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SLICES-RI Plain Orchestrating System (pos)

Reproducible Experiment Workflows by Design

Reproducibility by Design

Our goals:

How to limit the effort spent on reproducibility?
- ► Reduce effort for researchers
- ► Integrate reproducibility into experiment design
- ➔ **Automate entire experiment**
  (setup, execution, evaluation)

How to create robust, reproducible experiments?
- ► Documentation of all relevant parameters
- ► Automate the documentation of experiments
- ➔ **Well-structured experiment workflow**
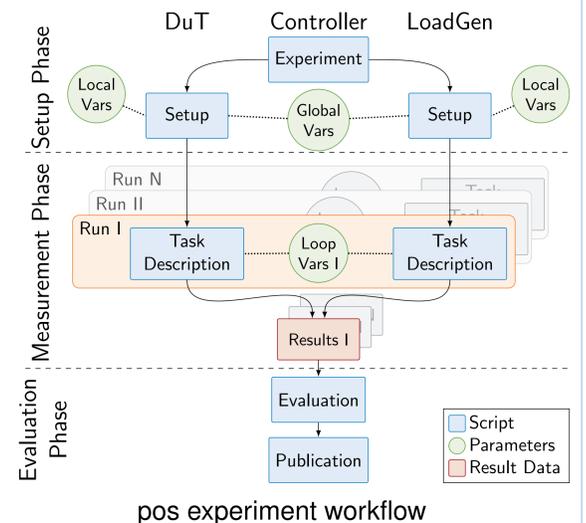 serving as experiment documentation

Our solution: plain orchestrating service [2]

Achieving Repeatability
- ► Full experiment automation
- ► Live images (clean slate on reboot)
- ➔ Experiments become **repeatable**

Achieving Reproducibility
- ► Sharing access to testbed
- ► Other researchers (re-)run experiment
- ➔ Experiments become **reproducible**

pos experiment workflow

Measurement Tools

MoonGen [1] packet generator for 100 Gbit/s Ethernet and beyond

- ► High performance based on DPDK
  - – Supports bandwidths of $\geq$100 Gbit/s
  - – Over 100 million packets per second

- ► Hardware timestamping functionality
  - – Utilizing off-the-shelf NICs
  - – Timestamps with ns-resolution
  - – High accuracy and precision

- ► Flexible configuration by Lua user scripts
  - – Support for new protocols can be added easily
  - – Modification of packets before sending via user-defined scripts

- ► MoonGen has been used for 350+ scientific publications since 2015

MoonGen

Reproducibility Across Heterogeneous Testbeds
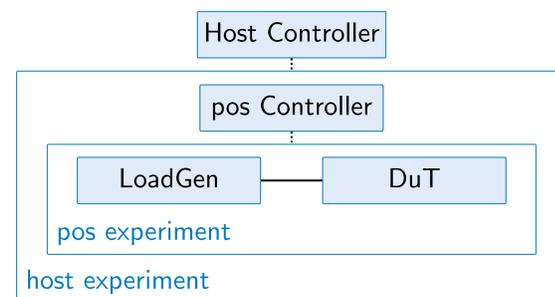
- ► Limitation: Experiment workflow depends on pos controller
- ➔ Solution: Export pos testbed controller to other testbeds
  1. Create experiment in host testbed
  2. Deploy pos inside the experiment of host testbed
  3. Deploy pos workflow inside the pos environment
- ► Ongoing work:
  - – Porting pos to other testbeds such as CloudLab or Chameleon

TUM Testbeds
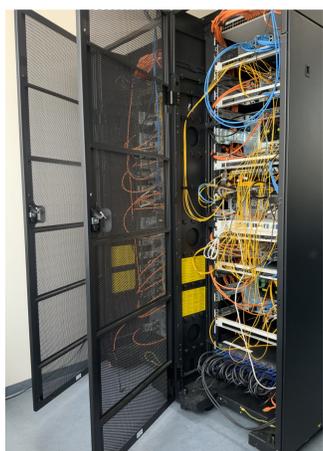
Four testbeds for network experiments
- ► 50+ experiment hosts available
- ► 4 programmable P4 switches
- ► Support for 1–100 Gbit/s links
- ► Optical splitters for timestamping

pos-managed testbeds
- ► Fully automated experiment execution
- ► Ensured reproducibility

SLICES-RI

slices RI

- ► EU initiative with 15 member countries
- ► Goal: Creation of a large-scale digital research infrastructure
- ► Shared pos-inspired API:
  - – Cross-reproduction of experiments on participating testbeds
  - – Establishing a widely-accepted template for reproducible research in computer science
- ► Reusability of experiment results:
  - – FAIR data principles
  - – Participation in European Open Science Cloud (EOSC)

[1] P. Emmerich, S. Gallenmüller, D. Raumer, F. Wohlfart, and G. Carle. MoonGen: A Scriptable High-Speed Packet Generator. In *Internet Measurement Conference 2015 (IMC'15)*, Tokyo, Japan, Oct. 2015.
[2] S. Gallenmüller, D. Scholz, H. Stubbe, and G. Carle. The pos Framework: A Methodology and Toolchain for Reproducible Network Experiments. In *Conference on emerging Networking EXperiments and Technologies (CoNEXT)*, Munich, Germany, 2021.