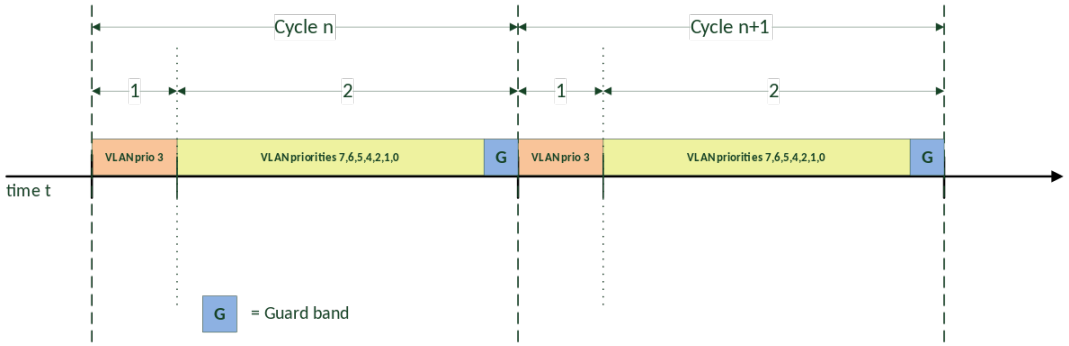
TECHNISCHE UNIVERSITÄT DRESDEN

ComNets
Deutsche Telekom Chair of Communication Networks

Faculty of Electrical and Computer Engineering Institute of Communication Technology

Intelligent Optimization using AI for Emerging Time-Sensitive Applications

Project Topic for Student/Master/Diploma Thesis



Source: Wikimedia, Ulgorash[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 is IEEE 802.1Qbv which defines a Time-aware Shaper (TAS). An Ethernet communication can thereby treated in a TDMA-manner. Since industrial communication is often cyclic, the Ethernet data stream is therefore treated similarly. In each cycle, *VLAN priorities* get (dedicated) channel access minimizing resource contention. The complexity of calculating the underlying schedule can increase significantly for large networks. Traffic with different priorities must be treated differently, which is subject to the scheduling. Additionally, dynamic changes in adding or dropping connections, e.g., caused by user mobility, amplifies the load on schedule computation.

Hence, the project work should investigate the possibility of using Artificial Intelligence (AI) for optimizing the TAS schedule. Optimizations have been studied in research before but in the

majority deterministic algorithms were used before. Specifically, Reinforcement Learning (RL) should be evaluated in the thesis to benefit of its online learning capabilities. It is needed to be adaptive for dynamic changes in system.

Tasks

- get familiar with the topic: TSN and TAS, AI and RL, OMNeT++ and RL Gym by OpenAI
- literature study
- setup testbed based on OMNeT++ network simulator
- develop enhancements/optimizations based on AI
- evaluate and discuss your results

Keywords

Time-Sensitive Networking, Artificial Intelligence, Programming, Networking, Performance Evaluation

Resources and Material

- Time-Sensitive Networking
  - Wikipedia[Link]
  - A. Nasrallah et al.: "*Ultra-Low Latency (ULL) Networks: The IEEE TSN and IETF DetNet Standards and Related 5G ULL Research*"[Link]
- OMNeT++ – Discrete Event Simulator[Link]
- Artificial Intelligence
  - AI introduction[Link]
  - RL introduction[Link]
  - Gym documentation[Link]

Requirements

- visited courses: ComNets1, ComNets2
- desired: knowledge about linear algebra

- very good understanding of packet-based networking
- program language: C++ (for OMNeT++), Python/C++ (AI, RL)
- 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