Bottleneck Analysis of DPDK-based Applications

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Agenda

Introduction

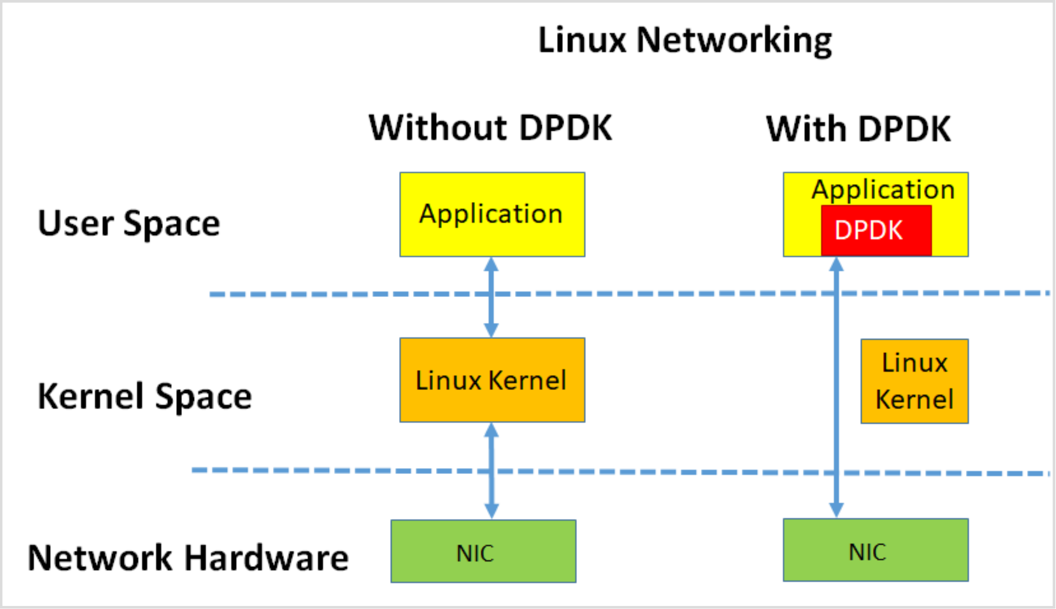
Investigation and use cases

- How to pinpoint a performance bottleneck ?
- Use cases

Conclusion

DPDK - Data Plane Development Kit

- Set of libraries and polling-mode drivers which can be leveraged to implement userspace dataplanes
- Many optimizations to accelerate packet processing (CPU affinity, huge pages, lock-less queues, batch processing, etc.)



Source : *https://telcocloudbridge.com/wp-content/uploads/2019/05/image-1.png*

Why DPDK-based apps might be bottlenecked ? (1)

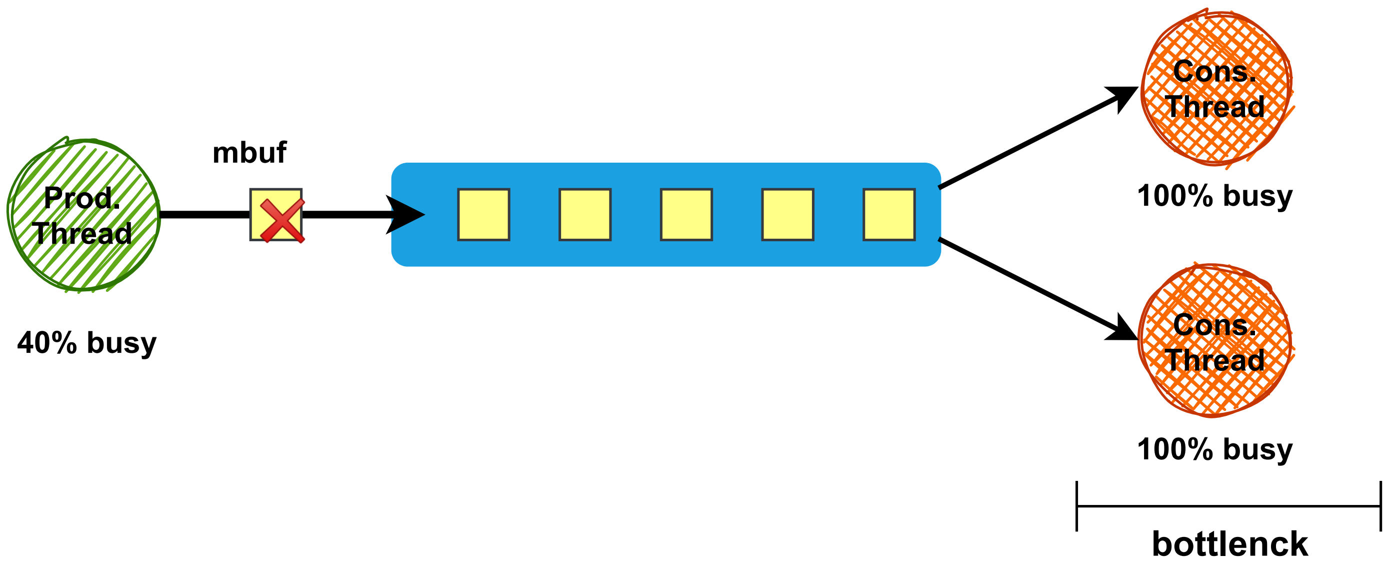
- A **network bottleneck** is a computing or networking resource that may limit the data flow in the network under some circumstances - obvious or unseen.

- **Bottleneck analysis** is a type analysis that aims at identifying which part of the system is causing the congestion

Why DPDK-based apps might be bottlenecked ? (2)

Reasons :

1) Mis-allocation of resources (**Example :** Traffic consumer threads are slower producer threads)



Why DPDK-based apps might be bottlenecked ? (3)

2) Contention for shared resources (**Example :** Contention for accessing LLC)

3) Buggy design or implementation (**Example :** usage of an inadequate scheduling mechanism – Elastic Flow Distributor library *vs* Eventdev library)

Bottleneck Analysis (1)

Performance Analysis Framework for DPDK-based Applications

1) **Data collection** : static instrumentation (lttng-ust, rte_trace library ?)

2) **Bottleneck Analyses** (Trace Compass)

- Flow classification libraries (Hash, ACL, LPM, etc.)
- Vhost-user library
- Pipeline library
- Eventdev library (SW and DSW schedulers)
- ...

Bottleneck Analysis (2)

Subset of computed performance metrics :

- Per-flow and per-NIC Packet rate, Enqueue/Dequeue rate, drop rate
- Occupancy of application buffers (NIC RX/TX queue, Software Queues, etc.)
- Latency of Software Queues
- Effective RX spins metric :

$$\%\ \textit{Effective RX Spins} = \frac{\textit{NB successful calls to } \boldsymbol{X\_dequeue\_burst()} * 100}{\textit{Total number of calls}}$$

Use Case 1: DPDK Packet Framework

- Bottleneck analysis of the *Internet Protocol (IP) pipeline* application
  - Super-pipeline composed of three pipelines, each executed by a thread mapped to a single CPU core.
    - ▻ **Pipeline_A** : Receiving and filtering packets
    - ▻ **Pipeline_B** : Encrypting packets belonging to specific flows before forwarding them to the next stage.
    - ▻ **Pipeline_C** : Transmitting packets to the external network
  - The three pipelines are interconnected via two software queues: SWQ0 and SWQ1

Problem *!!* The rate of outbound traffic is lower than that of inbound traffic

Use Case 1: DPDK Packet Framework

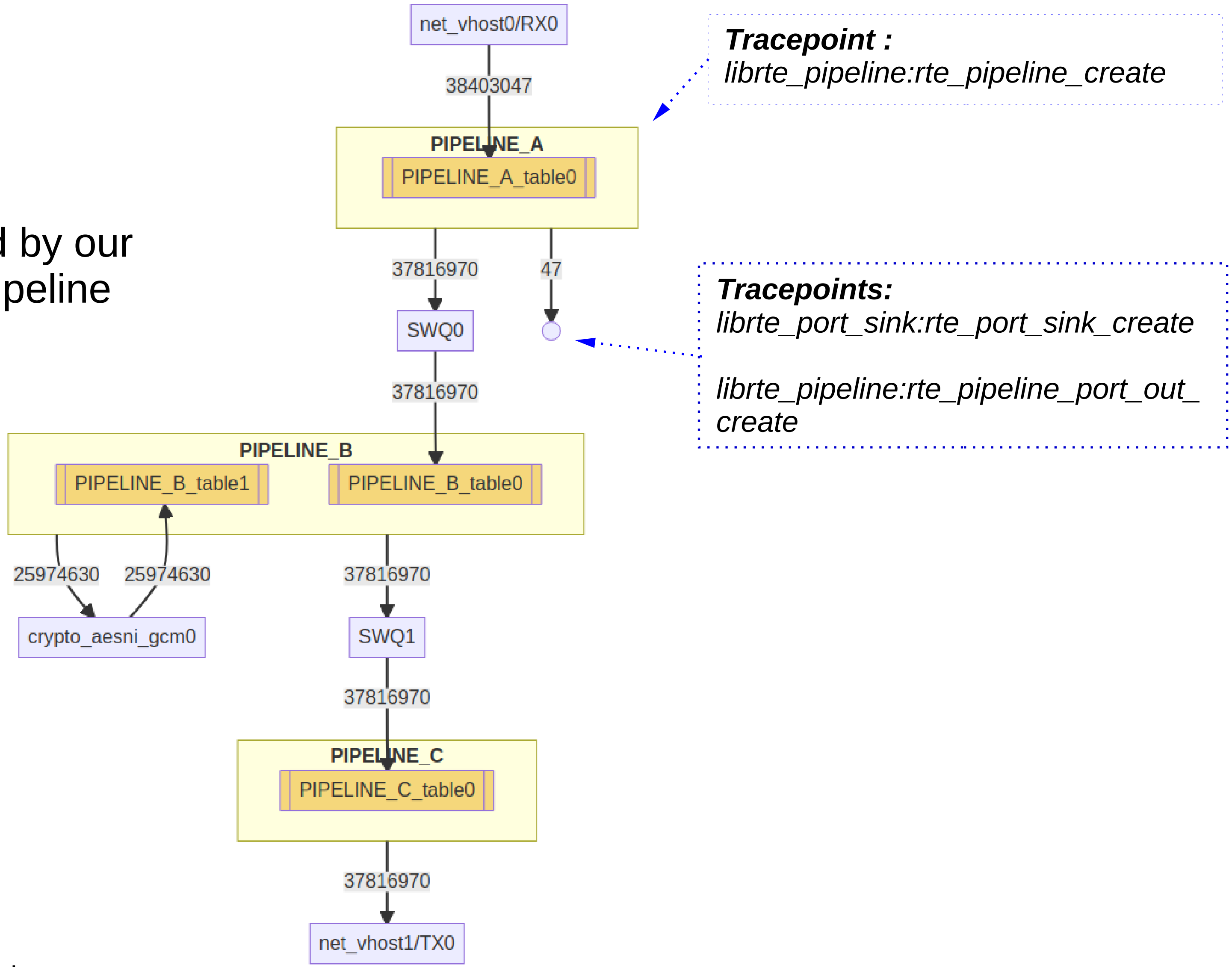


Fig. 1 : Diagram generated by our tool illustrating the super-pipeline architecture.

MERMAID
https://github.com/mermaid-js/mermaid

Use Case 1: DPDK Packet Framework

Fig. 1 : Super-pipeline transmission rate is below reception rate

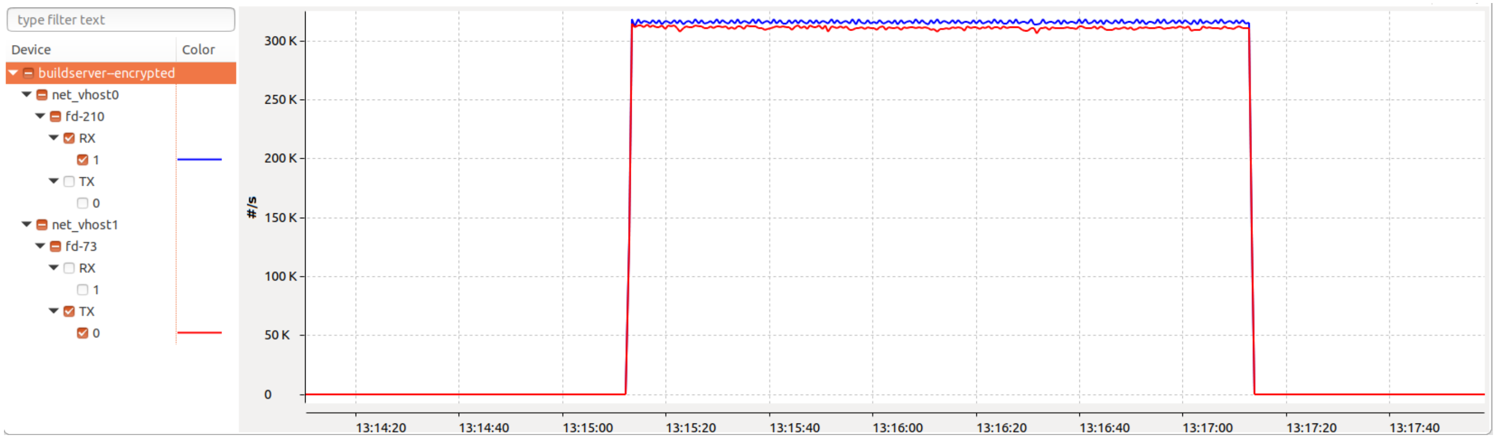
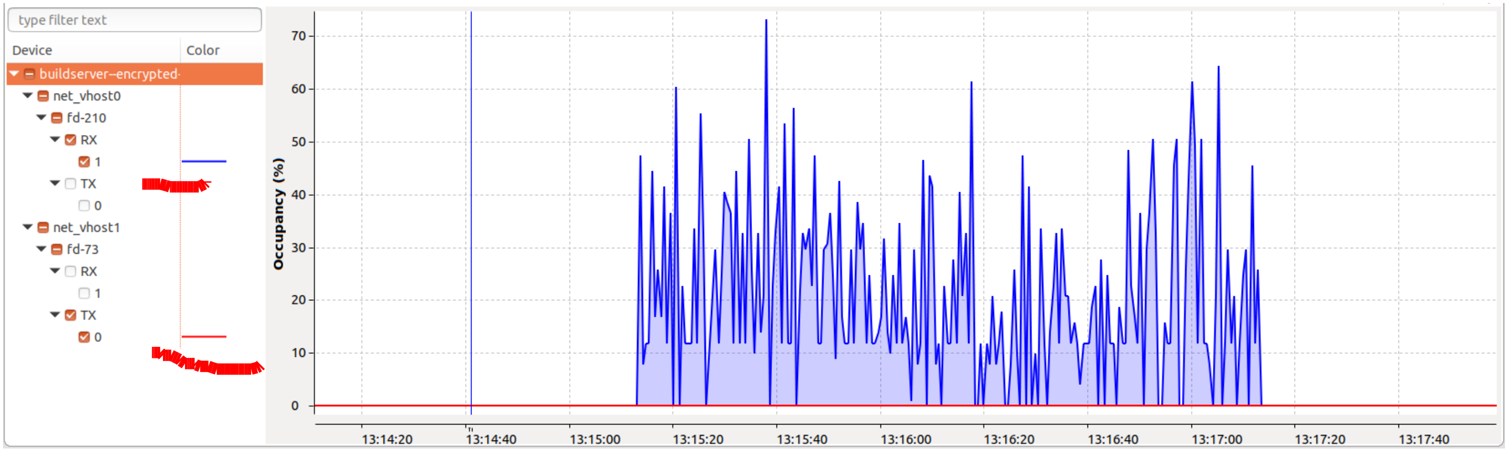


Fig. 2 : Generated traffic did not overflow the RX/TX buffers of vhost-user NICs



Use Case 1: DPDK Packet Framework

Fig. 1 : High latency of the software queue SWQ0

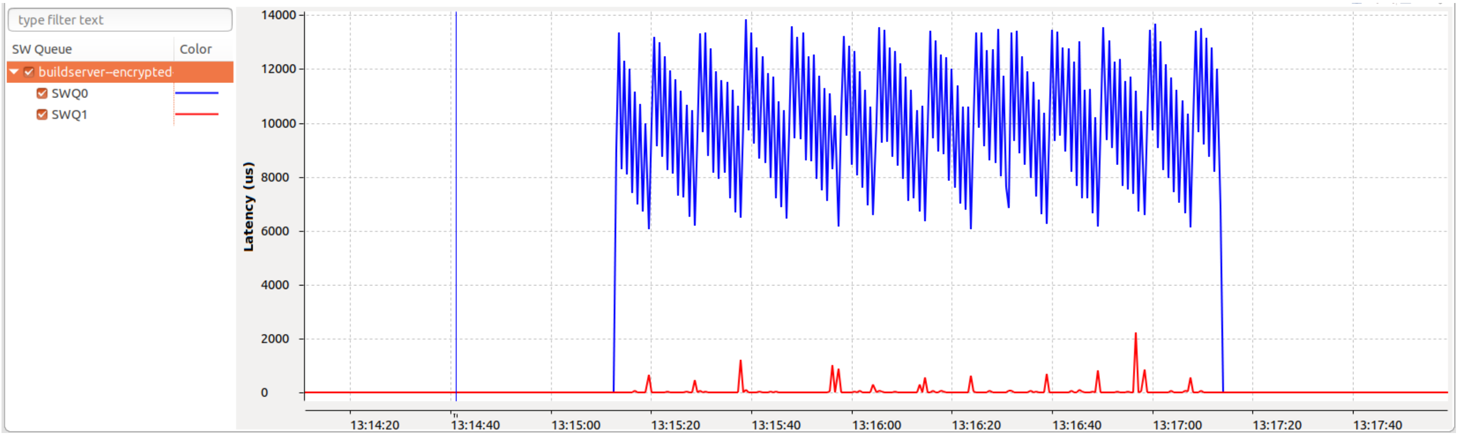
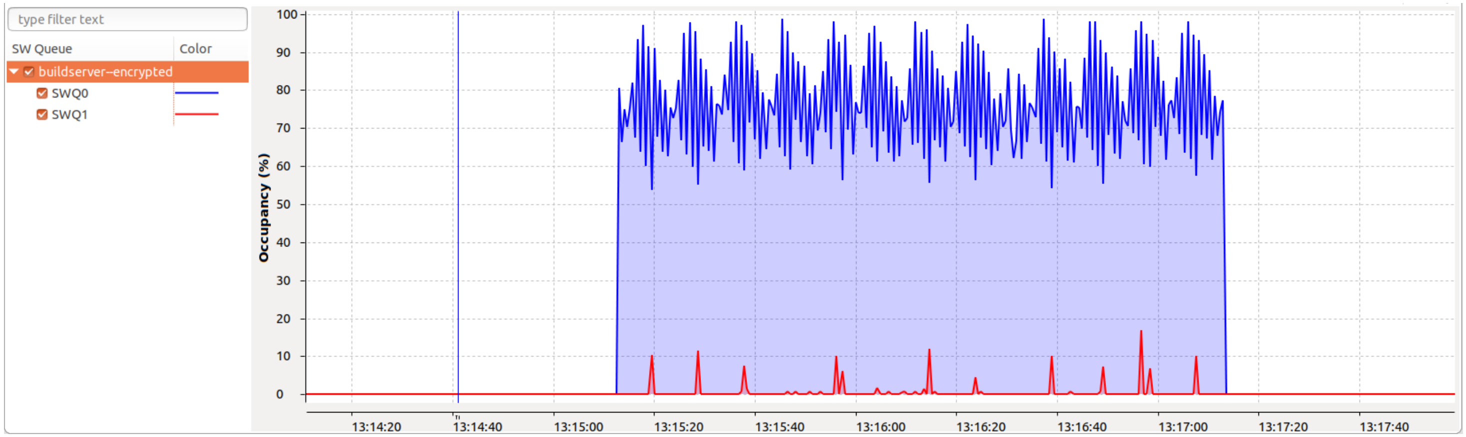


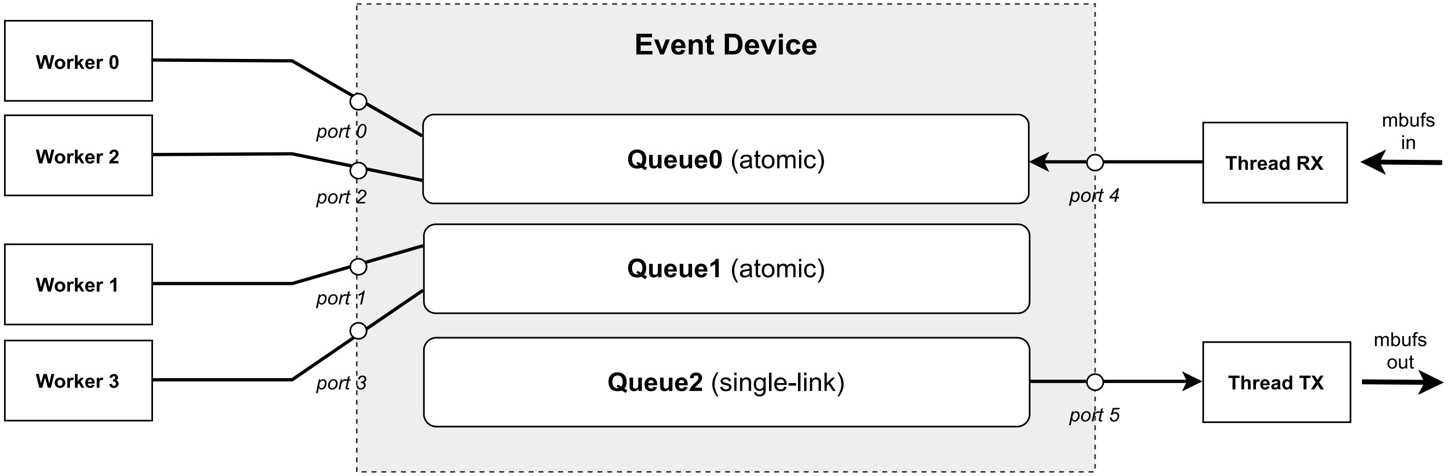
Fig. 2 : So often, SWQ0 reaches its full capacity and causes packets to be dropped



Use Case 2: EventDev Library

- Bottleneck analysis of the *Eventdev pipeline sample application*
  - Application : 1 RX thread, 1 TX thread, and 4 worker threads
  - Pipeline with 2 stages : 2 atomic queues

Fig. 1 : Architecture of the event device used in our application



Problem !! The rate of outbound traffic is lower than that of inbound traffic

Use Case 2: EventDev Library

Fig. 1: The RX buffer of the first vhost-user NIC is overflown

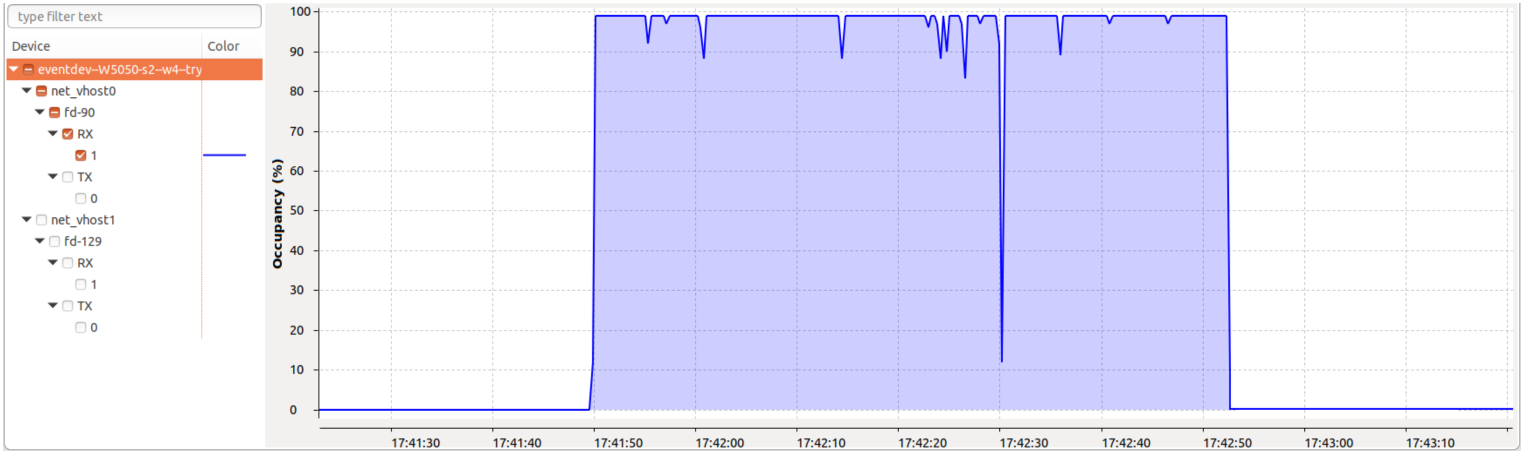
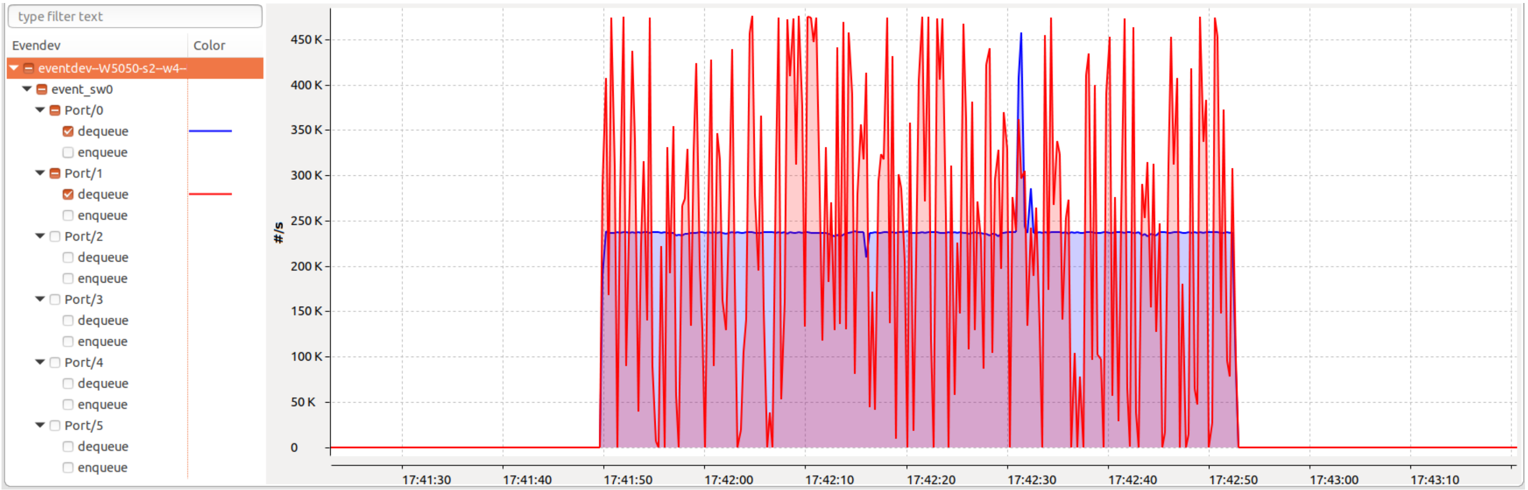


Fig. 2: Considerable fluctuation characterizes the dequeue rate of Worker1



Use Case 2: EventDev Library

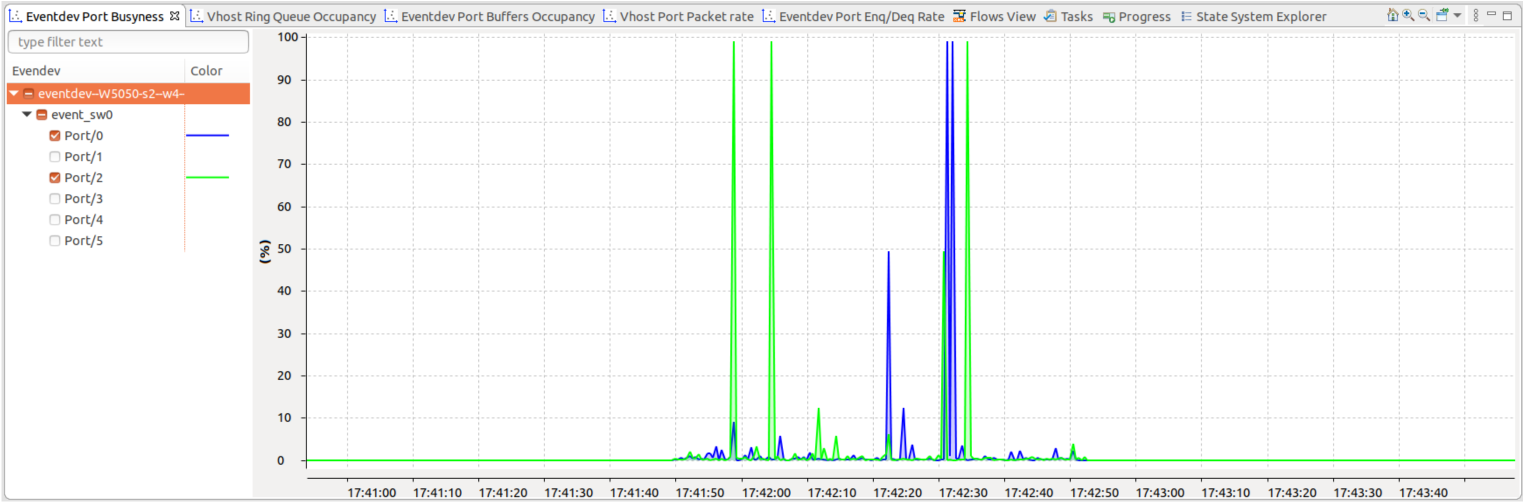


Fig. 1: The *Effective RX Spins metric* shows that the first stage workers were not overloaded

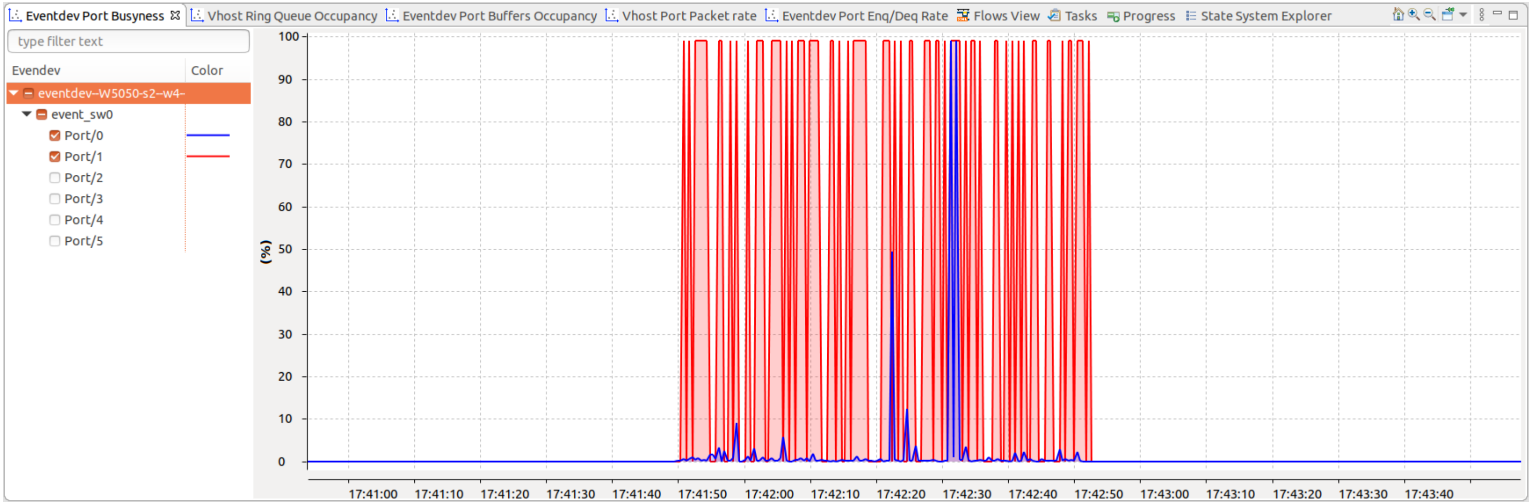


Fig. 2: The same metric shows that the second stage workers were overloaded

Use Case 2: EventDev Library

Fig. 1: *(zoomed view)* Second stage workers were dequeuing packets in turn and not in parallel !!

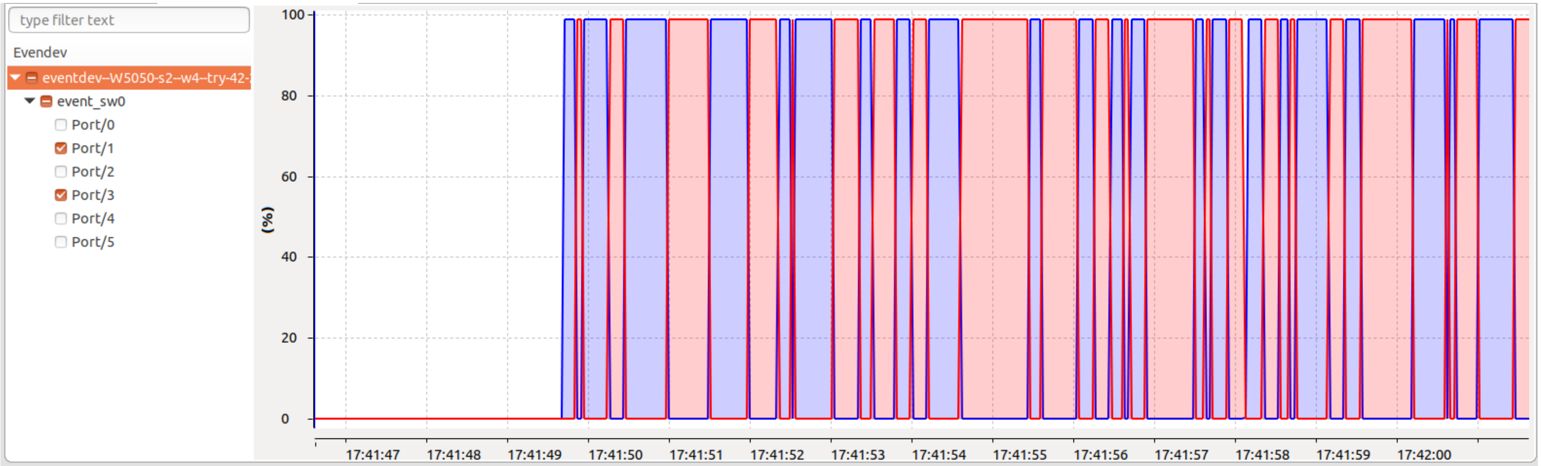
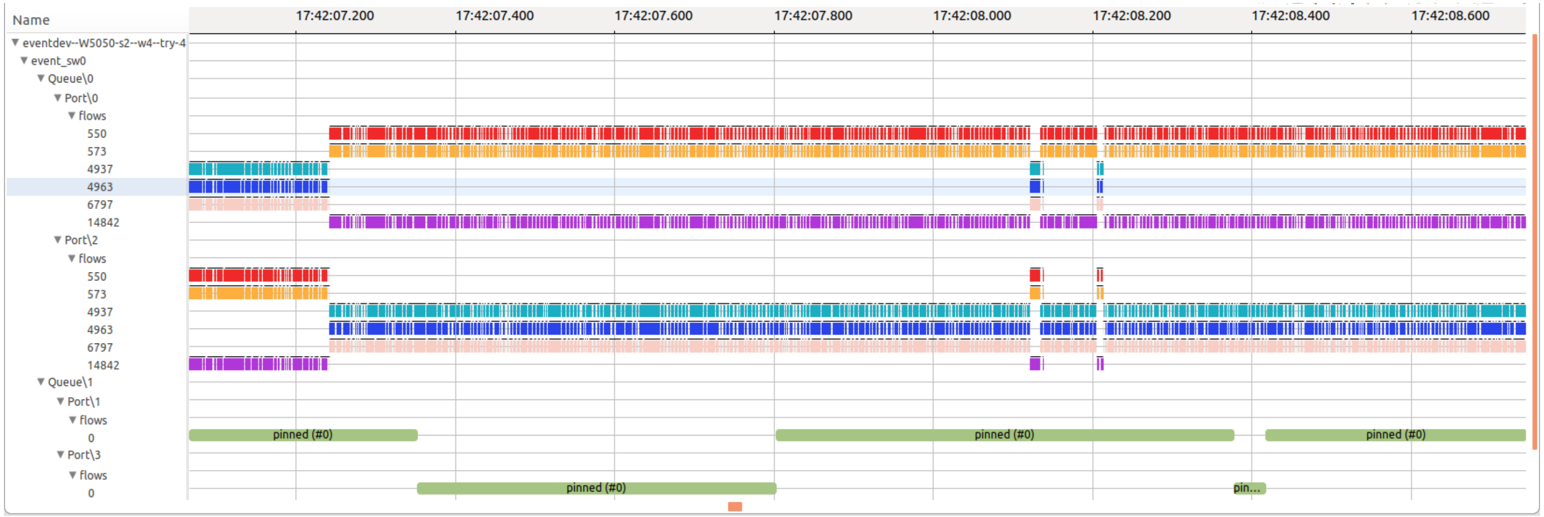


Fig. 2: The six flows processed in the first stage were merged in a single elephant flow in the second stage



Conclusion

- Tracing is an efficient technique to monitor the performance of DPDK-based applications and pinpoint their bottlenecks
- Data collection for less than 2% overhead

Questions?

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