



# The Path to DPDK Speeds for AF\_XDP

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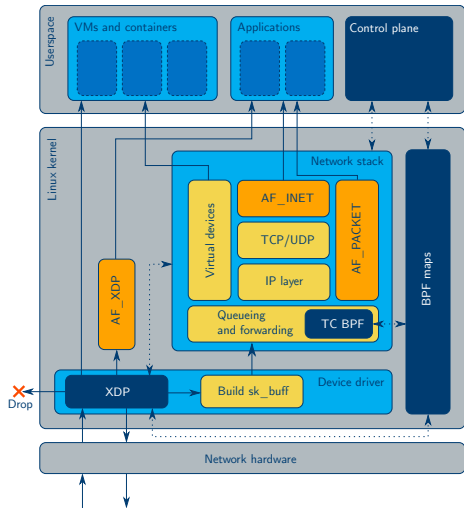
Linux Plumbers Conference, Vancouver, 2018



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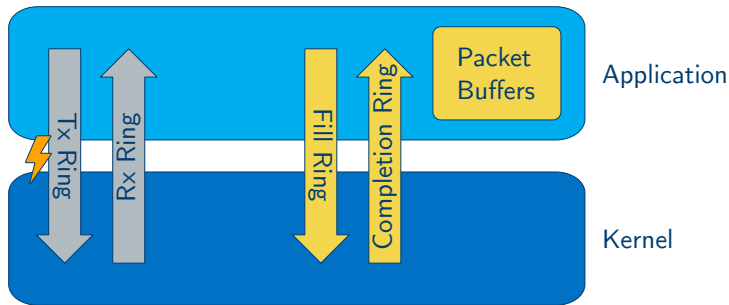
# XDP 101



"Kernel diagram" by Tole Høiland-Jørgensen licensed under CC-BY-SA

# AF\_XDP 101

- Ingress
  - Userspace XDP packet sink
  - XDP\_REDIRECT to socket via XSKMAP
- Egress
  - No XDP program
- Register userspace packet buffer memory to kernel (UMEM)
- Pass packet buffer ownership via descriptor rings



- Fill ring (to kernel) / Rx ring (from kernel)
- Tx ring (to kernel) / Completion ring (from kernel)
- Copy mode (DMA to/from kernel allocated frames, copy data to user)
- Zero-copy mode (DMA to/from user allocated frames)

# Baseline and optimization strategy

- Baseline
  - Linux 4.20
  - 64B @ ~15-22 Mpps
- Strategy
  - Do less (instructions)
  - Talk less (coherency traffic)
  - Do more at the same time (batching, i\$)
  - Land of Spectres: fewer retpolines, fewer retpolines, fewer retpolines

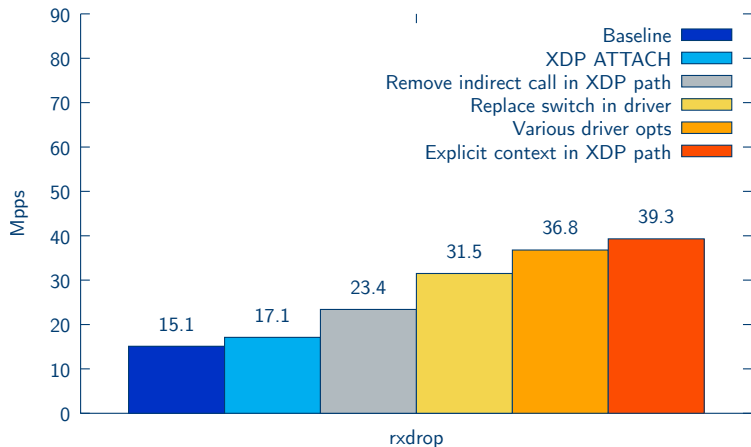
# Experimental Setup

- Broadwell E5-2660 @ 2.7GHz
- 2 cores used for run-to-completion benchmarks
- 1 core used for busy-poll benchmarks
- 2 i40e 40Gbit/s NICs, 2 AF\_XDP sockets
- Ixia load generator blasting at full 40 Gbit/s per NIC

- XDP\_ATTACH and bpf\_xsk\_redirect, attach at-most one socket per netdev queue, load built-in XDP program, 2-level hierarchy
- Remove indirect call, bpf\_prog\_run\_xdp
- Remove indirect call, XDP actions switch-statement ( $\geq 5 \implies$  jump table)
- Driver optimizations (batching, code restructure)
- bpf\_prog\_run\_xdp, xdp\_do\_redirect and xdp\_do\_flush\_map: per-CPU struct bpf\_redirect\_info + struct xdp\_buff + struct xdp\_rxq\_info vs explicit, stack-based context

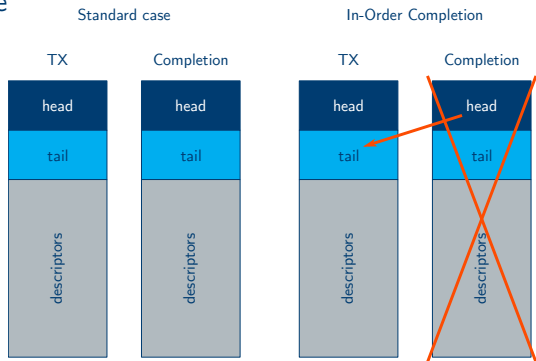


# Ingress, results, data not touched

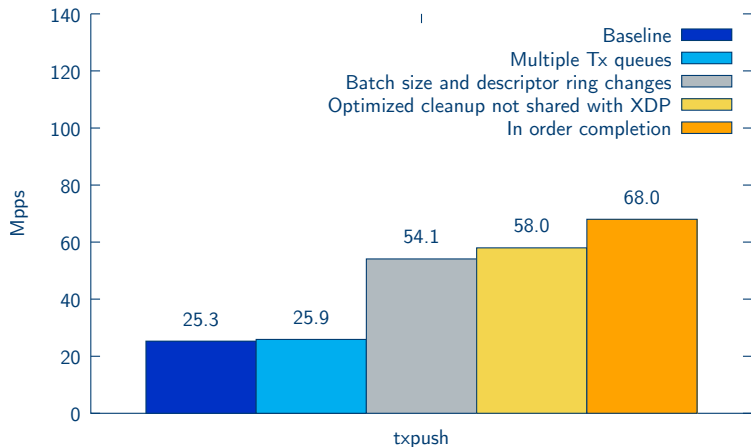


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- Tx performance capped per HW queue  
⇒ multiple Tx sockets per UMEM
- Larger/more batching, larger descriptor rings
- Dedicated AF\_XDP HW Tx queues
- In-order completion, setsockopt XDP\_INORDER\_COMPLETION

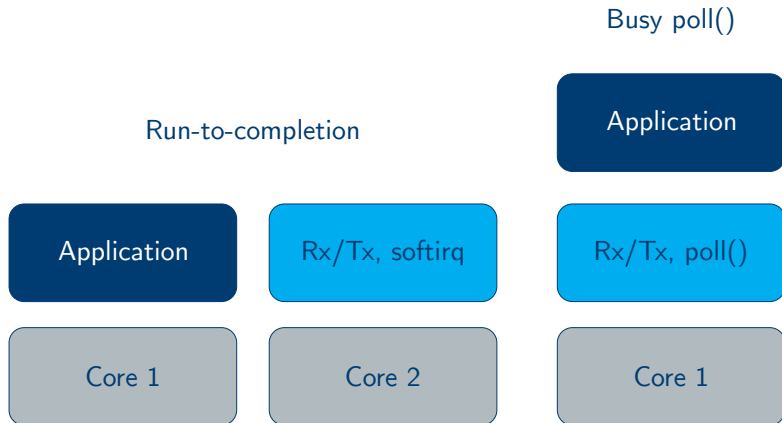


## Egress, results, data not touched

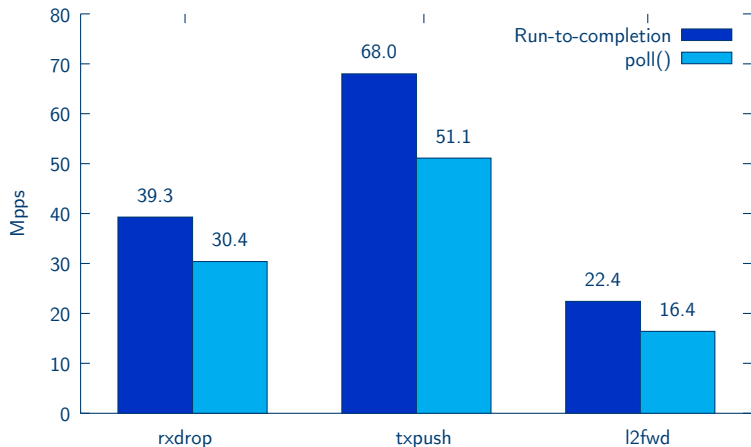


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## Busy poll() vs run-to-completion



## Busy poll() vs run-to-completion, results

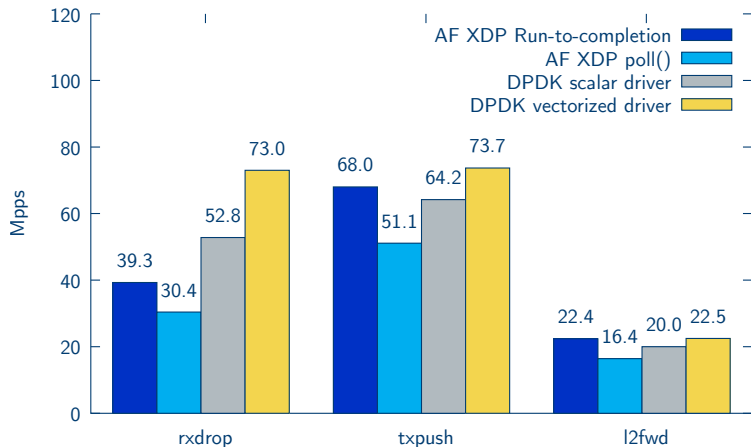


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## Comparison with DPDK

- Userspace, vectorized drivers
- “Learning from the DPDK” [http://vger.kernel.org/netconf2018\\_files/StephenHemminger\\_netconf2018.pdf](http://vger.kernel.org/netconf2018_files/StephenHemminger_netconf2018.pdf)

## Comparison with DPDK, results



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## Next steps

Upstream!

- XDP: switch-statement
- Rx/Tx: drivers
- Rx: XDP\_ATTACH and bpf\_xsk\_redirect
- libbpf AF\_XDP support
- Tx: multiple Tx sockets per UMEM
- selftest, samples



## Future work

- Hugepage support, less fill ring traffic (`get_user_pages`)
- `fd.io/VPP` work vectors (`i$`, explicit batching in function calls)
- “XDP first” drivers
- Collaborate/share code with RDMA (e.g. `get_user_pages`)
- Type-writer model (currently not planned)

## Summary

- Rx 15.1 to 39.3 Mpps (2.6x)
- Tx 25.3 to 68.0 Mpps (2.7x)
- Busy poll() promising
- DPDK still faster for “notouch”, but AF\_XDP on par when data is touched
- Drivers need to change when skb is not the only consumer

# Thanks!

- Ilias Apalodimas
- Daniel Borkmann
- Jesper Dangaard Brouer
- Willem De Bruijn
- Eric Dumazet
- Alexander Duyck
- Mykyta Iziumtsev
- Jakub Kicinski
- Song Liu
- David S. Miller
- Pavel Odintsov
- Sridhar Samudrala
- Yonghong Song
- Alexei Starovoitov
- William Tu
- Anil Vasudevan
- Jingjing Wu
- Qi Zhang

AF XDP

The logo features the text 'AF XDP' in a bold, italicized, sans-serif font. The letters are white with a thick black outline. Below the text are three parallel, curved white lines that sweep from left to right, creating a sense of motion or speed. The entire logo is set against a solid blue background.