OMNeT++ Community Summit, 2021

Time Sensitive Networking (TSN)
in the INET Framework

Background

- Application Areas

  - Originated from large multi-media networks

  - Nowadays used in industrial and in-vehicle networks

- IEEE 802.1 standard

- Goals

  - Bounded latency

  - Low packet delay variation

  - Low packet loss

  - Fault tolerance

Covered Topics

- Time synchronization (802.1 AS)

- Per-stream filtering and policing (802.1 Qci)

- Scheduling and traffic shaping (802.1 Qav, Qbv and Qcr)

- Frame replication and elimination (802.1 CB)

- Frame preemption and cut-through switching (802.1 Qbu)

Time Synchronization (802.1 AS)

- Standard INET application

- Master, bridge and end-station network nodes

- Link delay measurement and time synchronization

- Multiple time domains and synchronization trees

- Master clock failover

- Various clock and oscillator models

Time Synchronization Live Demo

DON'T PANIC

Per-stream Filtering and Policing (802.1 Qci)

- Composable mechanism using queueing model elements
  - Classifiers, meters, filters, gates, multiplexers, etc.
- Various frame classification methods
- Several stream metering and frame filtering methods
- Chained token buckets with token overflow
  - Committed and excess information rate
  - Committed and excess burst size
- Transmission eligibility time scheduling

Per-stream Filtering and Policing Live Demo

Scheduling and Traffic Shaping

- Composable mechanism using queueing model elements
  - Classifiers, queues, gates, schedulers, etc.
- Various frame classification methods
- Credit-based shaping (802.1 Qav)
- Time-aware shaping (802.1 Qbv)
  - Automatic gate scheduling (simple, SAT solver, TSNsched, etc.)
- Asynchronous shaping (802.1 Qcr)

Scheduling and Traffic Shaping Live Demo

WORKED BEFORE

Frame Replication and Elimination (802.1 CB)

- Layer 2 stream functions
  - Stream identification with arbitrary packet filters
  - Frame sequence numbering (802.1 R-tag)
  - Stream splitting and merging based on stream ids
  - Stream encoding and decoding (802.1 Q-tag)
- Automatic redundant path discovery
  - Protection against arbitrary link and node failures

Frame Replication and Elimination Live Demo

OR MAYBE NOT?

Frame Preemption and Cut-through Switching

- Reduce latency by aborting frame transmission
  - Using Ethernet frame fragmentation
- Frame forwarding after MAC header is received
  - Using intra-node and inter-node frame streaming

Frame Preemption and Cut-through Live Demo

Questions and Answers

Thank you for your attention!