

# THE OPEN BATON TOOLKIT



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WWW: [www.5G-Playground.org](http://www.5G-Playground.org) / [www.open-baton.org](http://www.open-baton.org)



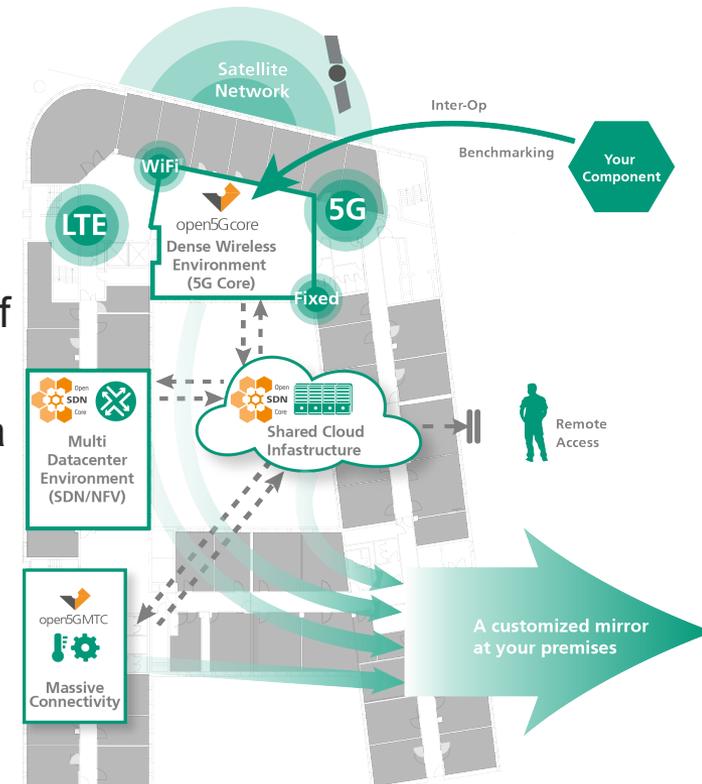
**OPEN BATON**



# THE FRAUNHOFER FOKUS 5G PLAYGROUND

## 5G Playground: A comprehensive testbed environment for prototyping 5G-ready NFs using OpenBaton orchestration

- Open5GCore providing the next wireless system beyond LTE/EPC with more efficient communication for the subscribers and improved automation/reliability (applying SDN and NFV principles)
- Open5GMTC enabling connectivity management and end-to-end service establishment for a huge number of connected devices
- OpenSDNCore enabling SDN experimentation for data path, backhaul networks or customized network environments
- All those are Software components and can be customized, deployed and configured on demand via OpenBaton enabling automatic just-in-time test environment creation, experimentation and demonstration



# MANY NFV POCS HAVE BEEN EXECUTED: WE KNOW IT CAN WORK!

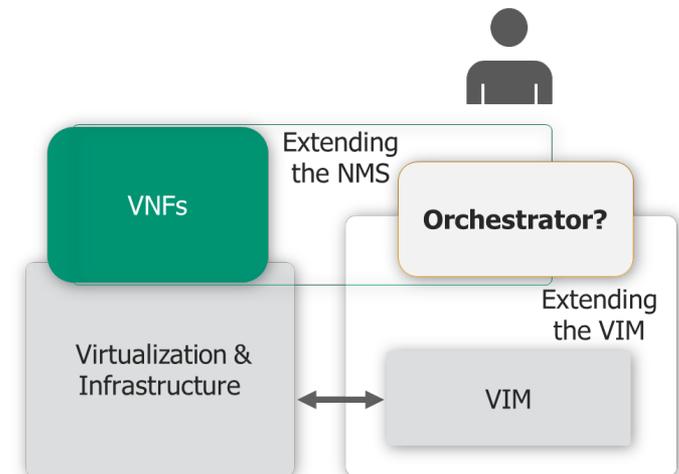
- ETSI NFV includes a framework for Proof-of-Concept implementations
  - Gives the opportunity to test in a live environment pieces of the NFV architecture
  - Give a level of certainty on the current advancements of the technology
  - A large number of industry partners congregate towards a specific goal
  - Provides directions for the next standardization items (hot topics):
    - Use of SDN in the NFV architectural framework
    - Test methodology for NFV
    - End-to-end fault correlation
    - Lawful interception
- Status: October 2015: 38 PoCs were initiated
- Commercial deployments up to this moment:
  - NEC and NTT DOCOMO tests a vEPC in Myanmar (May 2014)
    - [http://www.nec.com/en/press/201410/global\\_20141014\\_04.html](http://www.nec.com/en/press/201410/global_20141014_04.html)
  - NTT DOCOMO plans an initial NFV deployment (planned for 2016)
    - [https://www.nttdocomo.co.jp/english/info/media\\_center/pr/2015/0302\\_00.html](https://www.nttdocomo.co.jp/english/info/media_center/pr/2015/0302_00.html)



# A comprehensive MANO orchestrator is (still) missing...

## Two approaches in regard to orchestration were taken:

- Orchestrating from the infrastructure perspective
  - Extending the VIM functionality towards providing service orchestration. Missing:
  - Adaptation to complex network services requirements:
    - e.g. fault management, scaling, network function placement, virtual network configuration, information flow paths, security, reliability
- Orchestrating from the network service perspective
  - Extending the Network Management System to handle orchestration. Missing:
    - Capitalize through native developed components on the cloud opportunities: scaling, dynamic resource allocation
    - Fix the remaining problems: define the appropriate network service KPIs, end-to-end fault management, providing end-to-end reliability insurance, etc.

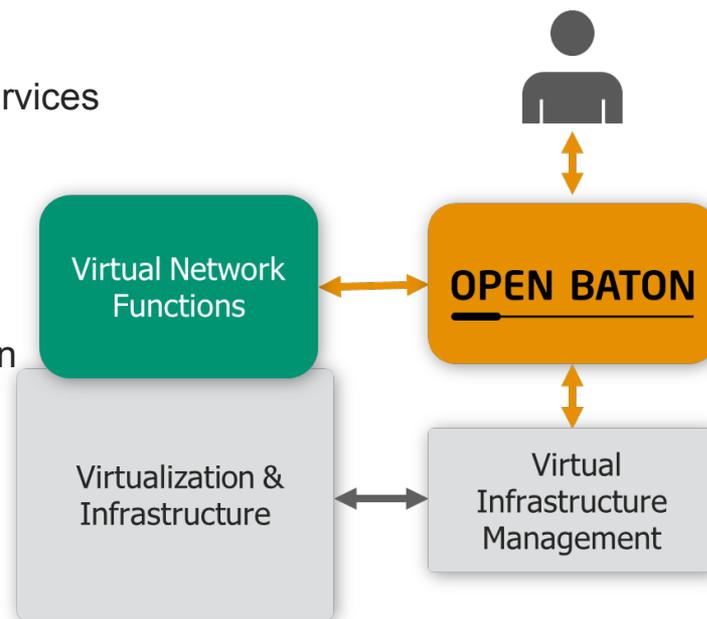


➔ With more than 10 years of experience in network services and network services implementation as software *and* in cloud management, Fraunhofer FOKUS is in the unique position to understand and practically implement the connection between the two worlds.

# What is OpenBaton?

## OpenBaton is an Open Source implementation of the ETSI MANO specification

- OpenBaton aims to foster, within the NFV framework, the integration between the:
  - Virtual Network Function providers
  - Cloud Infrastructure providers
- Functionality:
  - Installation, deployment and configuration of network services
  - Runs on top of multi-site OpenStack
  - Provides independent infrastructure slices
  - Support for generic or specific VNF management
  - A large amount of virtualization use cases  
e.g. core networks, M2M and Multimedia communication
- Designed for answering R&D requirements
  - Easy to configure and to deploy
  - Providing a centralized view of the testbed



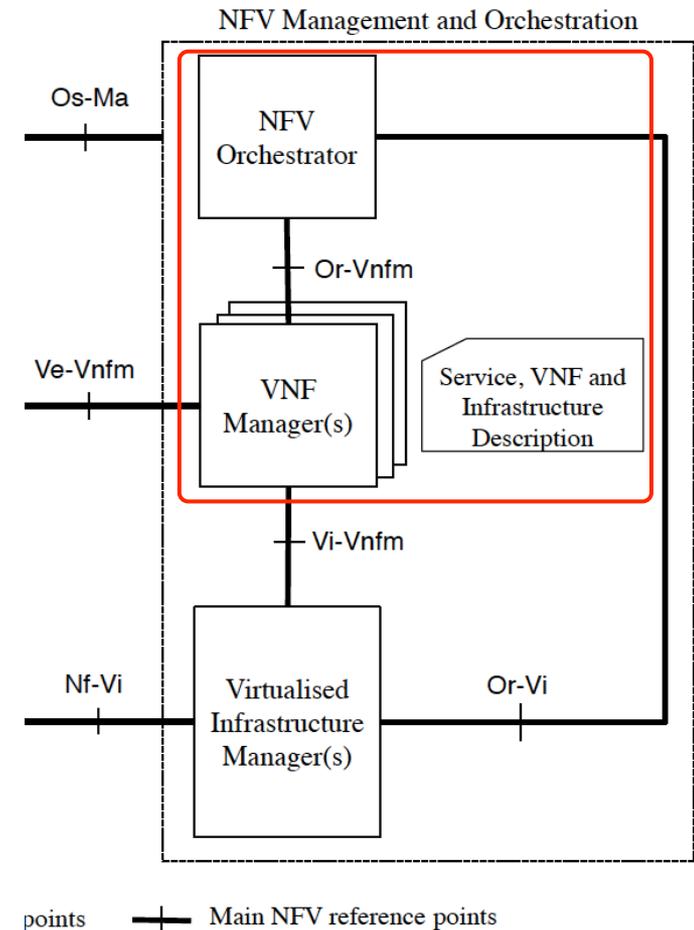
# What OpenBaton stands for

- No vendor lock-in: OpenBaton does not contain any vendor specific features. It follows open specifications and it is open to the community
- Built from scratch following the ETSI MANO specification.
  - The NFVO uses the ETSI NFV data model internally for the definition of the Network Service and Virtual Network Descriptors.
- Allows interoperability
  - Being interoperable is one of the challenges brought by the fragmented ecosystem in the management and orchestration area. It requires a lot of work to make two different vendors solution working together → need of a single vendor-independent platform
- Gives a fast access to Fraunhofer know-how
  - Large experience in network functions implementations (as software)
  - Large experience in cloud network management

# OPENBATON

## The reference implementation of the ETSI NFV MANO specification

- OpenBaton is based on the ETSI NFV MANO v1.1.1 (2014-12) (\*) specification. It provides
  - A **NFV Orchestrator** managing the lifecycle of Network Service Descriptors (NSD) and interfacing with one or more VNF Manager(s) (VNFM)
  - A **generic VNFM**, which can be easily extended for supporting different type of VNFs
  - A **set of libraries** which could be used for building your own VNFMs (vnfm-sdk)
  - A **dashboard** for easily managing all the VNFs
- It integrates with OpenStack as main VIM implementation



# From OpenSDNCore to OpenBaton

2013

2014

2015

Today

2020+

**Rel.1** of the platform providing basic NFV and SDN prototypes

Fully virtualization of the core network using SDN principles

**Rel.2** including a fully virtualized 5G-based core network, basic service function chaining

Software Defined Networks

Network Function Virtualization

## open SDN core

Fraunhofer FOKUS

**Service Function Chaining** components, MPLS, OSPF, **GTPU load balancing**, metering and queues for **controlled QoS**

New R&D projects

## OPEN BATON

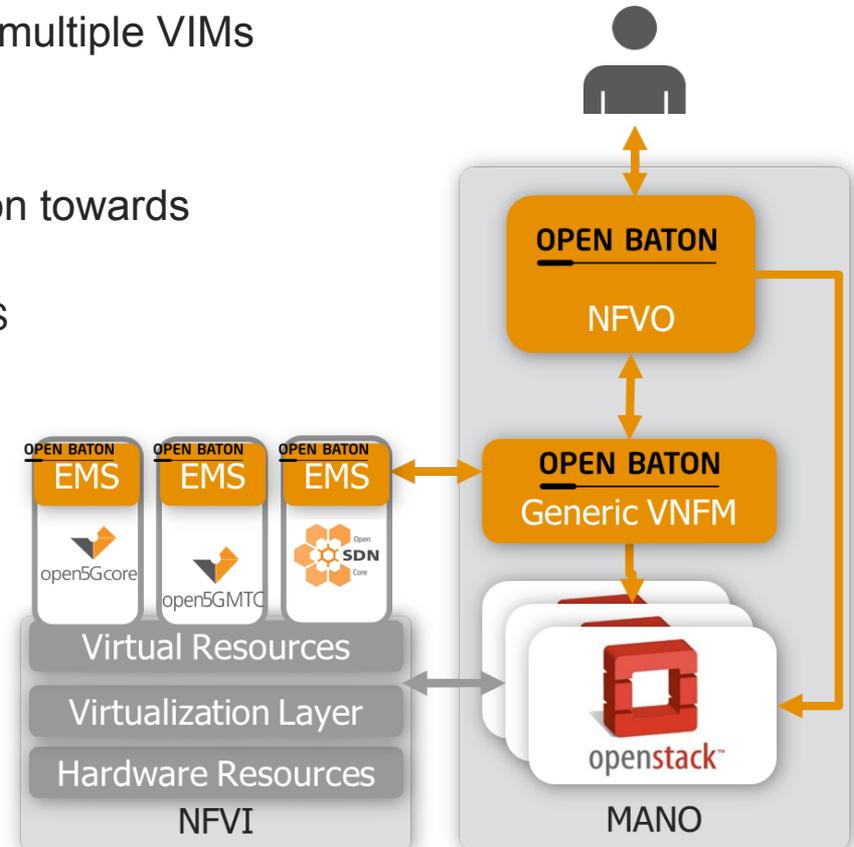
OpenSource implementation of the **NFV Orchestrator**, integrating with a **generic VNFM**

New R&D projects

# OpenBaton Environment

## OpenBaton is the missing piece of the larger virtualization ecosystem

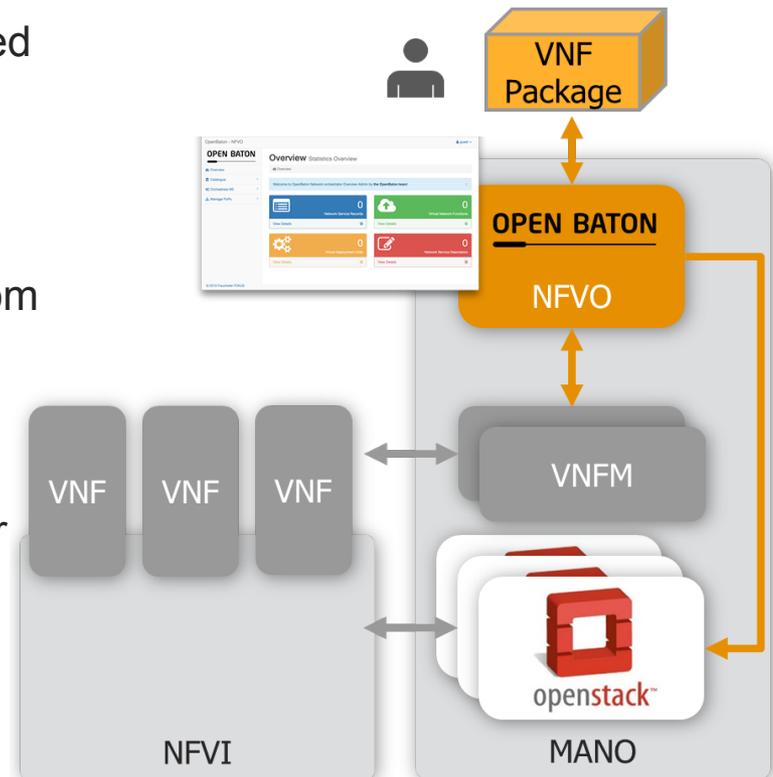
- OpenBaton was designed to interact with multiple VIMs
  - Currently OpenStack is supported
- OpenBaton extends the basic orchestration towards network functions management
  - Includes a generic VNFM and a generic EMS
  - Can interoperate with other VNFMs
- Enables the deployment of multiple customized network slices
- OpenBaton environment includes multiple data centers
  - Allocating resources on top of multiple OpenStack installations



# OpenBaton - Orchestrator

## The orchestrator implements the key functionalities of the MANO architecture

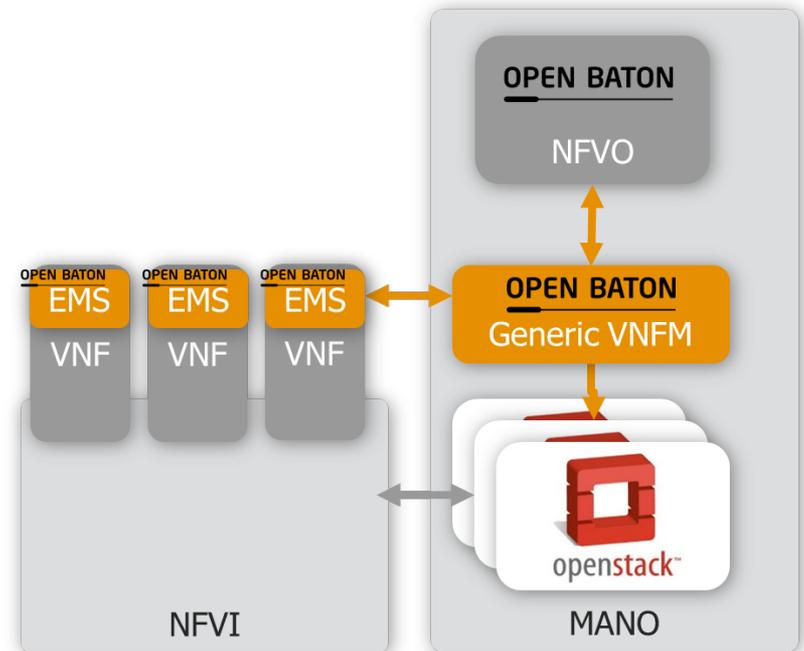
- Currently uses the OpenStack as first integrated NFV PoP VIM
- Maintains an overview on the infrastructure, supporting dynamic registration of NFV PoPs
- Receives virtual network function packages from the different users including VNF images and virtual network functions descriptors (VNFDs)
- Deploys on-demand the VNFs on top of an infrastructure consisting of multiple data center instances (NFV PoPs)
- Deploys in parallel multiple slices one for each tenant, consisting of one or multiple VNFs



# OpenBaton – Generic VNFM

**The Generic VNFM (together with the Generic EMS) has the following NFV functionality:**

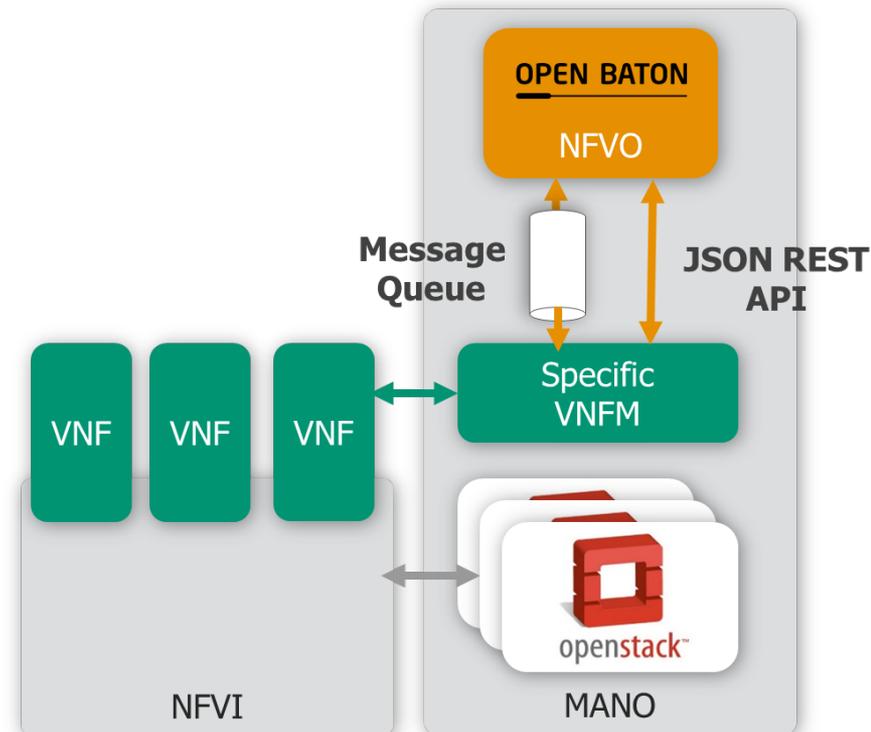
- Request to the NFVO the allocation of specific resources
  - for the virtual network instance
- Can request from the NFVO the:
  - instantiation,
  - modification,
  - starting and stoppingof the virtual services (or directly to the VIM)
- Instructs the generic OpenBaton EMS to save and to execute specific configuration scripts within the virtual machine instances



# OpenBaton – Supporting external VNFM

Albeit, OpenBaton offers a generic VNFM which can be easily extended for the different services, it includes also a set of mechanisms which enable the support for external VNFM

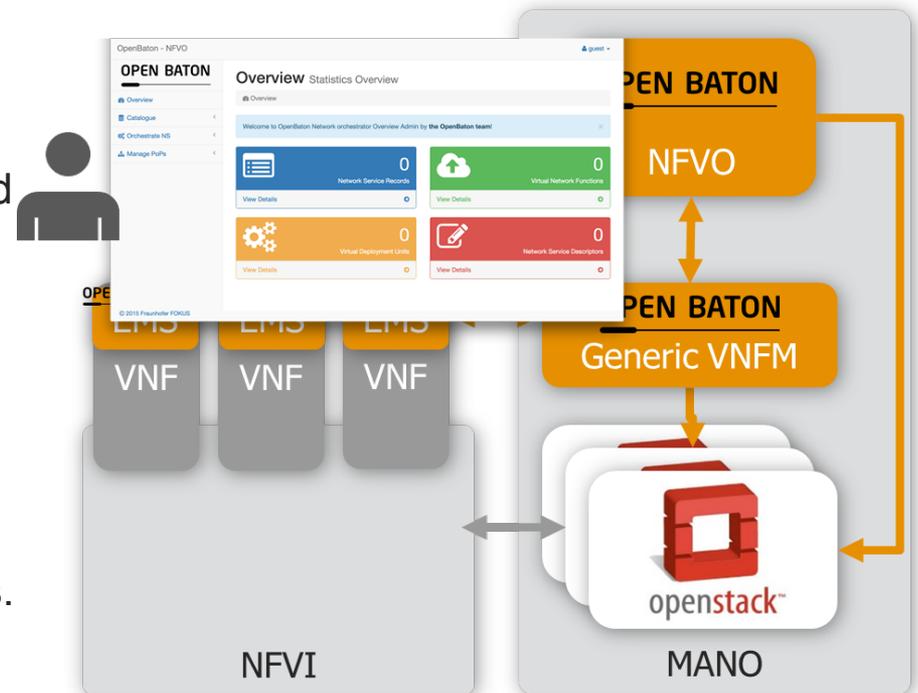
- The interface between VNFM and NFVO provides mechanisms for instantiating, modifying, terminating a VNF
  - A granting mechanism allow the VNFM to either directly instantiate the virtual resources or request their instantiation to the NFVO
- The NFVO provides two different mechanisms for interacting with VNFM:
  - Publish/Subscribe mechanism
    - Over a JMS message queue
  - RESTful API



# OpenBaton – The Dashboard

OpenBaton includes a user-user friendly dashboard which enables the management of the complete environment

- The control of the infrastructure
  - enabling the easy understanding and modification of the dynamic registered NFV PoPs;
- The management of the deployed network services
  - their creation (install, deploy, configure)
  - the overview of the deployed services.



# OpenBaton – The Dashboard (cont.)

The screenshot displays the OpenBaton dashboard interface. At the top, the browser address bar shows 'localhost'. The page title is 'OpenBaton - NETO' with a user profile 'guest' in the top right corner. A left sidebar contains navigation links: 'Overview', 'Manage Service', and 'Manage Infrastructure'. The main content area is titled 'Overview Statistics Overview' and features a welcome message: 'Welcome to OpenBaton Network orchestrator Overview Admin by the OpenBaton team!'. Below this, four data cards are presented in a 2x2 grid:

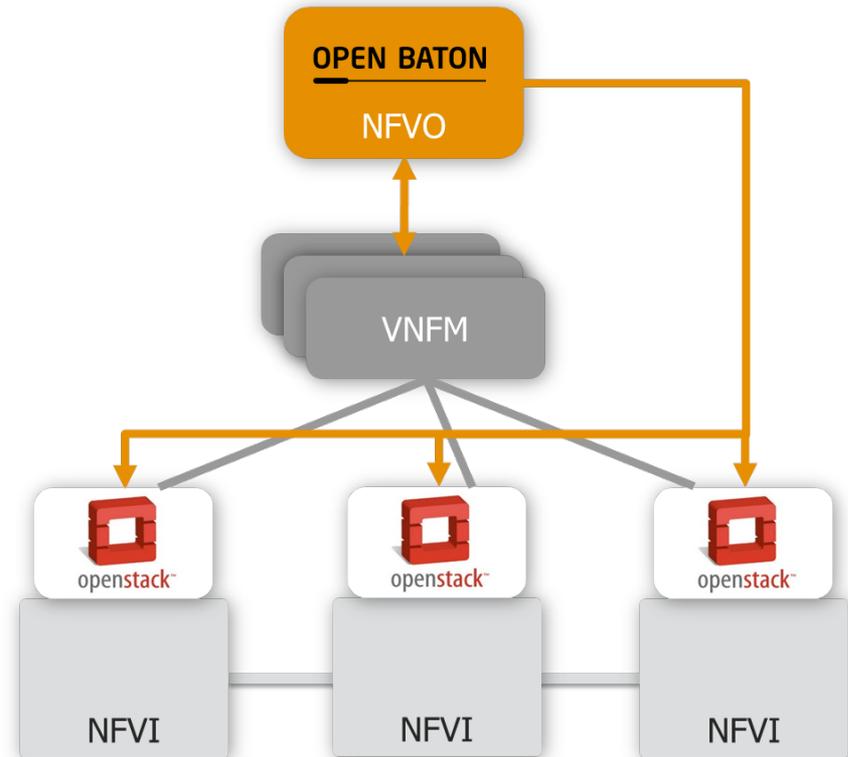
- Network Service Records:** 0 records. Card color: blue.
- Virtual Network Functions:** 8 functions. Card color: green.
- Units:** 5 units. Card color: orange.
- Network Service Descriptors:** 0 descriptors. Card color: red.

Each card includes an icon, a numerical value, the category name, and a 'View Details' link with a right-pointing arrow.

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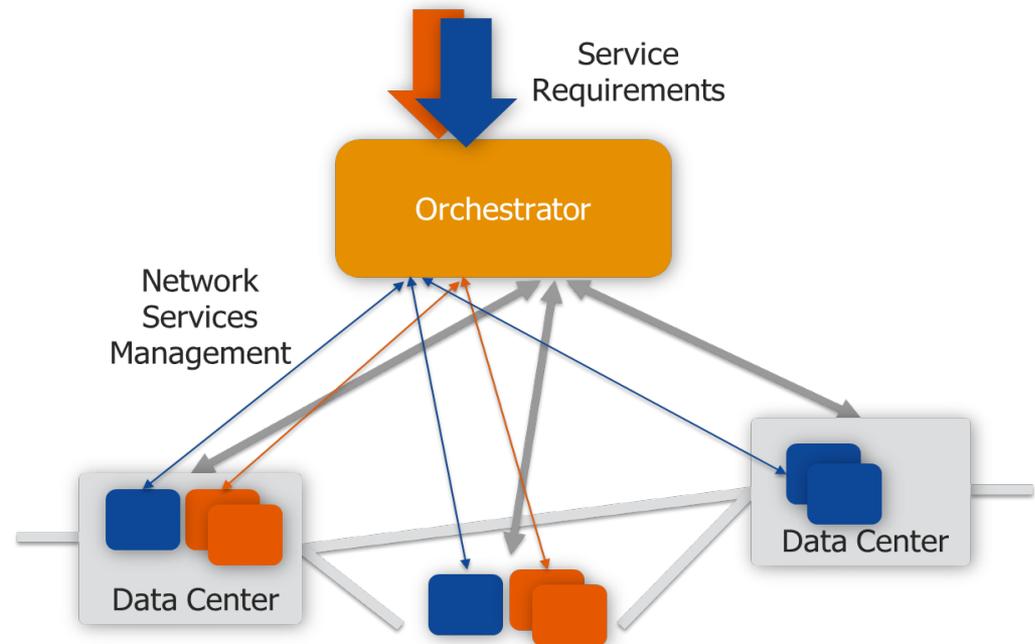
# OpenStack as the first integrated Point of Presence (PoP)

- OpenStack as the standard de-facto implementation of the VIM:
  - Creation of virtual networks based on the requirements provided by the VNFDs
  - Image management
  - Creation of virtual machines which are used for hosting the VNFCs
- NFVO uses the quota information provided by VIM for reserving the resources required by each NS



# Slicing

- OpenBaton enables the deployment of multiple virtual network services in parallel
  - Each network service is independently configurable and managed by the orchestrator
  - Services are isolated (having their own compute, storage and virtual networks)
  - Services may be composed from multiple VNFs

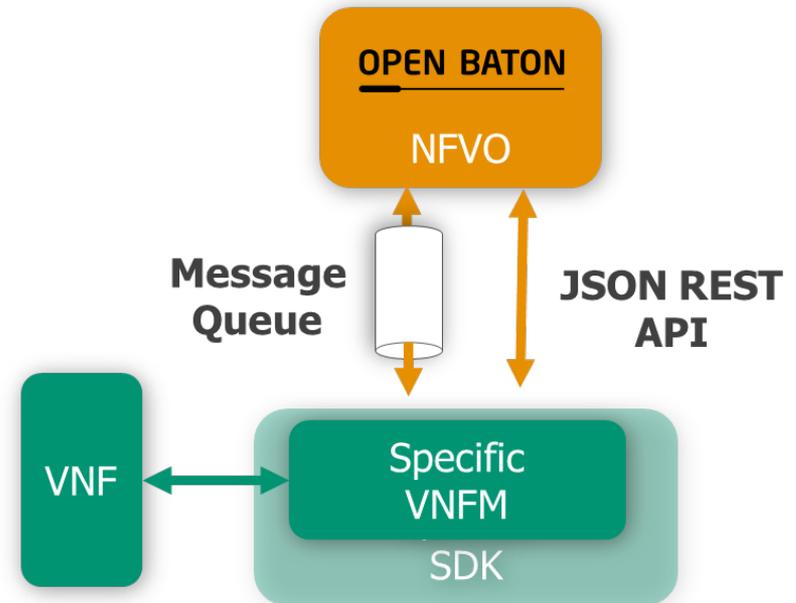


# Integrating your own network service

## OpenBaton provides a set of libraries for integrating new network services

Do you have a VNF, and would like to orchestrate it using OpenBaton?

- All you need to do is to implement your installation scripts and a VNFM. The NFVO supports two different mechanisms for interacting with your VNFM.
  - We provide a Java SDK (soon to be extended with a python version) which can help you on building your VNFM

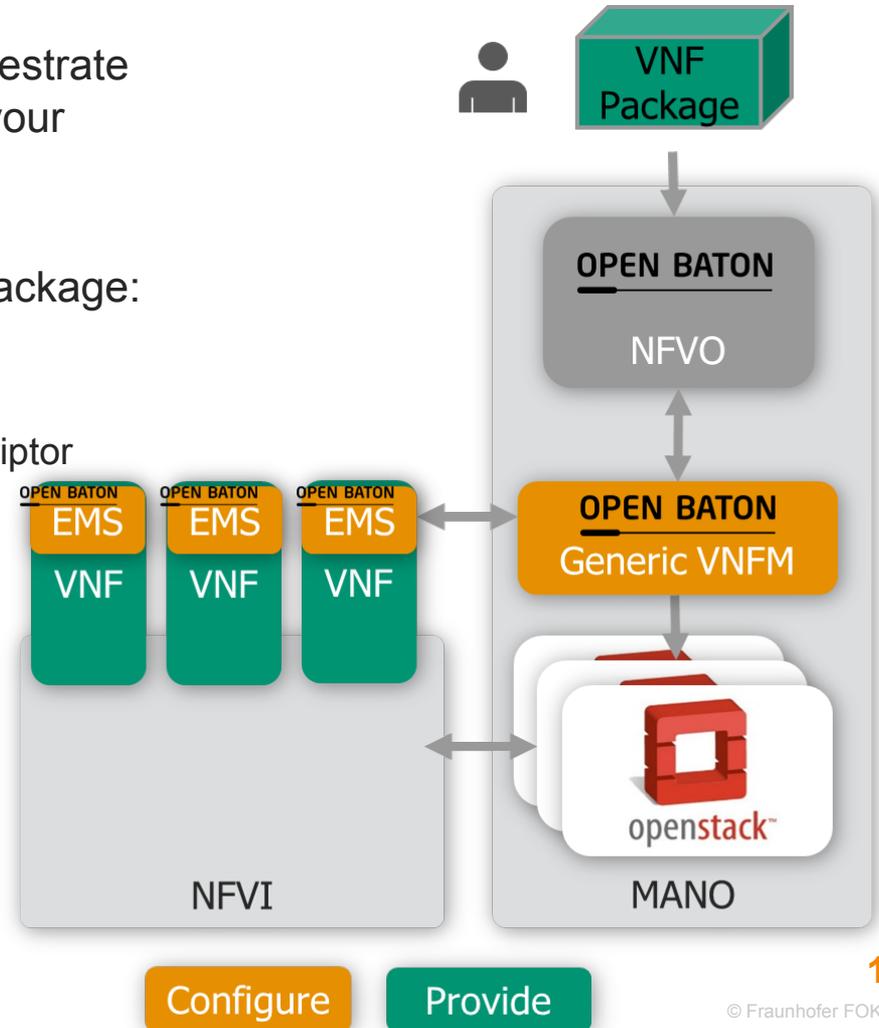


# Integrate Your Own VNF Using The Generic VNFM

## Make use of the EMS and Generic VNFM for integrating your own VNF

Do you have a VNF, and would like to orchestrate it using OpenBaton without implementing your own VNFM?

- All you need to do is to implement your installation scripts and build your VNF Package:
  - Configure the OpenBaton EMS
  - Configure the Generic VNFM
  - Provide the Virtual Network Function Descriptor (VNFD)
  - Provide the virtual machine images

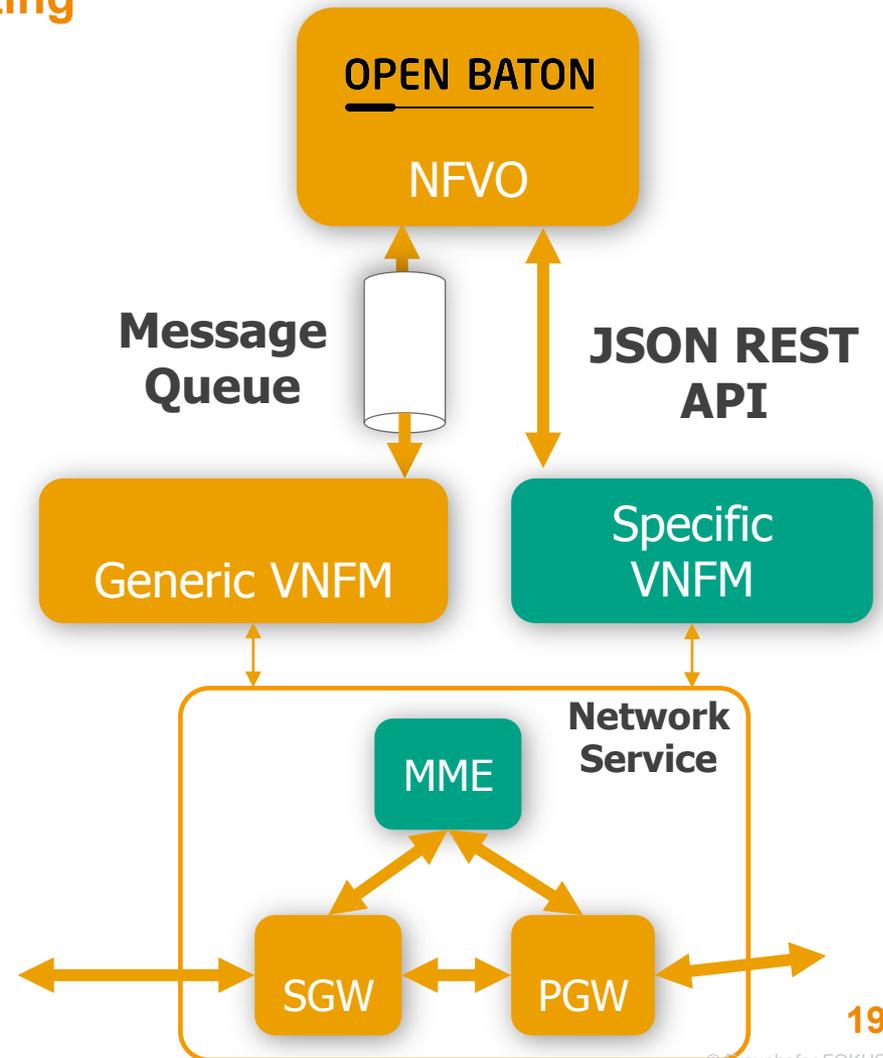


# Integrate Your VNF With Other VNFs

Soon to come a VNF catalogues where you can choose existing open source VNFs for interoperability testing

In case you are developing a specific VNF and would like to integrate in a Network Service

- Make use of the open catalogue for downloading and using existing VNFs
- Create your own instance independent of the catalogue
- Adapt your own VNF to the existing VNFs
- Contribute to the community with your own VNFs.



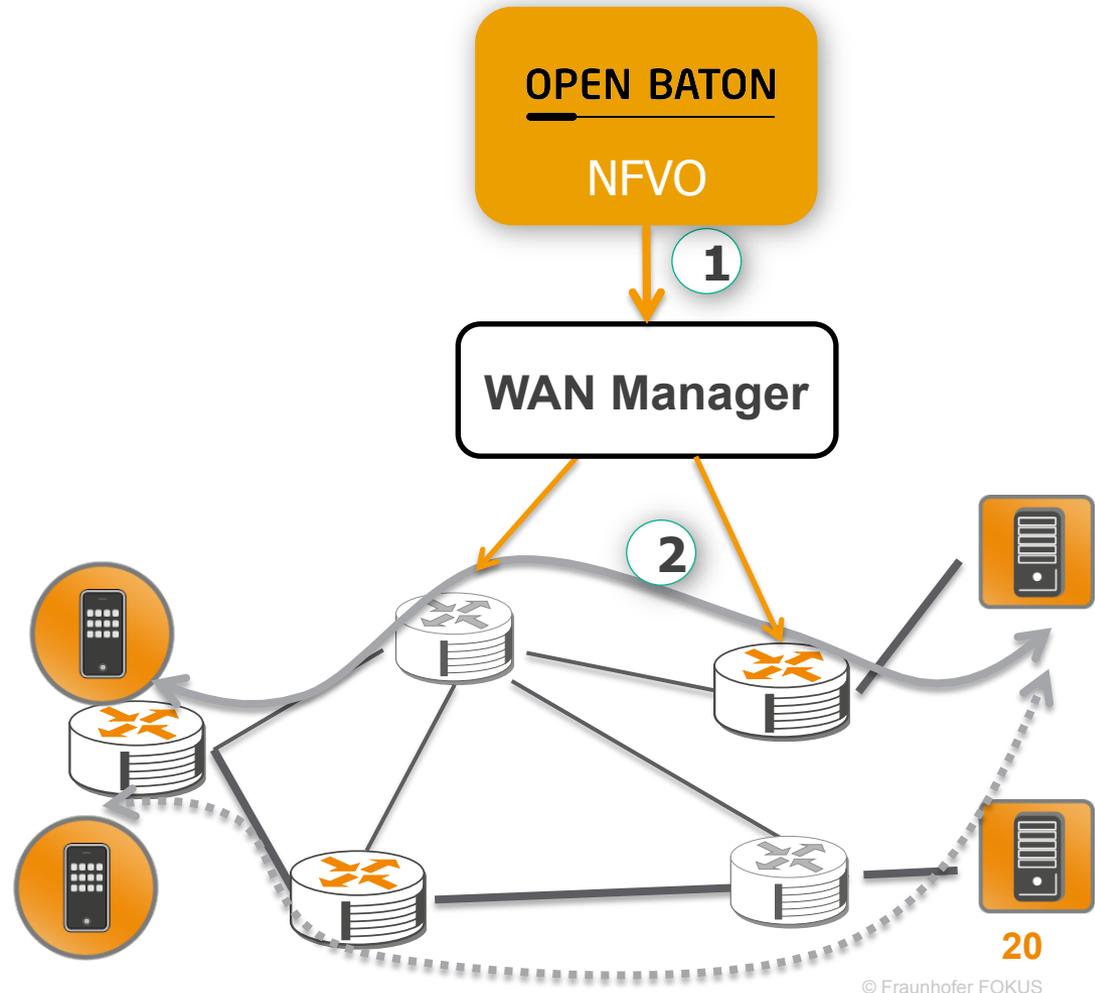
## Other Use Cases: Integration with the SDN WAN

For an end-to-end network requirements control the NFVO can be integrated with the WAN Manager

Instantiation of multiple slices on top of the real network for connecting VNFs

- Realizing traffic steering/QoS
- Dynamic adaptation to network conditions

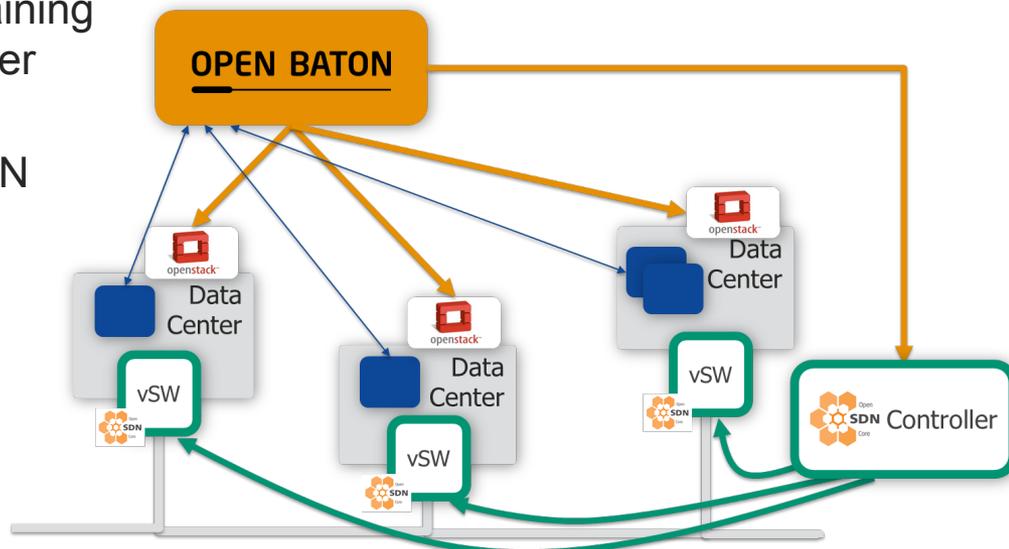
Service chaining: realizing data paths for the end subscriber sessions



## Other Use Cases: Deployment of an SDN/NFV infrastructure

### For a fully dynamic SDN/NFV infrastructure OpenBaton can be deployed together with the OpenSDNCore

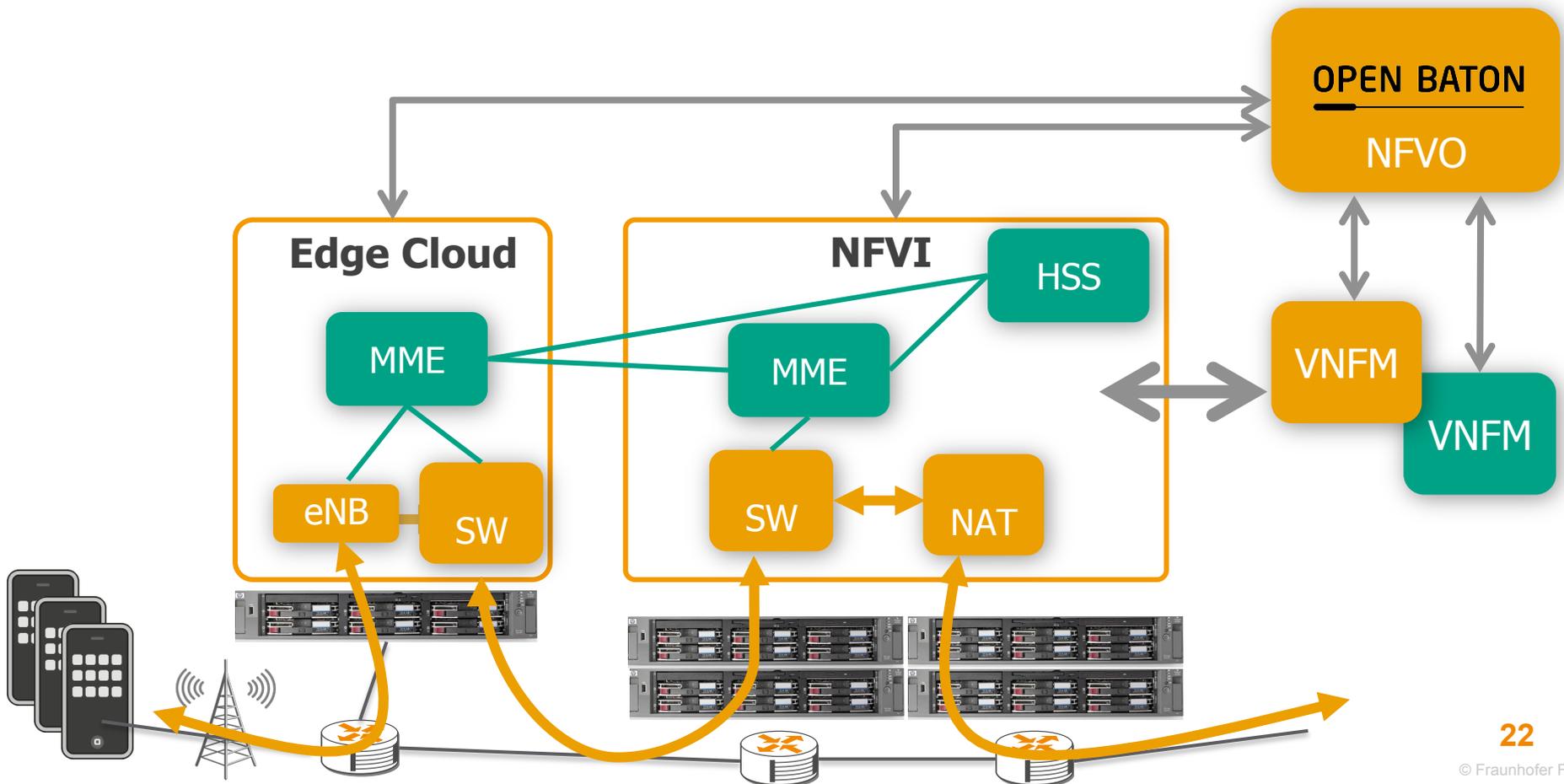
- OpenSDNCore provides an SDN infrastructure for backhauls (among other features)
  - Through the OpenSDNCore, the multiple data centers can be interconnected
  - The OpenSDN Controller receives network configuration commands from OpenBaton
  - The OpenSDN Switch installs forwarding rules for the intra-data center communication
  - Naturally integrating with the intra-data center SDN of OpenStack
  - (Alternatively) Service Function Chaining may be deployed for intra-data center SDN based configuration
    - On top of existing OpenStack SDN
    - Providing managed data path



## Other Use Cases: Deployment of a virtual core network

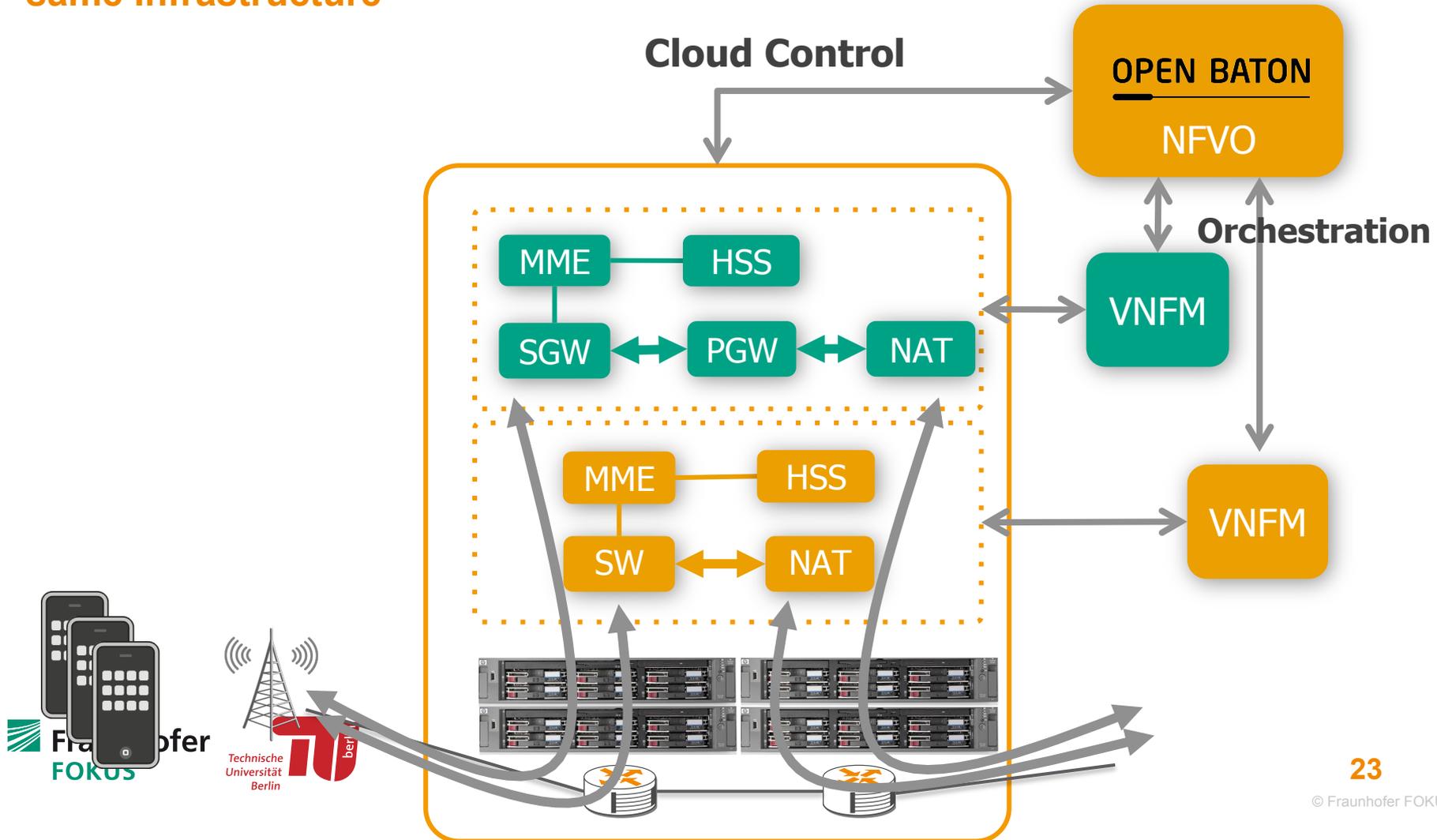
OpenBaton can deploy a large number of Virtual Network Functions (VNF)  
One main example is a mobile core network

- Example: two VNFs one for control plane and one for data plane



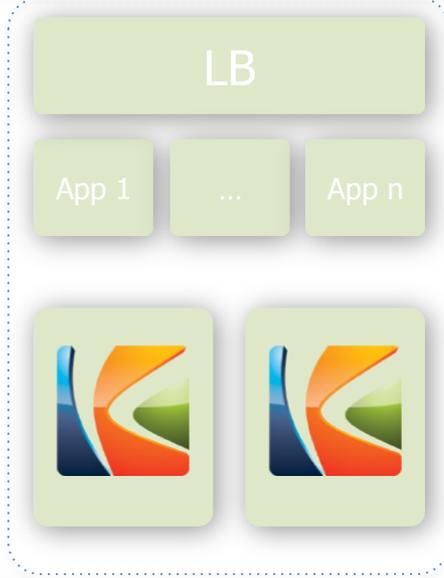
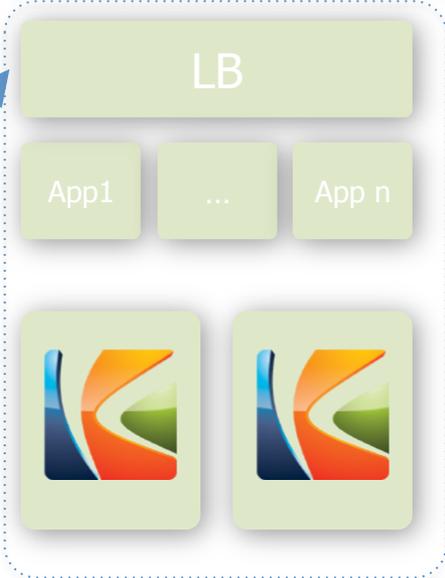
# Other Use Cases: Multiple slices of the mobile core network

OpenBaton can deploy multiple slices of the mobile core network on the same Infrastructure





NUBOMEDIA PaaS API



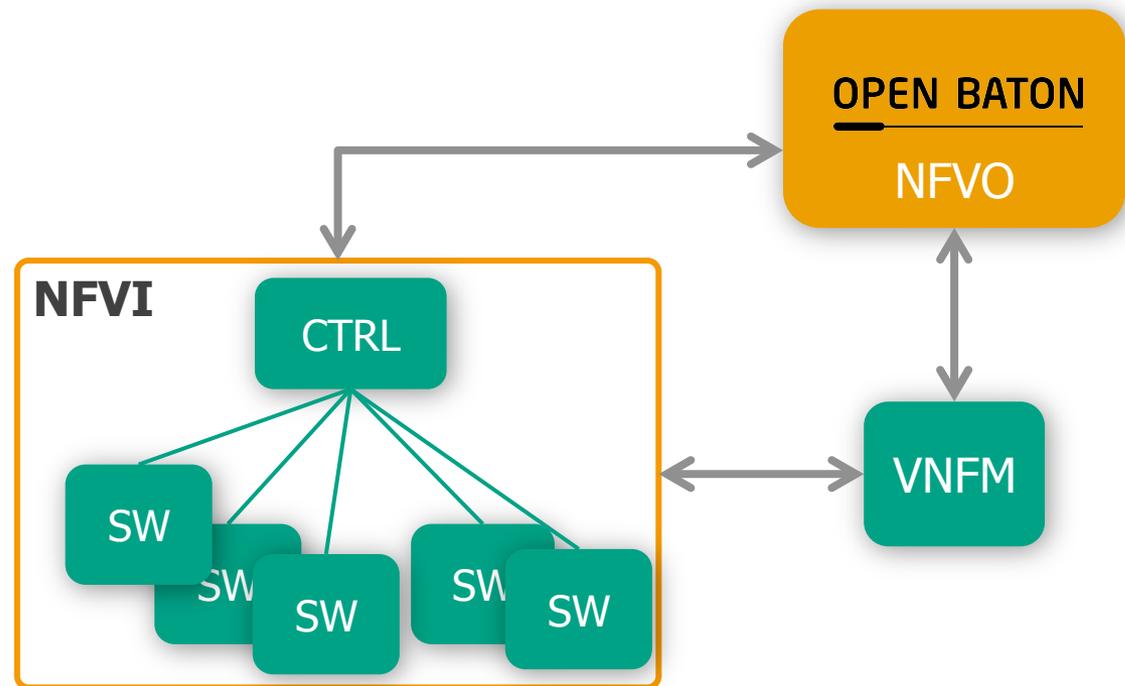
media signaling

## Other Use Cases: Deployment of an SDN test infrastructure

**For evaluating new SDN concepts in a cost effective manner, OpenSDNCore can be deployed within a virtualized network slice**

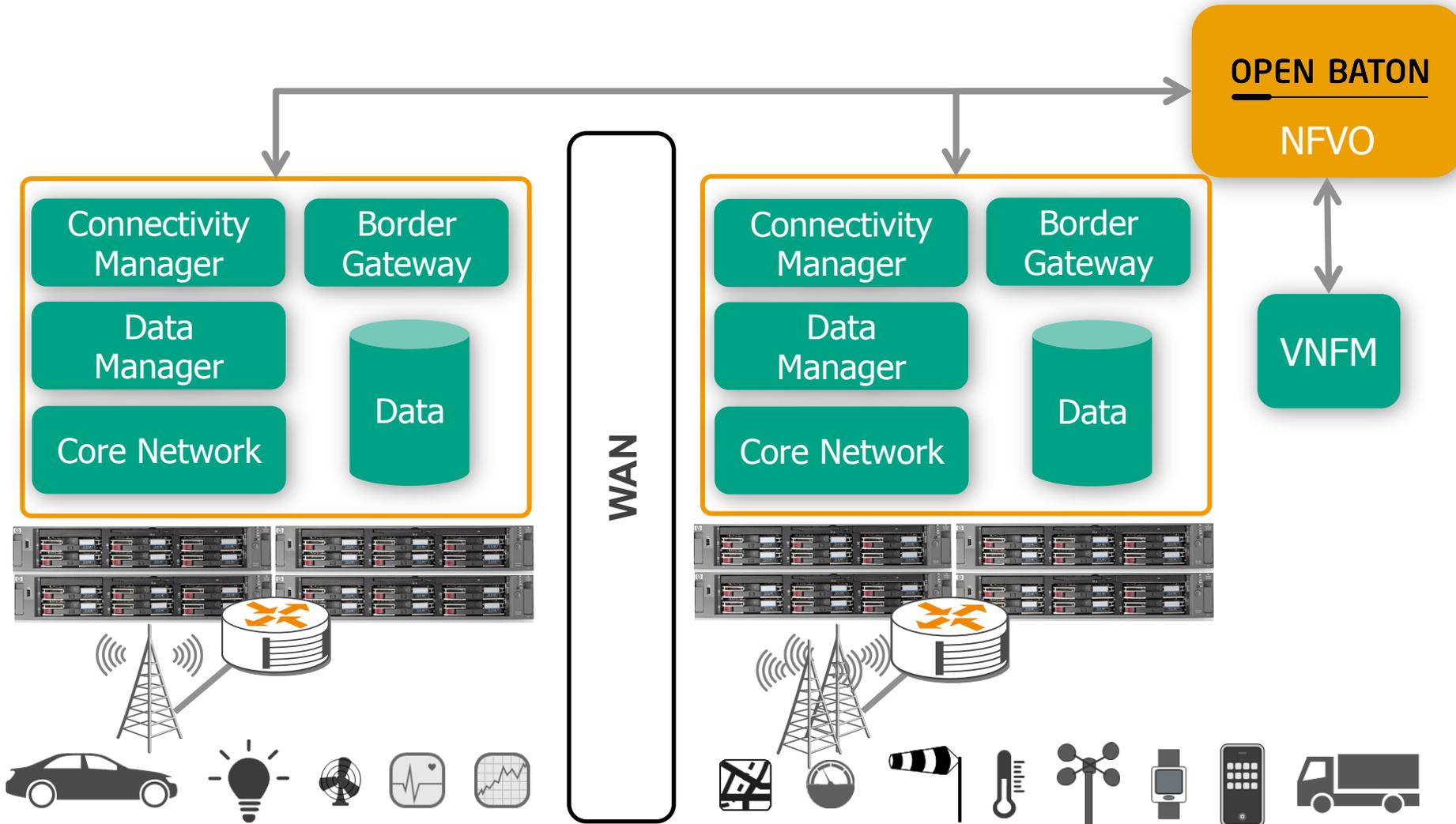
Dynamic deployment of SDN elements (Switches and Controller) allows the instantiation of overlay virtual networks:

- Increase flexibility in testing new SDN concepts
- Reduced costs



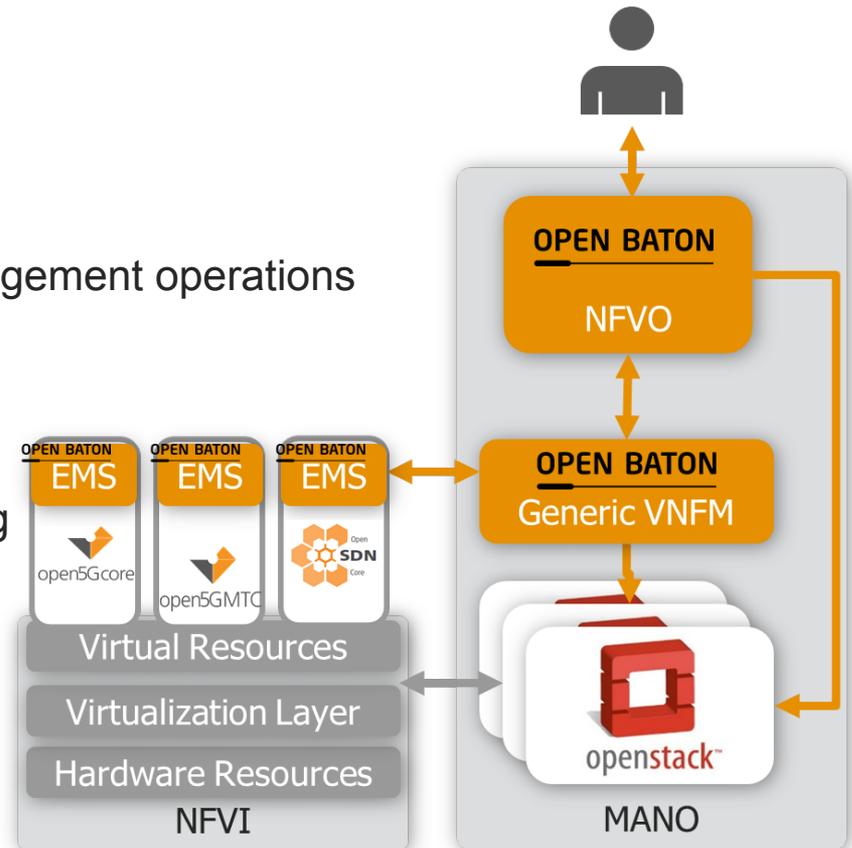
## Other Use Cases: Deployment of customized connectivity islands

For evaluating massive communication devices needs, OpenBaton can deploy on-demand next generation of M2M virtual network infrastructures



# OpenBaton Research Directions

- Short Term Research (already in progress)
  - Auto-scaling
  - Fault Management
  - Integration with monitoring solutions
- Long(er) Term Research
  - Simplification of administrative and management operations
  - Definition of virtual network service KPIs
  - End-to-end fault management
  - End-to-end reliability insurance
  - Support for automatic VNF benchmarking
  - Integrating Machine Learning for runtime management
  - Long-term testing and dynamic system compensation



# OpenBaton

## Implementation Details

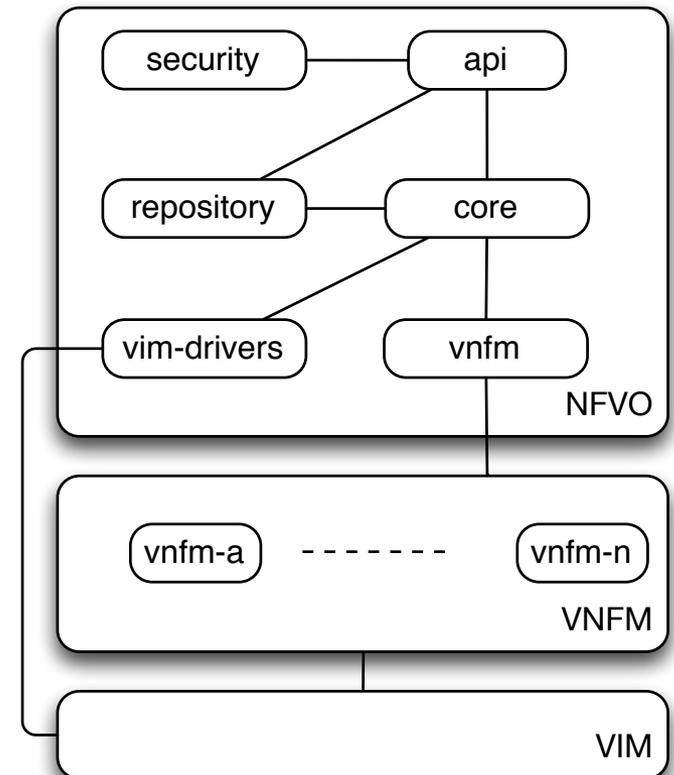
- Taking advantage of Spring Framework (last stable version available)
- Exposes ReST API on the northbound interface
- Event mechanism available on the northbound interface (ReST or Messaging System)
- All the main components are connected to an external messaging system broker
  - JMS (ActiveMQ 5.12.0) soon to be AMQP (RabbitMQ)
- Plugin mechanism allows to install/start and remove plugins at runtime, enabling different Virtual Infrastructure Managers and/or different Monitoring System
- Dashboard is a web GUI implemented AngularJS + bootstrap administrative template
- The information model, even internally, reflects one to one the ETSI NFV MANO information model
- All the interfaces between the main components follows the ETSI NFV MANO drafts



# OpenBaton Platform

## OpenBaton is implemented in Java, having a highly modular and reconfigurable architecture

- API: exposing a JSON-based RESTful API for the management of the Network Services
- Security: providing basic authentication mechanisms to the APIs
- Repository: managing the catalogue of network resources
- Core: implementing all the key functionalities of the NFVO
- Vnfm: for interoperating with the VNFM layer using the different mechanisms available (REST, JMS)
- Vim-drivers: providing an internal abstraction of the VIM interface



## Coming Up: New IEEE SDN Initiative on Open Source Toolkits

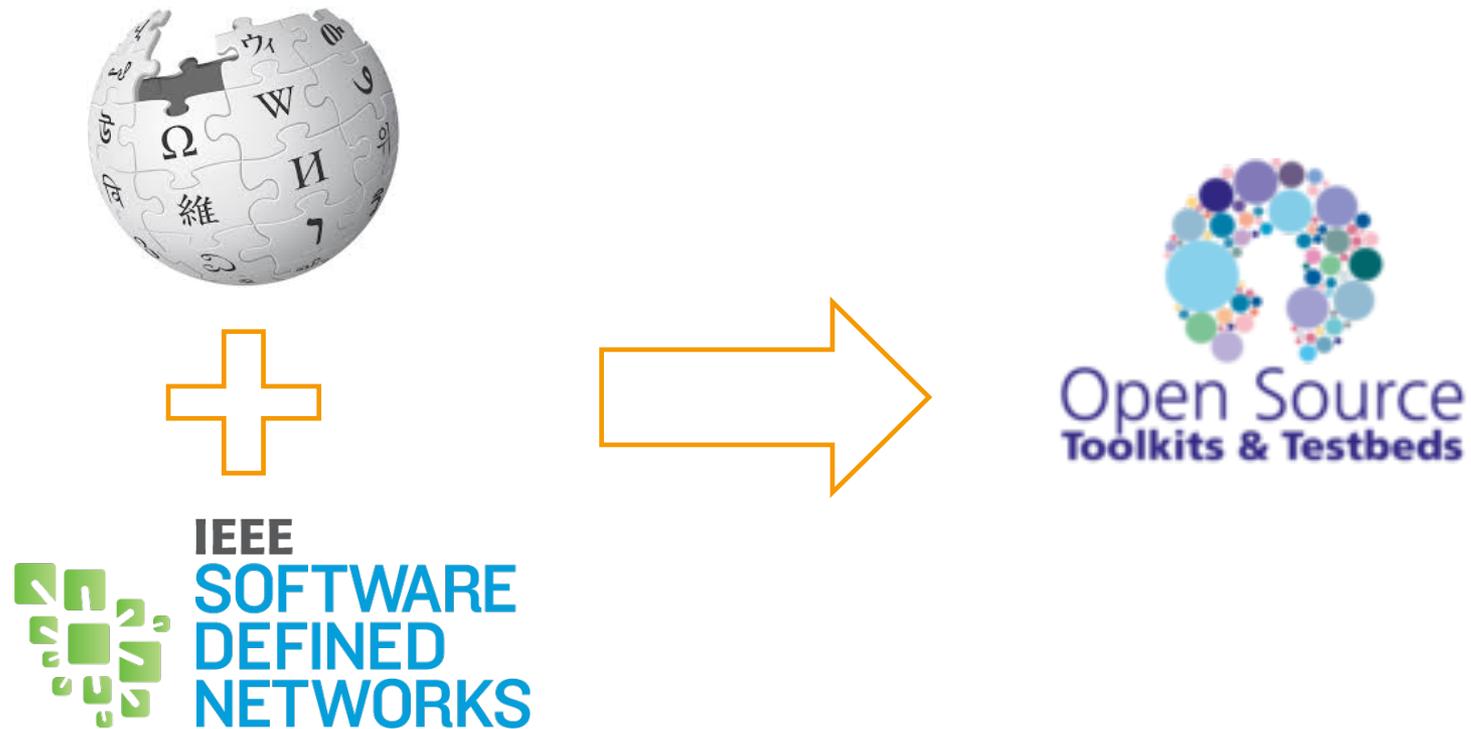
- There is a lot of SDN/NFV R&D in regard to build SDN/NFV/MEC/5G testbeds and related toolkits in academia, which might have a strong impact on the industry
- A lot of research projects build and utilize needed SDN/NFV software instead of using proprietary vendor products to maintain the open spirit of SDN
- Currently we face a zoo of toolkits and it is hard for starters and experts to maintain an overview what toolkits are available and which combinations make sense and work
- This new work group under the banner of IEEE SDN Initiative aims to provide a living catalogue of available open source toolkits in the SDN/NFV/MEC context allowing PhD students around the world to get started with SDN/NFV/MEC
- The [www.DAAD-UNIFI.org](http://www.DAAD-UNIFI.org) project (2012-2015) sparked the idea for this initiative
- In return they should extend useful toolkits and provide valuable input to emerging standards and products
- For more see soon: [www.SDN-OS-Toolkits.org](http://www.SDN-OS-Toolkits.org)

## Research challenges

- Research and development around Software Defined Networking (SDN) and Network Function Virtualization (NFV) is vast and testbeds and related toolkits in academia addressing SDN, NFV, Mobile Edge Computing (MEC) and 5G technologies are being set-up
  - A strong impact on the industry is anticipated

How to get started???

# Towards a “Wikipedia” of SDN/NFV/MEC Toolkits & Testbeds



<http://www.sdn-os-toolkits.org/> (coming soon)

The screenshot shows a web browser window displaying the SDN-Wiki website. The browser's address bar shows the URL `sdn-wiki.fokus.fraunhofer.de`. The website header includes the SDN-Wiki logo, a search bar, and navigation links for "Recent Changes", "Media Manager", and "Sitemap". A breadcrumb trail indicates the current page is "start" under the "nfvo-catalogue" section.

**Index**

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**NFV**

- ETSI NFV Architecture
- VNF Domain
- NFVI Domain
- MANO Domain

**SDN**

- Learn more about SDN
- Management Plane
- Control Plane
- Data Plane

**MEC**

- Learn more about MEC

**5G**

- Learn more about 5G

**Testbeds**

- Testbeds

**IEEE SDN Catalogue of Toolkits and Testbeds**

This wiki provides an overview of existing toolkits in the area of **Software Defined Network (SDN)** and **Network Function Virtualization (NFV)**. In particular, it provides a brief overview about the standardization activities currently ongoing, what are the available specifications describing their functional elements and architectures, and which tools can be used for implementing a comprehensive solution. All of this is supported by the **IEEE SDN Initiative**.

**NFV**

ETSI NFV is a recognized telco operator initiative fostering the development of virtual network infrastructures by porting and further adapting network functions to the specific cloud environment. ETSI NFV has defined a large set of virtualization use cases spanning from the cloudification of the main core network functions, such as IMS, Evolved Packet Core and Radio Access Networks, as well as provided on demand and complete virtualized infrastructures as IaaS and PaaS to third parties such as enterprises and professional radio stations. That enables providing elastic deployments of cost-efficient network infrastructures.

[Learn more about NFV](#)

**SDN**

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- IEEE SDN Catalogue of Toolkits and Testbeds
  - NFV
  - SDN
  - 5G
  - Mobile Edge Computing (MEC)
  - Existing testbeds

# Description of the topics

sdn-wiki.fokus.fraunhofer.de

SDN-Wiki

Open Source Toolkits & Testbeds

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- Testbeds

## NFV

ETSI Network Function Virtualisation is an initiative started in October 2012 when a group of Vendors and Operators published a [White Paper](#) describing the objectives, the motivations, and the use cases driving this new specification group.

The ETSI NFV group released in 2015 a [set of documents](#) as part of the first release of the specification. In these documents they proposed the ETSI NFV Architecture as the following

The diagram illustrates the ETSI NFV Architecture. It shows the interaction between the OSS/BSS system, the Service, VNF and Infrastructure Description, the EMS (Element Management System) and VNF (Virtual Network Function) components, and the NFV Management and Orchestration (MANO) components. The MANO components include the Orchestrator and the VNF Manager(s). The diagram shows the following components and their interactions:

- OSS/BSS**: The central system for service management.
- Service, VNF and Infrastructure Description**: A central component that provides descriptions for services, VNFs, and infrastructure.
- EMS 1, EMS 2, EMS 3**: Element Management Systems that manage the VNFs.
- VNF 1, VNF 2, VNF 3**: Virtual Network Functions that are managed by the EMSs.
- NFV Management and Orchestration**: A dashed box containing:
  - Orchestrator**: Manages the overall NFV architecture.
  - VNF Manager(s)**: Manages the VNFs.

Interactions are shown as follows:

- OSS/BSS is connected to the Orchestrator via **Os-Ma** (Orchestration Management) and **Se-Ma** (Service Management).
- The Orchestrator is connected to the VNF Manager(s) via **Or-Vnfm** (Orchestration to VNF Management).
- The VNF Manager(s) is connected to the VNFs via **Ve-Vnfm** (VNF Management to VNF).
- The VNFs are connected to the EMSs via **Ve-Vnfm** (VNF Management to VNF).
- The EMSs are connected to the VNFs via **Ve-Vnfm** (VNF Management to VNF).
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# Catalogue of open source solutions

The screenshot shows a web browser window displaying the SDN-Wiki website. The page title is "SDN-Wiki" and the URL is "sdn-wiki.fokus.fraunhofer.de". The page features a search bar, navigation links for "Recent Changes", "Media Manager", and "Sitemap", and a "Log In" button. A breadcrumb trail indicates the current location: "Trace: start · nfv · mano-domain · nfv-catalogue". The main content area displays the "NFVO Catalogue" table, which lists various open source solutions. A sidebar on the left provides navigation for different categories: Index, NFV, SDN, MEC, 5G, and Testbeds. The footer of the page indicates the file "nfv-catalogue.txt" was last modified on 2016/05/02 at 17:17 by gcarella.

SDN-Wiki

Open Source Toolkits & Testbeds

Trace: [start](#) · [nfv](#) · [mano-domain](#) · [nfv-catalogue](#)

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5G

- [Learn more about 5G](#)

Testbeds

- [Testbeds](#)

## NFVO Catalogue

Name	Description	wiki entry	Website
Open MANO	Telefonica implementation of an Open Source MANO Framework	<a href="#">openmano</a>	<a href="#">github/openmano</a>
Open Baton	Open Source NFV Orchestrator	<a href="#">openbaton</a>	<a href="#">Openbaton.org</a>
Open Source MANO	ETSI Initiative building an Open Source MANO Framework	<a href="#">etsi-osm</a>	<a href="#">osm.etsi.org</a>
Tacker	Open Source VNF Manager	<a href="#">tacker</a>	<a href="#">tacker.openstack.org</a>

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