The Path to DPDK Speeds for AF_XDP

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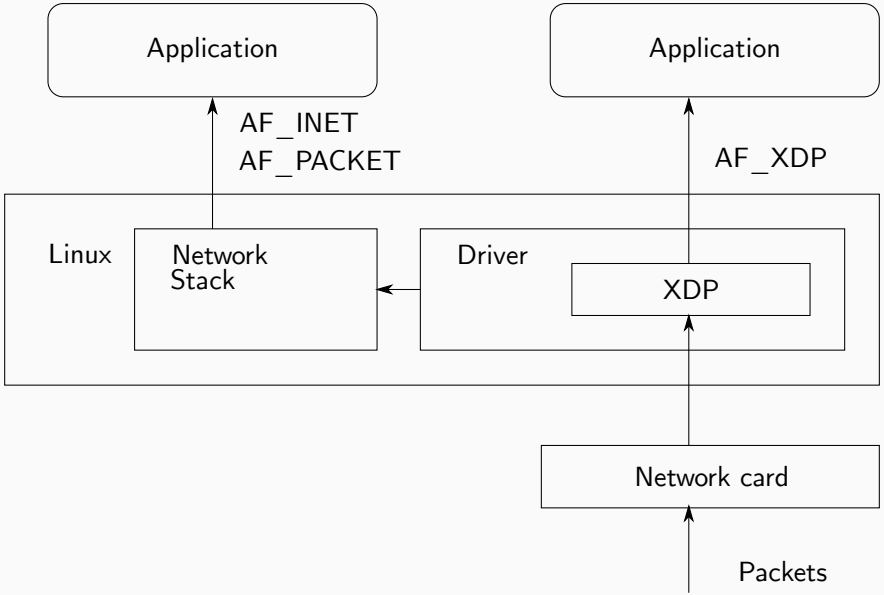
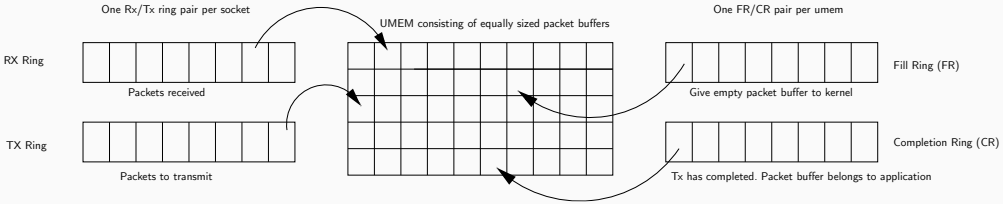
XDP 101


Application
Application
AF_INET
AF_PACKET
AF_XDP
Linux
Network Stack
Driver
XDP
Network card
Packets

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 repolines

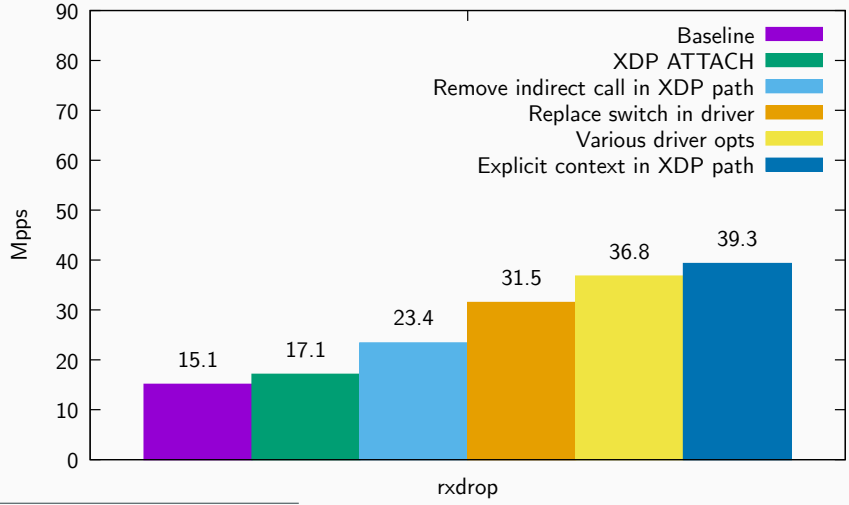
Experimental Setup

- 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

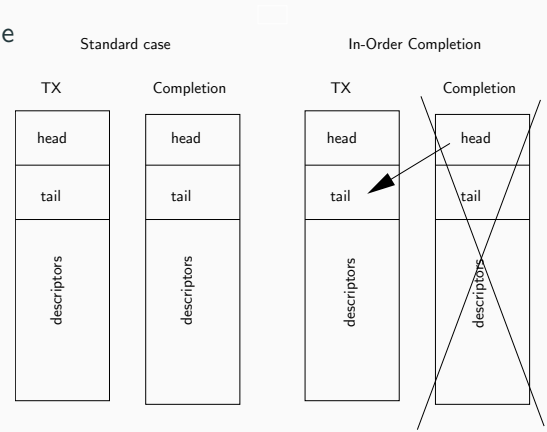
Ingress, results[1], data not touched



[1] Results have bee estimated based on internal Intel analysis and are provided for informational purposes only. Any difference in system hardware or software design or configuration may affect actual performance. Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more information go to http://www.intel.com/performance/datacenter.

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`



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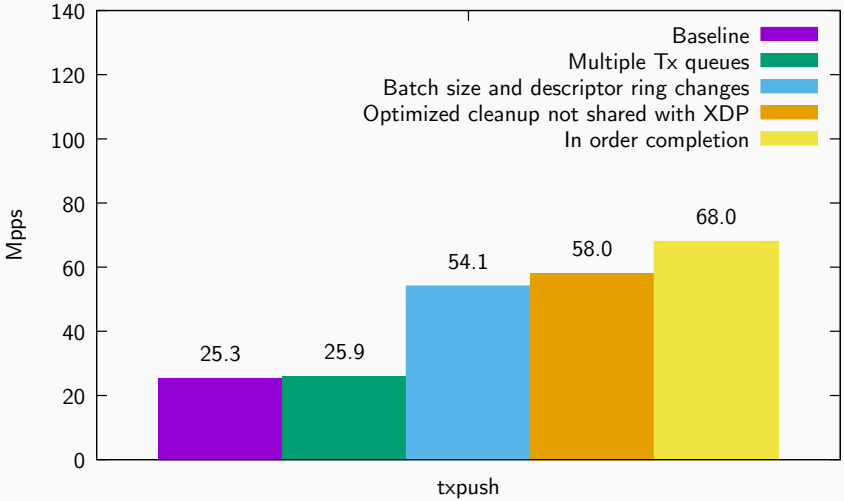

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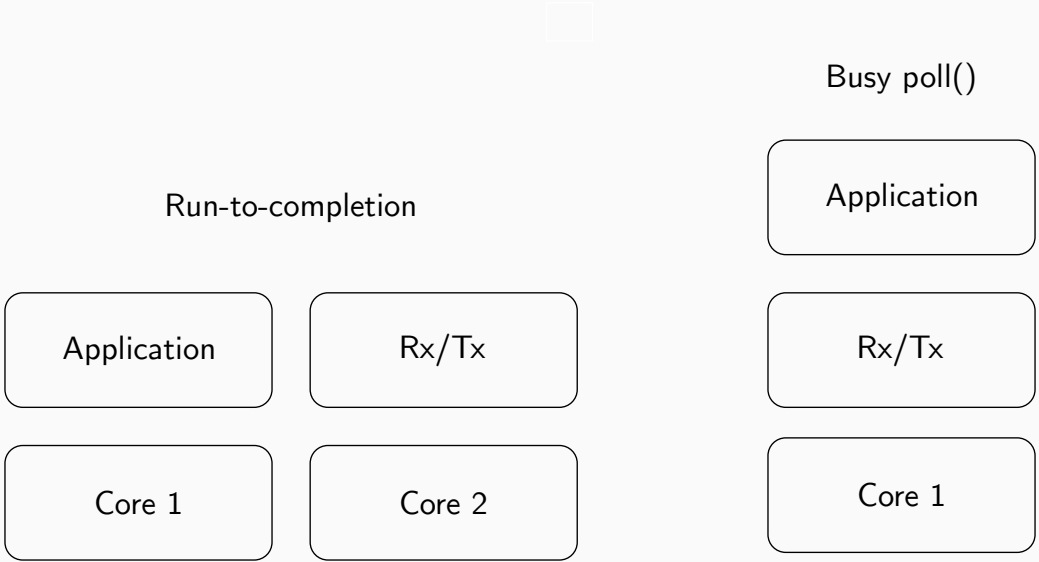
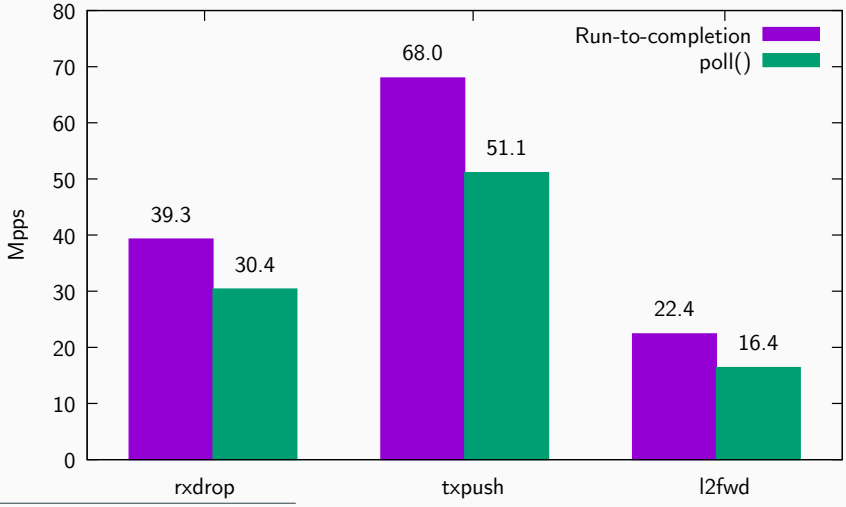
Busy poll() vs run-to-completion



Busy poll() vs run-to-completion, results[1]



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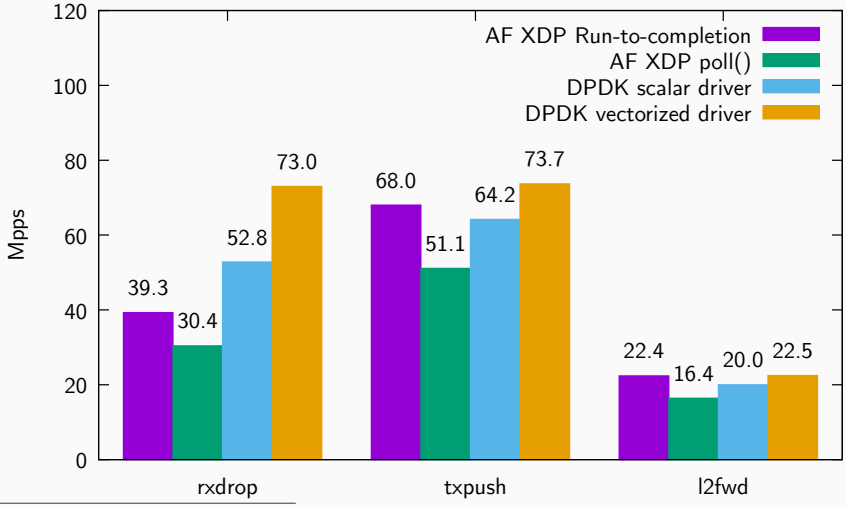
Comparison with DPDK

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

Comparison with DPDK, results[1]



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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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Questions?