



Software-Defined Networks Supporting Time-Sensitive In-Vehicular Communication

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1. TSN & SDN in Vehicular Networks
2. Concepts on Implementing TSN + SDN
3. Timing & Latency Analysis
4. Conclusion & Outlook

Why TSN?

- Quality-of-Service traffic classes with timing guarantees
- Synchronous (scheduled TDMA) and asynchronous (reserved bandwidth) traffic

Why SDN?

- OpenFlow standard and centralised control logic
- Global network knowledge

Why TSN + SDN = TSSDN

- Central (re-)calculation, verification and (re-)configuration of timings during runtime
- Robust safety and security methods

Step 1

Combine switching modules of SDN and TSN

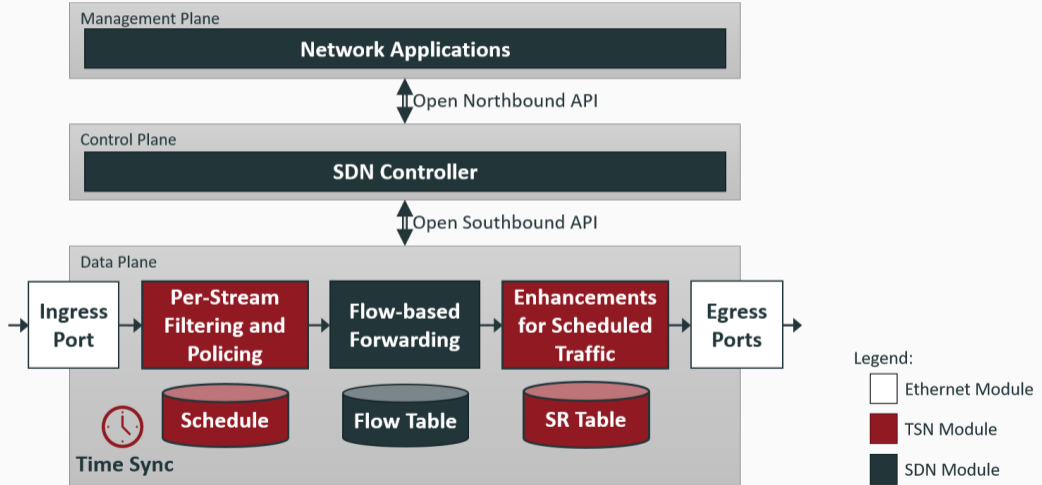
Step 2

Map signalling of TSN to SDN

Step 3

Define OpenFlow matching of time-sensitive flows

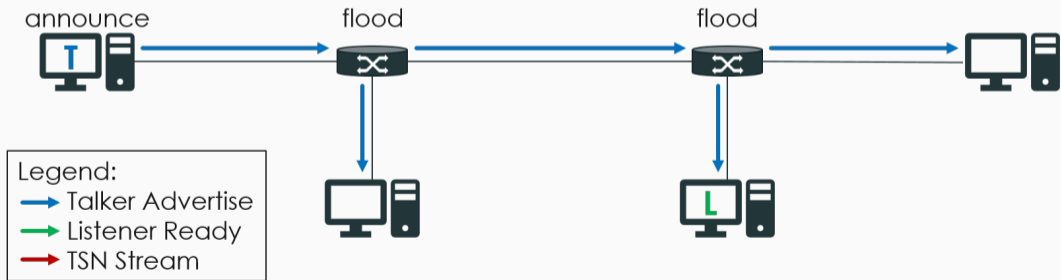
Combining Switching Modules of SDN and TSN



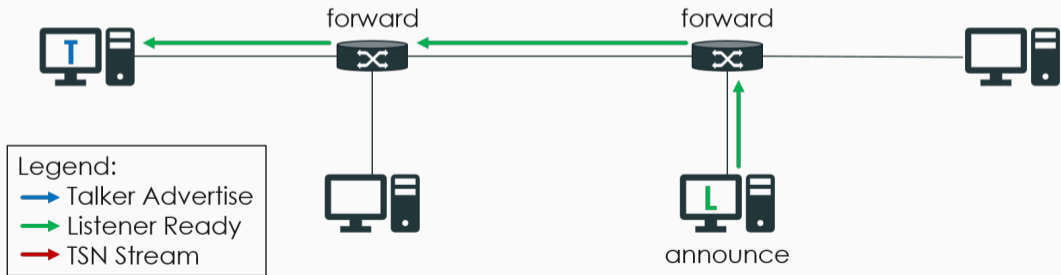
Signalling of TSN Stream Reservation



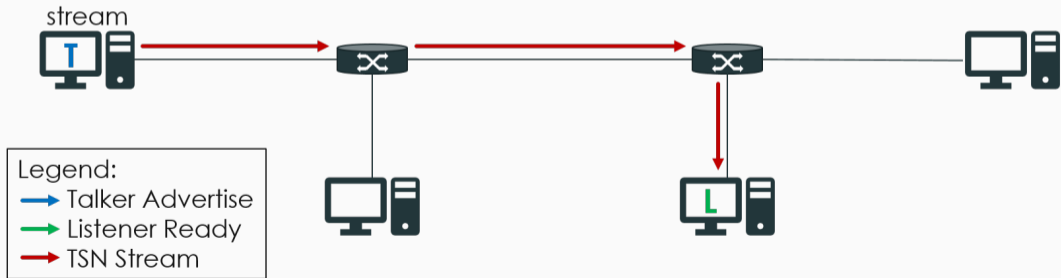
Signalling of TSN Stream Reservation



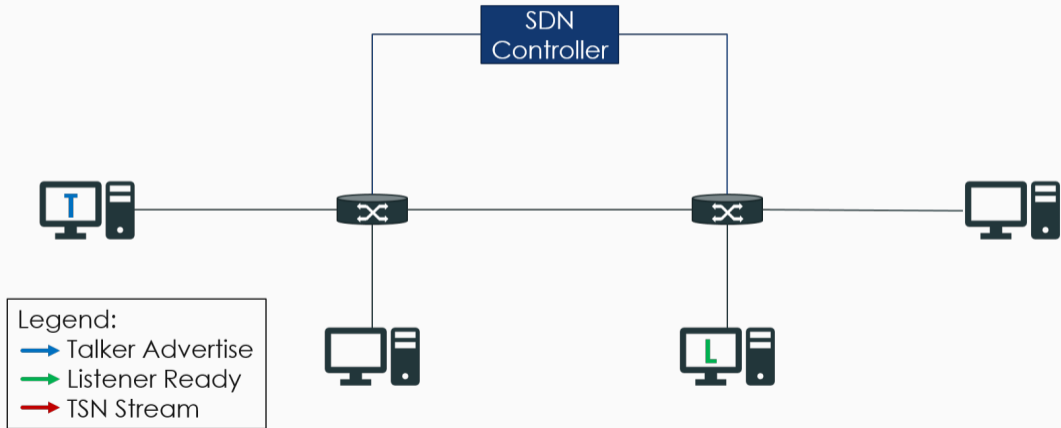
Signalling of TSN Stream Reservation



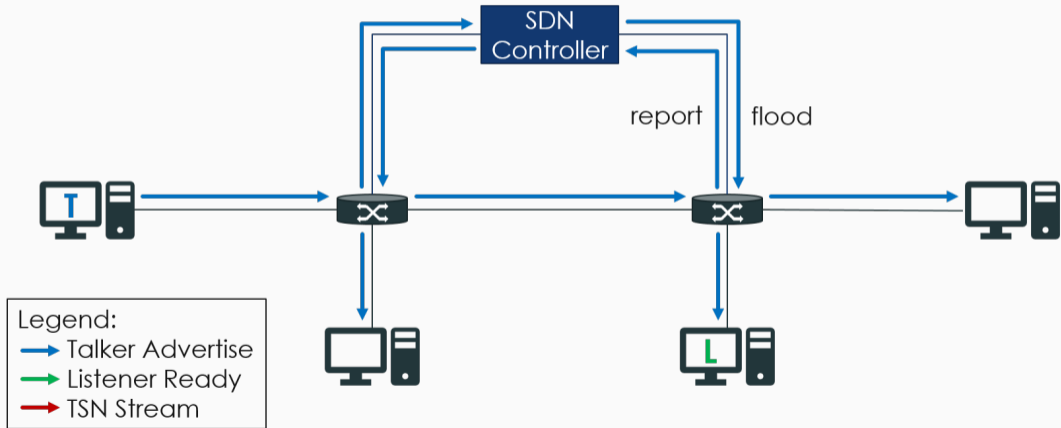
Signalling of TSN Stream Reservation



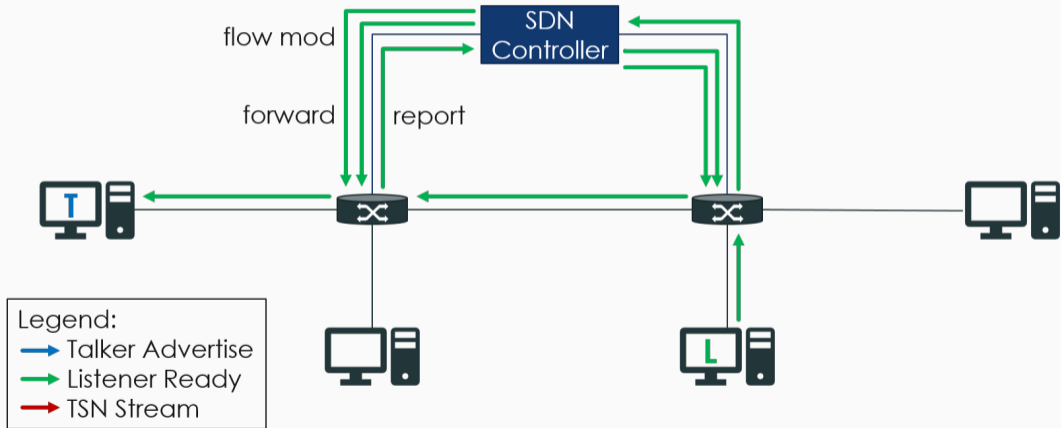
Mapping Signalling of TSN Stream Reservation to SDN



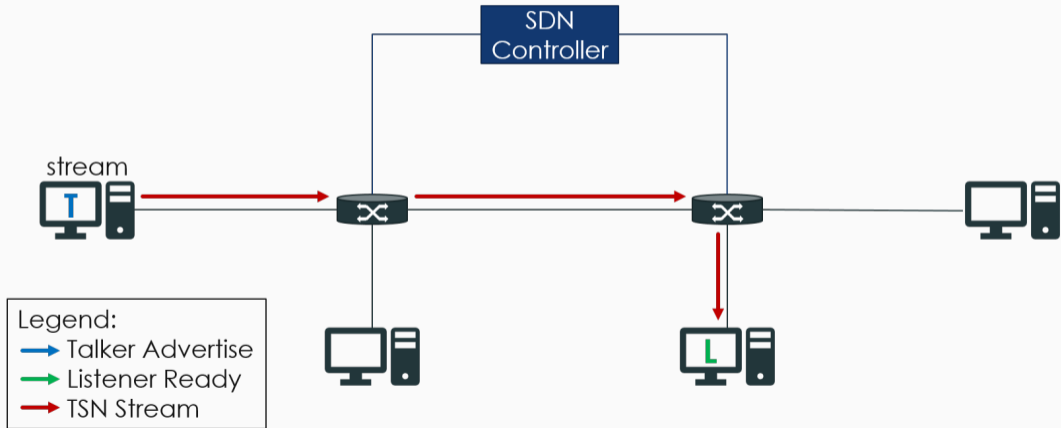
Mapping Signalling of TSN Stream Reservation to SDN



Mapping Signalling of TSN Stream Reservation to SDN

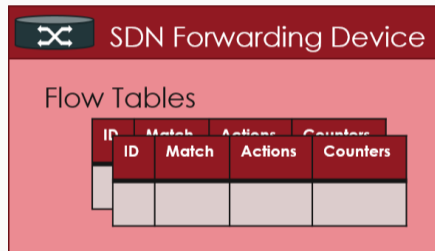


Mapping Signalling of TSN Stream Reservation to SDN

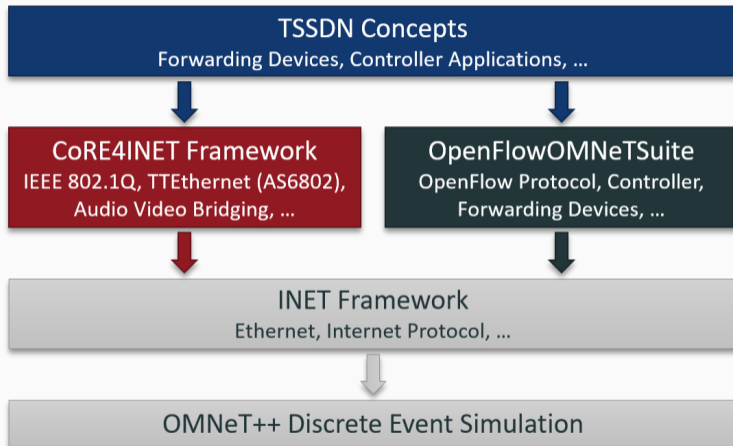


Defining OpenFlow Matching of Time-Sensitive Flows

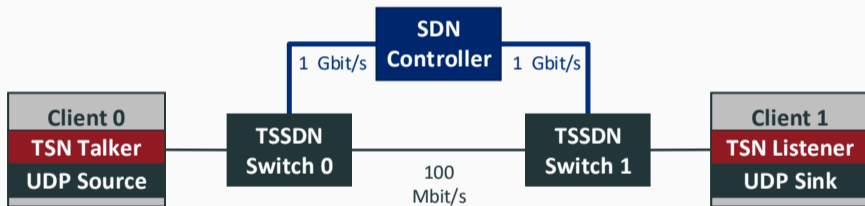
```
Match {  
  Listener Multicast Ethernet Destination Address,  
  Talker Ethernet Source Address,  
  Switch Ingress Port,  
  VLAN ID 802.1Q ID,  
  Stream Priority 802.1Q PCP  
}
```



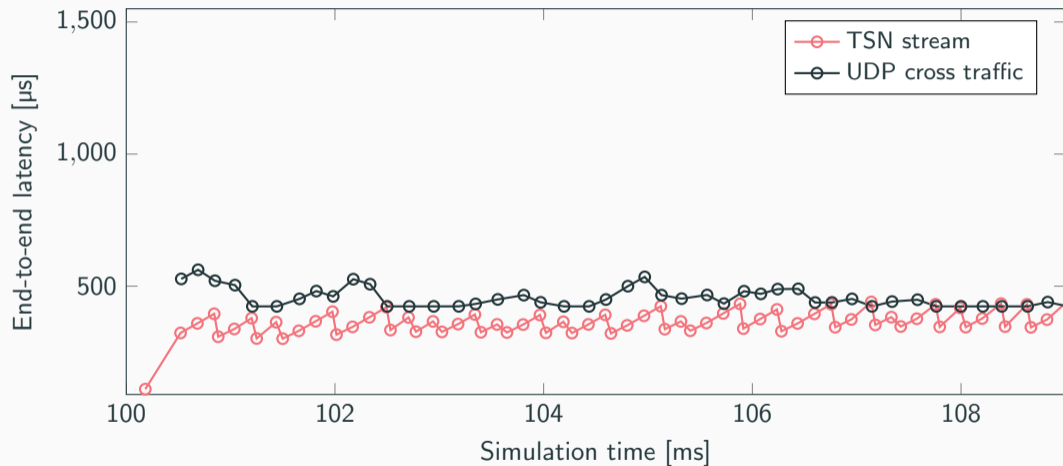
Simulation Environment



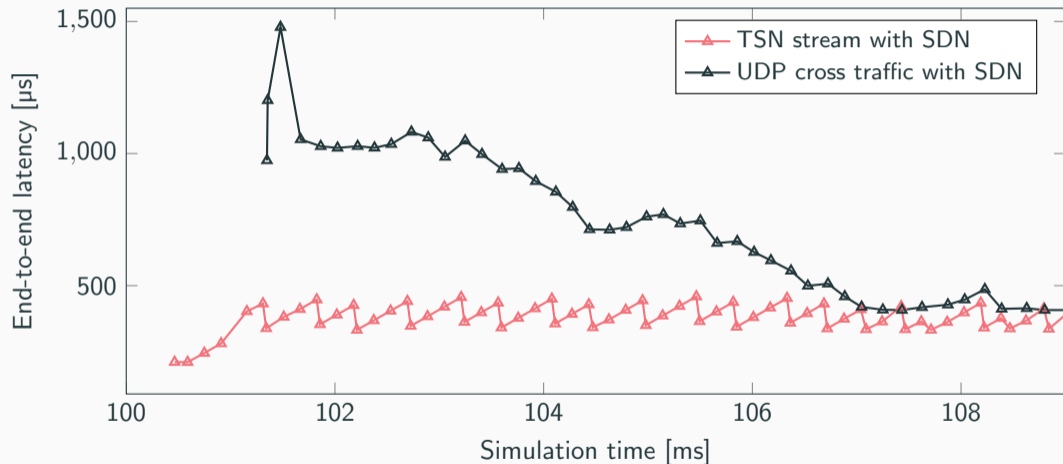
Simulation Case Study



Latency Measurement of TSN

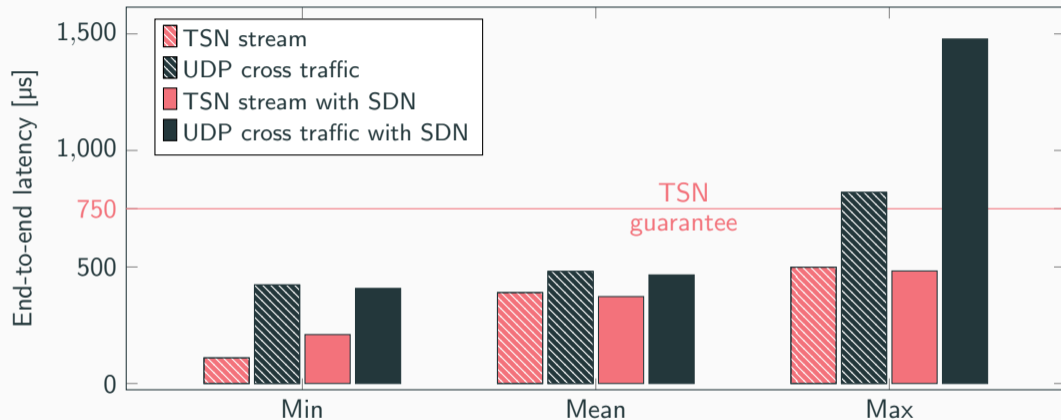


Latency Measurement of TSSDN



→ No delay penalty for time-critical flows, while taking advantage of SDN in vehicles

Comparing Maximum Latency



→ The timing guarantees are met for time-sensitive flows

Summary

- Combined TSN and SDN without a delay penalty for real-time traffic
- Presented our switching methodology that combines SDN and TSN
- Defined potentials of time-sensitive software-defined in-vehicular networks
- Opened the field of TSSDN in cars

Future Work

- Transfer more of TSNs control logic to the SDN controller
- Analyse the effect of SDN on synchronous TDMA flows
- Show potentials of TSSDN for vehicles including improvements on robustness and security

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