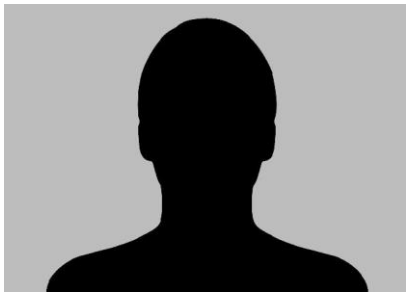
Zürcher Hochschule
für Angewandte Wissenschaften

School of
Engineering

ISC Institute for Signal Processing
and Wireless Communications

Direction Finding with Bluetooth 5.1



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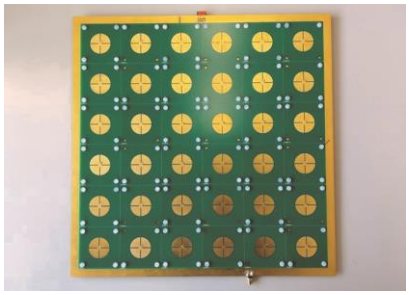
Bluetooth SIG has put out a new specification known as Bluetooth 5.1 on January 21st 2019 which supports a direction finding method known as angle of arrival. The main goal of AoA with Bluetooth Low Energy is to succeed where other localisation schemes like GPS fail, that is, to perform indoor localisation with sub-meter accuracy. This comes with a number of challenges such as multipath signal propagation, interference with strong emitters (WiFi) and moving targets.

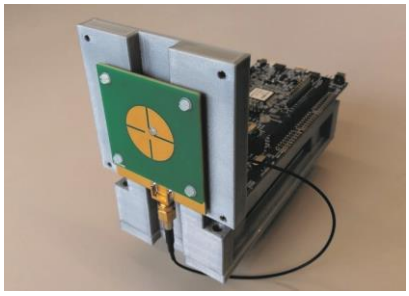
As of the first half of 2020, only a few capable chips are on the market and the list of direction finding development solutions is even shorter. Even though the newer generation of wireless devices slowly begins to be compliant with the Bluetooth 5.1 standard, the use of AoA is not yet widespread.

The aim of this thesis is threefold. Firstly, to analyse the possibilities that are offered by the Bluetooth 5.1 standard in terms of AoA localisation and to characterise the sources of error that arise during the AoA estimation. Secondly, to design a signal processing chain to be able to estimate the AoA of the signal and finally, to implement a hardware solution to be able to verify the simulated results.



Realized switched antenna array.

Like many other localisation methods involving smart antenna technology, Bluetooth 5.1 AoA relies on the observation of a sinusoidal signal with an array of antennas. In this thesis, the effects of a frequency error in the signal is analyzed and a frequency estimation algorithm is proposed which converges towards the Cramér-Rao lower bound. A simple multipath propagation model is analysed in order to gain insight on how fading affects the angle of arrival estimation. A circular polarised, 2.40 - 2.48 GHz antenna is designed and integrated in a 6-by-6 elements array with 50 mm inter-antenna spacing. A direction finding algorithm is developed in order to perform AoA estimation on data sampled by an antenna array.



Single antenna test setup.

First tests and simulations in a non reflective situation, at a range of 2m show that it is possible to achieve AoA estimation with an error of 5° by using a simple spectral approach. In a multipath environment however, the fading has a high impact on the performance of spectral methods and the AoA estimation error increases to 15-20° at a range of 2m.

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