INTERACTIVE TEST TOOL
FOR INTEROPERABILITY TESTING OF MULTI-VENDOR CACC

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V2X BENEFITS

• Safety
  • Beyond line-of-sight

• Efficiency
  • Platooning – wind resistance
TEST CORRECTNESS OF V2X

• Conformance testing
• Interoperability testing
  • On-site PlugTest
    • Expensive
    • What if there’s no hardware yet
• Remote PlugTest – for vehicle?
CHALLENGE

• Remote interoperability testing
• Early dev phases

• Enable GCDC participants test together before coming to the competition
  • Grand Cooperative Driving Challenge - www.gcdc.net
PREVIOUS TOOLS

- HLA High Level Architecture
- DIS Distributed Interactive Simulation
- FMI Functional Mock-up Interfaces for co-simulation

*Way too complicated for our simple domain*
DOMAIN: COOPERATIVE DRIVING

- Camera
- Radar
- Wireless communication
SIMPLE TASK: DELIVER ”HELLO WORLD” OVER V2V

• VPN is enough for networking
• Controller that generates the message refuses to work without the radar
INPUTS FOR CONTROLLER

• …are generated by Sensor Model
• Sensor model needs *Ground Truth*
• Deliver *Ground Truth* to everyone!
  • Gather from everyone and redistribute
INPUTS FOR CONTROLLER

Sensor model → Controller → Vehicle dynamics

GT → ITT Server

Controller

Sensor model → Controller → Vehicle dynamics

n x GT → ITT Server

1 x GT
INPUTS FOR CONTROLLER

Vehicle block – Standalone (no ITT)

Vehicle block – ITT
GROUND TRUTH CH & V2X CH
V2X CH

• OpenVPN
  • Layer 2 (TAP) virtual interface

• Use production stack
  • Replace only the lowest layers (MAC & PHY)

• Any protocol (IPv4, IPv6, GeoNetworking)
GROUND TRUTH CH

0. *(Receive your start position from server)*
1. Receive everyone’s positions from server
2. Compute updated position
3. Send position to server
Cooperative Adaptive Cruise Control (UDP adapter)

CAM-DENM

ASN.1 UPER

BTP

GeoNetworking

UDP-to-Eth

wlan

tap

OpenVPN Client

V2X / UDP

1. Get
2. Compute
3. Send
FEATURES: REMOTE

• Connect two Simulink instances over the Internet
FEATURES: HIL

• Mixed world (AR)
  • E.g. two physical cars, two virtual
  • Roller bench/dynamometer
FEATURES: NO SHARING

• Competitors do not reveal source code or models to each other
TIME

• Real-time
  • HiL
  • Only over low-latency network

• Non-real-time
  • All-virtual
  • Any network, even Internet
CONCLUSIONS

Architecture to test cooperative driving

- Remote
- MiL, SiL, HiL, AR
- No sharing – IP Protection
- RT/non-RT – HiL/Internet
- Simple!
- Open-source (github.com/alexvoronov/itt-gt)
Cooperative Adaptive Cruise Control

Sensor Model

Vehicle Dynamics

GT (position)

Ground Truth (GT) Server

OpenVPN Server

V2X stack

Access

Net & Transp.

Facilities

OpenVPN

Client

UDP-to-Eth

wlan

tap

n × V2X / UDP

n × GT

V2X / UDP

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(UDP adapter)

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(UDP adapter)