zhaw

School of Engineering

InES Institute of Embedded Systems

Time synchronization over WLAN

Networked systems in the industry require time synchronization with an accuracy of at least one millisecond. This accuracy is necessary, for example, for machine control processes and the data evaluation of sensor systems. This bachelor thesis aims to investigate whether this requirement can be achieved in a WLAN network with standard hardware.

Since WLAN networks communicate over a shared medium, the latencies of the two communication directions occur asymmetrically. This asymmetry negatively affects the accuracy of time synchronization. The magnitude and asymmetry of the latencies in both communication directions were investigated using TraGaL, a software developed at InES. For this purpose, a WLAN test system consisting of one access point (AP) and four stations (STA) was set up. This test system was used to perform latency measurements for three WLAN standards.

It was shown that the IEEE 802.11n standard exhibits significantly less asymmetry than the other two WLAN standards IEEE 802.11ax and IEEE 802.11ac when network load is low. In contrast, this advantage is not apparent with increased network load.

Analysis of these latency measurements resulted in initial parameters used in the next step for time synchronization. For the time synchronization software ElevatorTime, developed by InES, these parameters were optimized by a series of measurements. With these optimizations, a series of additional measurements were performed to evaluate the accuracy and robustness of time synchronization.

It was shown that time synchronization with a maximum deviation of ≤ 0.5 ms was possible with all the WLAN standards investigated under the conditions of the test system. Even under increased network load, the specification of a maximum deviation of ≤ 1 ms could be met for the WLAN standards investigated. With the IEEE 802.11n standard, the best results were achieved with a maximum deviation of ≤ 0.1 ms.

Additional improvements of the heuristic filter were investigated further to increase the accuracy and robustness of the time synchronization. Optimization led to an increase of accuracy by at least 26% for all three WLAN standards. Even under higher network load, accuracy was improved by at least 15%.
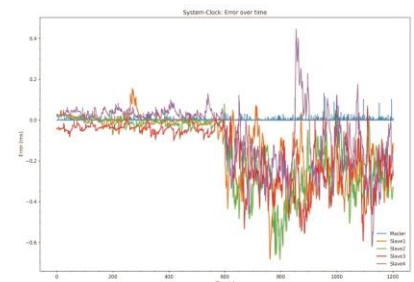
Diplomierende
Thomas Ruesch
Sebastian Senn

Dozierende
Martin Ostertag
Kilian Brunner
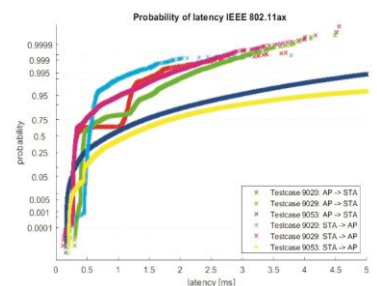
Probability plot of Latency with IEEE 802.11ax

Accuracy measurements with ElevatorTime