SLICES
European Scientific Large-Scale Infrastructure for Computing/Communication Experimental Studies

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IoTBDS 2023
Prague, April 21 2023
Thought experiments

Nobel Price in Physics 2022

Entangled states – from theory to technology

Alain Aspect, John Clauser and Anton Zeilinger have each conducted groundbreaking experiments using entangled quantum states, where two particles behave like a single unit even when they are separated. Their results have cleared the way for new technology based upon quantum information.
6G Research Infrastructures?
Third generation Mid-Scale Test Platforms


**NSF Fabric**: NSF, 20 M€, 2019-2023

**Colosseum**: NSF-DARPA, 20+7,5M$, 2017-2025.

**BRIDGES**: NSF, 2.5M€, 2020-2023

**EU Horizon Europe**
- ICT 17-19-52, 2018-2022, 205 M€
- SNS Stream C, first call, 2022-2025, 25M€

**Japan NICT R&D**
- Shared Open Platform
  - 200 M$  

**China CENI**
- Chinese Experimental National Infrastructure
  - 2018-2022, 190 M€

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Important “competition”

Large Scale Infrastructures as a support to the design and validation of systems

• ACM SigComm scientific publications
ACM SIGCOMM Papers

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Why?
Lessons learned from past and present platforms

*Previous and current generations are successful but however,*
  *Mid-scale*
  *Federation is not transformative*
  *Not sustainable*

*Change the narrative*
  *Science driven (The full research life-cycle)*
Research Infrastructures as a Scientific Instrument

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From mid-Scale (~100M€) to Large-Scale (~B€)

The European ESFRI framework
European Strategy Forum on Research Infrastructures
Supporting a scientific methodology

http://www.esfri.eu/
A vibrant community
Initiated in 2017, 25 partners from 15 countries:

- 12 political support from National Ministries
- included in 5 national roadmaps

SLICES will enable scientific excellence and breakthrough and will foster innovation in the ICT domain, strengthening the impact of European research, while contributing to European agenda to address societal challenges, and in particular, the twin transition to a sustainable and digital economy.
Current status of the partnership

### SLICES
ESFRI successful application – 2020

<table>
<thead>
<tr>
<th>Countries</th>
<th>Government</th>
<th>Research and Academia</th>
<th>Industry</th>
<th>Clusters, networks and others</th>
<th>NRENs</th>
<th>Worldwide support</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>National support</td>
<td>Partners</td>
<td>Support</td>
<td></td>
<td></td>
<td></td>
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A strong identity
SLICES, first in digital sciences to entered the ESFRI Roadmap 2021

• Launched in 2017, SLICES is an RI to support the academic and industrial research community that will design, develop and deploy the Next Generation of Digital Infrastructures:

  • **SLICES-RI** is a distributed RI providing several specialized instruments on challenging research areas of Digital Infrastructures, by aggregating networking, computing and storage resources across countries, nodes and sites.

  • **Scientific domains**: networking protocols, radio technologies, services, data collection, parallel and distributed computing and in particular cloud and edge-based computing architectures and services.

  www.slices-ri.eu
Fully Controllable, programmable Virtualized Digital Infrastructure Test Platform
Openness
A sustainable facility
SLICES timeline

- **2017**: Design
- **2018**: Preparation
- **2019**: Implementation
- **2020**: Continuous Upgrade
- **2021**: Operation
- **2022**: Early Operation
- **2023**: Full Operation
- **2024**: Full Operation
- **2025**: Termination

**MoU-1**
- 2017
- Legal structure established

**MoU-2**
- 2018
- Full operation funding secured and full staff in place

**Govern.**
- 2019

**Services opened**
- No
- 15%
- 30%
- 50%
- 80%
- 100%
- 80%
- No
SLICES governance
SLICES is a distributed RI

Centralised governance

Distributed Infrastructure

Single entry point, single access policy

Supervisory Board

Management Committee

CMO

Country 1

Country 2

Country ...

Central Hub

Node

Partners

Joint investment strategy

Decisions on new nodes

Decisions on core functions and data centre

Optimize the distribution of resources according to needs and competences: control plane, edge computing and slicing, terahertz, MIMO, ...
End Design & Preparation - Q1 2022

12/2022: Decision taken for an ERIC legal framework
Impact assessment
A real challenge
Prioritisation of research topics
What’s the methodology behind it?

- AI-centric DIs
- Indus. verticals demand
- Cloud-to-Edge scalable DIs
- Human-centric DIs
- Cross-prop.

**ADVANCED WIRELESS NETWORKING**
- New waveforms, higher frequencies up to THz.
- Spectrum and wireless management.
- Integrated sensing and communication.
- Heterogeneous radio management.

**SMART INFRASTRUCTURE**
**OPERATION AND MANAGEMENT**
- Advanced protocols and architectures (virtualization, softwareization, programmability).
- AI applied to infrastructure operation and optimization.
- Generation of data to train algorithms.
- Distribution of intelligence into (and beyond) the Edge of the network.

**DESIGN & VALIDATION**
**OF NEW DIs AND HYPER-CONVERGED INFRA**
- Fog/Edge/cloud hyper converged infras
- Software component deployment.
- Distributed resource management & microservices.
- Geo-distributed data management.
- Federated deep learning.
- Datacenters infras for distributed systems, appli. and software stacks.

**ADVANCED FUNCTIONALITIES**
- New challenges arising from the verticals and the ubiquitous networks.
- Interoperability, composable infrastructure services on-demand (RI as a Service).
- Seamless user experiences across technologies and domains.

5.

Breaking down in priority research topics

Simultaneous but progressive exploration of research topics
“The Network is the Computer”

*John Gage, Sun Microsystems, 1984*

“We will think of a network as a programmable platform” …
“We will no longer think in terms of protocols. Instead, we will think in terms of software.

*Nick McKeown, ONF Connect, 2020*

“The network will be programmed by many and operated by a few ».

*Nick McKeown, NetworkingChannel, March 2021*
Open source software and network disaggregation
A SLICES BluePrint

Playground deployment
Post5G Experimentation in SLICES-RI

• Short/Medium term
• Evolve around 5G using open 5G technologies on large-scale end-to-end platform
  • Multi cell-site and multi-region, common infrastructure “blueprints” across sites
  • Reproducible experiments and reusable/collaborative tools (HW/SW)
  • Align with SNS Streams C/D in EU and related national initiatives
  • Align with international academic initiatives (US, Japan, Brazil)

• Focus on technologies targeting integration of disaggregated post5G RAN and Core with cloud-native deployment framework
  • Reuse and contribute to open-source initiatives (OAI, ONF, LF)
  • Experiment with fine-grain automatic control of network functions
  • Contribute to O-RAN architecture evolution : EU/USA collaboration on blueprints
  • Integration of new applications on experimental post5G infrastructure (SNS C/D)
The Blueprint – Bottom-Up POC

- **Recommendations and deployment scripts for RAN/Edge**
  - Servers/OS Configurations for RAN/Edge
  - Radio sub-system deployment
  - Switching (High-performance)
  - Ansible for BM -> single-node K8S/Docker, Helm for existing K8S clusters

- **Ansible scripts for deploying cloud services in support of post-5G networks**
  - 5G core network control plane (OAI 5GC now), VPN tunnel setup
  - Disaggregated RAN control plane (CU-CP), O-RAN controllers, orchestration and management
  - Measurement collection

- **Generate requirements for SLICES-RI API**
  - Experiment management
  - Network management and orchestration

At a later stage

- *Cloud-based experiment development services (CI/CD)*
- *CD for Open-Source Communities (e.g. OAI, O-RAN OSC)*
SLICES-RI PoC Blueprint – post5G Cloud-Edge

RAN/Edge
Commodity Compute K8S, Whitebox P4 Switching/5G UPF, Off-the-shelf O-RAN O-RU, OAI O-DU, nRT-RIC (ONF/M5G), HW Acceleration tech.

Central Clouds
OAM, 5G RAN/Core C-Plane, nRT RIC, Non-RT RIC, CI/CD, Service Orchestration, Experiment management

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The master/control plane node of each testbed, handling all the workloads deployed at the different geographical sites of the node.

Local Databases for experiment measurements storing and analysis.

User gets access (e.g., ssh) here, and can access the workloads deployed in the compute space.

Generic Compute Infrastructure (servers/experimentation nodes)

Bare metal access to be clarified, Canonical MaaS is only an example. Essentially, going with an option allowing PXE booting of images on the Bare Metal nodes would suffice for such experiments.
5G Experiments Case

Can be a BS or an OAI USRP reachable from the respective BS-function (e.g. DU/RU) on the compute infrastructure.

User gets access (e.g. ssh) here, and can access the workloads deployed in the compute space.

Services forwarded back to the control plane node to be forwarded to the end users.

OAI Core Network (AMF, SMF, UDM, UDR, NRF, NSSF) Together with ONF UPF combined with P4 Switches.

SLICES Node preliminary blueprint – User Plane

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SLICES-Central Hub preliminary blueprint – User Plane

User gets access to either data of experiments only, or to schedule an experiment over the infrastructure.

Tools like Red Hat Submariner/Advanced Cluster Management to schedule experiments over different clusters & interconnect them.

User gets access to either data of experiments only, or to schedule an experiment over the infrastructure.

Generic Compute Infrastructure (servers/experimentation nodes)

Open Data server

Local Databases for experiment measurements storing and analysis

Central Hub

Portal for site selection, experiment parameter tuning (e.g. for 5G case, parameters that AETHER/OAI exposes)

User Plane

SLICES node

SLICES node

SLICES node

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Relation to O-RAN
User Perspective - Experiments

*Vertical service integration and testing*

- Users embed software **a)** in the network infrastructure user-plane, either in the **a1)** cloud center or **a2)** at the RAN/Edge (low-latency services).

- User’s can also embed software in **b)** terminals (e.g. drones, robots, fixed stations). We will also allow users to add HW (“bring your own device”) to the terminal end for special experiments (e.g. multimedia or connected robotics).

- We will provide an environment to build such services using the infrastructure itself (from source, binaries or pre-built container images).
User Perspective - Experiments

**Software Defined Networking**

- The user has access to well-defined interfaces to the network functions (e.g. O-RAN xAPP/E2 interface, O1 interface, 3GPP NEF interfaces) and writes applications which stimulate the interface to alter the network behavior or collect KPI.

- This typically involves writing software in the framework of a controller.

- Eventually it could even be in a DPU or programmable switches (P4) for low-level real-time behaviour.
Radio/Network Development Software

- Users without specific radio/processing HW can use a site for development and testing purposes (ssh access) with the objective of pushing software improvements to companion OSS projects.

- A user develops improved network function implementations using one of the CI/CD frameworks of companion projects (e.g. OAI, ORAN O-SC) used by SLICES-RI sites for CD. These go through the normal CI procedures (testing) and get deployed on SLICES-RI for larger-scale testing.
  - Physical layer procedures
  - MAC-layer scheduling
  - Crypto functions
Low-level access to radio resources

• Experiment with candidate 6G technologies. This will typically involve insertion of hardware elements into sites such as
  • Novel RF devices such as antennas, RIS, optical wireless devices, THz radios...
  • Hardware accelerators for key functions like channel decoders, cryptographic functions, user-plane packet-processing
  • Real-time edge devices (TSN, real-time multimedia, industrial IoT, etc.)
• Once inserted (or provided by sites) users can reserve time to develop and test scenarios using these devices
User Perspective - Experiments

**Joint use of Post5G infrastructure services and SLICES-RI HPC resources**

- **Example 1: Real-time Digital twin of radio network**
  - GPU farms can be used as real-time 3D radio emulators. When interconnected with radio and core network infrastructure can make a digital twin of a deployed network.
  - This requires tight interconnection between radio processing infrastructure and the GPU farm but can be used to perform experiments not possible on the real network (large number of terminals).
  - Novel aspect, joint radio and digital twin. This requires proximity of HPC and real radio infrastructure.

- **Example 2: Code analysis and bug fixing**
  - Protocol implementations are bug-ridden. In the CI/CD Type 3 experiment, developers of OSS networking software can make use of SLICES-RI GPU farms for code analysis and bug fixing.
  - Today in projects like OAI, CI makes use of “simple” tools like `cppcheck` to analyze community contributions. Use of AI/ML tools will take this to another level.
Roadmap

- **July 2023 - Initial PoC**
  - IEEE HPSR Tutorial (USA)
  - EUCNC demo
  - SLICES-SC Summer School tutorial

- **June 2023 - December 23 lessons / Deployment . Consolidation . Lessons learned**
  - Buildup of initial SLICES-RI post-5G sites (Targeting 6 countries – 10 physical sites)
  - Blueprint will provide input for planning new sites
  - Alignment with O-RAN NGRG platform activities and SNS Streams C/D
  - Alignment with other International activities (OpenRANGym, Japan, Brazil, 6G hubs in Germany)

- **January+ 2024 – SLICES-RI Pre-operation**
  - Development of required interfaces for SLICES-RI (portal, central cloud services, contribution to API development)
  - CD activities
SLICES and EOSC Interoperability and Integration

EOSC: European Open Science Cloud
https://eosc-portal.eu/
Lessons learned

What is your scientific question?

No Reproducibility – No Science!
Why Most Published Research Findings Are False

John P. A. Ioannidis

Summary

There is increasing concern that most current published research findings are false. The probability that a research claim is true may depend on study power and bias, the number of other studies on the same question, and, importantly, the ratio of true to no relationships among the relationships probed in each scientific field. In this framework, a research finding has credibility only if its statistical significance is very strong, and if the claim is based on a large number of studies or observations, if the effect size is substantial, if the result is consistent with previous findings, and if it is externally validated and can be reproduced by others.
Electronic Documents Give Reproducible Research a New Meaning

Jon F. Claerbout and Martin Karrenbach, Stanford Univ.

SUMMARY

A revolution in education and technology transfer follows from the marriage of word processing and software command scripts. In this marriage an author attaches to every figure caption a pushbutton or a name tag usable to recalculate the figure from all its data, parameters, and programs. This provides a concrete definition of reproducibility in computationally oriented research. Experience at the Stanford Exploration Project shows that preparing such electronic documents is little effort beyond our customary report writing, mainly, we need to file everything in a systematic way.

In 1990 we began experimenting with electronic documents that merge our scientific software with our word-processing software. A year later we manufactured a CD-ROM containing a new textbook, Joe Delling’s doctoral dissertation, and two progress reports of the Stanford Exploration Project. We distributed these CD-ROMs to sponsors and many friends at the 1991 SEG meeting.

In 1990, we set this sequence of goals:

- Learn how to merge a publication with its underlying computational analysis.
- Teach researchers how to prepare a document in a form where they themselves can reproduce their own research results a year or more later by “pressing a single button”.
- Learn how to leave finished work in a condition where co-workers can reproduce the calculation including the final illustration by pressing a button in its caption.
- Prepare a complete copy of our local software environment so that graduating students can take their work away with them to other sites, press a button, and reproduce their Stanford work.
- Merge electronic documents written by multiple authors (SEP reports).
- Export electronic documents to numerous other sites (sponsors) so they can readily reproduce a substantial portion of our Stanford research.

We met all these goals and set new ones:

- produce all new documents in this form, including lab reports in formal classes and “lab notebooks” of research progress.
- make incremental improvements in electronic-document software
- seek partners for broadening standards (and making incremental improvements).

Our basic goal is reproducible research. The electronic document is our means to this end. In principle, reproducibility in research can be achieved without electronic documents and that is how we started. Our first non-electronic reproducible document was a textbook in which the paper document contained the name of a program script in every figure caption. The program scripts were organized by book chapter and section so they could be correlated to an accompanying magnetic tape dump of the file system. The magnetic tape also contained all the necessary data to feed the program script.

Now that we have begun using CD-ROM publication, we can go much further. Every figure caption contains a pushbutton that jumps to the appropriate science directory (folder) and initiates a figure rebuild command and then displays the figure, possibly as a movie or interactive program. We normally display seismic images of the earth’s interior, but to reach wider audiences, Figure 1 shows a satellite weather picture which the pushbutton will animate as seen on commercial television. We include all our plot software as well as freely available software from many sources, including compilers and the \TeX word processing system. Naturally we cannot include licensed software, but with the exception of Fortran and C compilers and the UNIX system itself, our publication includes source code for everything needed. The CD-ROM, at 880 megabytes, is so large we have had room for many executable programs on popular brands of workstations. The presence of these executables gives our readers a fast start.

Nearly everyone would rather read a paper book than the bitmapped page images on a screen that you see with an electronic document. But the illustrations in the electronic book are mostly in color, many are movies, and some are interactive. So the electronic book gives the reader a better understanding of the results. We typically use an interactive movie program to compare seismic sections where successive frames include processing with various parameters. The movie medium is much more informative than comparing seismic sections side by side. 3-D volumes are much better exhibited by movies than static paper illustrations. We are delivering a volume of software that is accessed like a book.
SLICES Full research lifecycle
Open data & Reproducibility
Each Data Lifecycle stage – experiment, data collection, data analysis, and finally data archiving, works with own data set, which must be linked.

- All data sets need to be stored and possibly re-used in later processes.
- Many experiments and research require already existing datasets that will be available in SLICES data repositories or can be obtained/discovered in EOSC data repositories.
SLICES contribution to the development of the EOSC

Objectives: federate existing research data infrastructures in Europe and realise a web of FAIR data and related services for science.

**#1**
Enable experimentation at multiple network levels through SLICES RI

- Allow experimentation with future/emerging digital, IT and network technologies (e.g., 6G, IoT, Edge, AI, hyper-converged infrastructure).

**#2**
EU-wide availability of unique Software and App Repositories

- ICT research-related services (e.g., testing new infrastructure and network solutions);
- Applications deployed within SLICES;
- Simulation tools;
- Data analysis tools.

Published in the EOSC Catalog and Marketplace and accessible with different access options.

**#3**
Interoperability with Open and FAIR data

- Producers of unique data;
- Maximize data reuse by adopting of FAIR data principles in Data Management and Governance;
- Processing of sensitive and personal information.

**#4**
Integration of the SLICES communities to EOSC

- SLICES community building
  - More than 120 participants to the 1st SLICES workshop;
  - Thousands of users of existing infrastructures.
- Training services
Empowering Communities

OpenAIRE explorer: https://beta.openaire.eu/

Corona Virus Disease
COVID-19

Summary:
This portal provides access to publications, research data, projects and software that may be relevant to the Corona Virus Disease (COVID-19). The OpenAIRE COVID-19 Gateway aggregates COVID-19 related records, links them and provides a single access point for discovery and navigation. We tag content from the OpenAIRE Research Graph (10,000+ data sources) and additional sources. All COVID-19 related research results are linked to people, organizations and projects, providing a contextualized navigation.

Curated by: Alessia Barbi, Iryna Kuchma, Eugen Bobrov, Nana Truccolo, Erin Clary...

Created: 16-Mar-2020  Members: 87
Projects: 227  Content Providers: 18
Linked to 7 Zenodo Communities

Subjects:
Using CAMS European air quality analysis from Copernicus Atmosphere Monitoring with RELIANCE services

Authors: Mantovani, Simone


Publisher: Zenodo

This notebook shows how to discover and access the Copernicus Atmosphere Monitoring products available in the RELIANCE datacube resources. The process is structured in 6 steps, including example of data analysis and visualization with the Python libraries installed in L...
PM10 in France Jupyter notebook demonstrating the usage of CAMS
European air quality analysis from Copernicus Atmosphere Monitoring with
RELIANCE services

Anne Fouilloux, Jean Iaquinta

This Research Object demonstrates how to use CAMS European air quality analysis from Copernicus Atmosphere Monitoring with RELIANCE services and compute monthly map of PM10 over a given geographical area, here France
Focus on SLICES-EOSC Interop & Integration

**Requirement**: Compatibility and compliance with the EOSC Interoperability Framework

1. **Minimum viable infrastructure/service model** for SLICES regional nodes
2. **Integration with the EOSC**, external and domain specific RIs, and public clouds
3. API design approach to effectively **manage and publish SLICES-RI resources and services**
   - Differentiating accessibility zones/profiles: site local, SLICES internal, and external access modes
   - Federated access control and zero-trust security model (explicit identity and access session mgnt)
4. Data Management & Governance: Define **metadata** to be used for the resource and experimental facilities description. Define metadata for sharing and publication of data produced by SLICES.
   - Well defined metadata for research publications/data but limited metadata profiles for infrastructure resources and experimental data
SLICES Interoperability and Integration Architecture Model

• Common model for connecting to internal and external resources and services
  • Cloud native and IoT – Edge – Cloud continuum

• SLICES Common Infrastructure and Services
  • Platform for experimental research automation and SLICES Core services interoperable with EOSC

• SLICES Portal and Catalogue
  • To be federated with EOSC Catalog and Portal
  • API to SLICES services and data to be published

• SLICES Data Management and Governance: Infrastructure, Services, Policy
  • FAIR data principles and PDI infrastructure
SLICES Interoperability and Integration Architecture

- Compute, Storage, Network Resources (cloud/edge)
- Core network RIs (e.g., GEANT)
- Storage RIs
- HPC RIs (e.g., EGI)
- Federated AAI services
- Resource Directory & API
- Accounting and Budgeting
- Resource scheduling W/f & orchestration
- Computing and Storage services
- Resource Integration
- Service composition
- Resource discovery & Marketplace

SLICES APIs

- SLICES Infra & Services

Experimental facilities (testbeds, labs, verticals)

- Mobile edge RIs (e.g., CNR-Edge/AI)
- Last mile access and sensor RIs (e.g., POZNAN, Sorbonne)

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Conceptual view of the SLICES Interoperability Architecture

- Provides vision and roadmap to achieving interoperability with EOSC
  - Interoperability layers: Technical, Semantic, Organisational, Legal
- Some services can be used from EOSC, some services will require API with EOSC services of metadata mapping
- Data Interoperability and sharing is an important component of SLICES-RI
  - Compliance with the Open Science and FAIR data principles
  - Semantic interoperability
  - Supported by robust data infrastructure
  - Data Management and Governance
SLICES Reproducible Experiment Workflow
Dear Colleague Letter: Reproducibility and Replicability in Science

October 25, 2022

Dear Colleagues:

A 2019 consensus study report published by the National Academies of Sciences, Engineering, and Medicine (NASEM) discussed the meaning of the terms replicability and reproducibility and identified approaches for researchers, academic institutions, journals, and funders to improve reproducibility and replicability in science [1]. In July 2021, at NSF’s request, NASEM convened an expert meeting focused on National Science Foundation (NSF) policies and investments to make reproducible and replicable science easier for scientific communities to understand and execute and to embed reproducibility and replicability within the fundamental scientific method.

Through this Dear Colleague Letter (DCL), NSF reaffirms its commitment to advancing reproducibility and replicability in science. NSF is particularly interested in proposals addressing one or more of the following topics:

1. **Advancing the science of reproducibility and replicability.** Understanding current practices around reproducibility and replicability, including ways to measure reproducibility and replicability, what reproduction and replication means in practice, the right degree of replicability to target, quantitative measures of progress to understand the effectiveness of interventions to improve reproducibility and replicability, and exploration of reasons why studies may fail to replicate.

2. **Research infrastructure for reproducibility and replicability.** Developing and facilitating adoption of cyberinfrastructure tools and/or research methods that enable use...
No incentive, Regulation is needed

IEEE, ACM ... should make the publication of data **mandatory** (in most venues)
Motivation for Reproducibility

Problems with reproducibility
• Two workshops at SIGCOMM conference dedicated to reproducible research:
  • SIGCOMM’03: MoMeTools workshop
  • SIGCOMM’17: Reproducibility workshop
  • Problems remained the same over 14 years

Best solution so far...
• Artifact Evaluation Committees & Reproducibility Badges
• Problems:
  • High effort
  • Potentially low robustness (CCR Apr. ’2021 [1])

What is Reproducibility?

3-stage process according to ACM [2]:

1. **Repeatability**: *Same* team executes experiment using *same* setup
2. **Reproducibility**: *Different* team executes experiment using *same* setup
3. **Replicability**: *Different* team executes experiment using *different* setup

A testbed-driven approach targets the experimental setup:

- Focus on **repeatability** and **reproducibility**
- **Replicability** requires additional effort by others

Reproducibility-as-a-Service

How can we limit the effort spent on reproducibility?
- Reduce amount of work for experimenters to create reproducible experiments
- Reduce amount of work for other researchers to recreate experiments
- Make reproducibility an integral part of experiment design
  ➢ Automate entire experiment (setup, execution, evaluation)

How can we create robust, reproducible experiments?
- Document all relevant parameters for experiments
- Automate the documentation of experiments
  ➢ Well-structured experiment workflow serving as documentation
Testbed-driven Experiments

The plain orchestrating service (pos) [3], a framework for reproducible experiments:

1. A testbed management system
2. A well-defined experiment workflow

Achieving Repeatability
- Automation & Linux Live Images
  - Researchers **must** automate configuration
  - No residual state between reboots
  - Experiments become **repeatable**

Achieving Reproducibility
- Providing access to experiment infrastructure
- Other researchers can easily (re-)run experiment
  - Experiments become **reproducible**

Experiment Workflow

Setup phase
- Controller manages experiment
- Controller configures experiment nodes (DuT, LoadGen)
- Global/local variables (vars) parametrize setup

Measurement phase
- Repeated execution of measurement script
- Loop variables parameterize each measurement run
  - e.g., different packet rates
  - data of each run is connected to a specific set of loop vars

Evaluation phase
- Collected results/loop vars used for experiment evaluation
- Automated experiment release (git repository, website)
Establishing SLICES as a transformative initiative
SLICES International value

**SLICES able to engage a large community**

**SLICES Academy**

**SLICES Blueprint**

- Baseline software components that will form the backbone of SLICES

**Stimulate cooperation with important stakeholders**

- **EU:** SNS program (Stream C)
- **USA:** NSF PAWR, ONF/Aether/OAI
- **Brazil:** RNP
- **Japan:** NICT BY5G/6G?
Thanks for your attention

Questions?

For more information, please contact:
Serge Fdida
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Follow the *NetworkingChannel*,
brought to you by
ESFRI SLICES, NSF PAWR and ACM Sigcomm
Experience with Aether deployment

Options for deploying Aether:

- **Aether-in-a-Box on Hardware Radios**
  - AiaB: SD-Core / UPF / ROC
  - Sercomm Cell
  - SIM Cards and End Devices needed

- **Aether-in-a-Box for Developers**
  - AiaB: SD-Core / UPF / ROC
  - OAISIM needed
Our Setup

• Cloud Native Tools:
  • Openstack
  • Kubernetes

• Cells:
  • 2 CBRS LTE Sercomm ➔ Aether-in-a-Box on Hardware Radios
  • OAI SIM ➔ Aether-in-a-Box for Developers

• UEs:
  • iPhone 11
CONNECTING WITH OTHER TESTBEDS

AETHER
Connected Edge
Distributed Mobile Core User Plane provides local breakout at all remote Aether Edge sites

Shared Mobile Core Control
Central
Shared Mobile Core Control Plane in central cloud supports all Aether Edge sites

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Aether in a Box - démo

https://www.youtube.com/watch?v=bq4wu5w2_8c
theodoros@victoria:~$ kubectl get po -n omer