Can IoT device accurately localize itself by simply listening to ambient 5G signals? **mmWave 5G networks provide great opportunities for IoT localization**

- Small cell size leads to dense deployment of base stations, providing anchor points for accurate localization.
- Wide bandwidth (up to 400 MHz in mmWave bands) results in high Time of Flight resolution.

**Challenges:**
- Low-cost IoT devices, equipped with low-power low-speed ADCs are incapable of capturing wideband 5G signals.
- Scalable IoT self-localization techniques should not require any dedicated resources or active participation of the gNBs for coordination or synchronization.

### Capturing Wideband 5G Waveform on Narrowband IoT Devices

**MEMS (Micro-Electro-Mechanical Systems) Spike-Train Filters**

Synchronization offsets between gNBs and IoT nodes corrupts ToF estimation.

Prior work [2] measures differential ToF between two antennas to localize the IoT node. Limitation: Additional front-end and RF chain doubles power consumption and cost.

**Coordination-FreeLocalization – Leveraging MIMO Antenna Array in 5G gNB**

Leverages Unique Opportunities in 5G-NR

- Spatial diversity of MIMO antenna arrays in 5G gNBs, which allows for AoD estimation and triangulation-based localization.
- Particular resource allocation in the PDSCH DMRS waveform, which allows for resolving different gNB antenna ports.

**Physical Downlink Shared Channel (PDSCH) DeModulation Reference Signal (DMRS) in 5G-NR**

- Preamble-like waveform used for channel estimation in PDSCH data decoding.
- Different antenna ports are allocated with different sets of interleaved subcarriers, allowing for resolving different antennas.

### mm-ISLA System Pipeline

1. **(1) Overhearing ambient 5G PDSCH signals**
2. **(2) Sparsefying Wideband Spectrum Using MEMS Spike-Train Filter**
3. **(3) Sub-Nyquist Sampling the Filtered Spectrum**
4. **(4) Recovering DMRS Subcarriers for Each gNB Antenna Port**
5. **(5) Super Resolution CIR Estimation**
6. **(6) AoD Estimation & Triangulation**

**Experiment Setup**
- Due to the lack of MIMO-enabled mmWave fronds-ends, we evaluate mm-ISLA at 1 GHz.
- 5G gNB and mm-ISLA IoT node are emulated using X310 USRPs.
- Dual-antenna gNB transmitting 100 MHz OFDM waveform.
- mm-ISLA node samples at 6.25 MHz (16x lower than the Nyquist sampling rate).
- AoD estimation accuracy of mm-ISLA compared against that of narrowband receiver.

**Preliminary Results**

- 6x Higher Accuracy

**References**
