Performance Analysis of Time-Triggered Ethernet

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Abstract

The performance analysis and validation of distributed real-time systems poses significant challenges due to high accuracy requirements at the measurement tools. We introduce two low cost approaches to measure end-to-end latency and jitter of time-triggered Ethernet traffic, synchronization and hardware precision. A software based facility applies the real-time Kernel extension for Linux and uses COTS, whereas a hardware based approach uses a microcontroller and a standard workstation connected via dual port memory.

Motivation

- Missing performance analyzer instruments in tool chain
- Tools for standard Switched Ethernet are not suitable
- Flexible and low cost tools gain importance
- Verification of used network configuration and hardware

Comparison

	Software	Hardware
Precision	$<10\,\mu s$	$<0.3\,\mu s$
Bandwidth	100 MBit/s	24 MBit/s
Cost	$<350\,\$$	$<1200\,\$$

References

[1] F. Bartols, T. Steinbach, F. Korf, and T. C. Schmidt, "Performance Analysis of Time-Triggered Ether-Networks Using Off-the-Shelf-Components," in *14th IEEE International Symposium on Object/Component/Service-Oriented Real-Time Distributed Computing Workshops (ISORCW) 2011*, Mar. 2011, pp. 49–56.

[2] K. Müller, T. Steinbach, F. Korf, and T. C. Schmidt, "A Real-time Ethernet Prototype Platform for Automotive Applications," in *Proceedings of the 1st IEEE International Conference on Consumer Electronics - Berlin (ICCE-Berlin)*, 2011, to appear.

[3] F. Groß, "Microcontroller basierte Messung von Paketlaufzeiten in Time-Triggered-Ethernet Netzwerken," Aug. 2011, bachelorthesis.

Software Based Approach

Goals

- Low cost approach using off-the-shelf components
- Flexible and easy to use and configurable facility
- Synchronized packet generation of TT-Frames

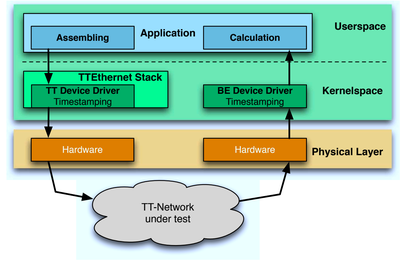

Fig. 1: Conceptual Overview

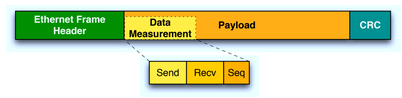

Fig. 2: Modified Measurement Frame

Realization

- Lowlevel based measurement → Linux Kernelspace
- Collecting timestamps while sending and receiving
- RT-Linux with enhanced interrupt handling

Systemtime & Timestamping

- The Kernel provides different functions to access the system time
- Highest precision by using the *get_cycles*-function
- Frames will be modified with actual timestamp
- Reading and storing information in kernel space is unnecessary

Hardware Based Approach

Goals

- Collecting timestamps in MAC unit
- Measure the TTEthernet Network latency
- Measure the real-time precision of hardware
- Measure in synchronized network time

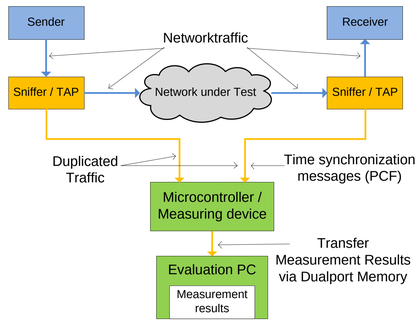

Fig. 6: Scenario: Measure the total network latency

Realization

- Duplicate traffic with zero latency TAPs
- Collect traffic in an ARM9 microcontroller
- Timestamping of arrival with minimum jitter
- Transfer of measurement results via dualport memory to host PC
- Analysis of results in the synchronized network time with Wireshark

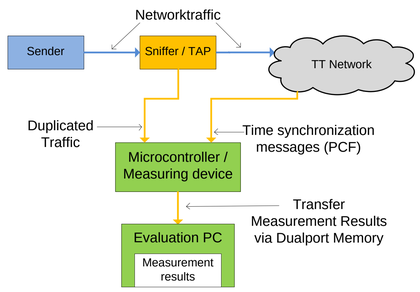

Fig. 5: Scenario: Measure the real-time precision of hardware

Comparison TTEthernet Switch with COTS Switch

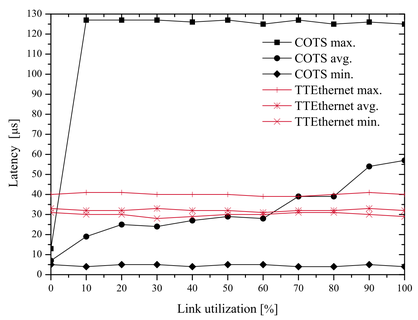

Fig. 3: Latency bounds

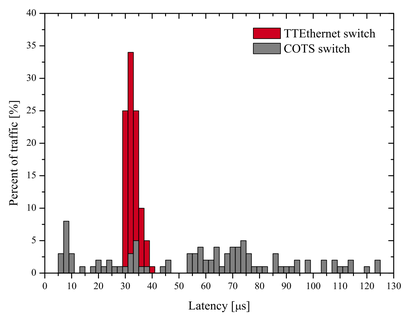

Fig. 4: Latency distribution

Measurement Use-case

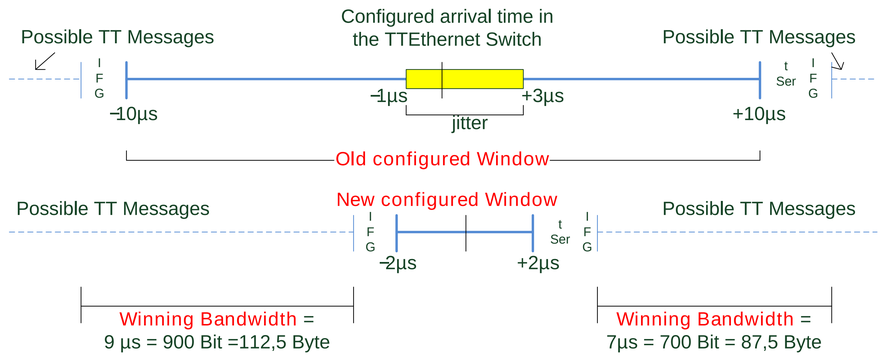

Fig. 7: Adjusting window size and position with measurement results

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