The Path to DPDK Speeds for AF_XDP

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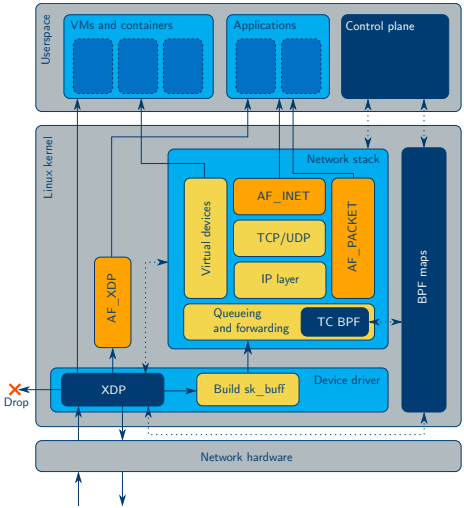
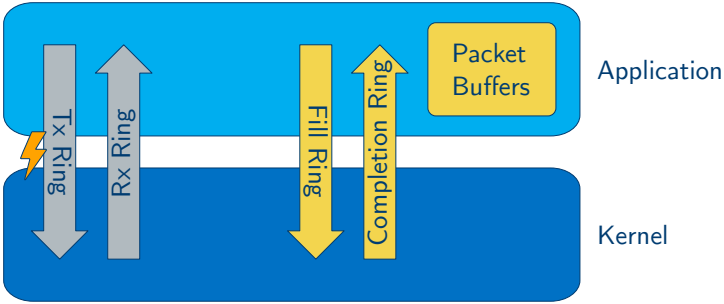
XDP 101



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

AF_XDP 101



- 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

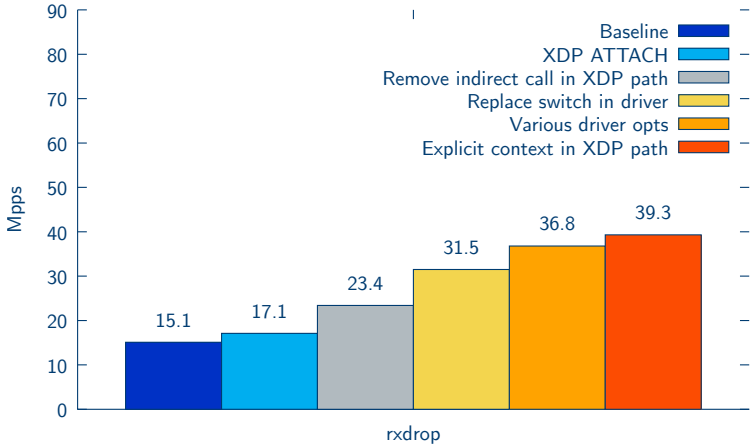
Experimental Setup

- 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

Ingress

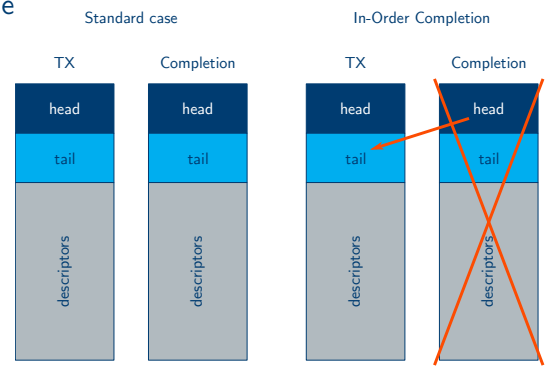
- `XDP_ATTACH` and `bpf_xsk_redirect`, attach at-most one socket per netdev queue, load built-in XDP program, 2-level hierarchy
- Remove indirect call, `bpf_prog_run_xdp`
- Remove indirect call, XDP actions switch-statement ($>= 5 \implies$ jump table)
- Driver optimizations (batching, code restructure)
- `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

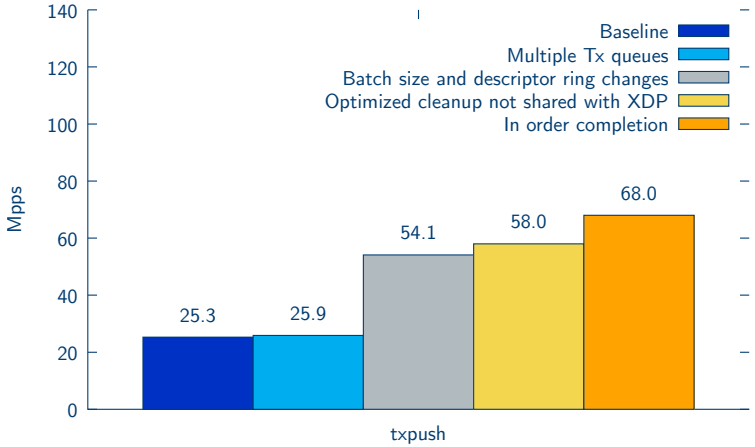


Egress

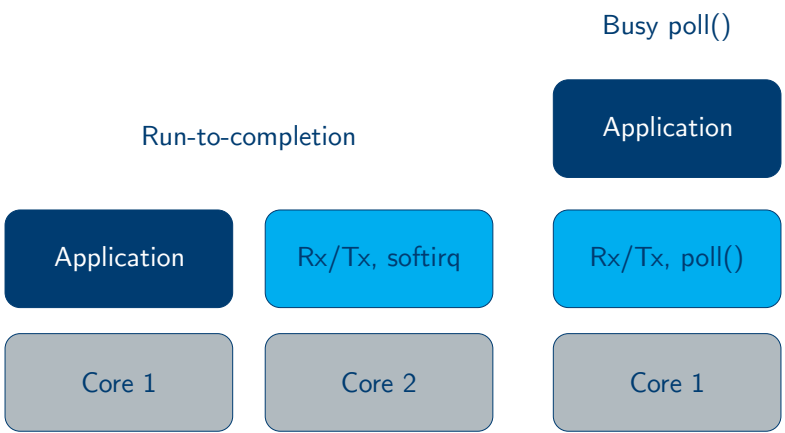
- Tx performance capped per HW queue $\Longrightarrow$ multiple Tx sockets per UMEM
- Larger/more batching, larger descriptor rings
- Dedicated AF_XDP HW Tx queues
- In-order completion, `setsockopt XDP_INORDER_COMPLETION`



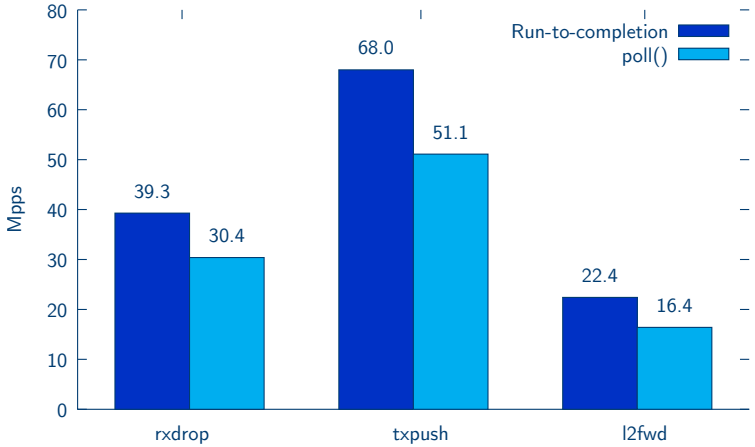
Egress, results, data not touched



Busy poll() vs run-to-completion



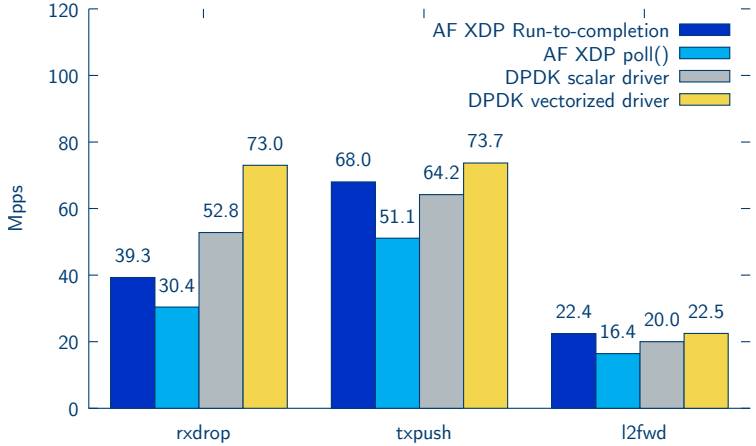
Busy poll() vs run-to-completion, results



Comparison with DPDK

- Userspace, vectorized drivers
- "Learning from the DPDK" `http://vger.kernel.org/netconf2018_files/StephenHemminger_netconf2018.pdf`

Comparison with DPDK, results



Next steps

Upstream!

- XDP: switch-statement
- Rx/Tx: drivers
- Rx: `XDP_ATTTACH` 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!

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AF
XDP