SLICES

**Scientific Large-scale Infrastructure
for Computing/Communication Experimental Studies**

www.slices-ri.eu

Summary

Digital Infrastructures as the future Internet, constitutes the cornerstone of the digital transformation of our society. As such, Innovation in this domain represents an industrial need, a sovereignty concern and a security threat. Without Digital Infrastructure, none of the advanced services envisaged for our society is feasible. They are both highly sophisticated and diverse physical systems but at the same time, they form even more complex, evolving and massive virtual systems. Their design, deployment and operation are critical. In order to research and master Digital infrastructures, the research community needs to address significant challenges regarding their efficiency, trust, availability, reliability, range, end-to-end latency, security and privacy.

Although some important work has been done on these topics, the stringent need for a scientific instrument, a test platform to support the research in this domain is an urgent concern. SLICES ambitions to provide a European-wide test-platform, providing advanced compute, storage and network components, interconnected by dedicated high-speed links. This will be the main experimental collaborative instrument for researchers at the European level, to explore and push further, the envelope of the future Internet. A strong, although fragmented expertise, exists in Europe and could be leveraged to build it. SLICES is our answer to this need. It is ambitious, practical but overall timely and necessary.

Although this RI is centered on the research related to Digital Infrastructures, it has a strong potential for interdisciplinarity. Indeed, on the one hand, lessons learned could be advantageously exploited in other RIs where such infrastructure might be relevant in the near future. On the other hand, the digital transformation of various application domains opens an avenue for research in verticals such as smart grid, smart agriculture, autonomous vehicle, connected health etc.

Partners

- Centre National de la Recherche Scientifique (CNRS) – FR
- Consiglio Nazionale delle Ricerche (CNR) – IT
- Consorzio Interuniversitario Nazionale per l'Informatica (CINI) - IT
- Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT) - IT
- EBOS Technologies Ltd (EBOS) – CY
- Fundacion IMDEA Networks (IMDEA) – ES
- Institut Mines-Télécom (IMT) – FR
- Institut National de Recherche en Informatique et en Automatique (INRIA) – FR
- Instytut Chemii Bioorganicznej PAN PCSS (PSNC) – PL
- Interuniversitair Micro-Electronica Centrum (imec) – BE
- IoT Lab (IoT Lab) – CH
- Johannes Gutenberg University Mainz (JGU) – DE
- Kungliga Tekniska högskolan (KTH) – SE
- Mandat International, International Cooperation Foundation (MI) – CH
- Simula Research Laboratory (SRL) – NO
- Sorbonne Université (SU) – FR
- Számítástechnikai és Automatizálási Kutatóintézet (SZTAKI) – HU
- UCLan Cyprus (UCLAN) – CY

- Universidad del País Vasco-Euskal Herriko Unibertsitatea (UPV) – ES
- Université du Luxembourg (UL) – LU
- Université de Genève (UG) – CH
- University of Amsterdam (UvA) – NL
- University of Thessaly (UTH) – GR
- University of Oulu (UOULU) – FI
- University of Würzburg (JUM) – DE

SLICES already received expression of interest from 60 international organizations (government, research and academia, industry, clusters and networks, NRENs), building a broad, diverse and vibrant community. For the application to the ESFRI-2021 roadmap, SLICES has received, so far, the supports listed in the table below and it is looking for further expressions of interest from the community.

Scientific vision and mission

The historic separation between the network and the compute has vanished. As defined by Sun microsystems long ago, "the Network is the Computer" (John Gage 1984); resources are everywhere supported by virtualization, distribution and cloud SaaS. This trend is going to impact the telecommunication and computer-based sectors, from design to products to operation. This will disqualify the multi-year planification approach based on new generations (2G/3G/4G/5G, etc.) and threat the corresponding industry, especially in Europe. The science of Digital Infrastructures raises multiple complex challenges to the research community that already started to explore them with an agenda sometimes branded as 6G! Experimentation is becoming an even more important methodology to assess and qualify the diverse design assumptions and choices in realistic conditions. It addresses the future Internet roadmap with an ambitious agenda regarding the fundamentals and technologies for operating reliable, safe, scalable and efficient infrastructures as well as support the vertical applications that will land on these digital infrastructures. This is the motivation for developing a holistic approach where all resources (compute, storage, network) are associated to continuously design, operate and automate the full life cycle management of applications and services.

The need for a RI in this domain is justified by the emergence of a future Internet including beyond 5G infrastructures that require adapted and well-tailored tools for testing and developing trust and confidence regarding the design and deployment phase. Experimental platforms should be able to address the end-to-end scenario, integrating all technologies and components. SLICES ambitions to provide a European-wide test-platform, providing advanced compute, storage and network components, interconnected by dedicated high-speed links. This will be the preferred collaborative instrument for researchers at the European level, to explore and push further, the envelope of this future Internet.

SLICES will allow researcher and industry to question scientific challenges regarding the future technologies and services. They will be based on a technology roadmap that will be consolidated on the basis of the analysis of several inputs provided by the community as for instance developed by the EU EMPOWER project regarding the wireless technology advances, that are pertinent to the evolution of new radio (NR) and core network (CN) over the next decade 2020-2030.

It is important to note that the competition at the international level is already in place with ambitious projects similar to the mission defined in SLICES, in the US (NSF PAWR 2017-2022 100M$, NSF FABRIC 2019-2024 20M€) and China (CENI 018-2022 190M€), and efforts also developing in Japan.

A non-exhaustive list of research directions enabled by using SLICES is provided below:

- Advanced wireless networking
    - New waveforms;
    - Higher frequencies up to THz;
    - Spectrum and wireless management;
    - Integrated sensing and communication;
    - Multiple heterogeneous radio management;
- Smart/intelligent infrastructure operation and management
    - Advanced protocols and architecture (virtualization, softwerization, programmability)
    - AI applied to infrastructure operation and optimization at all layers;
    - Generation of data to train algorithms;
    - Distribution of intelligence into the Edge of the network;
- Design and validation of new Edge/Fog infrastructures
    - Software and components deployment
    - Distributed resource management
    - Geo-distributed data management
    - Federated deep-learning
- Advanced functionalities
    - Power consumption and energy efficiency;
    - Security and privacy;
    - New security issues and challenges that arise from the verticals and the ubiquitous network;
    - Interoperability, composable infrastructure services on-demand (RI as a Service). Seamless user experiences across technologies and domains.

Impact

- Scientific and technological impact:
    - Equip researchers and practitioners with a wide range of scientific and experimental resources and tools by deploying and operating a large-scale platform providing access to cutting-edge technologies in wireless networking, IoT, and Cloud;
    - Offer a wide variety of advanced computing and networking resources in order to respond to the needs of future dynamic systems;
    - Provide advanced test tools to ensure reproducibility through an automated data repository and support an open data approach for these communities;

- o Build the capacity by strongly contributing to the important education effort targeting both students and engineers.
  - o Allow the evolution of the infrastructure following users' needs and availability of new technologies
- Socio-economic impact:
  - o Strengthening the competitiveness and growth of companies: SLICES will allow the testing of a wide range of technologies without investing in costly hardware and software platforms, reducing the risk associated with the design of new applications in the early stages of specification and design;
  - o Contribution to the development of the local economy and innovation environment: SLICES will be an enabler of digital transition by reducing significantly costs of development and investment for local actors such as SMEs, startups, and local public institutions;
  - o Contribution to the competitiveness of the digital ecosystem and socio-economic impacts;
  - o Contribution to education, teaching and learning by the introduction and use of the RI in the educational process;
  - o Contribution to European and global standards;
  - o Contribution to the United Nations Sustainable Development Goals.

ESFRI Roadmap 2021

- ESFRI call deadline 9 September 2020.
- Next steps after submission: the critical questions and invitation (if positive) to hearings are planned in for February 2021, hearings in April 2021, ESFRI Forum decision in June-September 2021, and finally ESFRI Roadmap launch in October-November 2021.

Financial support for preparing SLICES

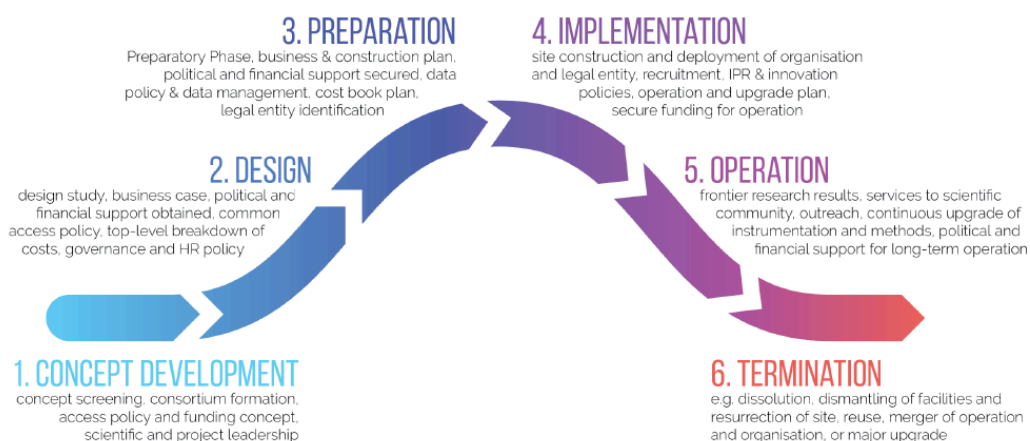According to the life cycle approach of an RI, as defined by ESFRI, SLICES in currently in its DESIGN Phase

Figure 1 – Lifecycle approach of a research infrastructure[1]

We are developing our community and business model based in particular on various funding coming from the partners, national and European sources. We already successfully secured two joint projects, namely SLICES-DS related to the design requirements and organization of our instrument as well as SLICES-SC aiming at organizing the community.

They are summarized below and are defined in order to serve the entire SLICES community, therefore fully inclusive.

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[1] https://www.esfri.eu/sites/default/files/ESFRI_Roadmap2021_Public_Guide_Public.pdf

Project name: SLICES-DS

SLICES-DS (Scientific Large-scale Infrastructure for Computing/Communication Experimental Studies – Design Study)

Summary

Strengthening innovation capacity in digital infrastructure design.

The digital transformation of our societies is enabled by the design, deployment and operation of continuously evolving, complex digital infrastructures. The research community needs a test platform to address significant challenges related to their efficiency, reliability, availability, range, end-to-end latency, security and privacy. The EU-funded SLICES-DS will design SLICES, a Europe-wide test-platform, to support large-scale, experimental research that will provide advanced compute, storage and network components, interconnected by dedicated high-speed links. The main aim of SLICES will be to strengthen the research excellence and innovation capacity of European researchers and scientists in the design and operation of future digital infrastructures.

Partners

- Sorbonne Université (SU) – FR
- Institut National de Recherche en Informatique et en Automatique (INRIA) – FR
- University of Thessaly (UTH) – GR
- Mandat International, International Cooperation Foundation (MI) – CH
- Instytut Chemii Bioorganicznej PAN PCSS (PSNC) – PL
- Universidad Carlos III de Madrid (UC3M) – ES
- UCLan Cyprus (UCLAN) – CY
- Consiglio Nazionale delle Ricerche (CNR) – IT
- Interuniversitair Micro-Electronica Centrum (imec) – BE
- University of Amsterdam (UvA) – NL

Duration and starting date – grant amount

24 months as of 1 September 2020; 2.9 M€

Call identifier

H2020-INFRADEV-2019-3

Project objectives

All project objectives have been defined in relation to the list of Minimal Key Requirements of the ESFRI 2021 Roadmap for the Preparatory phase, in order to be reached at the end of the Design Study.

Objective 1: To adequately design SLICES in order to strengthen research excellence and innovation capacity of European researchers and scientists in Digital Infrastructures

To achieve this objective the project will deliver the following results and outputs:

R.1-1. Scientific new frontier outlined; long-term vision, roadmap and mission outlined

We will translate (in WP1 and WP2) user needs (with categories identification and survey about expectations) into an architecture and a roadmap for long-term evolution of the new RI. It will identify the enabling technologies, and will refine the positioning in the European landscape and its added value (with links to other relevant RI and initiatives).

Linked deliverables: D1.1 Technological status and capabilities of existing ICT RIs; D1.2 Requirements and needs of scientific communities from ICT-based RIs; D1.4 Roadmap for long-term evolution of the Research Infrastructure; D2.5 Use cases validated.

R.1-2. Scientific leadership recruited and availability of scientific human resources proven

The Subject Matter Experts in a wide range of ICT-related disciplines have been recruited for the project (partners and Advisory Board members). WP3 will define all the required human resources with detailed required skills and plans for staffing SLICES (both for the scientific case and for the implementation case).

Linked deliverables: D3.1 Governance structure; D3.5 Roadmap for the implementation.

R.1-3. Services for the scientific community described

WP2 will be responsible for the definition of the architecture and services provided by the RI based on the identification of user demands and needs.

Linked deliverables: D2.2 SLICES Reference Architecture; D2.3/D2.4 SLICES as a Service, D4.1/D4.3 Data Management Plan and metadata.

R.1-4. Science concept, technical maturity and feasibility tested and achieved

WP2 will be responsible for delivering and testing new use cases to demonstrate capabilities of the new RI targeting beyond state-of-the-art technologies and solutions in the ICT field.

Linked deliverables: D2.5 Use cases validated.

Objective 2: To accomplish preparatory work and planning of the new Research Infrastructure

R.2-1. Design/feasibility study successfully completed

The successful completion of the project marks a point in time when the design study has been completed with the delivery of the SLICES conceptual design report.

Linked deliverables: D1.4 Roadmap for long-term evolution of the Research Infrastructure; D2.2 SLICES Reference Architecture; D2.4 SLICES as a Service; D3.5 Roadmap for the implementation of the governance and sustainability, D4.5 Recommendations and design patterns for SLICES infrastructure and services integration with EOSC, Open Science and FAIR; Ultimately D6.2 SLICES conceptual design report.

R.2-2. Clear business case and socio-economic impact developed

WP3 will develop cost analysis and sustainability models, with particular attention to potential business models applied to SLICES. It will be closely linked to a socio-economic impact study as benefits for users and society can lead to potential business models.

Linked deliverables: D3.2 Cost analysis; D3.5 Roadmap for the implementation of the governance and sustainability.

R.2-3. Detailed plan for preparation and implementation agreed, including relevant investment decisions; and risk analysis

WP2 will prepare the technical plan with a strategy to tackle technological and construction issues, and WP3 the corresponding budget and human resources plans. It will identify the major risks and mitigation strategies. Task 2.4 will define the procedures for selection and deployment of initial sites of SLICES based on the research capacity and current and potential geographical distribution.

Linked deliverables: D2.6 Plans for deployment of SLICES core; D3.1 Governance structure; D3.2 Cost analysis; D3.3 Risk analysis; D3.5 Roadmap for the implementation of the governance and sustainability.

R.2-4. Overall plan for operation and decommission defined

WP3 will deliver the plan for operation and decommission of the new Research Infrastructure.

Linked deliverables: D3.5 Roadmap for the implementation of the governance and sustainability.

Objective 3: To define governance and management of the new Research Infrastructure

R.3-1. **Satisfactory project organisation and management for preparation and implementation with clearly defined skills and staffing plans, responsibilities, human resources policy, KPIs and reporting lines approved**

WP2 and WP3 will focus on preparations and procedures for project organisation and management of the targeted Research Infrastructure.
Linked deliverables: D2.6 Plans for deployment of SLICES core; D3.5 Roadmap for the implementation of the governance and sustainability.

R.3-2. **Governance for operation with clearly defined responsibilities and reporting lines outlined, including Supervisory and other Advisory Boards**

WP3 will define and develop the governance model that will allow participants act together in an alliance to take decisions more efficiently and interact with regulatory bodies, national authorities and mobile operators; the governance will follow the guidelines provided by ESFRI.
Linked deliverables: D3.4 Final governance structure approved by the partners; D3.5 Roadmap for the implementation of the governance and sustainability.

R.3-3. **Access policy and Data Management defined**

WP4 will define the data management policy and data interoperability based on EOSC and FAIR principles. WP3 will define the access policy as well as the data protection and privacy policies.
Linked deliverables: D4.1 Data Management Policy, D4.3 Metadata profiles, D4.5 SLICES infrastructure and services integration with EOSC, Open Science and FAIR.

Objective 4: To define models for the financing of the new Research Infrastructure

R.4-1. **Financial commitment by lead country or EIRO forum Member and possible other entities satisfactorily covering the preparation and implementation phases**

Task 3.3 will target to obtain the financial commitments from countries and entities. It will be supported by WP5 which includes national authorities as one of the targeted stakeholders.
Linked deliverables: Expression of political Support (EoS) from the lead country; D3.2 Cost analysis; D3.5 Roadmap for the implementation.

R.4-2. **Top-level breakdown of cost elements with overall order of magnitude estimates, with identification of funding opportunities and outline of the in-kind contribution policy**
WP3 will provide a refined cost analysis and strategy for the whole lifecycle (including for the central hub, nodes and main upgrades), starting from the existing draft cost breakdown.
Linked deliverables: D3.2 Cost analysis.

Objective 5: To define stakeholder and engagement strategy on community-based research
To achieve this objective the project will deliver the following results and outputs:

R.5-1. **Clear strategy about how to gather necessary commitments at the institutional and governmental level**

WP3 and WP5 will work jointly to define the strategy and actions and tools.
Linked deliverables: Milestone MS6 Financial commitments from countries; Milestone MS16 Organisation of the events and presentation of SLICES; D5.1-D5.3 Dissemination, Engagement and Communication Strategy.

R.5-2. **Political support provided by a satisfactory number of prospective members**

WP3 will target to gather all political supports necessary to achieve the research excellence and innovation capacity full potential of SLICES.
Linked project deliverables: The list of EoS from relevant Member States; D3.5 Roadmap for the governance and sustainability.

R.5-3. **Memorandum of Understanding signed by all core partners**

A MoU will formally involve the core partners, to enter the ESFRI preparation phase.
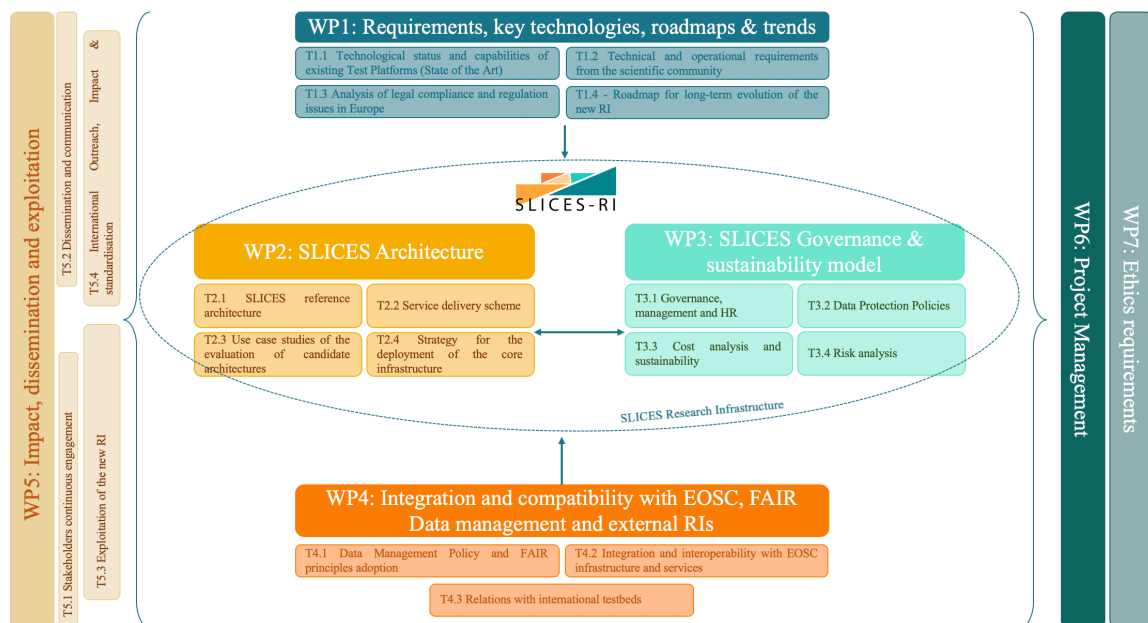*Linked deliverables: D3.1 Governance; D3.5 Roadmap for the governance and sustainability.*

R.5-4. Stakeholders continuous engagement and communication

WP5 will define the target groups and the strategy, put in place all communication actions to test the communication, start making the SLICES brand visible and promoting the platform, and prepare the communication strategy for the future preparation and implementation phases.
Linked deliverables: Milestone MS16 Organisation of the events and presentation of SLICES; D5.1-D5.3 Dissemination, Engagement and Communication Strategy.

Overall structure of the workplan

- **WP1 Requirements, key technologies, roadmaps and trends (WP lead: PSNC)**

The objectives of WP1 are:

- Identification of requirements coming from the research community;
- Collaboration with User Committee on requirements on ICT-based Research Infrastructures;
- Identification of enabling technologies to implement the new RI;
- Providing a state-of-art of regulations in Europe;
- Collaboration with Advisory Board on long-term roadmap and strategy for deployment of the new ICT-based Research Infrastructure.

- **WP2 SLICES Architecture (WP lead: SU)**

The objectives of WP2 are:

- Draft the global architecture of SLICES based on the requirements identified in WP1;
- Define a reference model for SLICES, including engineering plans and strategy for deployment;
- Understand the short/medium and long-term need regarding the physical infrastructure (hardware and software);
- Propose an IT infrastructure to handle user access, programmability and control, service support (including a user portal, that will provide access to all SLICES infrastructure services and provide a dashboard for users' services monitoring and management);

- Define the general security and data protection policies, and the corresponding implementation plans. This includes trust management mechanisms, federated access control and identity management (FedAAI) to allow using organisational identities of users, etc. We will validate functionally the above reference design through use cases and workflows envisioned for the new RI.

Year 1 will mostly be used to identify the various inputs and draft the candidate proposals for the reference design architecture of SLICES.

Year 2 will focus on specification, identification and validation of the solutions to be proposed for deployment and their qualification.

- ### WP3 SLICES Governance and sustainability model (WP lead: UC3M)

The objectives of WP3 are:
- To define and develop the governance model that will allow the SLICES-RI participants act together in an alliance to take decisions more efficiently and interact with regulatory bodies, national authorities and mobile operators; the governance will follow the guidelines provided by ESFRI.
- To define and implement the collaboration between all the stakeholders at national and international levels (regulators, government, agencies, academia and industry).
- To ensure the GDPR compliance of the RI;
- To define sustainability models, policies and guidelines for the RI;
- To develop the financial engineering plan for the construction of the infrastructure;
- To develop the business plans for its operation phase.
- To revise periodically both the governance and sustainability models to assure the correct application and evolution of them in the RI.

- ### WP4 Integration and compatibility with EOSC, FAIR Data management and external RIs (WP lead: UvA)

WP4 will study and provide recommendations to ensure the SLICES infrastructure is compatible and integrated with the EOSC and existing ESFRI infrastructures, and is ready to offer advanced ICT infrastructure services to other RIs and projects, with the special focus on the FAIR data management, protection and exchange. It will build on the requirements specified in WP1 and architecture defined in WP3.

The objectives of WP4 are:
- Define how SLICES will interact (and integrate) with the EOSC infrastructure and services;
- Guarantee the conformance of SLICES Data Management policy with the FAIR recommendations;
- Adopt (and contribute to) the best practices in sharing research data produced by SLICES (both own and hosted experiments) according to Open Data policies and FAIR principles;
- Develop an approach how to build relations and interact with the international testbeds (in relation with T2.2 about technical options for the liaison with existing infrastructures) related to advanced infrastructure and digital technologies, and in particular with the Next Generation Internet (NGI) European testbeds.

The WP4 and the project will actively interact and work in cooperation with the EOSC Secretariat, Research Data Alliance (RDA), and EOSC cluster projects EOSChub, FAIRsFAIR (Fostering FAIR Data Practices in Europe), and others, in developing consistent approaches and policies to enable effective SLICES cooperation, integration and compatibility with existing projects, initiatives, and policies.

- ### WP5 Impact, dissemination and exploitation (WP lead: UTH)

The objectives of WP5 are:
- To define a clear and distinctive brand identity for the new RI;
- To create broad visibility and raise awareness of the new RI;
- To promote the exploitation of SLICES-DS results across partners and stakeholders and contribute to its sustainability for the next phases of the RI lifecycle;

- To maximise the full benefits of SLICES-DS by proactively engaging the wider research and industrial community using a combination of marketing techniques to generate visibility and awareness of the SLICES-DS's primary goals;
- To prepare the future communication and exploitation strategy for the new RI.

- **WP6 Project Management (WP lead: SU)**
- Provide the needed framework to enable the SLICES-DS project to achieve its objectives while meeting its cost, time and quality requirements. This includes the administrative, financial and legal management and also a technical and scientific one;
- Carry out the management of the project, including project coordination, high-level coordination among work packages, representation and operation of the Administrative Team;
- Overall project administration and supervision of financial flows, on-time, on-budget, on-quality delivery of SLICES-DS at all levels;
- Communication with the European Commission (EC) and information flow within the Consortium;
- Coordination and control of the technical project activities according to work plan;
- Preparation of management reports to the European Commission, quality management and assurance, controlling delivery of high-quality project results according to plan;
- Self-assessment and risk management as well as overall conflict management.
- Deliver the final SLICES conceptual design report.

- **WP7 Ethics requirements (WP lead: SU)**

The objective is to ensure compliance with the 'ethics requirements' set out in this work package.

Project name: SLICES-SC

SLICES-SC (Scientific Large-scale Infrastructure for Computing/Communication Experimental Studies – Starting Community)

Summary

Today we are experiencing the digital transformation happening with an unprecedented pace, with the community constantly researching on new solutions to support this transformation with ample computational power and connectivity. Towards addressing such research efforts, Research Infrastructure (RI) specific to addressing Digital Sciences research efforts have been deployed worldwide, towards trying to address key aspects contrary to off-the-shelf commercial infrastructure: 1) Full control over the parameters of an experiment, 2) Repeatable experiments regardless of the physical infrastructure, 3) Valid experimental results, which are easy to cross-reference and replicate. As such, several RIs have emerged, offering experimentation services with bleeding edge resources, that otherwise are only offered only in industrial R&D laboratories, with limited functionality. Towards combating these issues, SLICES Research Infrastructure is about to be deployed, aiming to provide high quality experimentation services with emerging technologies around the area of digital sciences (5G/6G, NFV, IoT and Cloud Computing), in an Internet-scale setup. With SLICES-SC, we aspire to foster the community of researchers around this ecosystem, create and strengthen necessary links with relevant industrial stakeholders for the exploitation of the infrastructure, advance existing methods for research reproducibility and experiment repeatability, and design and deploy the necessary solutions for providing SLICES-RI with an easy to access scheme for users from different disciplines. A set of detailed research activities has been designed to materialize these efforts in tools for providing transnational (remote and physical) access to the facility, as well as virtual access to the data produced over the facilities. The respective networking activities of the project aspire in fostering the community around these infrastructures, as well as open up to new disciplines and industrial stakeholders.

Partners

- Sorbonne Université (SU) – FR
- University of Thessaly (UTH) – GR
- Mandat International, International Cooperation Foundation (MI) – CH
- Instytut Chemii Bioorganicznej PAN PCSS (PSNC) – PL
- Fundación IMDEA Networks (IMDEA) - ES
- Consiglio Nazionale delle Ricerche (CNR) – IT
- EURECOM (EURECOM) – FR
- Cosmote Kinites Tilepikoinonies AE (COSMOTE) – GR
- IOT LAB (IOT LAB) - CH
- Oulun Yliopisto (UOULU) – FI
- Institut National de Recherche en Informatique et en Automatique (INRIA) – FR
- Interuniversitair Micro-Electronica Centrum (imec) – BE
- Szamitastechnikai Es Automatizalasi Kutatointezet (SZTAKI) – HU
- Technische Universität München (TUM) – DE

36 months as of 1 March 2021; 4.9 M€

Call identifier

H2020-INFRAIA-02-2020

Project objectives

A set of objectives with specific validation metrics has been established, which are identified and discussed below.

Objective 1: To provide access to a fully-customizable Internet-scale ecosystem for driving experimental research with Digital Sciences

Description: SLICES-SC aspires to *foster researchers that benefit from Digital Sciences around a common reference architecture*, allowing to seamlessly apply and experimentally evaluate novel ideas and protocols. The infrastructure around which SLICES-SC is developed comprises the basic pillars for the communication network and computational resources evolution:

1. wired and wireless network access, including high-speed optical links and access to new wireless spectrum (e.g. mmWave and THz communications) allowing higher network capacity with lower latency times;
2. edge and core datacenters, allowing on-the-fly instantiation of new (network) functions and their chaining with the existing network operations;
3. resources that span the entire European continent, enabling Internet scale setup of experiments by mix-and-matching resources from multiple testbeds within a single experiment instance.

On top, *the infrastructure will be offered through a centralized portal solution, allowing the reservation of resources and user-friendly deployment of experiments in a single-click fashion*. Through a set of pre-defined experiments, SLICES-SC users will be able to bootstrap their activity from a pool of ready-to-deploy experiments by selecting the site(s) where they will be deployed, and accessing directly the experiment data. These experiments will be constantly updated with new community-developed experiments, for enabling further innovation over the infrastructure.

KPIs: number of nodes in the infrastructure, number of connected testbeds to the SLICES-RI, number of experiments available for deployment.

Objective 2: To enable virtually-anywhere access to the SLICES infrastructure

Description: One of the goals of SLICES-SC is to *provide seamless virtual-access to Digital Sciences experimenters from around the globe*. Through the definition of the proper interfaces, infrastructure governance and management models, and the user-authorization and authentication mechanisms, SLICES-RI will be able to provision the unified resources at large scale. Such mechanisms include a single sign-in process regardless of the site that the user accesses, and the adoption of the same tools for interacting with the infrastructure. Since the infrastructure is highly heterogeneous, and thus different tools may be used at each site for interacting with the hardware, a common API will be adopted for all of the sites, leveraging the concepts of Network Function Virtualization (NFV) and orchestration for the deployment of experiments.

KPIs: Number and location of users accessing the infrastructure, number of users accessing the data produced over the infrastructure.

Objective 3: To provide common experiment descriptions for cross-disciplinary domains over the converged research infrastructure

Description: SLICES-SC will *provide a pool of ready-to-deploy experiments over the infrastructure, addressing research on different domains*. Such experiments may consist of sectors horizontal to digital sciences, as for instance deploying a management application for sensor data, collecting data from sensors deployed in/outside the research

infrastructure, or vertical, as for example monitoring atmospheric precipitation based on the propagation of wireless signals. Common tools for deploying seemingly different experiments will be employed, allowing their extension by mixing different properties between experiments.

<u>KPIs</u>: **Number of experiments available from different disciplines, number of users actively experimenting with these experiments.**

Objective 4: To ensure repeatable and reproducible experimentation and validation of novel protocols

<u>Description</u>: Experiment repeatability and reproducibility is of major concern ensuring the impact of any research effort. ***SLICES-SC infrastructures have been designed in a manner that allows the repetition of experiments and the related data by controlling all the parameters affecting experiments***. This is of major importance for experiments dealing with wireless networking for instance, as external uncontrolled interference can widely affect the outputs of an experiment. Such experiments can be replicated across different sites as well, and over different architectures of compute infrastructure. Data and produced results from each experiment running over the infrastructure will be collected and appropriately stored in order to ensure the reproducibility of the experiments in other platforms as well. This includes the provisioning of repositories, governed by open source licenses, and registries for micro-services (e.g. docker/LXC) allowing the deployment of any experiment over similar infrastructures. A direct comparison between the produced results with a benchmarking provided over the infrastructures can assist to obtain less questionable research results or identify results that only occur under specific settings that are hard to find.

<u>KPIs</u>: **Available repositories for sharing research tools/code/results.**

Objective 5: To raise the awareness of the digital sciences key industrial players and promote the usage of the infrastructure

<u>Description</u>: One of the key aspects to address in a project like SLICES-SC is the ***engagement of the key industrial players globally to make use of the infrastructure***. Such experimental setups are mutually beneficial for all involved stakeholders, as the industrial players can gain access to bleeding edge equipment, programmed with standardized APIs, while their participation ensures the sustainability of the facilities. Specific activities have been planned for liaising with the relevant industry including Operators, Telecom providers, SMEs and start-ups and to create strong links between them.

<u>KPIs</u>: **Number of industrial users attending SLICES-SC events, number of industrial users exploiting the infrastructure.**

Objective 6: To empower, assist and sustain the growth of SLICES-RI user community through the engagement of stakeholders for broad socio-economic impact creation and reinforce the access to the SLICES-RI

<u>Description</u>: ***SLICES-SC*** *will* ***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 will coordinate and ***strengthen dissemination and communication efforts*** through a rich set of tools and actions that aim at ensuring visibility on different stakeholders and relevant initiatives in Europe and worldwide, so as to foster the creation of the user community and the access to the SLICES-RI. Moreover, dissemination and communication activities will target multidisciplinary user communities **at a global scale**. Specific liaisons with international partners will be established in order to raise the awareness of the platform and attract new users for the facilities around the globe. In addition, SLICES-SC will reach out multidisciplinary user communities from research/academia and industry to share knowledge, experience and favor matchmaking opportunities through the access of the SLICES-RI. Activities will accelerate community building and facilitate the circulation of knowledge and the opportunities. Several complementary tools will be used for that purpose including organisation of events, workshops, training seminars, support of researcher's mobility, hackathons, webinars, demonstrations in high-quality venues. Media presence around SLICES-SC activities and events. Raise public awareness towards research/academia, industry, SMEs and start-ups, policy makers, etc.

KPIs: Number of events, number of participants, diversity of participants, number of research mobilities, number of participants in the workshops and hackathons, etc. Feedback surveys. Presence in social media (No. of social media followers; no of website visitors; no of posts), presence in media (number of related articles).

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Objective 7: To launch and organise joint training programmes for higher education and training of researchers, for attracting young researchers and students (with enhanced female participation) in order to support digital sciences careers

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Description: SLICES-SC aims to *develop and organise joint training activities for its user community courses that will facilitate the deployment and the sustainability of the facility*. Research and industrial partners will be involved in the specific activities that will act as a bridge between the research and education institutes and the actual industrial sector. The training activities that will be designed will be directly aiming at bridging the gap from the untied with the industry's needs courses.
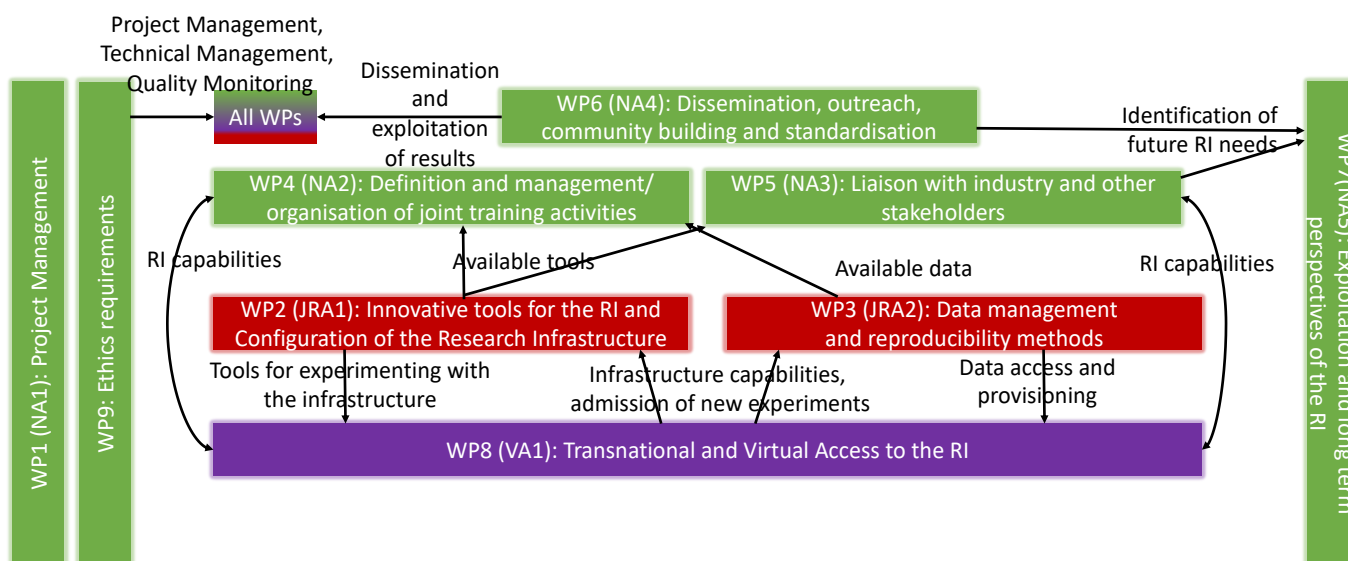
KPIs: Number of training courses, number of students/researchers participated in the events, number of training material, number of joint publications, number of hackathons, number of summer schools and number of participants, etc.

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Objective 8: To support the sustainability and exploitation potential of the SLICES-RI by facilitating promotion of their results towards the interested stakeholders via a set of tools towards new sustainability and exploitation paths

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Description: SLICES-RI is more than sharing a set of facilities and promoting the cross-fertilization of knowledge, since it aims at preserving and maintaining a long-term research infrastructure for digital sciences for research/academia and industry. This will be obtained by implementing a continuous monitoring of the SLICES-RI in order to evaluate the users and communities' requirements and needs as well as the continuous technology evolution for improving the overall quality of the infrastructure. To this end, a sustainability plan will be drawn with respect to the community around digital sciences, the governance model that will be applied and the business positioning of the infrastructure.

KPIs: Development and delivery of long-term sustainability and exploitation plan, costs for the operation of the infrastructure that can be covered from external funding.

Overall structure of the workplan

- WP1 NA1 - Project Management (WP Lead: SU)

WP1 is dedicated to the project management, overall progress supervision and quality assurance for the developed contributions of SLICES-SC. In detail, the objectives of this WP are the following:

- Provide the needed framework to enable the SLICES-SC to achieve its objectives while meeting its cost, time and quality requirements. This includes the administrative, financial and legal management and also a technical and scientific one;
- Carry out the management of the project, including project coordination, high-level coordination among work packages, representation and operation of the Administrative Team;
- Overall project administration and supervision of financial flows, on-time, on-budget, on-quality delivery of SLICES-SC at all levels;
- Communication with the European Commission (EC) and information flow within the Consortium;
- Coordination and control of the technical project activities according to work plan;
- Preparation of management reports to the European Commission, quality management and assurance, controlling delivery of high-quality project results according to plan;
- Self-assessment and risk management as well as overall conflict management.

- WP2 JRA1 - Innovative tools for the RI and Configuration of the Research Infrastructure (WP Lead: UTH)

WP2 is related to Joint Research Activities. This WP will design and develop all the respective protocols, common procedures and mechanisms that will enable different users (including researchers, entrepreneurs, students, young professionals) to access efficiently the RI, with focus on transnational access. More specifically the technical objectives of this specific WP are:

- To define the guidelines for exposing the experimental infrastructure to external users;
- To define a common set of APIs for interacting with the different experimental islands;
- To unify access of all the different experimentation islands through a common portal framework;
- To eventually provide online access for the RI as a service;
- To produce guidelines and walkthroughs for accessing the infrastructure;
- To integrate AI technologies as a means for automatic experiment code generation and helpdesk for the infrastructure.

- WP3 JRA2 - Data management and reproducibility methods (WP Lead: MI)

This WP is related to Joint Research Activities and it will set in place the adequate data management policy and facilitate virtual access on the experiment data collected and distributed through the SLICES-SC project. The WP will set the framework policy for the collection, management and protection of data through the infrastructure. Moreover, it will set the guidelines for its management and exploitation by the reproducibility tools and the benchmarks used by the infrastructure to validate new protocols and ideas. In detail, the objectives of this WP are summarized in the following:

- Setting the guidelines and policy for data protection and management through a data management plan;
- Establish the framework for reproducibility methods and benchmarks;
- Establishment of a data protection office and an open data server.

- WP4 NA2 - Definition and management/organisation of joint training activities (WP Lead: EURECOM)

This WP aims to organize and deliver training events for SLICES-SC. The training events will target in getting novice and expert users, from multiple disciplines, acquainted with the tools and infrastructure of SLICES-RI. 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.

- **WP5 NA3 - Liaison with industry and other stakeholders (WP Lead: COSMOTE)**

The aim of this WP is to liaise with the relevant industry including Operators, Telecom providers, SMEs and start-ups and to create strong links between them. The RI partners are proposing to organize and attend a number of research to business events, to build, maintain and pamper industrial networks, by fostering the interaction with industry and, in particular, with SMEs. Specifically, the objectives are:

- to promote technology transfer from academic research to innovation in industry;
- to support small start-ups and SMEs by offering access to state-of-the-art experimental research infrastructures;
- to create links to established relevant industries including telecom providers;
- to maintain and grow industrial networks, raise awareness of RI services to the industrial community, engage industrial R&D staff.

- **WP6 NA4 - Dissemination, outreach, community building and standardisation (WP Lead: IoT Lab)**

The ambition of WP6 is to engage and empower multidisciplinary user research communities around the SLICES-RI and to create a sustainable and dynamic ecosystem by fostering synergies and liaisons that will lead to increased and durable impact. The objectives are to:

- Reinforce the cooperation between multidisciplinary stakeholders through common activities. Promote and support the policy dialogue;
- Ensure broad visibility of SLICES-SC by disseminating and communicating results to all stakeholders through a rich set of tools and actions;
- Empower and assist the growth of the collaboration around the SLICES-RI through enhanced capacity building activities, which include the facilitation of researcher mobility, the organisation of hackathons, events, webinars, etc.;
- Coordinate and empower dissemination and communication efforts through a rich set of tools and actions that aim at ensuring visibility about the relevant initiatives so as to foster for increased collaboration and synergies among different players;
- Ensure participation in and the organisation of events to engage the target stakeholders and related initiatives by coordinating know-how exchange and awareness creation;
- To ensure that SLICES-SC results benefit as many stakeholders such as Researchers, Research Policy makers, R&D entities, Industrial stakeholders, SMEs, Universities, Science and Technology Parks, as possible at European and National level;
- To enhance the scope and results of SLICES-SC by seeking and ensuring cooperation with other relevant regional, national and European projects, initiatives and platforms;
- To develop SLICES-SC Collaborative Platform aiming to engage new user communities and to support the use of the RI and the implementation of the experiments.

- **WP7 NA5 - Exploitation and long-term perspectives of the RI (WP Lead: SU)**

This WP is devoted to defining a long-term plan regarding the sustainability of the infrastructure, the availability of data even beyond the end of SLICES-SC, and identifying the future needs in terms of tools and equipment for keeping up with the trends in research in digital sciences. The specific objectives of this WP are the following:

- To define how to ensure scientific excellence through the future infrastructure;
- To define methods for attracting and training the managers, operators and users of tomorrow;
- To measure and consider the socio-economic impact of RI;
- To better exploit the data generated by the RI;
- To establish adequate framework conditions for effective governance and sustainable long-term funding for the RI at every stage in their life-cycle;
- To structure the future international outreach of RI.

- **WP8 VA1 – Transnational and Virtual access for the RI (WP Lead: SZTAKI)**

This WP is related to Transnational accesses to the provisioned facilities. All nodes of the RI will be described in a similar fashion below. In addition, work in this WP will describe the general rules valid for the RI transnational access activities including (1) Modality of access under the proposal, (2) Support offered under the proposal, (3) Outreach to new users, (4) Review procedure under the proposal.

Provision of access to the infrastructures:

- SILECS-FIT / OneLab, France
- NITOS – UTH, Greece
- Open5GLab - EURECOM, France
- PIONIER-LAB, Poland
- 5TONIC, Spain
- LeonR&Do - COSMOTE, Greece
- 5G Test Network (5GTN), Finland
- FIT-R2lab – INRIA, France
- FIT-R2lab – INRIA, France
- MTA Cloud – SZTAKI, Hungary
- TUM lab, Germany
- CNR lab, Italy

- **WP9 Ethics requirements (WP Lead: SU)**

The objective is to ensure compliance with the 'ethics requirements' set out in this work package.