Multi-site orchestration of end-to-end 5G networks

The 5G EVE approach for the inter-working of multiple 5G experiment facilities

Francesco Lombardo, Matteo Pergolesi (CNIT)
Outline

• The 5G EVE Project
• System architecture and trial sites
• Adaptation Layer
  • Multi-Site Catalogue SBI
  • MSO-LO interface
• Conclusion & Future Work
The 5G EVE vision

From: Two Worlds

Industries’ Digitalization

To: One Innovation Ecosystem

5G-enabled Industry Applications

European 5G Validation Platforms

5G Technologies

- Agile
- Diverse
- Specialized
- Transformative

- Open
- Ease-to-use
- Trustworthy
- Automated

- Performing
- Scalable
- Standard
- Secure
- Evolving

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The 5G EVE platform

5G EVE – Participating Verticals
- Industry 4.0
- Utilities
- Smart Cities
- Tourism
- Media
- Transport

Horizon 2020 ICT-19 Projects
- Vertical Apps

Foreground input

5G EVE’s Integrated Portal for 5G Experimentation and Validation
- with interworking capabilities among trial sites

Spanish Site
- STONIC
- Telefónica
- ERICSSON

French Sites
- Orange
- b.com
- EURECOM

Italian Site
- TIM
- ERICSSON
- NEXTWORKS
- CNIIT

Greek Site
- OTE
- ERICSSON
- NOKIA
- WINGS
System Architecture

- Vertical Exponenter

5G EVE Portal

Inter-Working NBI

- Multi-Site Network Service Orchestrator
- Multi-Site Catalogue
- Runtime Configurator
- Multi-Site Inventory
- Data Collection Manager

Adaptation Layer

- Italian Site
- Spanish Site
- Greek Site
- French Site

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The 5G EVE site facility is composed of a cluster of sites facilities in several countries:

- **France**
  - 4 nodes: Nokia Paris Saclay, b<>com Rennes, Eurécom Nice, Orange Paris
  - Orchestrator: ONAP

- **Greece**
  - Athens with Ericsson, Nokia, Wings, OTE
  - Orchestrator: commercial/proprietary

- **Italy**
  - Turin with Ericsson, Networks, A2T, CNIT, TIM
  - Orchestrator: OSM, Ericsson

- **Spain**
  - Madrid with Ericsson, Nokia, UC3M, TID
  - Orchestrator: OSM
Sites interconnection

- **Phase 1:**
  - Star topology for both control and data plane
  - Center located in Turin

- **Phase 2:**
  - Star topology for control plane
  - Full or partial mesh for data plane

- **Technology**
  - S2S IPsec tunnels
  - Routable private plan
Sites interconnection

- Phase 1:
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French site facility
Greek site facility

Ericsson AGV platform

NOKIA GR – Smart Ambulance

WINGS - Smart cities - Utilities
Italian site facility

Libellium WiFi Scanners

NSA 5G antennas

Smart Tourism app
Spanish site facility
Inter-Working Layer components

- Vertical Experimenter
- 5G EVE Portal
- Inter-Working NBI
  - Multi-Site Network Service Orchestrator
  - Multi-Site Catalogue
  - Runtime Configurator
  - Multi-Site Inventory
  - Data Collection Manager
- Adaptation Layer
- Italian Site
- Spanish Site
- Greek Site
- French Site
## 5G EVE Inter-Working principles

### Blueprints (YAML)

<table>
<thead>
<tr>
<th>5G EVE Portal</th>
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<tbody>
<tr>
<td>Experiment Design Tool</td>
<td>Experiment Monitoring &amp; Data Collection Module</td>
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<tr>
<td>TT Tool</td>
<td>Run Experiment Tool</td>
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</tbody>
</table>

NSD defined using NFV-IFA 014 and VNFD using & NFV-IFA 011

### Interworking API

NSD stored in IWL using NFV-SOL 001 format

**5G EVE Interworking Framework**

- Multi-site Network
- Service Orchestrator

### Adaptation Layer

**Driver 1**
- M&O Site 1

**Driver 2**
- M&O Site 2

**Driver 3**
- M&O Site 3

**Driver 4**
- M&O Site 4

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Inter-Working Layer facts

• ETSI NFV compliant
  • VNFD, NSD: NFV-SOL 001
  • REST API interfaces: NFV-SOL 005

• To interact with local NFVOs we need:
  • Descriptors translation
  • API methods adaptation
Multi-Site Catalogue

• Catalogue service for VNFDs, PNFDs and NSDs modelling single & multi-site experiments
  • Onboarding across multiple and heterogeneous per-site NFV catalogues
  • Standard, ETSI-compliant data models and APIs to address the fragmentation of per-site NFV MANOs

• Inter-working logic and procedures for automated multi-site catalogue population
  • Catalogues synchronization, to retrieve available NSDs and VNFDs from each site facility
  • VNF onboarding, for dynamic collection of new VNFDs on-boarded in the 5G EVE sites
  • VNF removal, for dynamic removal of VNFDs when VNFs are no longer available in the 5G EVE sites
  • NSD onboarding, to allow the 5G EVE portal to onboard new NSDs for single & multi-site experiments
  • NSD removal, to allow the 5G EVE portal to remove NSDs whenever single or multi-site experiments are no longer available in the 5G EVE platform
Multi-Site Catalogue prototype

- **ETSI NFV SOL005** compliant REST API
- **ETSI NFV SOL001** compliant data model
  - TOSCA NSDs, VNFDs, PNFDs
- Embedded inter-working adaptation features
  - NSDs, VNFDs, PNFDs translation
    - **TOSCA <-> per-site NFVOs data models**
    - Mapping of IDs for multi-site orchestration
    - Adaptation to per-site NFVOs catalogue REST APIs
      - **OSM driver for R3, R4, R5, R6**
      - Planned ONAP driver

![Diagram showing the architecture of the Multi-Site Catalogue prototype](https://github.com/nextworks-it/5g-catalogue/tree/v3.0)

Adaptation layer features

- Site-dependent
- NFVO X driver
- OSM driver
- Abstract NFVO driver
- Catalogue service + Multi-site logic
- Catalogue Service Interface
- REST controller (SOL 005 Open API)

Policy management

GUI

AuthN/AuthZ

Filesystem

Information model library (SOL 1 – v2.6.1)

Extensions to fill IFA gaps + 5G-EVE info model extensions

code available at: [https://github.com/nextworks-it/5g-catalogue/tree/v3.0](https://github.com/nextworks-it/5g-catalogue/tree/v3.0)
REST API inspired by SOL 005 with

- Operations to retrieve information about local NFVOs registered with the 5G EVE platform.
- Operations to retrieve, create, instantiate, scale, terminate, and delete NS instances.
- Operations to retrieve, create, and delete subscriptions to notifications about the status of one or more NS instance.
A new request arrives for OSM-Turin

1. A new request arrives for OSM-Turin
2. Select NFVO driver
3. Translate request
4. Route request
5. Translate response
6. Route request
7. Return response to IWL

Local DB

Italian Site
Spanish Site
Greek Site
French Site

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• Factory method design pattern: the app module stays separated from the specific driver implementation
• The Driver abstract class realizes a contract for the driver implementation
Conclusion & Future Work

• Easy-to-use, intent-based blueprints for describing services and experiments
• Realization of an open VNF framework
• Multi-domain orchestration and slicing
• Contribution to ETSI standards
• Contribution to OSM compliance
Thank you!

Any questions?

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https://www.5g-eve.eu/
@5G_EVE
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Platform architecture

Vertical End-User Service is delivered at one or more sites.

Vertical Tester/Experimenter interacts with 5G EVE platform through 5G EVE Portal
Italian Site Facility

- **LTE eNB**
- **5G gNB**
- **APN**
- **HSS**
- **MME**
- **EPG**
- **5G ENM field**

**Ipsec tunnels:**
- Madrid
- Parigi
- Atene

**Lab Core**
- **APN**
- **HSS**
- **MME**
- **EPG**
- **ENM**

**Prisma network emulator**

**CNIT (PoliTo)**

**TIM LAB**

**IW layer**
Italian Site Facility

Four physical servers available

- 3 Openstack compute nodes
- 1 dedicated for control/management
  - NFV Orchestrator: OpenSource MANO
  - Openstack controller
Italian Site Facility

- Verticals
  - Transport: Trenitalia
  - Smart City: Torino 5G
  - Campus: CNIT

- Cloud and IoT Platform
  - IoT Platform: oneM2M
  - Partners' Platform: CNIT

- Mobile Access
  - 5G
  - 4G/LTE
  - NB-IoT
  - WiFi

- Infrastructures
  - TIM Labs
  - Network
  - NR Access + 5G-Core
  - TIM Facilities
  - Railway station
  - 5G campus
  - Politecnico
Spanish Site Facility