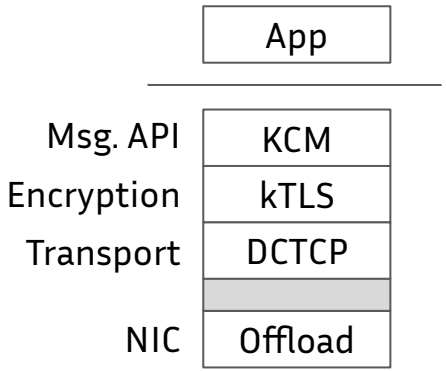
HomaLS: Tunneling Messages through Secure Segments

Tianyi Gao and Michio Honda
University of Edinburgh

Netdev 0x16
October 26, 2022, Lisbon

Motivation

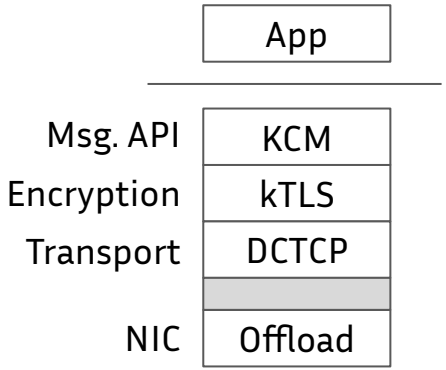
- Datacenter transport needs encryption
  - Third-party network/hardware/software on the paths



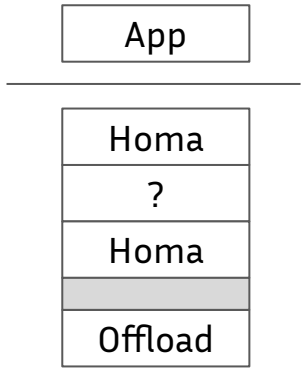
Datacenter networking stack
[NetDev 1.2 2016]

Motivation

- Datacenter transport needs encryption
  - Third-party network/hardware/software on the paths
- Homa enables low latency and message-native transport



Datacenter networking stack
[NetDev 1.2 2016]



It's time to replace TCP in
the datacenter [NetDev 0x16 2022]

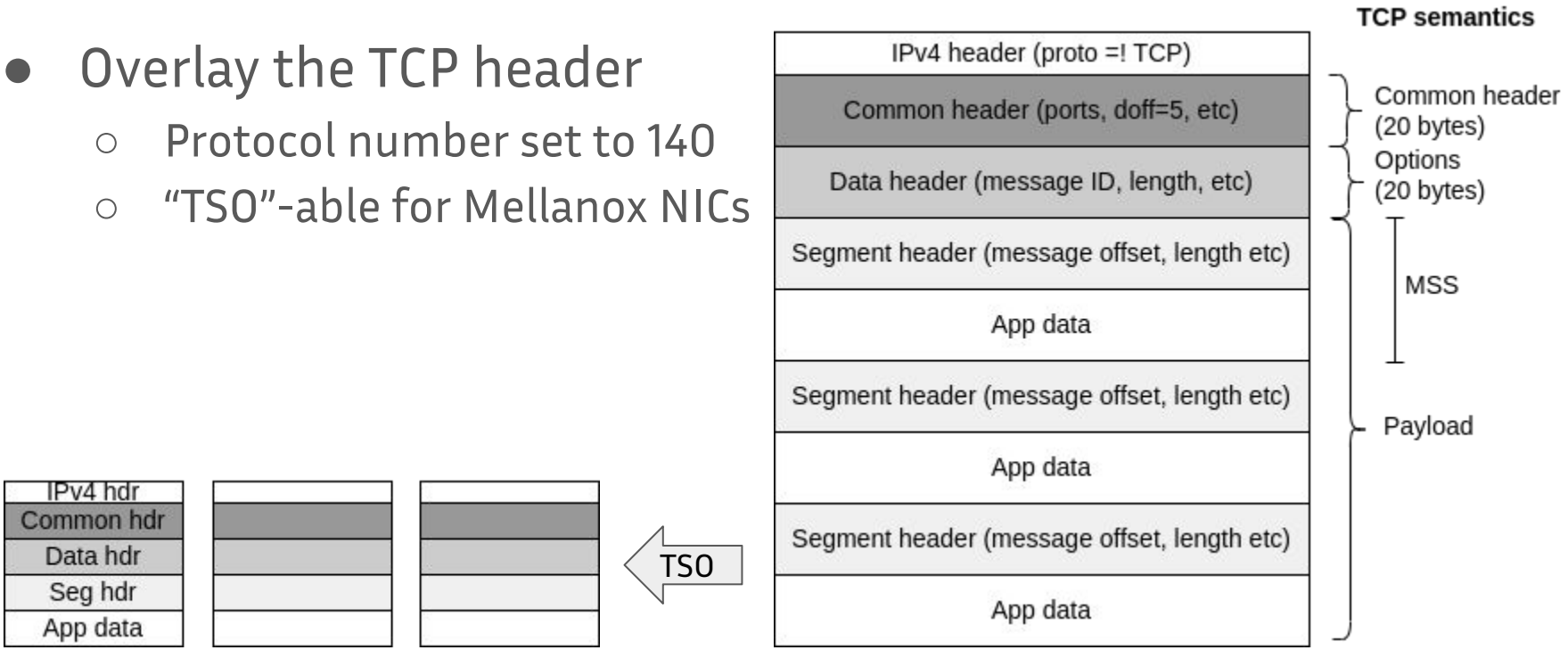
How to get encrypted?

Review: Encryption in transport

- Ubiquitous encryption
- Encryption at segmentation
- Opportunistic hw offload
- In-kernel users

Homa GSO segment

- Overlay the TCP header
  - Protocol number set to 140
  - “TSO”-able for Mellanox NICs



Encrypting Homa segments

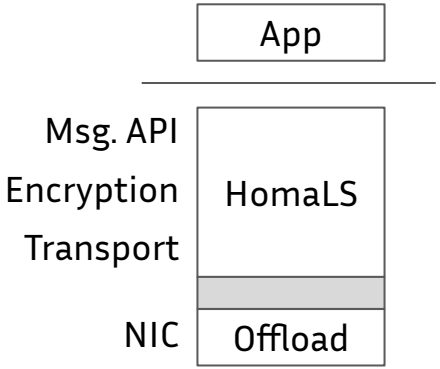
- kTLS offload (TLS_DEVICE) is a candidate
  - Together with TSO
- We need NICs that work for:
  - Non-TCP in the IPv4 header
  - Preserve TCP options
- ~~Chelsio T6~~
- **Mellanox CX-6**

Encrypting Homa segments

- **TLS offloading seems to work for Mellanox CX6**
- Preliminary experiment:
  - Rewrite the proto no. in the IPv4 header in a TCP's GSO segment in the driver (`mlx5e_xmit_core()`), and see what are generated
    - Non-TSO TX command needs a driver patch to avoid `eth_get_headlen()` in `mlx5e_calc_min_inline()`

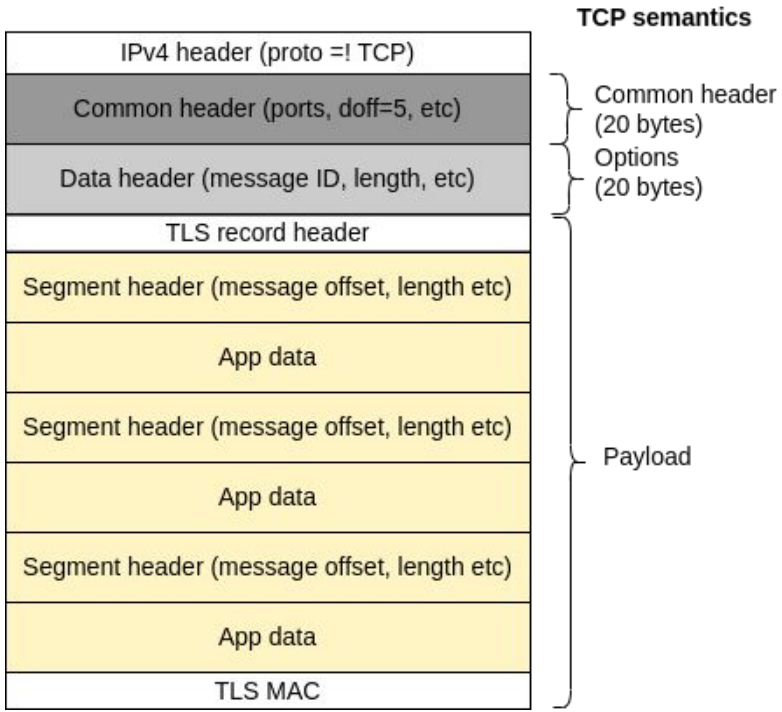
HomaLS (Homa-Layer Security)

- Integrate Homa with TLS



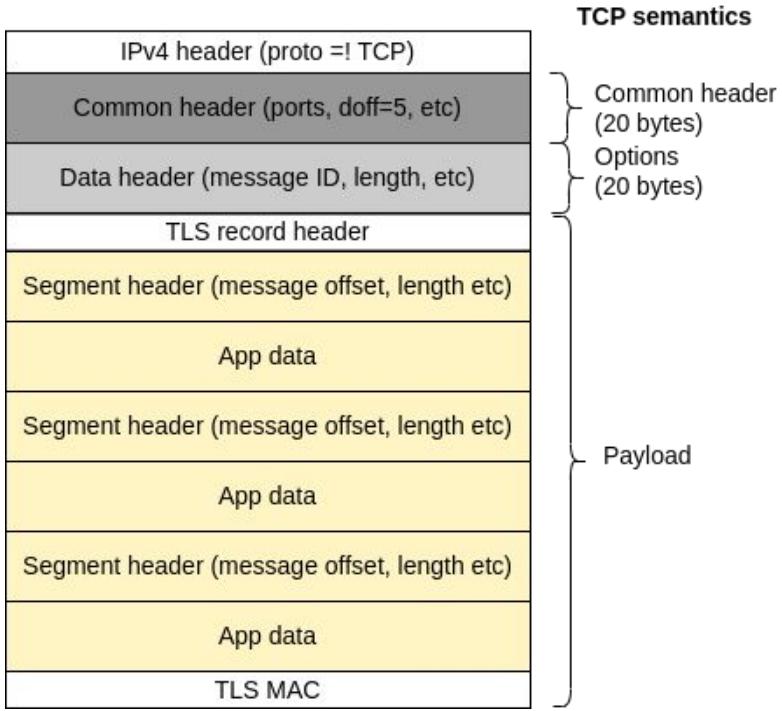
HomaLS (Homa-Layer Security)

- Integrate Homa with TLS
  - Resemble TLS/GSO segment to the hardware (except for proto no.)



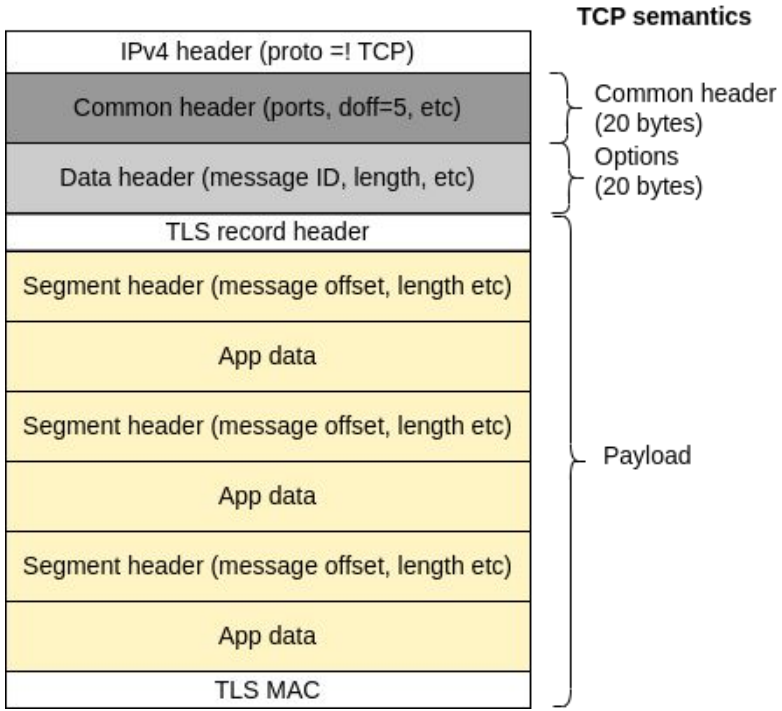
HomaLS (Homa-Layer Security)

- Integrate Homa with TLS
  - Resemble TLS/GSO segment to the hardware (except for proto no.)
  - (for now) IPID for reassembling
    - Will switch to TCP seqno



HomaLS (Homa-Layer Security)

- Integrate Homa with TLS
  - Resemble TLS/GSO segment to the hardware (except for proto no.)
  - (for now) IPID for reassembling
    - Will switch to TCP seqno
  - Per-client (4-tuple) key
    - `setsockopt()` like kTLS

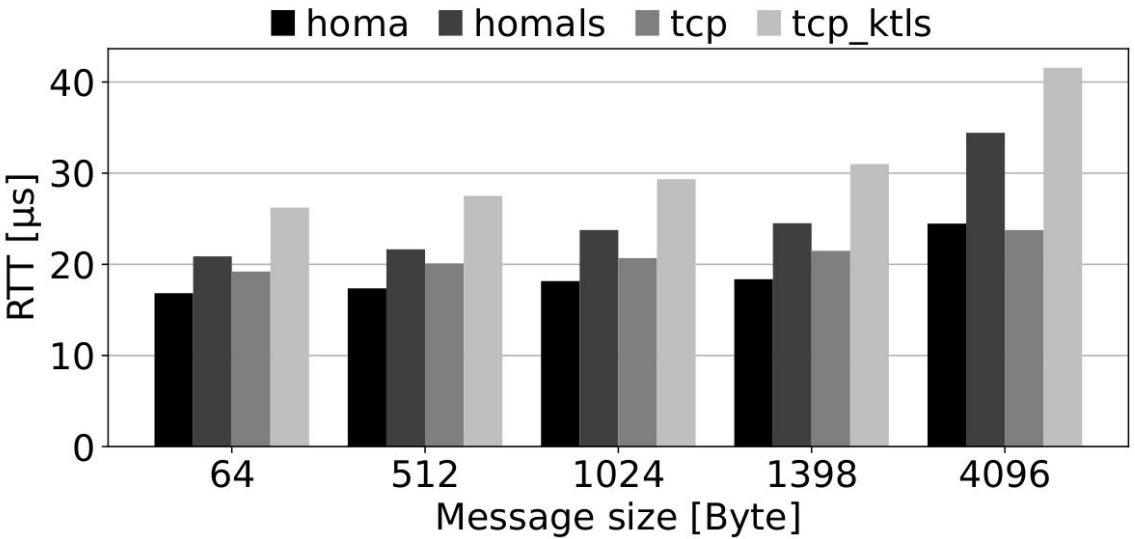


Software architecture

- Like kTLS
  - `setsockopt()` to register (exchanged) key to a socket
- Unlike kTLS
  - No ULP - integrated into Homa closely
  - TLS context holds remote address and port
    - Homa socket is one-to-many
- ~800 LoC
  - SW implementation
  - HW offloading is work-in-progress

Performance

- Message RTTs
- SW crypto
  - TSO but no TLS offload
- 17-21% shorter RTT than kTLS/TCP



Two machines equipped with Xeon E5-2640v4 and ConnectX-4 NIC

Summary and discussion

- RX-side offload
- Test more NICs for kTLS offload over non TCP packets
  - Netronome NFP3800, Intel IPUs, any others?
- Use of PSP instead of kTLS
  - When will the hardware offloading be ubiquitous?

https://github.com/uoenoplab/HomaLS-netdev0x16