# HORIZON 2020
# H2020 - INFRAIA-2020-1

# D4.1.  Report on the first round of training activities and related material

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| Acronym | SLICES-SC |
| Project Title | Scientific Large-scale Infrastructure for Computing/Communication Experimental Studies – Starting Community |
| Grand Agreement | 101008468 |
| Project Duration | 36 Months (1/3/2021 – 28/2/2023) |
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| Reviewers | All consortium members |

www.slices-sc.eu

## Executive Summary

The objective of this document is to report the first round of training activities of the consortium partners for training external users of SLICES research infrastructure. This deliverable serves several purposes, firstly to describe the SLICES framework for training activities, composed by preparation of training material, organization of summer schools, hackathons, training sessions and research mobility program. Secondly, this document reports all the training activities during the course of the project. As a main conclusion of the organization of the training activities during this first period, the consortium has decided the construction of a common framework for all the training activities that constitute a new open educational ecosystem, the SLICES Academy.

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# 1. Introduction

## 1.1. Intended audience

The potential audience of this document is SLICES-SC consortium members and the external communities related to SLICES-SC that includes novice and expert users from multiple disciplines from R&D staff at industry and academia, all targeting to use the SLICES research infrastructures. The document reports the initial activities of the consortium partners towards the training activities and the plans for future joint training activities that foster the participation of external users in SLICES.

## 1.2. Document structure

The document is structured into the following sections:

- Chapter 1 – **Introduction**. It introduces the intended audience of the document and its structure.
- Chapter 2 – **Objectives of SLICES-SC and WP4**: It describes the objectives of SLICES-SC and WP4. This document is the first deliverable of WP4
- Chapter 3 – **Promoting and fostering training activities**: It describes the methods and tools used to deploy the different training activities that increase the awareness of the external and internal users on the capabilities and the opportunities of RIs.
- Chapter 4 – **Current training activities**: It describes the current training activities that will bring the expertise and tools to develop and promote future training activities.
- Chapter 5 – **SLICES Academy**: It describes the plan for the creation of the SLICES Academy as the flagship framework that articulates all the training activities within SLICES community and fertilizes the engagement of a larger number of external stakeholders.
- Chapter 6 – **Conclusions**.

## 2. SLICES-SC and training context

### 2.1. Objectives of SLISES-SC

SLICES-SC aims to develop and provide services related to experimentation in the context of digital sciences such as 5th and 6th generation cellular networks (5G, 6G), Network Function Virtualisation (NFV), Internet of Things (IoT) and cloud computing. The project is currently building a community of researchers, which will offer the necessary solutions to create and manage efficiently experiments performed using the RIs of the project partners. SLICES-SC will also investigate a facilitated access for the experiments, the reproducibility of the research experiments, the validation of the experiment results, and the publication of the results in open data access.

SLICES-SC will provide access to the following research infrastructures depicted in the figure below:

- SILECS-FIT / OneLab, France
- NITOS – UTH, Greece
- Open5GLa - EURECOM, France
- PIONIER-LAB, Poland
- 5TONIC, Spain
- LeonR&Do - COSMOTE, Greece

- 5G Test Network (5GTN), Finland
- FIT-R2lab - INRIA, France
- MTA Cloud - SZTAKI
- TUM, Germany
- CNR lab, Italy



Figure 1. SLICES-SC Facilities

### 2.2. Objectives and tasks of WP4

The main objective of WP 4 is to organize and deliver training events for SLICES-SC with the goal of promoting SLICES research infrastructure and fostering the engagement of external R&D community on experimentation in digital science. The training events will target in getting novice and expert users, from multiple disciplines, acquainted with the tools and infrastructure of SLICES research infrastructure. In detail, the technical objectives set by this WP are the following:
- to efficiently identify the training needs and training methodologies that will be followed
- to develop and provide the respective training material to organize SLICES-SC training events

(training sessions, webinars, plugfests, hackathons)

- to facilitate researcher mobility for the exchange of know-how among the users of the facilities.
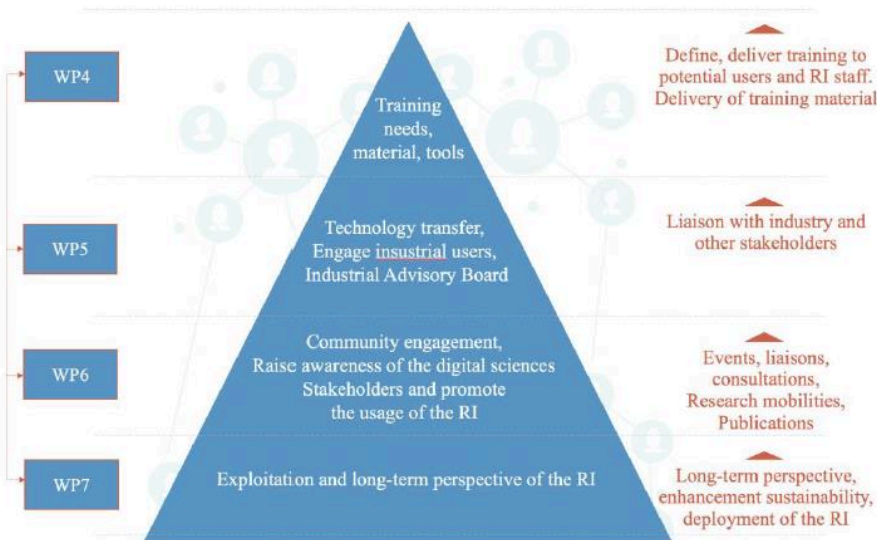


*Figure 2. SLICES-SC training and work plan*

The training framework defined in WP4 are composed of three main tasks:

- ***Task 4.1. Identification of training needs, training methodologies and contents.*** The work on this activity has been done during the first year of the project and its objective is to create a full working plan on the training activities

- ***Task 4.2: Development of training content and material.*** The outputs of this task will be the actual training courses and material. Stemming from the requirements analysis that will be performed in T4.1, this task will actually build the education material that will be used for the provided courses.

- ***Task 4.3: Organisation and delivery of training sessions for the RI community.*** The task aims to organize the collaboration among all partners in order to develop training methods and content.

- ***Task 4.4: Organisation of Hackathons on specific themes related to the RI***. The exact research topics will be further decided based on the exact needs and the results of WP2 and WP3, and will include joint proposals for demonstration on innovative technologies also including the technical components developed. An independent panel of evaluators will be responsible for the evaluation of the ideas proposed by the competing teams.

- ***Task 4.5: Summer Schools for training new users.*** The Summer Schools are seen as a multi-disciplinary opportunity to train new users of the RI. The summer schools will help interested students and academics as well as individuals working in the academia, research or the private sector, to better understand the specific opportunities of the RI within the selected thematic priorities and get comprehensive knowledge on the various aspects of the selected theme.

- ***Task 4.6: Researchers mobility.*** The goal of this activity is to increase ties to transnational research in digital sciences and to promote the knowledge flows and collaboration between institutions promoting new interdisciplinary academic-industrial networks. This activity is targeted both to members of the consortium, as well as researchers not affiliated with any of the consortium partners. This mobility initiative aims to transfer skills and expertise between academia and industry in order to contribute to the development and the improvement of a

common understanding of research infrastructures for Digital Sciences (and of SLICES-RI in particular) and to foster cooperation between stakeholders.

## 3.  Promoting and Fostering Training activities

One of the main objectives of SLICES-SC is to *empower and assist the growth of the user community* as a vibrant and disruptive framework by implementing community building strategies to effectively link and embrace different target groups and players in Europe and beyond. In doing so, SLICES-SC is *coordinating and strengthen training efforts* through a rich set of tools and actions that aim at ensuring visibility on different stakeholders and relevant initiatives to foster the creation of the user community and the access to experimentation services in SLICES research infrastructure.

Moreover, training activities are targeting *multidisciplinary user communities* at a global scale from *research/academia and industry*. Training activities are accelerating community building and facilitate the circulation of knowledge and the opportunities. Some of the *tools* used for that purpose are the organization of training events, workshops, seminars, support of researchers' mobility, hackathons, webinars, demonstrations in high-quality venues. SLICES-SC joint training activities aim to provide the mechanisms for the definition and delivery of training for both experts using the platforms, as well as novice users in order to get acquainted with the experimentation methodology followed in SLICES-SC.

The *novelty of the approach on SLICES-SC training activities* is the focus on bringing the problem of using the RIs and technology learning to the attention of a *wider audience* than technical elite of people. All the training activities are be designed with multi-culture awareness towards attracting people from different backgrounds, as SLICES research infrastructure aspires to be the umbrella infrastructure for multiple disciplines that make use of *Digital Sciences* resources. In addition, the joint training activities focus to engage industrial stakeholders to use the research infrastructure and to facilitate the technology transfer between academia and industry and potentially reduce the brain drain from Europe.

A *new generation of researchers* is educated that is ready to optimally exploit the tools and services of the SLICES research infrastructure. As several of the SLICES-SC partners are academic institutes, similar activities are being organized in the context of under- and post-graduate courses, who can take advantage of SLICES for educational purposes. The knowledge and experience acquired by students will provide them with better job opportunities and will be the driving force for distilling know-how to industry. Researchers, junior faculty and students will be educated through research conducted along the lines of the project in the form of theses, fellowships or research internships in industrial or other academic partners. These activities are training young researcher that would represent the future key actors in their universities.

SLICES-SC has a main goal to have *impact on education, teaching and learning* by the introduction and use of the *research experimentation testbeds in the educational process*, which is highly innovative. Traditional courses in telecommunications and networking are based in theoretical analysis and simulations. Access to real equipment is rather limited and, more often than not, this equipment is outdated. The recently established availability of remote experimentation with state-of-the-art equipment offers new educational opportunities at no extra cost. It is known that there is a lack of skilled software engineers in Europe. The SLICES-SC training platform is a candidate to support advanced training, lifelong learning, and professional learning and contribute actively to the *EU Skills*

*and Qualifications Agenda[1] in the domain of the Digital Sciences*, in particular to the 2023 European Year of Skills recently launched by the EC.

## 4.    SLICES-SC Training Activities

SLICES-SC consortium organized a specific *WP4 Workshop on Training Needs and Methodology on 22 December 2021*. The main objective of this workshop was to identify the SLICES-SC training needs and methodology and kick-off the development of the training content and material that corresponds to the Tasks 4.1 and 4.2 respectively.

As a result of that meeting, there was a survey on current training activities lunched with the whole SLICES community, not only SLICES-SC consortium with the objective of collect as much as possible training activities and plans of the whole SLICES community. The result of that survey is collected in the following subsections per each institution.

### 4.1.  Training activities – SU

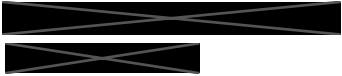| | |
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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Master 1 course – Telecommunications networks |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms. |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | Sorbonne University<br>Thi-Mai-Trang Nguyen<br>Associate Professor |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Networking – Telecommunications networks<br><br>Learning objectives: Teaching network architecture and protocols of telecommunications networks. The course is composed of three parts<br>- Fixed and core network technologies: circuit switching, packet switching, routing, Ethernet, ATM, MPLS, SD-WAN<br>- Wireless and mobile networks: introduction to wireless networks (e.g., Wi-Fi, random access) and mobile networks (cell concept, 2G-5G network architectures)<br>- Cloud-based and virtualized network infrastructure (SDN, NFV)<br><br>Learning outcome: The students understand evolution of telecommunications networks from the telephone networks to the converged IP-based network that we have today. The trend towards cloud-based and virtualized network infrastructure is presented at the end.<br><br>Expertise level: basic |
| **Timeline** | Active: |

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[1] EC European Skills Agenda. https://ec.europa.eu/social/main.jsp?catId=1146&langId=en, [Last accessed 10 November 2022]

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| (Active, future plans…) | - Simulation of Ethernet, MPLS and Wi-Fi networks using OMNeT++, LTE using NS3<br>- Emulation of Software-Defined Networks using Mininet and OpenDaylight<br>- Network optimization with GLPK<br>Future plans:<br>- NFV lab<br>- AWS IaaS services (EC2, VPC)<br>- OpenStack |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Master 1 students |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | About 70 students (3 classes) |
| **Access conditions**<br>(open/ closed/restricted) | Restricted to students of Sorbonne University and international exchange students. |
| **Industrial participation** | Nokia course on SDN-based Optical network control |
| **URL of the website(s)** | https://lip6.fr/Thi-Mai-Trang.Nguyen/teaching.html<br>https://sciences.sorbonne-universite.fr/formation-sciences/masters/master-informatique/parcours-res |


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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Master 1 course – Cloud Computing |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and a server at LIP6 |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | Sorbonne University<br>Thi-Mai-Trang Nguyen<br>Associate Professor<br>~~████████████~~<br>~~██████~~ |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Cloud computing<br>Learning objectives: Teaching Public Cloud and Private Cloud<br>Learning outcome: The students understand the concept of public cloud and private cloud with hands-on with AWS and Openstack.<br>Expertise level: basic |
| **Timeline**<br>(Active, future plans…) | Active:<br>- AWS as an example of public cloud. Each student has an account on AWS Academy and do the labs of the AWS Academy Cloud Foundations course. |

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|  | • Openstack as an example of private cloud. Each student can build a private cloud, create tenants, virtual machines and virtual networks using command lines and the Horizon graphical interface.<br><br>Future plans:<br><br>• We need more infrastructure resources for the Openstack lab. The capacity of the server at LIP6 is quite limited. Students have to reserve the server to do the lab at different timeslots. |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Master 1 international students |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | About 10 students (1 classes)<br><br>The Public cloud and Private Cloud lectures are only part of the Cloud Computing. Each subject (private cloud, public cloud) has a 2-hour lecture and a 4-hour lab. |
| **Access conditions**<br>(open/ closed/restricted) | Restricted to international exchange students (course given in English). |
| **Industrial participation** |  |
| **URL of the website(s)** | https://lip6.fr/Thi-Mai-Trang.Nguyen/teaching.html<br><br>https://sciences.sorbonne-universite.fr/en/formation-sciences/masters/master-informatique/digit-International |

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Master 2 course – Cellular networks |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms. |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | Sorbonne University<br>Thi-Mai-Trang Nguyen<br>Associate Professor<br><br> |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Networking – telecommunications networks – Cellular networks<br>Learning objectives: Teaching network architecture and protocols of mobile networks.<br>Learning outcome: The students understand the evolution of cellular mobile networks from 2G to 5G and the new demands in 6G.<br>Expertise level: basic |
| **Timeline**<br>(Active, future plans…) | Active:<br>• Simulation of LTE-EPC networks using NS3<br>• Emulation of IMS using Open IMS-core of Franhofer FOKUS |

- Simulation of propagation model using Matlab
- Mobile data analytics using Python, Matlab and the Telecom-Italia dataset

Future plans:

- Simulation of 5G-NR using NS3
- Lab on 5G RAN and core using OpenAirInterface (to build a completely virtualized mobile network)
- Demonstration of network slicing

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| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Master 2 students |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | 1 class of 30 students |
| **Access conditions**<br>(open/ closed/restricted) | Restricted to students of Sorbonne University and international exchange students. |
| **Industrial participation** | |
| **URL of the website(s)** | https://lip6.fr/Thi-Mai-Trang.Nguyen/teaching.html<br><br>https://sciences.sorbonne-universite.fr/en/formation-sciences/masters/master-informatique/digit-International<br><br>https://sciences.sorbonne-universite.fr/formation-sciences/masters/master-informatique/parcours-res |

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Official MSc teaching units |
| **Name of the infrastructure(s) involved** | Edge-Net (https://www.edge-net.org/) |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | Olivier Fourmaux (Sorbonne Université)<br>▬▬▬▬▬▬▬▬▬ |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Computer science, observation of the operation and performance of the Internet and its associated protocols, for example study of congestion control on long distance connections, probing and cartography of the Internet... intermediate to expert level |
| **Timeline**<br>(Active, future plans…) | The labs using this platform are already active. More intensive use with more labs is expected. An extension of this platform would allow more varied and interesting observations. |

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| **Target audience** <br> (Technical staff, managers of RI, researchers, students, general public) | Students |
| **Metrics of previous editions** <br> (Students surveys, indicators of participant….) | Students survey |
| **Access conditions** <br> (open/ closed/restricted) | Closed |
| **Industrial participation** | - |
| **URL of the website(s)** | The web site of the modules is restricted (university Moodle) |

## 4.2. Training activities – INRIA

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | EnosLib: Tool and Tutorials |
| **Name of the infrastructure(s) involved** | Grid'5000/FIT IoT Lab |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | Adrien Lebre<br>Prof. IMT Atlantique / Inria / LS2N<br>Head of the STACK Research Group<br>http://stack.imt-atlantique.fr/alebre.html |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | INRIA - developing a library to help researchers/engineers/… perform experiment driven research activities on top of testbeds such as the SLICES-RI we envisioned: EnosLib<br>INRIA - tutorials, leveraging Grid'5000/FiT IoT Lab/… at different schools |
| **Timeline**<br>(Active, future plans…) | Active |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Students/researchers/engineers/… perform experiment driven research activities on top of testbeds such as the SLICES-RI |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | - |
| **Access conditions**<br>(open/ closed/restricted) | Open |
| **Industrial participation** | - |
| **URL of the website(s)** | Documentation : https://discovery.gitlabpages.inria.fr/enoslib/<br>Some tutorials:<br>https://discovery.gitlabpages.inria.fr/enoslib/jupyter/index.html |


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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Courses for undergraduate/graduate students |
| **Name of the infrastructure(s) involved** | Grid'5000/FiT IoT Lab |
| **Name(s) of the Institution(s) /Person(s) involved** | Adrien Lebre |

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| (Author(s) of the learning and training resources, affiliation and contact details) | Prof. IMT Atlantique / Inria / LS2N<br>Head of the STACK Research Group<br>http://stack.imt-atlantique.fr/alebre.html |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Utility Computing (Cloud, Fog, Edge) with a focus on OpenStack (up to three days tutorial: lectures/practical sessions)<br>• GreenIT/Computing<br>• Industrial IoT<br>• Distributed architectures (micro-services, REST, gRPC, etc.) |
| **Timeline**<br>(Active, future plans…) | Active |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Students/researchers/engineers/… perform experiment driven research activities on top of testbeds such as the SLICES-RI |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | - |
| **Access conditions**<br>(open/ closed/restricted) | Open |
| **Industrial participation** | - |
| **URL of the website(s)** | |

### 4.3. Training activities – OULU

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | University of Oulu Graduate School (UniOGS) / Information Technology and Electrical Engineering Doctoral Programme (ITEE-DP) / Communications Engineering |
| **Name of the infrastructure(s) involved** | 5G Test Network (5GTN) / SLICES-SC Finnish node |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | UniOGS and Faculty of ITEE professors and teachers / Visiting professors, researchers and teachers |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | The aim of the doctoral studies at the Centre for Wireless Communications (CWC) is to provide skills for the student to master the research methodology in the field, to work in companies, academic or other non-academic expert positions, both nationally and internationally. The student's doctoral thesis research focus can be on communications networking, communications signal processing, radio access technologies, radio frequency (RF) engineering, wireless medical communications, or wireless systems and applications. |
| **Timeline** | Active |

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| (Active, future plans…) | |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | PhD students |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | Student surveys, participation rate, completion rate of PhD studies, etc. |
| **Access conditions**<br>(open/ closed/restricted) | Open |
| **Industrial participation** | Co-operation with several industrial partners during the studies |
| **URL of the website(s)** | https://opas.peppi.oulu.fi/en/doctoral-training/11741 |

### 4.4. Training activites – UvA

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Course on Research lifecycle management (new) |
| **Name of the infrastructure(s) involved** | - |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | Yuri Demchenko<br>Senior Researcher<br>System and Network Engineering Research Group<br>University of Amsterdam, Amsterdam |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | The course is composed of the following 6 tutorials:<br>• Research Methods and Project Management (2 tutorials)<br>• Research Data Management, data lifecycle (1-2 tutorial)<br>• DevOps and data science projects deployment (1 tutorial)<br>• Data preparation and statistical analysis (optional 2 tutorials) |
| **Timeline**<br>(Active, future plans…) | Active |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Researcher in computer/digital technologies |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | - |
| **Access conditions**<br>(open/ closed/restricted) | Open |

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| **Industrial participation** | Co-operation with several industrial partners during the studies |
| **URL of the website(s)** | |

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| **Type of the training activity** (Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | UvA have quite a number of training materials that are currently either taught as both academic and/or professional or vocational training courses. |
| **Name of the infrastructure(s) involved** | - |
| **Name(s) of the Institution(s) /Person(s) involved** (Author(s) of the learning and training resources, affiliation and contact details) | Yuri Demchenko Senior Researcher System and Network Engineering Research Group University of Amsterdam, Amsterdam |
| **Description of the training material/activity** (Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Cloud Computing and cloud native technologies (8 tutorials/sessions and practice) DevOps and Cloud based Software development (8 tutorials and practice) Big Data Infrastructure and Technologies (for Data Analytics) (10 sessions and practice) Cloud and Big Data Security and Compliance (4 tutorials and practice) Data Management and Governance (enterprise and research) (4 tutorials) Research Data Management (4 tutorials) Research Methods and Project Management (4 tutorials) Data Science Analytics Foundation (6 tutorials) |
| **Timeline** (Active, future plans…) | Active |
| **Target audience** (Technical staff, managers of RI, researchers, students, general public) | Academic and/or professional or vocational training courses. |
| **Metrics of previous editions** (Students surveys, indicators of participant….) | - |
| **Access conditions** (open/ closed/restricted) | Open |
| **Industrial participation** | Co-operation with several industrial partners during the studies |
| **URL of the website(s)** | |

## 4.5. Training activities – UCLan

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| **Type of the training activity** | MSc Data Analytics – Official MSc Program |

| (Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Includes: Lectures, Tutorials, Labs, Video Lectures, Guest Lectures, Self-assessment exercises, assignments and exams. |
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| **Name of the infrastructure(s) involved** | Azure, AWS, Mongo |
| **Name(s) of the Institution(s) /Person(s) involved** <br> (Author(s) of the learning and training resources, affiliation and contact details) | UCLan Cyprus – MSc Data Analytics team |
| **Description of the training material/activity** <br> (Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Exploratory Data Analysis <br> • Field(s) of Science: Data Science, Statistics <br> • Length: 13 sessions x 3 hours <br> • Content summary: exploratory data analysis, numeric predictions, trend analysis <br> • Tools: R + R Studio <br> • Expertise level: Beginner, Intermediate <br><br> Knowledge Discovery <br> • Field(s) of Science: Data Science, Statistics, Computer Science <br> • Length: 13 sessions x 3 hours <br> • Content summary: supervised, unsupervised, semi-supervised learning techniques: classification, clustering, frequent pattern mining, outlier analysis, ethics <br> • Tools: SAS Enterprise Guide, SAS Enterprise Miner, Python <br> • Expertise level: Intermediate <br><br> Enterprise Data Management <br> • Field(s) of Science: Data Science, Management of Data <br> • Length: 13 sessions x 3 hours <br> • Content summary: information modelling and optimization, database implementation, database deployment and access, information retrieval. <br> • Tools: SQL, SQL Server, Azure (other database systems, such as Oracle, MongoDB, Neo4J) <br> • Expertise level: Beginner, Intermediate <br><br> Business Intelligence and Data Analytics <br> • Field(s) of Science: Data Science, Business Intelligence <br> • Length: 13 sessions x 3 hours <br> • Content summary: descriptive analytics, diagnostic analytics, predictive analytics, prescriptive analytics <br> • Tools: SAS Visual Analytics, MatLab, Tableau, Excel, PowerBI <br> • Expertise level: Beginner, Intermediate <br><br> Data Science with Python <br> • Field(s) of Science: Data Science |

- Length: 10 hours
- Content summary: data pre-processing, descriptive analytics, diagnostic analytics, predictive analytics, prescriptive analytics, visualizations
- Tools: Python, Anaconda, PyCharm
- Expertise level: Beginner, Intermediate

Research Methods and Research Data Management

- Field(s) of Science: Qualitative and Quantitative Research
- Length: 13 sessions x 3 hours
- Content summary: Qualitative and Quantitative Research, interpreting data and statistics, Designing and conducting a simple experiment/survey
- Tools: Statistical tools (e.g., SPSS, R, Python)
- Expertise level: Beginner

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| **Timeline** <br> (Active, future plans…) | Active <br> Future – continuous refinement and introduction of additional topics |
| **Target audience** <br> (Technical staff, managers of RI, researchers, students, general public) | Technical staff, managers of RI, researchers, students, general public |
| **Metrics of previous editions** <br> (Students surveys, indicators of participant….) | Student Evaluations <br> Student Staff Liaison Meetings <br> Participation/Attendance and Performance Statistics |
| **Access conditions** <br> (open/ closed/restricted) | Restricted |
| **Industrial participation** | Yes |
| **URL of the website(s)** | |

## 4.6. Training activities – UC3M/IMDEA

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Master in Network Function Virtualization (NFV) and Software Defined Networks (SDN) for 5G Networks<br>Includes: Lectures, Tutorials, Labs, Video Lectures, Guest Lectures, Self-assessment exercises, assignments and exams. |
| **Name of the infrastructure(s) involved** | 5TONIC |
| **Name(s) of the Institution(s) /Person(s) involved**<br><br>(Author(s) of the learning and training resources, affiliation and contact details) | UC3M, IMDEA, Ericsson (it is also part of internal company training) |
| **Description of the training material/activity**<br><br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Courses and hand-on sessions on:<br><ul><li>Virtualization Technologies for NFV</li><li>Cloud Mangement and Orchestration for NFV</li><li>Data Center Communications</li><li>Network Function Virtualizatin (NFV)</li><li>Softwarized and Programmable Networks (SDN)</li><li>SDN, NFV and Virtualization Lab</li><li>Network Technologies and Protocols for IoT</li><li>Security in 5G Networks</li><li>Business Models for Software Based Networks</li><li>Access and Edge Networks in 5G</li><li>Core Networks in 5G</li></ul> |
| **Timeline**<br>(Active, future plans…) | Active (since 2018) |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Technical staff, managers of RI, researchers, students, telco industry |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | Student Evaluations<br>Participation/Attendance and Performance Statistics |
| **Access conditions**<br>(open/ closed/restricted) | Restricted |
| **Industrial participation** | Yes (co-organized with Ericsson and part of Ericsson worldwide training program) |
| **URL of the website(s)** | https://www.uc3m.es/master/NFV-SDN-5g-networks |

## 4.7. Training activities – UTH

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Course on Computer Networking Course |

| Name of the infrastructure(s) involved | We currently use on-site lab rooms and multiple nodes in the NITOS testbed |
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| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | University of Thessaly<br>Thanasis Korakis<br>Associate Professor<br>▨▨▨▨▨▨ |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Computer Networking<br>Learning objectives: Teaching computer networking basic concepts and protocols, host intercommunication and application intercommunication over the network,<br>Expertise level: basic |
| **Timeline**<br>(Active, future plans…) | Active:<br>• Each student gets a pair of containers instantiated over the NITOS testbed. They are required to execute and observe simple exercises on concepts such as routing, switching, application message exchange, etc. The containers are instantiated from the instructor using the Kubernetes framework. |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Undergraduate Students |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | About 300 students (1 classes)<br>Each subject has a 3-hour lecture and a 4-hour lab. |
| **Access conditions**<br>(open/ closed/restricted) | Restricted to students of UTH |
| **Industrial participation** | N/A |
| **URL of the website(s)** | http://web.nitlab.inf.uth.gr/networks1/ |

| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Course on Computer Networks 2 |
|---|---|
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and a server node in the NITOS testbed |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | University of Thessaly<br>Thanasis Korakis<br>Associate Professor<br>▨▨▨▨▨▨ |
| **Description of the training material/activity** | Domain: Software Defined Networking |

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| (Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Learning objectives: Teaching basic concepts of Software Defined Networking, using the OpenFlow protocol as a paradigm. Students get hands-on experience with OpenFlow controllers<br>Expertise level: basic |
| **Timeline**<br>(Active, future plans…) | Active:<br>• Each student gets a mininet instance running in the NITOS testbed, where they can apply simple tutorials provided by the instructor, and can test their new protocols for switching.<br>Future Plans:<br>• Extend current capacity of the servers to host more mininet instances in order to support higher numbers of students |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Undergraduate students |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | About 30 students (1 classes)<br>The course has a 2-hour weekly lecture and a 2-hour lab. |
| **Access conditions**<br>(open/ closed/restricted) | Restricted to UTH students and international students visiting UTH |
| **Industrial participation** | |
| **URL of the website(s)** | http://web.nitlab.inf.uth.gr/networks2/ |


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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Course on Advanced Topics on Networking |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and multiple nodes in the NITOS testbed |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | University of Thessaly<br>Thanasis Korakis<br>Associate Professor |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Software Defined Radios<br>Learning objectives: Teaching basic concepts on wireless networking using Software Defined Radios. The students become acquainted with tools like GnuRadio and the UHD driver, while they also use multiple types of SDR devices (e.g., USRPs, or PlutoSDR devices)<br>Expertise level: basic |
| **Timeline**<br>(Active, future plans…) | Active:<br>• Each student gets a pair of SDR devices in order to experiment with different schemes applied in the lower MAC layer or the PHY layer. The students are challenged to operate their devices under |

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| | the presence of a dynamic interferer that randomly changes its operation. All the solutions are set in order to compete to each other in a final workshop during the course, with the solution managing to send the most packets being given an award.<br><br>Future plans:<br><br>• As the current SDR devices in the testbed are rather limited (can provide for pairs of up to 15 students), future plans include the extension of the infrastructure in order to include more of such devices. |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Undergraduate students |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | About 15 students (1 classes)<br>The course has a 2-hour weekly lecture and a 2-hour lab. |
| **Access conditions**<br>(open/ closed/restricted) | Restricted to UTH students and international students visiting UTH |
| **Industrial participation** | |
| **URL of the website(s)** | http://web.nitlab.inf.uth.gr/advanced_topics/ |

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Course in Wireless Communications |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and multiple nodes in the NITOS testbed |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | University of Thessaly<br>Thanasis Korakis<br>Associate Professor<br>✕✕✕ |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Wireless Communications<br><br>Learning objectives: Teaching basic concepts on wireless communications using the WiFi operation as a guideline. The students become acquainted with the driver of Qualcomm Atheros chipsets, while they develop solutions and new mechanisms at the driver level.<br><br>Expertise level: basic |
| **Timeline**<br>(Active, future plans…) | Active:<br><br>• Each student gets nodes in the NITOS testbed that are equipped with at least one wireless card. During the lab sessions, they are taught basic functions of the driver (e.g., rate adaptation, packet encapsulation, etc.) and are asked to complete a project using the wireless driver by the end of the semester. |

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| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Undergraduate and graduate students |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | About 20 students (1 classes)<br>The course has a 2-hour weekly lecture and a 2-hour lab. |
| **Access conditions**<br>(open/ closed/restricted) | Restricted to UTH students and international students visiting UTH |
| **Industrial participation** | |
| **URL of the website(s)** | https://www.e-ce.uth.gr/studies/undergraduate/courses/ece436/?lang=en |

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Course on Inter-network protocol design |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and multiple nodes in the NITOS testbed |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | University of Thessaly<br>Thanasis Korakis<br>Associate Professor<br>▬▬▬✕▬▬▬ |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Computer Networking protocols<br>Learning objectives: Teaching basic concepts on computer networking protocols, with respect to the principles that they are built and the operation that they are targeting. The course is delving into the internals of different protocols used for intercommunication (TCP, BGP and other inter-domain routing protocols). |
| **Timeline**<br>(Active, future plans…) | Active:<br>• Each student gets nodes in the NITOS testbed. Messaging related libraries and tools are taught (e.g., Google Protocol Buffers, ASN.1) in order to understand the basics of network communication. The students are asked to design and implement their own protocol by the end of the semester. |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Undergraduate students |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | About 30 students (1 classes)<br>The course has a 2-hour weekly lecture and a 2-hour lab. |

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| **Access conditions**<br>(open/ closed/restricted) | Restricted to UTH students and international students visiting UTH |
| **Industrial participation** | |
| **URL of the website(s)** | https://www.e-ce.uth.gr/studies/undergraduate/courses/ece441/?lang=en |

### 4.8. Training activities – EURECOM

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Master 2 course – Mobile Communication Systems<br>Formats: live or recorded in 3 hour-modules. Several Lab sessions using EURECOM/SophiaNode computing resources. |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and are migrating to SophiaNode SLICES-RI infrastructure |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | EURECOM<br>Raymond Knopp, Navid Nikaein, Adlen Ksentini<br>Professor<br>██████████████████████<br>████████████<br>████████████████████ |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Networking – 3GPP Telecommunications networks<br>Learning objectives: Teaching 3GPP network architecture and protocols, focus on 5G<br>Learning outcomes:<br>• be able to Identify the basic functions of the 3GPP 5G radio protocol stack, and the functions of the 4G/5G core network;<br>• be able to analyze traces on the radio interface for the various procedures;<br>• be able to analyze traces in the core network for the attachment procedures and handover.<br>Expertise level: moderate |
| **Timeline**<br>(Active, future plans…) | Active since beginning of EURECOM teaching program and continuously updated with the evolution of the 3GPP xG standard<br>Future plans: tighter integration with SLICES-RI infrastructure for lab component and derivation of targeted modules on-demand for continuing education. |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Master 2 students. Active engineers for continuing education. |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | About 40 students |
| **Access conditions**<br>(open/ closed/restricted) | Restricted to students of EURECOM and international exchange students. |
| **Industrial participation** | Occasionally members of EURECOM's industry board members in MSc course. Tailored versions for continuing education |
| **URL of the website(s)** | https://www.eurecom.fr/en/course/mobsys-2022fall |

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| **Type of the training activity** (Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Master 2 course – Network Softwarerization |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and are migrating to SophiaNode SLICES-RI infrastructure |
| **Name(s) of the Institution(s) /Person(s) involved** (Author(s) of the learning and training resources, affiliation and contact details) | EURECOM<br>Adlen Ksentini<br>Professor |
| **Description of the training material/activity** (Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Networking – Computing<br><br>Learning objectives: This course covers the principle of Network Softwerization by introducing and detailing the concepts of SDN, NFV and Cloud Computing (focusing on the IaaS model and Edge Computing). Besides covering the theoretical aspects, the course will provide an overview of the enabling technologies, and how combining these concepts will allow building flexible and dynamic virtual networks tailored to services, e.g., Anything as a Service (AaaS) and Network Slicing.<br>• Be able to control a network using a NoS (SDN controller);<br>• Be able to deploy a virtual network architecture.<br><br>Expertise level: advanced |
| **Timeline** (Active, future plans…) | Active since beginning of EURECOM teaching program and continuously updated with the evolution of computing paradigms.<br><br>Future plans: tighter integration with SLICES-RI infrastructure for lab component and derivation of targeted modules on-demand for continuing education. |
| **Target audience** (Technical staff, managers of RI, researchers, students, general public) | Master 2 students. Active engineers for continuing education. |
| **Metrics of previous editions** (Students surveys, indicators of participant….) | About 40 students |
| **Access conditions** (open/ closed/restricted) | Restricted to students of EURECOM and international exchange students. |
| **Industrial participation** | Occasionally members of EURECOM's industry board members in MSc course. Tailored versions for continuing education |
| **URL of the website(s)** | https://www.eurecom.fr/en/course/mobsys-2022fall |

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Master 2 course – IoT COMMUNICATION PROTOCOLS |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and are migrating to SophiaNode SLICES-RI infrastructure |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | EURECOM<br>Adlen Ksentini<br>Professor |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Networking – Computing<br>Learning objectives: This course covers the Low Power Wide Area Network (LPWAN) protocols dedicated to IOT. LPWAN is a technology that intends to offer Internet connectivity to a large number of objects ("Things") under very strict requirements in terms of cost, power consumption, long distance, battery life, indoor penetration, etc. This course presents two families of LPWA protocols specially developed for IOT: (i) LPWAN for unlicensed spectrum (e.g., LoRa, SigFox ...) and (ii) Cellular LPWAN for licensed spectrum (e.g., 3GPP LTE Cat. M1 or Cat. NB).<br>Teaching and Learning Methods: The course is organized in 4 lectures and 3 labs.<br>Expertise level: advanced |
| **Timeline**<br>(Active, future plans…) | Active.<br>Future plans: tighter integration with SLICES-RI infrastructure for lab component and derivation of targeted modules on-demand for continuing education. |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Master 2 students. Active engineers for continuing education. |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | About 40 students |
| **Access conditions**<br>(open/ closed/restricted) | Restricted to students of EURECOM and international exchange students. |
| **Industrial participation** | Occasionally members of EURECOM's industry board members in MSc course. Tailored versions for continuing education |
| **URL of the website(s)** | https://www.eurecom.fr/en/course/protiot-2023spring |

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Master 2 course – IoT COMMUNICATION PROTOCOLS |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and are migrating to SophiaNode SLICES-RI infrastructure |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | EURECOM<br>Adlen Ksentini<br>Professor<br><br> |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Networking – Computing<br><br>Learning objectives: This course covers the application-level protocols dedicated to IOT. Knowing the limited capacity, in terms of battery and CPU, of the things, the classical application protocols used in the Internet like HTTP are not adequate. This course presents the recent application protocols specially developed for IOT. These protocols are organized into two categories: (i) Client/server (like COAP) and (ii) Publish/Subscribe (like MQTT, XMPP). In addition to these protocols, this course introduces two types of architecture, specifically dedicated to host IOT services, like 3GPP MTC and oneM2M.<br><br>Teaching and Learning Methods: The course is organised in lectures and labs.<br><br>Course Policies: Labs are Mandatory (attendance + reports)<br><br>Expertise level: advanced |
| **Timeline**<br>(Active, future plans…) | Active.<br>Future plans: tighter integration with SLICES-RI infrastructure for lab component and derivation of targeted modules on-demand for continuing education. |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Master 2 students. Active engineers for continuing education. |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | About 40 students |
| **Access conditions**<br>(open/ closed/restricted) | Restricted to students of EURECOM and international exchange students. |
| **Industrial participation** | Occasionally members of EURECOM's industry board members in MSc course. Tailored versions for continuing education |
| **URL of the website(s)** | https://www.eurecom.fr/en/course/appiot-2023spring |

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Master 2 course – Mobile Applications and Services |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and are migrating to SophiaNode SLICES-RI infrastructure |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | EURECOM<br>Navid Nikaein<br>Professor |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Networking – Computing<br>Learning objectives: This course presents the three main mobile platforms and their ecosystems, namely Android, iOS, and PhoneGap/WebOS. It explores emerging technologies and tools used to design and implement feature-rich mobile applications for smartphones and tablets taking into account both the technical constraints relative to storage capacity, processing capacity, display screen, communication interfaces, and the user interface, context and profile.<br>Teaching and Learning Methods: Lectures, Lab sessions (group of 2 students), and a challenge project (group of up 2 4 students).<br>Expertise level: advanced |
| **Timeline**<br>(Active, future plans…) | Active.<br>Future plans: tighter integration with SLICES-RI infrastructure for lab component and derivation of targeted modules on-demand for continuing education. |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Master 2 students. Active engineers for continuing education. |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | About 40 students |
| **Access conditions**<br>(open/ closed/restricted) | Restricted to students of EURECOM and international exchange students. |
| **Industrial participation** | Occasionally members of EURECOM's industry board members in MSc course. Tailored versions for continuing education |
| **URL of the website(s)** | https://www.eurecom.fr/en/course/mobserv-2022fall |

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| **Type of the training activity**<br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Master 2 course – Wireless Access Technologies |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and are migrating to SophiaNode SLICES-RI infrastructure |
| **Name(s) of the Institution(s) /Person(s) involved**<br>(Author(s) of the learning and training resources, affiliation and contact details) | EURECOM<br>Jérôme Haerri<br>Professor |
| **Description of the training material/activity**<br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Networking – Computing<br>Learning objectives: This module addresses the access methods in Wireless Local Access Networks (WLAN). The basic contention and management mechanisms are detailed. Current and emerging standards of WLAN toward 5G are also presented.<br>Wireless Local Access Network Basics<br>• IEEE 802.11 Family of standards<br>• IEEE 802.11 MAC<br>• IEEE 802.11 PHY<br>WLAN extensions<br>• Vehicular WiFi – IEEE 802.11p<br>• WiFi MIMO – IEEE 802.11n<br>• WiFi Giga – IEEE 802.11ac/ad<br>Advanced Topics...<br>• WiFi OFDMA – IEEE 802.11ax<br>• WiFi-Direct<br>• 3GPP LTE D2D<br>**Learning outcome:**<br>• To be able to identify the basic functions of the IEEE 802.11 WLAN as well as the basic function of a WiFi network<br>• To be able to understand the challenge of the WLAN contention-based channel access methods<br>**Teaching and Learning Methods**: Lectures and Lab sessions (group of 2 students)<br>**Course Policies**: Attendance to Lab session is mandatory.<br>**Expertise level**: advanced |
| **Timeline**<br>(Active, future plans…) | Active.<br>Future plans: tighter integration with SLICES-RI infrastructure for lab component and derivation of targeted modules on-demand for continuing education. |
| **Target audience** | Master 2 students. Active engineers for continuing education. |

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| (Technical staff, managers of RI, researchers, students, general public) | |
| **Metrics of previous editions** (Students surveys, indicators of participant….) | About 40 students |
| **Access conditions** (open/ closed/restricted) | Restricted to students of EURECOM and international exchange students. |
| **Industrial participation** | Occasionally members of EURECOM's industry board members in MSc course. Tailored versions for continuing education |
| **URL of the website(s)** | https://www.eurecom.fr/en/course/mobwat-2023spring |

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| **Type of the training activity** (Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Master 2 course – Mobile Advanced Networks |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and are migrating to SophiaNode SLICES-RI infrastructure |
| **Name(s) of the Institution(s) /Person(s) involved** (Author(s) of the learning and training resources, affiliation and contact details) | EURECOM Navid Nikaein Professor ▬▬▬ ▬▬ |
| **Description of the training material/activity** (Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Networking – Computing Learning objectives: The mobile communication networks are undergoing a rapid revolution and are becoming multi-disciplinary with a blend of advanced networking, computing, and data analysis. This course, by focus on modern mobile networks, will explore these key technologies and concepts that are either used in the mobile networks or expected to be deployed in the future. This course is a research-oriented course on mobile networking (algorithm, protocol, and architectures) and is prepared to stimulate students' critical thinking and analysis. It starts by introducing modern mobile networks (5G and 6G) and a survey on expectation from such networks, and covers a fusion of possible solutions in the areas of: 1. Networking technologies/protocols (new network paradigms, 4 sessions) 2. Network virtualization and slicing following emerging enabling technologies including NFV, SDN, MEC 3. Autonomous and self-organized networking 4. Ultra-dense and heterogeneous networking in urban environment 5. Intelligent Mobile Advanced Networks (2 sessions) |

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| | 6. Data-Driven Network Control and Management<br><br>7. Applications of AI, Machin Learning and Deep Learning in 5G and 6G<br><br>**Case Study:**<br><br>• Pick an open research problem<br><br>• Analyze the proposed solution and try to improve it by applying some of the techniques learnt during the course<br><br>• Evaluate the performance of the proposed approach<br><br>**Learning outcomes**<br><br>• Provide an in-depth understanding of new network paradigms and technology enablers for Mobile Advanced Networks<br><br>• Understand protocol and networking issues of future Mobile Communication Networks, esp. Mesh and Self-organizing Networks<br><br>• Develop critical analysis and thinking on mobile networking, and get prepared for interdisciplinary research in future Data-Driven Mobile Networks<br><br>**Teaching and Learning Methods**: Lectures, Homework (2-3), and a case study (study and present a research paper in a group of 2-3 students).<br><br>**Course Policies**: Mandatory participation, Case study optional, but recommended.<br><br>**Expertise level**: advanced |
| **Timeline**<br>(Active, future plans…) | Active.<br>Future plans: tighter integration with SLICES-RI infrastructure for lab component and derivation of targeted modules on-demand for continuing education. |
| **Target audience**<br>(Technical staff, managers of RI, researchers, students, general public) | Master 2 students. Active engineers for continuing education. |
| **Metrics of previous editions**<br>(Students surveys, indicators of participant….) | About 40 students |
| **Access conditions**<br>(open/ closed/restricted) | Restricted to students of EURECOM and international exchange students. |
| **Industrial participation** | Occasionally members of EURECOM's industry board members in MSc course. Tailored versions for continuing education |
| **URL of the website(s)** | https://www.eurecom.fr/en/course/mobadv-2023spring |

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| **Type of the training activity**<br><br>(Video lectures, webinar, tools, official MSc/PhD program, hackathon…) | Master 2 course – Radio Engineering |
| **Name of the infrastructure(s) involved** | We currently use on-site lab rooms and are migrating to SophiaNode SLICES-RI infrastructure |
| **Name(s) of the Institution(s) /Person(s) involved**<br><br>(Author(s) of the learning and training resources, affiliation and contact details) | EURECOM<br>Florian Kaltenberger<br>Professor |
| **Description of the training material/activity**<br><br>(Domain (field of science), learning objectives, learning outcome, expertise level (basic, intermediate, expert)) | Domain: Networking – Computing<br><br>Learning objectives: This course treats the subject of modern radio engineering and includes typical RF architectures and their characterizations, modeling, prediction and simulation of radio-wave propagation, cellular planning, systems-level aspects of modern radio network design.<br><br>• Introduction, history of mobile communications, technical requirements and limitations, and technical challenges.<br>• Definition and revision of some basic terms, such as thermal noise, amplifiers, noise figure, receiver sensitivity, fading margin, path loss, link budget<br>• Antennas and propagation<br>• Propagation Measurements, Modelling and Simulation: Models for path loss, shadowing, multipath propagation. Time, frequency, and spatial properties of radio channels (MIMO).<br>• Cellular Architectures: Link budget analysis, cellular coverage, duplexing strategies, multiple-access methods, network topologies, hand-over strategies.<br>• Three practical lab sessions analyzing real measurements<br>• A guest lecture on state-of-the art LTE network planning by Infovista, creator of the Mentum Planet tool is organized if possible<br><br>**Learning outcomes:**<br>• To be able to do a simple link budget analysis and planning of a wireless system<br>• Know the technical limitations and possibilities when building a wireless system<br>• Ability to analyze and interpret channel measurements<br>• Know which channel model is adapted best to my requirements and how to implement it<br>• Understand basic cell planning tools<br><br>**Teaching and Learning Methods**: Lectures and Lab sessions (group of 2 students)<br><br>**Course Policies**: Attendance to Lab session is mandatory. |

| | Expertise level: advanced. |
|---|---|
| **Timeline**<br>(Active, future plans…) | Active.<br>Future plans: tighter integration with SLICES-RI infrastructure for lab component and derivation of targeted modules on-demand for continuing education. |

## 5.   SLICES Summer School

The *1st SLICES Summer School* was organized in Volos in 19-21 June 2022 on the topic of *Open-RAN/Core/Edge Solutions for Cloud-Native Telco Experimental Platforms*. The three-day school took a deep-dive into some of the available open-software and hardware solutions for building experimental telco networks that can be used by researchers to develop innovations leading to 6G network architectures in initiatives such as SLICES-RI, PAWR, Fabric and Horizon Europe SNS JU. A key objective of the school is to highlight cloud-native tools leading to fully converged cloud and telecommunication infrastructures. The school covered initiatives including O-RAN, ONF Aether/SD-Fabric/SD-RAN, OpenAirInterface RAN and Core, Mosaic5G, Magma and related cloud-native frameworks based on Kubernetes. In addition, for newcomers to the 3GPP ecosystem, the school also provided a crash course on 3GPP networks and protocols. More than 70 people participated physically and much more online. More information on: https://slices-sc.eu/events/slices-sc-summer-school/.

Initial plans for organizing the *2nd SLICES Summer School hosted by University of Oulu during the week 12-16 June 2023*. Currently there is discussion on the topics and the organization of the summer school.

## 6.   SLICES 1st Industry Day

Of particular interest to SLICES is the engagement of industrial and academic researchers to the use of research infrastructures. In order to achieve this goal, COSMOTE organized the 1st SLICES-SC Industry Day on May 27, 2022, which was an online free of charge event. The purpose of this event was to promote and advertise SLICES research infrastructure mainly to industry users, presenting the various testbed capabilities and explaining to the audience what and how can a researcher accomplish by using the SLICES RI to perform advanced experiments.

The event was very broadly advertised through our industrial and academic connections, together with 6G-IA and 5GPPP. A special site for the event was also created by UTH (https://slices-sc.eu/events/slices-sc-1st-industry-day/). There were in total 15 presentations with 12 presentations having to do with the description of SLICES testbeds and their benefits to the industrial users, as shown in the agenda below.

| Timeslot | Presentation | Presenter's Name (Partner) |
|---|---|---|
| 10:00 - 10:10 | **Welcome** | **Konstantinos Filis**<br>COSMOTE Mobile Communications |

| 10:10 - 10:30 | **SLICES Vision** | **Serge Fdida**<br>Sorbonne University |
|---|---|---|
| 10:30 - 10:50 | **Transnational access Open Call and evaluation process for experimenting on SLICES infrastructures** | **Peter Kacsuk**<br>SZTAKI |
| 10:50 - 11:10 | **"The pos Framework: A Methodology and Toolchain for Reproducible Network Experiments"** | **Sebastian Gallenmuller**<br>Technical University of Munich |
| 11:10 – 11:30 | **IoT Lab** | **Anna Brékine, Cédric Crettaz**<br>IoT Lab, Mandat International |
| 11:30– 11:50 | **OneLab: Cloud Infrastructure for Researchers** | **Albert (Yiu Quan) Su**,<br>LIP6, Sorbonne University |
| 11:50 – 12:10 | **The Stack4Things framework for Cloud-IoT integration in an industrial environment** | **Antonio Puliafito,**<br>University of Messina |
| 12:10 – 12:30 | **The LeonR&Do Lab: Experimental facilities fostering research, innovation and collaborations** | **Konstantinos Filis**<br>COSMOTE Mobile Communications |
| 12:30 – 12:50 | **The offer of the Polish Node for industry and SMEs** | **Bartosz Belter**<br>Poznan Supercomputing and Networking Center |
| 12:50 – 13:10 | **The NITOS testbed: an integrated facility for beyond 5G research** | **Nikos Makris**<br>University of Thessaly |
| 13:10 – 13:30 | **5TONIC Lab** | **Carmen Guerrero**<br>University Carlos III of Madrid |
| 13:30 – 13:50 | **The imec testbed portfolio for networking, cloud, AI and IoT research** | **Brecht Vermeulen**<br>imec/Ghent University |
| 13:50 – 14:10 | **Applying 5G and beyond to smart manufacturing with SN4I** | **Eduardo Jacob**<br>University of the Basque Country |
| 14:10 – 14:30 | **SOPHIA-NODE: Testing beyond-5G cloud-native network functions and services** | **Raymond Knopp,** EURECOM<br>**Walid Dabbous,** INRIA |
| 14:30 – 14:40 | **Closing comments** | **Konstantinos Filis**<br>COSMOTE Mobile Communications |

The event was quite successful with more than 50 participants attending it.

## 7. SLICES Research Mobility

The *SLICES Research Mobility Programme* targets members of the consortium, as well as researchers not affiliated with any of the consortium partners, who want to use SLICES-SC facilities in other countries to conduct their experimentation. There are two mobility categories:

- *Research Mobility for Knowledge Transfer*. This is a short mobility program (limited to one week, up to 3KE reimbursement of travel costs and related subsistence) that is meant only for training (i.e., learning the infrastructure of a SLICES site and how to use it), and it reserved to the members of the consortium. The definition of a concrete exploitation and dissemination plan are essential parts of this mobility scheme.
- *Research Mobility for Micro-project.* This is a long mobility program (up to four weeks, typically split into two visits, up to 6KE reimbursement of travel costs and related subsistence) that is meant for carrying out a micro-project with a tangible scientific output for SLICES-SC (e.g., a dataset, a software package, a joint collaboration for a publication, or official technical report), and it is open to both members of the SLICES consortium and researchers not affiliated with any of the consortium partners. The main justification for organizing this mobility program into two stages is that the first stage might be needed to learn how to use the experimental facility while the second stage will be dedicated to use the RI to complete the planned experimentation.

It is important to point that the kick-off of the SLICES researcher mobility programme has been delayed due to the uncertainty about travel restrictions during the peak of the COVID pandemic. Furthermore, the SLICES researcher mobility programme is meant as complementary to Transnational Access activities, as the focus of the former is mainly on the training and the knowledge transfer. During this first period, we have mainly finalized the specification of the Call for Applications for both mobility schemes, which are now ready for being launched and announced inside and outside the SLICES community.

## 8. SLICES Academy

During this first period, and with the previous experience of different training materials organized by individual institutions, the success of the organization of the TheNetworkingChannel, SLICES-SC has identified the need for the creation of the *SLICES Academy as a common framework for SLICES digital education ecosystem*. The needs for SLICES Academy are listed below:

- Need for the development of a high-performing digital education ecosystem in advanced networking systems and technologies seeking to organise new curricula aiming to enhance researchers' competencies and skills;
- Need to support the delivery of high-quality education;
- Need for the development of new skills and competencies in advanced digital technologies;
- Need for boosting innovation and digital competencies in all educational institutions;
- Need for open education systems.

The objectives of SLICES academy are to develop new educational material that can be organised in order to support the needs of the community. Educational material can be collected from different partners / sources, such as summer school, hackathons, etc.  SLICES has the tools and the resources to support the development of the Academy, which is expected to support the sustainability of SLICES towards the development of new skills. The creation and development of the SLICES Academy will take place during the second period of SLICES-SC.

## Conclusions

This deliverable reported the activities of the consortium partners towards the ***training activities*** of SLICES-SC until month 18 of the project. Firstly, it described the objectives of SLICES-SC and *WP4*. Then it presented the ***current training material available within SLICES-SC community***, the ***1st SLICES Summer School 2022 in Volos*** and the plans for the ***2nd edition in Oulu in 2023***. Finally, the recently launched activities of the ***SLICES Research Mobility Program*** and the new ***SLICES Academy*** open education ecosystem, both aiming the creation of new skills and competences in advanced digital technologies.