Bridging the Gap: A Realistic V2X Simulator for Cooperative Autonomous Driving

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01 · Introduction

Cooperative autonomous driving systems rely on Vehicle-to-Everything (V2X) communication to exchange safety-critical messages beyond onboard sensor range. Real-world channels exhibit multipath fading, distance-dependent attenuation, and obstacle shadowing, under which message delivery failures are most probable. Yet most cooperative driving algorithms assume ideal communication, creating a systematic gap between simulation and deployment.

We integrate **Veins** into the **Autoware** autonomous driving stack via **scenario simulator**, enabling physics-based V2X channel modeling within closed-loop scenario simulation. This integration introduces a realistic wireless channel into autonomous driving simulation.

02 · Veins — Physics-accurate V2X simulation

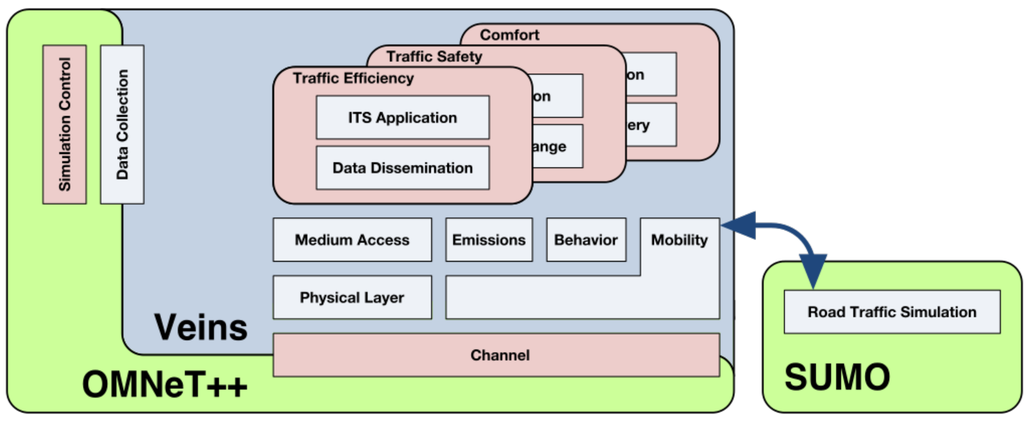
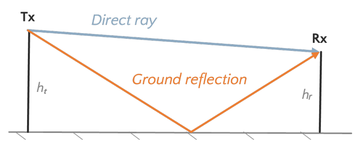
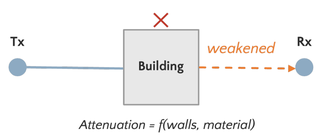


Fig 1. Veins Structure (https://veins.car2x.org)

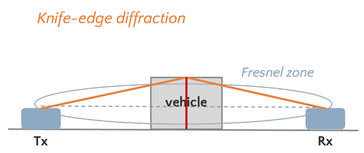
Veins is an open-source vehicular network simulator built on OMNeT++. It implements the full IEEE 802.11p / ITS-G5 protocol stack.



Two-Ray Ground Reflection



Obstacle Shadowing



Vehicle Shadowing

- IEEE 802.11p PHY + MAC / 1609.4 with EDCA
- Two-ray ground-reflected path-loss model
- Per-packet RSSI, SNR, received power, path-loss indicators
- Dynamic RSU and vehicle node spawning at runtime

03 · Autoware and scenario simulator

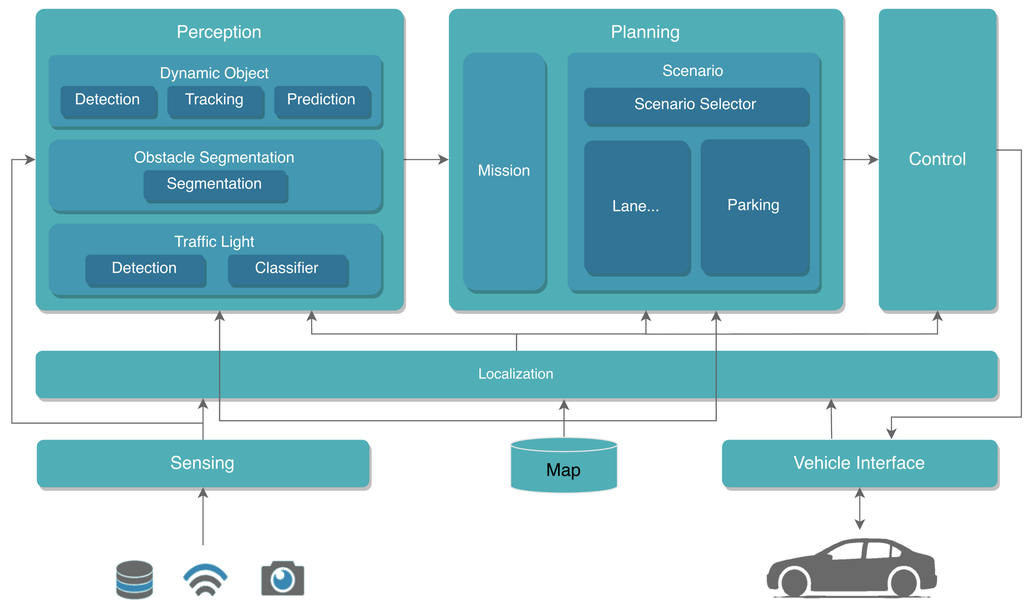


Fig 2. Autoware Structure (https://autowarefoundation.github.io)

The baseline simulation environment is built by integrating the scenario simulator with the Autoware autonomous driving stack, enabling closed-loop evaluation of V2X-assisted autonomous driving scenarios.

- RSU models with occlusion, sensor noise, and detection delays
- V2X emulated via UDP proxy with latency, jitter, packet loss
- No wireless channel physics simulation

04 · Our Method

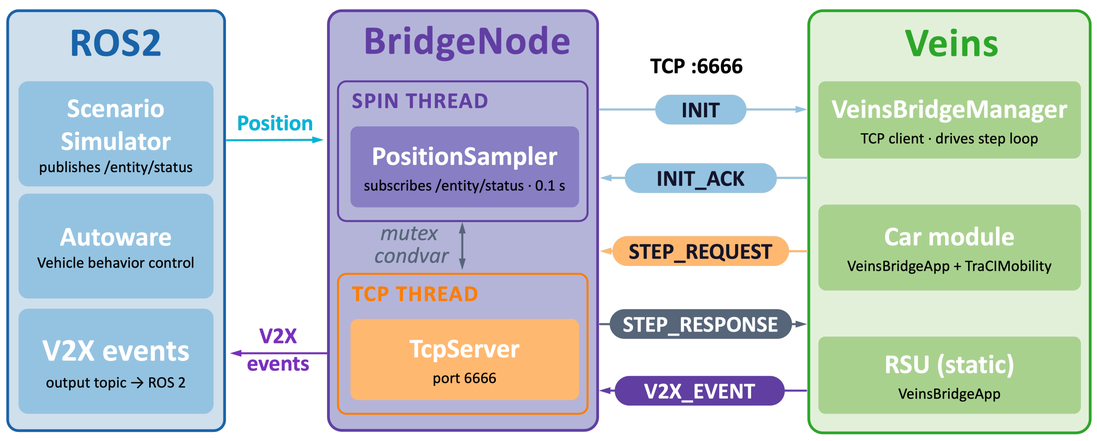


Fig 3. Veins and Autoware Integration System Structure

We integrate Veins / OMNeT++ with Autoware via scenario simulator, adding realistic V2X channel modeling to closed-loop autonomous driving simulation as a parallel process.

- Vehicle positions forwarded to OMNeT++ over TCP
- Veins simulates the full IEEE 802.11p channel and returns the channel conditions
- V2X channel conditions published back to the scenario simulator for downstream consumption

05 · Results

The bridge exposes per-packet channel and network metrics as output. Buildings and vehicles are modeled as physical obstacles, capturing realistic channel conditions.

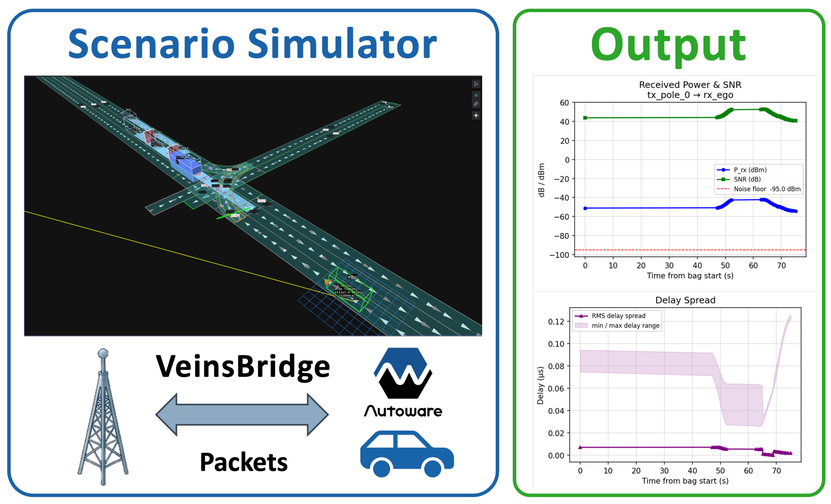


Fig 4. Simulation results

06 · Conclusions

- We couple Veins / OMNeT++ with Autoware via scenario simulator, adding physics-based IEEE 802.11p channel modeling to a closed-loop autonomous driving simulation.
- Per-packet RSSI, SNR, and delay are exposed as ROS 2 topics, enabling V2X evaluation under realistic wireless conditions.
- Future work will integrate received V2X data into the Autoware perception pipeline.

Acknowledgements

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