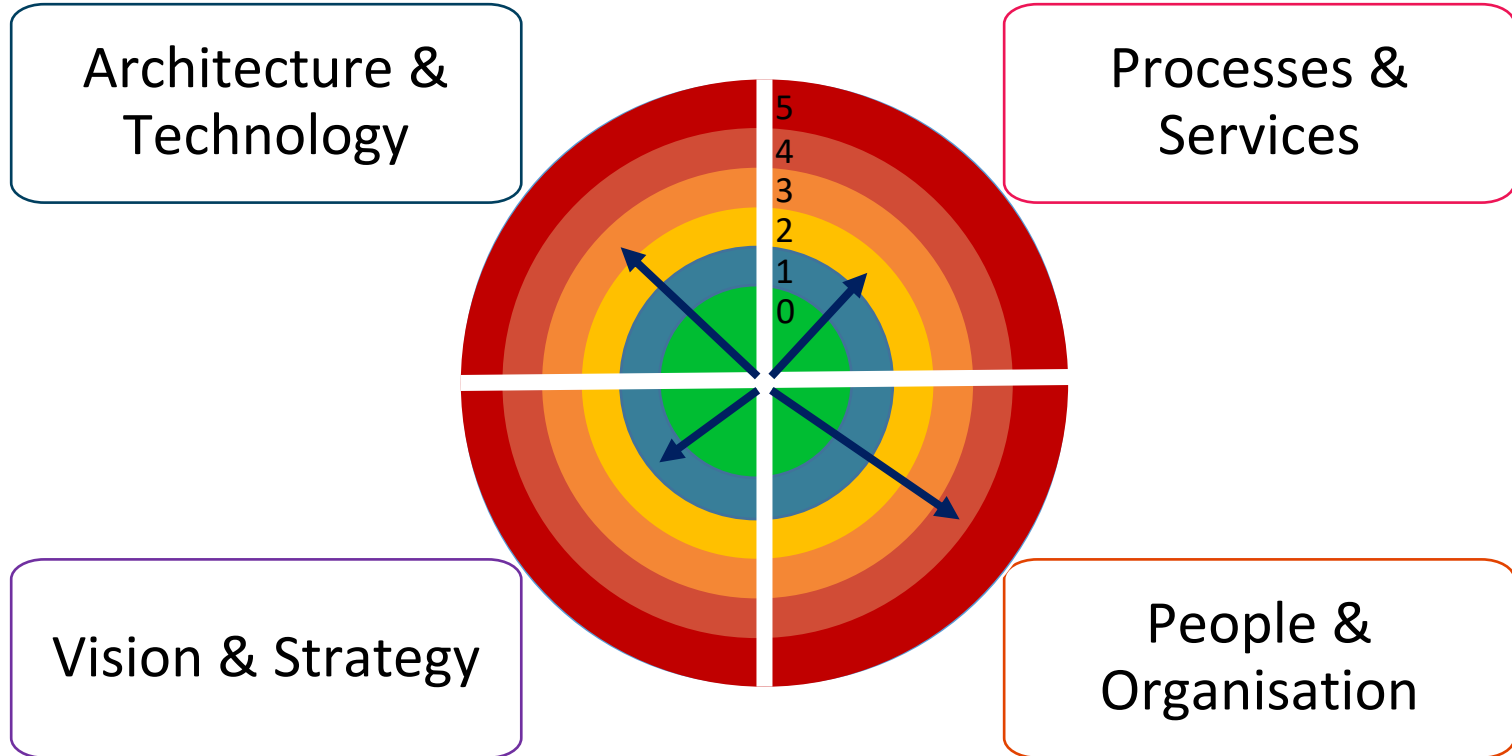
Survey (31 questions)\*: <https://www.surveymonkey.com/r/SPYDQVB>

Information on stages and dimensions: <https://wiki.geant.org/display/NETDEV/OAV+Maturity+Model>



## OAV Maturity Model - Dimensions

Maturity Model



# OAV Maturity Model - Stages










Maturity Model



# Wiki

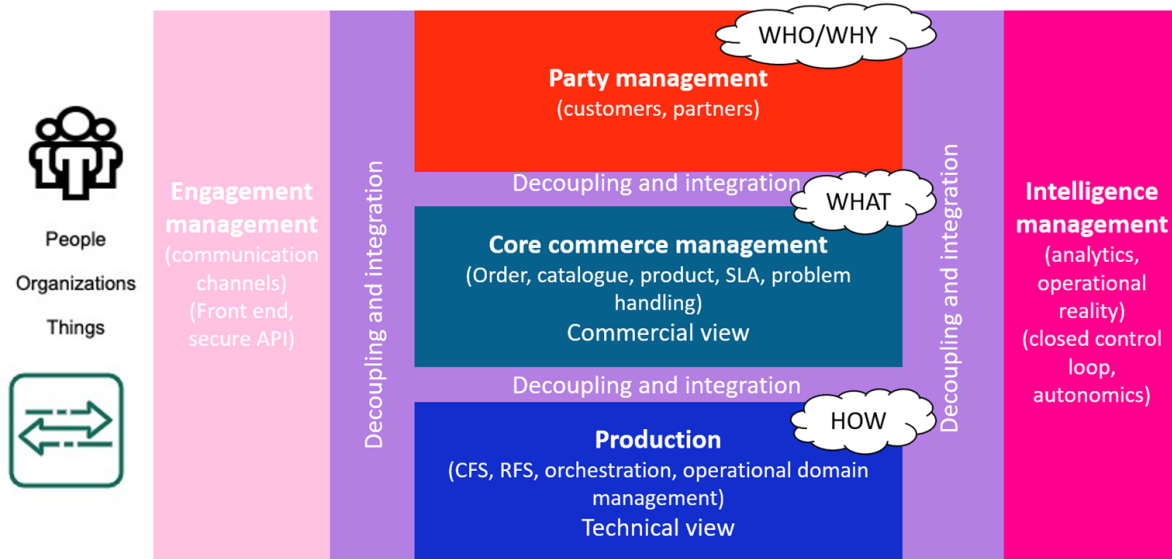
# Wiki

- [Community Portal](#)
- Sections for OAV:
  - [Architecture](#)
  - [Training](#)
  - [Maturity Model](#)
  - [Terminology](#)
  - [Literature](#)
  - [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   |
| <b>AARNET, Australia</b>  | <ul style="list-style-type: none"> <li>• <a href="https://www.aarnet.edu.au/">https://www.aarnet.edu.au/</a></li> <li>• Hendrik Buijning, David Jencho. Orchestration, Automation and Virtualisation, BOF, TNC19, Tallinn, Estonia, June 20, 2019 (pdf)</li> </ul>  |
| <b>ARNES</b>              | <ul style="list-style-type: none"> <li>• <a href="https://www.arnes.si/">https://www.arnes.si/</a></li> <li>• 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).</li> <li>• They have built the ARNES network service orchestration stack, automation based on Ansible.</li> <li>• <a href="https://geant.app.box.com/s/46892sq4bbo9683j8eybg65du7jhtz">https://geant.app.box.com/s/46892sq4bbo9683j8eybg65du7jhtz</a></li> </ul>  |
| <b>CARNET</b>             | <ul style="list-style-type: none"> <li>• <a href="https://www.carnet.hr/">https://www.carnet.hr/</a></li> <li>• Damir Regvar, Lidija Jakovčević, Siviđe Mišić. CARNET OAV, BOF, TNC19, Tallinn, Estonia, June 20, 2019 (pdf)</li> <li>• CARNET is also working on a national project to offer wireless connection within the schools in the country (<a href="https://www.e-skole.hr/en/results/adequate-ict-infrastructure-in-pilot-schools/">https://www.e-skole.hr/en/results/adequate-ict-infrastructure-in-pilot-schools/</a>), with a network management system built by them (Management system for the educational system). CARNET does the network provisioning and monitoring through an API: <a href="https://geant.app.box.com/s/9j5tdtbv2dshuffed137x7m9806mm16">https://geant.app.box.com/s/9j5tdtbv2dshuffed137x7m9806mm16</a></li> <li>• See the lightning talk during the Network Management and Monitoring Workshop.</li> </ul> |
| <b>CSUC</b>               | <ul style="list-style-type: none"> <li>• <a href="https://www.csuc.cat">https://www.csuc.cat</a></li> <li>• 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).</li> <li>• For the Internet Exchange, CATNIX, CSUC has an internal portal where customers can add their new MAC addresses and the filters are uploaded in the switches through Python scripts.</li> </ul>  |
| <b>CyNet</b>              | <ul style="list-style-type: none"> <li>• <a href="http://www.cynet.ac.cy/">http://www.cynet.ac.cy/</a></li> <li>• <a href="https://www.geant.org/Resources/Documents/GN4-3_White-Paper_CyNET_OAV_Architecture_Analysis.pdf">sibila@acac: CyNET OAV Architecture Analysis</a>, <a href="https://www.geant.org/Resources/Documents/GN4-3_White-Paper_CyNET_OAV_Architecture_Analysis.pdf">https://www.geant.org/Resources/Documents/GN4-3_White-Paper_CyNET_OAV_Architecture_Analysis.pdf</a></li> <li>• Iacovos Ioannou. Active member of OAV working group of WP6-T2.</li> </ul>  |
| <b>ESnet, USA</b>         | <ul style="list-style-type: none"> <li>• <a href="http://es.net/">http://es.net/</a></li> <li>• John MacKuley. Service orchestration in ESnet6, BOF, TNC19, Tallinn, Estonia, June 20, 2019 (pdf)</li> </ul>  |
| <b>FUNET</b>              | <ul style="list-style-type: none"> <li>• <a href="https://www.csc.fi/funet-kalkki-palvelut">https://www.csc.fi/funet-kalkki-palvelut</a></li> <li>• Aapo Hakala. Workshop on Network Management and Monitoring, Copenhagen, October 2019: <a href="https://wiki.geant.org/download/attachments/131629403/_funet%20kampus%20service.pdf?version=1&amp;modificationDate=1571047052736&amp;api=v2">https://wiki.geant.org/download/attachments/131629403/_funet%20kampus%20service.pdf?version=1&amp;modificationDate=1571047052736&amp;api=v2</a>.</li> <li>• Kampus Service Project. All new customer provisioning is automated, with no manual configuration (only physical installation).</li> <li>• Everything automated using Ansible, configuration stored in YAML files.</li> </ul>  |
| <b>GEANT</b>              | <ul style="list-style-type: none"> <li>• <a href="https://www.geant.org/">https://www.geant.org/</a></li> <li>• Bram Peeters. Orchestration, Automation and Virtualisation (OAV) in GEANT, GN4-3 Future Service Strategy Workshop, Amsterdam, May 9, 2019 (pdf)</li> <li>• Mian Usman. Orchestration and Automation, BOF, TNC19, Tallinn, Estonia, June 20, 2019 (pdf)</li> <li>• Tony Barber. 10th SIG-NOG meeting presentation</li> </ul>   |

## Architecture & Mappings

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



### NREN mappings to date:

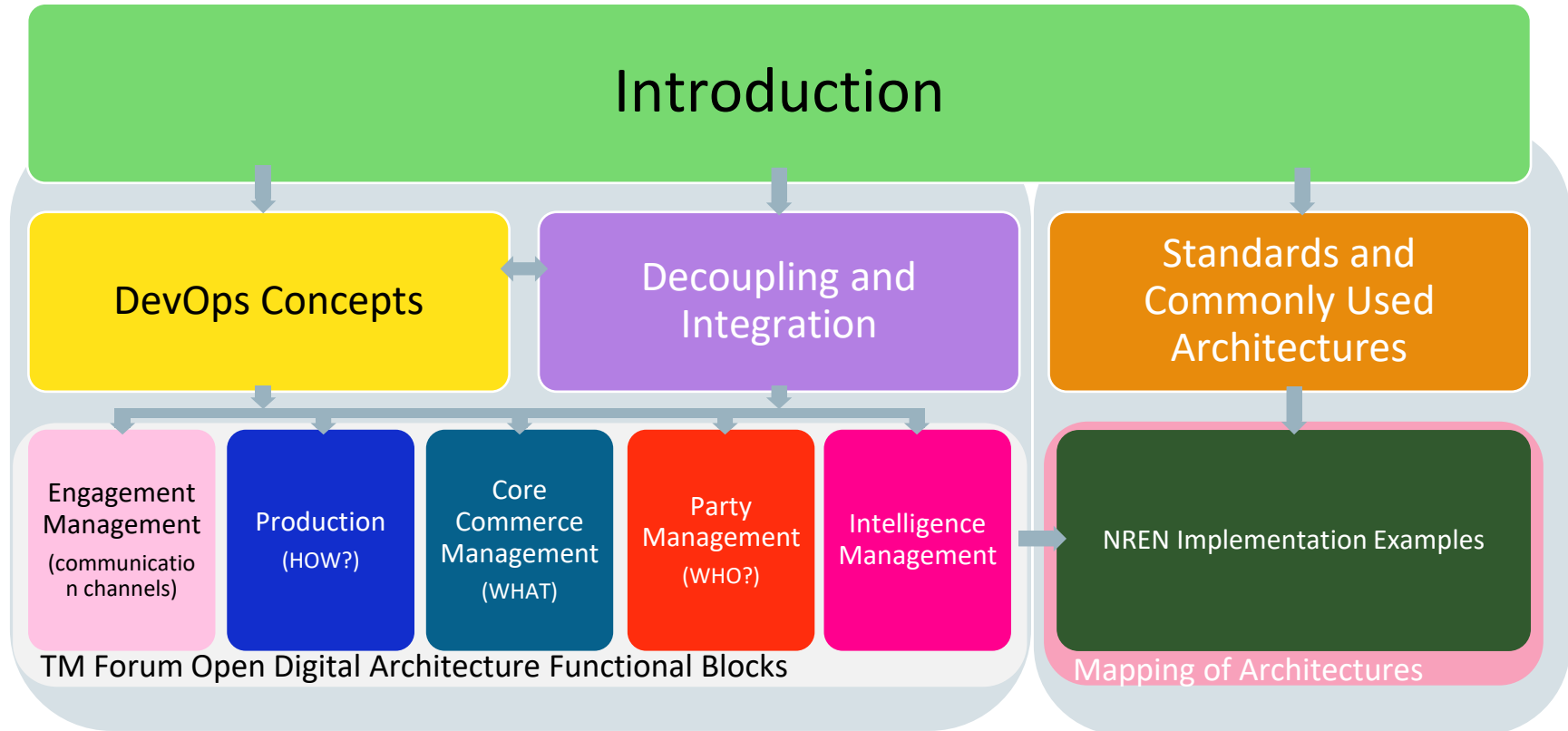
- [CARNET](#)
- [CYNET](#)
- [GÉANT](#)
- [GRNET](#)
- [HEAnet](#)
- [PIONIER](#)
- [SURFNET](#)

### Platform mappings to date:

- [Argus](#)
- [NMaaS](#)
- [PMP](#)

# Knowledge Map for the Training

Training



# Network Automation eAcademy



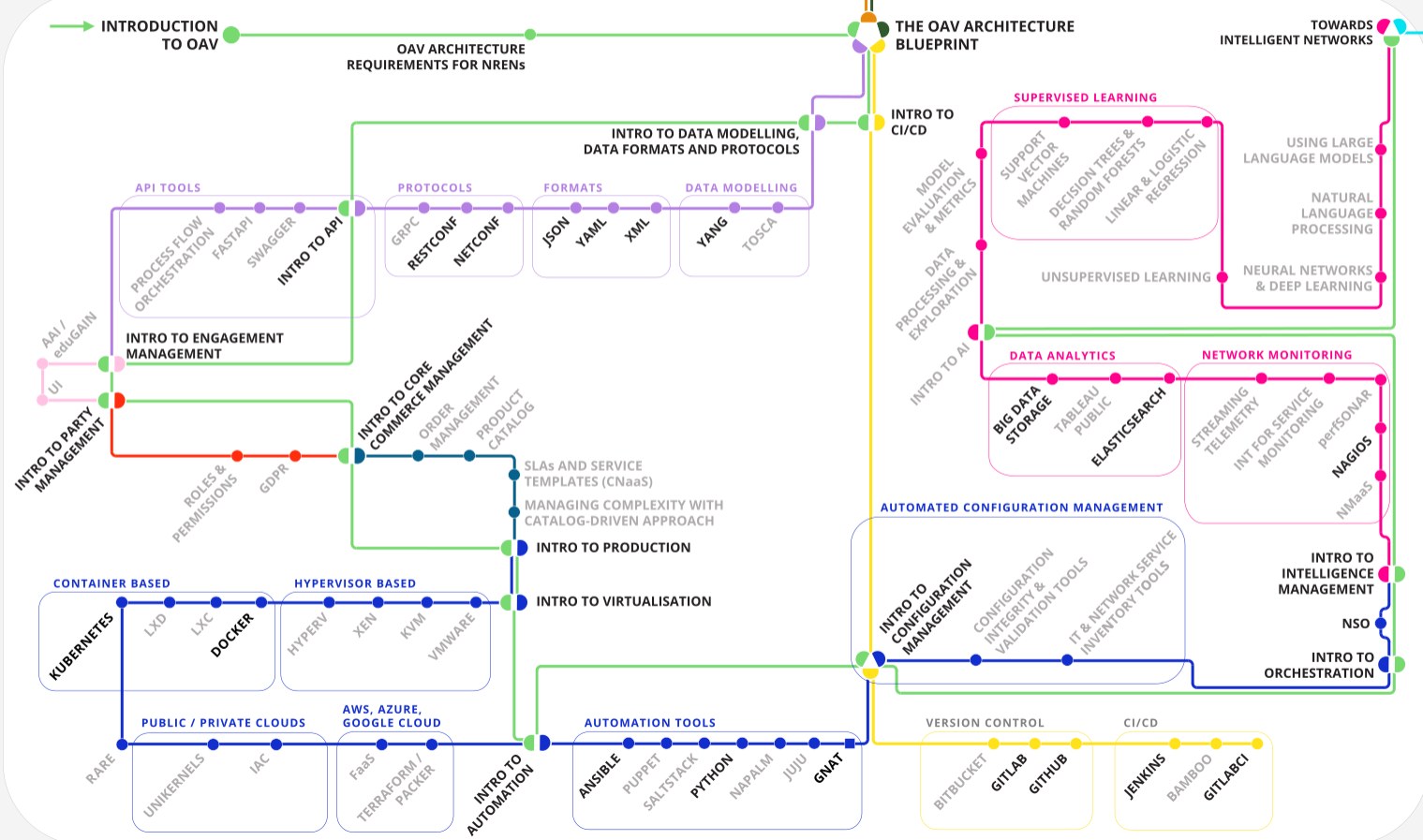
**Legend**

- Unit / ■ Document
- Released / ● Not released
- Exchange point

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

**Tracks**

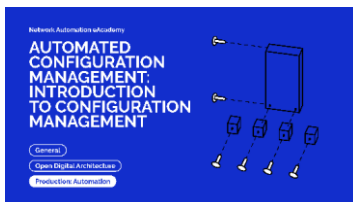
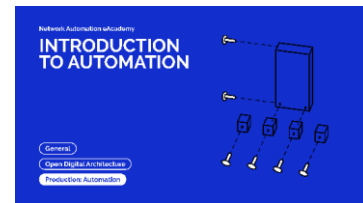
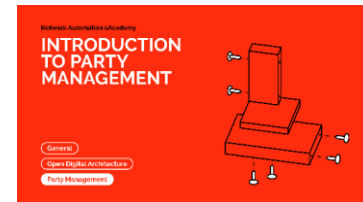
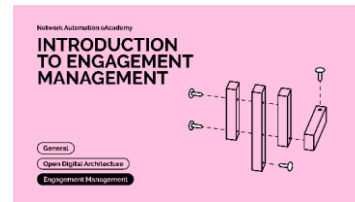
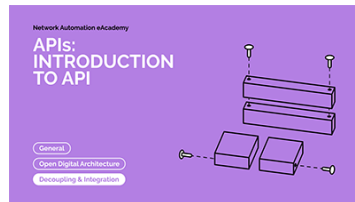
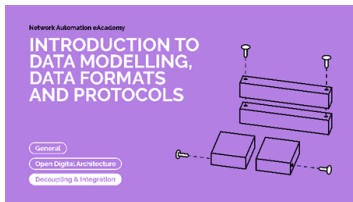
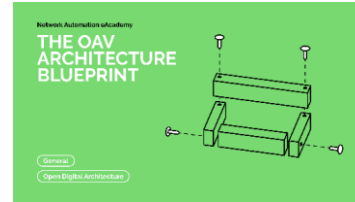
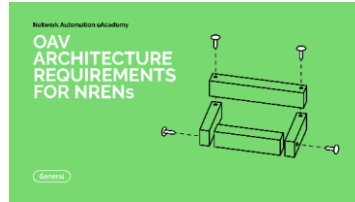
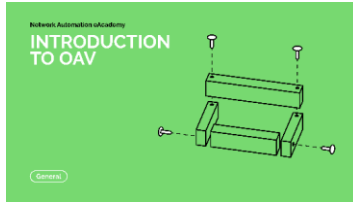
- GENERAL INTRODUCTION
- AGILE, DevOps, CI/CD
- DECOUPLING & INTEGRATION
- PRODUCTION
- ENGAGEMENT MANAGEMENT
- PARTY MANAGEMENT
- CORE COMMERCE MANAGEMENT
- INTELLIGENCE MANAGEMENT
- OAV REALISATION
- USE CASES AND EXAMPLES
- ARCHITECTURE



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

# General Introduction Line

## Training



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

+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

2h

Network Automation Academy

**APIs: INTRODUCTION TO API**

General  
Open Digital Architecture  
Decoupling & Integration

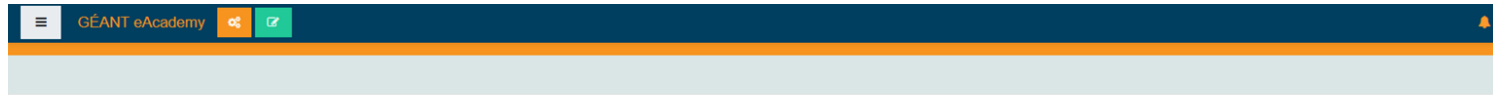
45'

<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



|  |                                       |   |
|--|---------------------------------------|---|
| <b>COURSE DATE:</b><br><br>On Demand                   | <b>DURATION:</b><br><br>60 minutes    | <b>COMMITMENT:</b><br><br>60 minutes + lab time |
| <b>REQUIREMENT:</b><br><br><b>YAML Learning Module</b> | <b>COURSE TYPE:</b><br><br>Self-paced | <b>CREDENTIAL:</b><br><br>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



**COURSE DATE:**

From September 2021



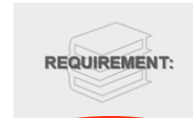
**DURATION:**

20 min



**COMMITMENT:**

30 min



**REQUIREMENT:**

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



**COURSE TYPE:**

Selfpaced



**CREDENTIAL:**

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 modeling, 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

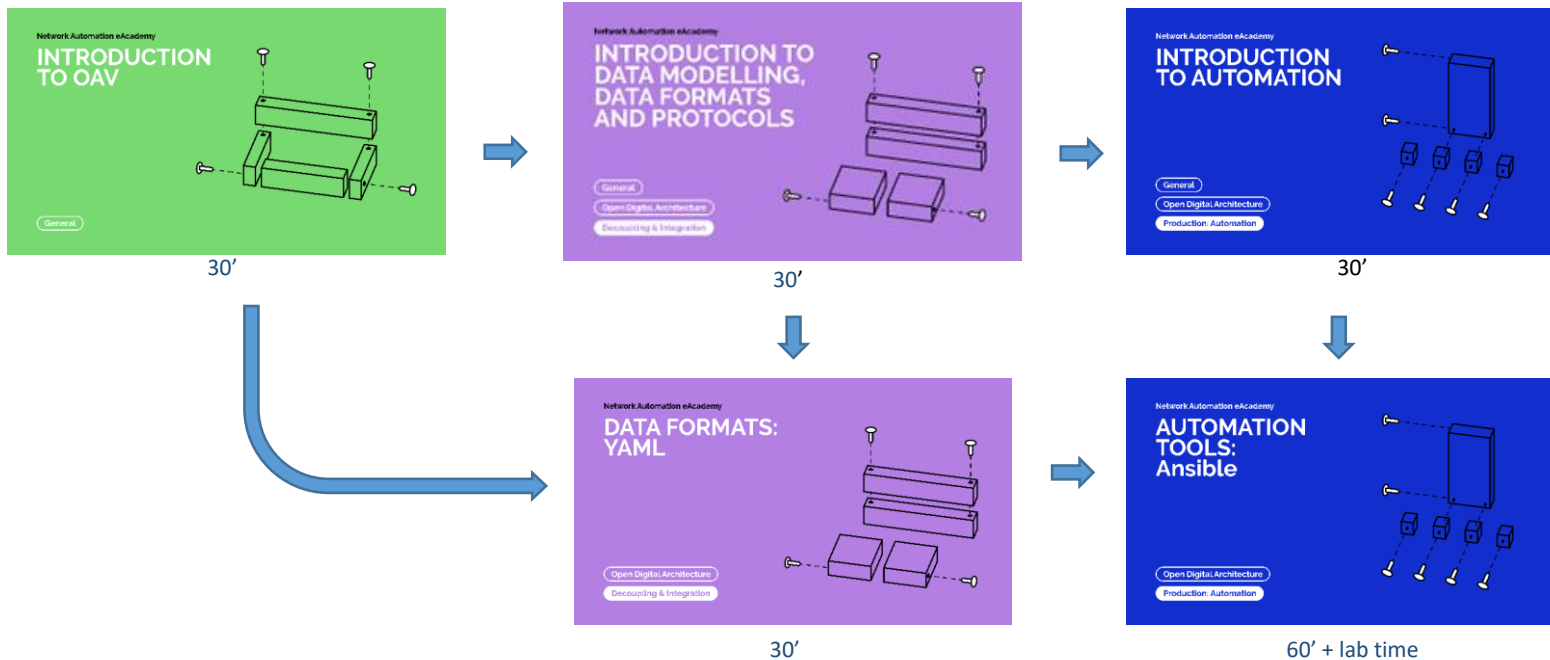
CREDENTIAL:

Certificate of Completion

|                |   |
|----------------|---|
| Learning path: | <a href="#">OAV Training Portal</a>   |
| Preceded by:   | <a href="#">Introduction to CI/CD</a>   |
| Followed by:   | <a href="#">Introduction to APIs in the Introductory line</a><br><a href="#">Data Modelling: YANG in the Open Digital Architecture line</a> |

<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

☰ GÉANT 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

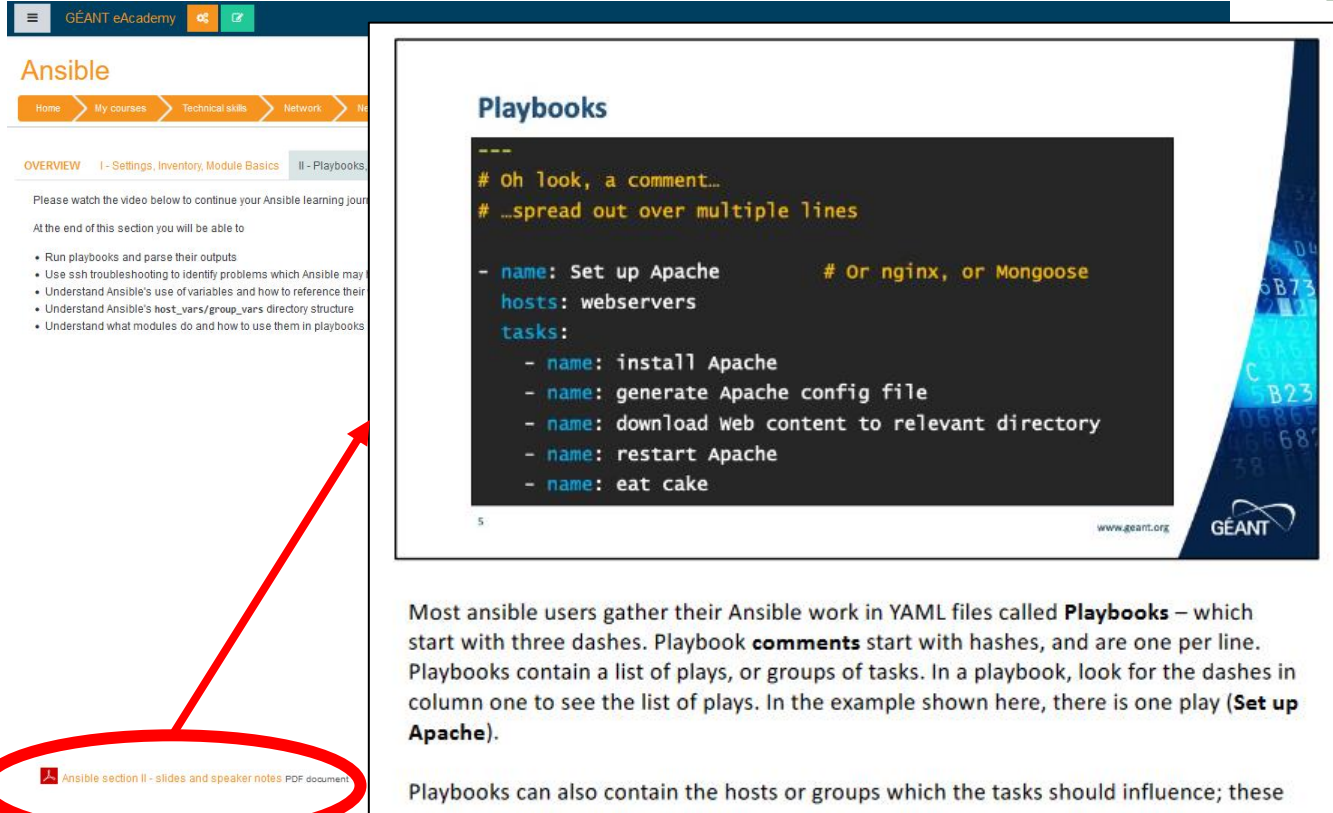
    - name: enable mod_rewrite
      apache2_module: name=rewrite state=present
      notify:
        - restart_apache2

  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




The slide content is as follows:

## 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')
- **Version control: Gitlab** (40')
- **Version control: GitHub** (2h)
- **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')
- **Protocols: RESTCONF** (2h)

### 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')

### Data Analytics

- **Big Data Storage** (1.5h)
- **Elasticsearch** (30')

## OAV Realisation

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

## ADDITIONAL READING

### Architecture Mappings

#### NREN use cases

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

#### other use cases

- Argus
- NMAaS
- **New: PMP**
- SPA

### Architectures

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

### External Collaborations

- **New: Automation tools: GNAT** (GNOC)

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

## 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

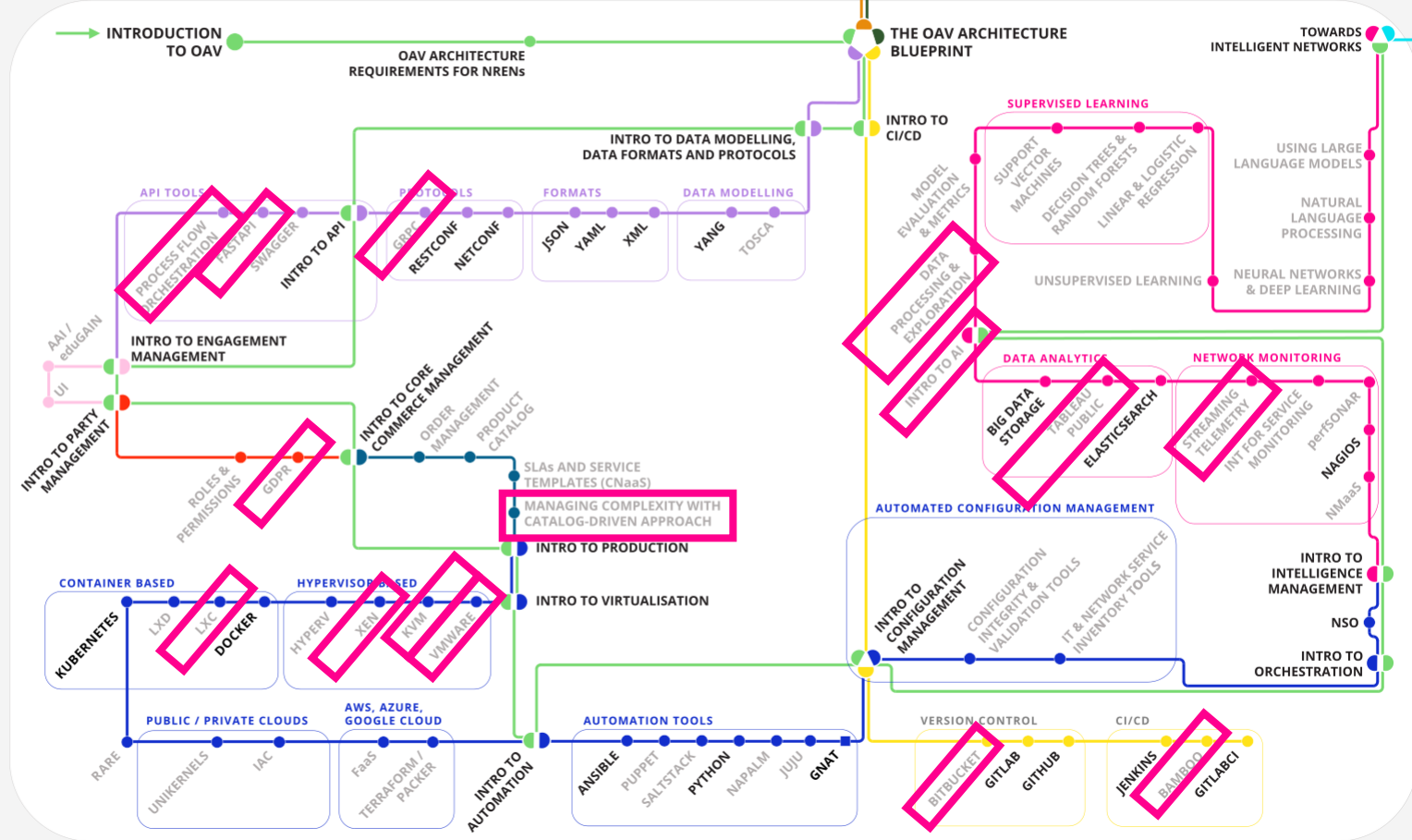


**Legend**

- 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



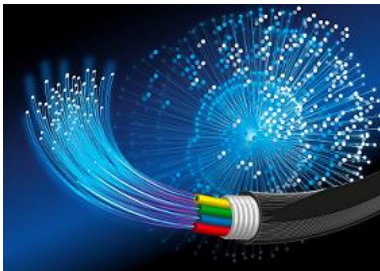
Functional Blocks in the TM Forum OPEN DIGITAL ARCHITECTURE (ODA)

## Currently Working also on Training for:

Training




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



[Quantum Technologies](#)


# 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



# Thank You!

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Co-funded by  
the European Union