Userspace OVS with HW Offload and AF_XDP

Linux Plumber

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Agenda

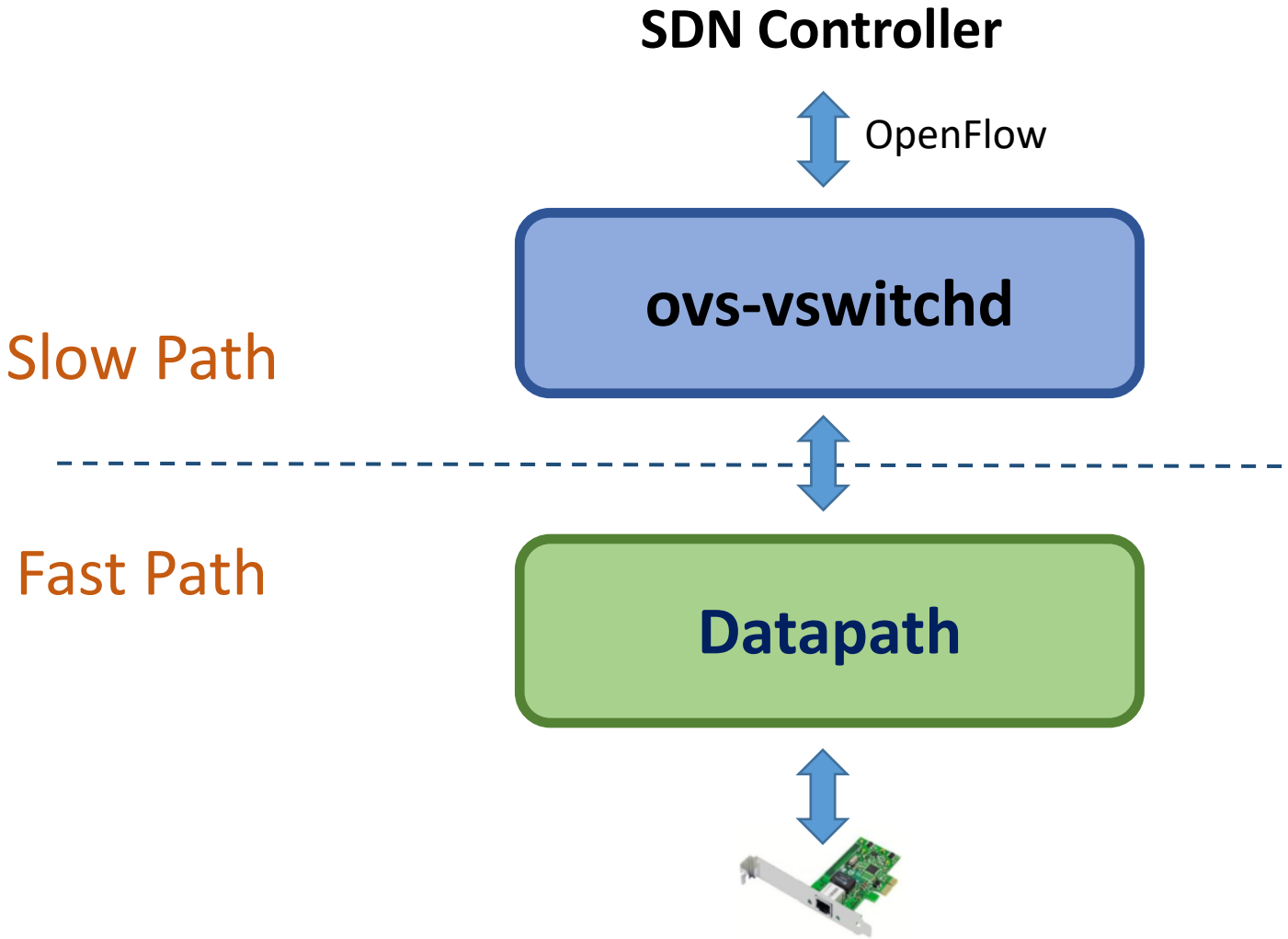
Introduction

- OVS Kernel and userspace datapath
- DPDK and AF_XDP netdev interface
- tc-flower and rte_flow offload

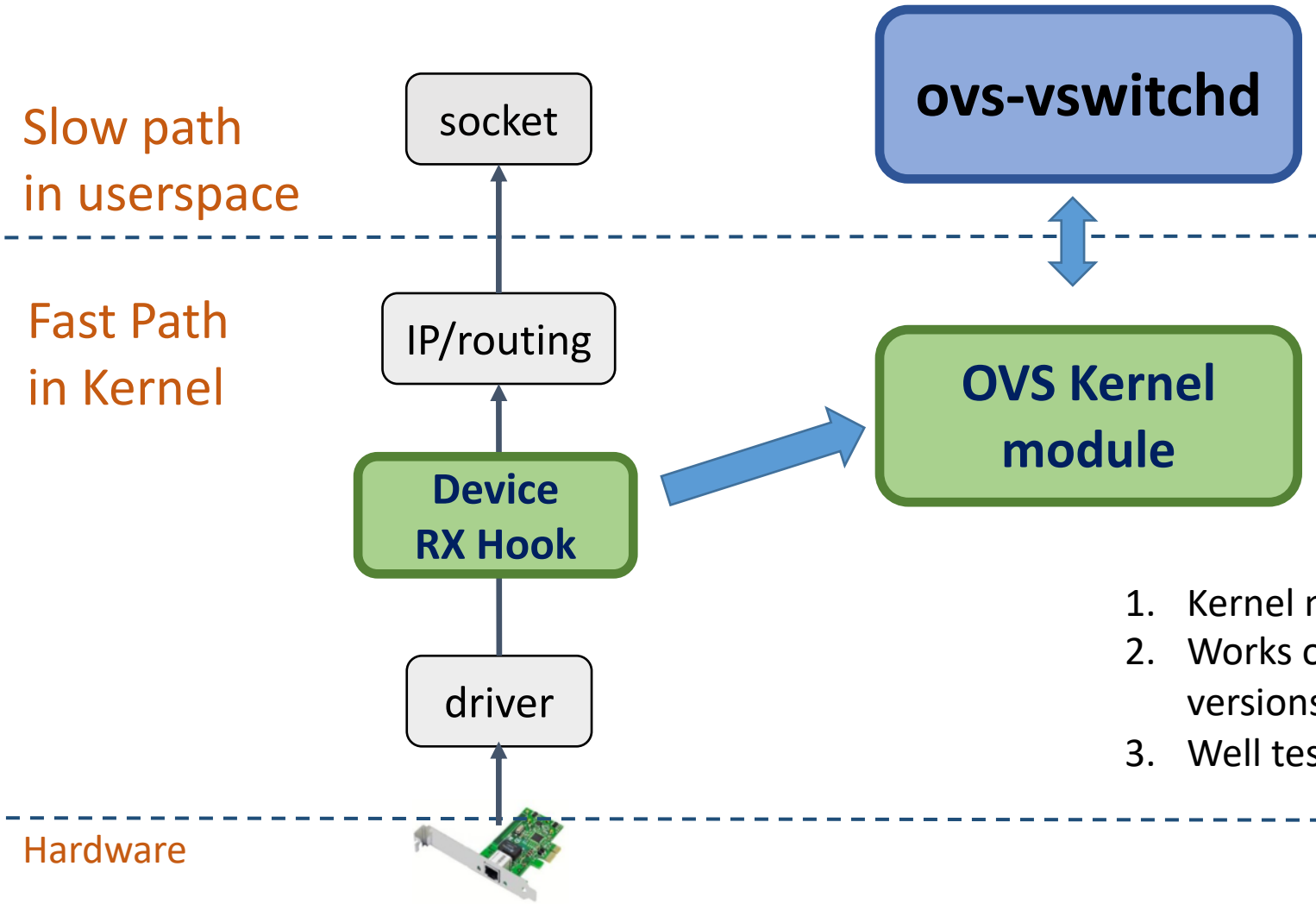
Design and Evaluation

- Userspace datapath with tc-flower offload and AF_XDP
- Performance

What is OVS?

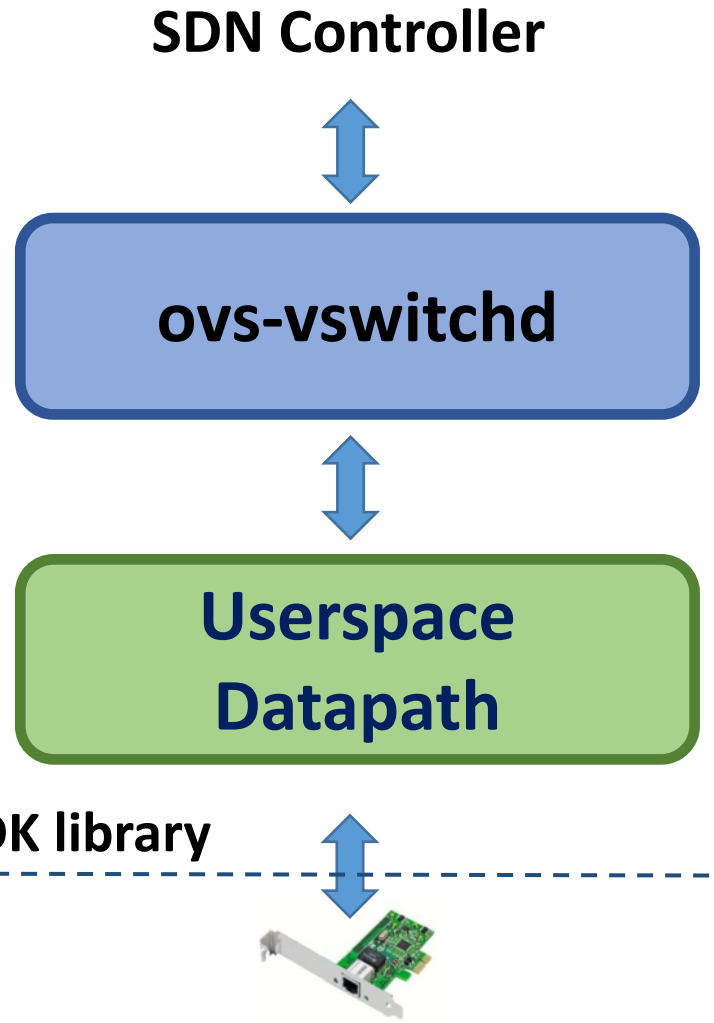

SDN Controller
OpenFlow
ovs-vswitchd
Slow Path
Fast Path
Datapath

OVS Linux Kernel Datapath



1. Kernel module: openvswitch.ko
2. Works on a wide variety of distributions and versions
3. Well tested, widely used, but with kernel overhead

OVS Userspace Datapath



Both slow and fast path in userspace

1. Used by OVS-DPDK
2. Fast due to kernel by-pass
3. Deploy/Debug DPDK is hard
4. Usually for appliance with dedicated HW

Motivation

Customers deploy either one of the two:

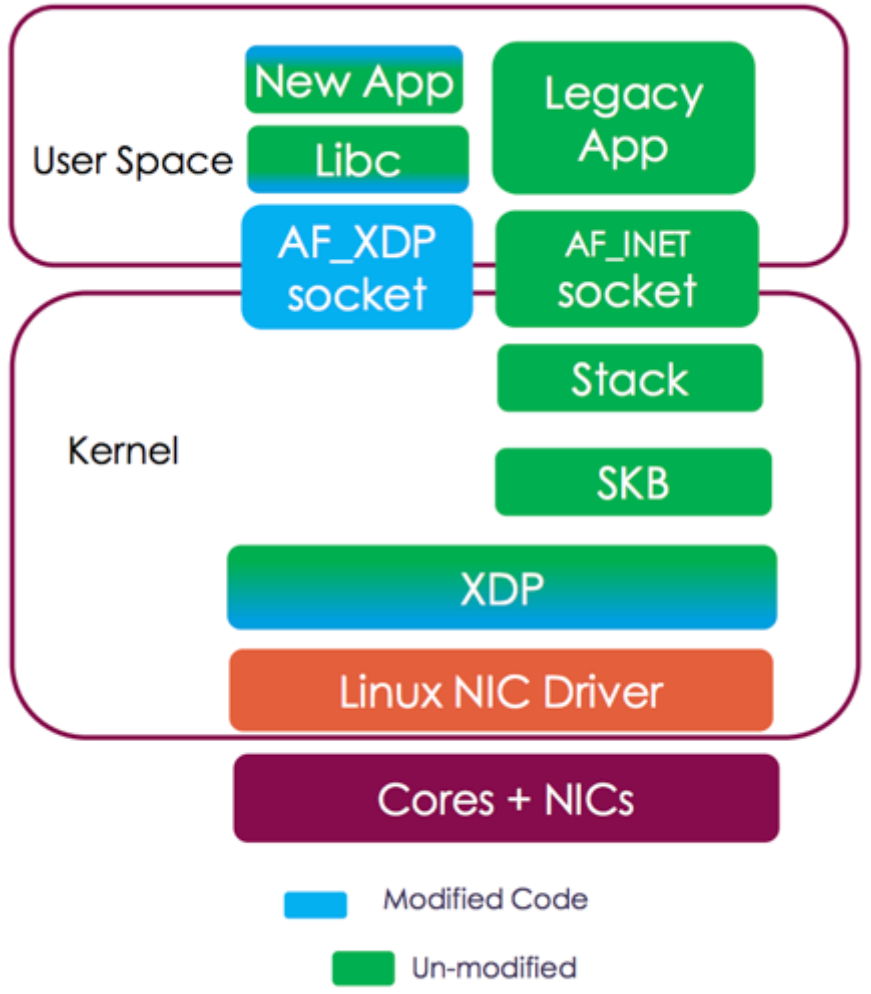
- OVS Kernel Datapath:
  - stable, feature-rich, and for typical hypervisor/enterprise
- OVS-DPDK Userspace Datapath
  - high performance, used in appliance

However,

- Maintaining and running both datapaths is hard
- Can we have single datapath for both use cases?

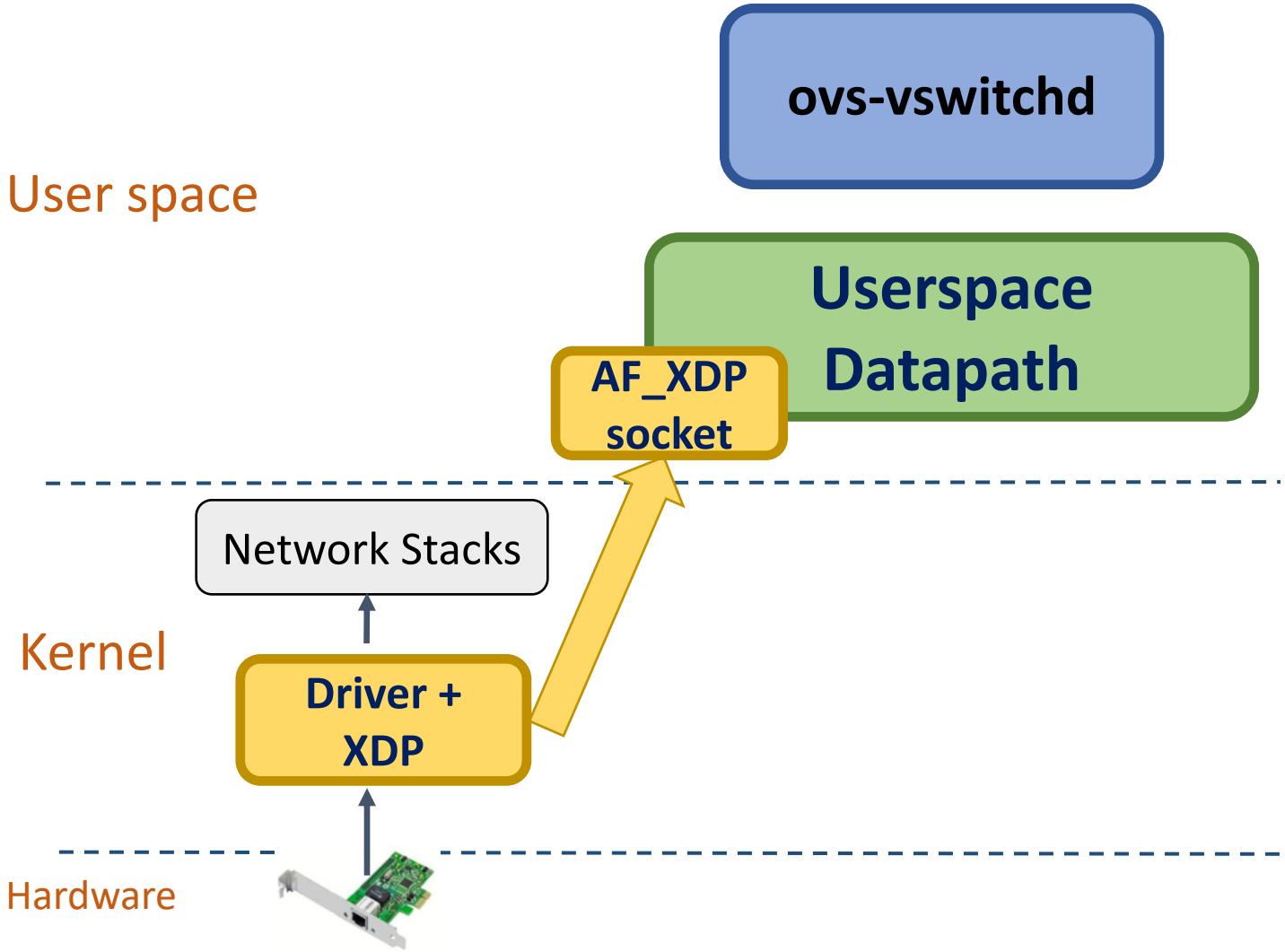
XDP and AF_XDP

- XDP: eXpress Data path
  - An eBPF hook point at the network device driver level
- AF_XDP:
  - A new socket type that receives/sends raw frames with high speed
  - Use XDP program to trigger receive
  - Userspace program manages Rx/Tx ring and Fill/Completion ring.
  - Zero Copy from DMA buffer to user space memory, achieving line rate (14Mpps).



From “DPDK PMD for AF_XDP”

OVS AF_XDP netdev

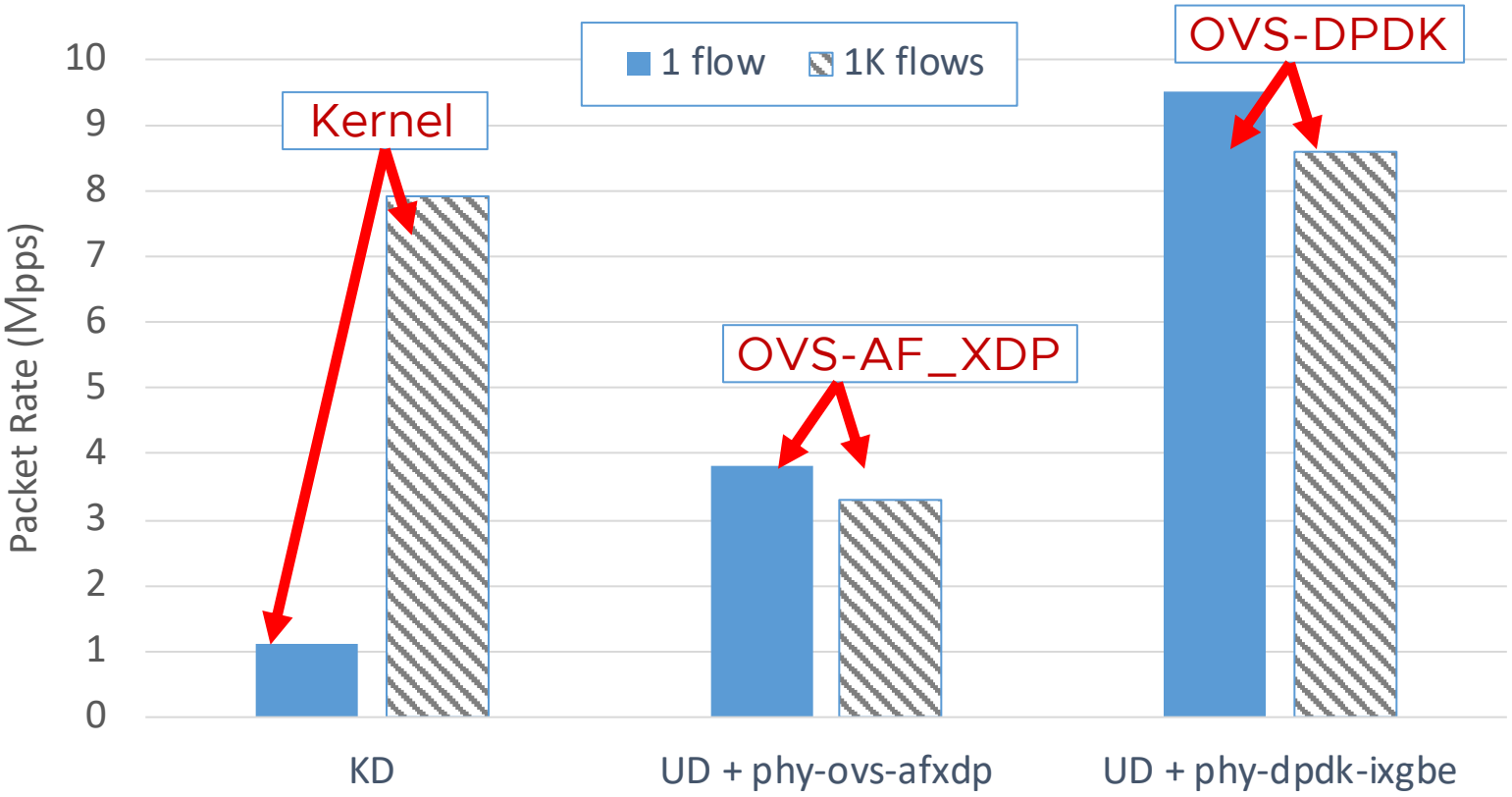


Goal

- Available since OVS 2.12
- Use AF_XDP socket as a fast channel to usersapce OVS datapath
- Flow processing happens in userspace
- Same datapath as used by OVS-DPDK

Performance

Physical-to-physical port, using 64B 1 flow and 1K flows, with different packet I/O



- Different Datapaths:
  - **KD**: Kernel Datapath
  - **UD**: Userspace Datapath
- Different Packet I/O:
  - **Phy-ovs-afxdp**: OVS's AF XDP packcet I/O code on physical port.
  - **Phy-dpdk-ixgbe**: DPDK's ixgbe PMD on physical port

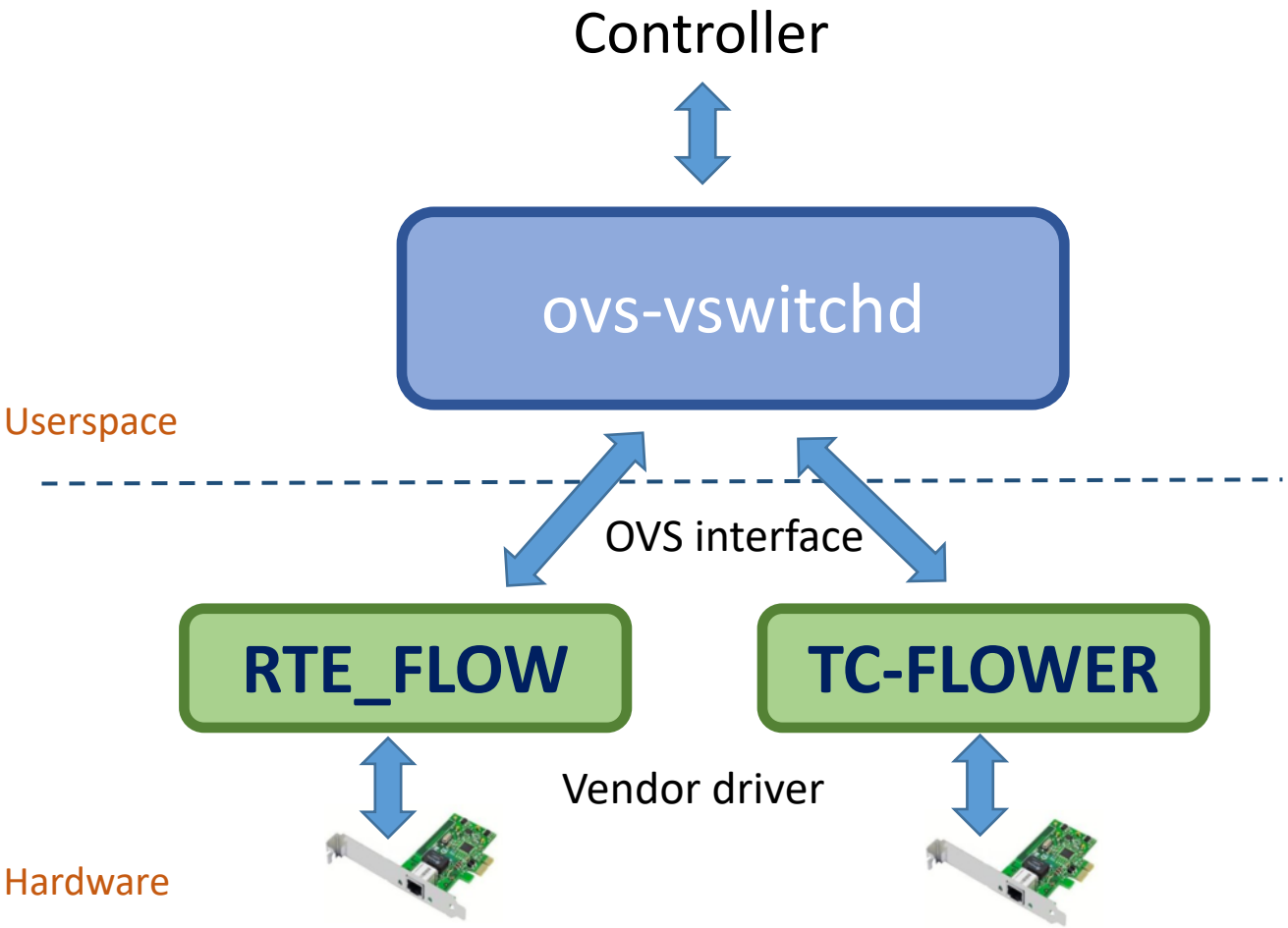
Summary

- Userspace datapath with AF_XDP netdev performs
  - Much better than kernel datapath
  - Slower than using DPDK netdev

- Future work
  - More improvement on the OVS AF_XDP netdev
  - Explore the idea of OVS HW offload:
    OVS-DPDK -> rte_flow, OVS kernel datapath-> tc-flower

- Observation
  - With AF_XDP netdev, userspace datapath can enable tc-flower offload.

HW offload: rte_flow v.s tc-flower APIs



- OVS HW offload interface
  - Translate the datapath flow into rte_flow or tc-flower
  - ovs/lib/netdev-offload-{dpdk, tc}.c
- Vendor driver
  - Check whether the API is implemented in vendor-specific driver

Target Use Case: Tunnel and Conntrack

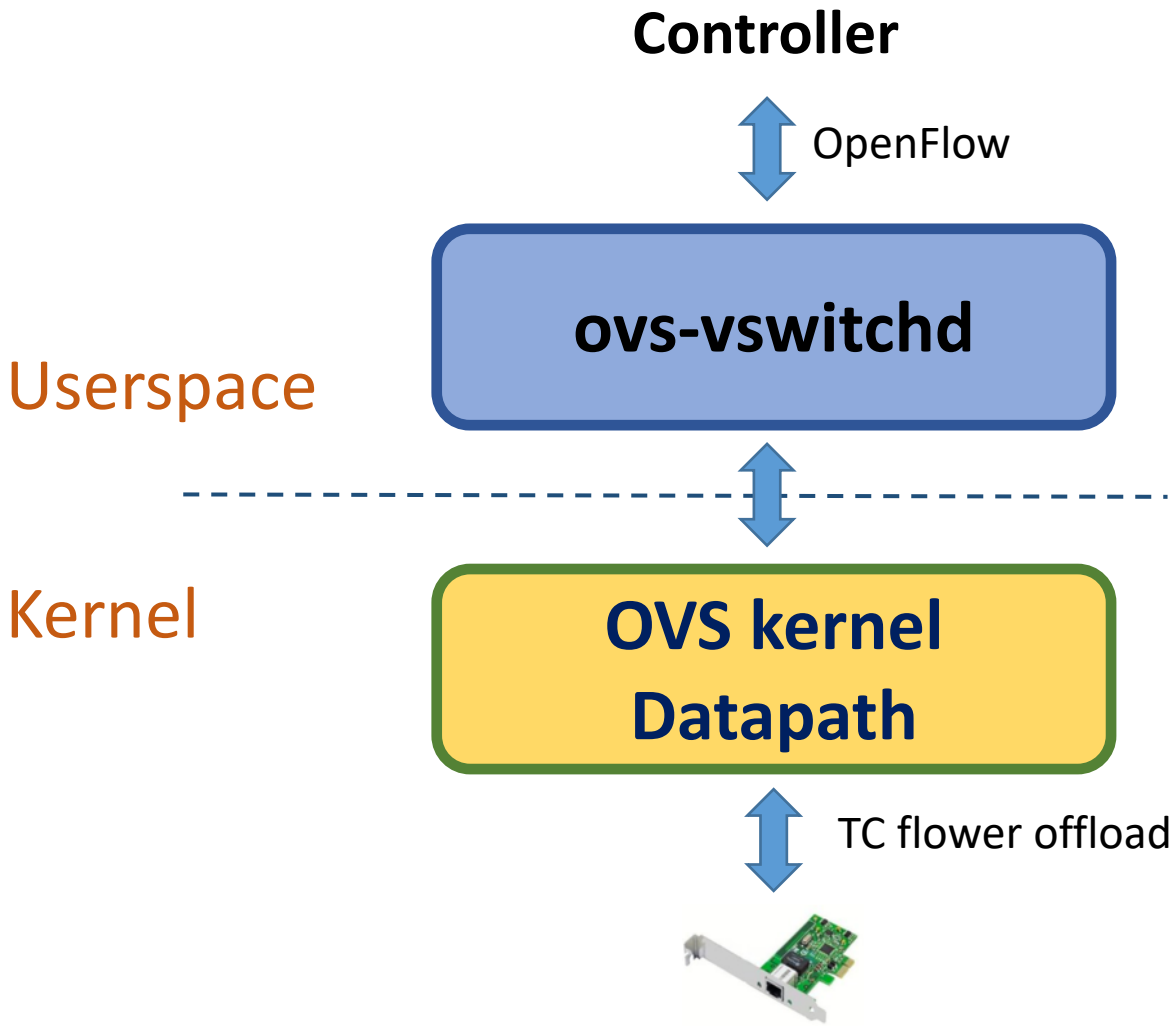
- Simple 5 tuple match and action no longer meets today's firewall requirements, typical use cases:
  - Each packet goes through three OVS datapath flows
- Example for incoming packets (rx):
  1. Match and Tunnel decap (ex: Geneve or VxLAN), **Recirc**
  2. Match on tunnel md and send to Connection tracking, **Recirc**
  3. Match on CT states and forward/drop

Requirements:

A. Need to do all of them in hardware, no partial offload.

B. if not A, process the flow in a fast SW path.

A. Kernel DP + tc-flower



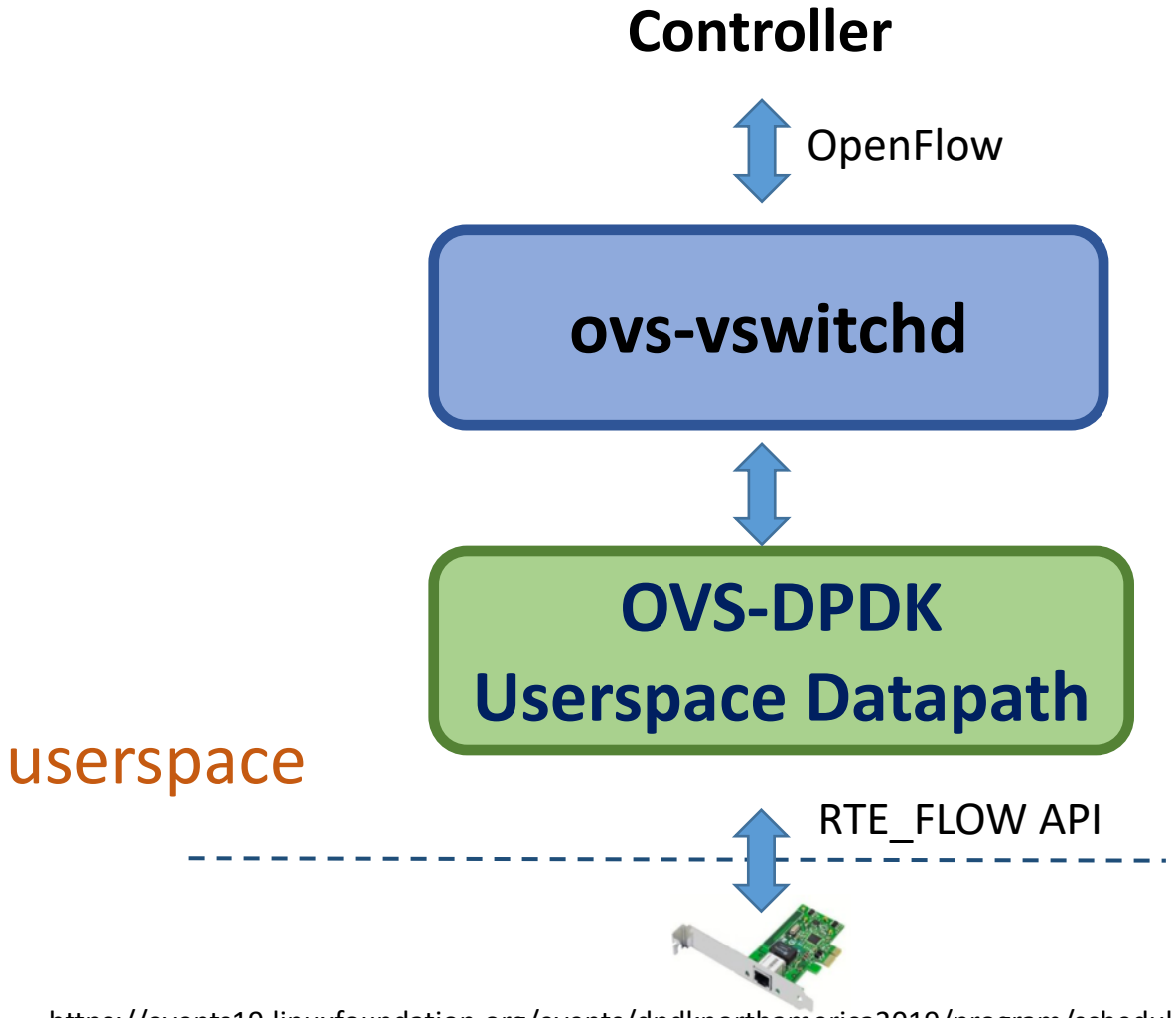
Pros:

- Support tunnel and connection tracking
- Better integrate into Linux kernel
- Easier to ship and test

Cons:

- Fall-back performance in software OVS or TC (2Mpps)

B. DPDK rte_flow



Pros:

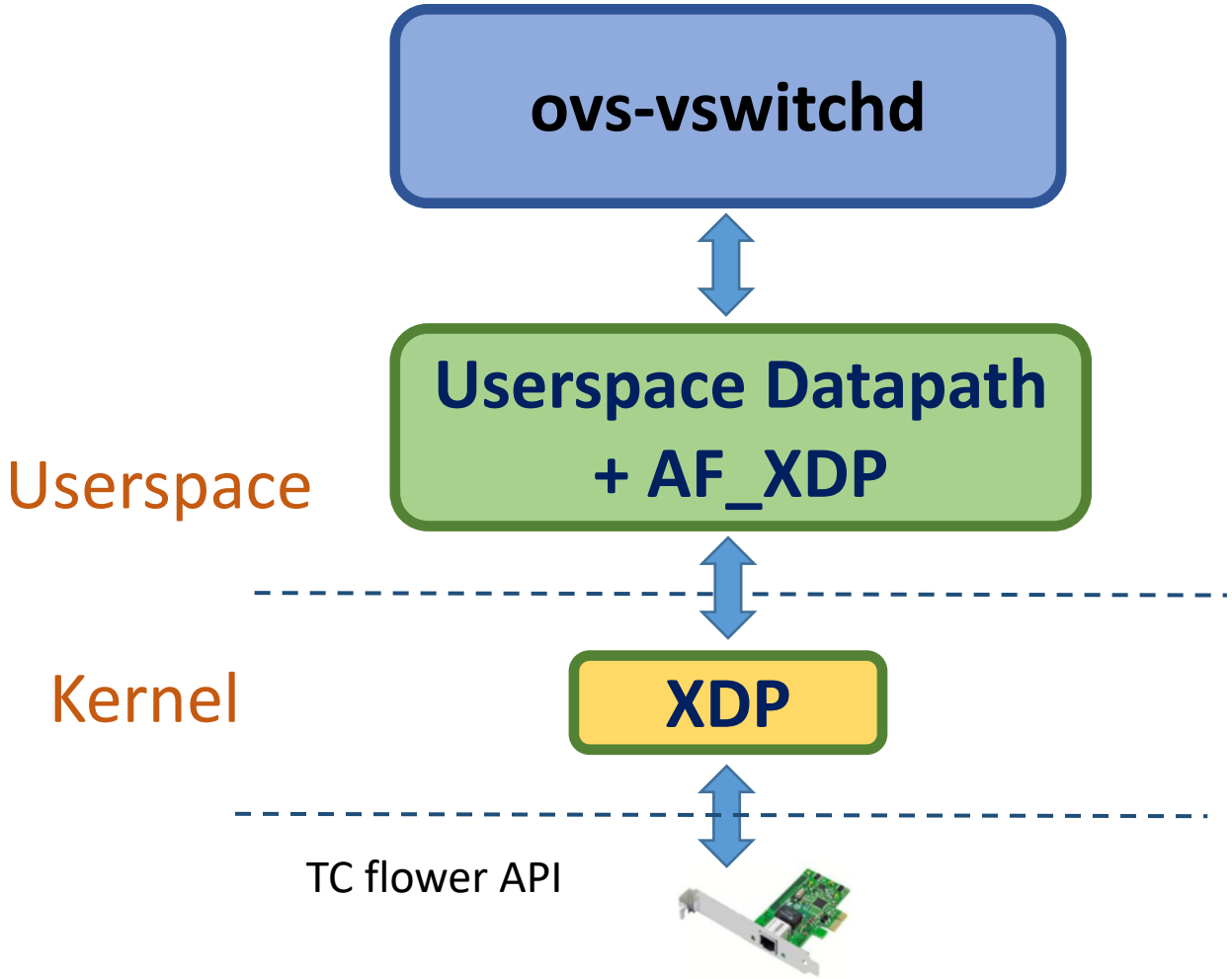
- Support tunnel encap
- Better SW fallback performance
- More active in community from different vendors

Cons:

- No connection tracking API support
- Need to deploy OVS-DPDK

https://events19.linuxfoundation.org/events/dpdknorthamerica2019/program/schedule/

C. Userspace Datapath + tc-flower + AF_XDP

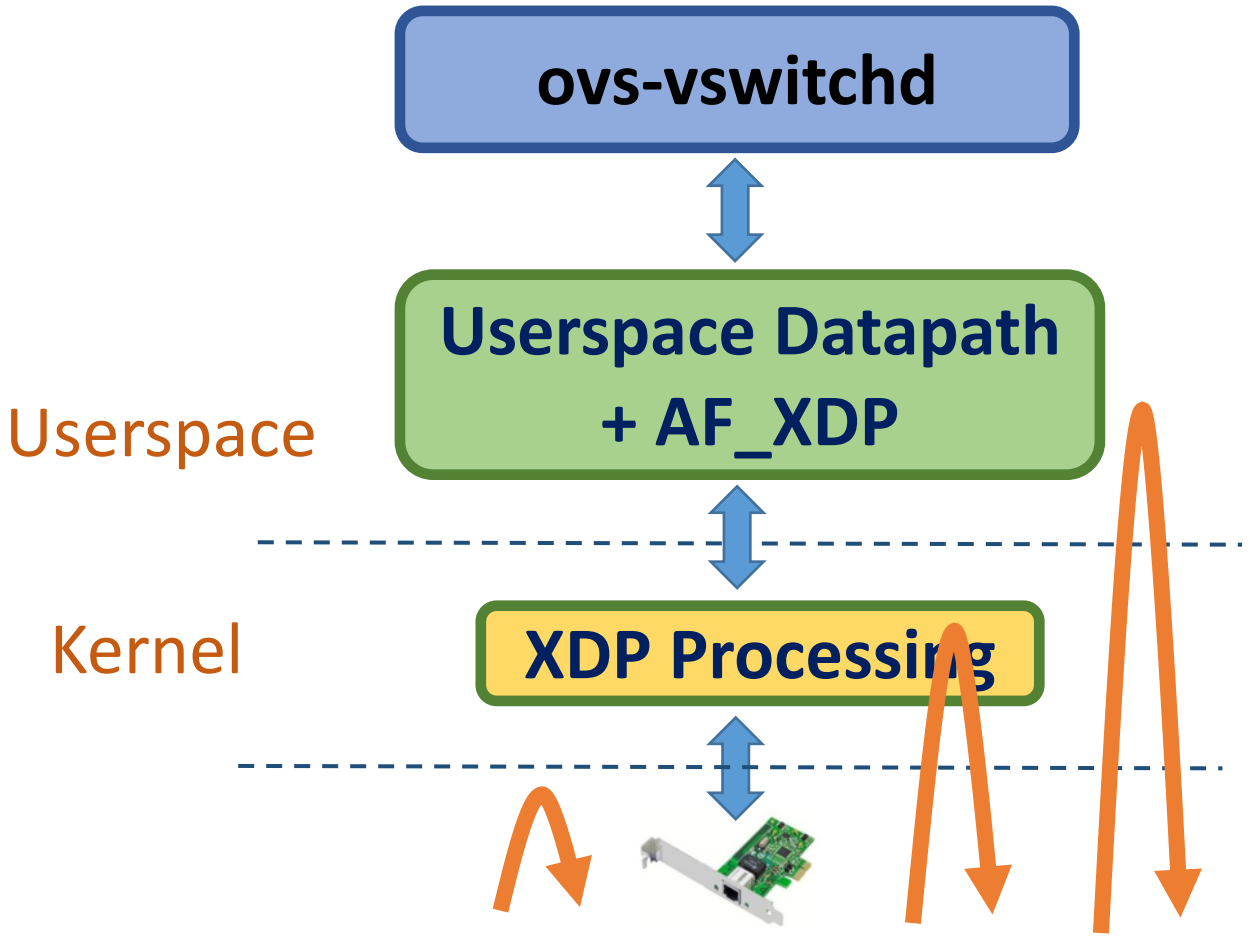


A flow could be processed

1. In HW with tc-flower, if not
2. In XDP, which is safe and performant, if not
3. In OVS userspace with AF_XDP

- Better integration into Linux kernel
- Better fallback performance in XDP/ userspace
- Each stage has its own limitations, need to probe its supported features

C. Userspace Datapath + tc-flower + AF_XDP



Performance of P2P using 1 flow, 64B UDP packet:

A. HW offload: 31Mpps
B. HW offload + VxLAN encap: 21Mpps
C. XDP[1] : 3.5Mpps
D. Userspace DP + AF_XDP poll-mode: 4.5Mpps (uses 2 cores)

[1] https://netdevconf.info/0x14/session.html?talk-fast-OVS-data-path-with-XDP

Summary of using Approach-C

For enterprise use case:

- Use userspace datapath with AF_XDP interrupt-mode netdev
- If need more performance, enable software XDP processing or AF_XDP polling-mode

For high performance use case:

- Use HW offload through tc-flower (fastest)
- Use software XDP processing (2nd)
- Use userspace datapath with AF_XDP polling-mode netdev

Future Work

- Validate tc-flower offload for conntrack and tunnel decap

- OVS XDP Processing patch
  - [ovs-dev] [PATCH v4 0/5] XDP offload using flow API provider
  - https://mail.openvswitch.org/pipermail/ovs-dev/2020-August/373915.html
- More optimization for OVS AF_XDP netdev
  - OVS with AF_XDP - what to expect, OVS conference 2019

Thank you