A QoS Aware Approach to Service-Oriented Communication in Future Automotive Networks

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4 December – 6 December 2019, Los Angeles, California
2019 IEEE Vehicular Networking Conference (VNC)

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Outline

In-Vehicle Networks - State of the Art

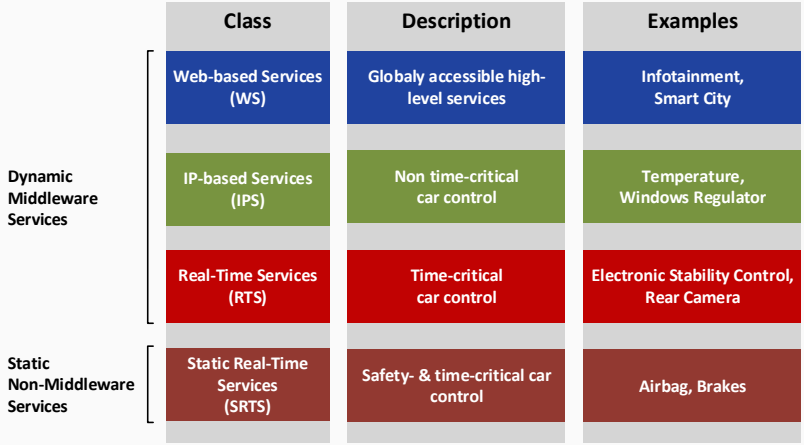
- Scenarios such as Autonomous driving and V2X pose new challenges on in-vehicle networks
- Automotive services have heterogeneous communication requirements
- Ethernet as high-bandwidth communication medium replaces legacy bus systems
- SOME/IP introduces Service-Oriented Architecture (SOA) and promises flexibility
- Time-Sensitive Networking (TSN) provides Quality-of-Service (QoS) with hard deadlines

A mechanism is missing that merges the concepts of SOA and QoS-enhanced communication for dynamically changing communication relations.

Our Contributions

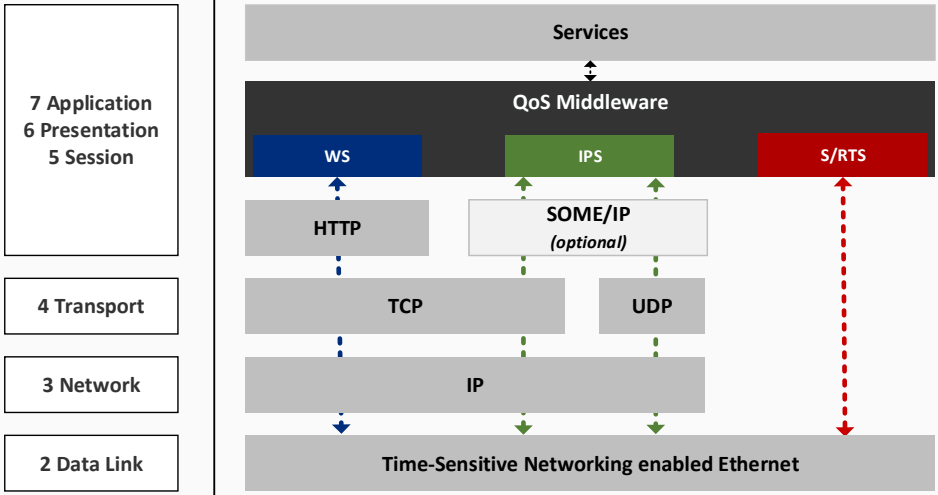
- We derived four QoS classes based on automotive service requirements
- We developed an automotive specific multi-protocol stack
- We designed a protocol for dynamic QoS agreements
- We evaluated the performance of our middleware in simulation

Classification of Automotive Services

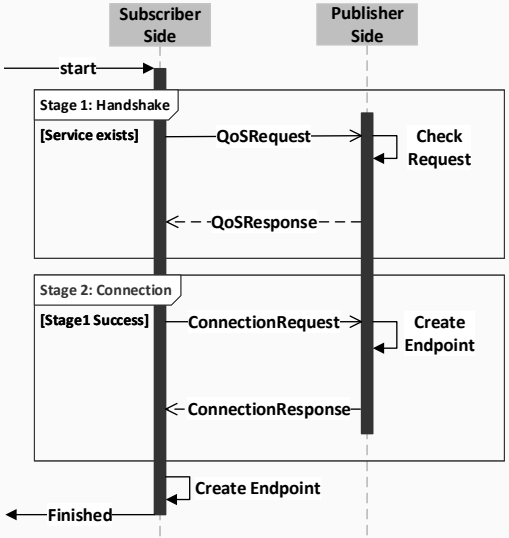


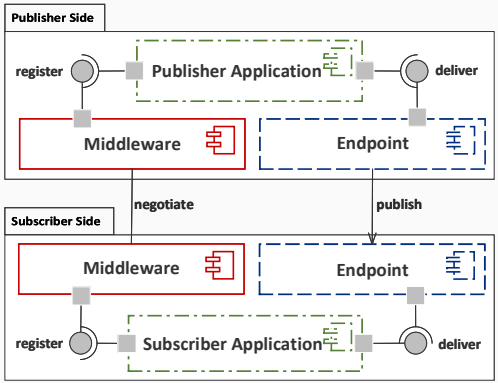
An in–depth explanation can be found in the paper.

Multiprotocol Approach



QoS-Negotiation Protocol

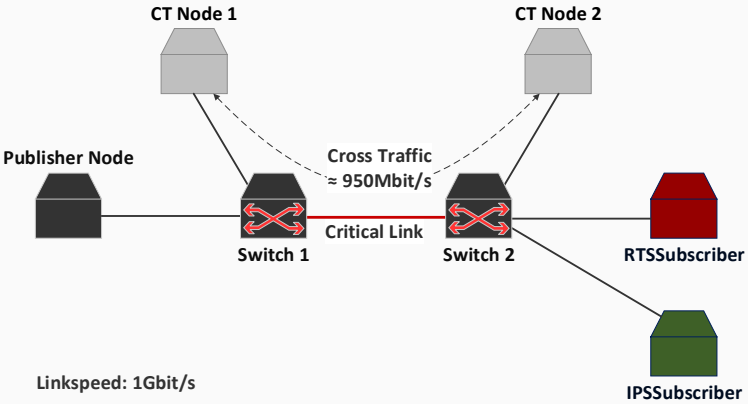




Performance Evaluation

- Impact of cross-traffic on the latency of different QoS classes
- Scaling of setup time in relation to the number of services
- Setup time in a realistic automotive network with cross-traffic

Latency Behaviour of Mixing Different QoS Classes



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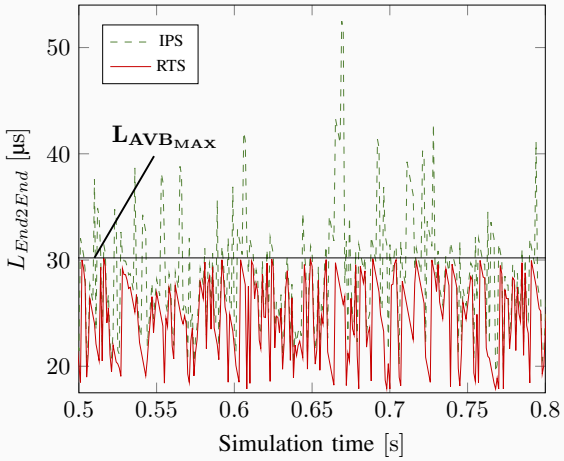
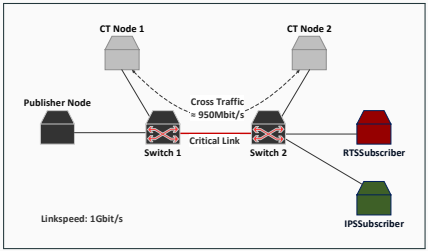
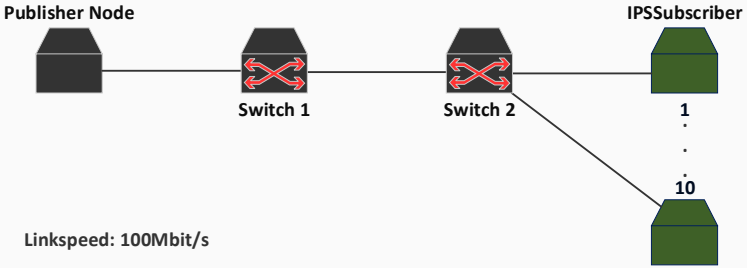




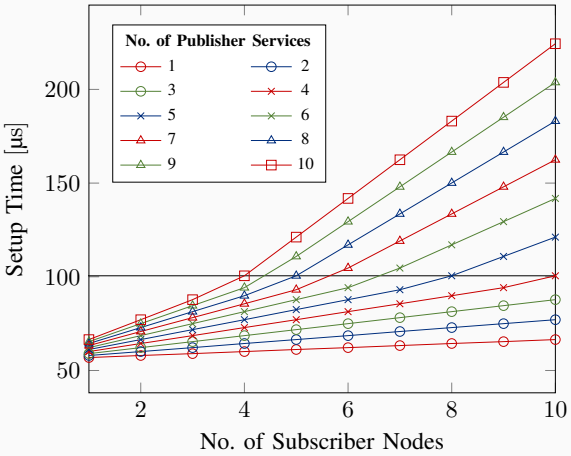
$$L_{AVB_{max}} = t_{MTU} + 3 \cdot t_{AVBFrame} + 2 \cdot t_{Switchdelay} + IPG + 2 \cdot t_{Nodedelay}$$

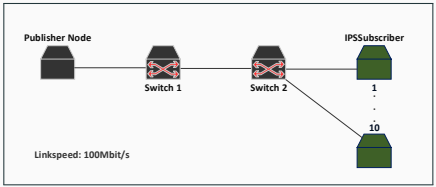
Result: QoS can be guaranteed for heterogeneous client requirements

Setup Times with Increasing Numbers of Nodes



Setup Times with Increasing Count of Nodes

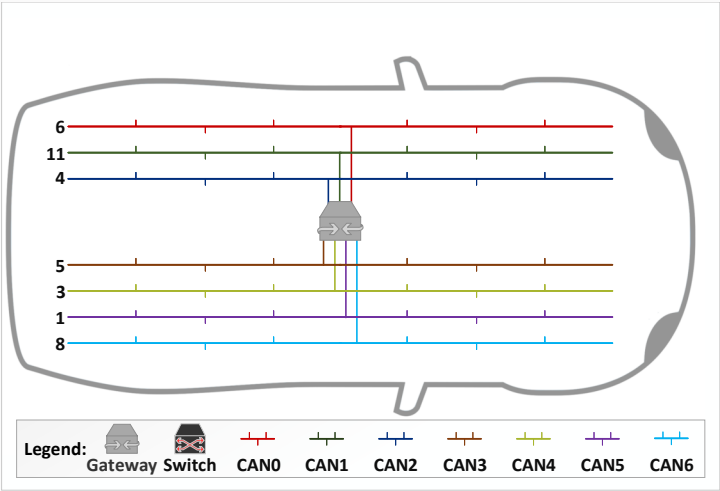




From 40 simultaneous negotiations the maximum bandwidth of 100 Mbit/s is exceeded and the network traffic becomes congested.

Result: The behaviour of the setup time is linear with the number of negotiations

Setup Times in a Realistic Automotive Network with Cross-Traffic



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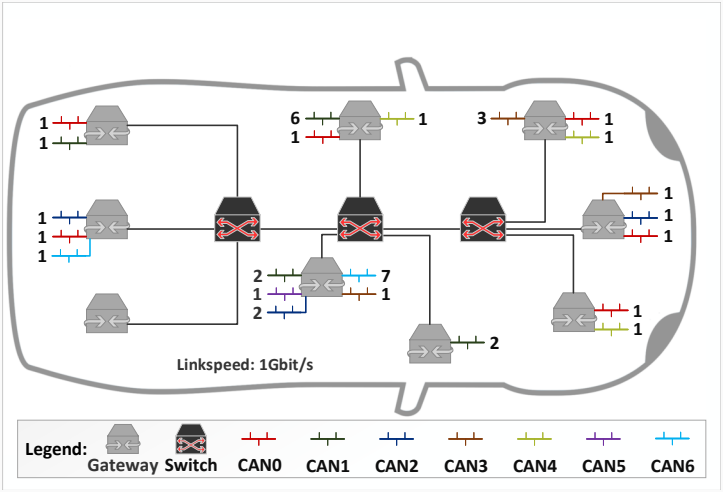

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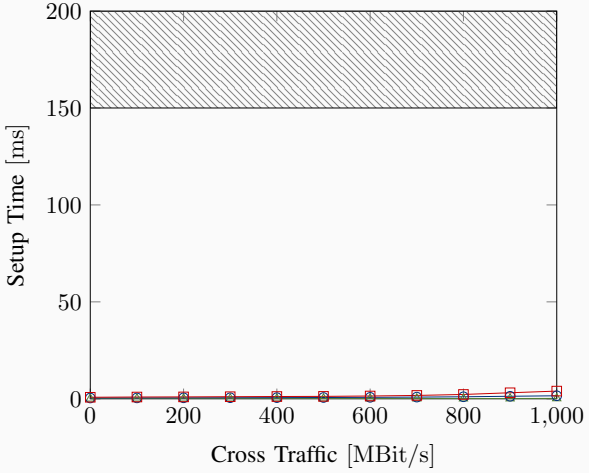
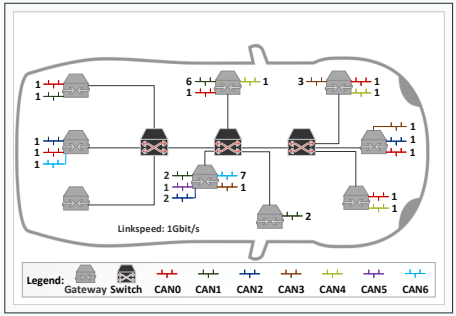
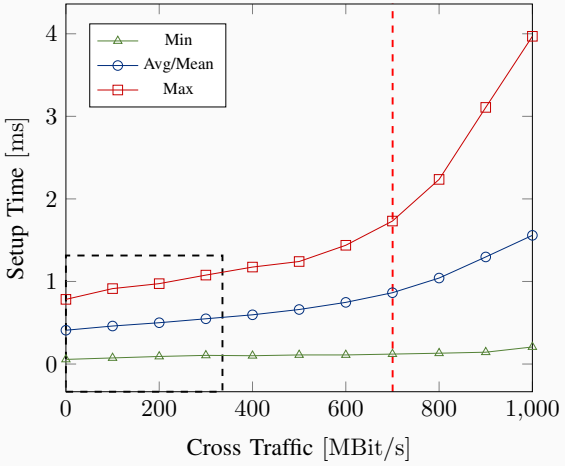
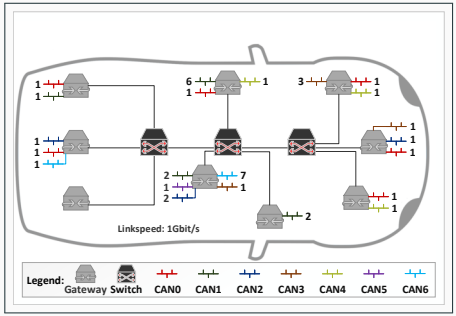




Maximum system setup time in cars is $\approx$ 150 ms to 200 ms. The measured setup time is well below the requirements.

Setup Times in a Realistic Automotive Network with Cross-Traffic





With cross-traffic of around 300 Mbit/s the setup time takes ≈ 1 ms. From cross-traffic of around 700 Mbit/s the setup time rises exponentially.

Result: The setup time complies with automotive requirements of ≈ 150 ms to 200 ms

Conclusion & Outlook

Summary

- Introduced four QoS classes with a multi-protocol stack
- Presented a dynamic QoS negotiation protocol
- Showed successful support of mixed-critical communication
- Achieved acceptable setup-times in a realistic automotive network
- Implemented and evaluated with OMNeT++ Discrete Event Simulator
  Sourcecode available at: https://github.com/CoRE-RG/SOQoSMW

Future Work

- Determine real-world runtime delays with real car components

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Sposored by the
Federal Ministry of Education and Research