Telecommunication Networks Group

Toward Enhanced Accuracy of Sensing-Assisted Beam Tracking Frameworks in mmWave Networks

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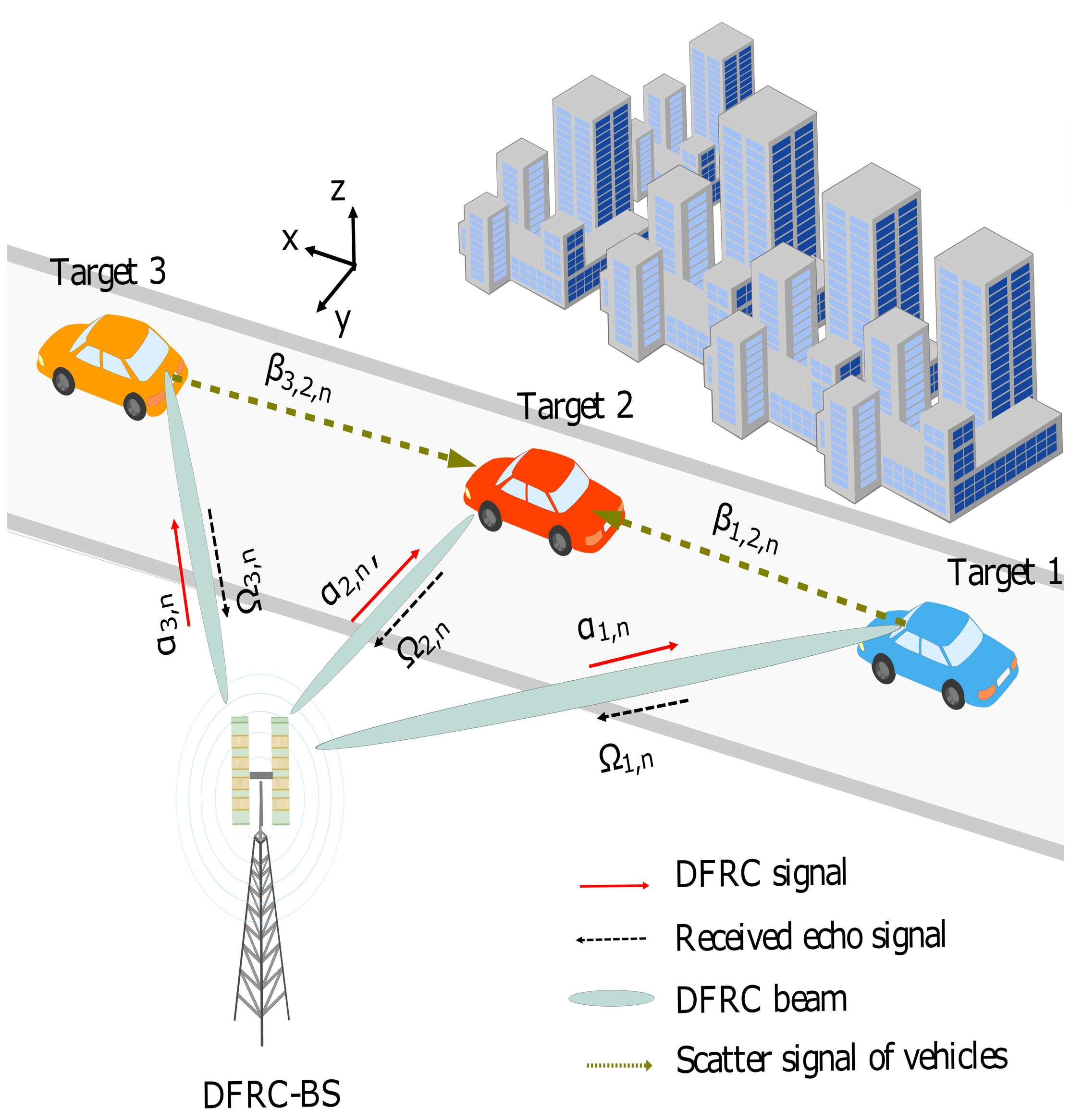
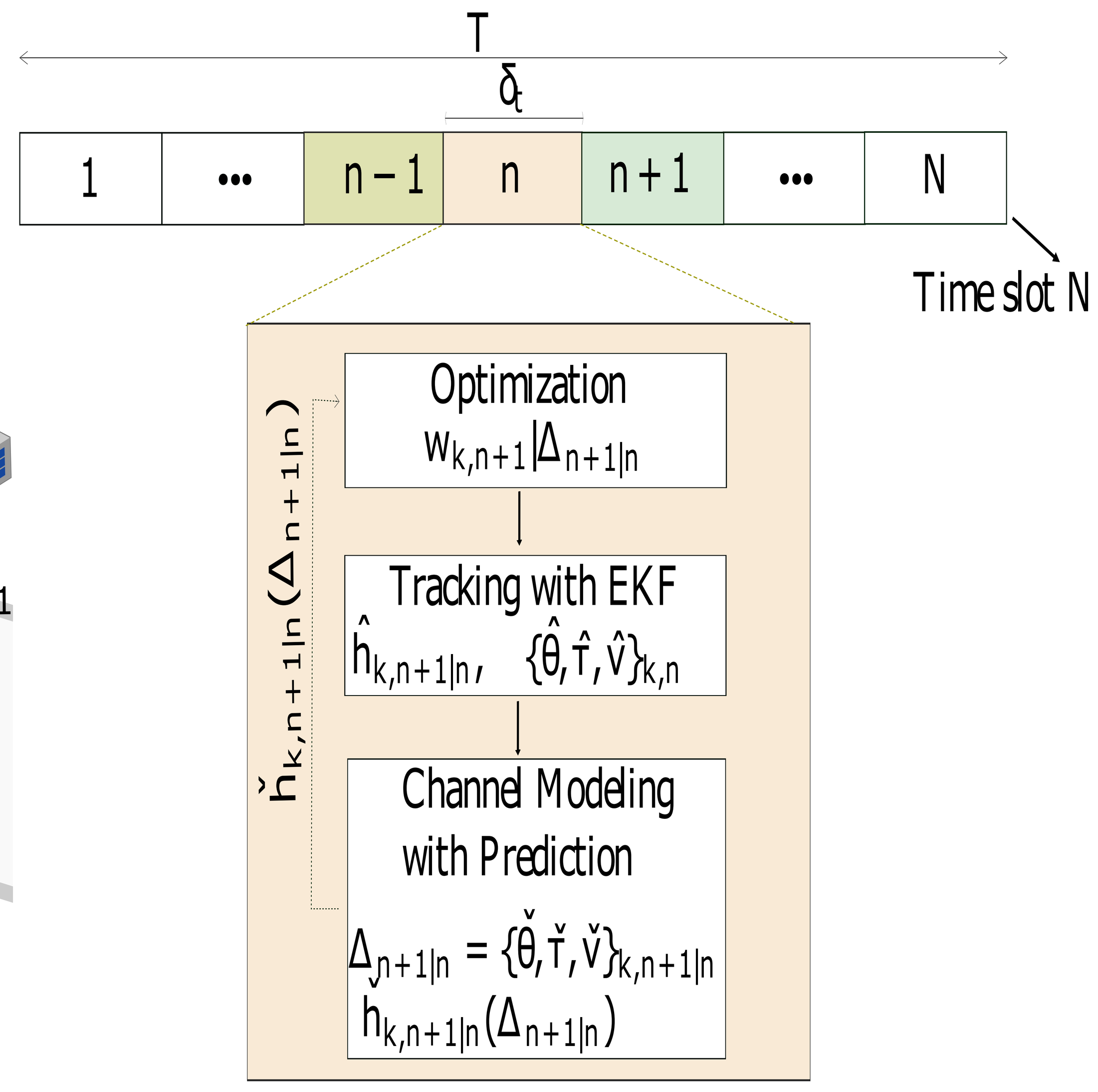
Motivation & Contributions

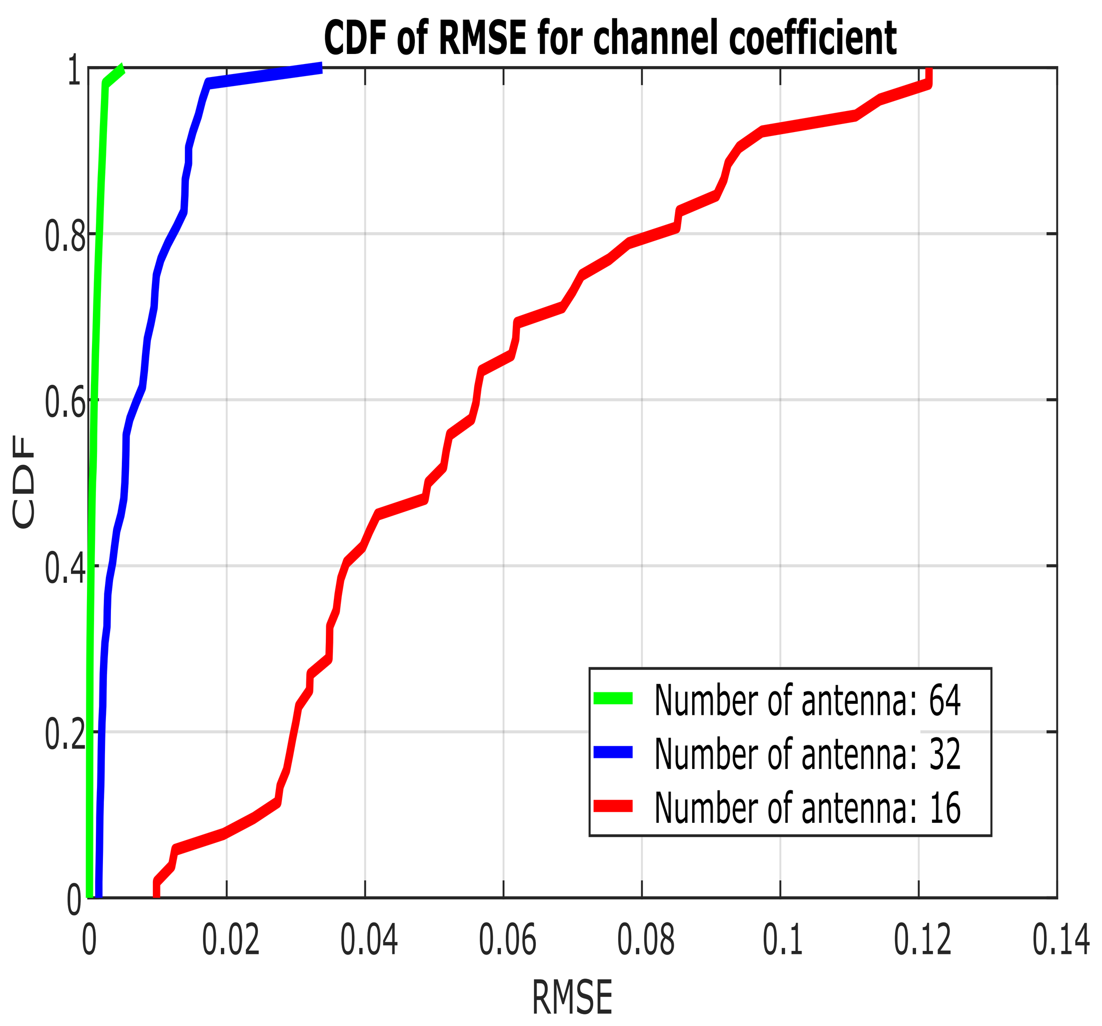
Application: Sensing assisted automation framework design to enhance robustness, coverage, and situational awareness

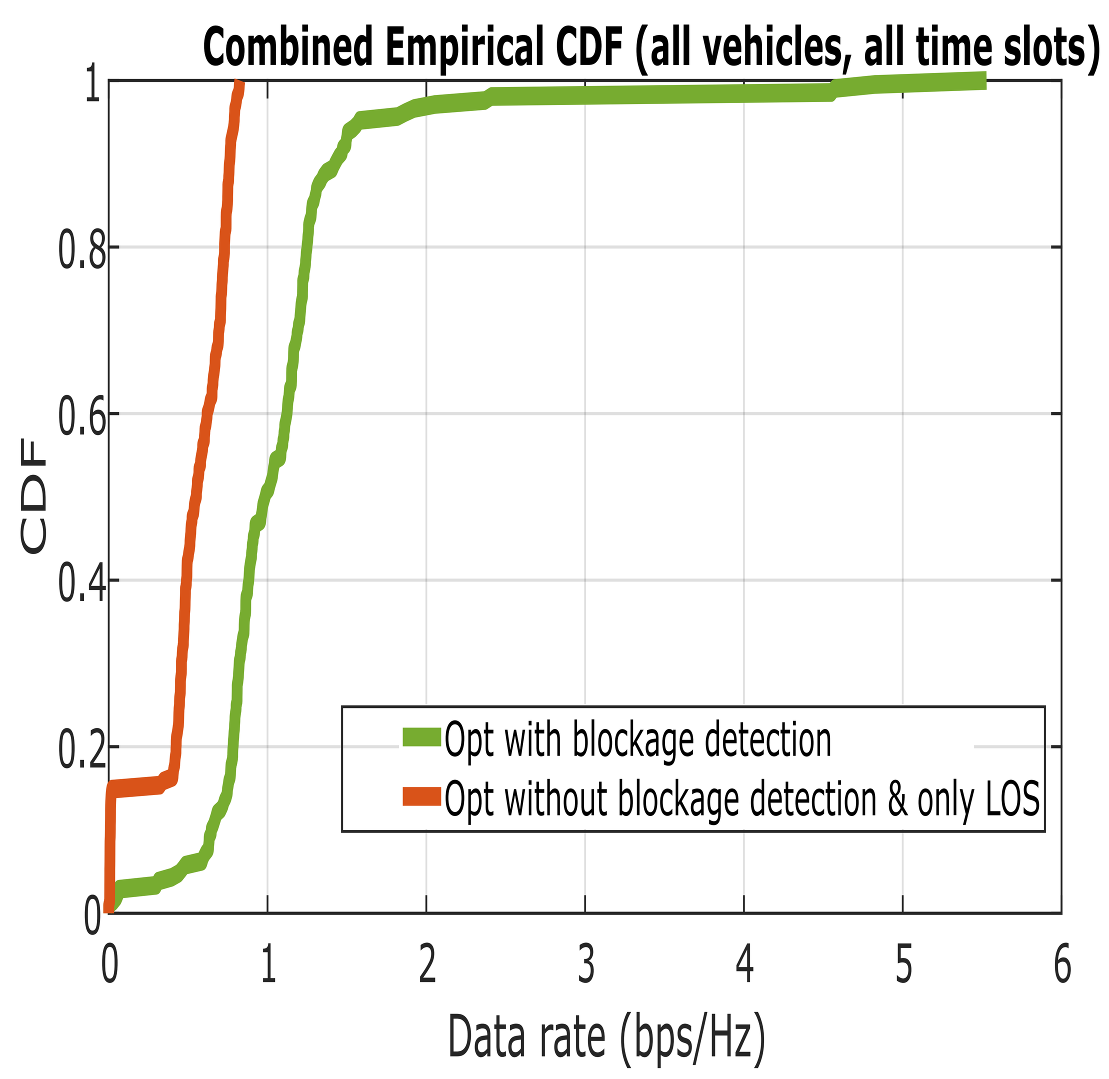
- **Tracking the mobility of target and potential mobile scatters:** Increasing accuracy with high quality sensing and EKF
- **Channel model including LoS and NLoS components** → Resource allocation based on the predicted channel in the next step
- **Improved resilience against blockages:** Reliable detection of blockages in dynamic environments with utilization of NLoS paths and spatial awareness to maintain connectivity

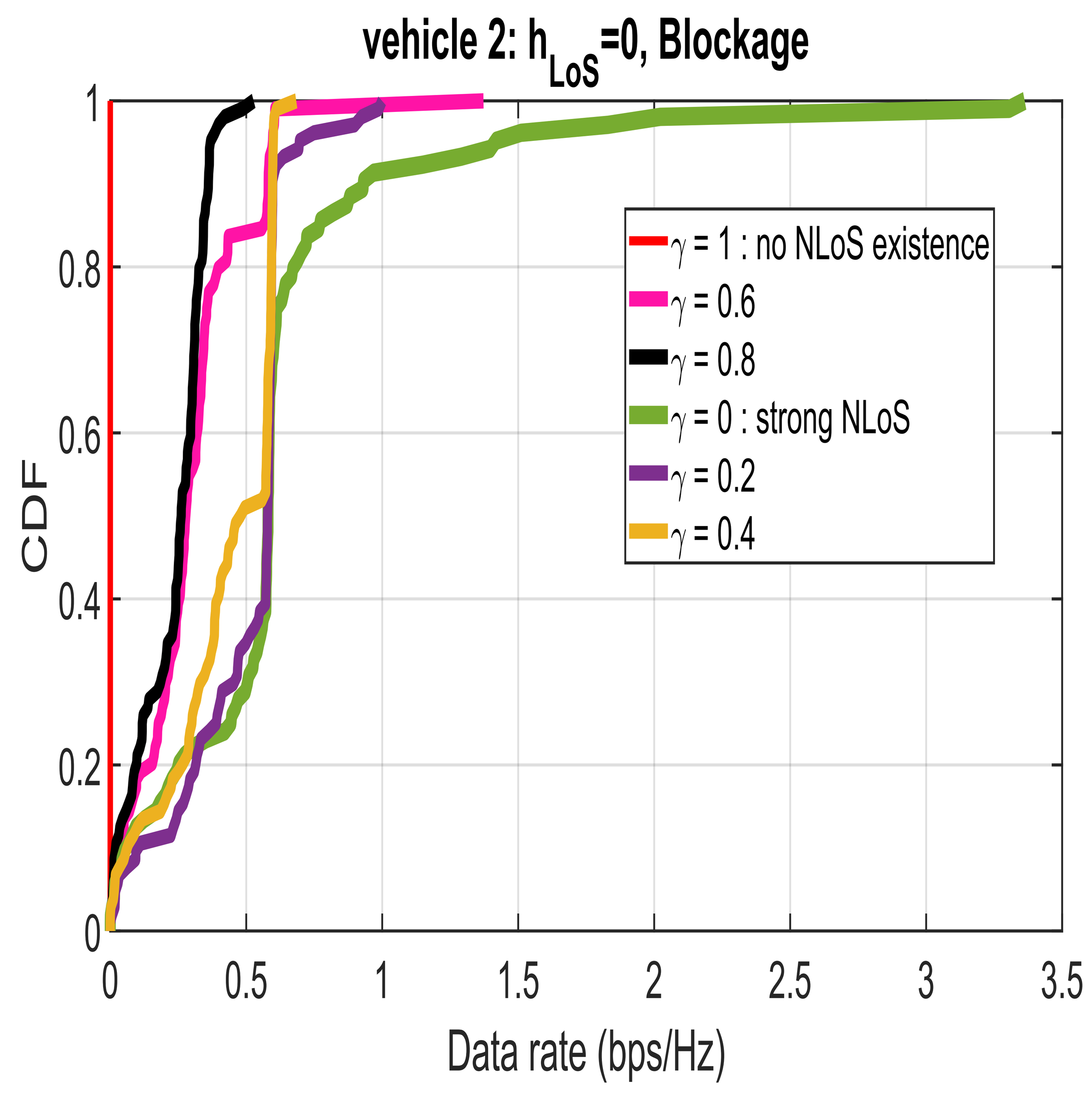




Simulation Results







- Validation of the proposed multi-target mobile tracking framework with emphasis on estimation accuracy.
- Number of antennas matters for the channel estimation accuracy.

- With blockage detection, performance improves since mobile scatterers can be utilized.
- Without scatterer estimation and relying only on LoS, the data rate drops to zero when a blockage occurs.

- The achievable data rate for a fully blocked user is evaluated under different NLoS contribution coefficients.
- When the NLoS contribution is zero, the user fails to establish a connection.
- With strong NLoS contributions, the user can still achieve a high data rate, even without a LoS link.

Problem Formulation

Optimization: Beamforming design for enhanced sensing performance guaranteeing KPIs:

- Achievable data rate
- Cramér–Rao bound
- Fairness among users

$$\mathcal{P}: \min_{\mathbf{w}_{k,n}} \max_{\theta_{i,n}, i\in\mathcal{K}} \zeta_{\theta_{i,n}}$$

$$\text{s.t.} \quad \text{C1}: R_{k,n} \geq C^{\text{th}}_{k,n}, \forall k, n,$$

$$\text{C2}: \sum_{k=1}^{K} \|\mathbf{w}_{k,n}\|^2 \leq p^{\text{lim}}_{\max}, \forall n.$$

References

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[2] Z. Du, F. Liu, W. Yuan, C. Masouros, Z. Zhang, and S. Xia, "Integrated Sensing and Communications for V2I Networks: Dynamic Predictive Beamforming for Extended Vehicle Targets," IEEE Transactions on Wireless Communications, vol. 22, no. 6, pp. 3612 – 3627, 2023.

[3] Y. Zhang, S. Li, D. Li, J. Zhu, and Q. Guan, "Transformer-Based Predictive Beamforming for Integrated Sensing and Communication in Vehicular Networks," IEEE Internet Things J., vol. 11, no. 11, pp. 20 690–20 705, 2024.

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