University of Catania

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Management and Orchestration in 5G Environment

PhD in Systems, Energy, Computer and Telecommunications Engineering

XXXIII cycle

Tutor: Prof. Giovanni Schembra

Research topic

The research activity was mainly focused on **5G** networks, an architectural revolution as compared to previous technologies, thanks to the increasing use of cloud-based networking paradigms like **Software Defined Network (SDN)**, **Network Function Virtualization (NFV)** and **Multi-Access Edge Computing (MEC)**.

A key feature of 5G is **Network Slicing** that consists in the creation of a dedicated virtual network architecture with the aim of providing specific functionalities for certain services sharing the same resources of the real available physical network.

Research Activities

Use of MEC UAVs to extend Network Slice

This activity proposes to extend a **5G Network Slice Edge** with a fleet of UAVs, each providing computing facilities, and for this reason referred to as MEC UAV.

In the realized framework, MEC UAVs of the same fleet can apply a cooperation algorithm based on job offloading, aiming at minimizing power consumption due to active computers providing MEC, job loss probability and queueing delay.

To choose whether to do offloading or not, the number of offloaded jobs and the number of active computing elements, a **Reinforcement Learning (RL)** approach is used to support the System Controller in each decision.
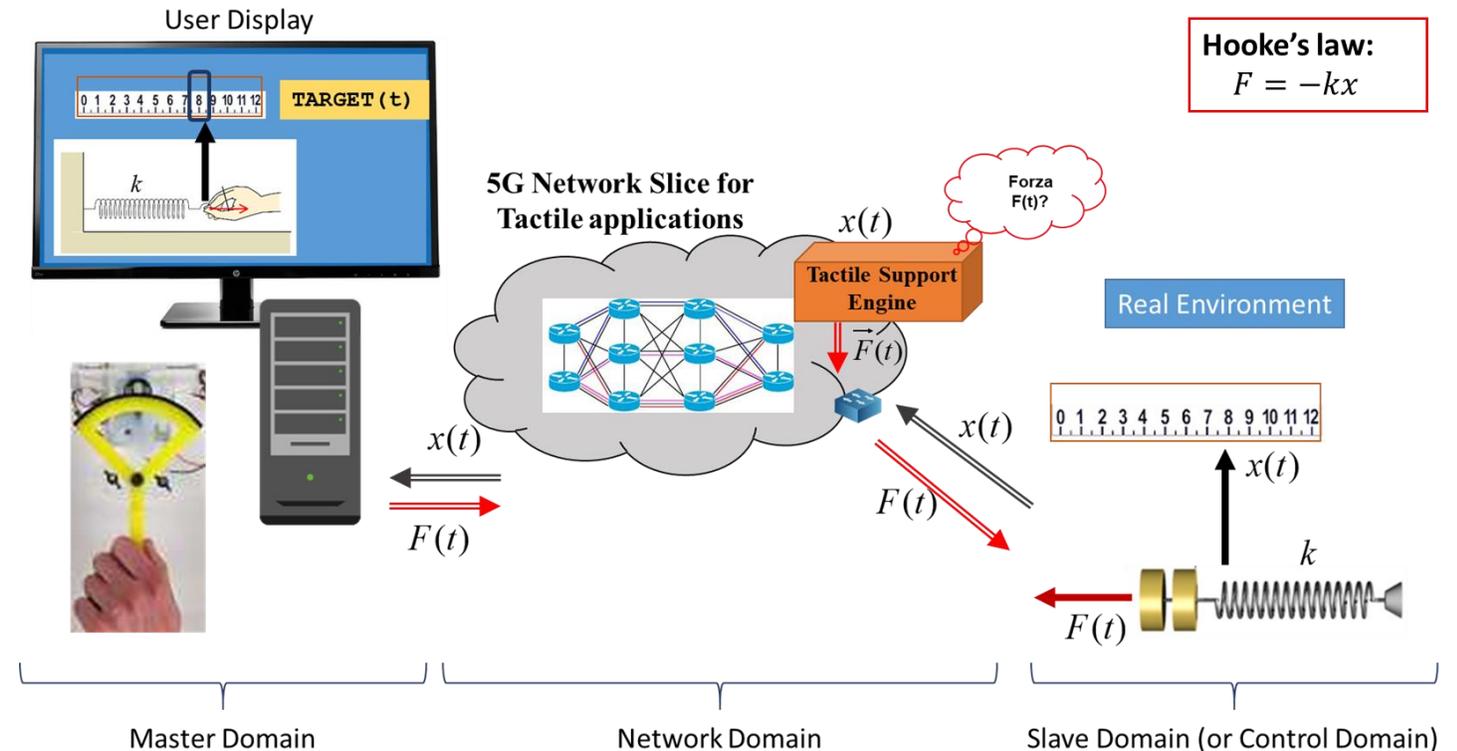
Research Activities

Use of MEC UAVs to extend Network Slice

Management and Orchestration in 5G environment
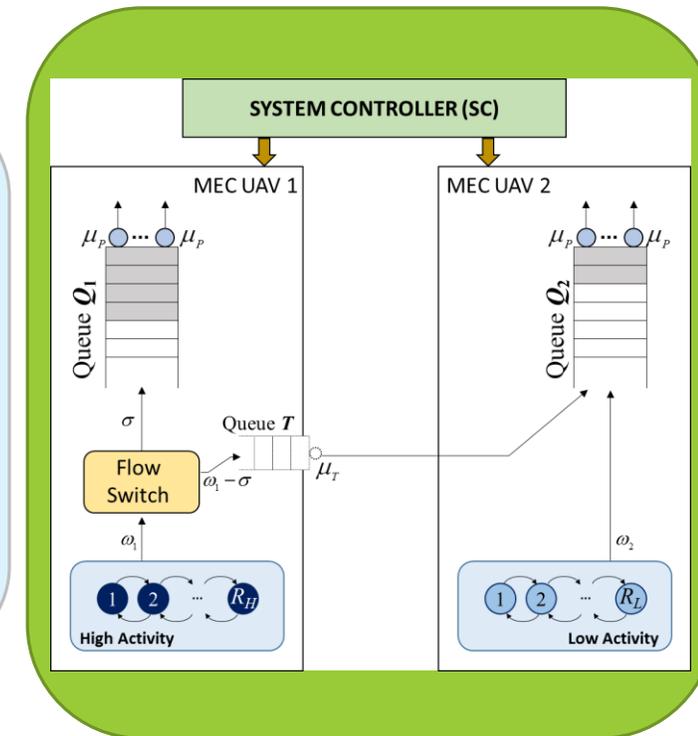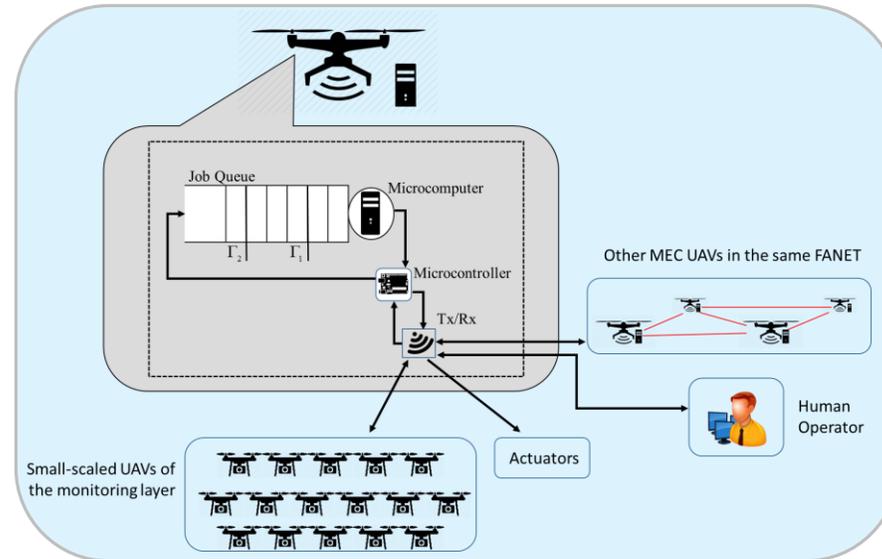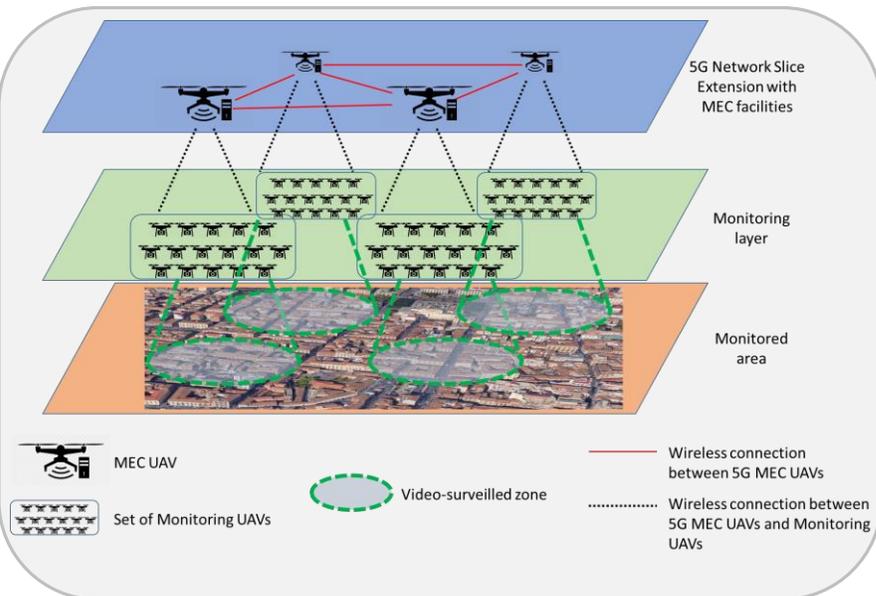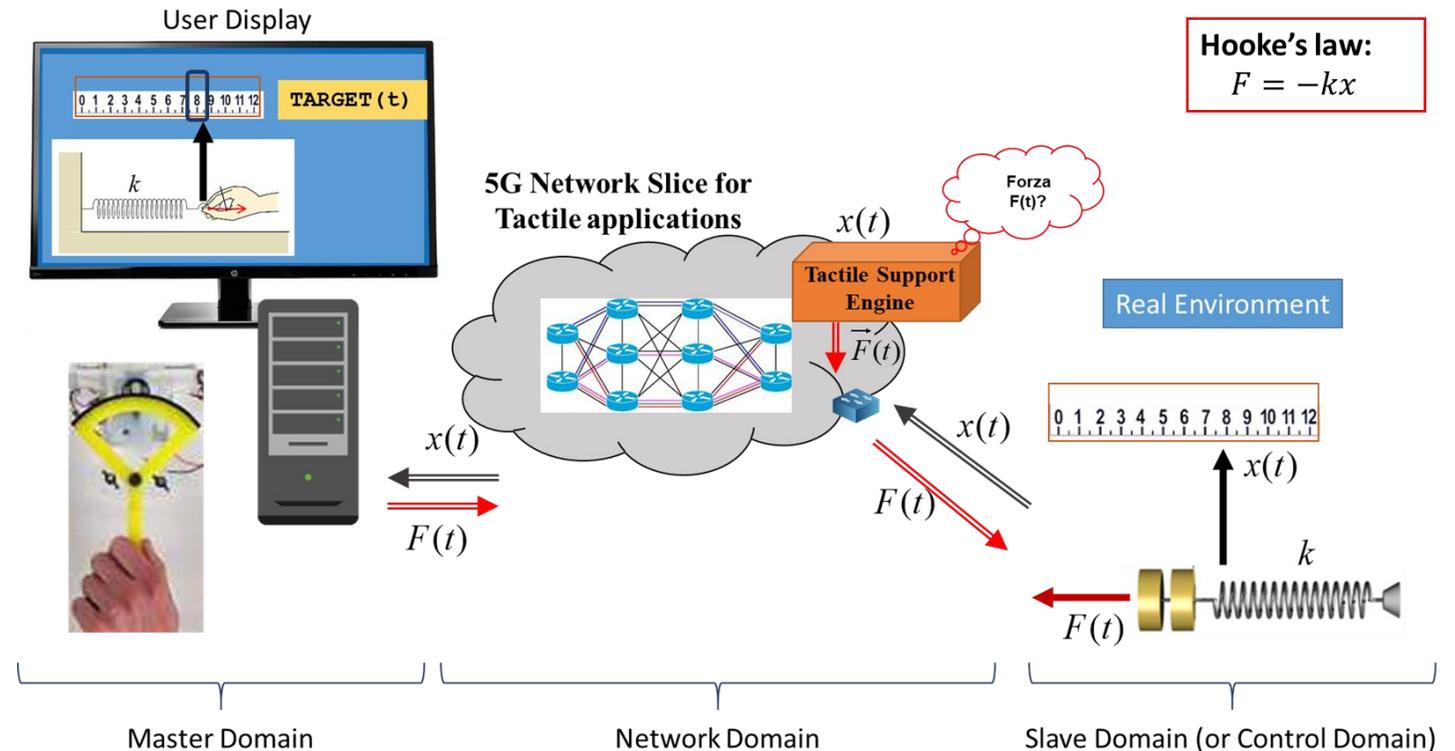
Research Activities

Tactile Internet

- In the **Slave (Control) Domain** there is the real environment with N springs (in this case one spring), each with a value of K.

- In the **Master Domain**, the human operator controls the position of the spring in the Control Domain.

- The **tactile device** (**Hapkit**) is connected to a local motor controlled by Arduino that transmits the feeling of having the end of the spring in hand to the operator.

User Display

TARGET (t)

Hooke's law:
$F = -kx$

5G Network Slice for Tactile applications

Forza F(t)?

Tactile Support Engine

Real Environment

$x(t)$

$\vec{F(t)}$

$x(t)$

$x(t)$

$F(t)$

k

$F(t)$

$x(t)$

$F(t)$

Master Domain   Network Domain   Slave Domain (or Control Domain)
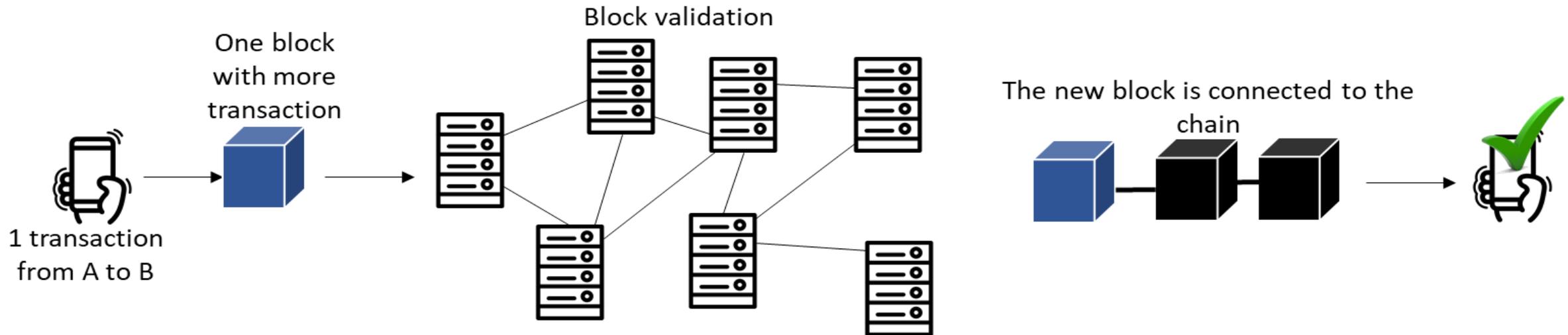
Research Activities

Tactile Internet

- A **Tactile Support Engine (TSE)** is associated with each spring. The TSE listens on a certain port and receives from the **Sniffer** only the information related to its own spring.

- The TSE uses the messages of $F(n)$ and $x(n)$ related to its own spring as training set to estimate the force $\tilde{F}(n)$.

User Display

TARGET (t)

0 1 2 3 4 5 6 7 8 9 10 11 12

k

5G Network Slice for Tactile applications

Forza F(t)?

$x(t)$

Tactile Support Engine

$\vec{F}(t)$

Real Environment

Hooke's law:
$F = -kx$

0 1 2 3 4 5 6 7 8 9 10 11 12

$x(t)$

$x(t)$

$F(t)$

$x(t)$

$F(t)$

k

$F(t)$

Master Domain · Network Domain · Slave Domain (or Control Domain)

Research Activities

One block with more transaction

One block with more transaction

Block validation

The new block is connected to the chain
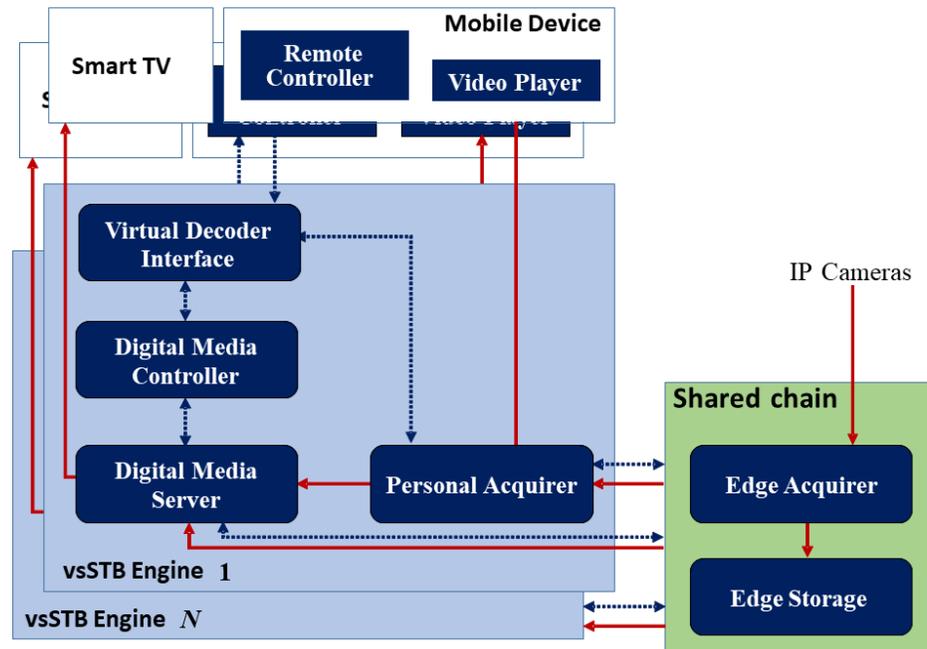
1 transaction from A to B

- Implementation of an event-based Matlab simulator of all the Blockchain phases (from the transaction's arrival to the addition of a new block in the chain).

- Use of smart contracts to negotiate resource allocation in 5G environment

Management and Orchestration in 5G environment

Partecipation to EU projects

TRIANGLE Project

DiMoViS (in collaboration with Scuola Superiore Sant'Anna of Pisa)

◦ The main goal was to reproduces a small Proof of Concept (PoC) of a bigger capillary video surveillance platform over a 5G network infrastructure with a huge number of IP cameras.

Partecipation to EU projects

5GINFIRE Project

Tourist Eyes (in collaboration with ONLUS vEyes)

◦ Tested in Millennium Square at Bristol, has the objective of providing blind tourists, visiting a smart city, with a framework for supporting their activities.

5Gamer

◦ It is an experiment aiming at demonstrating the gain received by online games when supported by 5G technologies. The experiment is a very basic game, a Pong reproduction, with the addition of network and Machine Learning (ML) functionalities.
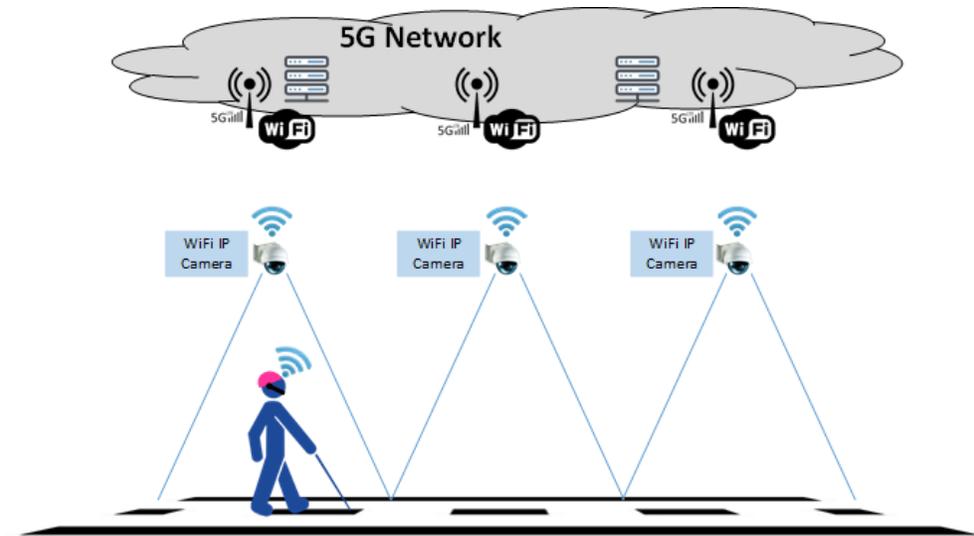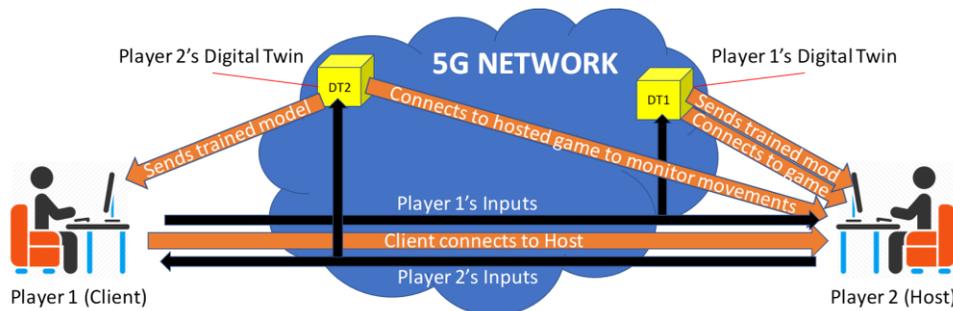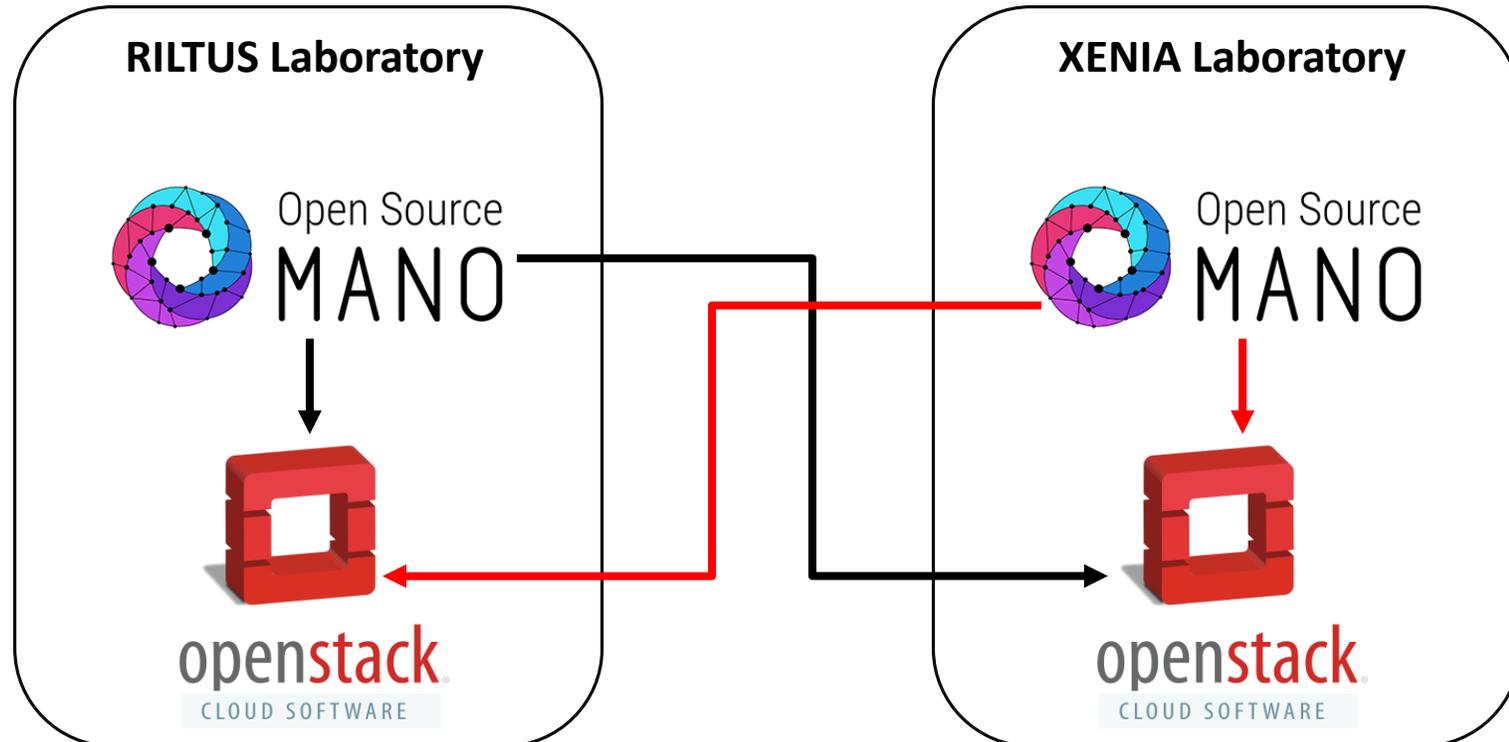
In collaboration with Xenia

Implementation of a joint SDN/NFV network

1. Installation and configuration of open source Management and Orchestration stack (MANO)

2. Installation and configuration of an NFV-PoP: Openstack

RILTUS Laboratory

XENIA Laboratory

Followed conferences, seminars and PhD Schools

Conferences

- *14th International Conference on Network and Service Management*, Rome, Italy, 5 - 9 November 2018

- *1st Workshop on Sustainable networking through Machine Learning and Internet of thiNGs (SMILING 2019)*, in conjunction with IEEE INFOCOM 2019, April 29 – May 2, 2019, Paris, France

- *ACM Mobihoc 2019*, July 2-5, 2019, Catania, Italy

- *2019 IEEE International Symposium on Measurements and Networking (M&N)*, July 8-10, 2019, Catania, Italy

Followed conferences, seminars and PhD Schools

Seminars

- *Making the Edge: a journey through MEC and Fog Computing*, Angelo Corsaro, Chief Technology Officer in ADLINK, 12-13 March 2019, University of Catania

- *Learning for Sequential Data: Tools and Applications*, Michele Rossi, Department of Information Engineering in University of Padova, 24-25 September 2019, University of Catania

PhD Schools

- *1st International School on Informatics and Dynamics in Complex Networks*, 15-19 October 2018, University of Catania

- *5G International PhD School* aggregated at the 5G Italy conference, 4-6 December 2018, CNR Roma

- *International School on Data Science and IoT*, 9-13 September 2019, University of Catania

Other activities

SEMINARY

Network softwarization, virtualization, artificial intelligence, resource management and orchestration: the key 5G enablers

Other activities

Publications

- G. Faraci, C. Grasso and G. Schembra, "Design of a 5G Network Slice Extension with MEC UAVs Managed with Reinforcement Learning," **Submitted to JSAC Special Issue on Advances in Artificial Intelligence and Machine Learning for Networking**

- G. Faraci, C. Grasso and G. Schembra, "Fog in the Clouds: UAVs to Provide Edge Computing to IoT Devices," **Submitted to ACM Transactions on Internet Technology, Special issue on Evolution of IoT Networking Architectures**

- C. Grasso and G. Schembra, "5G-Hander: A Network Service for Handover Detection in 5G Networks," **Special issue article on Internet Technology Letters**, Wiley Online Library

- C. Grasso and G. Schembra, "A Fleet of MEC UAVs to Extend a 5G Network Slice for Video Monitoring with Low-Latency Constraints," Published in **MDPI Special Issue on Softwarization at the Network Edge for the Tactile Internet**, January 2019, Volume 8, Issue 1,3

Publications

Conferences

▪ L. Galluccio, C. Grasso, M. Grasso, R. Raftopoulos and G. Schembra, "Measuring QoS and QoE for a Softwarized Video Surveillance System in a 5G Network," 2019 IEEE International Symposium on Measurements and Networking, Catania, 2019

▪ G. Faraci, C. Grasso and G. Schembra, "Reinforcement Learning for Management of a 5G Network Slice Extension with UAV's," 2019 IEEE INFOCOM Workshops: SMILING 2019: Sustainable networking through Machine Learning and Internet of Things, Paris, 2019

▪ L. Galluccio, C. Grasso, S. Milardo, G. Schembra and E. Sciacca, "An Experimental Testbed for Managing BAN Services at the Network Edge," 14th International Conference on Network and Service Management (CNSM), Rome, Italy, 2018

▪ C. Grasso, R. Raftopoulos and G. Schembra, "The Triangle Platform for End-to-End Performance Anaysis of a 5G Video Transmission Network Slice," 15th International Symposium on Wireless Communication Systems (ISWCS), Lisbon,Portugal, 2018.

Publications

Conferences

■ F. D'Urso, C. Grasso, C. Santoro, F. F. Santoro and G. Schembra, "The Tactile Internet for the flight control of UAV flocks," 2018 4th IEEE Conference on Network Softwarization and Workshops (NetSoft), Montreal, QC, Canada, 2018, pp. 470-475.

■ C. Grasso and G. Schembra, "Design of a UAV-Based Videosurveillance System with Tactile Internet Constraints in a 5G Ecosystem," 2018 4th IEEE Conference on Network Softwarization and Workshops (NetSoft), Montreal, QC, Canada, 2018, pp. 449-455.

■ G. Baldoni, C. Grasso, A. Lombardo, C. Rametta, A. Scala and S. Sottile, "Set-top box virtualization as a personal cloud server for 5G users," 2018 21st Conference on Innovation in Clouds, Internet and Networks and Workshops (ICIN), Paris, 2018, pp. 1-3.

■ A. Lombardo, C. Rametta and C. Grasso, "A Network-Assistent Platform for Multipoint Remote Learning," 28th International Tyrrhenian Workshop (TIWDC), Palermo, Italy, 2017, pp 183-196.

Thanks for your attention