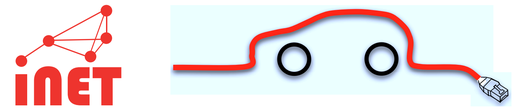
Comparing Time-Triggered Ethernet with FlexRay: An Evaluation of Competing Approaches to Real-time for In-Vehicle Networks

Till Steinbach, Franz Korf, Thomas C. Schmidt

Department Informatik, Hamburg University of Applied Sciences

Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences



Abstract

FlexRay is considered the next generation state-of-the-art technology for in-car networks, while time-triggered Ethernet (e.g. TTEthernet by TTTech [2]) emerges with the promise to integrate real-time and best-effort traffic into one homogeneous backbone. By showing that it is possible to transfer a fully utilized FlexRay system to a system based on time-triggered Ethernet, it is demonstrated that time-triggered Ethernet is a suitable replacement of current in-vehicle bus-systems.

Motivation

- Bandwidth requirements increase rapidly
- Current in-vehicle networks are inhomogeneous
- Usage of components of the shelf
- Benefit from the expertise of plenty of Ethernet developers

Objectives

- Competitive analysis of FlexRay & TTEthernet
- Mathematical model that shows the eligibility of TTEthernet for in-vehicle applications
- Discussion of group communication for in-vehicle applications

Comparison

- Comparison based on a sample configuration with a topology of two active stars / switches and a cycle time of 16 ms
- Number of real-time messages per cycle and the correspondent maximum bandwidth is compared over various payload sizes
- Latency and Jitter are calculated based on the sample configuration

Background

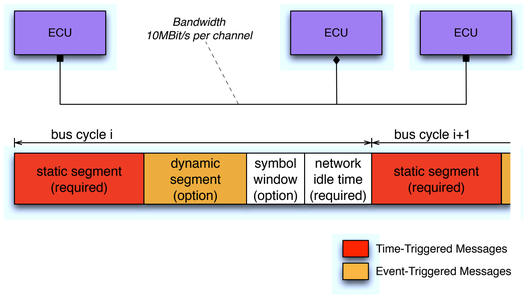


Fig. 1: FlexRay bus structure and cycle scheme

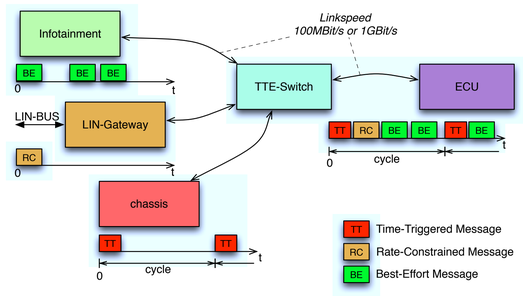


Fig. 2: TTEthernet network and cycle scheme

Analytical Results

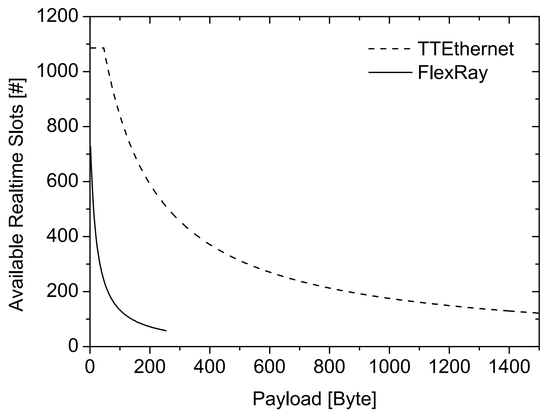


Fig. 3: FlexRay and TTEthernet slots at payload size (16 ms cycle)

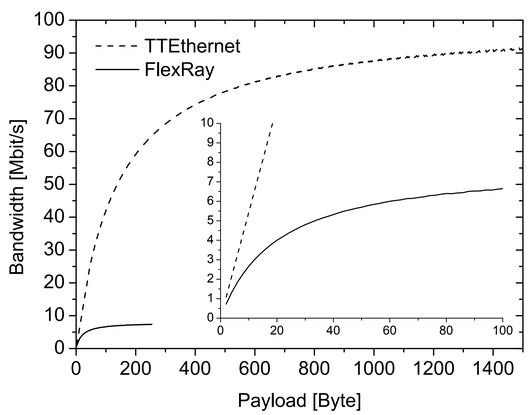


Fig. 4: FlexRay and TTEthernet net bandwidth at payload size (16 ms cycle)

	FlexRay	**TTEthernet**
latency min. payload	$12.2\mu s$	$24\mu s$
latency max. payload	$265.2\mu s$	$372\mu s$
jitter bounds	$6.4\mu s$	$< 10\mu s$

- Calculated jitter and latency for FlexRay and TTEthernet are comparable
- Traffic of a fully utilized FlexRay configuration can be embedded in a TTEthernet network
- Especially for larger payload sizes the bandwidth gain is significant higher for TTEthernet

Conclusion

- FlexRay real-time traffic can be embedded in real-time Ethernet
- The TTEthernet correspondent of a fully utilised FlexRay configuration is utilised by approx. 11%
- Bandwidth utilisation can further profit from group communication

Outlook

- Currently we analyse in-vehicle networks in simulation and build a mockup based on TTEthernet for measurement and load analysis
- Future work will analyse how event-triggered traffic, segmentation and priority functionalities of Ethernet can guarantee a smooth integration of time-triggered Ethernet
- Further questions concern the consolidation of current in-vehicle bus systems into one homogeneous backbone, or the optimisation and validation of configuration parameters

References

[1] FlexRay consortium, “Protocol specification,” Stuttgart, Germany, Specification 2.1, Dec 2005.

[2] W. Steiner, “TTEthernet specification,” TTTech Computertechnik AG, Vienna, Austria, Nov 2008. [Online]. Available: http://www.tttech.com

[3] Aeronautical Radio Incorporated, “Aircraft data network,” ARINC, Annapolis, MD, USA, Standard 664, 2002.

Contact information: Till Steinbach, Franz Korf, Thomas C. Schmidt: HAW Hamburg, Dept. Informatik, Berliner Tor 7, D-20099 Hamburg – Email: {*till.steinbach, korf, schmidt*}*@informatik.haw-hamburg.de*