LF ENERGY

SEAPATH

Virtualization for Real-time Power Grid Substation Automation

About Seapath

SEAPATH is the result of a collaboration between 2 major european electricity players and Open source expertise.

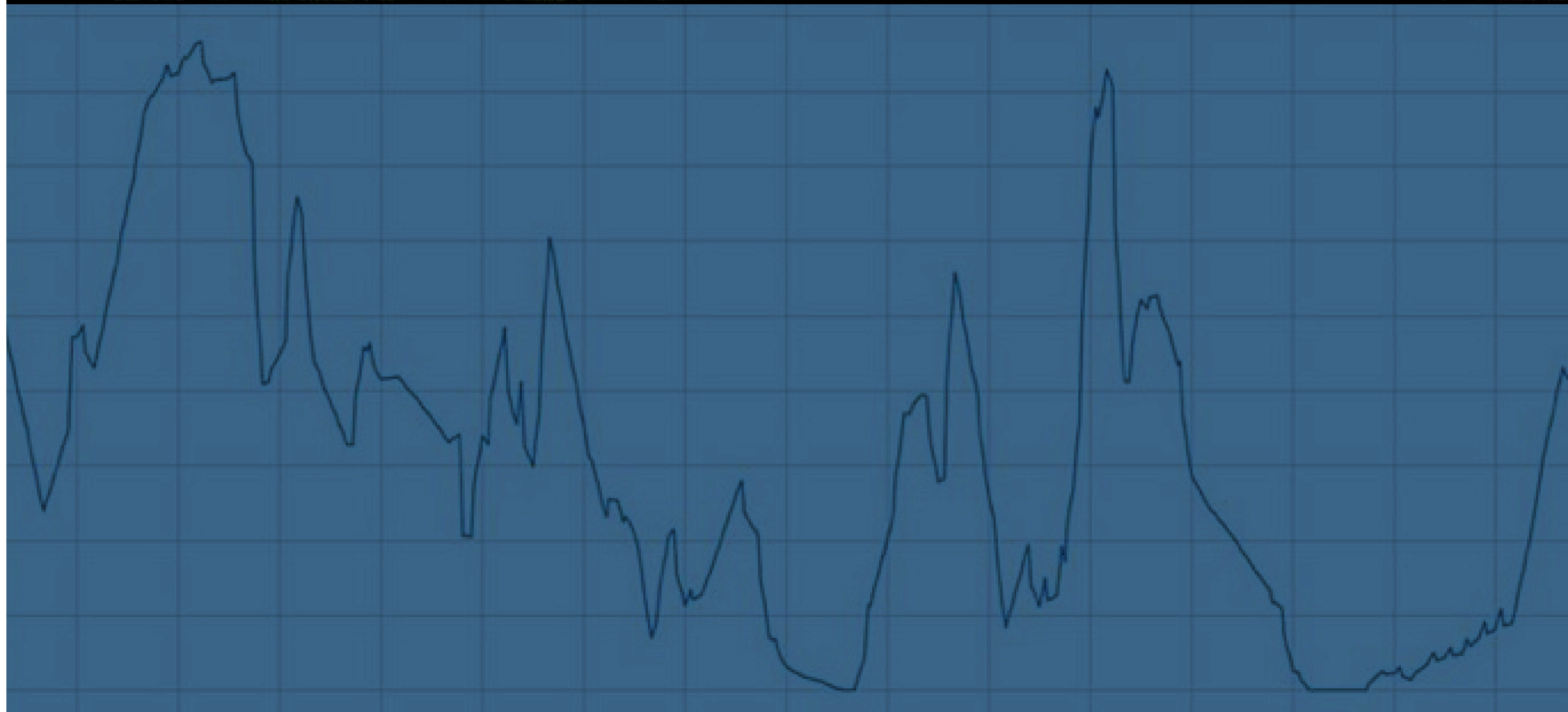
Context

Energy Transition drives change in power transmission and distribution grids

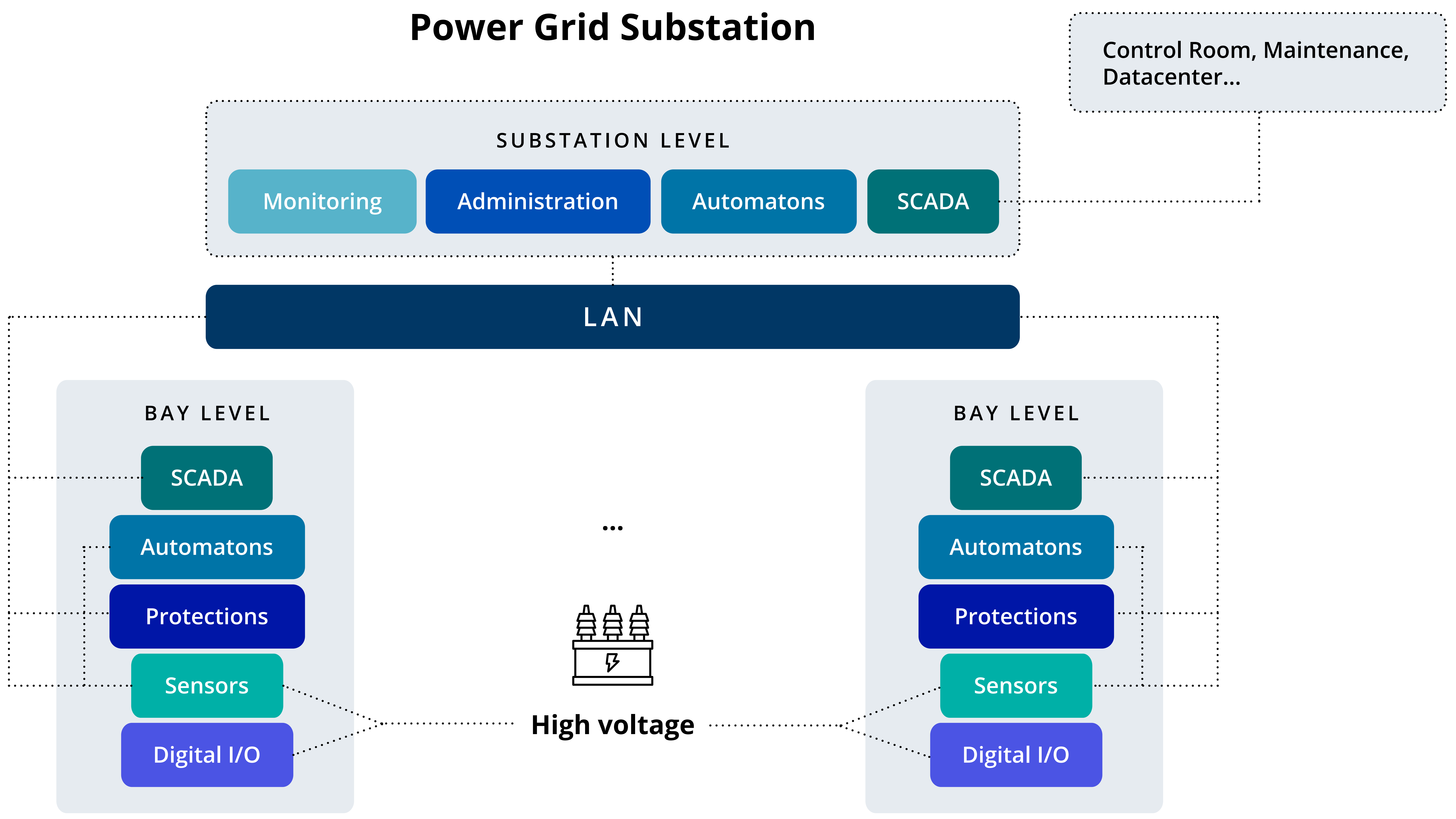
- Distributed renewable energy sources
- Demand response
- Electric mobility
- Smart services to the grids from a growing number of third-parties

Need to **swiftly adapt grid control architectures**

- Multiplication of distributed controls
- More dynamic and adaptive automation functions
- Increased data management needs

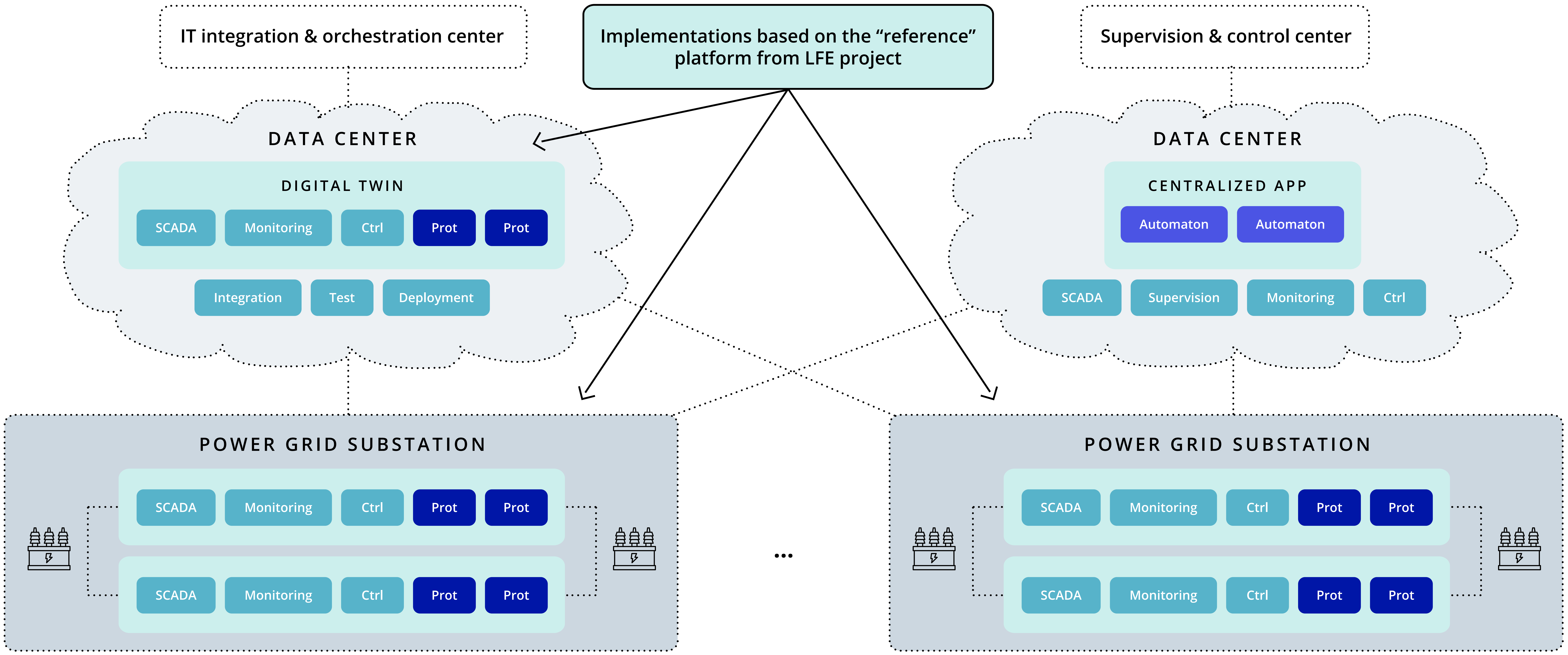


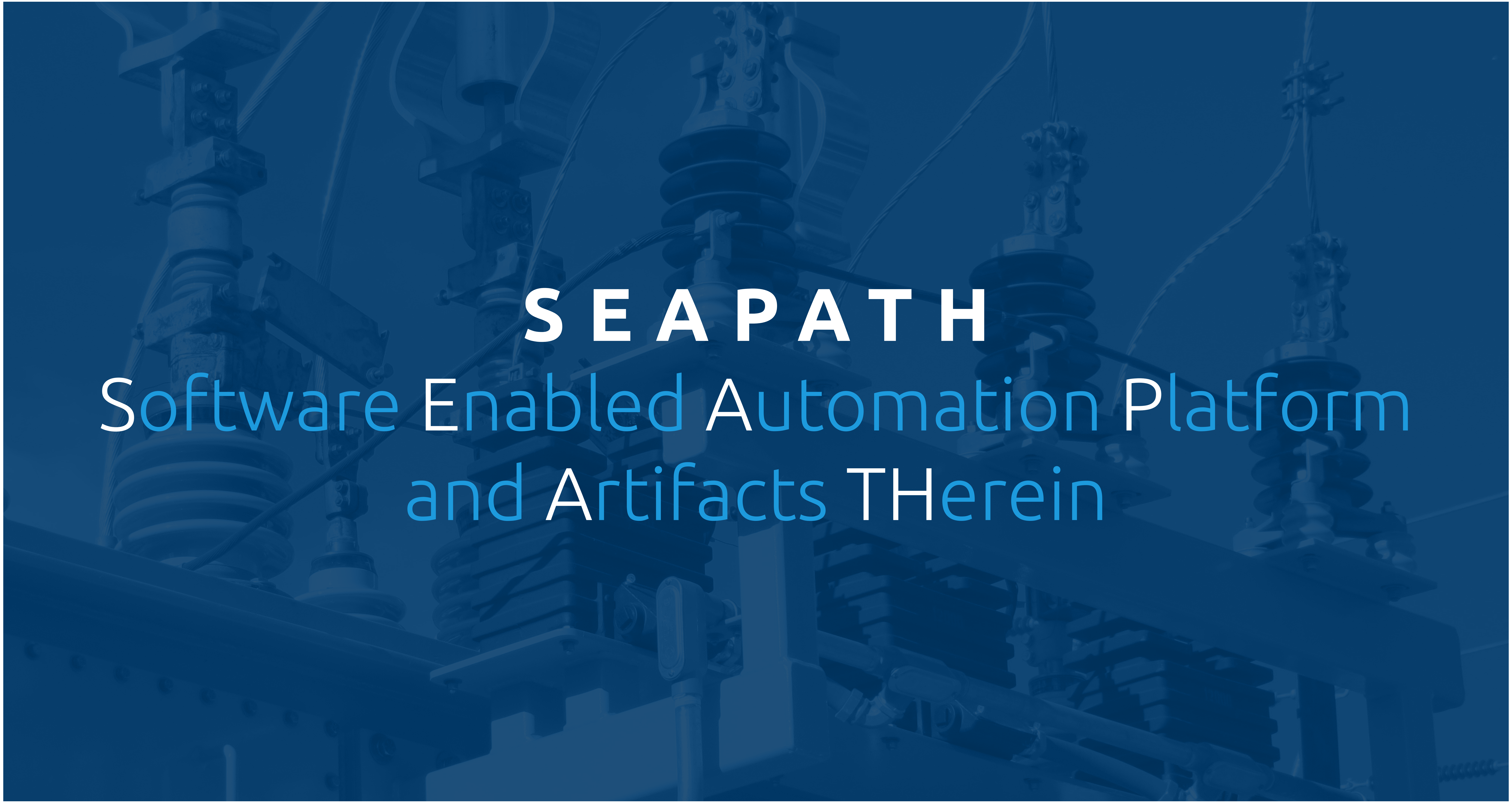
From where we start (digital substation)



Virtualization for new grid control architecture

LF ENERGY CoMPAS




SEAPATH
Software Enabled Automation Platform
and Artifacts THerein

The goal of Seapath

Develop

a **reference design** and **industrial grade** open source real-time platform

Host

virtualized **automation and protection** applications

Share

a platform between **multi-provider applications** (hardware agnostic)

Combine

performance and **safety**

Vision & technical concept

Technical requirements

- Virtualization
- High availability
- Software Defined Network
- Cybersecurity
- Minimal services / configurations
- Low network latency
- Real-time

High layer

Low layer

Existing solutions

Off-the-shelf solutions providing either

- HA & Virtualization platform
- Real-time platform
- Low-latency platform

But not a mix of that !

- Minimal firmware
- Highly configurable

The Yocto Project

yocto PROJECT

Collaborative Linux Foundation project.
Allows to:

Create custom Linux based systems from source code

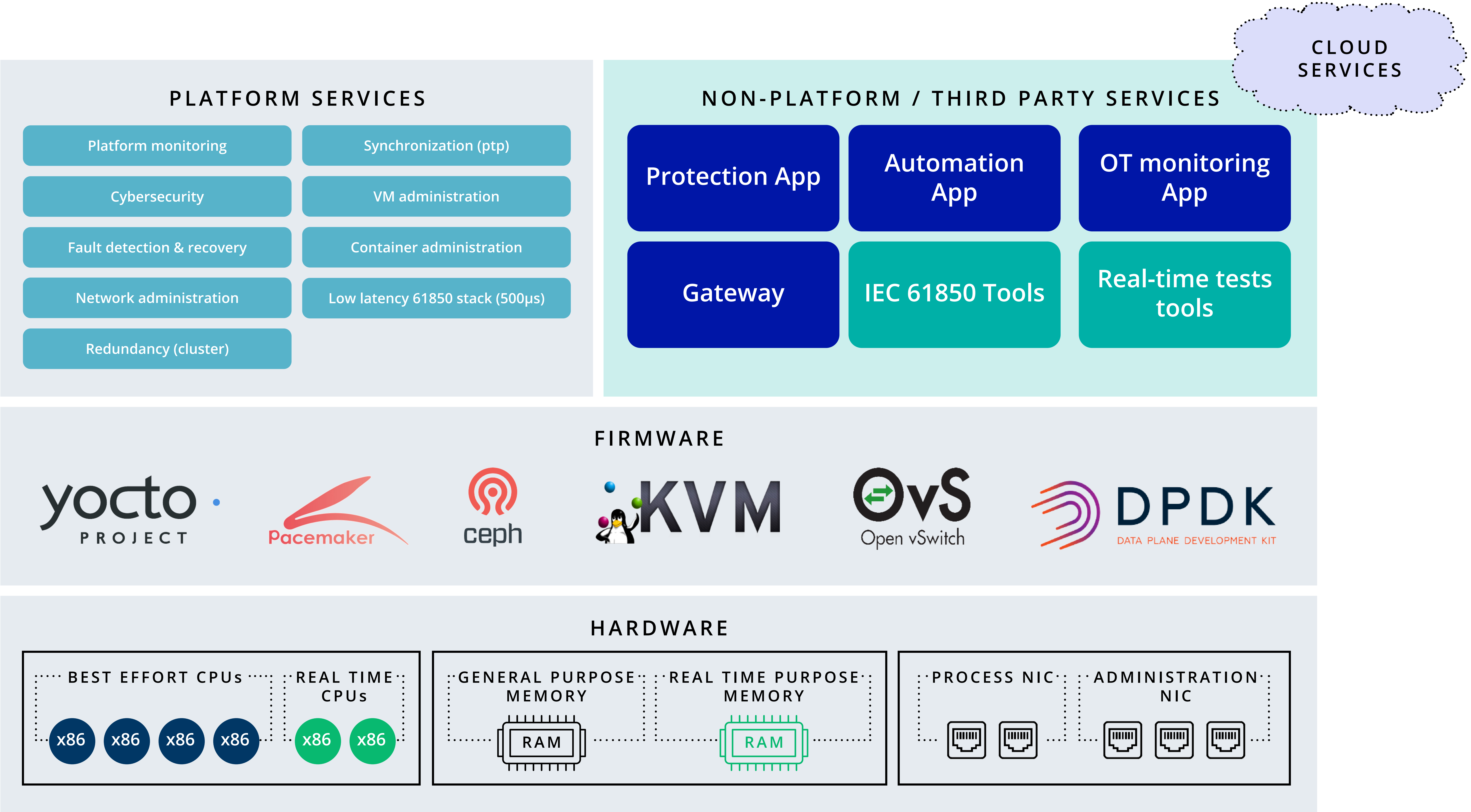
Be agnostic of the hardware architecture

Aggregate tons of Open Source components (including Virtualization and HA)

Configure, modify each component

Check / patch Common Vulnerabilities and Exposures (CVE)

Technical architecture and stack



Ensuring reliability

Continuous Integration

- **To speed-up adopting new technologies** in a critical infrastructure environment that is growing in complexity, **a shift-left is needed**.

- **Using containerization and virtualization**, combined with infrastructure-as-code enabling technologies (such as ansible) **will allow automated DTAP environments**.

- **Early testing** (fail early) in such an environment will help **to create a streamlined development process**.

- Such technology will **limit start-up cost for new innovations, and open up the industry to newcomers**.

SEAPATH CI building blocks

1

SEAPATH recipes (including docker and Virtual Machine) in github

2

Automated image build process including unit tests provided by the Yocto project

3

Automatic build pipeline and orgistration by Jenkins

4

Automated deployment and configuration by Ansible

5

Platform integrity tests using Cukinia

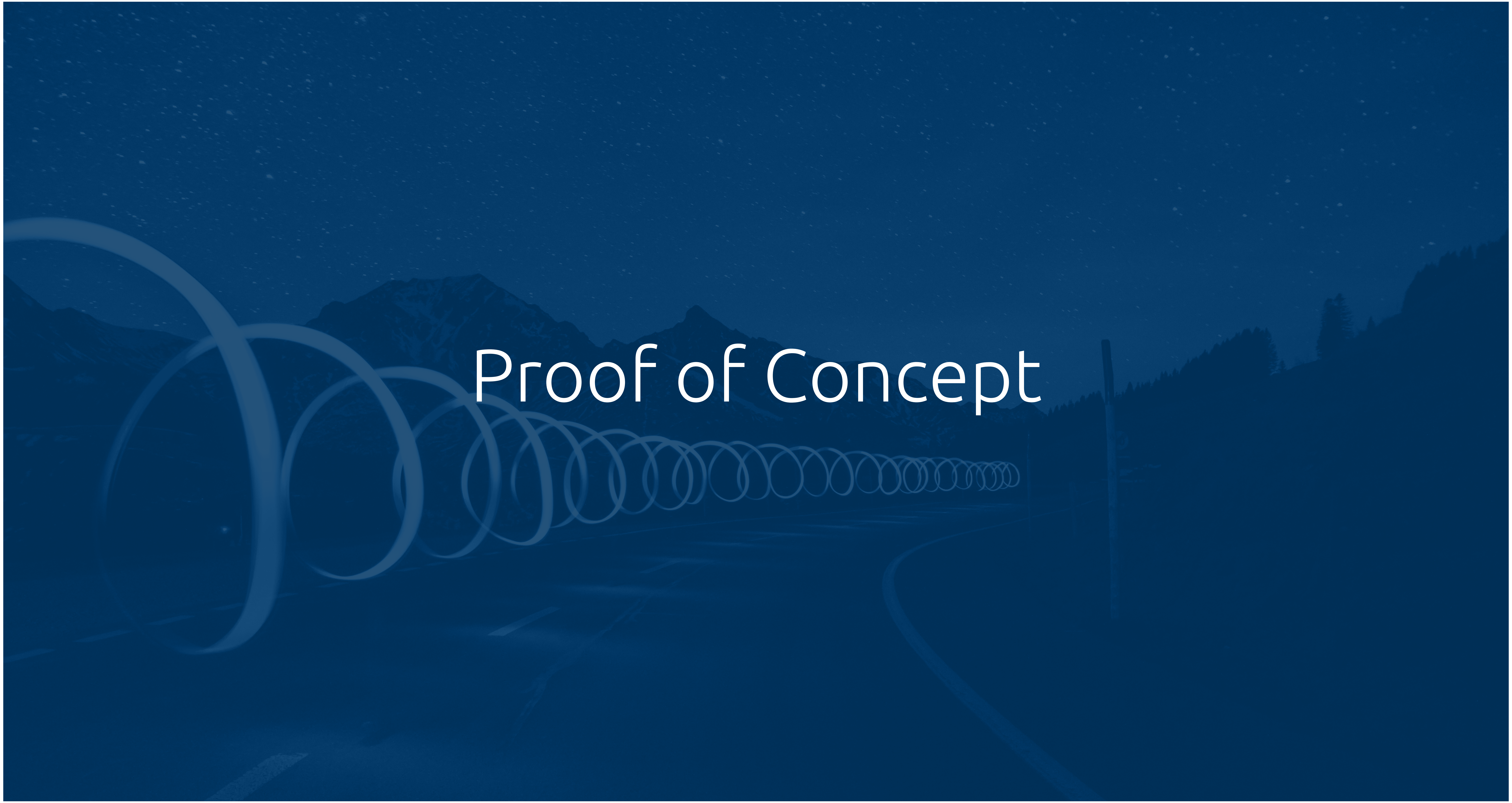
6

Integration testing of typical substation applications

7

Real-time test bench for evaluation of real-time requirements

… (interoperability testing, Site Acceptance Test, …)


Proof of Concept

Latency checking (cyclic test): Host

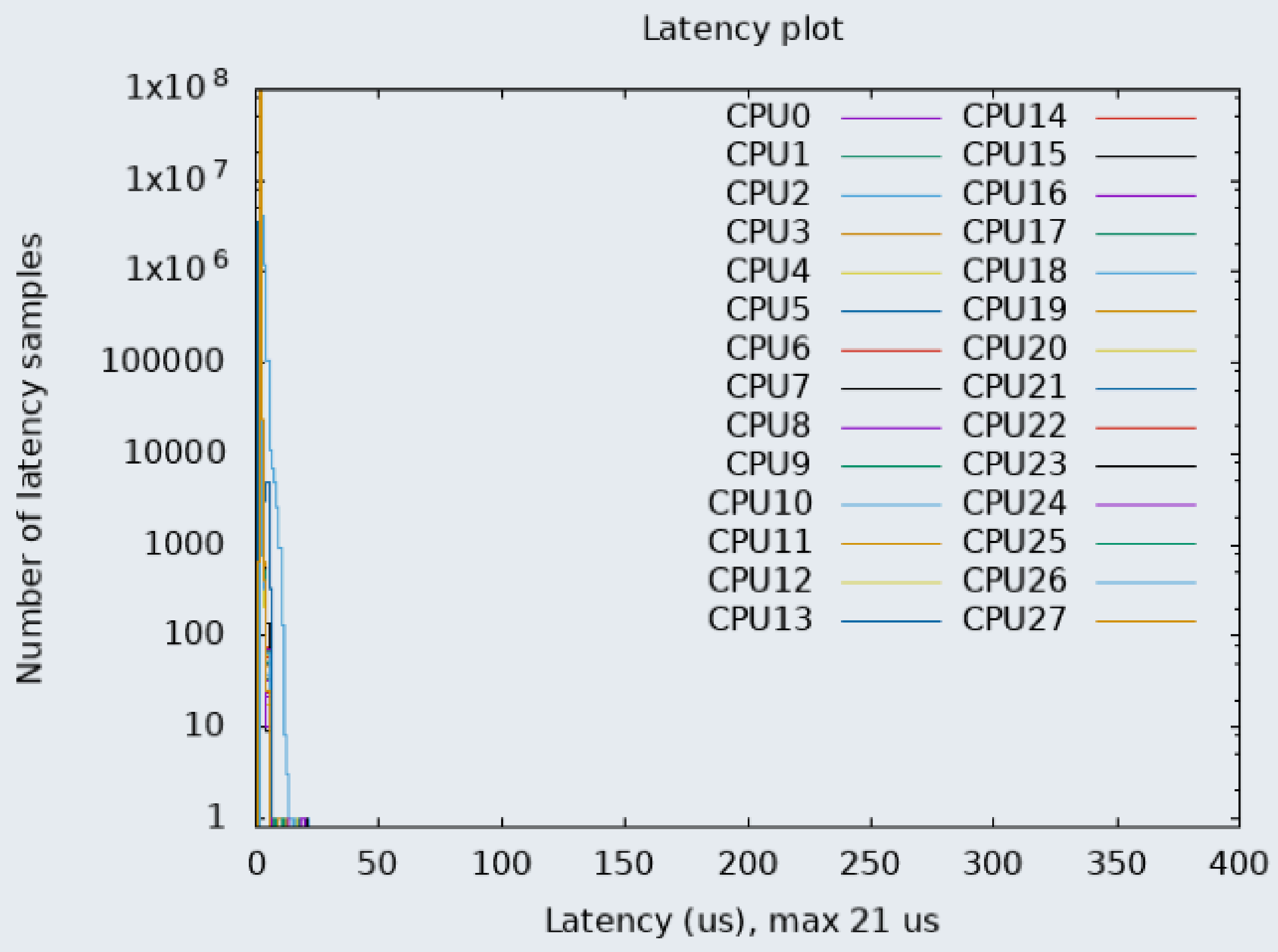
Configuration:

Operating system:

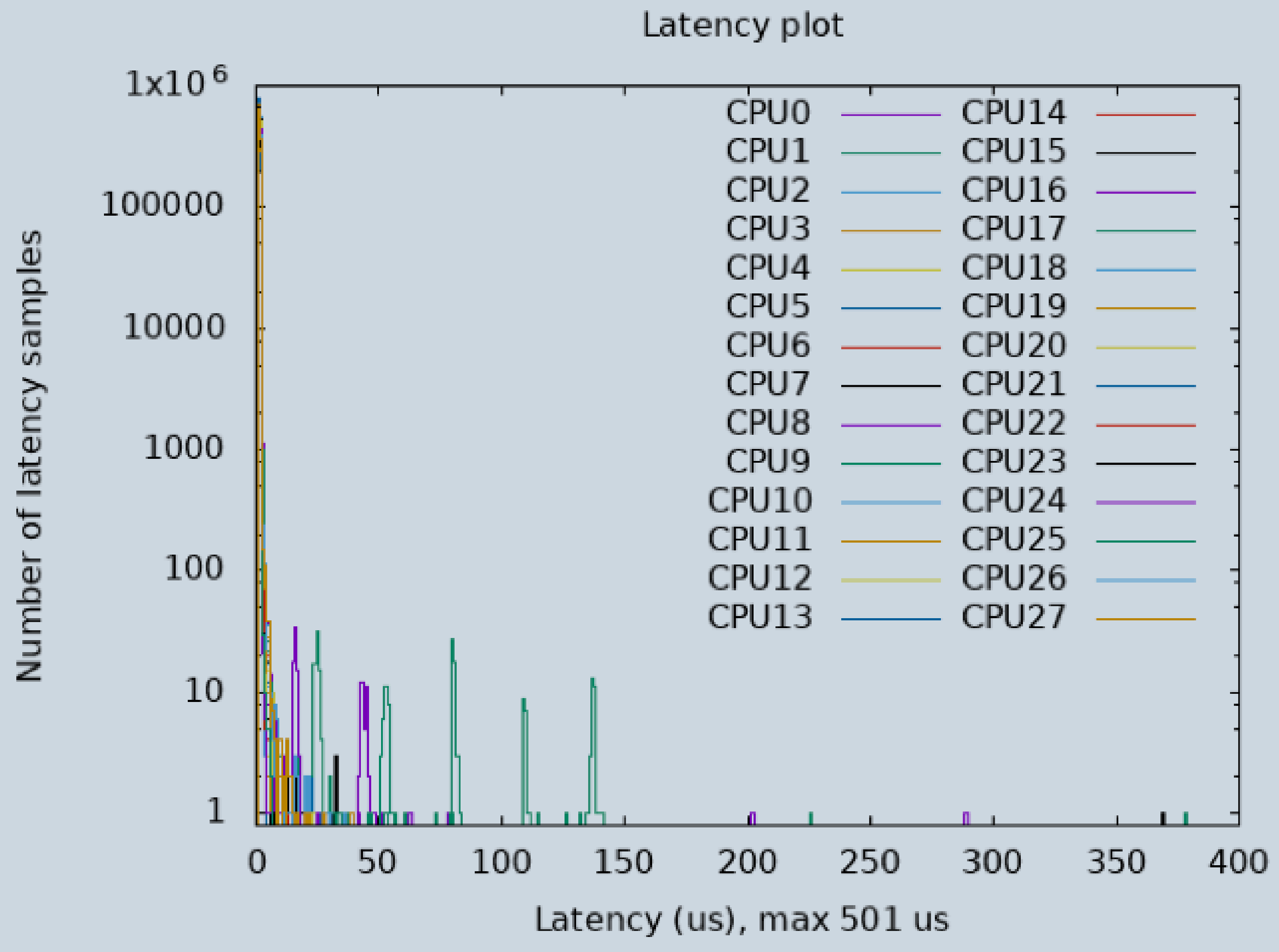
Image based on yocto including KVM, Pacemaker Corosync and Ceph, Kubernetes, OvS-DPDK, Docker.
Kernel: 4.19 (preempt-rt and non preempt-rt)

Hardware:

CPU: 14 Core E5-2680V4
Memory: 32GB DDR4
Circuit Board: ASMB-8231-00A1E



Preempt-rt



non Preempt-rt

Latency checking (cyclic test): Guest

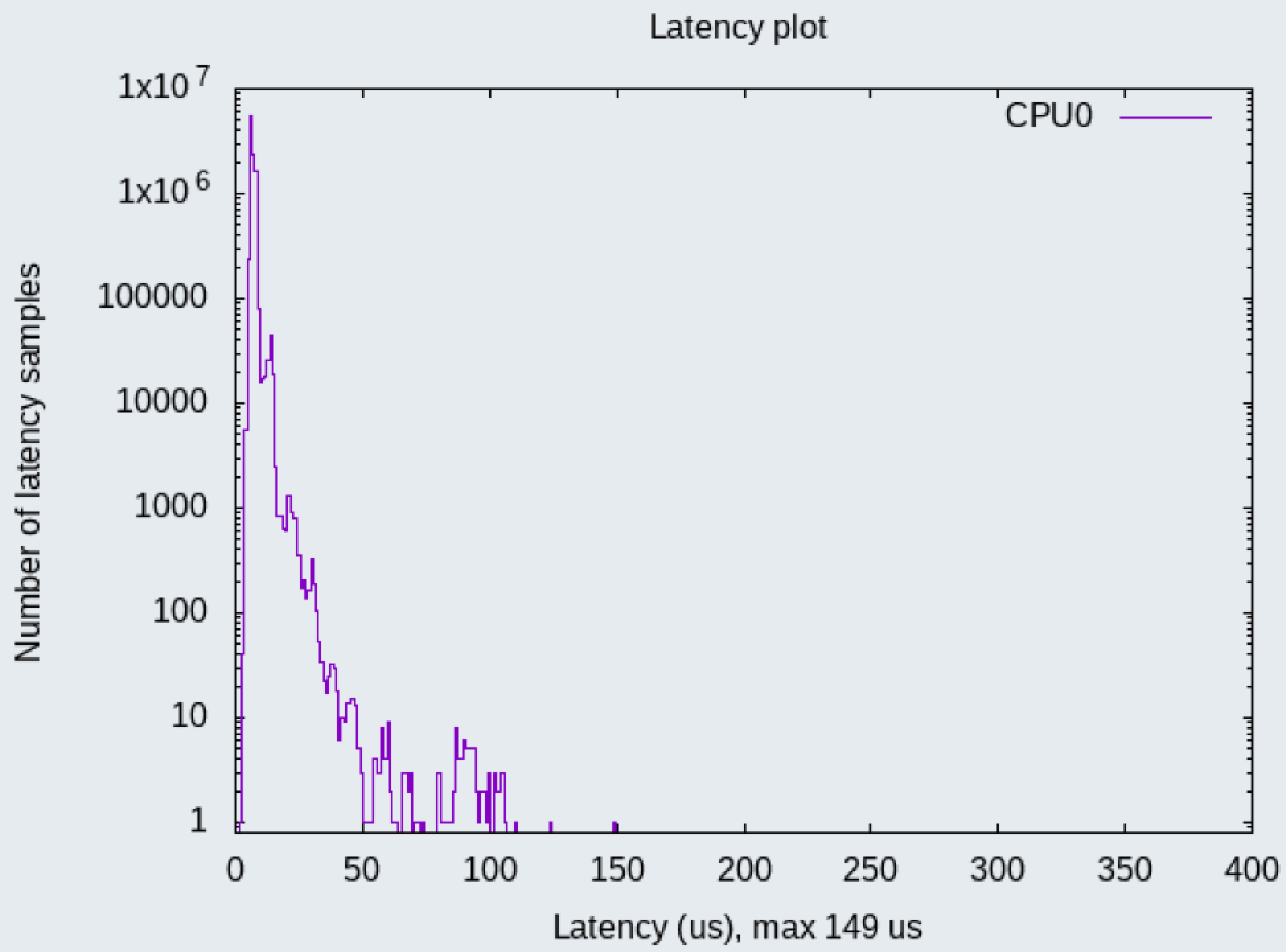
Configuration:

Host Operating system:

Host: see previous slide
Kernel : 4.19 preempt-rt

Guest:

Same as host without kvm, Ovs-DPDK
Kernel: 4.19 preempt-rt



Real-time testing SEAPATH

It will allow anyone to:

Ensure a specific set-up has the real-time characteristics suitable for its critical application in the substation.

Benchmark different hardware platforms to see if it can meet all the required performance criteria.

Understand the scale-ability potential of different setups.

Validate the real-time performance-impact of any configuration, or **changes** made during development and operations.

Real-time testbench

Required hardware

Measurement hardware:
PC with 2 NIC’s, 1 DPDK supported network card

Required software

MoonGen
https://github.com/emmericp/MoonGen

TestBench
https://github.com/robidev/moongen-rfc2544

Test applications
https://github.com/seapath/meta-seapath-tools

Output

Report of performance measurements, “inspired” by RFC2544

Example test report

RFC 2544 Test Report

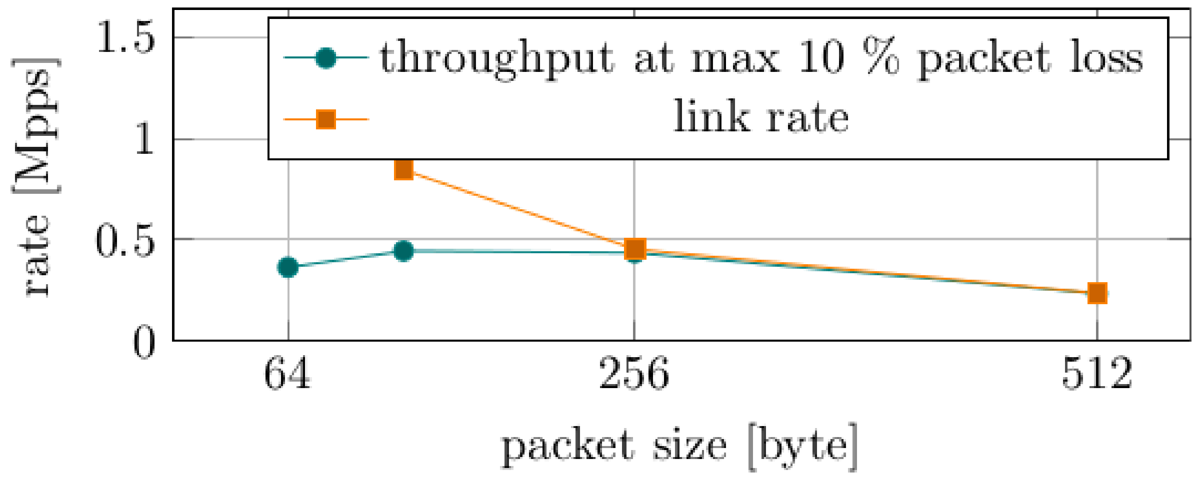
1 General Test Information

Device Under Test:	KERNEL
Operating System:	votp
Date:	2021-03-22

2 Throughput

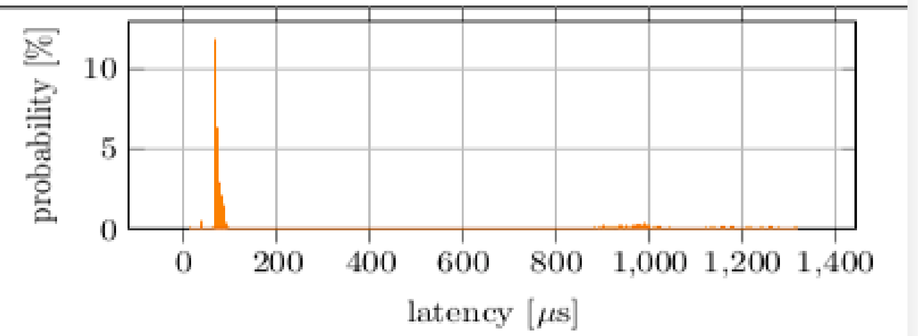
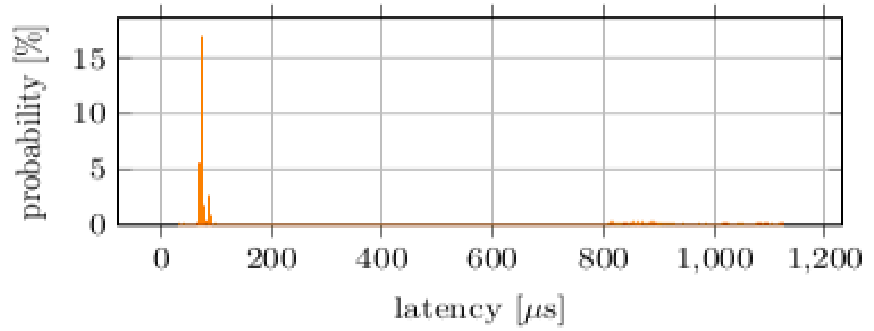
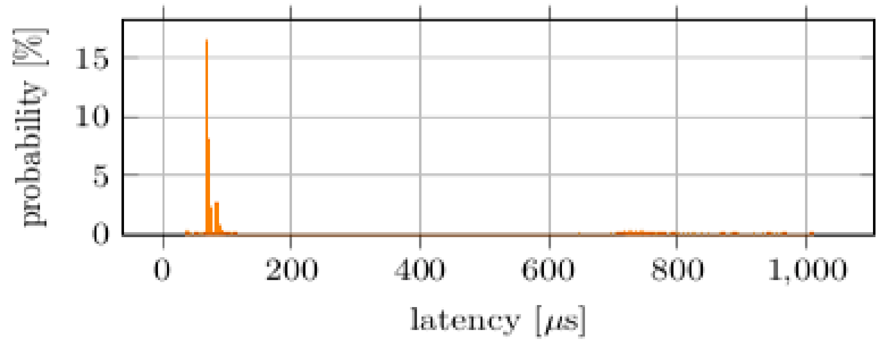
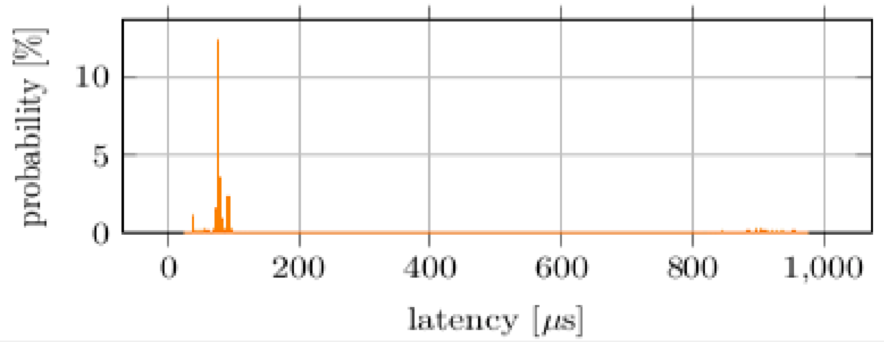
Test Duration:	1 s
Maximal Loss Rate:	10.000 %
Accuracy:	100 Mbps

Frame Size (bytes)	Iteration	Total Tx Frames	Total Rx Frames	Throughput (Mpps)	Throughput (Mbps)
64	1	363384	363384	0.363	244.194
128	1	444150	444150	0.444	525.874
256	1	435393	435393	0.435	961.348
512	1	233226	231432	0.233	992.610



3 Latency

Test Duration: 1 s

Frame Size (bytes)	Throughput (Mpps)	Latency Min (µs)	Latency Avg (µs)	Latency Max (µs)	
64	0.360	11712.0	193497.4	1314224.0	
128	0.440	31984.0	199184.2	1123120.0	
256	0.433	35024.0	187931.2	1009152.0	
512	0.233	25160.0	194260.6	978208.0	

Call to Arms

Desired contributions:

- We need end user feedback!
- End user applications
- Feedback regarding the platform's features (do we miss any?)
- Test bench validation, and checks for completeness

https://github.com/seapath/

Thank you for your attention

https://github.com/seapath/

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