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Precise Real-Time Monitoring of Time-Critical Flows

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Motivation

- Ethernet is replacing many specialized field bus systems
  - pervading areas with time deterministic and reliable communication requirements
  - transporting heterogeneous traffic such as application specific data and internet protocols at high packet rates
- Ethernet extended with Time-Sensitive Networking (TSN) enables deterministic and reliable communication

⚡ complex configuration and hardware/software architectures ⚡

Goals

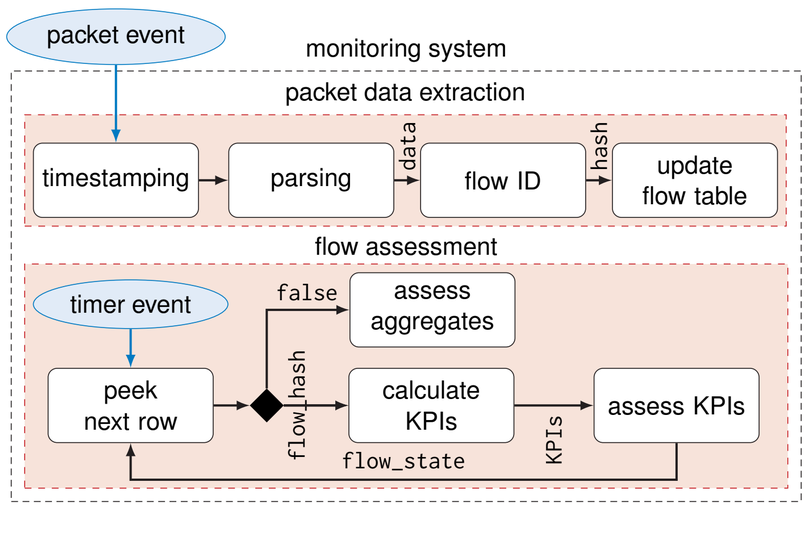
"Guaranteed that flow specifications are never violated?"

⇒ monitoring to supervise time-critical network flow properties

Requirements

- short detection latency
- easy integration
- scalable to high flow counts and packet rates
- per-flow measurement and classification of relevant time-critical Key Performance Indicators (KPIs)

Design



- DPDK-based software
  - portable (e.g. to SmartNICs)
  - low-latency poll-mode drivers
- optionally: use in-band information from encapsulation or application protocols (e.g. transmit timestamps or sequence numbers)

Components

packet data extraction

- *timestamping* using Intel© X550 NICs
- *parsing* free adaptability to use-case
- *flow ID* e.g. the 5 tuple or stream ID
- *update flow table* hash table, holding flow state

flow assessment

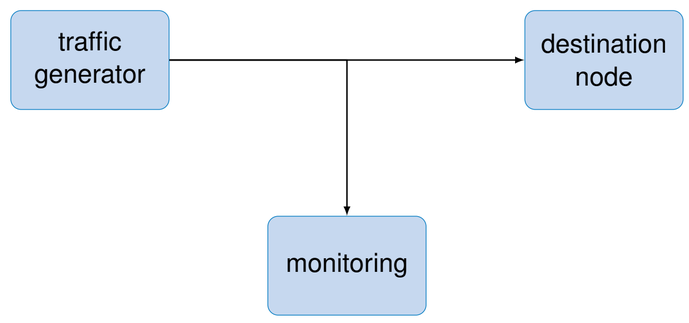
- time-triggered, use-case specific logic
- assessment using (historic) state data
- KPIs covering flow requirements
- classification using threshold values

aggregation

- based on nodes, applications or links

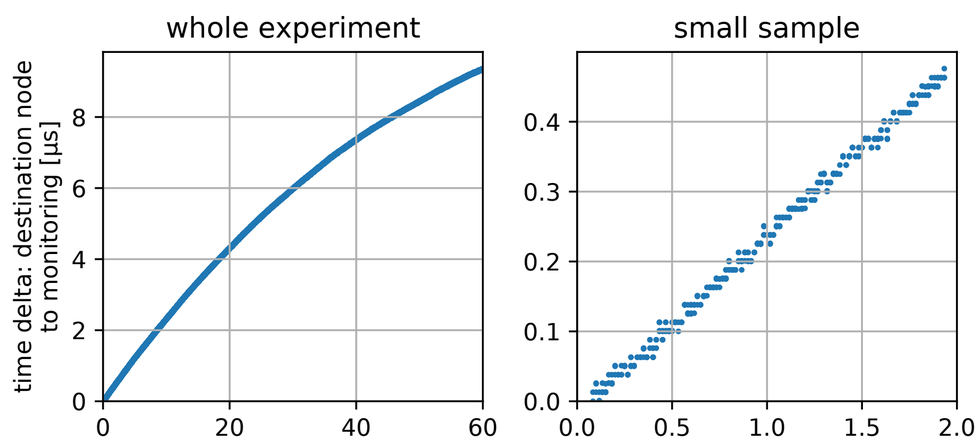
⇒ facilitate root cause analysis

Evaluation Setup



- *traffic generator* sends automotive camera traffic [3]
- *destination node* packet sniffing using MoonGen [1, 2]
- *monitoring* receives signal, split using passive fiber TAPs

Evaluation Results



Difference between timestamps taken at *monitoring* and *destination node*; right plot shows subsample

- systematic non-linear errors (e.g. clock drift) dominate result
- discretization resolution of 12.5 ns is visible in right plot

⇒ high timestamping accuracy

⇒ viable approach for monitoring time-critical flows

[1] P. Emmerich, S. Gallenmüller, D. Raumer, F. Wohlfart, and G. Carle. Moongen: A scriptable high-speed packet generator. In *Proceedings of the 2015 Internet Measurement Conference*.
[2] S. Gallenmüller, J. Naab, I. Adam, and G. Carle. 5G QoS: Impact of Security Functions on Latency. In *NOMS 2020-2020 IEEE/IFIP Network Operations and Management Symposium*. IEEE.
[3] J. Migge, J. Villanueva, N. Navet, and M. Boyer. Insights on the Performance and Configuration of AVB and TSN in Automotive Ethernet Networks. In *Proc. ERTS 2018*.