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D8.4 Report on 1st Period of Virtual Access

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1. Executive Summary

Virtual Access (VA) to the SLICES Research Infrastructures is an open and free access provided to the Starting Community of users and researchers. The provision of VA to the SLICES-RI is aided through datasets and tools that allow the preparatory work for experiments and even also for offline running of experiments. The Transnational Access (TA) (physical or remote access) mainly consists of high-performance computer systems that host bleeding-edge communication and networking technology equipment, testing networks and grids. The VA mainly consists on the exposure of repositories and archives of produced experimentation results.

The objective of this document is to report the main activities conduced in the Task 8.5 on Virtual Access (VA) during the first period of the SLICES-SC project. The VA activities in SLICES-SC act complementary to the TA access, described in Deliverable D8.2 on First Report on Transnational Access, with data and tools produced either through the latter, or created and provided from the testbed operators. Access to virtual access services is free-of-charge, and directly findable and discoverable in the SLICES Open Data and Tools repositories (CKAN and GitLab servers respectively). The datasets are semantically annotated, towards promoting the migration to EOSC-II, and provided in different formats. The current deliverable addresses how these repositories are loaded with data and tools. On the other hand, the usage of these data as virtual access has not started yet and hence this deliverable does not contain the assessment report from the User Committee. Such an assessment will be carried out in the coming months and provided in D8.5.

2. Virtual Access Definition

2.1. Analysis of Virtual Access in Research Infrastructures

A key element for defining the principles of RI access policy has been the European Charter for Access to Research Infrastructures[1]. The Charter promotes the harmonization of access procedures as well as the enhanced transparency of access policies adopted by Research Infrastructures with the final purpose of enabling users to access the best Research Infrastructure to perform their work, wherever it might be located.

The recent pandemic and energy crises, along with rapid digital developments, have drastically changed the conditions for accessing Research Infrastructures. Despite the continued EU and national support that facilitated transnational and virtual access to RIs for many researchers, there are still challenges hindering broader and more sustainable access to European RIs and their services and in particular in the SLICES scientific dimension of Digital Sciences. To address these challenges, the SLICES community is conducting an analysis of RI access, considering various modes of access and their key dimensions (such as technology, data, and legal issues). Their goal is to find ways to overcome these challenges and potentially revise or add elements to the European Charter for Access to Research Infrastructures. In this work in progress, SLICES community is contributing to EU R&I ecosystem positions on access to RIs as valuable input to define and build the future access services for the Digital Science community.

2.2. Virtual Access in SLICES

SLICES is providing two different types of accesses for the provided Research Infrastructure (RI): Transnational Access (TA) and Virtual Access (VA). Deliverable D8.2 clearly describe the main differences between both accesses and define the global framework for accessing the RI.

This document is focused on the VA activities that have taken place during the first period of accesses. Overall, SLICES-SC develops tools regarding both access schemes, in order to provide high-quality services to the end users who access the infrastructure. SLICES-SC complies with the EU guides for accessing RIs.
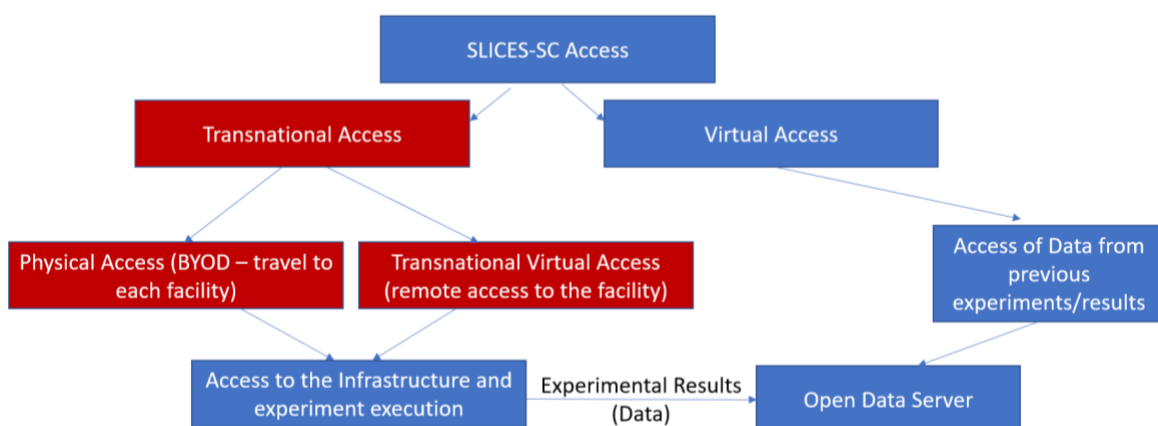

Figure 1. Definition of accesses in SLICES

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[1] European Commission, Directorate-General for Research and Innovation, *European charter of access for research infrastructures: principles and guidelines for access and related services*, Publications Office, 2016, https://data.europa.eu/doi/10.2777/524573 [Last accessed 28 January 2023]

Figure 1 from the Deliverable D8.2 clearly shows the difference between Transnational Access and Virtual Access. Transnational Access requires the real access of the research infrastructure either physically or remotely. In the case of Virtual Access, the user does not use the research infrastructure rather uses the data that is collected during the Transnational Access experiments or provided by the the SLICES testbed operators. The advantage of this form of using the SLICES RIs is that access to the data is not limited due to the capacity issues and hence any researchers can access these data freely without the competition of an application procedure. On the other hand, in the case of IT systems it is not so trivial how to generate data that could be useful in the virtual access mode and how to use the data produced by someone else's experiments. The difficulties have been witnessed during the first 24 months of SLICES SC project both in providing the data and especially in using the data.

The vision of SLICES for allowing virtual access is to offer a pan-European operational networking and computer infrastructure to facilitate scientific research with instrumentation and experimentation capabilities. The aim is to attract a wider audience stemming from multi-disciplinary domains by providing digital services that ease the experimentation and reduce the burden to novice users and boosts the experimentation potentials to the experienced ones. The data and tools that will be offered through VA will assist in either facilitating easy experimentation with SLICES-RI, or adding up to the knowledge of the community through data sets, analytical results from them and tools.

SLICES has defined an initial set of categories of datasets available through the SLICES Open Data Server:

- Experiment descriptions for advanced and complex experiments with technologies like 5G/6G technologies, wireless sensor devices and IoT, cloud and AI/ML for networking.
- Analytical Datasets from experiments that have been conducted over SLICES-RI will be provided. Traces of experiments regarding network optimization, network conditions, performance related data (e.g., throughput, consumption of computing and memory resources per application) allows the community to benefit from their results, and their broader analysis from a higher number of researchers. Such data can trigger further experiments over the platform, towards validating a specific behaviour/developing new protocols and methods.
- Visualization services for directly visualizing experiment outputs on the fly/post the experimentation, enabling the deep analysis and processing of collected data.

3. Virtual Access Services and Tools

3.1. SLICES Open Data Repository

The SLICES Open Data Repository is instantiated in the SLICES CKAN server (http://ckan.iotlab.eu/organization/slices-sc) and include experiments results and datasets offered by the testbed operators.

3.2. SLICES Software and Tools Repository

The SLICES Software and Tools repository is instantiated in the SLICES GitLab (https://gitlab.distantaccess.com/slices). The objective is to provide open access to source code and tools available offer from the SLICES community to the research community to give support for the experiments in SLICES-RI across all kind of access.

In particular as a successful example of tool provided by SLICES, we provide open access to **"pos"** as a testbed management tool. TUM developed a testbed management system with an integrated experiment controller called plain orchestrating service or short pos. The main feature of the experiment controller is the creation of reproducible experiment workflows. Reproducibility is achieved through a structured experiment workflow, that offers enough flexibility for experiment designers to realize experiment involving different domains such as compute, network or storage. By adhering to the workflow's structure experiments are created in an inherently reproducible way leading to a property that we call reproducibility by design.

The workflow relies on a fully automated workflow that involves the setup of the experiment, the actual creation and collection of the measurement data, and the evaluation. All of these steps need to be automated via scripts. POS testbed tool provides only live images for the experiment nodes. On the one hand, live images require the recreation of the configuration after a reboot. On the other hand, a reboot also ensures a well-defined state for each experiment node when starting a new experiment. Live images and automation ensure that experiments become **repeatable**. This means that an experimenter can recreate its experiments using the identical testbed. **Reproducibility** is achieved if other researchers can also recreate the original experiment, which can be achieved by providing access to the original testbed.
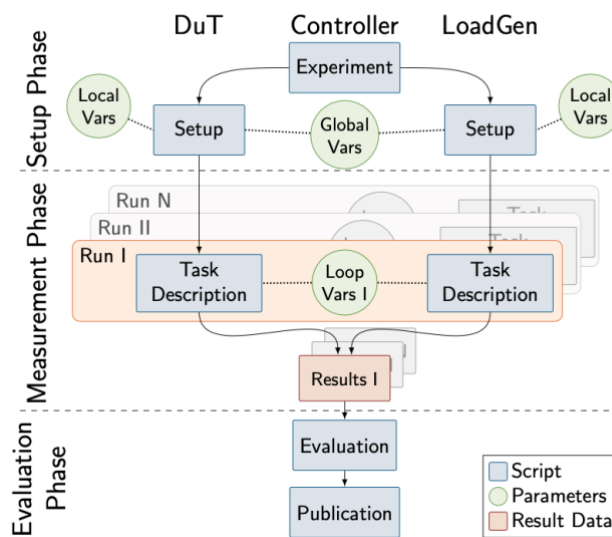

Figure 2. pos experiment workflow

Figure 2 shows the pos experiment workflow involving the setup, measurement, and evaluation phase. Each of these phases uses different script files, such as the setup scripts, the task description, and finally the evaluation and publication scripts. Parameters for these scripts are stored in separate files. This clear structure makes pos experiments easier to understand and follow for experimenters. This clear structure allows the automated collection of all experiment artifacts. These artifacts can be released as a git repository that represents the experiment workflow and its results. We prepared such a repository containing all files of the workflow definition, the measured results, and the final evaluation using SLICES repositories such as gitlab and CKAN (cf. Section 4.11)

We also provide access to an instance of a pos-driven testbed as part of our virtual access activity (cf. Section 4.11) to simplify the setup process for a pos testbed for interested users. We are currently in the process of porting the pos controller to different testbeds managed using the geni lib. Such a portable version of pos would allow the execution of pos experiments also on other testbeds.

3.3. SLICES Virtual Access Metadata

SLICES community within the SLICES-SC project, and targeting the EOSC catalog/marketplace, is proposing a metadata profile for EOSC in the deliverable D4.5, section 5.3, and in the deliverable D4.3. The virtual access metadata follows this already defined profile based in Dublin core metadata schema.[2]

4. Virtual Access activities at SLICES Testbeds

4.1. SILECS-FIT / OneLab, France

SILECS-FIT is a large-scale Research Infrastructure allowing experimentation with a broad range of technologies through the federation of testbeds. It is structured in three pillars for research on IoT, wireless and Cloud technologies.

SU contributes to the Virtual Access activities by operating and providing access to its Cloud Infrastructure. The Cloud Infrastructure consists of two different components, FIT CloudLab (https://portal.onelab.eu/testbeds#tab14) and FIT Openstack (https://portal.onelab.eu/testbeds#tab15) allowing cloud-based experiments related to the development and deployment of Cloud Software Stack, Cloud components and services with visibility all the way down to the bare metal.

The Cloud Infrastructure is not fully integrated to the SLICES-SC Testbed Portal, however integration plan has already been determined.

4.2. NITOS – UTH, Greece

NITOS is a long-established wireless testbed, with particular focus on several technologies for wireless networking, and their integration in an Internet-like ecosystem. Different experimenters have been using NITOS, generating multiple measurements from their under-test scenarios, under real-world settings. Within SLICES-SC, some example measurements that can be used for reproducing the experiment results are published in the project's Open Data Server. The datasets that have been published during the first period of transnational access are detailed in the following subsection. Beyond these, existing datasets that come from the integration of vertical activities over the testbed are in progress of being integrated, to be made available for the second period of Virtual Access.

4.2.1 UTH Datasets provided through the OpenCKAN server

4.2.1.1. **AI-driven Application-Aware 5G Network on K8s**

This dataset collected through NITOS testbed includes real-world time-series statistics from network traffic on real commercial LTE networks in University of Thessaly (UTH), Greece. The purpose of this dataset is to capture the QoS/QoE of three COTS UEs interacting with three edge applications. Specifically, the following features are included: Throughput and Jitter for each UE-Application and Channel Quality Indicator (CQI) for each UE. The interactions were generated from a realistic network behavior in an office by developing multiple network traffic scenarios. These scenarios are based on real network patterns observed at a specific time interval during the day (early morning from 10:00 AM to 11:00 AM) on users in our office facilities in Volos, Greece. The mobility of users is considered

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[2] Dublin Core, DCMI Schemas, https://www.dublincore.org/schemas/, [Last accessed 28 February 2023].

as well, since we developed attenuation scenarios from real commercial networks in Volos, Greece. These attenuation scenarios emulate cars traveling a specific city route with speeds that vary from 40 to 60 km/h. These car scenarios were used to collect 182500 CQI data from 73 cars capturing a large spectrum of the route's traffic. To attenuate the signal in order to emulate the realistic mobility scenarios, we utilized Programmable Attenuators that were connected directly to the RAN. The CQI dataset is publicly available here. Traffic monitoring, as well as traffic analysis and CQI, is captured/calculated in almost real-time from our custom Data Analytics Function (NWDAF) named Core & Ran Analytics Function (CRAF). CRAF utilizes the PyShark to live capture the traffic and FlexRAN controller to obtain RAN Statistics such as the CQI. Then it stores all the data in a MySQL database. The data are available in the SLICES-SC Open CKan server (http://ckan.iotlab.eu/dataset/ue-network-traffic-time-series-applications-throughput-latency-cqi-in-lte-5g-networks), and GitHub (https://github.com/teo-tsou/app_aware_5g).
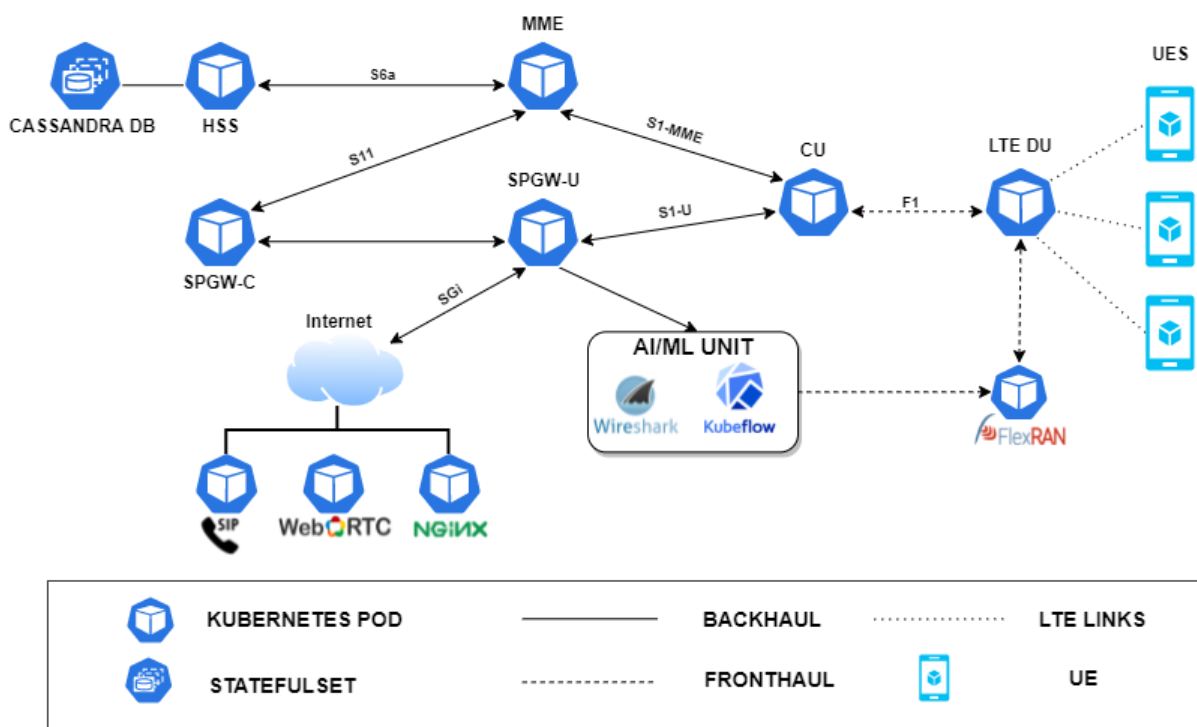

Figure 3. Experimental Topology on NITOS, on which the data have been collected

4.2.1.2. UE STATISTICS TIME-SERIES (CQI) IN LTE NETWORKS

The second dataset collected over NITOS and provided through the project's CKAN server consists of real-world Channel Quality Indicator (CQI) values from UEs connected to real commercial LTE networks in Greece. Channel Quality Indicator (CQI) is a metric posted by the UEs to the base station (BS). It is linked with the allocation of the UE's modulation and coding schemes and ranges from 0 to 15 in values. This is from no to 64 QAM modulation, from zero to 0.93 code rate, from zero to 5.6 bits per symbol, from less than 1.25 to 20.31 SINR (dB) and from zero to 3840 Transport Block Size bits. In total, we collected approximately 182500 CQI values from 74 cars that drive through a specific road in the city of Volos, Greece with velocities that vary from 40 to 60 km/h with the road's limit being 50 km/h. The data are available in the SLICES-SC Open CKan server (http://ckan.iotlab.eu/dataset/ue-statistics-time-series-cqi-in-lte-networks), and GitHub (https://github.com/ilias-chatzistefanidis/HetNets-steering).
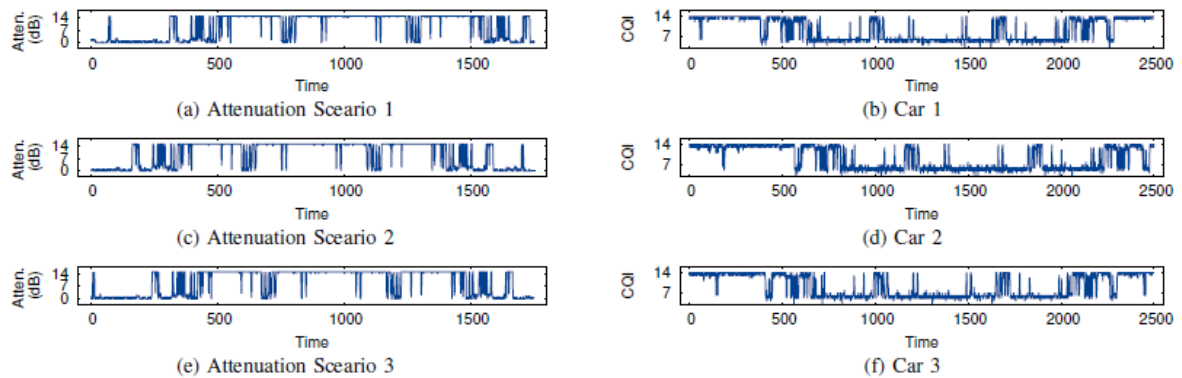
Figure 4. Example of channel attenuation values and reported CQIs from cars, collected through the NITOS testbed

4.2.2 UTH Datasets in the process of being integrated

4.2.2.1 Data from agricultural installations

UTH operates a distributed extension to the NITOS testbed named AgroNIT, consisting of IoT devices that monitor different parameters from agricultural crops. The testbed consists of over 200 IoT nodes, deployed in different rural regions of Greece, supporting diverse data collection and edge-analysis for multiple use cases (e.g., crop monitoring, weather prediction, image analysis). The Figure 5 presents the current status of deployment across Greece, showcasing the number of different gateway nodes that are deployed per each region. Each gateway node controls a number of different sensors, depending on the application.

Figure 5. UTH AgroNIT deployment in Greece

The setup is highly modular, and supports a number of different interconnection technologies for the IoT sensors: WiFi, ZigBee, LoRaWAN for forming mesh networks between the sensors, while the gateways are connected to the NITOS Cloud through 4G LTE connections. Each gateway and sensor are solar powered, so efficiency is needed in terms of task distribution, depending on the application.
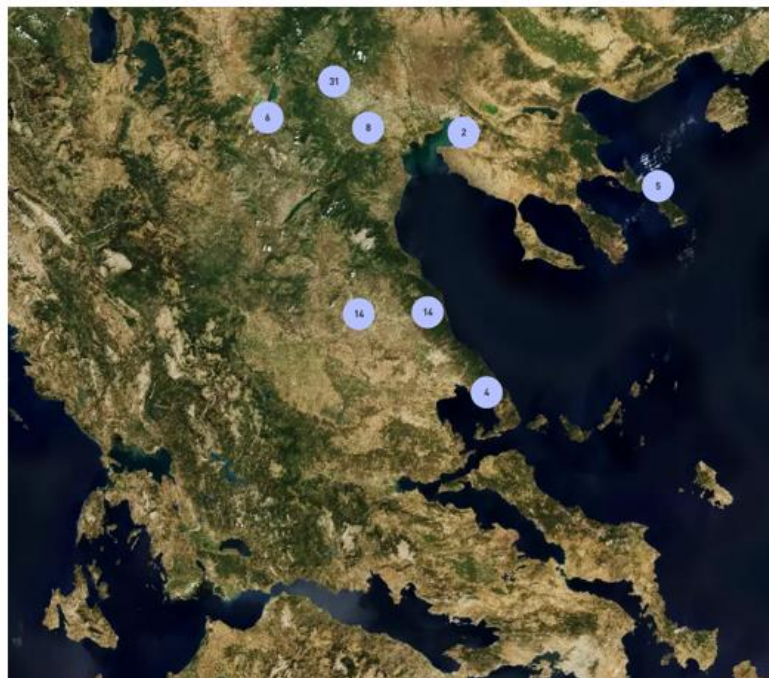
The deployed sensors are devices for precision agriculture (soil humidity/temperature, precipitation, air temperature/humidity), cameras (mainly for monitoring and analyzing crop production but can be steered to other applications), and weather stations. The gateways are based on the Beaglebone platform, which allows the execution of different scenarios in a containerized format.
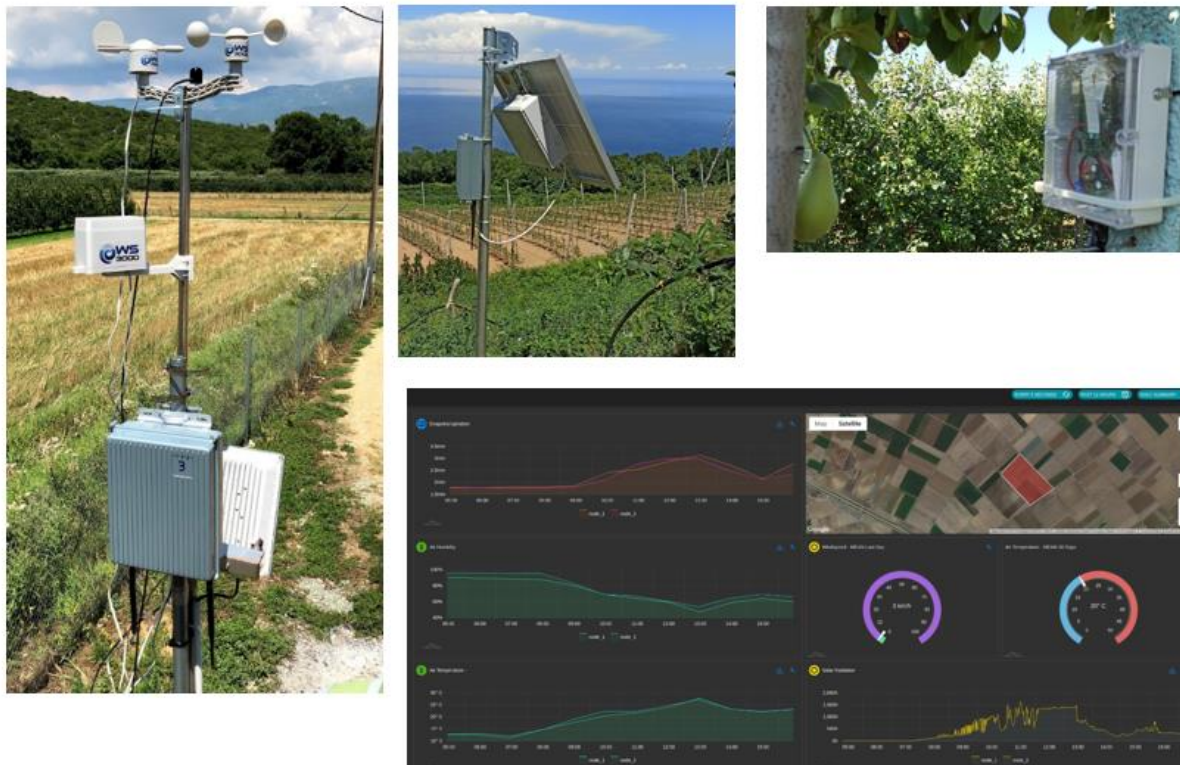
Figure 6. Rural Sensor deployment. Top left shows a weather monitoring station, upper middle a gateway node, upper right a camera node that monitors the produce growth. All the collected metrics are presented to each user (bottom right) using an interactive dashboard

Such sensors have been collecting data for over 3 years, regarding ambient weather conditions (temperature, humidity, light luminosity, wind direction and speed), soil conditions (temperature, humidity), and calculated others (e.g., the evapotranspiration of plants) that are used from the UTH Dept. of Agronomist and meteorologists for their research. The data are currently being processed and will be integrated into the Open CKAN server of SLICES-SC to enable transdisciplinary research.

4.2.2.2 Energy consumption data from an office environment

A new component of the NITOS testbed is a framework for monitoring smart-homes in terms of power consumption, towards concluding on proper and efficient power usage. The system is capable of monitoring real time the consumption of each device/appliance and switch them on/off remotely. It integrates a plethora of heterogeneous sensors coming from different vendors and utilizing different

access technologies (WiFi, BLE, ZigBee, Z-Wave and more). The sensors include but are not limited to temperature, humidity, pressure, luminosity, motion, contact, gas detection, water leakage, cameras, sirens, and speakers. Everything is connected to a dedicated Gateway which leverages the Open Source framework OpenHAB, together with in-house services that offer collection and persistence of the data to our cloud. In addition to the interface offered by OpenHAB, customized dashboards are provided to the users through a mobile application for monitoring and control their home.

To this aim, several parameters are installed at different homes, participating in an initial pilot, with rich measurements including ambient temperature per each installed room, power consumption monitoring for the entire home using smart meters, and dedicated appliance monitoring using smart plugs. The data is collected from a gateway and pushed to a dedicated NITOS server for analysis and depiction. In the Figure 7, the overall framework architecture is depicted.
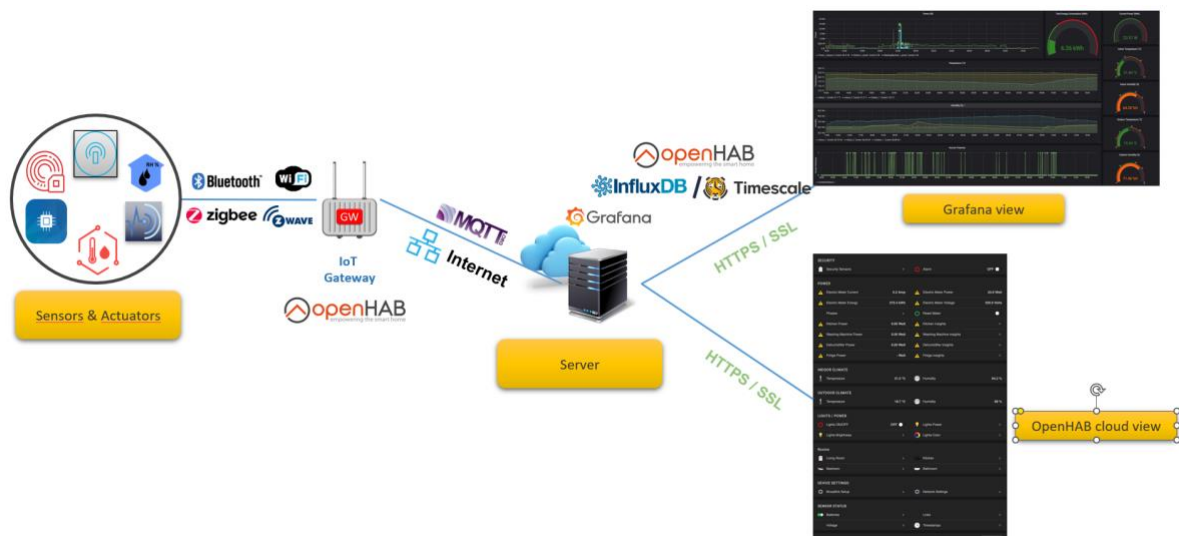

Figure 7. UTH power monitoring tool and dataset collection

For the purpose of the project, UTH will make part of the dataset available, containing measurements of an office space in the UTH premises, that contains measurements from approx. 2 years.

Meter	Output	Meter connected to electrical panel that measures total power, energy, voltage and current
PowerOutlet	Output	Smart switch (socket)
boiler	Output	Smart boiler (water heater) switch
Dryer	Output	Dryer as appliance
DishWasher	Output	DishWasher as apppliance
WashingMachine	Output	WashingMachine as appliance
MultiSensor	Output	Sensor metering temperature,humidity etc
MotionSensor	Output	Sensor for motion detection
ContactSensor	Output	Sensor for doors/windows etc (open/close)
Power	Output	Total power consumption of the device
PowerPhase_a	Output	Power Phase A of the device
PowerPhase_b	Output	Power Phase B of the device
PowerPhase_c	Output	Power Phase C of the device
Energy	Output	Total energy of the device
Temperature	Output	Temperature Parameter
Humidity	Output	Humidity Parameter
Pressure	Output	Pressure Parameter
Status	Output	devices that can be switched on and off
Contact	Output	Value that shows if a door/window is open/close
Motion	Output	Value that shows if motion has been detected from the device
Light	Output	Value that shows the illuminance of the space where the device is located
watt	Output	Units for power
kilowattHour	Output	Units for energy
degreeCelcius	Output	Units for temperature
percent	Output	Units for humidity
hectopascal	Output	Units for Pressure
Status_units	Output	Units for on/off of power outlets
Motion_units	Output	Units for whether motion was detected
Contact_units	Output	Units for whether a door/window is open/close
Illuminance	Output	Units for Illuminance

Figure 8. Monitored parameters populating the UTH dataset

4.3. SophiaNode - EURECOM, France

Although SophiaNode-EURECOM is not yet connected to the SLICES-SC portal, we provide an overview of the current capabilities of the SophiaNode at EURECOM and the means to achieve interoperability through an appropriate API.

4.3.1. Current Switching, Computing and Radio Capabilities

4.3.1.1. Switching

The infrastructure has a modern SDN switching fabric currently made up of

- 2 x 3.6 Tbit/s EdgeCore Tomahawk-based switches (AS7312-54XS) configured as top-of-rack (ToR) leaf switches providing redundant connections for multiple servers and some of the radio equipment (e.g., networked USRPs, indoor and outdoor AW2S radio units).

- 2x3.2Tbit/s EdgeCore Tofino-based switches (1xWedge100BF-32X-O-AC-F and 1xWedge100BF-32QS-O-AC-F) used to implement the Open Networking Foundation (ONF) SD-Fabric and 5G User-plane Function (UPF).

The ToR switches will be replaced in Q2 2023 with 3 Cisco Nexus 9k SDN switches which will be combined with similar switches at SophiaNode-INRIA to form a 2 Spine 4 leaf switching fabric topology. In addition, the facility has two PTP/TSN switches (200 Gbit/s FibroLan Falcon-RX) for real-time fronthaul links to radio-units requiring PTP (e.g., O-RAN O-RU). A PTP grandmaster is connected to these switches and makes use of an outdoor GPS antenna to obtain a time and frequency reference. Some servers have dedicated network interface cards to interface with these PTP/TSN switches.

The switching fabric is interconnected with SophiaNode-INRIA facilities via 6x100G fiber links. It is also interconnected with EURECOM's main gateway which provide 1Gbit/s access to the internet. VPN tunnels are in place with certain partners in collaborative projects. A future 100Gbit/s interconnection with partner sites of the French SLICES nodes (SLICES-FR) is planned to provide a high-speed and QoS-aware link with the SLICES-RI community.

4.3.1.2. Computing

SophiaNode-EURECOM is organized as a collection of three clusters each in a different IP subnet. These are

- A bare-metal sandbox which comprises various machines including
    - x86 (36-core Xeon Gold 6154/6354, AMD Milan) servers
    - ARM (Gigabyte Ampere) servers
    - USRP (N300,N310,N320,N321,X410). Some are connected for short-range and wired testing while others are used for indoor medium-range testing (e.g., LTE-M)
    - AW2S (Jaguar n38, Jaguar n78, Panther n78). n78 radios currently provide indoor coverage while n38 is used for outdoor coverage around EURECOM's premises. UEs can be deployed in vehicles, including drones.
    - O-RAN O-RU (VVDN n78, LiteOn n78/n79/n258, Mavenir n78) radios
    - networked 5G and LTE-M UEs (indoor and a few outdoor). New 5G connected-objects for experimenters will be made available in 2023 (e.g., mini racers, mini tractors, robotic arms).
    - dedicated x86 machines with high-end GPUs for the NVidia Aerial 5G platform
    - testing equipment (QXDM stations, protocol testers, Amarisoft UE emulator)
- Real-time Redhat OpenShift (Kubernetes) Single-Node Cluster (128-core AMD Milan server)
- A Redhat OpenShift (Kubernetes) Cluster comprising six 36-core worker nodes, three master nodes)

The three subnets are interconnected via the switching fabric and can be used jointly in experiments, for instance 5G core network and RAN control plane on the main OpenShift cluster and gNodeB and UEs on bare-metal sandbox.

4.3.2. Current Virtual Access Possibilities

Virtual access to SophiaNode-EURECOM is possible via secure-shell (ssh) access to the jumphosts of three subnets described above. The jumphosts are accessed via (csinfra.eurecom.fr) on three particular ports. Users of the facility are currently required to gain access from EURECOM and via exchange an RSA public key. Baremetal resources can be reserved on an on-demand basis and access to the OAI slack channel can be used to exchange with other researches using the facility in real-time. This type of access is typically for development and testing purposes or to obtain data from live 5G networks and testing equipment provided by the facility.

Access to the OpenShift clusters can be provided so that users can deploy services in dedicated namespaces (OpenShift projects) or make use of 5G services that are continuously-deployed (e.g., OAI 4G and 5G Core Networks, OAI 4G/5G RAN) and maintained by OpenAirInterface Software Alliance and/or EURECOM staff. Edge applications can also be deployed on these clusters. EURECOM has used these resources in recent H2020 projects such as ICT-17 5G-EVE, ICT-19 5G!DRONES and ICT-42 5G-RECORDS and provided external access to the facility. A high-level view of the means to deploy services is shown in Figure 9.
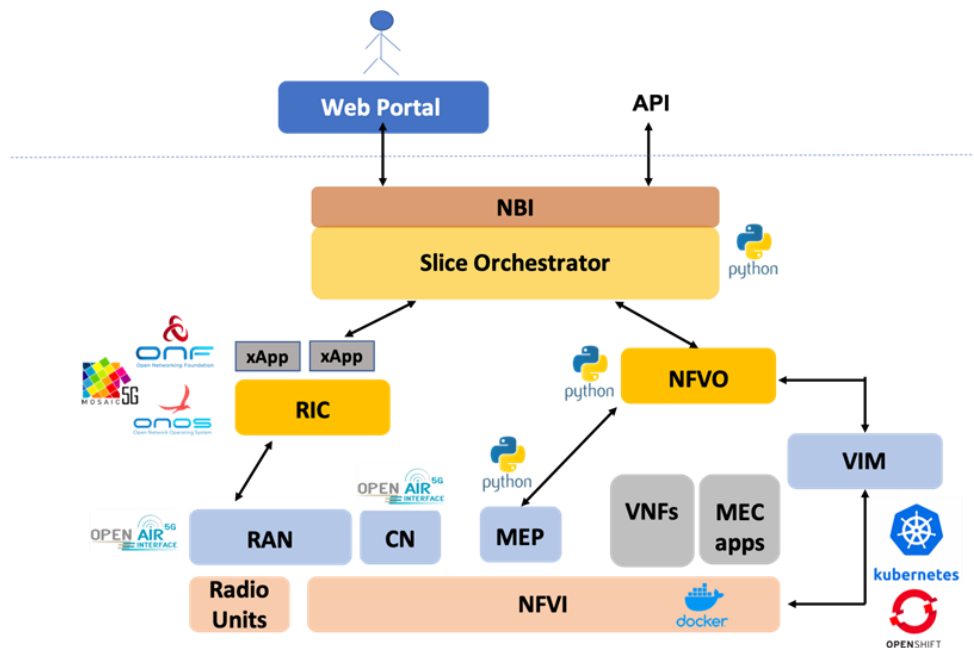
Figure 9. Interacting with SophiaNode-EURECOM in Collaborative projects

This is an example of the framework that was used in 5G-EVE and 5G!DRONES to interact with the resources made available by SophiaNode-EURECOM. At the highest level, two distinct means are provided to deploy containerized network and service functions and to collect measurements.

Firstly, a http-based portal with GUI developed in the context of 5G!DRONES which can interact with the OpenShift clusters (or vanilla K8S as well) to both build using native OpenShift features and deploy vertical services on the infrastructure. Building a service can be from source code, binaries or pre-built container images. In this mode of functioning, pre-built network configurations (5G RAN, Core and controllers) are continuously deployed by EURECOM staff for the duration of the experimental phase of the project and users can develop and test their own vertical services.

Raw access to the infrastructure using native k8s and OpenShift APIs is also made available to allow for external orchestration of the computing resources, e.g., using ONAP and soon Nephio. This was used in the case of the 5G-EVE project where standard Helm-chart descriptions of network functions were provided so that networks could be built on the infrastructure from a remote ONAP portal in an on-demand fashion.

Finally, as was done successfully in the 5G-RECORDS project and depicted in Figure 10, SophiaNode-EURECOM provided the means to deploy both physical and virtual network functions and end-user devices to remotely test an end-to-end system. In this instance the k8s-ready network functions were provided by partners (Accelleran and Cumucore) and deployed on the infrastructure along with those from the OpenAirInterface community and extended by EURECOM during the course of the collaborative project. End-user devices and edge-computing hardware was provided by Sennheiser to build an end-to-end 5G-based multimedia system. The system was controllable remotely by partners during the pandemic. In particular, Sennheiser's devices were controlled by a cloud-service running on a commercial cloud platform (Azure). Control and measurement collection was done over the timespan of the project and allowed the experimenters to experiment with real-time 5G networks.
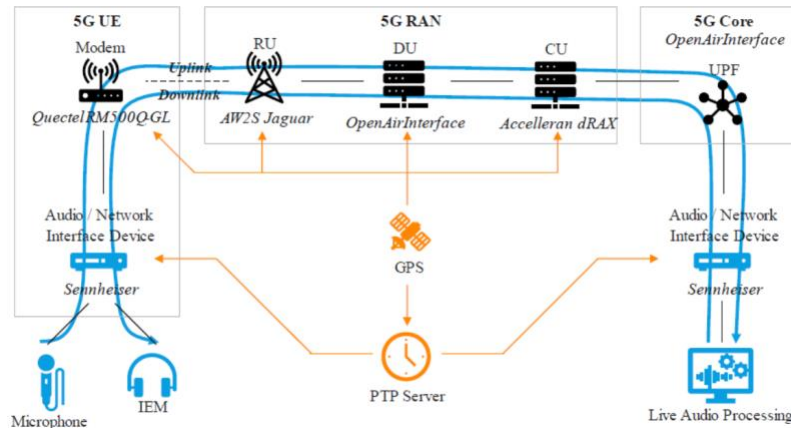
Figure 10. Example of physical and virtual deployment of experimenters' resources on SophiaNode-EURECOM

4.3.3. Extensions for SLICES-RI

In the context of SLICES-SC EURECOM is adapting the 3 experimentation-use-cases described above to allow the SLICES-RI community to benefit from the experience of the three projects. In particular, the API used by the web portal application will be embedded into the future SLICES-RI portal to allow for similar deployment on SophiaNode (EURECOM and INRIA). With partners (UTH, SU, INRIA) a multi-cluster orchestration platform will be deployed to control k8s-based resources and allow for multi-site experiments with distributed network functions. We currently envisage using Google Nephio for this purpose because of the budding ecosystem around this project. Finally, standard ssh-based access will be enhanced using the SLICES-RI reservation mechanisms for bare-metal nodes.

4.4. PIONIER-LAB, Poland

SLICES Research Infrastructure in Poland is currently being developed as part of national projects from Polish Roadmap of Research Infrastructures. Therefore, at this moment only limited research services and resources are available for the first Open Call for Experiments in SLICES-SC. Below we present the list of research services and resources available through Virtual Access:

- **Cloud services**
  - Total: 512 vCPU, 2 TB RAM, 40 TB of disk space
  - Single reservation max 16 vCPU, 64 GB RAM, 1,25 TB of disk space
- **Optical and measurement equipment**
  - SPIRENT N11U IP Tester (full set of protocols), QSFP, 100G (CFP2), 10G, 1G interfaces

All these elements are accessible remotely by potential users of the RI in Poland.

4.5. 5TONIC, Spain

5TONIC Testbed is currently deployment its integration in SLICES-RI infrastructure and has limited offer of the virtual access services that can be provided in the future through SLICES. Previous experiences in building testbeds for experimentation in 5G in 5G-EVE, 5G-VINNI ict-17 projects will be included as initial seed on the corresponding datasets and tools repository and can bring previous experiences to illustrate the future definition of virtual access in SLICES-RI.

4.6. LeonR&Do - COSMOTE, Greece

COSMOTE's RI is not yet connected to the SLICES-SC Testbed Portal, but we are in close collaboration with UTH (WP2 leader) towards that direction. Our RI is used in several European funded projects and its use is free of charge in the context of these projects under certain limitations.

COSMOTE's LeonR&Do IoT platform (depicted in the Figure 11) has been used for data collection from houses and telco sites using a wide variety of sensors. A number of these datasets has been made available through the SLICES-SC CKAN server.
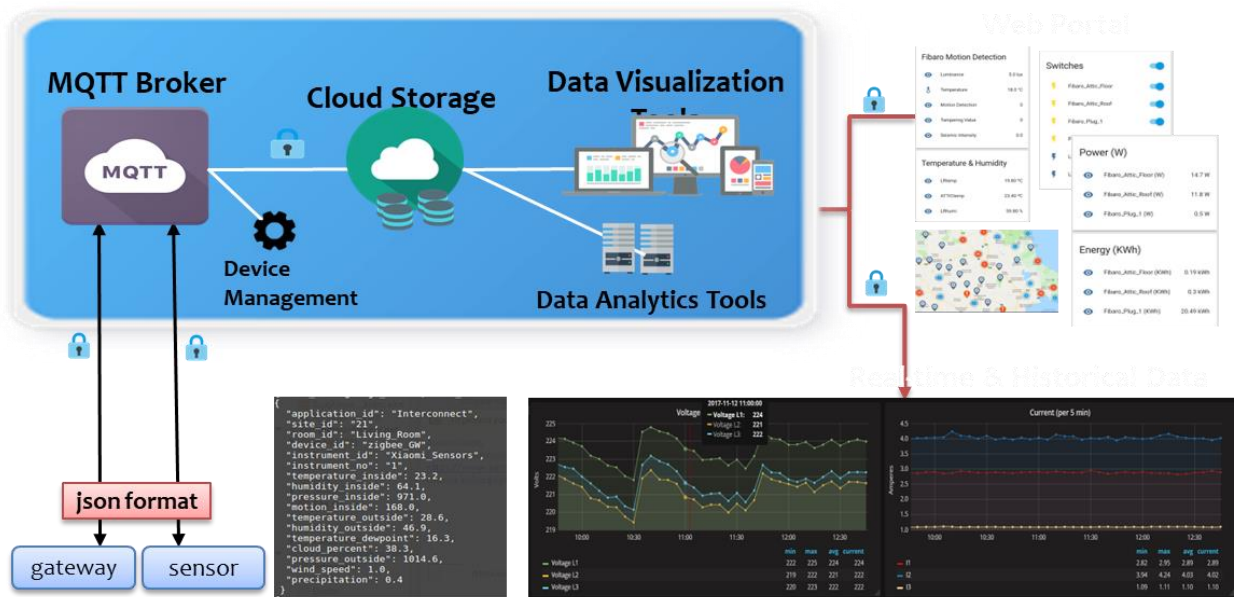
Figure 11. COSMOTE IoT platform

COSMOTE Datasets uploaded to CKAN server:

- **Measurements from 24 environmental sensors (1 room, 1 month)**

This JSON file contains data collected from 24 environmental sensors deployed in a single room for one-month period. The data is structured as a set of objects, each representing a measurement taken by the 24 sensors at a specific time.

Each object has two fields: "columns" and "values". The "columns" field is an array of strings that represent the names of the columns in the "values" array. The "values" field is an array of arrays, with each inner array representing a single measurement taken from each of the 24 sensors at a specific timestamp.

Each inner array contains the mean value of each measurement taken over a 15-minute time interval. The first element of the inner array is the timestamp at which the measurement was taken.

- **Three sets of measurements of total power consumption of three houses for a period of one year**

These three JSON files contain information about the total power consumption of three houses for one year. The data is stored in a series of objects, with each object representing a measurement of

the power consumption at a specific time. The columns field is an array of strings that represent the names of the columns in the values array. The values field is an array of arrays, with each inner array representing a single measurement of power consumption. The first element of each inner array is the timestamp, and the second element is the mean total power consumption of a 15-minute time interval. The power consumption is measured in watts.

- **Mobile Network Statistics (at Base Station level)**

This dataset includes real network traffic statistics and BS configuration-related information for a number of 3G/4G/4G+ Base Stations covering a specific stadium (hotspot site and greater area), located in Greece.

Base Station Configuration Info:

- BS ID: Increasing number starting from 1 (not the real BS ID)
- 4G/4G+ BS configuration data (if the BS supports 4G): incl. the number of cells and the operational frequency (in MHz), e.g., 3 sectors (A,B,C) @1800/ 2600/ 800MHz
- 3G/HSPA/HSPA+ BS configuration data (if the BS supports 3G), incl. the number of cells and the operational frequency (in MHz), e.g., 3 sectors (K, L, M) @2100MHz.

Additional Info:

- Discrimination of BS in terms of covering the area inside (In) or outside (Out) the stadium
- #Users in the area under study during specific time periods.
- 3G/HSPA/HSPA+ network statistics:
- Time: in the form of 2015-11-25 00:00:00.0.
- Cell Name: The BS ID (1,2,3, …) along with the sector ID (A,B,C, …).
- Speech Traffic (Erlang): The total speech traffic in Erlangs.
- Video Call Minutes: The sampled video call minutes for 64Kbps channel.
- Data Traffic (MB): The hourly UL/DL Data traffic in MB.
- Average number of users: The sampled average number of simultaneous users performing HSDPA and HSUPA sessions.
- RRC Connection Setup Failure Rate and Attempts: The access failure rate due to Radio Resource Control (RRC) setup failure as % of total sessions (for CS and PS connections), and the total number of attempts (successful and failed); for CS and PS.
- RAB Setup Failure and Attempts: The access failure rate due to Radio Access Bearer (RAB) set-up failure rate as % of total sessions and the total number of attempts (successful and failed); for CS, PS, HSDPA/HSUPA.
- Admission Control Blocking: The Admission Control (AC) Blocking Rate as % of total admission requests and the total number of AC Blocks.
- Drop Call Rate (% of total) for various Sessions: The Drop Call Rate (% of total sessions) for Speech (CS), PS, HSDPA, HSUPA Sessions. For the Speech Channels also the Total Speech Channel Releases (Normal + Dropped) are available.

4G/4G+ network statistics:

- Time: in the form of 2015-11-25 00:00:00.0
- Cell Name: The BS ID (1,2,3, …) along with the sector ID (A,B,C, …)
- Data Traffic (MB): The quarterly UL/DL Data traffic in MB as well as the Carrier Aggregated traf-fic e.g., traffic transmitted on two carriers equals the total cell traffic is the sum of UL+DL+Aggregated Traffic

- Mean Cell Throughput (Mbps): The quarterly average LTE UL/DL throughput in Mbps
- RRC Setup Failure Rate (%) and Attempts: The Radio Resource Control (RRC) Setup Failure Rate (% over total) and RRC Setup Attempts (Successful + Failed)
- E_RAB Initiate Failure Rate (%) and Attempts: The E-RAB (Evolved Radio Access Bearer) Initiate Failure Rate (% over total) and E-RAB initiate Attempts (Successful + Failed)
- E-RAB Drop Rate (%) and Releases: The E-RAB Drop Rate (% over total) and Total E-RAB Releases (Normal+ Drops)
- Average Physical Uplink Control Channel (PUCCH) Signal to Interference plus Noise Ratio (SINR): The average PUCCH SINR
- Average Physical Uplink Shared Channel (PUSCH) SINR: The average PUSCH SINR
- PUCCH Interference: The PUCCH average Interference Level
- PUSCH Interference: The PUSCH average Interference Level
- Max Simultaneous Active UEs: The sampled maximum simultaneous Active UEs
- Max Simultaneous RRC Connections: The sampled maximum simultaneous RRC Connections

4.7. ILabT – *IMEC, Belgium*

imec has made available multiple testbeds for Virtual Access file://localhost/(https::doc.ilabt.imec.be).
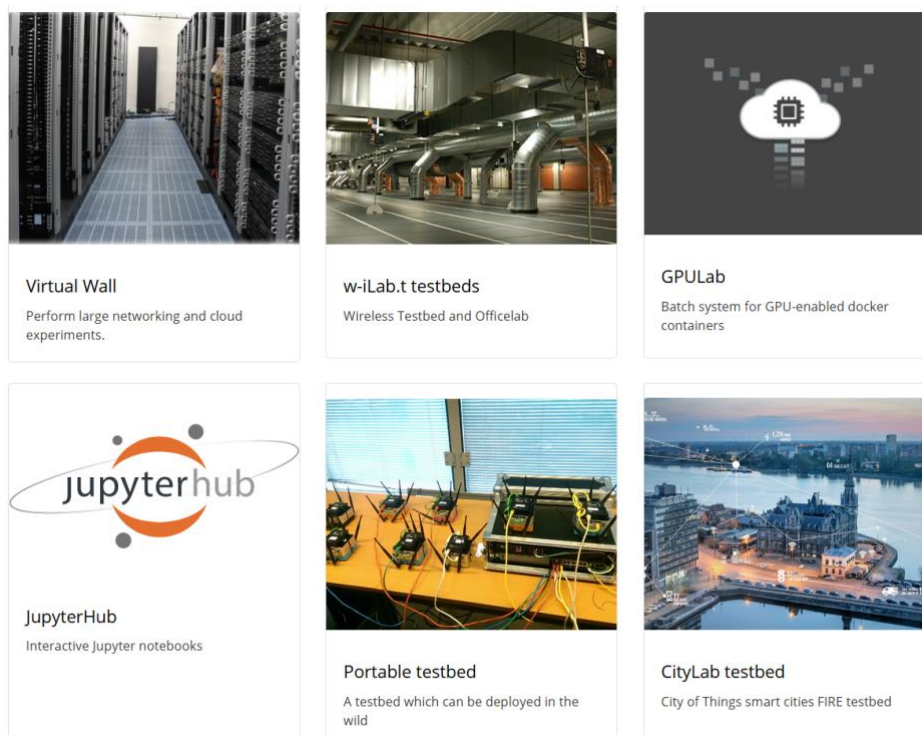
Figure 12. imec testbed portfolio available through SLICES-SC

- Virtual wall (Gent): to perform wired networking, cloud, distributed software, service backends and scalability experiments. 550+ installed servers.
- w-iLab.t (Gent): pseudo shielded environment for wireless and IoT research with over 150 wireless nodes (fixed and mobile), including software defined radios
- Officelab (Gent): a real office environment for wireless and IoT research with over 110 embedded PCs spread over the building.

- GPULab (Gent and Antwerpen): testbed with 125+ GPUs with over 570.000+ cuda cores and 1.8TB+ GPU RAM for AI research and everything which needs GPUs. Available through interactive jupyter notebooks and scheduled jobs.
- CityLab (Antwerpen): testbed for wireless networking experimentation in the unlicensed spectrum in the city of Antwerp. 50 nodes are spread over an area of 1 square km.

All testbeds are available through the SLICES portal and tools. The testbeds are open to externals. All testbeds are perfectly accessible through virtual access, which is also the main usage of the testbeds. At the moment of writing, we had about 15 external users coming in on our testbeds through SLICES.

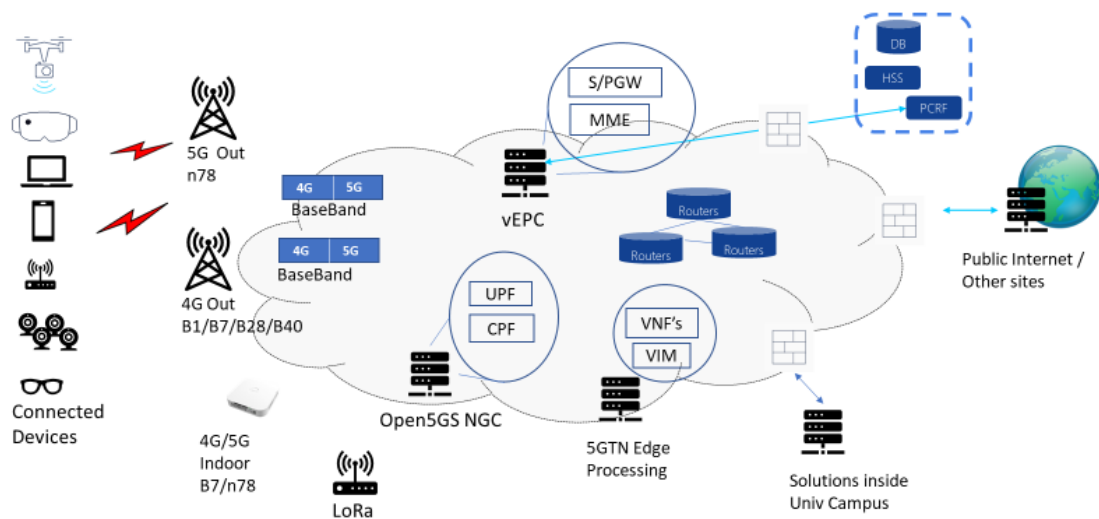### 4.8. 5G Test Network (5GTN), Finland

Figure 13. 5G Test Network

Virtual access to 5GTN is now possible only through proprietary system developed for 5G!Drones project. Separate adaptation layer was implemented to offer access to 5GTN resources. As this implementation is developed for certain need, it does not well suit other research and test needs than the ones that are as similar to those that were defined for 5G!Drones. For that reason, the development done in Slices-SC to offer an easy-to-use virtual access in similar way for several test beds over the Europe is welcome.

Data from the experiments and test done in 5GTN is currently mainly being published by individual researchers or research projects in a way that they see best fit their needs. Through Slices-SC 5GTN data will have a well-defined way to publish and make the data available in similar way with other Slices-SC nodes. Current University of Oulu Smart Campus indoor climate dataset that is collected from our Iot sensor network covering the whole campus is published at https://etsin.fairdata.fi/dataset/98ff83ec-96fb-45d2-af82-c041200a3fb2. This data will be made available in the near future in the Slices-SC CKAN database with related metadata so that it is findable and available for use for the Slices and EOSC users.

5GTN already has ways to automate KPI measurements and data storage and transfer implementation and those will be adapted to Federation AM API and the ways to publish Data as well as possible. Current data is viewable by Grafana.

During the first period University of Oulu has analysed both WP2 and WP3 Virtual Access related documentation. Most relevant documents from those Work Packages from the virtual Access perspective are D2.1 Requirements Analysis for exposing the RI and D3.1 SLICES-SC Data Management Plan. D2.1 describes the VA access requirements including the Federation AM API how the RI that is to be used to connect to the Slices-SC web portal. D3.1 on the other hand defines for example the needed Data Centre structure including different repositories and tools.

Based on the analysis actions are ongoing to fulfil the needs. In WP2 activities to connect the 5GTN to Federation AM API has been started. API definition is currently being studied. Current abstraction layer and automated testing implementation will be adapted to the need of the Federation AM API and required changes and implementation will be done according to the study. As the D2.1 has been rejected a new version of the document is to be done. When it is available it will be studied and any changes and/or additions will be considered in the 5GTN implementation.

Node Data Centre requirements (D3.1) has been studied. It has been decided that 5GTN will invest at first phase to a Data Centre with 100TB data storage space. The size of the data centre can be expanded if there is a need for that. SW tools that the Data Centre will use will be as defined in Slices-SC D3.1.

Human Resource needs for these tasks have been analysed. Persons for the studies and Data Centre HW build-up have been defined and they are already actively working. Roles for the SW tool implementation, SW environment, maintenance and support work needed (System Engineer and Data Engineer) have been defined and resources are already being recruited.

4.9. FIT-R2lab - INRIA, France

R2lab is an open tested located in an anechoic chamber for reproducible research in wireless WiFi and cellular 4G/5G/NG networks. R2lab is part of the FIT federation, an open large-scale testing infrastructure for systems and applications on wireless and sensor communications. Located at INRIA Sophia-Antipolis, R2lab proposes thirty-seven customisable commercial off-the-shelf wireless devices, together with USRP nodes and commercial LTE phones, fit to create rich experimental setups. The testbed also features advanced software like leverage OpenAirterface (OAI) and GnuRadio, as well as efficient software tools, to support easy experimentation. These tools allow to book the whole testbed, to remotely control the wireless devices, to easily deploy various scenarios and to collect results. The R2lab platform sits in an insulated anechoic chamber of ≈ 90m 2. It hosts thirty-seven nodes scattered on a fixed grid; about one third of these nodes feature a USRP board of various kinds. In addition, commercial phones are available for connecting to a simulated 4G network.

The testbed is reservable remotely as a whole in a very user-friendly manner. Once the testbed is booked, registered users can control all the resources in the testbed. Users have full control, and can run their OS of choice with any experimental software they need for achieving their goals.Experiments can then be orchestrated with standard tools. For convenience, we also provide software tools as python libraries, that allow to quickly script efficient experiment deployment capabilities, complete from nodes provisioning to data collection.

Access to R2lab is open 24/7. R2lab is used by more than 150 users, half of them from France and the other half from all over the world (Australia, Belgium, Brazil, Canada, Chile, Spain Finland, Germany, India, Indonesia, Italy, Japan, Luxembourg, Netherlands Norway, Tunisia, Turkey, UK, US, Vietnam,

etc.) to evaluate a wide range of wireless networking scenarios in realistic and reproducible environment.

Tools and data that are usable for accessing FIT-R2lab virtually

A large number of experiments has been conducted on FIT-R2lab. As the testbed resources can be controlled using the experimenters' tools, the scripts implementing the experiment scenarios and the datasets produced can easily re-used by the experimenters in other environments, allowing so-called virtual access to the testbed. In the following we describe several experiments run on FIT-R2lab and associated tools, articles and/or datasets when available.

- Mininet-WiFi (https://mininet-wifi.github.io/). Mininet-WiFi is a fork of the Mininet SDN network emulator and extended the functionality of Mininet by adding virtualized WiFi Stations and Access Points based on the standard Linux wireless drivers and the 80211_hwsim wireless simulation driver. The Mininet-WiFi emulator fills a gap in the experimental platform space between reproducible and not-so-realistic simulations and physical experimental testbeds. This contribution showcase the applicability of the Mininet-WiFi emulator in an SDN wireless context by illustrating the support of a number of use cases aiming to address the question on how far we can go in realistic Software Defined Wireless Networks (SDWN) experiments, including comparisons to the results obtained in the FIT-R2lab wireless testbed. We discuss the ability to replay packet-level and radio signal traces captured in the real testbed towards a virtual yet realistic emulation environment in support of SDWN research. More details can be found in the paper published in the Computer Journal and in the Mininet WiFi Github repository.

- Distrinet. With the ever-growing complexity of networks, researchers have to rely on test-beds to be able to fully assess the quality of their propositions. In the meanwhile, Mininet offers a simple yet powerful API, the goldilocks of network emulators. The Mininet API is the right level of abstraction for network experiments. Unfortunately, it is designed to be run on a single machine. To address this issue a distributed version of Mininet called Distrinet was developed. Distrinet can be used to perform network experiments in any Linux-based testbeds, either public or private (FIT-R2lab, Grid5000, Amazon Web Service). To properly use testbed resources and avoid over-commitment that would lead to inaccurate results, Distrinet uses optimization techniques that determine how to orchestrate the experiments within the testbed. Its programmatic approach, its ability to work on various testbeds, and its optimal management of resources make Distrinet a key element to reproducible research. More details can be found in the paper published in the GEFI'2019 workshop and in the Distrinet GitHub repository.

Runnable papers using R2lab

The combination of R2lab's controllable environment and experiment orchestration tools, together with the Jupyter notebook paradigm, paves the way for a new era in the reproducible research domain. This contribution argues that, even though the technical background is not quite available yet, it should be possible eventually for researchers to submit papers written in a completely redesigned format, as compared to camera-ready paperware that is, fundamentally, similar to what Gutemberg could have printed in the late XVth century. Such a medium would allow to bundle, in a more relevant manner, (a) text that describe ideas, and related mathematical material, (b) environment described either as data or as parameters, (c) code to collect, process and render output data, and (d) the raw data as collected by the authors. The separation currently made between, on the one hand, material belonging in the (a) family - "the paper" - perceived as the first-class citizen, and on the other hand the other (b..d) classes - "the artifacts", is actually wrong in the first place. It is important to study, as part of future work, the missing pieces that could in the future allow for papers

to be submitted in a form closer to a runnable paper. For the sake of illustrating a methodological approach to publish experiment results, we have defined a dummy experiment, that consists of measuring, for all couples of nodes (a, b) in the FIT-R2lab testbed, the power received by b when a is sending. It is a dummy experiment in the sense that we do not intend to interpret the result in any significant way, although it does help to understand the disposition of the room and its peculiarities, particularly the impact of the pillars and of blind corners. Jupyter notebooks are hybrid documents that mix formatted text and executable code. In this section, we are exploring the capabilities offered by using Jupyter notebooks, in conjunction with publicly available infrastructures like github.com and mybinder.org, as a step towards runnable papers. More details can be found in a fully runnable report and in the FIT-R2lab Radio map demo GitHub repository.

CEFORE evaluation

There has been a considerable increase in the demand for high quality mobile video streaming services, while at the same time, the video traffic volume is expected to grow exponentially. Consequently, maintaining high quality of experience (QoE) and saving network resources are becoming crucial challenges to solve. This contribution proposes a name-based mobile streaming scheme that allows efficient video content delivery by exploiting a smart pulling mechanism designed for information-centric networks (ICNs). The proposed mechanism enables fast packet loss recovery by leveraging in-network caching and coding. Through an experimental evaluation of our mechanism over an open wireless testbed and the Internet, we demonstrate that the proposed scheme leads to higher QoE levels than classical ICN and TCP-based streaming mechanisms. To evaluate the proposed mobile video streaming mechanism, a vehicular scenario in which a mobile user (a video consumer in a vehicle) streams a video from the infrastructure through a hybrid wireless/wired network is chosen. Then the performance obtained with two other streaming mechanisms: (1) a classical CCN (Cefore-based) streaming application that uses only regular interests (RGI), and (2) a basic TCP streaming application are compared. The scenario also uses the ns-3 network simulator in emulator mode with direct code execution (DCE) on one of the FIT-R2lab nodes to emulate two mobile content consumers (cars) running real application software (such as Cefore and TCP streaming). A consumer is connected to a real LTE network and the Internet through a ns-3 WiFi link (between the car and the road side unit RSU) to play a live video service content. Note that consumer adaptation mechanisms used to dynamically select the appropriate quality version are not included in the scenario to focus on the mobility and in-network functions. The publisher thus provides a video content with a single bitrate of about 1.0 Mbps. More details details can be found in a paper published in CCNC'20 and in the FIT-R2lab Cefore-demo repository.

4.10. ELKH Cloud – SZTAKI

SZTAKI has made many reference architectures publicly available on the SLICES GitLab source code repository (https://gitlab.distantaccess.com/slices/reference-architectures). The uploaded projects are organized into their own subgroup, titled 'Reference Architectures', as illustrated on Figure 14.
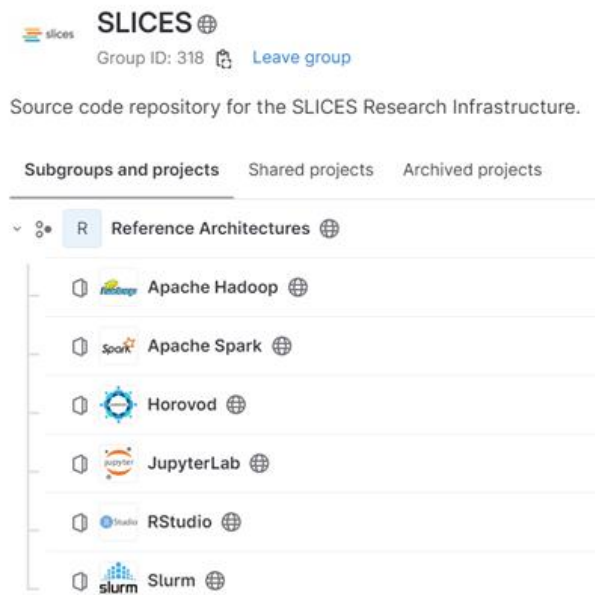
Figure 14. Reference Architecture Projects in the SLICES Repository

Reference Architectures are architectural blueprints composed of proven solutions and built with best practices in mind. While they were originally developed and tested on ELKH Cloud, they are compatible with any OpenStack based cloud platform (some version constraints may apply). The aim of reference architectures is to aid the work of researchers by easing the deployment of complex software systems. They are based on the principles of Infrastructure-as-Code (IaC) methodology, which in combination with the orchestration and configuration management tools applied, enables the automated deployment of digital research environments in a matter of minutes.

Being developed by researchers who work closely together with other members of the scientific community, reference architectures provide up-to-date and suitable tool sets for a variety of common use-cases such as deep learning, high performance computing, workload management, and others. They contain some of the most prominent open-source tools, technologies, and platforms, ensuring that researchers can smoothly carry out their work. To ensure the quality of reference architectures on the long term, they are all automatically tested on a weekly basis.

Existing reference architectures are continuously being maintained and developed further, and occasionally completely new ones are released. These releases will continue to be published on the SLICES GitLab repository.

Furthermore, SZTAKI has published two data sets in the SLICES CKAN repository. Both data sets were generated as part of performance evaluations executed on ELKH Cloud with the Horovod and Kafka frameworks respectively. The data sets each served as a basis for a scientific publication. As the evaluation was performed on distributed environments (clusters) in both cases, scalability was an important factor for the experiments. For Horovod, image processing performance and model accuracy were evaluated, while in the Kafka case, scalability and performance using different configurations were in focus. The data sets contain raw data, summarized reports of the measurements, and the scientific publications.

4.11. TUM lab, Germany

TUM provides access to one of its testbeds (https://testtestbed.net.in.tum.de/web/index.html). The testbed is currently not connected to the SLICES Testbed Portal but uses a local authentication and account management platform. We plan to integrate access via the SLICES Testbed Portal during the remaining phase of the project. We developed our authentication platform based on the OpenID API, an API that is also supported by the SLICES Testbed Portal.

The provided testbed relies on a fully virtualized environment with VMs as experiment nodes and a bare-metal network connection. This approach was developed during SLICES to keep the resource consumption as low as possible. At the same time, this setup provides realistic network performance. Virtualization allows the consolidation of several physical machines onto a single server. However, a virtualized network can have a major impact on the measured network performance. To avoid this kind of negative impact on measurements, we use real networking hardware. This was achieved by a hardware acceleration feature called Single-Root IO Virtualization (SR-IOV). SR-IOV allows the partitioning of network cards into separate, isolated, virtual network cards or so-called virtual functions (VFs). Figure 15 shows the architecture of the testbed using four experiment VMs sharing a single network card and its physical link between both ports.
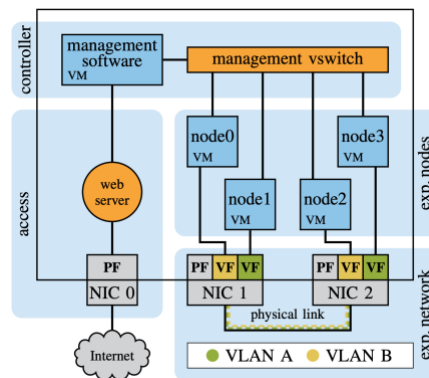

Figure 15. Architecture of the virtualized TUM testbed

All of our testbeds, the virtualized and the non-virtualized testbeds support the same automated and reproducible experiment workflow. This allows the execution of each experiment on any of the available testbeds. The virtualized testbed acts as a resource-efficient solution to develop experiments that we provide to interested parties. The finished experiment can then be run automatically on a bare-metal testbed of TUM. We currently offer only access to the virtualized testbed infrastructure. However, researchers can send us their experiments to be executed on one of our hardware testbeds.

In addition to testbed access, TUM contributed to the creation of the SLICES repositories. We released a data set containing packet traces of a 5G Quality of Service experiments on the CKAN server (http://ckan.iotlab.eu/dataset/5g-qos-measurements). The packet traces were created using high-accuracy hardware timestamps that allow for latency evaluation with nanosecond resolution. The experiment scripts that were used to create the measurements were released as a git repository. The repository was added to the SLICES gitlab instance (https://gitlab.distantaccess.com/slices/5g-qos-measurements).

4.12. CNR lab, Italy

CNR's RI is under development and it is not yet connected to the SLICES-SC Testbed Portal. We plan to connect it when i) the first release of the new SLICES experimental plane will be available for

integration, and ii) we complete the integration of the new RI components supporting a full-fledged 5G-enabled edge cloud. Currently (part of) our RI is used free of charge only in the context of ARTRES 4.0, a regional digital innovation hub on advanced robotics and enabling digital technologies for Industry 4.0. Thus, there is not data collected by our RI that can be offered for VA yet.

5. Future steps for Virtual Access activities

5.1. Evolution of Virtual Access in SLICES

Virtual Access is an important element of the SLICES offering. Currently only limited resources are available for experimentation due to the fact, that the Research Infrastructures are being continuously built at Member States and some of them are planned to become operational in 2024. However, for SLICES-SC the consortium made an effort to consolidate the current offering and present it to potential users of the RI. The details of resources and services available for experimenters in the Virtual Access mode are discussed in Section 4. As it can be immediately noticed, the Virtual Access concerns mainly remote access to the resources and services available in particular testbeds. A user can request access to a specific, named resource or a service, which is listed in the portfolio of a testbed. As long as SLICES-RI is entering a pre-operational phase, with limited resources available for users, it is sufficient for majority of the experiments. However, it is desired to gradually transform the RI towards more "cloud" approach, where the actual location of services is hidden from the end user view and the user express the technical requirements for the research service, while the Management Platform proposes a Virtual Access to the selected service. Similarly, to popular commercial cloud services the emphasis is put on the technical specification of a service, not the actual location of a service. The Figure 16 presents the two perspectives on cloud computing, focused on capabilities and access.
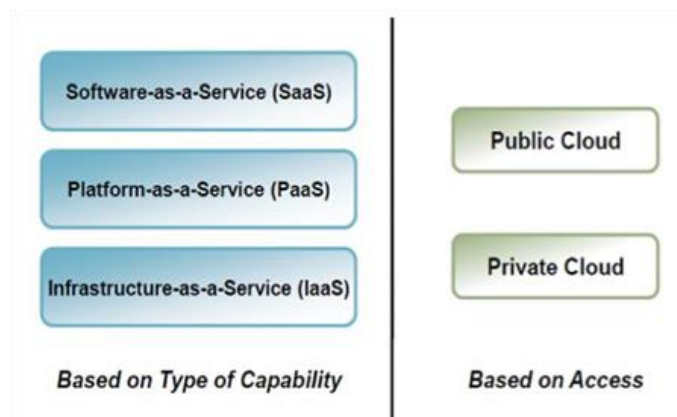

Figure 16. Cloud Computing Types Based on Capability and Access[1]

This concept can be adopted for future SLICES-RI evolution, where selected research services can be accessible through the Virtual Access regardless of their location, but based on offered specific capabilities.

[1] Lewis, Grace. "Basics about cloud computing." *Software engineering institute Carniege Mellon University, Pittsburgh* (2010)

5.2. Virtual Access link to Research Mobility

Within the framework of the WP4 activities, SLICES-SC is financially supporting a mobility of researchers programme to enable researchers and professionals from academia and industry to physically visit a SLICES site and to learn how to use the research facility of that site for experimentation purposes. The mobility of researchers 'programme entails different types of visits that are managed through dedicated calls, targeting both members of the consortium, as well as researchers not affiliated with any of the consortium partners. Of particular relevance for the Virtual Access activities are the calls for "*micro projects*"[3]. Specifically, micro-projects are short research visits from one up to four weeks, aiming not only at offering to the visiting researcher a specific training on the SLICES research facility of the hosting institution, but also at producing a tangible scientific output (e.g., a data set, a software package, a joint collaboration for a publication, an official technical report) to be made available to the research community at large through the SLICES open data and software and tools repositories. Thus, micro-projects can greatly contribute to enrich the SLICES repositories with datasets and software packages that will be directly contributed by the relevant research communities and not only by the members of the SLICES-SC consortium.

The mobility of researchers programme has been officially launched in January 2023 and the call for micro-projects has been opened in February 2023 (see the link for a detailed description of the application procedures). Applications for micro-projects will be evaluated on a first-come, first-served basis until resources are available. Thus, we expect that a first set of micro-projects could be completed within the first semester of 2023.

5.3. Virtual Access link to Open Calls

Open Calls aim to support transnational access of SLICES research infrastructures (SLICES RIs). Experimenters do on-site or remote experiments on the selected SLICES RIs. Applicants have to explicitly declare that they will place their research data related to their experiment in the SLICES repositories. In the 2nd Open Call Proposal Template Section E contains the following instructions: *"Please, explicitly declare that you will upload the experiment results to the SLICES-SC Experiment Results Repository."*

These data include the description of the experiment, input data of the experiment, data obtained during the experiment based on monitoring the experiment, and finally result data of the experiment. The goal is that based on these stored data other SLICES users either can reproduce the experiment using the stored data or can exploit these data to create their own virtual experiment, simulation, etc. without physically accessing the SLICES RIs.

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[3] Please note that micro projects have been also described in D8.4 to explain the link between research mobility and the Transnational Access activities.

6. Conclusion

This document reports a first step on the definition of the virtual access in SLICES, mainly composed of open access to datasets produced by both the testbeds operators and the execution of experiments (open calls, research mobility, internal researchers, industry, etc.) and a set of tools and software available for the research community.

The SLICES Open Data Repository currently contains 55 datasets. 4 of them derived from the successful experiment of the University of Pannonia executed in the framework of the 1st Open Call at the SLICES RI of Imec. The other 49 datasets are placed by the SLICES testbed operators. The upload of data to the SLICES Open Data Repository just has started in this initial period of the project and hence there was no virtual access usage of these data. As a result, the User Committee was not asked to make an assessment report on virtual access services and statistics on data submissions, data access and analysis. We expect much more experiment data to be produced in the SLICES Open Data Repository during the 2nd Open Call and we will focus our advertisement, promotion and dissemination activity to invite researchers to use the virtual access services of SLICES with the increased available data in the Open Data Repository.

A final report at the end of the SLICES-SC lifetime will include the assessment report of the User Committee and an analysis of the vision and evolution of the virtual access services that will be available for SLICES community during its full operation.