Research project and supervisory team

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Short introduction & description of research project	The rapid proliferation of autonomous vehicles, connected infrastructure, and urban mobility platforms is fundamentally reshaping the requirements placed on wireless communication networks. As transportation systems evolve toward full autonomy and pervasive connectivity, Vehicle-to-Everything (V2X) communications must simultaneously deliver ultra-reliable, low-latency data exchange and high-resolution environmental sensing across highly dynamic environments. Sixth-generation (6G) networks are expected to play a pivotal role in meeting these demands, yet realizing this vision in high-mobility vehicular scenarios remains a profound challenge. The proposed project aims to develop advanced division multiplexing waveforms that are natively suited to high-mobility V2X and integrated sensing and communication (ISAC) requirements. Recent advances have introduced promising alternatives to legacy orthogonal frequency division multiplexing (OFDM), including delay-Doppler domain waveforms such as orthogonal time frequency space (OTFS) modulation and chirp-domain waveforms such as Affine frequency division multiplexing (AFDM), which offer inherent resilience to high mobility V2X communications and favorable sensing ambiguity properties. By leveraging these unique characteristics, the project will pursue innovations in waveform design, and dual-functional ISAC signal processing, with the objectives of enhancing communication and sensing performance, reducing system overhead, and advancing the state-of-the-art in 6G-enabled V2X systems. The project is mainly structured into **two work packages (WPs) for two PhD candidates**. **WP1** focuses on the design of novel ISAC waveforms and physical-layer signal processing algorithms tailored for high-mobility V2X environments by leveraging advanced waveforms such as AFDM. It will investigate dual-functional waveform design and optimization that simultaneously satisfies communication spectral efficiency and radar sensing ambiguity function. By exploiting the inherent chirp pulse compression properties and tunable delay-Doppler orthogonality of AFDM, this project aims to design AFDM-ISAC waveforms to achieve high-resolution range-Doppler estimation while maintaining robust data transmission under doubly dispersive vehicular channels. WP1 include the following main research works:

	Designing AFDM-ISAC dual-functional waveform optimization strategies, including ambiguity function shaping, chirp parameter selection, and pilot-data multiplexing schemes that balance sensing resolution and communication throughput. Designing sensing signal processing algorithms for multi-target detection and tracking in dense scattering environments and addressing self-interference cancellation for full-duplex ISAC transceivers. Establishing theoretical performance bounds, including Cramér-Rao bounds for sensing parameter estimation and rigorous characterization of the communication-sensing trade-off at the physical layer, providing a principled foundation for the overall system design. **WP2** is dedicated to the design of intelligent and efficient resource allocation schemes for ISAC-enabled V2X networks under 6G framework, aiming to minimize system overhead, maximize overall efficiency, and ensure ultra-reliable low-latency communication for safety-critical vehicular applications. The joint framework is developed to formulate multi-objective optimization problems that balance throughput, sensing accuracy, latency, and reliability under high-mobility constraints. WP2 includes the following research works: Developing joint communication-sensing resource allocation frameworks that co-optimize time-frequency resource partitioning, power allocation, and beamforming, formulated as multi-objective optimization problems and solved via convex relaxation or learning-based approaches. Designing proactive scheduling schemes that exploit real-time ISAC sensing outputs, including estimated vehicle positions, velocities, and trajectory predictions, to anticipate channel variations and pre-allocate resources ahead of demand, reducing signaling overhead and handover latency in high-mobility scenarios. Investigating distributed and hierarchical coordination mechanisms for multi-vehicle, multi-cell dense V2X deployments, where lightweight inter-node signaling enables scalable local resource decisions while meeting the stringent end-to-end latency and packet reception probability requirements of safety-critical applications.
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