Performance analysis of DPDK-based applications

Adel Belkhiri   Michel Dagenais

January 8, 2021

Polytechnique Montréal

DORSAL Laboratory

Agenda

Introduction

Investigation and use cases

- Classification libraries (lpm, hash, acl, array, etc.)
- Pipeline library
- Eventdev library

Conclusion and future work

Linux Kernel bypass

- Linux kernel network stack is too slow

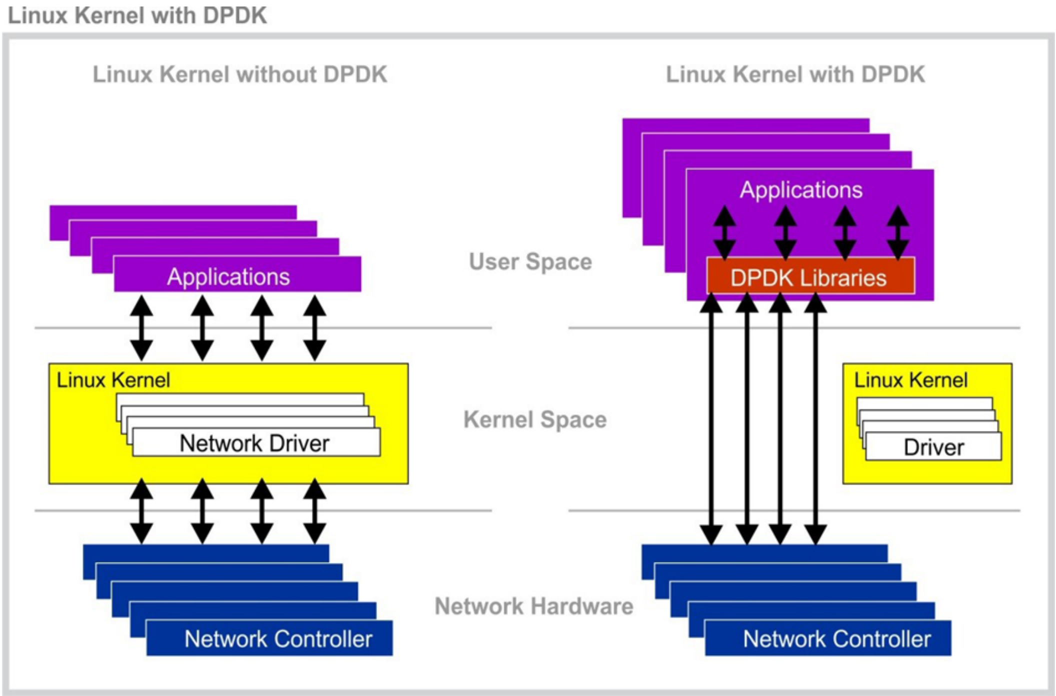
  - Overhead of traditional system calls (read, write, etc.)
  - Interrupts and NAPI (New API)
  - Huge skb_buff data structure
  - Packets are processed individually

- **Few solutions exist ...**

  - Kernel bypass tools (DPDK, PF_RING, Netmap, etc.)
  - XDP (eXpress Data Path)

DPDK - Data Plane Development Kit

- Set of data plane libraries and NICs polling-mode drivers for offloading packet processing from the kernel to userspace processes
- Many optimizations to accelerate packet processing (huge pages, lock-less queues, batch processing, etc.)



***Source :**https://www.accton.com/Technology-Brief/intel-dpdk-performance-on-the-sau5081i-server/*

What we want

What is the problem ?

- Kernel-bypassing techniques prevent the applications from using traditional management and monitoring tools.

How do we intend to solve it ?

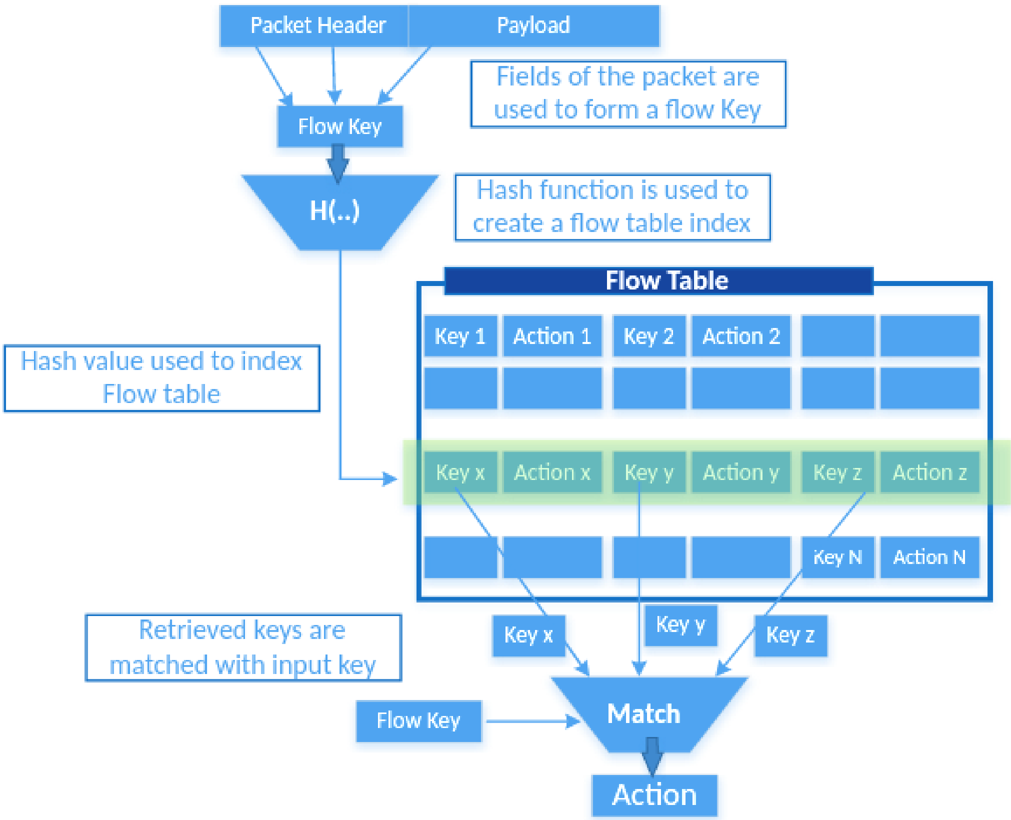
- Propose a tracing-based debugging tool for DPDK applications
  - Static instrumentation of DPDK libraries
  - Development of trace analyses capable of uncovering packet processing bottlenecks and latencies.

Work Environment

- **Software Setup :**
  - DPDK (version 19.05)
  - LTTng (version 2.10)
  - Trace Compass framework
- **Experimental Setup (for use cases)**
  - Hardware : 8 CPU cores + 32 GB memory
  - Ubuntu 18.04 (Kernel version 4.14.0)
  - Trex Traffic Generator (version 2.81)
  - Stress-ng (version 0.09.25)

Classification tables (1)

- **DPDK provides many classification libraries, such as :**
  - LPM (Longest Prefix Match)
  - ACL
  - HASH
  - ARRAY
  - Classifier

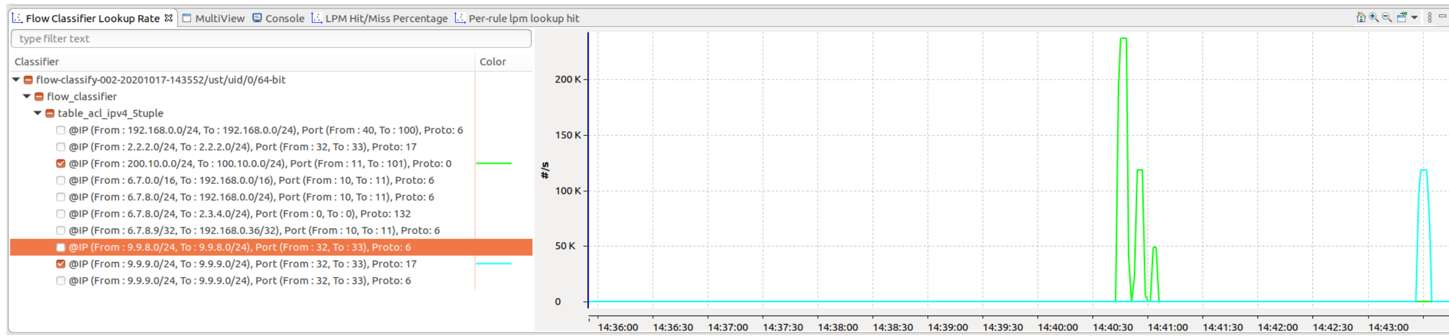


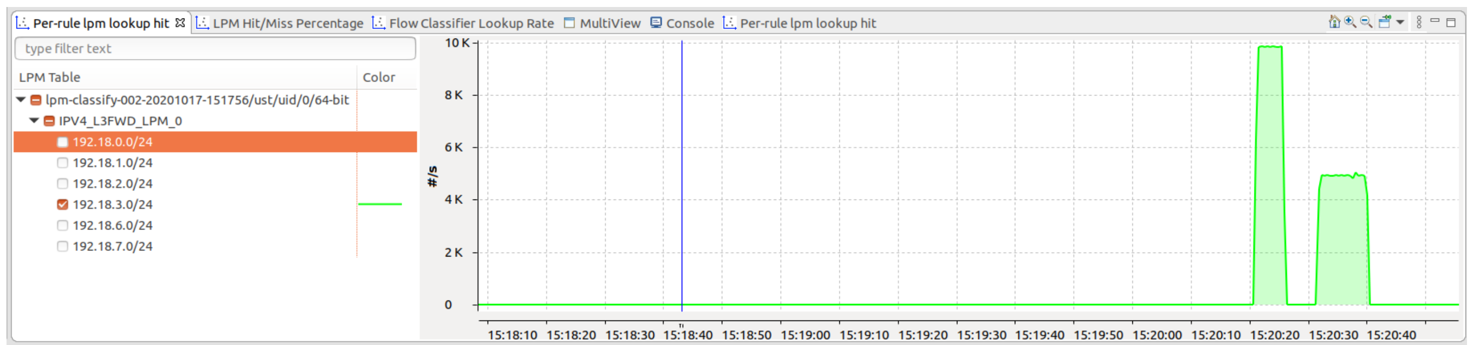
Classification tables (2)

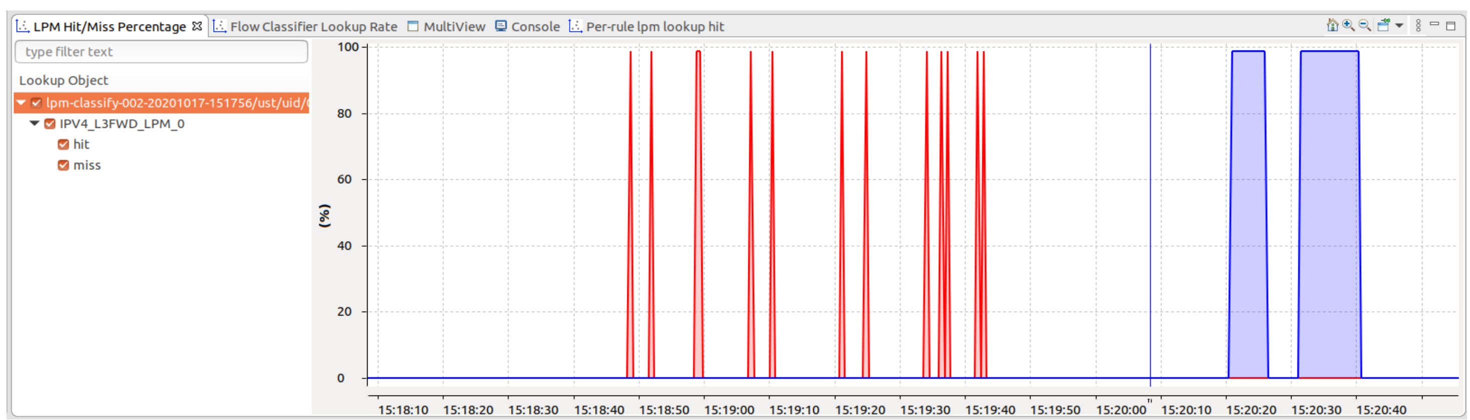
Metrics :

* Per-flow lookup rate

* Table hit/miss percentage



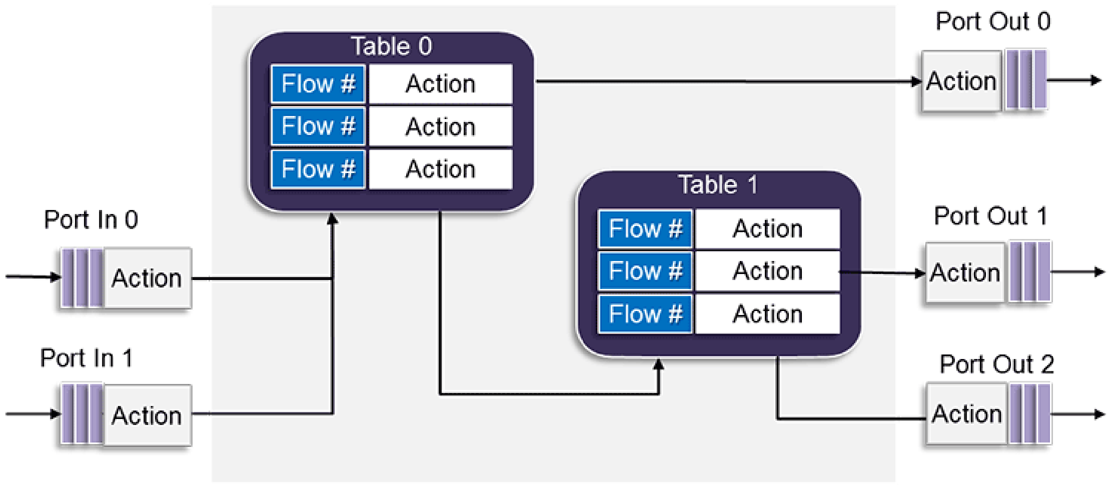




Pipeline Library

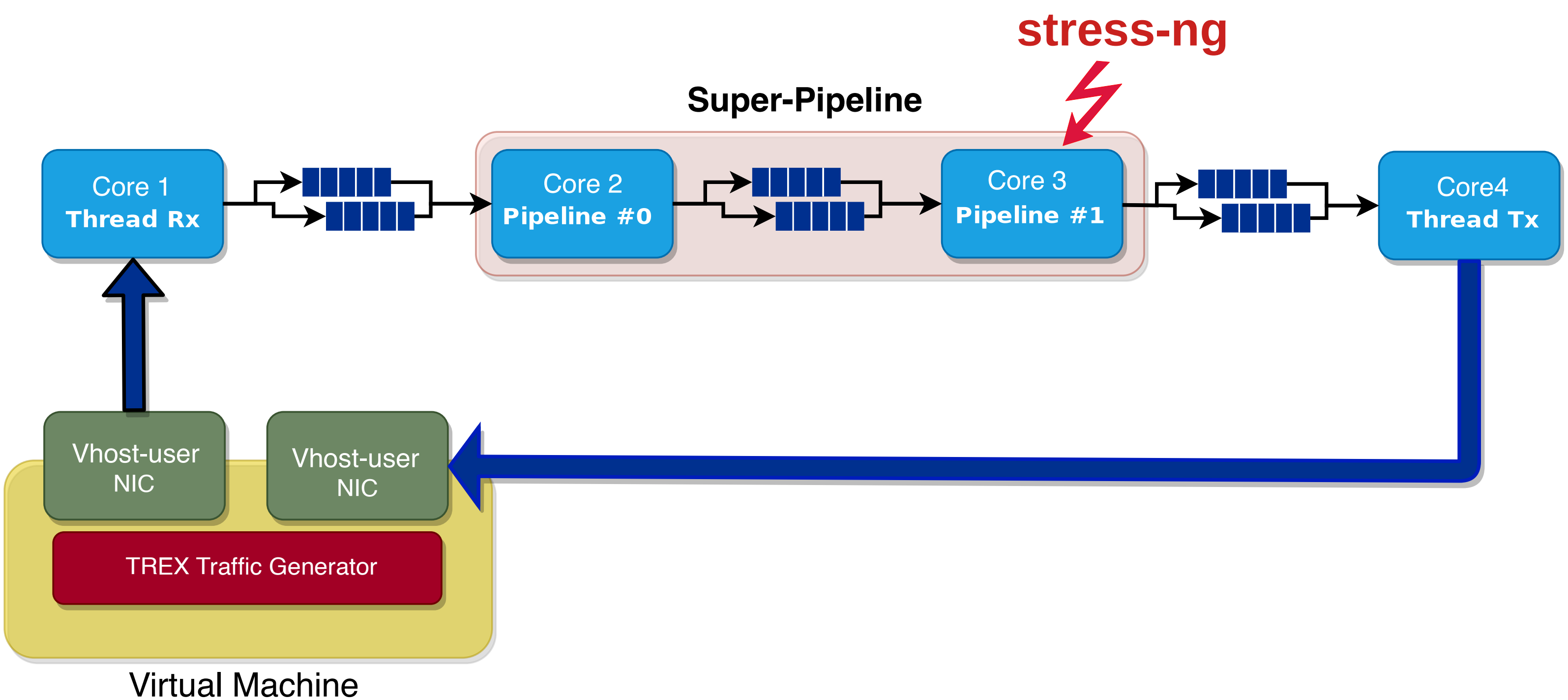
- The DPDK Packet Framework : a set of DPDK libraries (*librte_port*, *librte_table*, and *librte_pipeline*) defining a standard methodology for building complex packet processing applications

- Each pipeline module is constructed of three primitive entities: input ports, output ports, and tables



Use Case 1: Pipeline Library

- **Analyzed Application :** *./dpdk-ip-pipeline*
  - 1 main thread + 4 threads (1 thread RX, 2 threads for the super-pipeline, 1 thread TX)



Use Case 1: Pipeline Library

First execution (without stress)

Second execution (with stress)

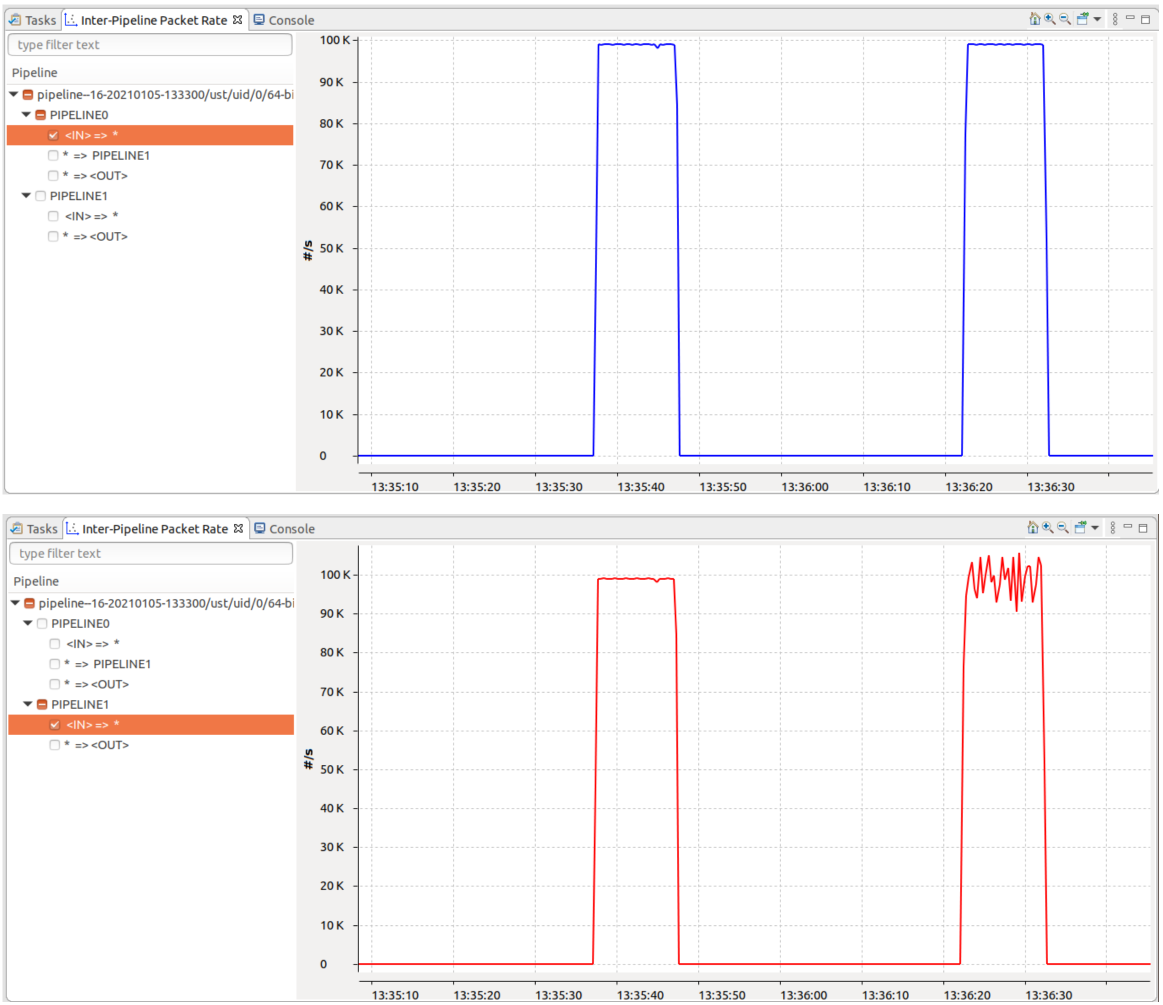
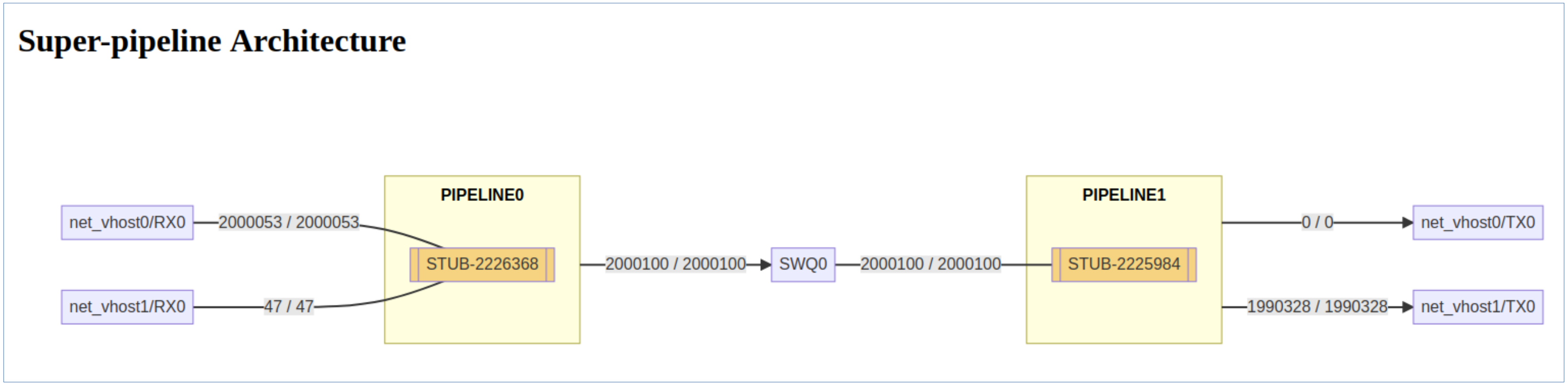


Figure : View to show the Inter-pipeline packet rate

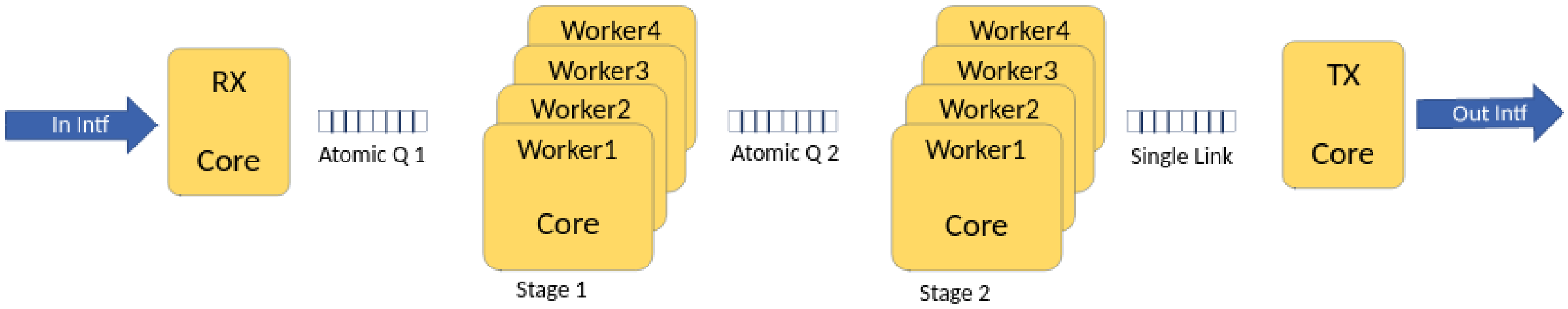
Use Case 1: Pipeline Library



EventDev Library (1)

- EventDev framework provides applications with automatic multi-core scaling, dynamic load balancing, pipelining, synchronization services, etc. via the usage of the event driven programming model.

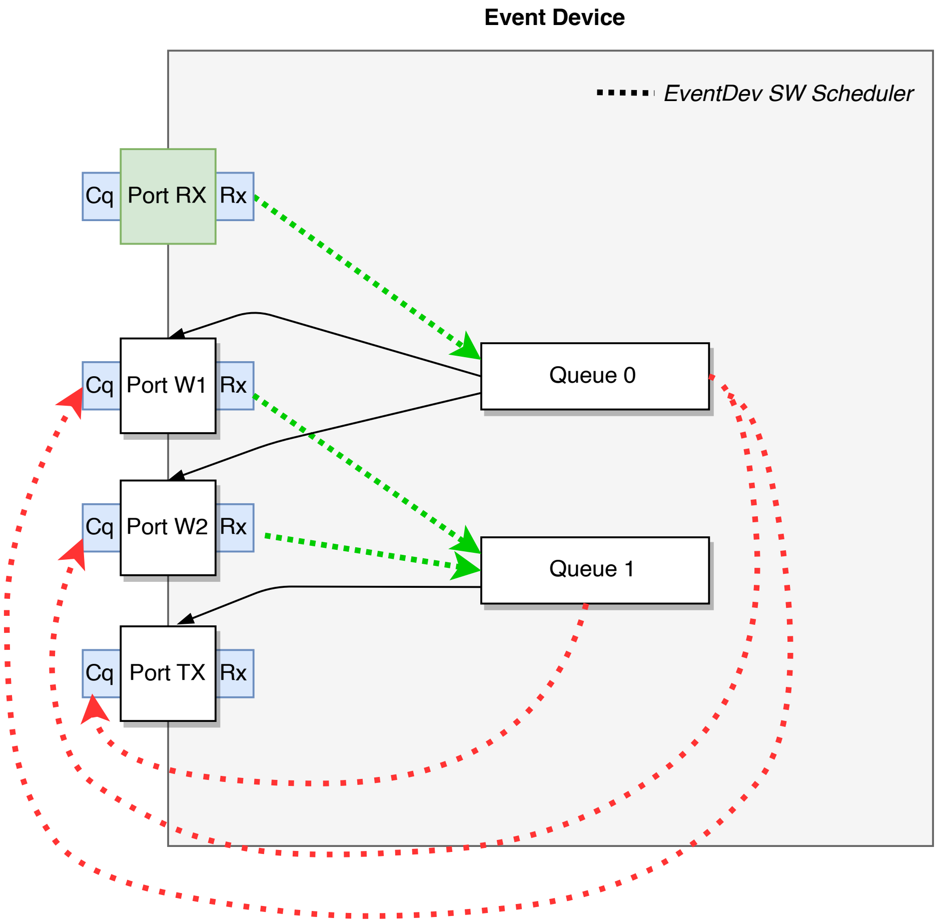
- Event Device :
  - **Ports**
  - **Queues** (Atomic, Ordered, and Parallel)
  - **Events** (packets, time events, crypto)



Source : *https://doc.dpdk.org/guides/prog_guide/eventdev.html*

EventDev Library (2)

- **Data flow within an event device**



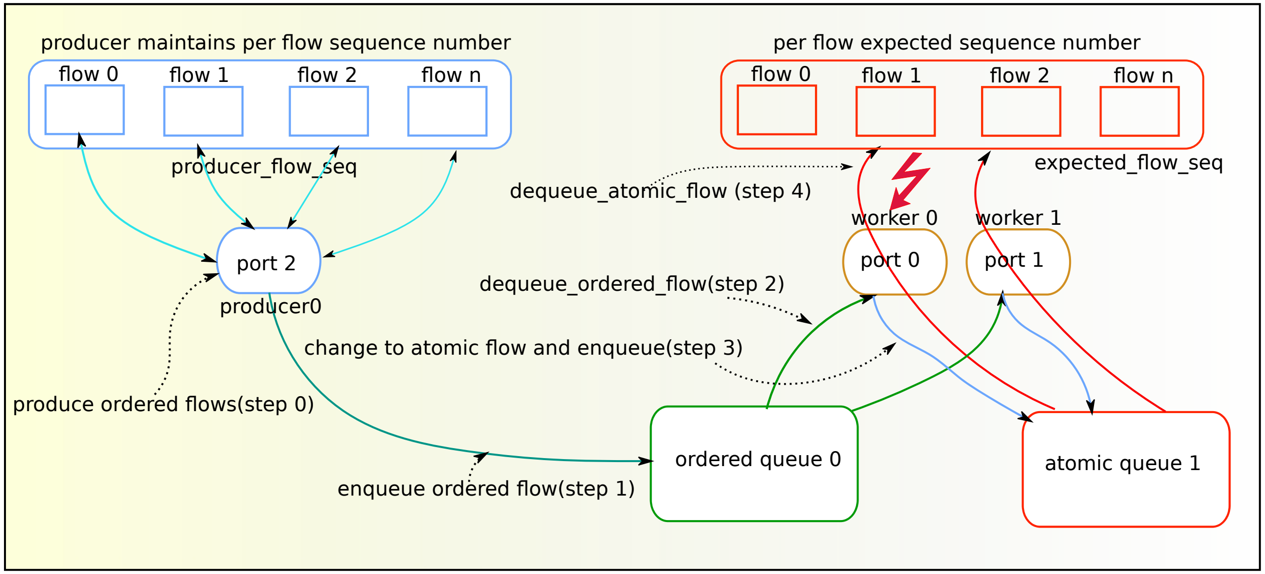
Use Case 2: EventDev Library

- **Analyzed Application :** *./dpdk-test-eventdev*

  -- Port 2 : producer

  -- Port 0, Port 1 : Worker threads

  -- Pipeline composed of two stages (queues)



Use Case 2: EventDev Library

- **Experiment #1 :**

  Ordered queue
  +
  Atomic queue

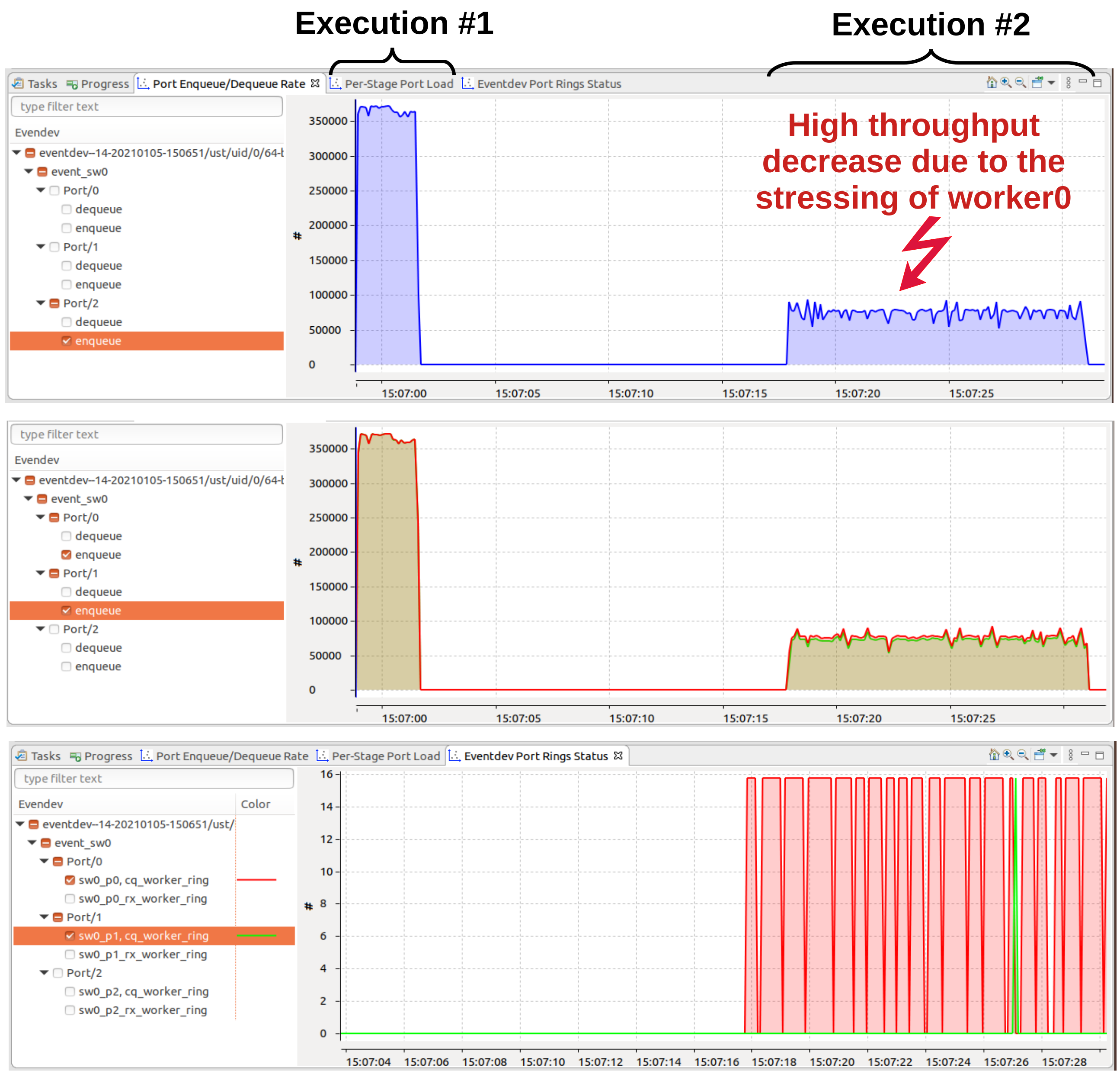
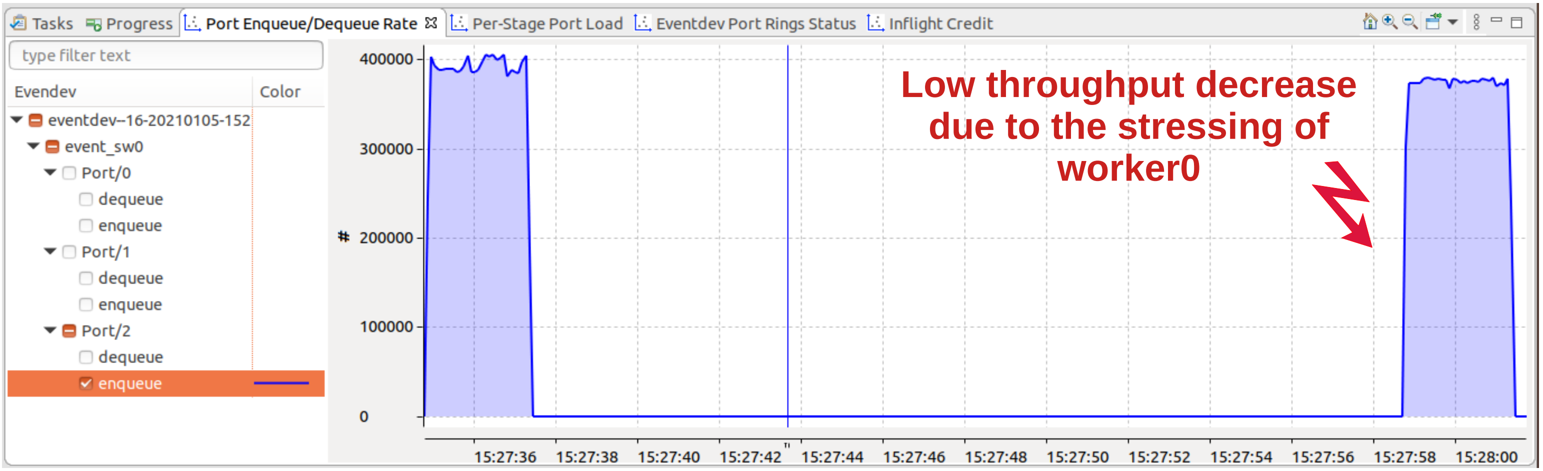


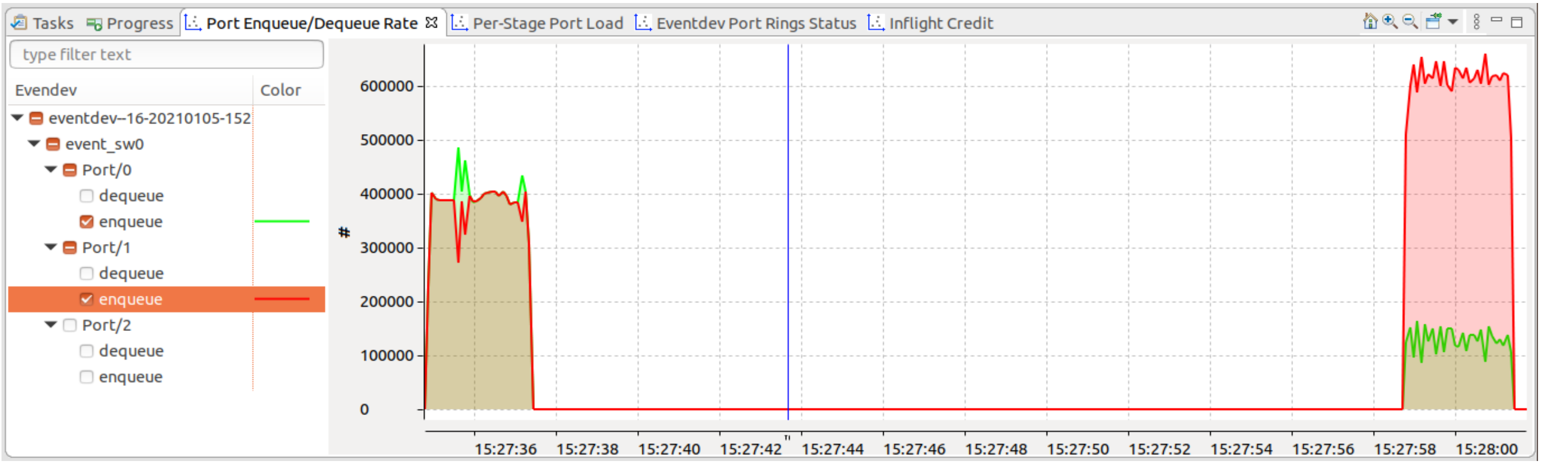
Figure : Occupancy of consumer ring buffer (size = 16)

Use Case 2: EventDev Library

- **Experiment #2 :** Parallel queue + Parallel queue

Execution #1 **Execution #2**





Use Case 2: EventDev Library

Figure :
Per-stage Port Load View

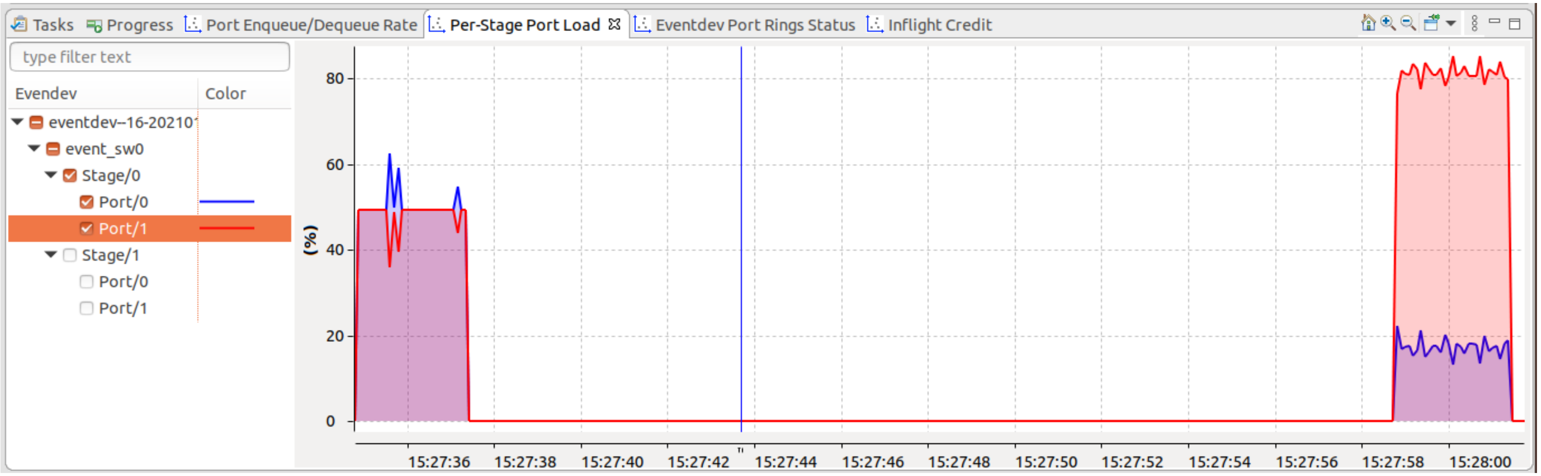
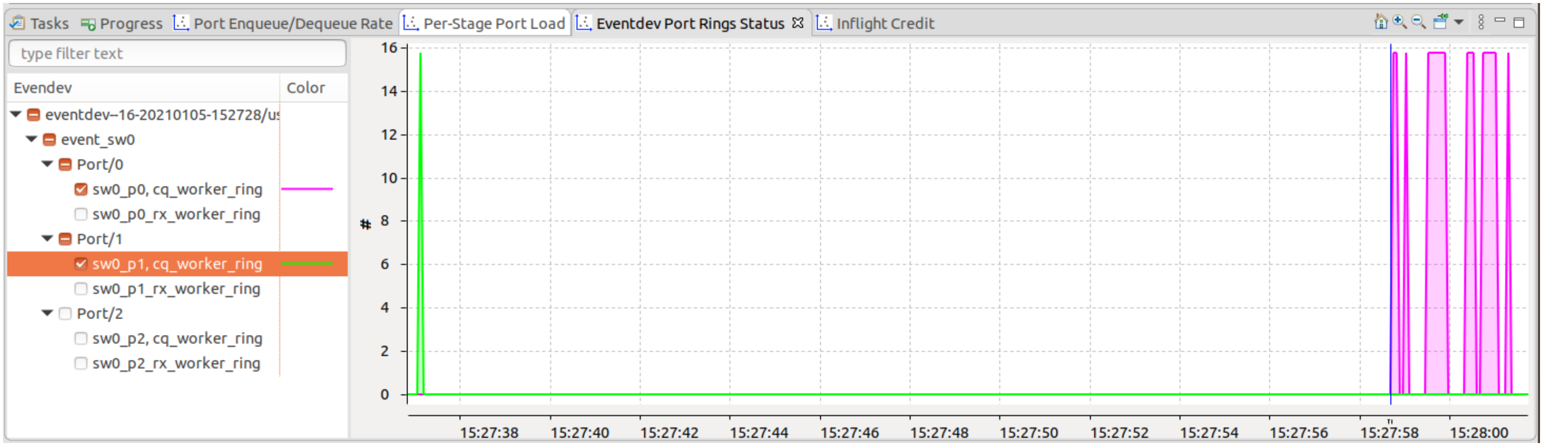


Figure :
Port Rings Occupancy View



Conclusion

- Many successful projects depend on DPDK such as OVS-DPDK, FD.io VPP, and TREX.

=> Need for efficient debugging and monitoring tools

Future Work

- Leverage our analyses to study the performance of “real” DPDK applications
- Estimate and analyze the overhead of tracing

Questions?

adel.belkhiri@polymtl.ca