STORAGE DEVELOPER CONFERENCE

SDC 23

BY Developers FOR Developers

Open Programmable Infrastructure Project Introduction

How we can together implement DPU/IPU Infrastructure across all Vendors

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Abstract

The Open Programmable Infrastructure (or OPI) is an open-source effort within the Linux Foundation to develop a standard API for utilizing SmartNICs, DPUs and IPUs, and other coprocessors or processing elements. It will allow users to provision and orchestrate all devices in the same way, thus allowing them to handle many different devices, implement new devices, and change or replace devices without learning a new command structure.   It will also allow manufacturers to create a standard API, deliver new or upgraded devices faster, and benefit from a large ecosystem. It makes learning curves for new devices shorter and implementation or software errors easier to find. It opens new markets for devices and eliminates concerns over one-of-a-kind implementations.

This session will explore the goals and progress that the OPI project has undertaken. DPUs have many different use cases implemented by many different vendors. Our goal is to define a common framework for all of these devices to meet those use cases: This includes Infrastructure/ workload isolation, Security, Network offload and acceleration, and Storage offload and acceleration. Over the last year since OPI joined the Linux foundation we have welcomed 14 member companies to our project spanning the landscape from vendors, to integrators, to test infrastructure vendors, end users, as well as operating system and ISV vendors.

We have sought to create common provisioning and lifecycle management frameworks, defined APIs for the management of these devices to meet the most common use cases we have researched from end users and developed a developer platform and lab to test and explore these common frameworks.

Come listen to industry experts as we explore the DPU/IPU ecosystem and the OPI project's progress toward a common set of frameworks, and how these assist end users with ease of deployment, lowers the total cost of development and ownership, and thus provides for broader adoption of this new class of devices.

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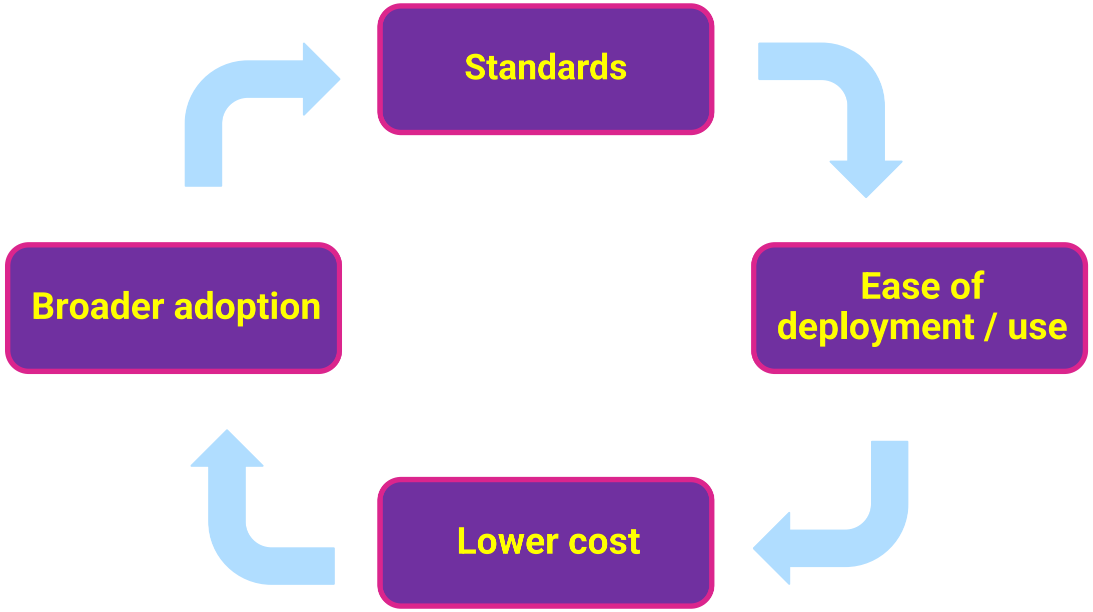
OPEN PROGRAMMABLE INFRASTRUCTURE PROJECT

opiproject.org

Why should you care about OPI for DPU/IPU?

- With Moore's law slowing down, ever increasing demands for compute, and exponential growth in data traffic…
  - We need heterogeneous compute
  - We need composability.
  - Workload specific resources per host
- Hyperscalers deploy DPU/IPUs w/ non-standard frameworks
  - We want Standard APIs for Edge, Telco, Enterprise
- Hardware needs to be abstracted
  - solution providers can focus on deploying services
  - Ease of development & deployment
- Need to drive efficiency in large computing environments > TCO savings
- Standards and common APIs needed to drive broader adoption of DPU/IPUs
  - Flywheel effect



OPI Premier Members

arm

DELL Technologies

f5

intel

KEYSIGHT TECHNOLOGIES

MARVELL

NVIDIA

Red Hat

Tencent 腾讯

ZTE

OPI General Members

DreamBig SEMICONDUCTOR

FUJITSU

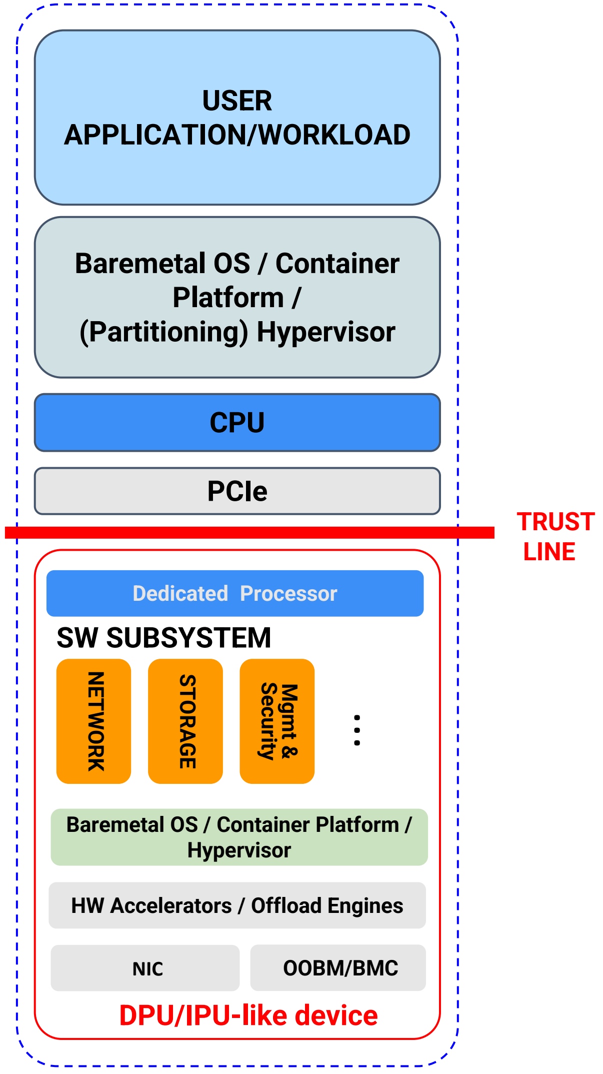
Hewlett Packard Enterprise

SolidRun

Unifabrix

Project Goals

- Create community-driven standards-based open ecosystem for DPU/IPU-like technologies
- Create vendor agnostic framework and architecture for DPU/IPU-based software stacks
- Reuse existing or define a set of new common APIs for DPU/IPU-like technologies when required
- Provide implementation examples to validate the architectures/APIs



USER APPLICATION/WORKLOAD

Baremetal OS / Container Platform / (Partitioning) Hypervisor

CPU

PCIe

TRUST LINE

Dedicated Processor

SW SUBSYSTEM

NETWORK

STORAGE

Mgmt & Security

Baremetal OS / Container Platform / Hypervisor

HW Accelerators / Offload Engines

NIC

OOBM/BMC

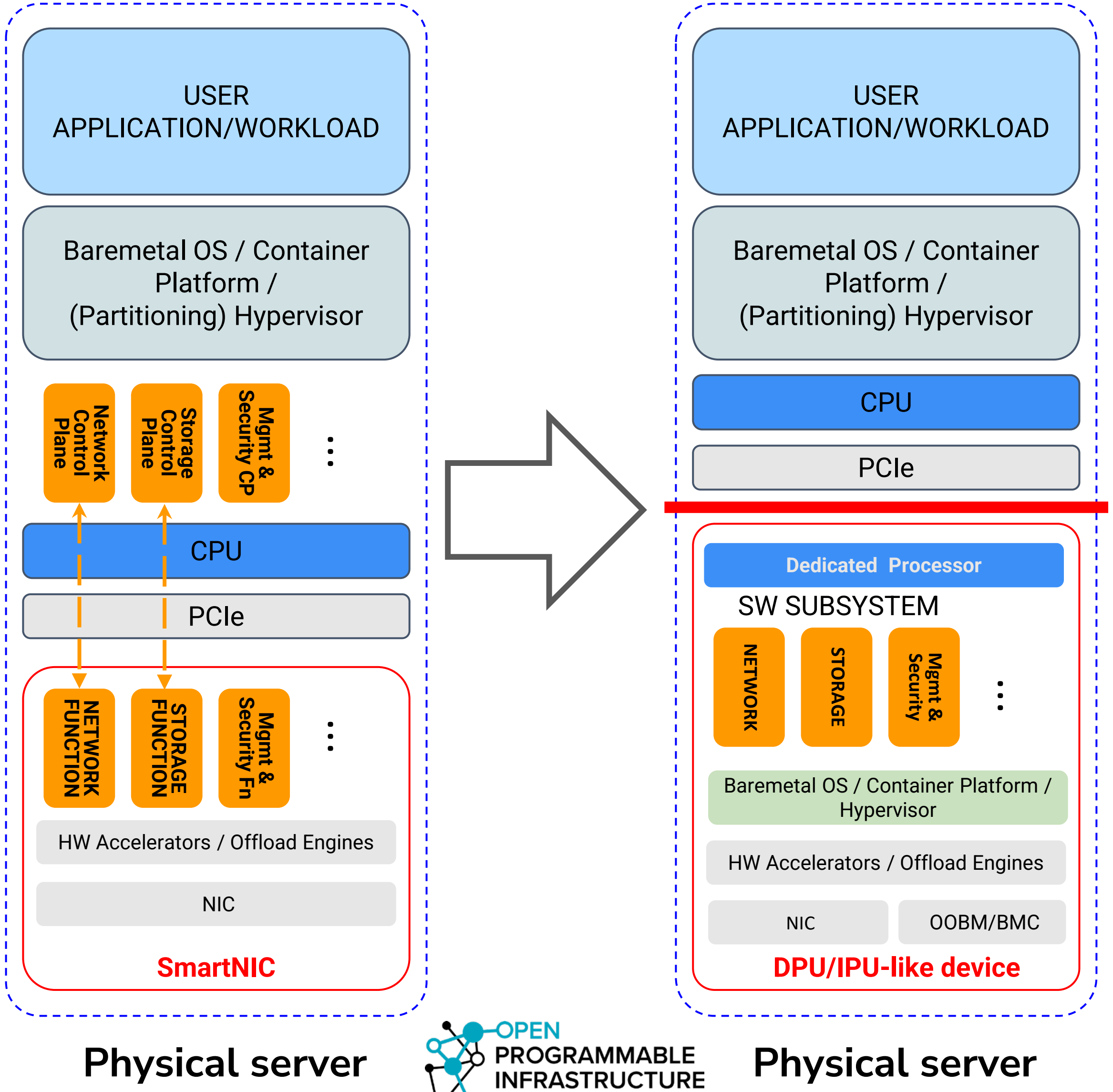
DPU/IPU-like device

Physical server

New chapter in modern system architecture

Traditional SmartNIC model

- Computer is CPU + SmartNIC as peripheral that is fully controlled by the CPU
- CPU + domain-specific HW acceleration
- Static device function



USER APPLICATION/WORKLOAD
Baremetal OS / Container Platform / (Partitioning) Hypervisor
Network Control Plane
Storage Control Plane
Mgmt & Security CP
⋮
CPU
PCIe
NETWORK FUNCTION
STORAGE FUNCTION
Mgmt & Security Fn
⋮
HW Accelerators / Offload Engines
NIC
SmartNIC
Physical server
USER APPLICATION/WORKLOAD
Baremetal OS / Container Platform / (Partitioning) Hypervisor
CPU
PCIe
TRUST LINE
Dedicated Processor
SW SUBSYSTEM
NETWORK
STORAGE
Mgmt & Security
⋮
Baremetal OS / Container Platform / Hypervisor
HW Accelerators / Offload Engines
NIC
OOBM/BMC
DPU/IPU-like device
Physical server

DPU/IPU model

- NIC & HW accelerators move to DPU/IPU-like device with its own CPU
- Software defined device function
- Computer is an aggregation of independently intelligent subsystems

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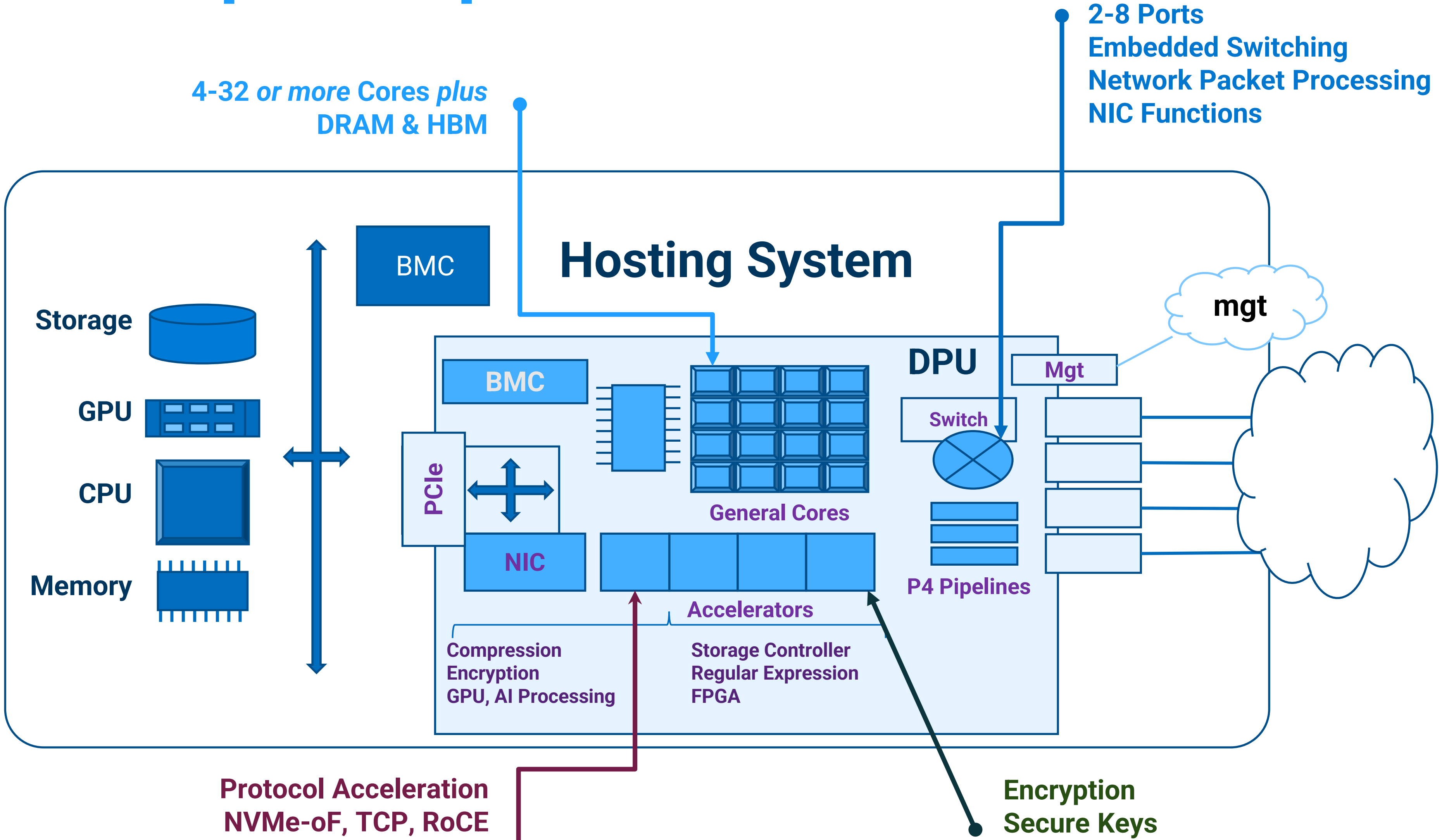
DPU Example Expanded



4-32 *or more* Cores *plus*
DRAM & HBM

2-8 Ports
Embedded Switching
Network Packet Processing
NIC Functions

Compression
Encryption
GPU, AI Processing

Storage Controller
Regular Expression
FPGA

Protocol Acceleration
NVMe-oF, TCP, RoCE
P4 Pipeline
Inline micro-processors

Encryption
Secure Keys
RegEx
Hashing

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DPU / IPU Use cases

Infrastructure workload isolation

Control Plane offload

Host Lifecycle and Provisioning

Host Offloads

Security

Security domains (Host and DPU/IPU)

FW, intrusion detection and prevention

Networking offload and acceleration

Virtual switch offload, IPSEC , TLS

Storage offload and acceleration

nvme/tcp offload, compression, and dedupe acceleration

Applies Across:

Edge

Enterprise

Cloud

Telco Core & Edge

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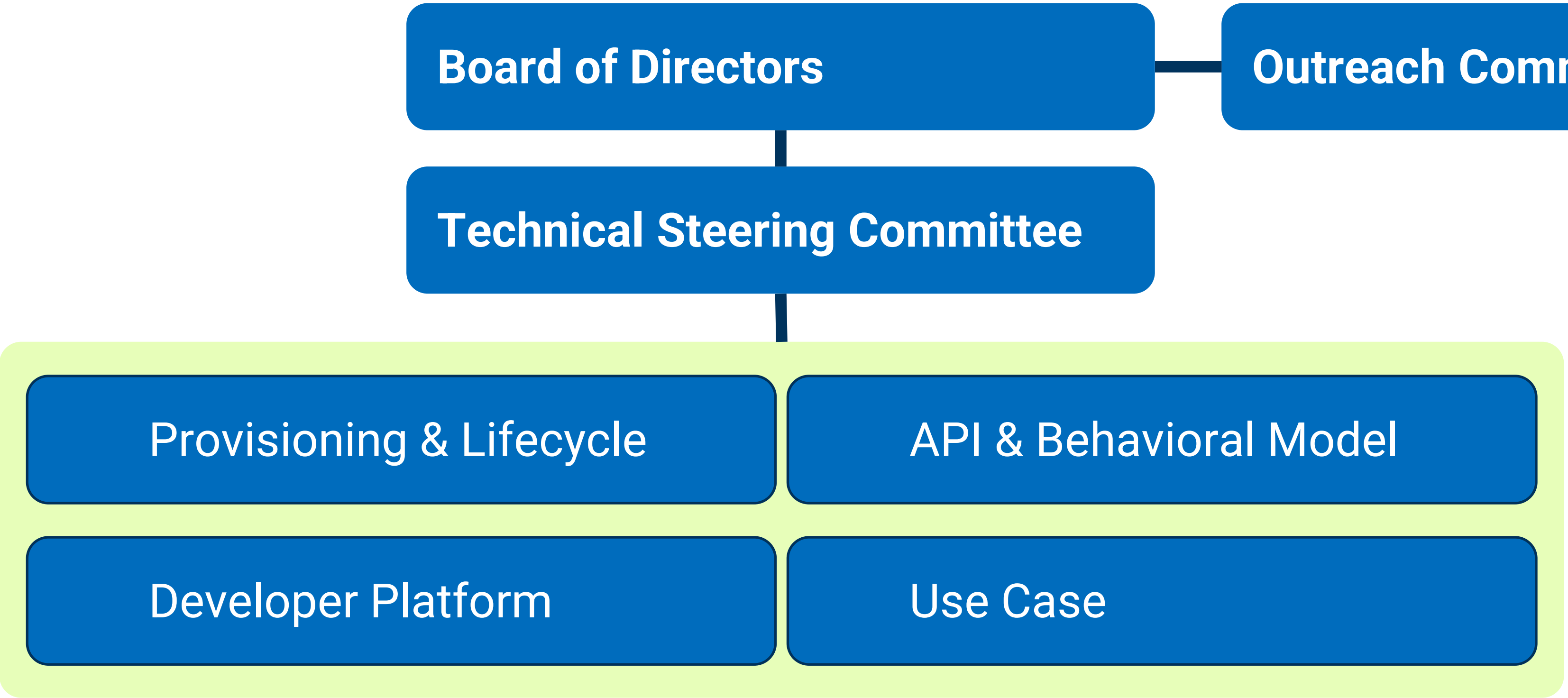
OPI Organizational Structure



OPI Technical Deliverables

- Open-Source Projects
- Specifications/Standards
- Reference Platforms
- Test Suites & Cases
- POC/Prototypes

Scope and Goals of Working Groups

Provisioning & Lifecycle

- Discovery & Provisioning
- Inventory
- Boot sequencing
- Lifecycle & Updates
- Monitoring & Telemetry

API & Behavioral Model

- Object models
- Host & Management facing APIs
- Taxonomy for Services (Networking, Storage, Security)
- Re-use industry standard APIs (OpenConfig, VPP, FRR, etc)
- Reference Orchestration Client

Developer Platform

- Independent testing Lab
- Virtual & Hardware POCs
- Simulation Environment
- CI/CD

Use Case

- Areas of high interest
    - Storage, Security, Networking, AI/ML
- Use cases gathered from end users
    - OVS/OVN
    - NVMe/PCIe to NVMe/TCP bridge
    - Basic Firewall.

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OPI Repositories

opi
OPI Main Repository

opi-prov-life
Provisioning, Lifecycle and Platform Management

- Discovery & Provisioning
- Inventory
- Boot sequencing
- Lifecycle & Updates
- Monitoring & Telemetry (OTEL)

opi-poc
Developer Platform and PoC Work

- Integration Platform Definition
- Software Networking PoC via p4-ebpf
- spdk based storage device PoC

opi-api
Open Programmable Infrastructure API and Behavioral Model

Create a Taxonomy for services:

- Networking
- Security
- Storage
- Gateway
- Telemetry
- AI/ML

SPDK

- **opi-spdk-bridge**
  - OPI Storage gRPC to SPDK json-rcp bridge POC
- **opi-nvidia-bridge**
  - OPI gRPC to Nvidia bridge third party repo
- **opi-marvell-bridge**
  - OPI gRPC to Marvell bridge third party repo
- **opi-spdk-bridge**
  - OPI storage gRPC to SPDK json-rpc bridge
- **spdk-csi** (Forked from spdk/spdk-csi) & spdk
  - CSI driver to bring SPDK to Kubernetes storage through NVMe-oF or iSCSI. Supports dynamic volume provisioning and enables Pods to use SPDK storage transparently.

godpu A Container Storage Interface (CSI) library, client, and other helpful utilities created with Go for OPI
pydpu Python library and cli to communicate with DPUs and IPUs

sessionOffload (Forked from att/sessionOffload)
Open API for IP Applications to Offload TCP/UDP Session Packet Processing to Hardware

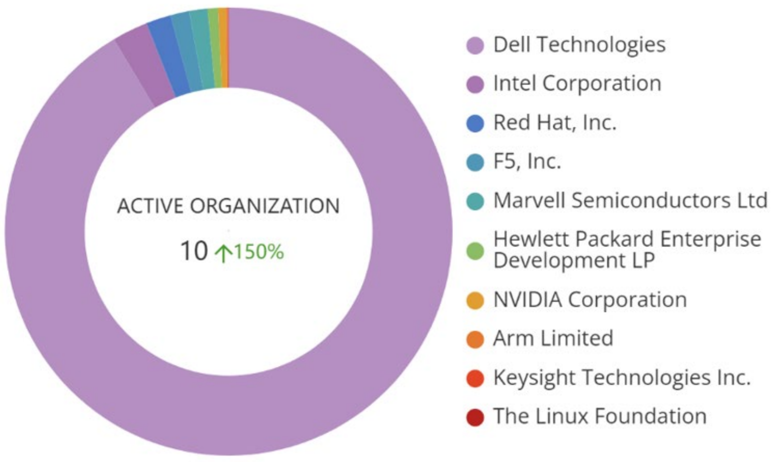
opi-strongswan-bridge
OPI IPSEC gRPC to strongSwan vici API bridge

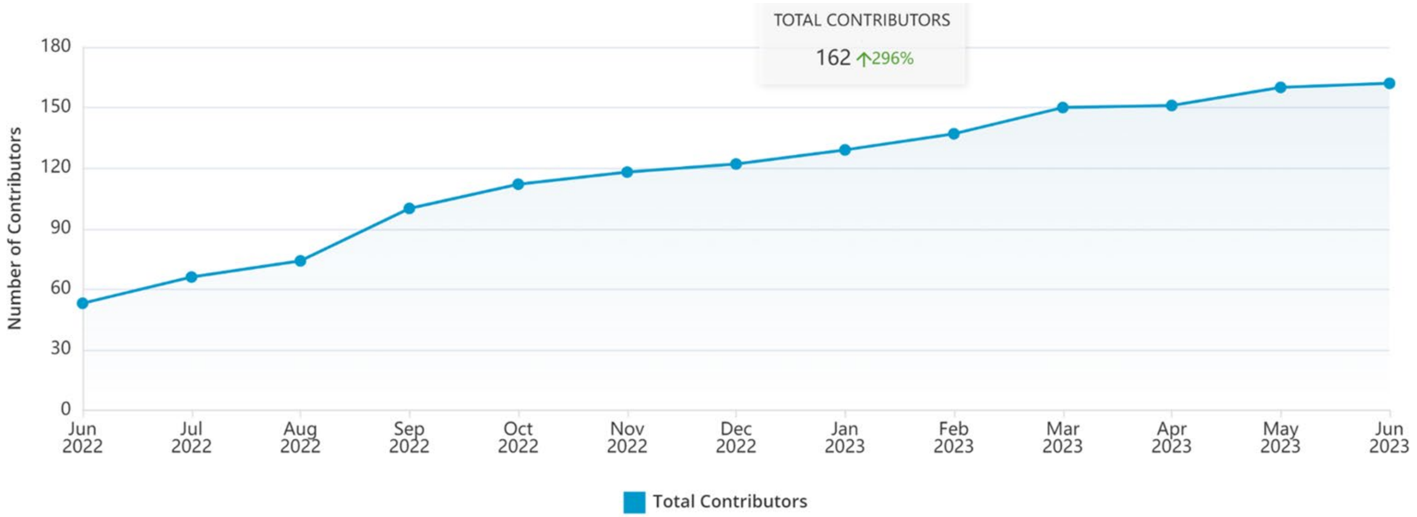
opi-smbios-bridge
OPI gRPC to SMBIOS bridge for inventory
smbios-validation-tool (Forked from google/smbios-validation-tool)
sztp & sztpd
Secure Zero Touch Provisioning (sZTP) in OPI

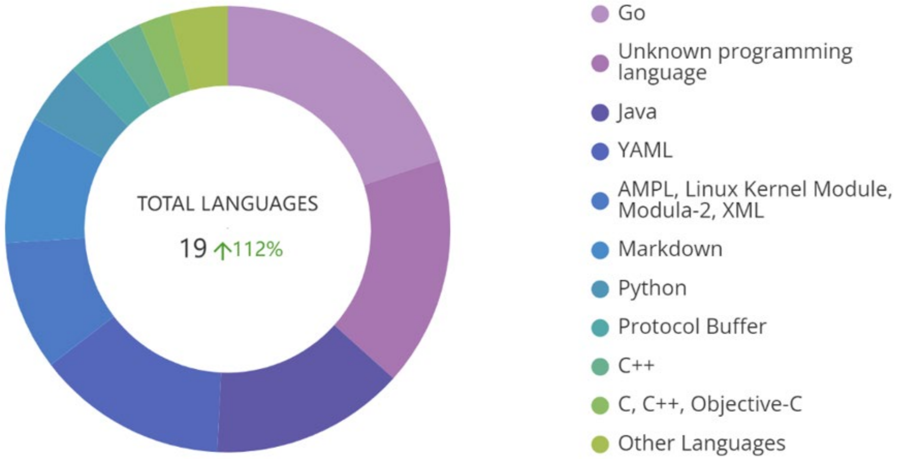
otel
Common DPU Telemetry definition

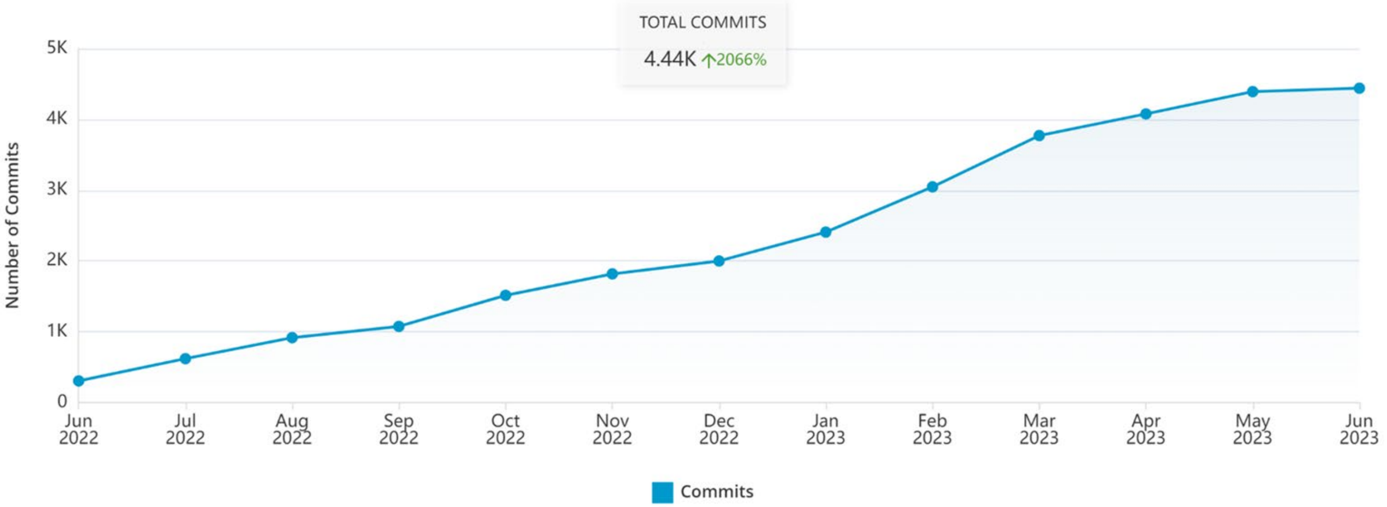
opiproject.org
OPI Hugo Website
artwork
OPI related logos and artwork.

Momentum and Progress









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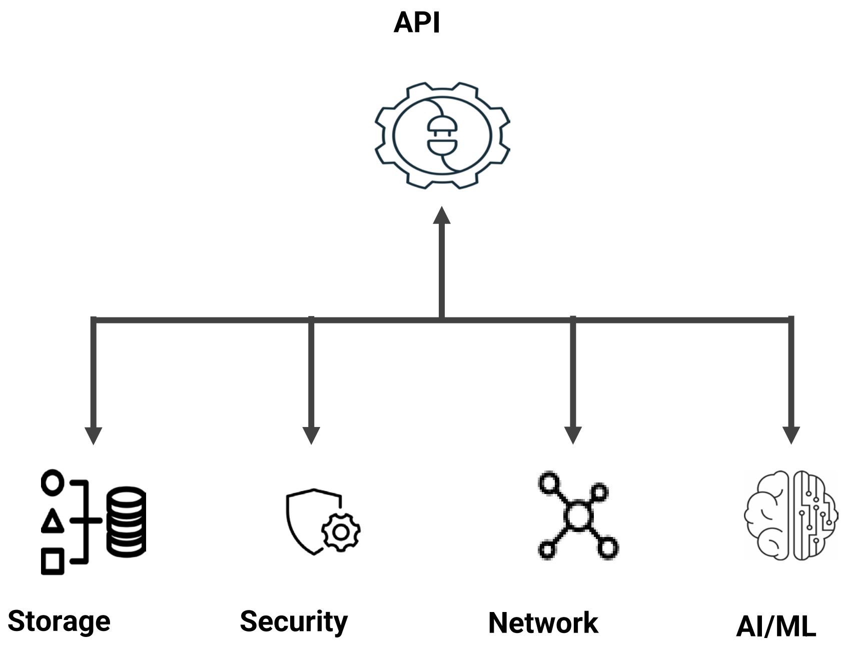
API Objectives

Create a Multi-Vendor Open API definition for

Storage Services
Network Services
Security Services
AI/ML
Telemetry
System and Lifecycle Management



Provide Industry standard interface for DPU/IPU

Consistent, standardized, protobuf based GRPC APIs for network and storage objects
Various orchestration systems could integrate with the APIs once for various DPU/IPU vendors
DPU/IPU vendors would write the shim/translation to underlying vendor specific SDK

API Goals

Target use cases

Data center: On-prem cloud, public-cloud, 5G cloud
K8s clusters
Physical/Virtual appliance acceleration

Initially focus on Networking and Storage Interfaces for DPU/IPU

Multi-Tenant Shared Cloud
EVPN Gateway
IPSec (strongSwan)
Storage Initiator/Target

Provide open source prototype/reference implementation to the APIs

API Mechanism

gRPC for configuration/control interface through API Gateway

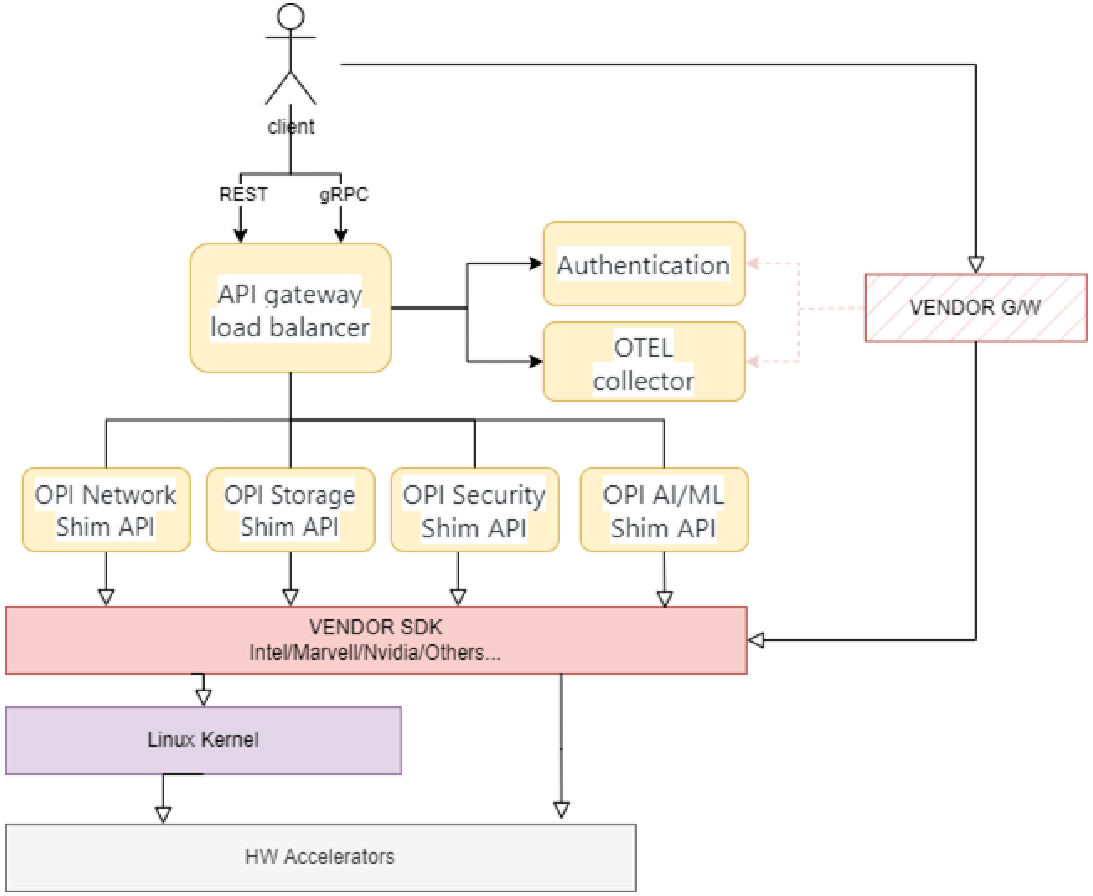
Direct delivery of gRPC messages to appropriate shim layer

gRPC to REST translation

Support gNMI and gNOI

Expose VF/PF for data consumption

Networking	Multi-tenant public cloud EVPN based telco cloud K8s based on-prem deployment
Storage	NVMe Initiator/Target based storage virtualization
Security	Strongswan based IPSec implementation



Progress: Storage API

v1alpha API definition for storage solution

frontend (host facing), middle-end (services for volumes), and backend (target specific) APIs

Reference implementation ready

To map the OPI APIs to SPDK code running on the DPU/IPU

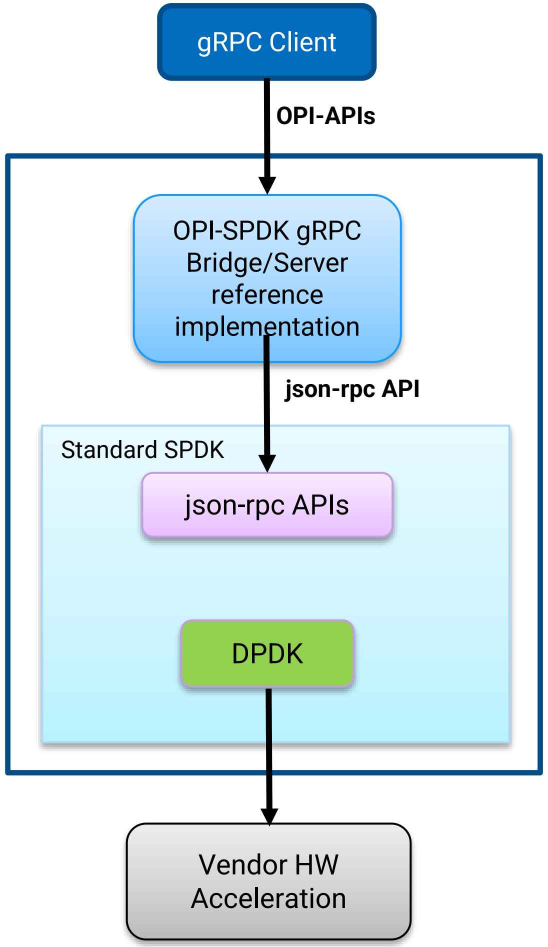
OPI SPDK Bridge https://github.com/opiproject/opi-spdk-bridge

Vendor support

Open source bridge code for AMD, Intel, Marvell, and Nvidia DPU/IPUs

CI/CD Integration

Continuous testing/validation against the reference implementation



Networking API

Create a common API framework and extensions for

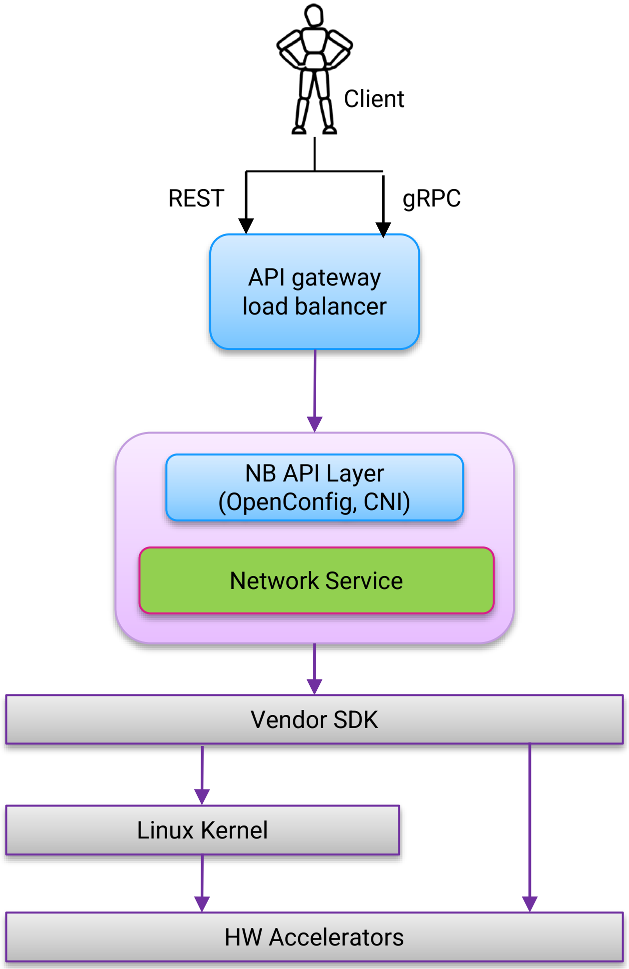
- Cloud
- Telco
- K8s

Support network service capabilities

OVS, VPP, SONiC, …

Leverage existing API models

OVS, OpenConfig, CNI, …



Progress: Network API

v1alpha API definition for cloud

Multi-tenant public cloud: https://github.com/opiproject/opi-api/tree/main/network/cloud/

EVPN based telco-cloud use cases: https://github.com/opiproject/opi-api/tree/main/network/telco

IPSec on DPU/IPUs: https://github.com/opiproject/opi-api/tree/main/security

Reference implementations

Proposals to leverage open source to build reference implementations

IPSec with strongSwan https://github.com/opiproject/opi-strongswan-bridge

Vendor support

Cloud APIs: AMD

Telco Cloud APIs: Intel

IPsec Security APIs: Intel, Nvidia

CI/CD Integration

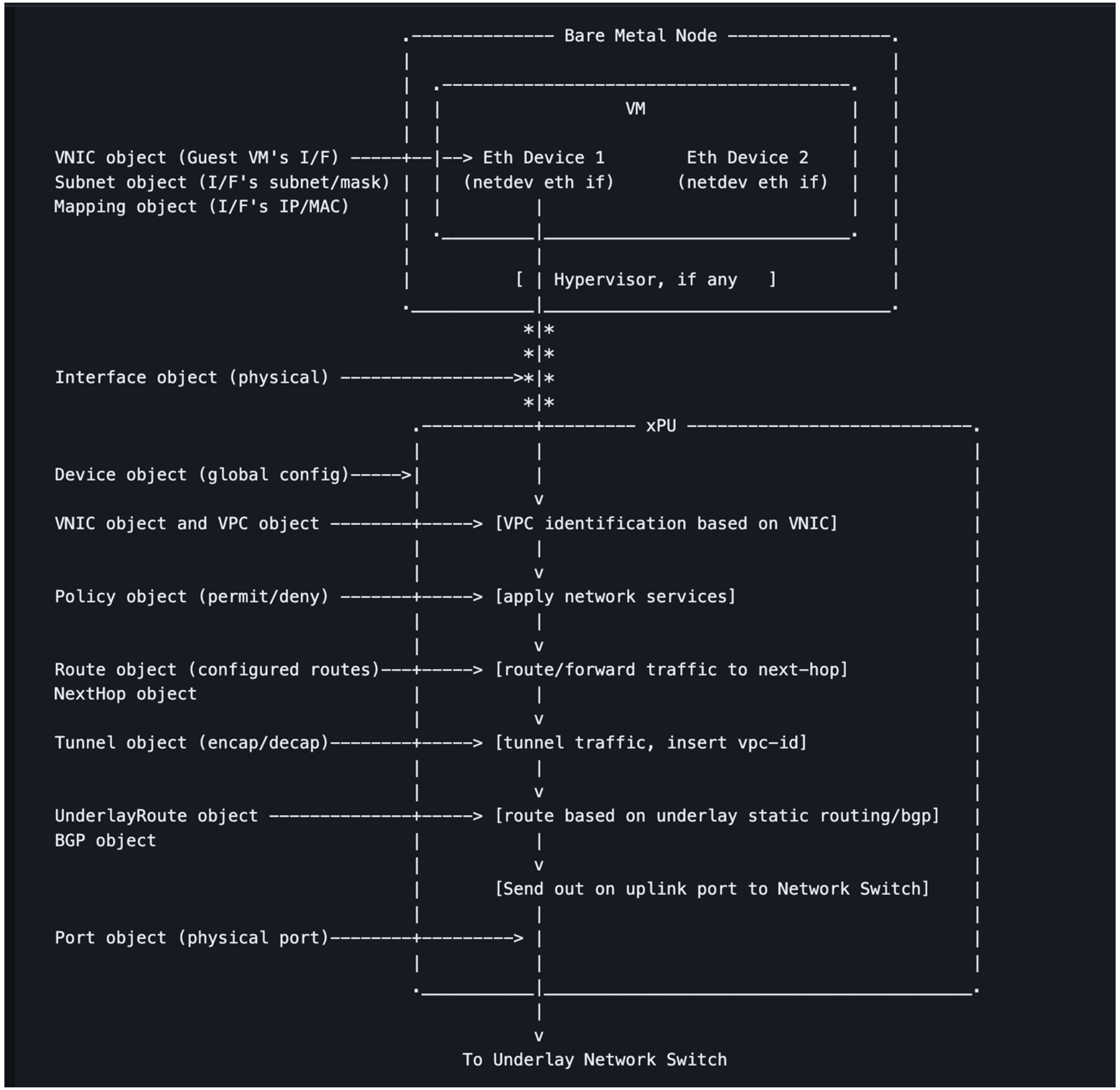
Continuous testing/validation on the API definition

OPI Networking API – Multi-tenant Public Cloud

APIs for implementing multi-tenant VPC (virtual private cloud)

- Tenant (VPC)
- Subnets/Networks
- Mapping (Endpoints)
- Routes
- Network Security Policies
- VPC Peering

Looking to making a reference implementation



```
                                  .-------------- Bare Metal Node ----------------.
                                  |                                               |
                                  |  .----------------------------------------.   |
                                  |  |                  VM                    |   |
                                  |  |                                        |   |
VNIC object (Guest VM's I/F) -----+--|--> Eth Device 1        Eth Device 2    |   |
Subnet object (I/F's subnet/mask) |  |  (netdev eth if)      (netdev eth if)  |   |
Mapping object (I/F's IP/MAC)     |  |         |                              |   |
                                  |  ._________|______________________________.   |
                                  |            |                                  |
                                  |          [ | Hypervisor, if any   ]           |
                                  .____________|__________________________________.
                                              *|*
                                              *|*
Interface object (physical) ----------------->*|*
                                              *|*
                                   .-----------+--------- xPU ----------------------------.
                                   |           |                                          |
Device object (global config)----->|           |                                          |
                                   |           v                                          |
VNIC object and VPC object --------+-----> [VPC identification based on VNIC]             |
                                   |           |                                          |
                                   |           v                                          |
Policy object (permit/deny) -------+-----> [apply network services]                       |
                                   |           |                                          |
                                   |           v                                          |
Route object (configured routes)---+-----> [route/forward traffic to next-hop]            |
NextHop object                     |           |                                          |
                                   |           v                                          |
Tunnel object (encap/decap)--------+-----> [tunnel traffic, insert vpc-id]                |
                                   |           |                                          |
                                   |           v                                          |
UnderlayRoute object --------------+-----> [route based on underlay static routing/bgp]   |
BGP object                         |           |                                          |
                                   |           v                                          |
                                   |       [Send out on uplink port to Network Switch]    |
                                   |           |                                          |
Port object (physical port)--------+---------> |                                          |
                                   |           |                                          |
                                   .___________|__________________________________________.
                                               |
                                               v
                                        To Underlay Network Switch
```

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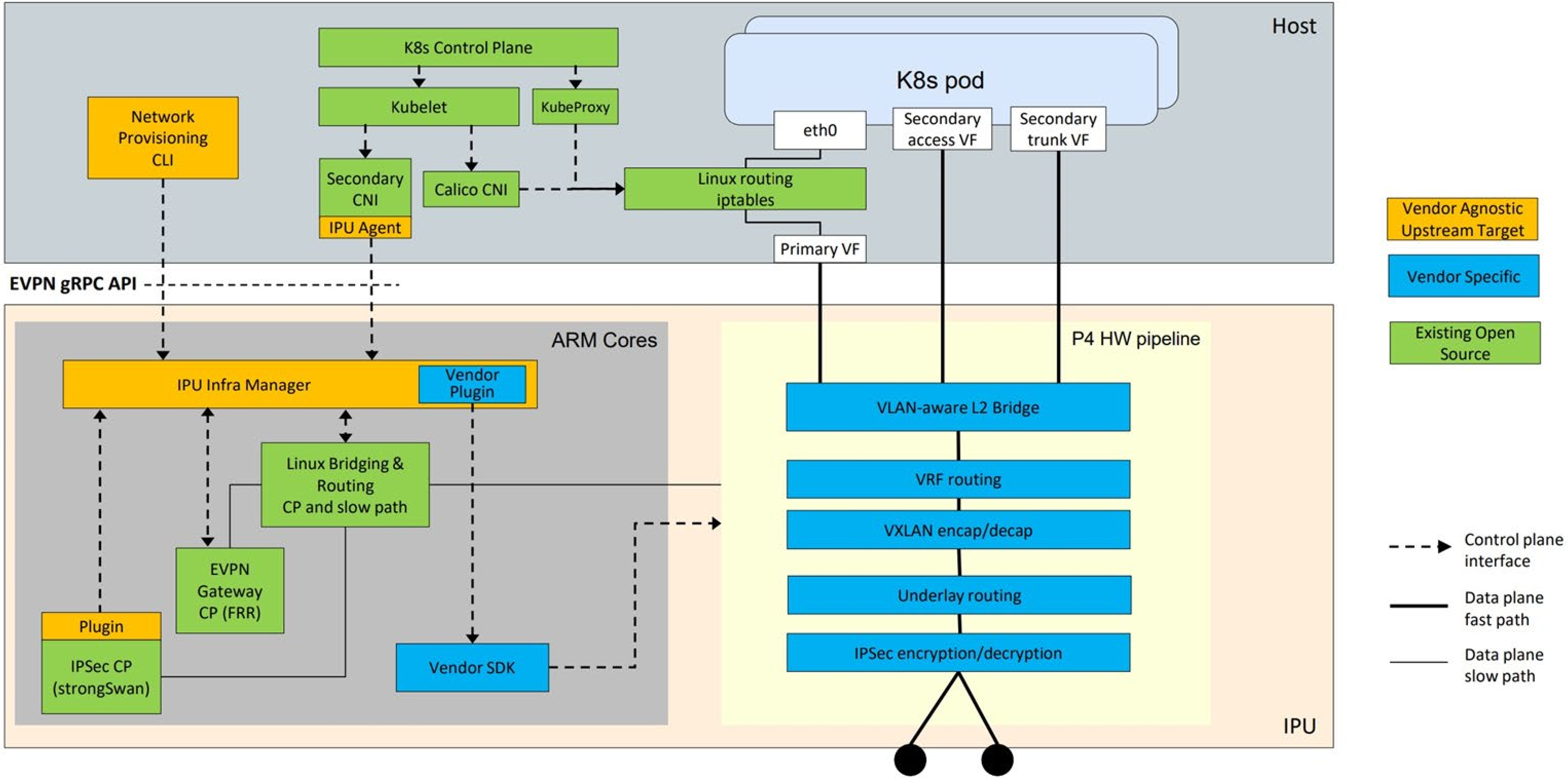
OPI Networking API – EVPN Gateway



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Demos

- ## Networking Cloud Demo
  - Video recording
  - API protocol buffers
  - clients https://github.com/opiproject/pydpu and https://github.com/opiproject/godpu

- ## IPSec Demo
  - Video recording
  - API protocol buffers
  - clients https://github.com/opiproject/pydpu and https://github.com/opiproject/godpu

- ## Storage Demo
  - Video recording TBD
  - API protocol buffers
  - clients https://github.com/opiproject/pydpu and https://github.com/opiproject/godpu

NGINX POC Example – F5 OPI Team

"Acceptance Test" for HW acceleration

Ability to measure and compare HW acceleration features
"Inbound" DPU, handle traffic inbound to host

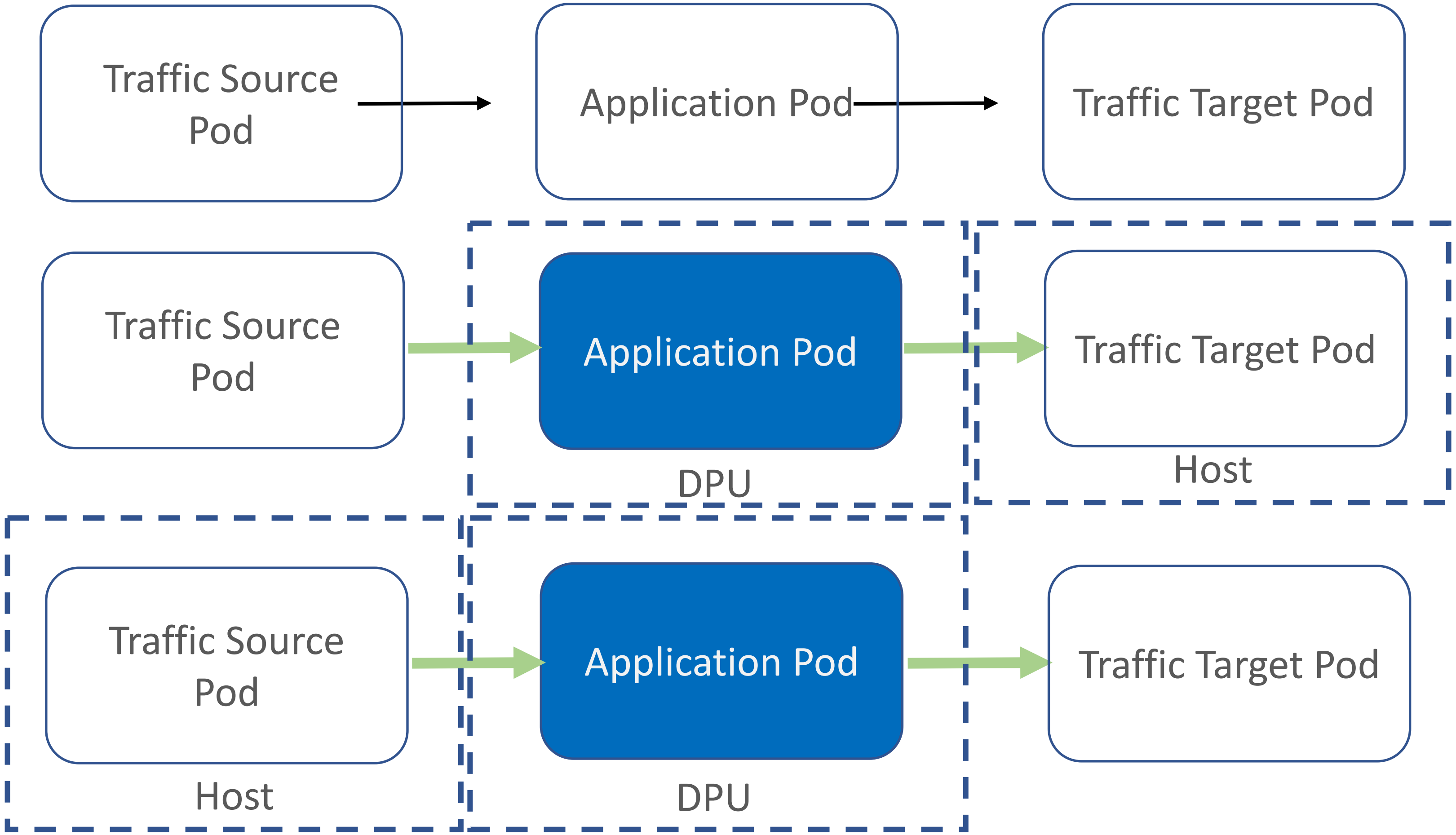
Firewall and TLS offload
"Output" DPU, handle traffic from host

Switching and Loadbalancing, ECMP

Works well if Host is a proxy of some sort

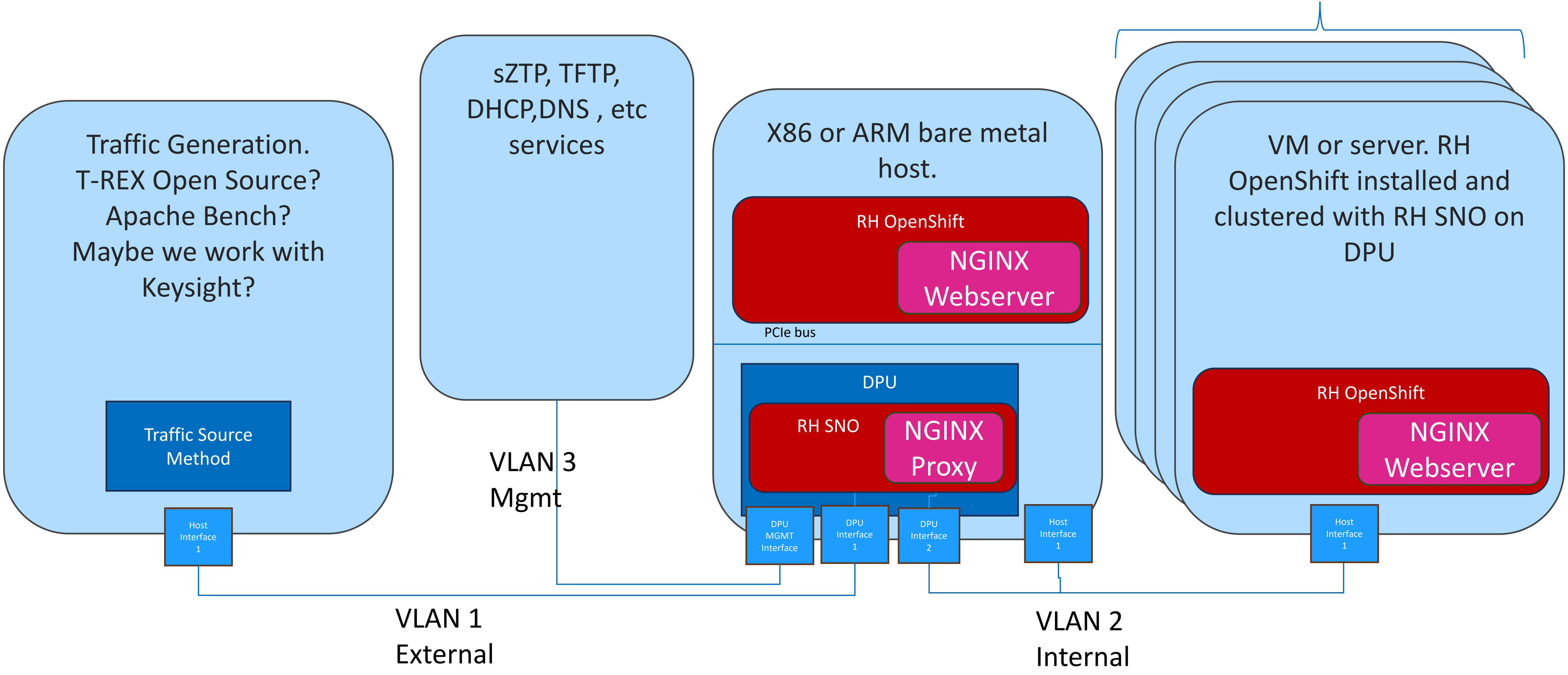
"Hairpin" Host->DPU->Host pure HW acceleration test
No expensive optics or switching required!

Source->DPU->Host->DPU->Target is valid customer use case, but test is intended to be simpler



NGINX POC Example – F5 OPI Team

Enough NGINX webservers to Max out DPU throughput



Traffic Generation. T-REX Open Source? Apache Bench? Maybe we work with Keysight?

sZTP, TFTP, DHCP,DNS , etc services

X86 or ARM bare metal host.

VM or server. RH OpenShift installed and clustered with RH SNO on DPU

OPEN PROGRAMMABLE INFRASTRUCTURE PROJECT

THE LINUX FOUNDATION

The objective of the Open Programmable Infrastructure Project is to foster a community-driven standards-based **open ecosystem** for next generation architectures and frameworks based on **DPU/IPU-like technologies**.

opiproject.org

github.com/opiproject

lists.opiproject.org/g/opi

youtube.com/@OPI_project

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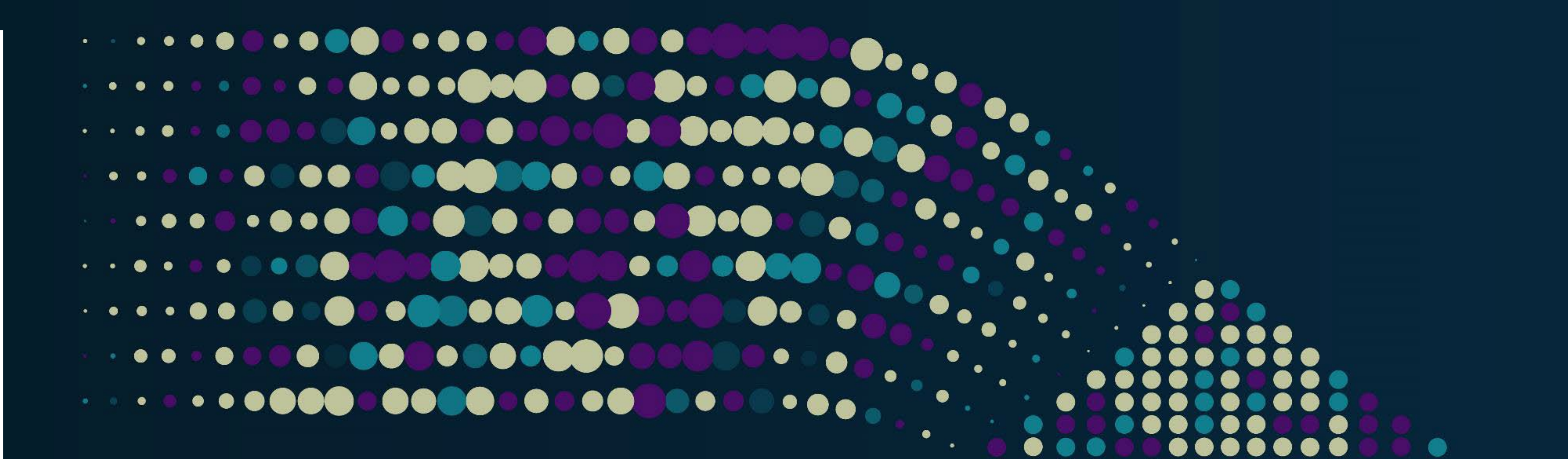

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