<Theme: Research trends in Sensing, Localization, and IRS towards 6G>
8th November

Localization techniques towards 6G Networks

by

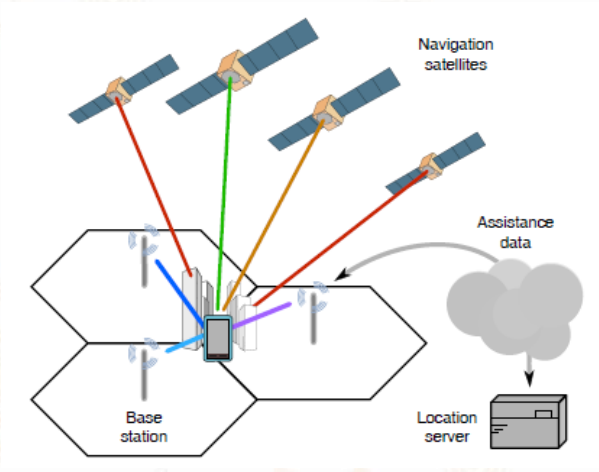
Ratnakar Rao V R

(Samsung R&D Institute, Bengaluru)

Localization Landscape

Jargon:
- Localization Vs Positioning
- Active Vs Passive target
- Radar Vs Communication

Localizing what?:
- Anchor locating terminal
- Terminal locating anchor
- Either of them mapping their environment



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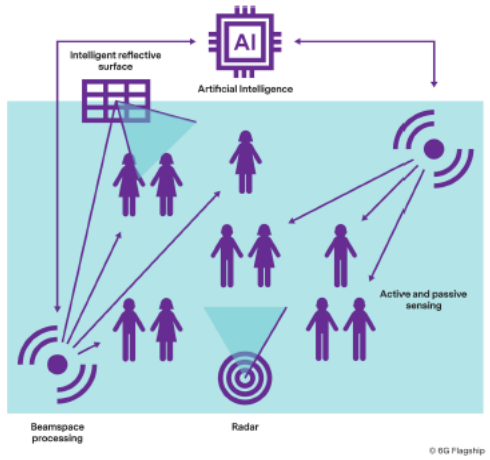
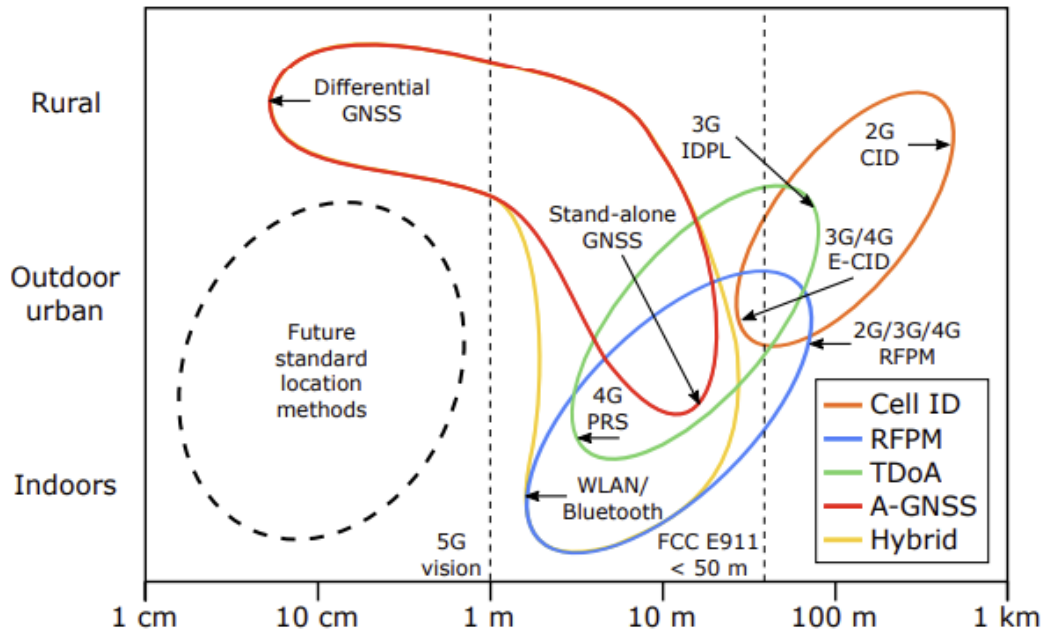


6G White Paper on Localization and Sensing; Andre Bourdox et al., arXiv:2006.01779, University of Oulu 6G research vision.12, June 2020

Positioning Technologies
- Satellite
- Mono / Bi-static Radars
- Cellular
- Short-range Wireless
- UWB
- Database search
- On-device sensors

	Passive	Active
Network driven	• RF Sensing (examples: Cell mapping, beam management, power saving, RIS activation) • Uplink techniques (using existing signalling like SRS, UL AoA/AoD)	• UE assisted (examples: Cell-ID, PRS based measurements, TDoA, DL AoA/AoD etc)
Terminal Driven	• RF Sensing (examples: SLAM extension, Intruder detection, Health monitoring) • Finger-printing DB • Sensor fusion	• GNSS Satellite positioning • Network assisted (examples: LMF based inferences) • Collaborative (multiple terminals exchanging information)

Localization Techniques & Journey



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Technique	4G	5G	Comments
RSS & Path loss measurement based	• Using existing signalling	• Using existing signalling	More suitable for WiFi/BLE
Time difference of arrival (TDoA)	• PRS in Downlink • SRS in Uplink	• PRS in Downlink • SRS in Uplink	Relies on accurate sync between the base stations
Angle of arrival methods (and phase)		• DL beam idx (AoD) • UL beam idx (AoA)	Depends on antenna array size, shape, Orientation (suitable for beamforming)
IMU Sensor Hubs On-Device	• Independently at UE	• Independently at UE	Accelerometer/magnetometer/gyroscope, UWB
Doppler shift	• Independently at UE and BS	• Independently at UE and BS	
Finger-printing data bases	• Independently at UE	• Independently at UE	Several proprietary data bases being built
Cell-ID based			More accurate methods available

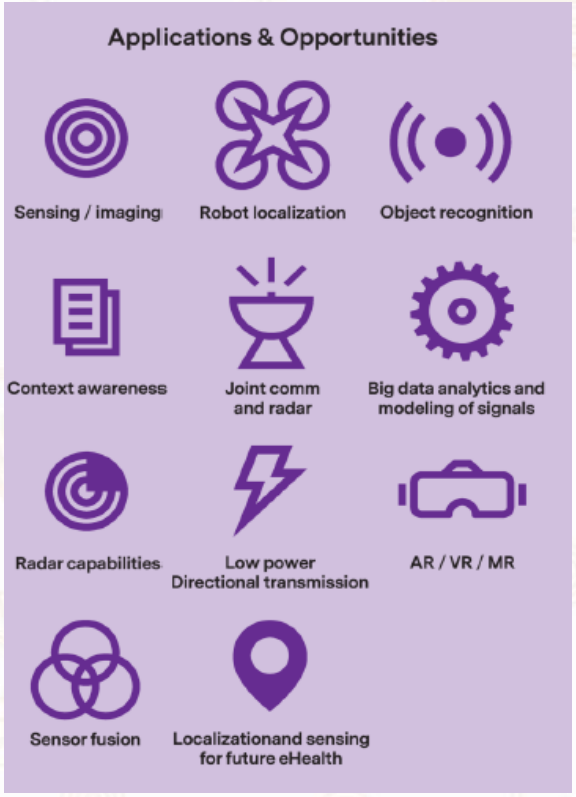
New Drivers for Positioning

Drivers for Positioning in 5G & Beyond:

- Autonomous driving
- Drone tracking in outdoors
- Robot tracking in indoors
- Asset tracking and monitoring
- Extended reality

And also:

- Intelligent beam management
- Network efficiencies, SON
- Optimized RRM



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What Positioning needs	5G	6G
• Identify as many reflections of interest as possible	• Higher bandwidth for more delay resolution	• > 1 GHz Bandwidths
• Sparse Multipath	• Higher carrier frequencies	• > 0.1 THz frequencies
• Precise direction and angle of arrival/departure	• Large number of antennae, beamforming	• Very high density antenna arrays
• Collaborative localization	• Using D2D, V2X	
• Multiple anchor points for quick and easy triaging	• Network densification	
• Higher coverage		• RIS for better SNR and create virtual LOS anchors
• Estimation in the presence of large number of variables		• AI/ML

	Release-16	Release-17	Release-18
Positioning Accuracy	< 50 meters	< 20 cms	< 1 cm
Positioning Latency	< 30 seconds	< 100 ms	< 10 ms

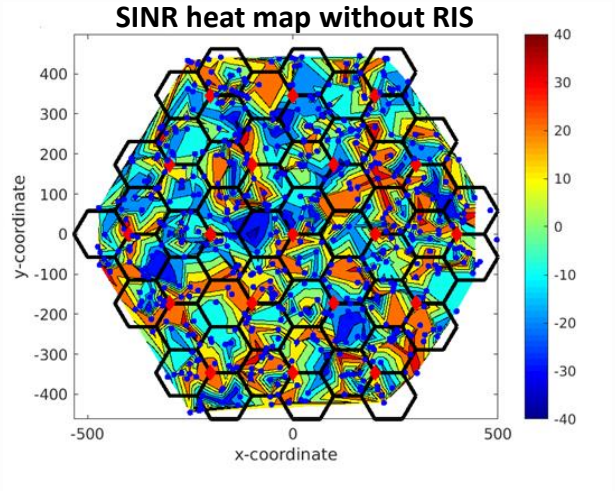
Indoor Positioning Trends in 5G-Advanced: Challenges and Solution towards Centimeter-level Accuracy
Jakub Nikonowicz, Aamir Mahmood, Muhammad Ikram Ashraf, Emil Bj¨ornson, Mikael Gidlund
ArXiv, year 2022, volume 2209.01183

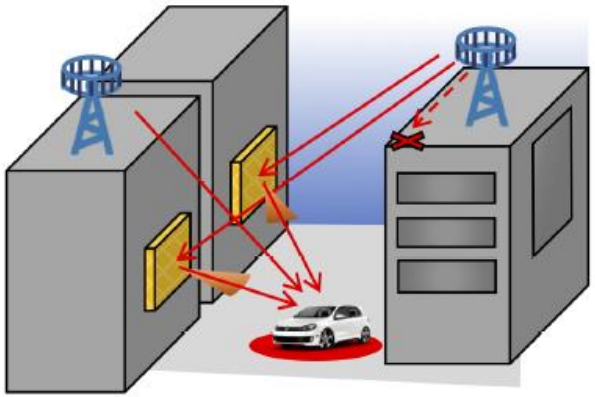
RIS Assisted Localization

RIS Purpose:
Reduce blockage probability & Improve received signal strengths in DL & UL

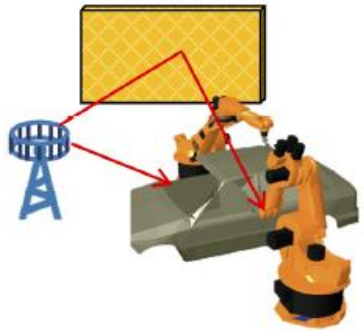
RIS for Localization Vs Localization for RIS

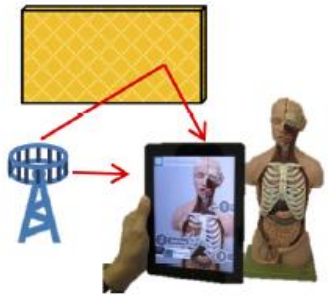
Challenges for Localization:
- Channel modelling and Channel estimation
- Waveform Design
- Near-field propagation




Localization under LOS Blockage


Near-field Localization


Localization in Industry 4.0


Augmented Reality

Wymeersch, H., He, J., Denis, B. et al (2020). Radio Localization and Mapping with Reconfigurable Intelligent Surfaces: Challenges, Opportunities, and Research Directions. IEEE Vehicular Technology Magazine, 15(4): 52-61.

Wireless AI based Location Detection

ITU AI/ML in 5G Contest 2021

Top Solution

Integrated Sensing and Communication

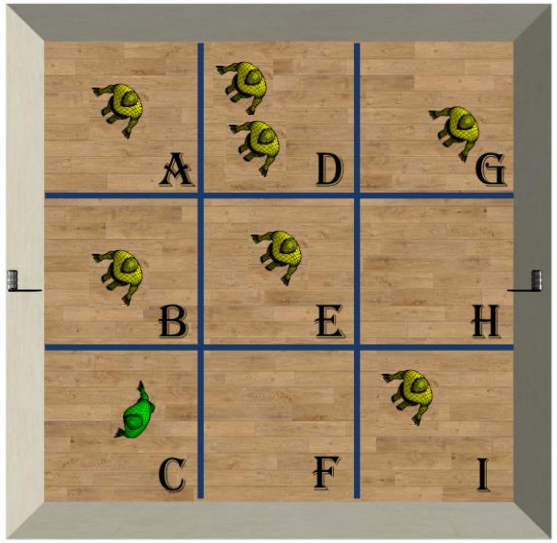
Data Transmission and reception

+

Sense the environment

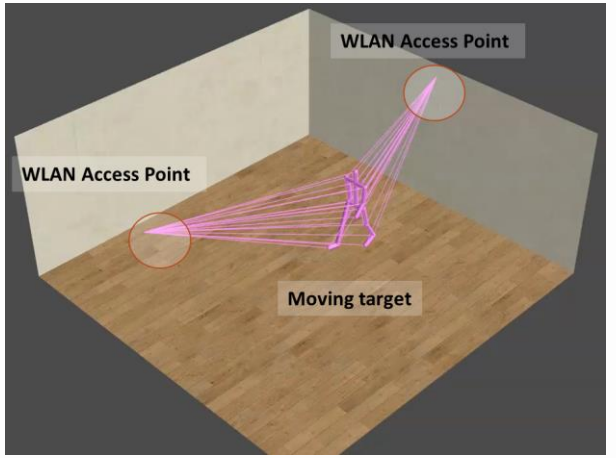
Problem statement:

1. Localization: Find number of persons in each sector
2. Counting: The total number of persons in the room.



Tx

Rx



Use:
Received signal (raw)

Given Received Signal : Channel estimation field of conventional IEEE 802.11ay packets :
Total 128 packets each of 1ms duration.

Sector	No of people
A	1
B	1
C	1
D	2
E	1
G	1
I	1
Rest of the sectors	0
Total	8

System:
Frequency: 60GHz
Bandwidth: 1.76GHz

Team name: The Sixth Sense

Team Github Repo: ITU-AI-ML-in-5G-Challenge/ITU-ML-5G-PS-002-WALDO_TheSixthSense_SRIB_Final

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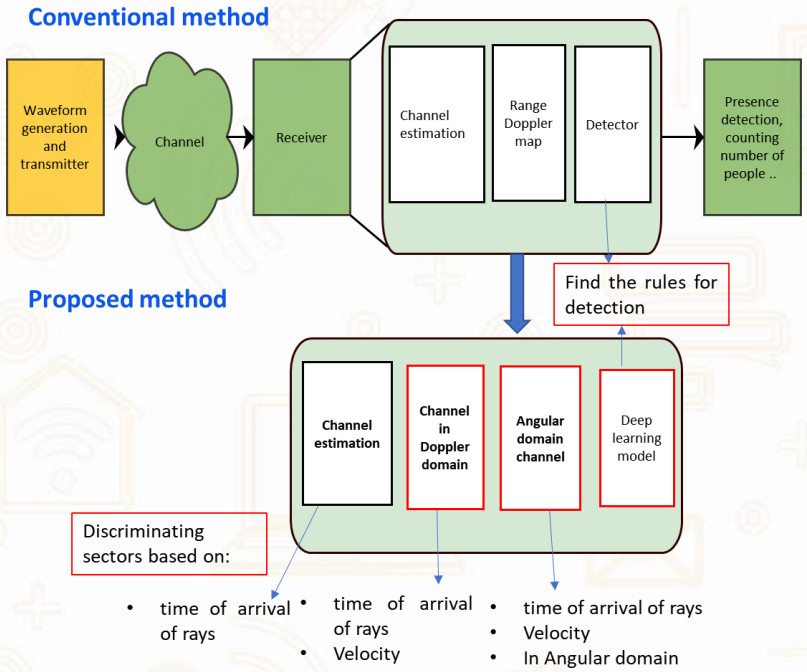

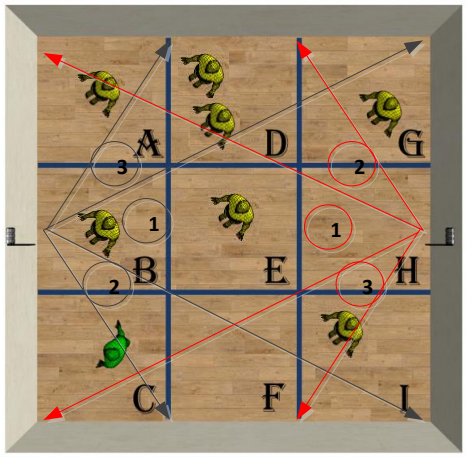

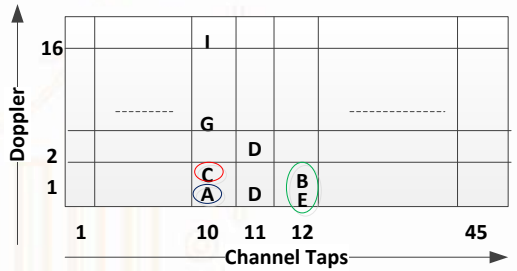

Result:

Counting model accuracy: Number of times the total number of persons in the room are predicted correctly.

Localisation model accuracy: Number of times the number of persons in each sectors are predicted correctly.

Counting Model accuracy

SNR	% Accuracy
18	99%
0	99%
-18	39%

Localisation model accuracy

SNR	% Accuracy
18	99%
0	85%
-18	2%

Conclusions:

- Possible solution for joint communication and sensing
- Novel method for drawing sensing features for Joint communication and sensing
- Can separate persons :
  - Distance : 17 cm
  - Velocity: 2 cm/sec
  - Angular separation: 30 deg

Conclusions

What's going for Localization in B5G systems:

- Very good chunks of spectrum reserved for radar (aviation, defense, automotive etc.) (spectrally very inefficient)
- Two or more separate infras for Comms. and other positioning use-cases
- Beyond-5G use-cases (XR, Driverless car, Radio SLAM) & enablers (THz, RIS, New mmWave bands) being proposed all need Sensing/Localization

What's not going :

- Privacy & security concerns related to the handling by Comm. Infra Providers
- Rise of alternative technologies like LIDAR, Sensor-Fusion, UWB and Finger-printing
- Viability of 6G enablers like THz/RIS for commercial use

SAMSUNG

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India's Telecom SDO

Thank You

ratnakar.rv@samsung.com