Investigation on Positioning Techniques for Indoor Office Scenario

Popular Science Summary

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The fifth generation of mobile technology is designed to support three major use cases: Enhanced Mobile Broadband, Ultra-Reliable Low Latency, and Massive Machine Type Communications. These three use cases will provide high-speed data transmission for Enhanced Mobile Broadband, low latency with high-reliability data transmission for Ultra-Reliable Low Latency, and low power vast number of devices for Massive Machine Type Communications. Positioning support is an additional feature for these use-cases. One of the requirements is that the horizontal positioning error should be lower than 3 meters under the indoor scenario for 80% of the user equipments.

This master's thesis aims to investigate positioning techniques and find novel algorithms for improving positioning performance in the indoor scenario. The indoor office environment is one of the challenging scenarios. Hence, this thesis work focuses on the indoor office scenario as part of our study in the investigation of positioning techniques.

The applied positioning techniques in this thesis are based on downlink time difference of arrival and downlink angle of departure. The downlink time difference of arrival technique requires to measure the time of flight of signals from at least three different base stations to the user equipment. The estimated user equipment position is the intersection of the hyperbolic curves determined by the time differences. In the thesis, we implement an adaptive-threshold method to filter out unwanted noise in the received signals. Furthermore, based on the angle of departure measurements from the different base stations, the position of the user equipment is estimated as the intersection of these corresponding angular sectors. Specifically, we propose to use the first path information from the received signal at user equipment to estimate the angle of departure.

In this thesis, the primary investigated positioning algorithms are based on the least-squares approach and the maximum likelihood approach. The least-squares approach is a method to minimize the sum of the squared residuals (a residual being: the difference between an observed value and the value by a model). The maximum likelihood approach searches for the estimation that maximizes the partial conditional probability. Since the least-squares approach is frequently used with robust performance, we use it as a

reference in comparisons with other algorithms.

Non line-of-sight error is one of the significant issues in delay based positioning techniques. We investigate the residual weighting algorithm and residual testing method together with the downlink angle of departure and downlink time difference of arrival positioning techniques. Residual weighting algorithm is a technique to mitigate the non line-of-sight influences by averaging all the candidate measurement combinations. The residual testing method is to identify the non line-of-sight affected measurements. The simulation results show that combing the residual weighting algorithm and the residual testing method can result in better performance better than only applying residual weighting algorithm.

This thesis also proposes a positioning algorithm based on a maximum likelihood approach combining downlink time difference of arrival and downlink angle of departure techniques. By using this approach, the performance in term of positioning accuracy is better than other known methods. The obtained positioning accuracy is less than 3 meters.

For future studies, the positioning accuracy can be further improved by combining the hybrid downlink time difference of arrival associated with downlink angle of departure maximum likelihood algorithm and residual weighting algorithm.