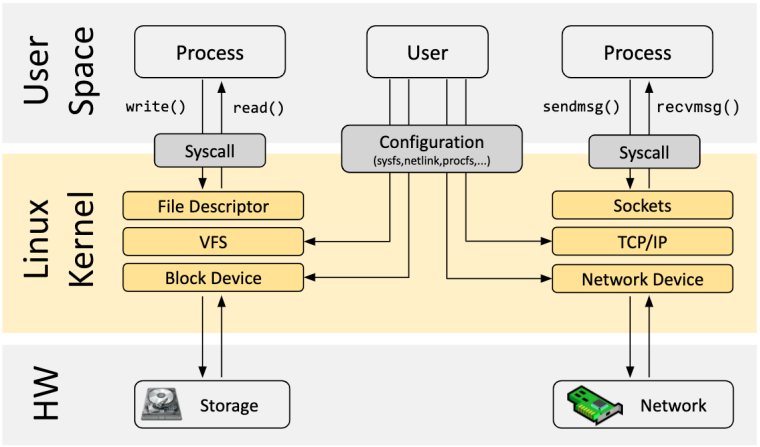
TECHNISCHE UNIVERSITÄT DRESDEN

ComNets
Deutsche Telekom Chair of Communication Networks

Faculty of Electrical and Computer Engineering Institute of Communication Technology

Implementation of Asynchronous Traffic Shaper in Linux Kernel Space using High-Performance Data Processing

Project Topic for Student/Master/Diploma Thesis



Source: ebpf.io[Link]

Description

Traditional networks provide best-effort connections. While they can achieve end-to-end latencies of a few milliseconds, the variance is often too high for certain use-cases. However, for future industrial applications, guaranteed ultra-Low latency on the scale of a few microseconds to a few milliseconds is required.

Time-Sensitive Networking (TSN) is a set of IEEE standards to achieve deterministic[Link] communication over Ethernet networks. This is especially relevant for industrial domains, such as medical, banking, avionics, or automotive. The communication is characterized by strict requirements on delay, packet delay variations, and packet loss. In order to achieve certain guarantees, the TSN standards provide different algorithms, metrics and tools.

One very important part of TSN are *traffic shapers*. In order to multiplex different connections in a communication node, e.g., a network switch, it is necessary to *schedule* them. Broadly speaking, arriving packets are put in one or multiple network queues, and a scheduler determines when to enqueue them for transmission. There are lots of existing scheduling algorithms, such as in the simplest way *FIFO - First In First Out*.

The IEEE standard 802.1Qcr provides an Asynchronous Traffic Shaper (ATS). In contrast to the Time-aware Shaper (TAS) defined by IEEE 802.1Qbv, it does not rely on tight time synchronization. Unfortunately, to best of our knowledge, there is no hardware implementation. Therefore, the thesis should investigate the performance of the ATS under real world conditions. Furthermore, the implementation should leverage eBPF in conjunction with Express Data Path (XDP) to build on top of the existing Linux network features. eBPF and XDP offer great performance and possibilities for packet processing on x86 hardware. As a result, the thesis should provide a comparison with a Commercial-of-the-Shelf (COTS) TAS-capable switch.

Tasks

- get familiar with the topic: TSN and ATS; Linux, eBPF and XDP
- literature study (as well as code examples, tutorials, etc.)
- setup test environment (concept, hardware/software implementation, test procedure, measurement possibilities)
- implement the ATS with eBPF and XDP
- evaluate and discuss your results

Keywords

Time-Sensitive Networking, Linux, Programming, Networking, Performance Evaluation

Resources and Material

- Time-Sensitive Networking
  - Wikipedia[Link]
  - very informative survey paper, don't be afraid of the number of pages, only focus on TSN part, use as reference: A. Nasrallah et al.: "*Ultra-Low Latency (ULL) Networks: The IEEE TSN and IETF DetNet Standards and Related 5G ULL Research*"[Link]
  - Z. Zhou et al.: "*Analysis and modeling of asynchronous traffic shaping in time sensitive networks*"[Link]
- eBPF, XDP
  - eBPF.io project page[Link]
  - BPF and XDP Reference Guide[Link]
  - eBPF XDP: The Basics and a Quick Tutorial[Link]

Requirements

- visited courses: ComNets1, ComNets2
- good understanding of packet-based networking, Linux network stack
- program language: C, Go
- motivation(!) to work on the topic; ability to work independently and communicate with supervisors; solve emerging problems (we provide a good supervision but we expect that the student can work on his/her own)

Contact

- Supervisors: Stefan Senk, Hosein K. Nazari, How-Hang Liu
- Language: German or English
- Start: as soon as possible