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学术论文

MULoc: 通过锚点监听实现无限数量UWB标签的毫米级定位

MULoc: Towards Millimeter-Accurate Localization for Unlimited UWB Tags via Anchor Overhearing

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Project page: https://github.com/MULoc

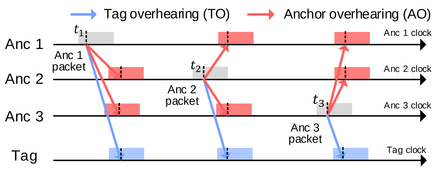
Motivation

- The **accurate and efficient localization** for mobile devices has been a longstanding pursuit in the IoT and wireless sensing community.
- Recent years have witnessed rapid development in **UWB-based localization** systems. However, most of existing solutions can provide only **centimeter-level accuracy** for **a few number of devices** simultaneously.

UWB localization-enabled applications

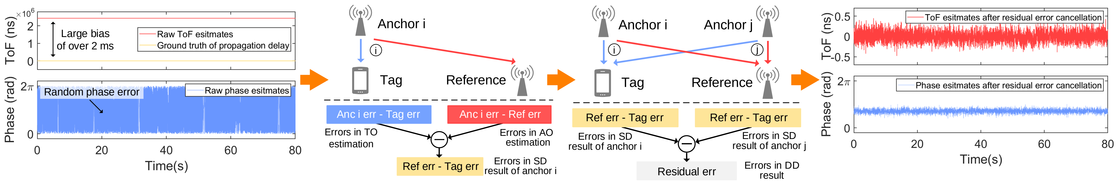
MULoc design

- MULoc is a **phase-based** UWB localization system, which can offer **millimeter-level accuracy**
- **Key innovation:** Different from traditional TDOA-based systems, MULoc involves **anchor overhearing (AO) scheme**, where UWB anchors can **overhear the packets sent from other anchors**.



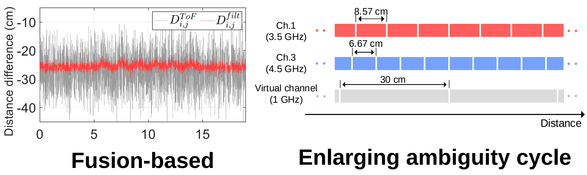
MULoc's anchor scheduling scheme

- **UWB signal recovery:** To obtain fine-grained UWB phase for localization, we leverage the insight that **both TO and AO signals** in MULoc **share similar error components** (*e.g.*, CFO, PLL offset, antenna delay), and can **be fully cancelled out using a two-step signal difference operation**.



Raw UWB signal with noise | **Single difference** | **Double difference** | **Recovered UWB signal**

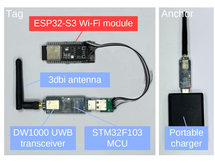
- **Fine-grained UWB tag localization:** To resolve phase ambiguity and obtain absolute tag locations, we combines **a fusion-based filtering** and **frequency hopping** across different UWB channels



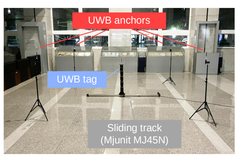
Fusion-based filtering method | **Enlarging ambiguity cycle via frequency hopping**

Evaluation & Results

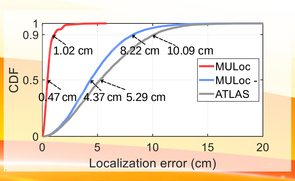
- We implement MULoc **on commercial UWB modules** (Jiuling X1) with DW1000 chips and TCXO oscillators. MULoc **does not require any wire/wireless sync** between UWB anchors.
- We conduct experiments to evaluate MULoc's performance for both **single-point localization** and **trajectory tracking**.
- Experimental result demonstrate that MULoc achieves a **median localization accuracy of 0.47 mm**, reducing the error of traditional method by **91.12%**.

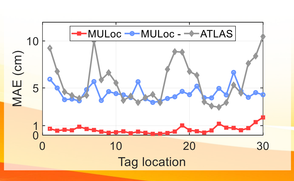


MULoc's tag & anchor

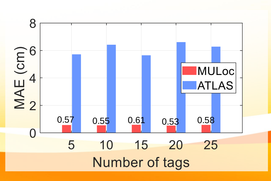


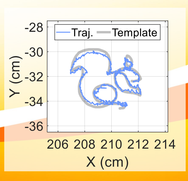
Experimental setup





Single-point localization performance





Tracking performance