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Realization of a public safety vertical use case based on OSM and aerial/vehicular NFV infrastructures

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Key Takeaways

- This work presents the definition of an NFV framework capable of integrating aerial and vehicular NFV infrastructures, enabling the cost-effective and flexible deployment of vertical services.
- It details the realization of a public safety vertical use case to emphasize the practicality and potential benefits of the proposed framework.
- The integration of two remote NFV infrastructures is presented: an infrastructure of SUAVs and an automotive infrastructure.
- These NFV infrastructures are provided by research groups of different countries (Spain and Portugal).
- OSM is intended to support the orchestration of network services over these both NFV infrastructures.
- The implementation of both the framework and the network services is based on open-source technologies (such as OSM or OpenStack).
- A novel solution based on the publish-subscribe model is included to agilely carry out the configuration of VNFs, significantly reducing the deployment times.

Motivation

- 5G considers a paradigm shift:
  - Oriented human communication services → Adoption of verticals requirements for services provisioning.

- Global digital transformation, bringing a more comprehensive portfolio of services and applications with resulting multiplicity of requirements (mMTC, uRLLC, and eMBB).
- One of the most relevant challenges: flexibly integrate heterogeneous network infrastructures capable of supporting the cost-effective deployment of vertical services.
- Two research lines intersect to tackle this challenge:
  - Deploy communication services on-demand using an infrastructure of Small sized Unmanned Aerial Vehicles (SUAVs).
  - Support the opportunistic provision of services by means of an automotive infrastructure.
  - **Result**: definition and implementation of a comprehensive framework capable of dynamically integrating heterogeneous NFV infrastructures distributed across different geographical locations in order to support the deployment of elaborated vertical services [1].

- All the details available in [1]: https://doi.org/10.3390/s21041342

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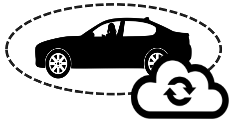

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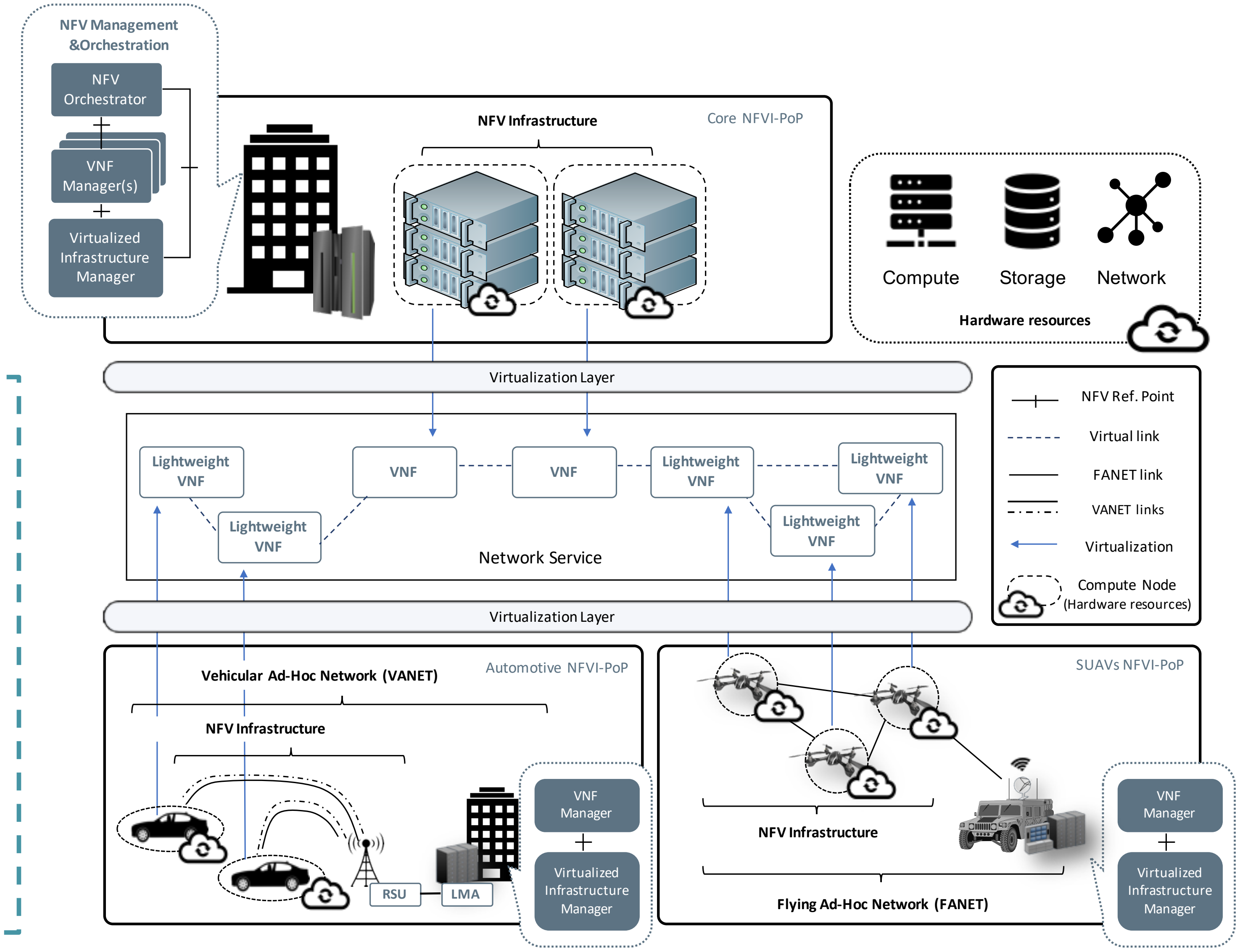
Aerial and Vehicular NFV Framework

- Aligned with the design principles of the NFV architectural published by ETSI.
- Consists of three NFVI-PoPs:
  - Core NFVI-PoP with high availability of resources in terms of computing, network, and storage → Core network domain.
  - SUAVs NFVI-PoP, enabling the execution of lightweight VNFs over the computational units offered by the SUAV devices.
  - Automotive NFVI-PoP, supporting the deployment of lightweight VNFs within vehicular networks.
- Support the cost-effective and flexible deployment of vertical services.



Core NFVI-PoP

Design and Implementation Details

- NFVI with high availability of resources in terms of computing, network and storage to accommodate services corresponding to the core network domain.
- Located in the 5G Telefonica Open Network Innovation Centre (5TONIC) laboratory (Madrid, Spain).
- Management and Orchestration (MANO) software stack provided by OSM:
  - OSM Release SEVEN.
  - Orchestrate and manage the deployment of services that will be hosted within the whole ecosystem.
- Include two independently-operated cloud computing platforms:

❖ **Purpose:** Supply limited computing capacity to support the development of network services focused on environments beyond the edge.

❖ **VIM:** OpenStack Release Ocata.

❖ **NFVI:**

- 2x mini-ITX computer server (KVM based virtualization technology):
  - 8 GB RAM, 8 CPUs and 100 GB HD
- 10x Raspberry Pis model 3B+ (Linux Container-based virtualization technology support):
  - 1 GB RAM, 4 CPUs and 32 GB HD

❖ **Purpose:** Accommodate complex functions that may be expected in the core network domain.

❖ **VIM:** OpenStack Release Ocata.

❖ **NFVI:**

- 3x computer server (KVM based virtualization technology):
  - 32 GB RAM, 8 CPUs and 2 TB HD

- Each SUAV device comprises a computational unit that offers its hardware resources in terms of computation, storage, and networking, with the aim of enabling the execution of VNFs.
- Computational capabilities provided by Single Board Computers (SBCs).
- Resource-constrained devices due to their compact size → lightweight VNFs.
- Provide on-demand communication infrastructure wherever it is needed, either in areas where telecommunication infrastructure is not provided, or insufficient (e.g., rural areas or areas severely damaged because of an emergency).
- This SUAV NFV-based platform is equipped with :

❖ **VIM:** OpenStack Release Queens.

❖ **NFVI:**

- 4x SUAV units:
  - Model Parrot Bebop 2
- 4x Raspberry Pis model 3B+ (Linux Container-based virtualization technology support):
  - 1 GB RAM, 4 CPUs and 32 GB HD

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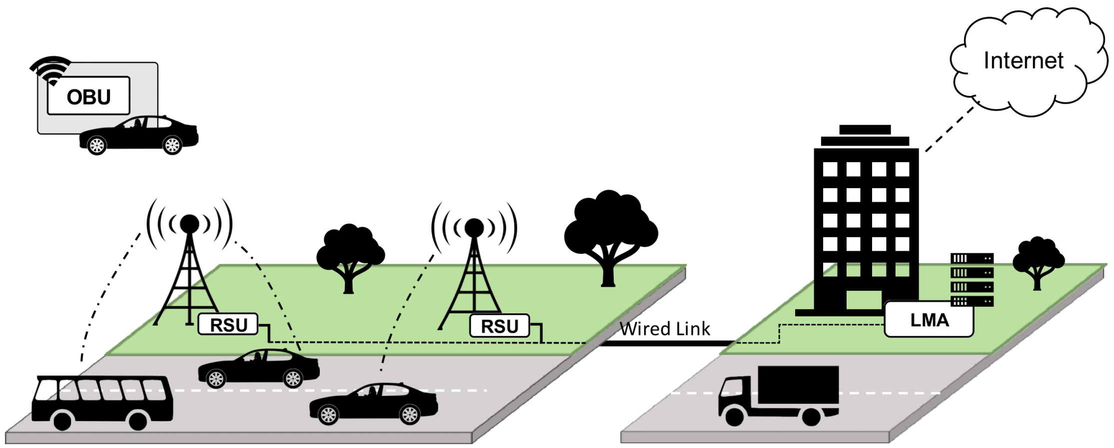
SUAVs NFVI-PoP

Design and Implementation Details

- Automotive infrastructure is a VANET with mobility and multihoming support based on the Network-Proxy Mobile IPv6 architecture (N-PMIPv6).
- Road Side Units (RSUs) provide connection points for the On-board Units (OBUs).
- OBUs are placed inside the vehicles and provide connectivity to the end-users.
- The Local Mobility Anchor (LMA) manages the whole network and provides connectivity to the outside.



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Automotive NFVI-PoP

Vehicular Network

On-Board Unit

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Automotive NFVI-PoP

Design and Implementation Details

- To make up the NFVI, a general-purpose hardware platform is connected to each OBU.
- This platform offers its hardware resources with the aim of enabling the deployment of the VNFs inside the vehicles.
- Resource-constrained devices due to their small size → lightweight VNFs.
- This Automotive NFV-based platform is equipped with:

- **Automotive:**
  - 1x RSU and 1x OBUs:
    - SBCs with IEEE 802.11p, 802.11b/g/n interfaces
- **VIM:** OpenStack Release Ocata.
- **NFVI:**
  - 1x Raspberry Pi model 3B+ (Linux Container-based virtualization technology support):
    - 1 GB RAM, 4 CPUs and 32 GB HD
  - 1x Laptop computer (KVM based virtualization)

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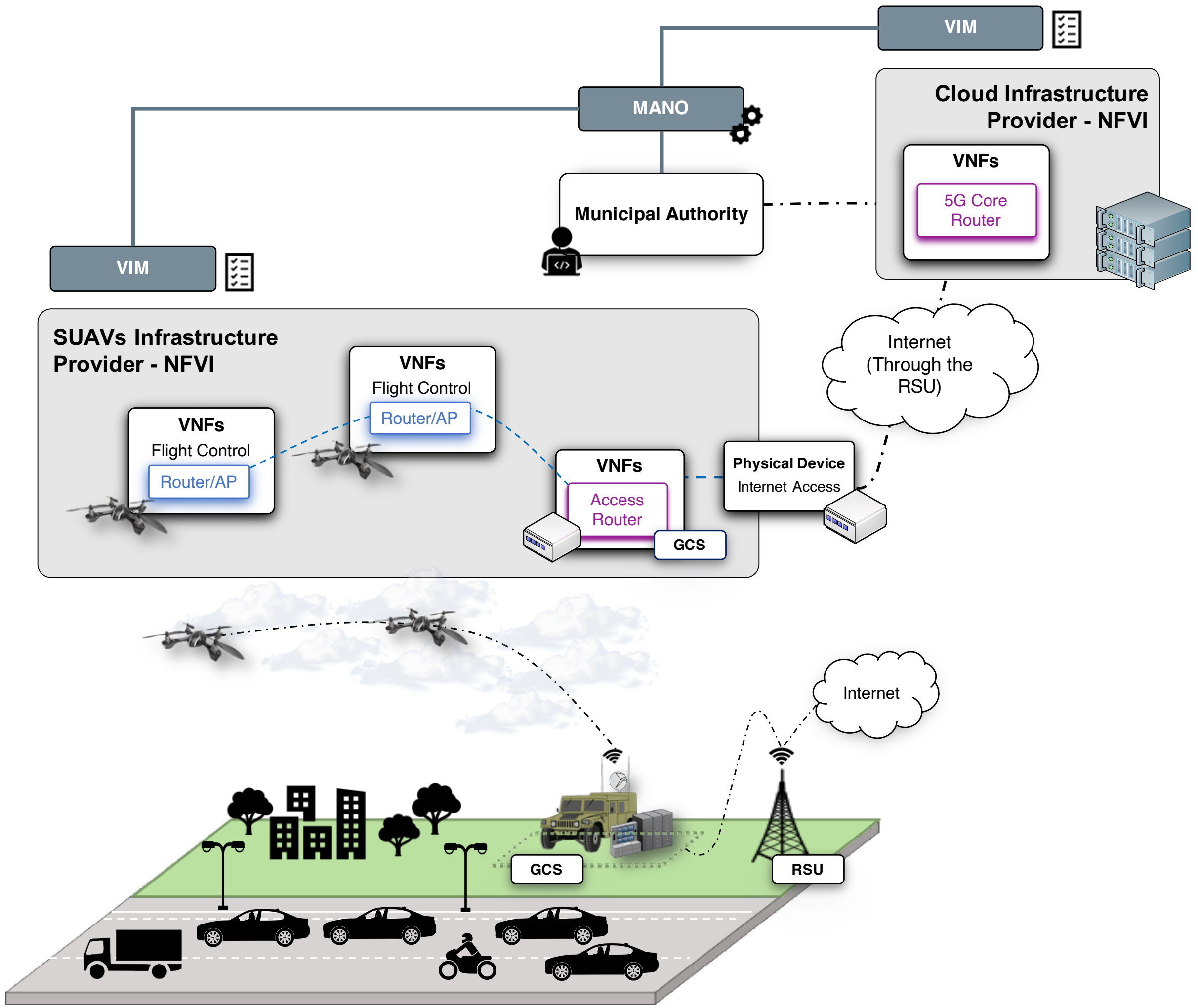
Use Case Description

Public Safety Vertical Service

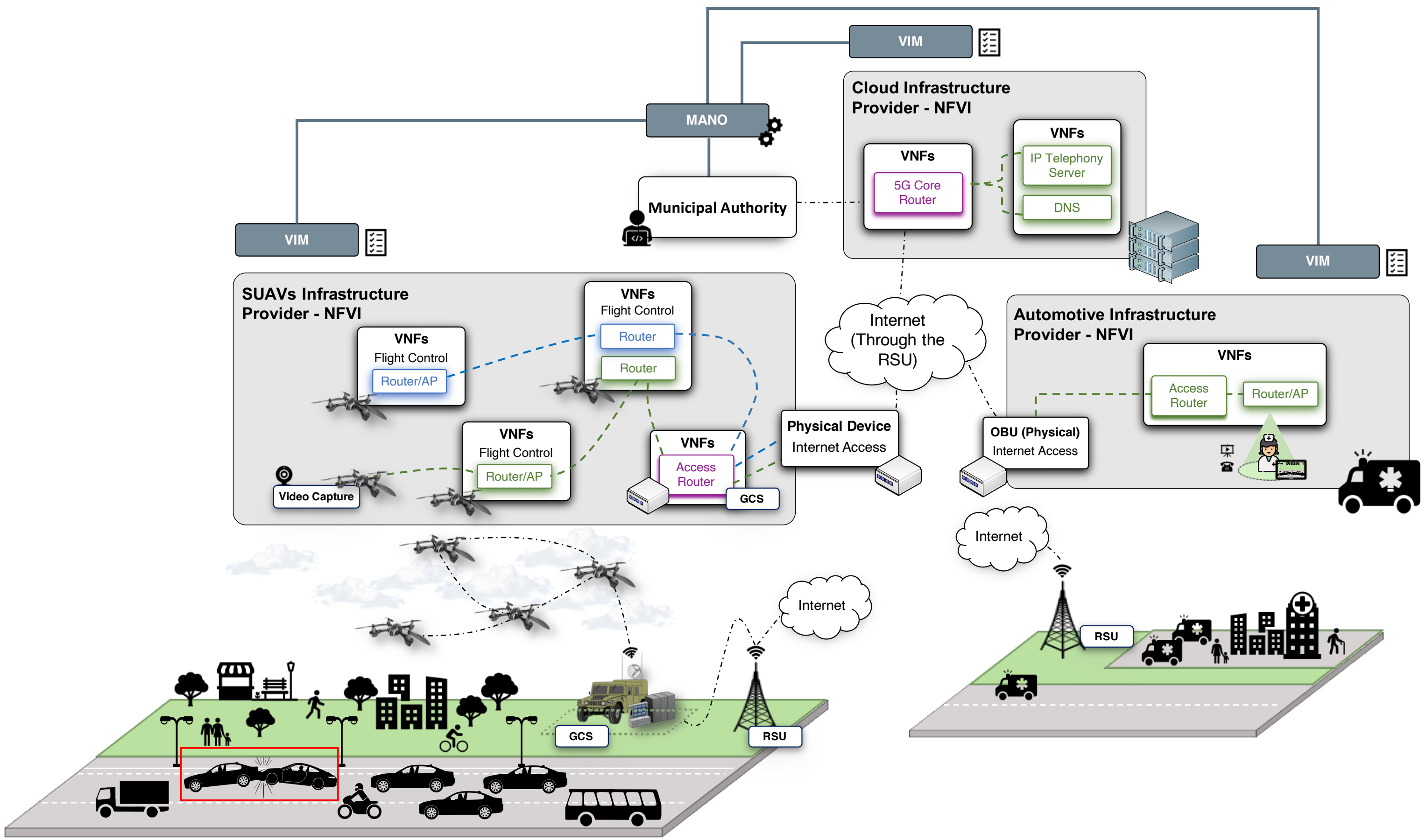
Network service: road traffic surveillance

- Dense road traffic conditions expected due to the beginning of a holidays period.
- SUAVs network deployed by a public safety department to improve the situational awareness of the road conditions.
- Provision of a service composed by different virtual functions, capable of:
  - Collecting relevant information (e.g., images and videos) and delivering to the public safety department in order to facilitate the decision-making.
  - Complement the resources of cellular access networks serving the users, and thereby preventing a potential stage of network traffic congestion.
  - Disseminate relevant information from the public safety department to the users connected to the aerial network.



Creating an unheralded emergency service

- Adapt the functionalities of the service to address emerging demands by altered circumstances (e.g., an emergency with a vehicle collision):
  - Integrate additional SUAVs.
  - Modify SUAVs trajectories.
  - Execute new functionalities.
  - Release allocated resources.
- **Objective**: enable the communications from the UAVs to an emergency response team whereas the team moves towards the location of the emergency.



Implementation details

Virtual Function	Brief description of functionality	Technical requirements	Featured software
5G Core Router	Implementation of the user-plane protocol stack of a 3GPP N3IWF, as well as routing functionalities towards external networks.	Prototyped as a VM, using Ubuntu 16.04; 2 vCPUs, 1 GB RAM, 5 GB storage.	Linux ip-gre and ip-forwarding modules, and the ipsec-tools package.
Access Router	Implementation of the user-plane protocol stack of a 3GPP UE, providing access to 5G core network via an untrusted non-3GPP access.	Prototyped as a VM, using Ubuntu 16.04; 1 vCPU, 1 GB RAM, 5 GB storage.	Linux ip-gre and ip-forwarding modules, and the ipsec-tools package.
Router/AP	Implementation of a Wi-Fi access point, supporting the assignment of IP addresses using DHCP, and routing functions.	Prototyped as LXC container, using Ubuntu 16.04; 1 vCPU, 128 MB RAM, 4 GB storage.	Linux ip-forwarding module and isc-dhcp-server package.
DNS	Support a name resolution service, to enable user identification in a functional IP telephony service.	Prototyped as a VM, using Ubuntu 16.04; 1 vCPU, 1 GB RAM, 5 GB storage.	Dnsmasq, an open-source DNS server (Linux package).
IP Telephony Server	Provide the functions of an IP Telephony service based on the SIP protocol (i.e., proxying of call signalling messages and user registration).	Prototyped as a VM, using Ubuntu 16.04; 1 vCPU, 1 GB RAM, 5 GB storage.	Kamailio, an open-source SIP server (Linux package).

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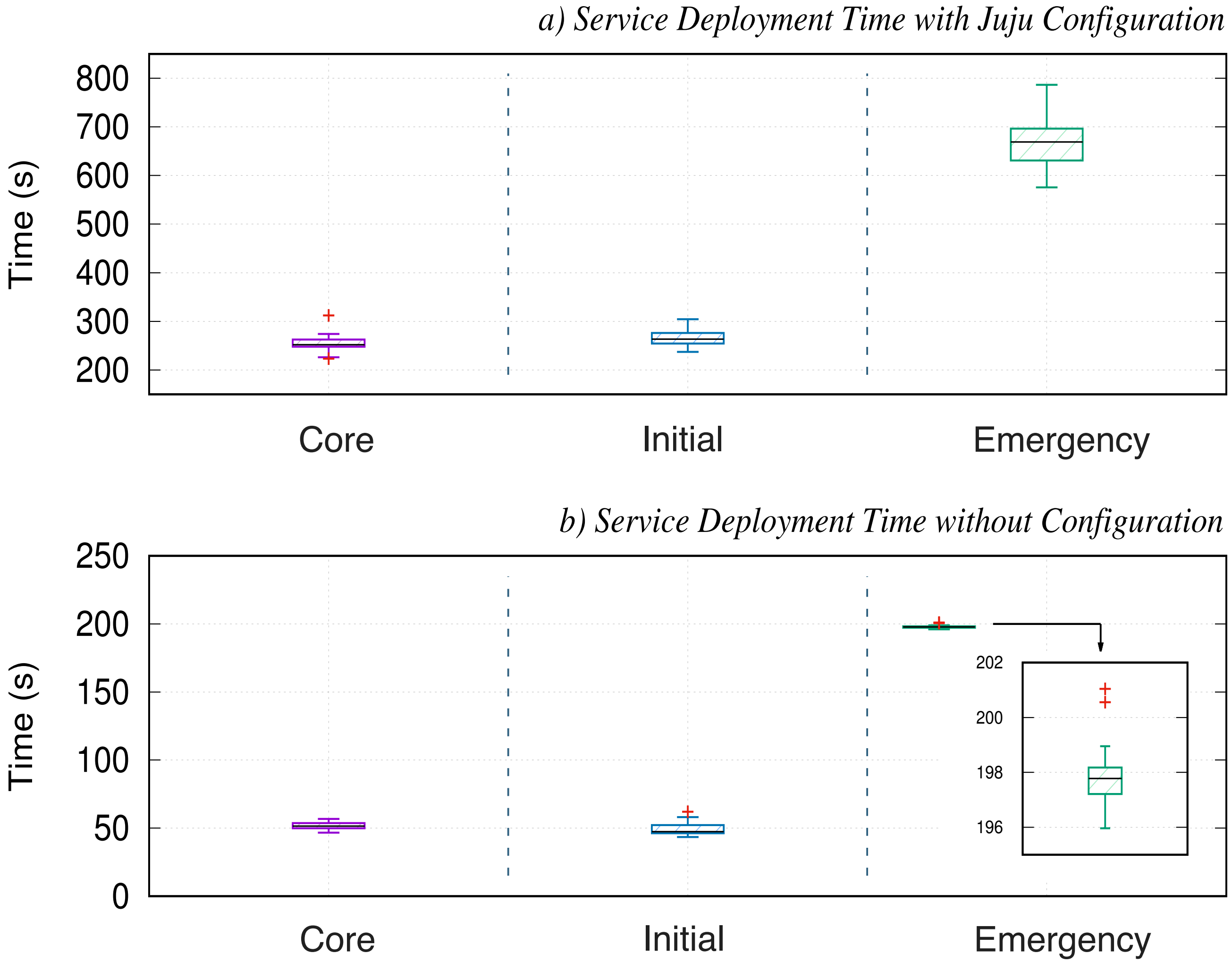
Deployment Times Profiling

- **Objective:** verify the ability of the experimental platform to adapt to emergency situations.
- Measure the time OSM takes to deploy each service.
- Upward trend with the number of VNFs.
- Lead to consider if the proposed framework has the sufficient capability to agilely and flexibly be adapted in scenarios where the service requires greater complexity.



Publish-Subscribe Configuration Function

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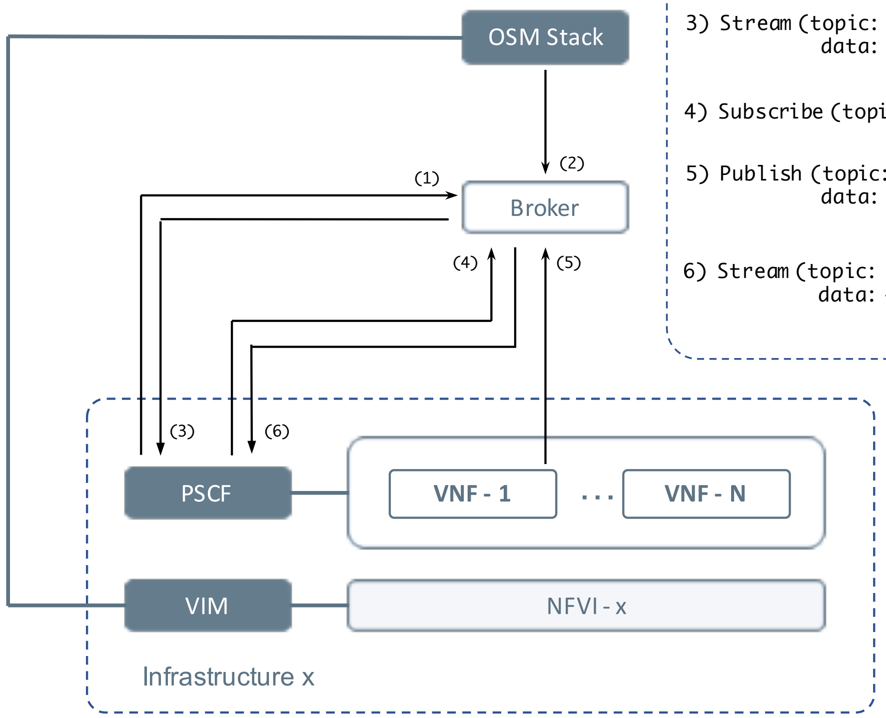
- VNF configuration stage identified as a potential candidate to reduce the service deployment times [2].
- Novel solution to overtake this limitation:
  - Decentralization of the VNF configuration function so that it does not result in a processing overload for the host executing the MANO stack.
  - Based on a publish-subscribe model → efficient and asynchronous exchange of information.
- PSCF prototype:
  - Implemented as a virtual machine (Debian stretch as OS, 1 vCPU, 1 GB RAM and 20 GB storage).
  - Installed software: Kafka and Ansible.

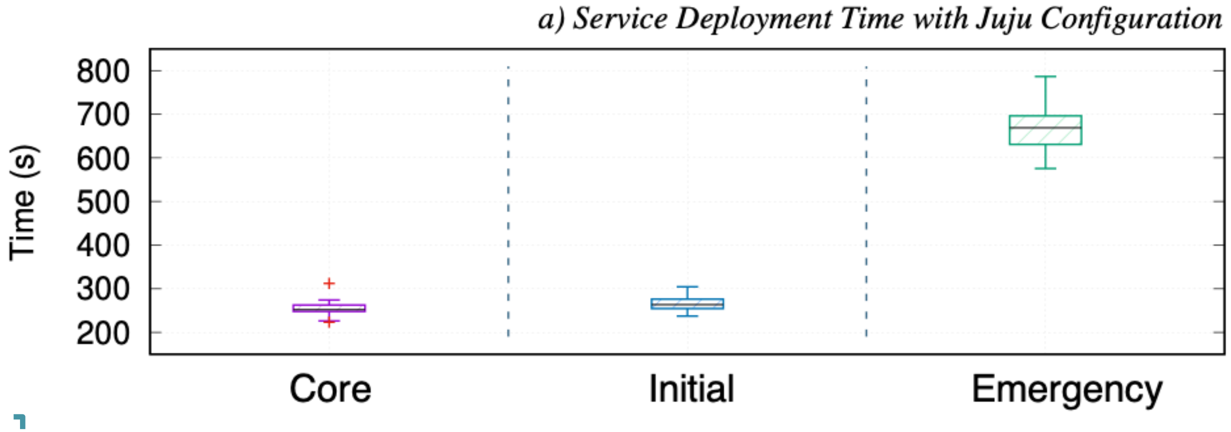
List of operations:

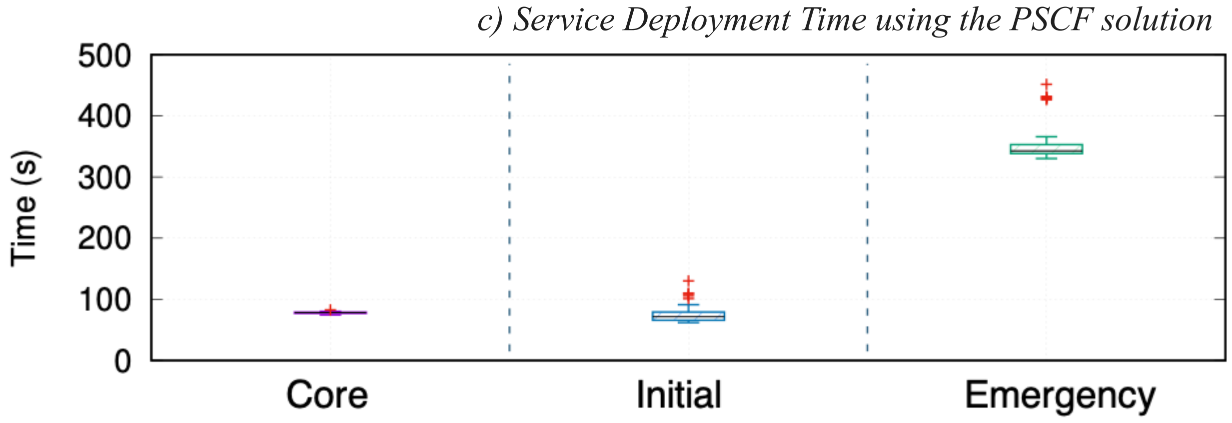
```
1) Subscribe (topic: 'vnfs_info_nfvi_x')

2) Publish (topic: 'vnfs_info_nfvi_x',
            data: {'vnf-id: 1',
                   'conf: vnf_1_conf'})

3) Stream (topic: 'vnfs_info_nfvi_x',
           data: {'vnf-id: 1',
                  'conf: vnf_1_conf.yaml'})

4) Subscribe (topic: 'vnf_ready_nfvi_x')

5) Publish (topic: 'vnf_ready_nfvi_x',
            data: {'vnf-id: 1',
                   'ip-addr: 10.4.16.10'})

6) Stream (topic: 'vnf_ready_nfvi_x',
           data: {'vnf-id: 1',
                  'ip-addr: 10.4.16.10'})
```

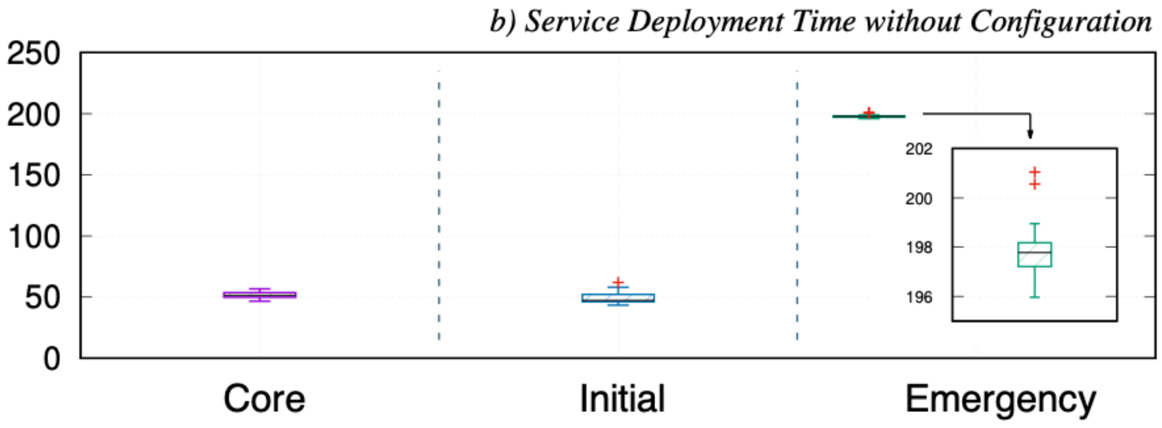


[2] I. Vidal et al. **A Multi-Site NFV Testbed for Experimentation With SUAV-Based 5G Vertical Services**, in *IEEE Access*, vol. 8, pp. 111522-111535, 2020, doi: 10.1109/ACCESS.2020.3001985.

Deployment times significantly reduced!!

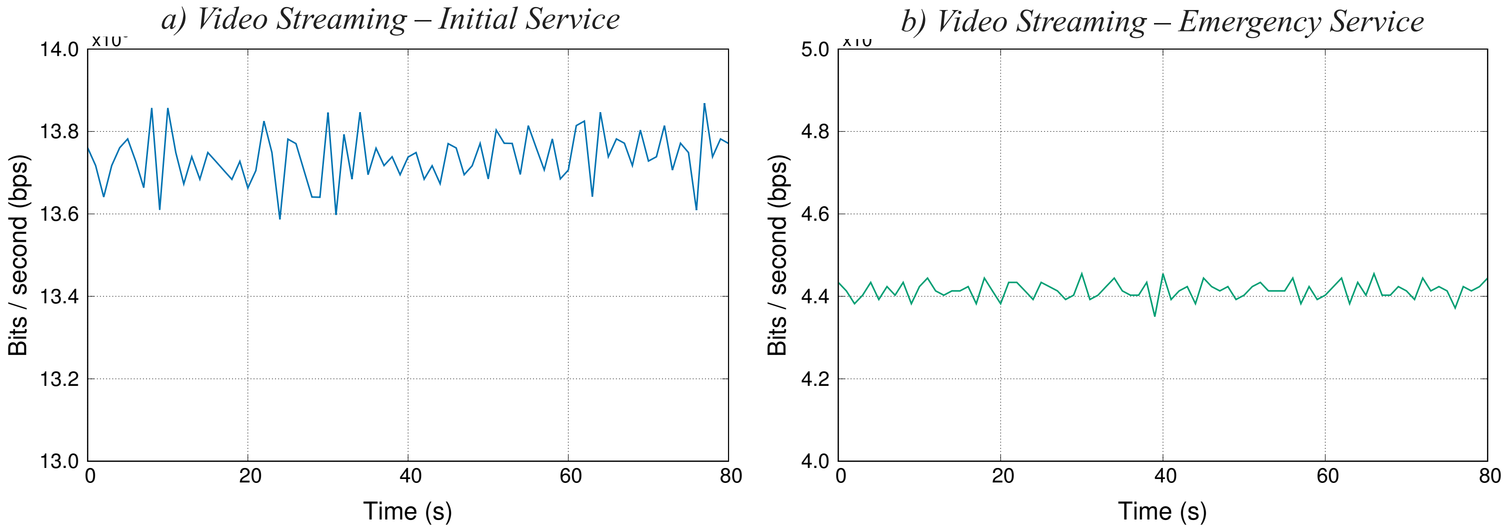






Video service

- Validate that the overall service can offer the expected functionality by means of the interoperation between the three network services:
  - Municipal authority can become aware of the emergency and effectively coordinate the required operations for handling the emergency.
- Services deployed using OSM and the PSCF solution.
- Two simultaneous streams of different real-time videos:
  - Monitor a section of road improving the situational awareness.
  - Capture in detail the occurrence of the emergency to allow the definition of an action plan.



Conclusions and Future Work

- Novel framework that considers the joint integration of three types of NFV infrastructures, with the aim of creating a distributed and more complete NFV ecosystem capable of supporting the flexible deployment of vertical services.
- A complex use case involving the public safety vertical is also defined throughout the work in which the practicality and the potential benefits of the proposed framework are underlined.
- Orchestration different network services from OSM, with the objective of tailoring a video streaming service.
- Detected that the process followed in the deployment of the services may not be properly adapted in terms of deployment times to an emergency.
- Innovative solution of the VNF configuration function based on a publish–subscribe model and its distribution along each infrastructure.
- Future work aims to further explore the use of the slicing technologies in mobile networks such as those included in the framework by means of the SUAVs and the vehicles.

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Work partially funded by:

5GINFIRE Labyrinth — Ensuring drone traffic control and safety TRUE5G 5GO.pt

Thanks for your attention!

Any questions? 🤔