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

SHOULD WORK
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

ANYWAY
Thank you for your attention!