Decimeter Accurate, Long Range Non-Line-of-Sight RF Localization Solution for Public Safety Applications

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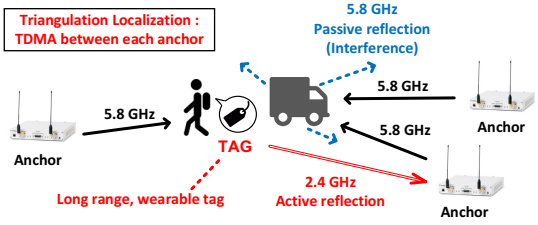
Introduction

A new RF solution for location based services

- Decimeter accuracy localization with > 100m localization range
- Low cost, small size form-factor, and ultra-low power for wearable tags
- Operable in NLOS and rich multipath environments
- Rapidly deployable, low complexity infrastructure anchors

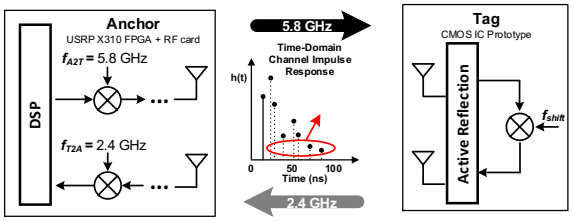


	GPS	RSSI	UWB	This work
Range	Global	<20m	<5m*	**>80m**
Power	High	Low	Medium	**Low**
Accuracy	10s m	<10 m	mm	**< m**
Indoor / Outdoor	Outdoor	Both	Both	**Both**
Need Synchronization?	Yes	No	Yes	**No**

*Typically for accurate locationing

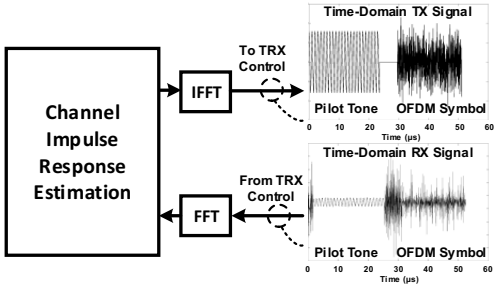
System Overview

Overall system block diagram



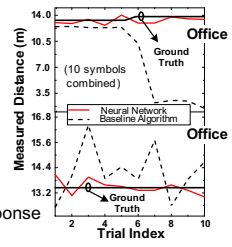
Key Techniques

1. Active Reflection: Frequency Converting RF Echo



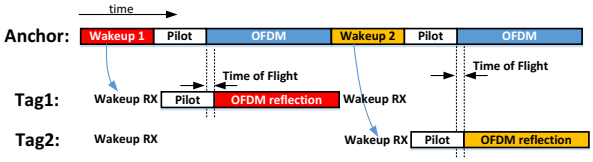
- Increased the maximum operation range
- Distinction from passive reflections
- Flexibility of anchor waveform scheme
- Simple tag design
- No need for tag-anchor synchronization

2. ToF Resolution Enhancement via Neural Network:



- Interpolated time-domain channel impulse response
- Fully connected feedforward neural network
- Training data synthesized in Matlab (simulation)
- *No need to use real-world training data*
- Good improvement in multipath-rich environment

3. ULP Tag IC Design with Wakeup Receiver:



- To lower the average power to < 100μW
- Reflection is activated by wakeup command
- Q-enhancement receiver for better energy efficiency
- Fully integrated with antenna in centimeter-scale form factor

4. Emergency Beacon TX:

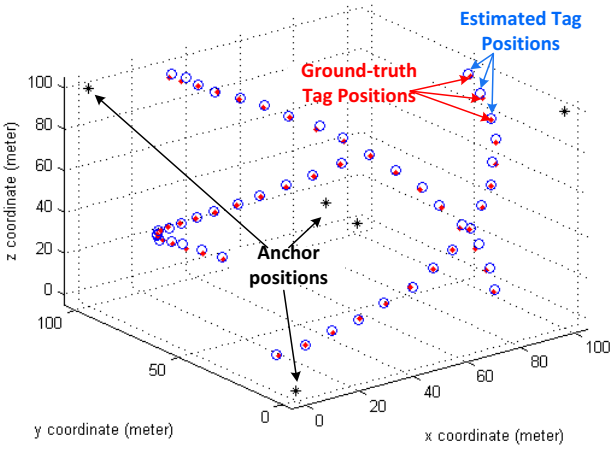
- Narrowband transmitter for longer range (>5km)
- Antenna and circuit co-designed
- Non-coherent modulation for TRX
- No need for off-chip crystal or PLL

5. Semantic Localization:

- Distinguish different environments base on channel impulse response machine learning
- Identify the tag either inside or outside a specific domain

Expected Results

Matlab simulation results



System Target Specification

Tag Spec.	• Power: <100μW in average, <200mW peak power. • Full-duplex frequency-conversion active reflector with 5.8GHz / 2.4GHz dual-band • Built-in wakeup receiver (<100μW) to initiate localization • Built-in narrowband (1kHz) transmitter (10km link distance) for emergency beacon TX
Anchor Spec.	• USRP X310 software defined radio • MIMO, 80MHz bandwidth, -100dBm sensitivity with OFDM symbol combining
Algorithm	• OFDM based time-of-flight estimation • MIMO processing and OFDM symbol coherent combining • Neural network based localization accuracy enhancement • Neural network based semantic localization • Real-time 3D localization with <1ms update rate via coordination among anchors
System Spec.	• Localization range: >100m per dimension in NLOS • Localization accuracy: standard deviation error e_{std} <30cm per dimension in NLOS • Performance: real-time, 1ms refresh rate per localization fix