PhD Position – Thesis offer (M/F)
Reference: CS/DS/GEOLOC/082021

Research topics	Geopositioning in IoT Networks
Department	Communication Systems Department
Publication date	08/2021
Start date	ASAP
Duration	Duration of the thesis
Web page	http://www.eurecom.fr/en/people/slock-dirk

Description
This PhD thesis contributes initially to the French FUI project GEOLOC, "Multi-Standard Geolocation for the Internet of Things", https://www.pole-scs.org/en/projects/geoloc-3/ https://geoloc.univ-cotedazur.fr/?lang=fr

Background
According to the operators, a significant share of the applications of the Internet of Things (IoT) requires the geolocation (management of fleets of vehicles, applications related to the security in the broad sense,…). The geolocation of connected objects, in exterior and interior environments, and in particular its precision at a reduced cost (fabrication and energy consumption), is thus a major stake. The GEOLOC project proposes to study, develop and try out innovating techniques of multichannel geolocation estimation. The standards that will be used are both the standards using the free bands (LoRa, WiFi, Bluetooth low energy (WHEAT)) as well as the cellular technologies derived from 4G/5G.

Objectives
The GEOLOC project aims in particular:

- To combine information from the various standards supported by an object (LoRa, LTE-M) but also (WHEAT, Wifi, GPS), as well as various sensors (barometer, accelerometer) to improve the precision of the geolocation (information fusion) while controlling consumption
- In a way complementary to the primary goal, to improve the existing techniques of geolocation estimation
- To use geolocation information to improve the effectiveness of the transmissions between the object and the infrastructure
- To minimize the total consumption of the infrastructure and of the connected objects

Research Topics of this PhD thesis
An initial series of topics to be explored in this thesis includes:

- Current GPS-based solutions are not optimized for IoT geolocation and mainly suffer from high power consumption, low accuracy in urban settings, and limited indoor coverage. Novel algorithms have been developed in order to overcome these drawbacks. With the help of the proposed signal processing solutions we are targeting to provide high accuracy and fast signal acquisition at low Line-of-Sight signal levels (e.g., behind buildings or indoor with signal strength 1,000 or 10,000 times weaker than in open, outdoor locations) or in the presence of signal reflections in urban environments (multipath). Further improvement and extensions of these algorithms are to be explored, for instance by exploiting multi-antenna reception.

- One of the innovations envisaged concerns the use of multi-band signals (or frequency hopping or multi-standard). The ToA (Time of Arrival) resolution is inversely proportional to the signal bandwidth. So with the low bandwidth of IoT communications, the accuracy of distance measurement is a problem. In multi-band, if we receive in bands $[f1, f2]$ and $[f3, f4]$, then the bandwidth determining the resolution is not $(f2 - f1) + (f4 - f3)$ but $(f4 - f1)$, which can be much wider. The exploitation of multiband signals therefore allows in principle enormous precision corresponding to the fictitious situation in which the whole spectrum between the bands would be occupied too. On the other hand, the consequence of the absence of $[f2, f3]$ from the spectrum is that ambiguities appear (multiple ToA values being consistent with the signals). The determination of these ambiguities can however be carried out by exploiting other information in the signals (for example the amplitudes of the multipath). For LTE Cat. M for example, with frequency hopping of signals of width 1.25MHz in a band of 20MHz, a gain of precision of 16 is possible! This multi-band approach is still largely unexplored. The first reference is [A]. It should be noted, however, that exploiting the enormous potential gain of multiband for geolocation first requires perfect synchronization and calibration of the signals in the different bands and how this problem would be dealt with in [A] is not clear.

- Positioning in wireless systems (e.g. Wi-Fi) is often based on the exchange of RSSi (Received Signal Strength indicator) information. The RSSi is a fairly sensitive and imprecise measurement of distance induced attenuation. We would like to pursue the separation of a channel response into multipath propagation components in order to e.g. extract more reliably the (amplitude of the) Line-of-Sight (LoS) direct path or single-bounce paths. To this end the channel needs to be explored in as many dimensions as possible, including delay spread, Doppler spread and possibly multiple antennas. Depending on the configuration, the array of antennas may be operating in the near field.

[A] D. Vasisht, S. Kumar, and D. Katabi, “Decimeter-Level Localization with a Single WiFi Access Point”, 13th USENIX Symp. on Networked Systems Design and Implementation (NSDI), March 2016, Santa Clara, CA, USA.

Requirements

- Education Level / Degree : Master
- Field / specialty: Electrical Engineering
- Profile: a strong background in applied mathematics and signal processing as well as excellent programming skills (Matlab). Previous experience in the area of statistical signal processing, possibly applied to wireless radio communications will also constitute a significant advantage. English language and general communication skills also constitute a plus.

Application

The application must include:

- Detailed curriculum,
- Motivation letter of two pages also presenting the perspectives of research and education,
- Name and address of three references.

Applications should be submitted by e-mail to slock@eurecom.fr with cc to secretariat@eurecom.fr with the reference : CS/DS/GEOLOC/082021

Important Dates

- Screening will start immediately.
- Applications will be considered until the position is filled.
- Start date : ASAP

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