Outdoor mmWave band Tx Localization using scattering path under Spectrum Sharing scenario

AOTULE 2021

09th November, 2021

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Content

Background

Fig.1 Spectrum allocation in USA

Taken from:United_States_Frequency_Allocations_Chart_The_Radio_Spectrum.

The spectrum resources are artificially scarce because the static legacy regulatory prevents the spectrum to be shared more intensively.

Spectrum

Spectrum resources is a key point for future development of International Mobile Telecommunication (IMT).

According to WRC 19 conclusions, **24.25-27.5GHz** frequency band is identified to IMT.

Existing Problem

However, as you can see in Fig.1. The different color means different radio services. 0kHz to 300GHz is divided in every10GHz.

Background

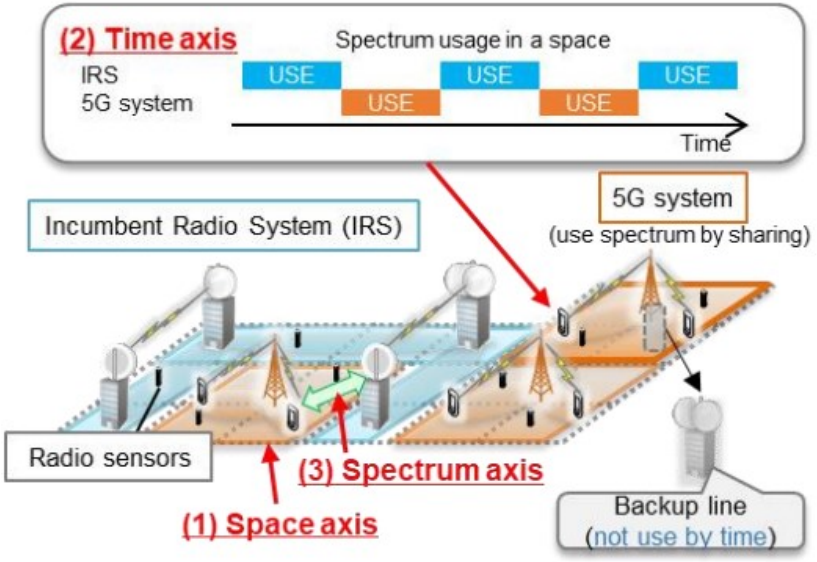


Fig.2 Spectrum Sharing Concept

Taken from: [1] SHINBO, Hiroyuki & YAMAZAKI, Kosuke & KISHI, Yoji. (2021). Research & Development of the advanced dynamic spectrum sharing system between different radio services. IEICE Transactions on Communications. 10.1587/transcom.2020DSI0001.

Spatial Spectrum Sharing

Spectrum sharing helps to solve the scarce spectrum resources problem.

- Space axis
- Time axis
- Spectrum axis

Fixed Wireless Access

The targeted frequency band is the millimeter wave (mmWave) band of Fixed Wireless Access (FWA) using in Japan.

FWA is a way of providing wireless connectivity through radio links between two **fixed stations**.

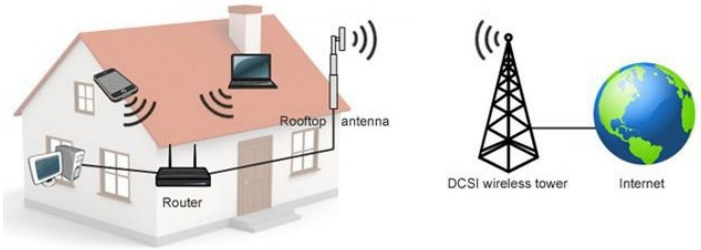


Fig.3 Fixed Wireless Access Concept

Background

Application Background

- **Problem 1**

Though FWA is fixed, there are also **portable** ones plays as **temporary station**. The operation parameters of portable FWA may not be registered in the spectrum sharing database in advance.

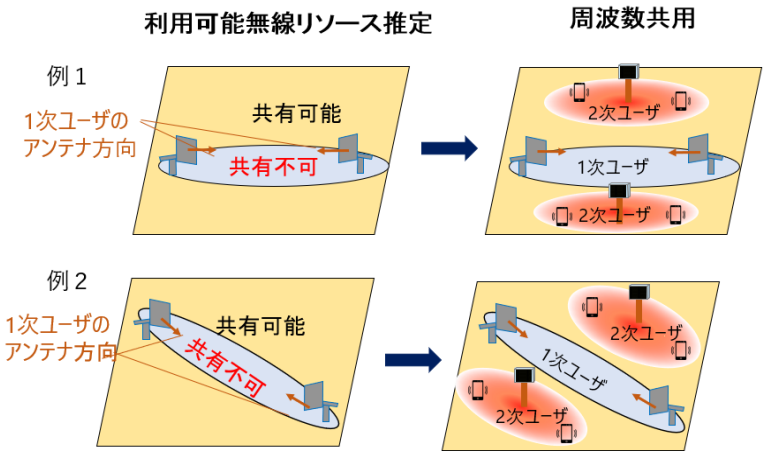


Fig.4 Antenna pattern

Taken from: [2] 異システム間の周波数共用技術の高度化に関する研究開発, Figure 10-7 , page 113

- **Problem 2**

The conventional localization scheme only estimate the position of Tx. However, under the spectrum sharing scenario, we need to estimate more operation parameters:

1. The antenna pattern of Tx
2. Beamwidth

- **Problem 3**

  Localize with LoS can get good accuracy. However, LoS is unlikely guaranteed in urban environment and NLoS path can lower the accuracy. So, the analysis of it is crucial.

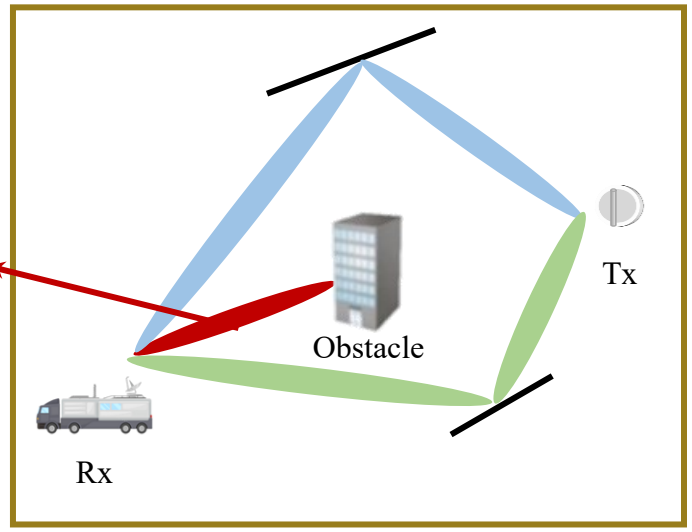


Fig.6 Propagation mechanism in mmWave

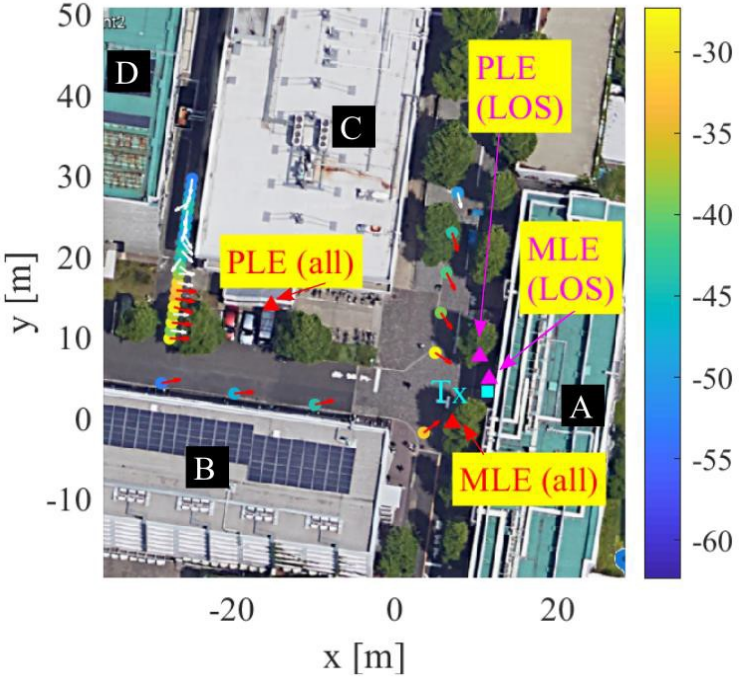


Fig.7 localization results

Taken from: [2] 異システム間の周波数共用技術の高度化に関する研究開発, Figure 10-5 , page 112

Distance Error

	PLE	MLE
LOS only	4.5m	1.7m
All points	28.6m	5.7m

Research Content

- **Problem 4**

mmWave can be easily blocked by buildings

- The propagation is very site specific
- Localization with empirical site general model may not be applicable
- Environment map is necessary

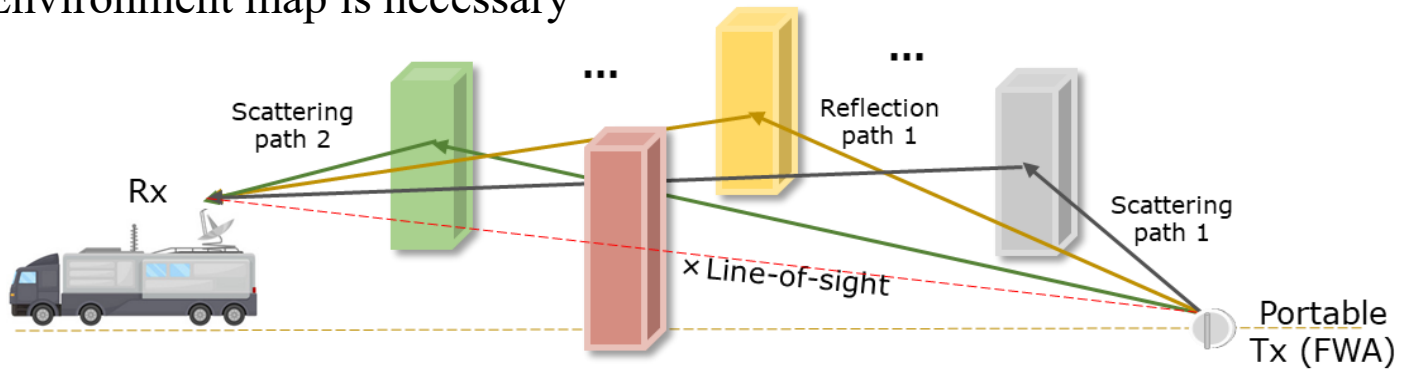


Fig.8 NLOS Localization Concept

Research Objective

Localization of Tx under non-line-of-sight (NLOS) environment at millimeter wave band.

Research Plan

NLoS detection

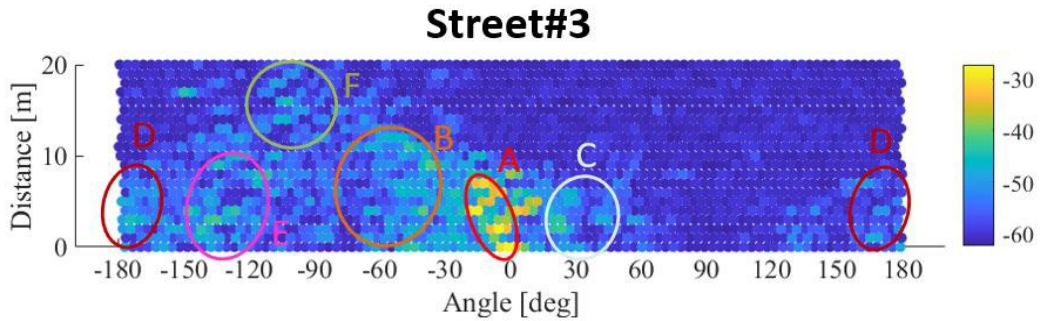
NLoS path propagation estimation using environment map

Localization with MLE based on the estimated NLoS propagation paths

Research Content

NLOS paths Detection

LOS and NLOS path presents the salient difference in many aspects:



Cluster	Major Mechanism
A	LOS, tree shadowing
C, D, E	Building/ tree reflection/scattering
B	1. Building scattering 2. Diffraction
F	Waveguiding effect

(i) More attenuation [3] due to reflection , and resulting in relatively smaller received power.

(ii) Large angular spread due to the diffuse scattering paths and vice versa to the LoS path due to the direct path.

Fig.9 NLOS Localization Concept

Taken from: [2] 異システム間の周波数共用技術の高度化に関する研究開発, Figure 10-8 , page 201

[3] S. Maran`o, W. M. Gifford, H. Wymeersch, and M. Z. Win, "Nlos identification and mitigation for localization based on uwb experimental data," IEEE Journal on Selected Areas in Communications, vol. 28, no. 7, pp. 1026–1035, 2010.

Research Content

Overview in Traditional Localization Methods

Maximum Likelihood Estimation (MLE) utilize the angular power spectrum obtained from the spatially separated receiver [4]. However, previous works utilized MLE **only for estimating Tx location** which is not sufficient for spatial spectrum sharing. (unknown peak direction and beamwidth)

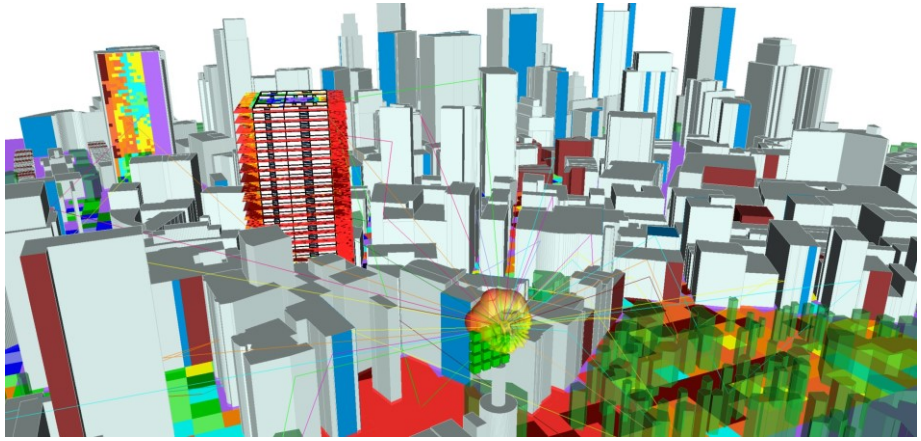


Fig.9 Urban Small-Cell Analysis

Taken from: https://www.remcom.com/

Goal: Tx location, peak direction, and beamwidth

Input: Environment model, Rx power.

Output: Estimated location

Before measurement, the test with the RT simulation to validate the estimation methodology is crucial.

[4] K. Do˘ganc¸ay and G. Ibal, "3d passive localization in the presence of large bearing noise," in 2005 13th European Signal Processing Conference, 2005, pp. 1–4.

References

[1] SHINBO, Hiroyuki & YAMAZAKI, Kosuke & KISHI, Yoji. (2021). Research & Development of the advanced dynamic spectrum sharing system between different radio services. IEICE Transactions on Communications. 10.1587/transcom.2020DSI0001.

[2] **異システム間の周波数共用技術の高度化に関する研究開発** (2020)

[3] S. Maran`o, W. M. Gifford, H. Wymeersch, and M. Z. Win, "Nlos identification and mitigation for localization based on uwb experimental data," IEEE Journal on Selected Areas in Communications, vol. 28, no. 7, pp. 1026–1035, 2010.

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Thank You
for your attention