Maximizing Vehicle Fuel Economy through the Real-Time, Collaborative, and Predictive Co-Optimization of Routing, Speed, and Powertrain Control

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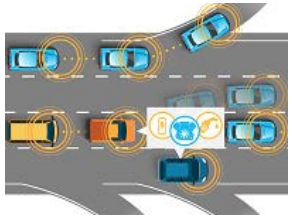


Introduction of the team

Massachusetts Institute of Technology

Domitilla Del Vecchio
Expert in connected and automated vehicles, coordinated vehicle control, and intersection automation.

VOLVO

Samuel McLaughlin
External Research Manager whitin Advanced Technology and Research for Volvo Groups Trucks Technology

UNC CHARLOTTE

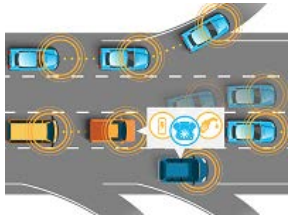
Chistopher Vermillion
Expert in hierarchical control, model predictive control, and optimal energy management

PennState

Hosam Fathy
Expert in powertrain modeling, vehicle power management, and hardware-/engine-in–the-loop simulation

Sean Brennan
Expert in connected vehicles, vehicle automation, and vehicle control

Stephanie Stockar
Expert in modeling and control of internal combustion engine and vehicle powertrain



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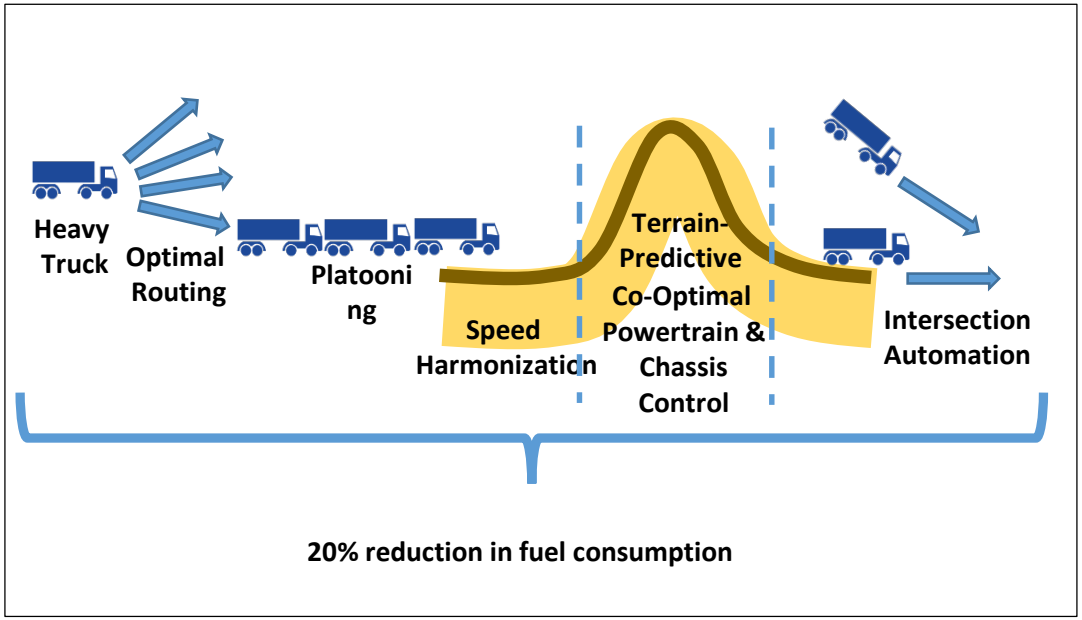
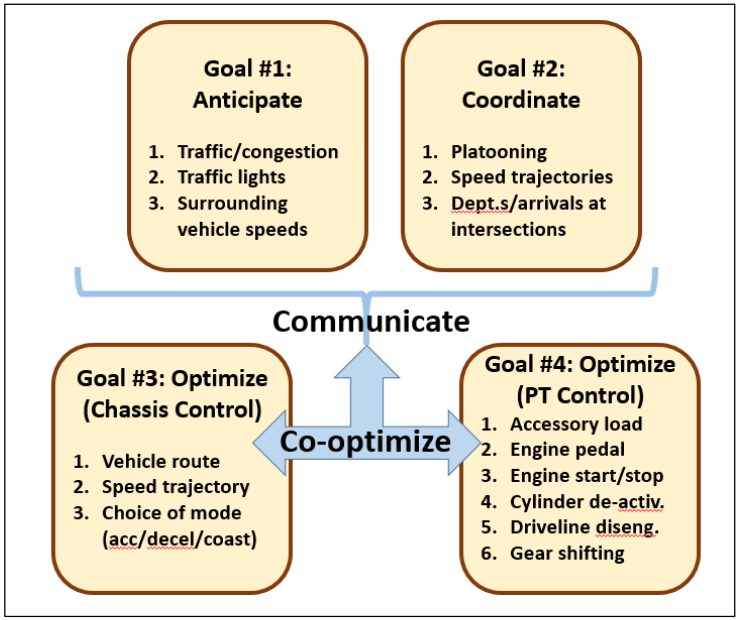
Project Objective and Description

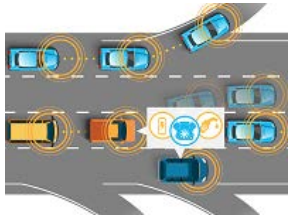
Improve fuel economy through combined **collaborative** and **predictive** optimization, using **hierarchical model predictive control** to merge vehicle control and powertrain control.

Vehicle control level:
route optimization, speed trajectory optimization, platooning, intersection management

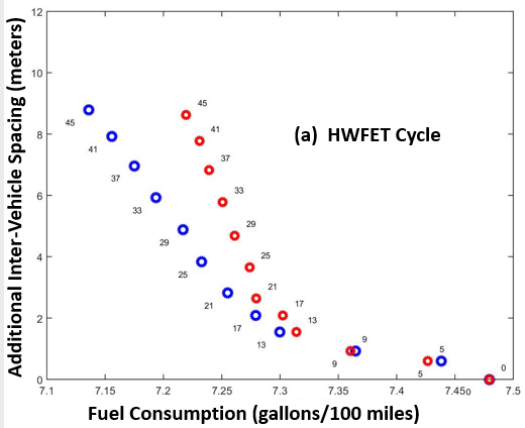
Powertrain/engine control level:
transmission optimization, engine/accessory optimization

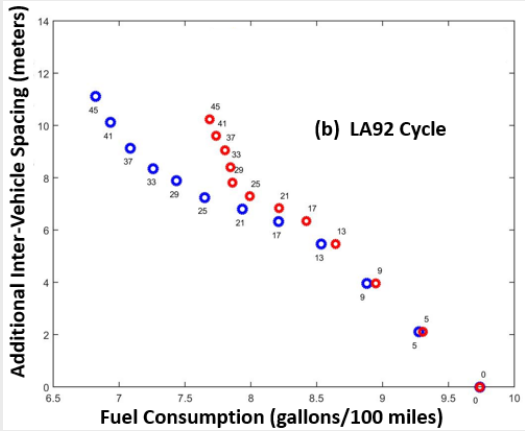




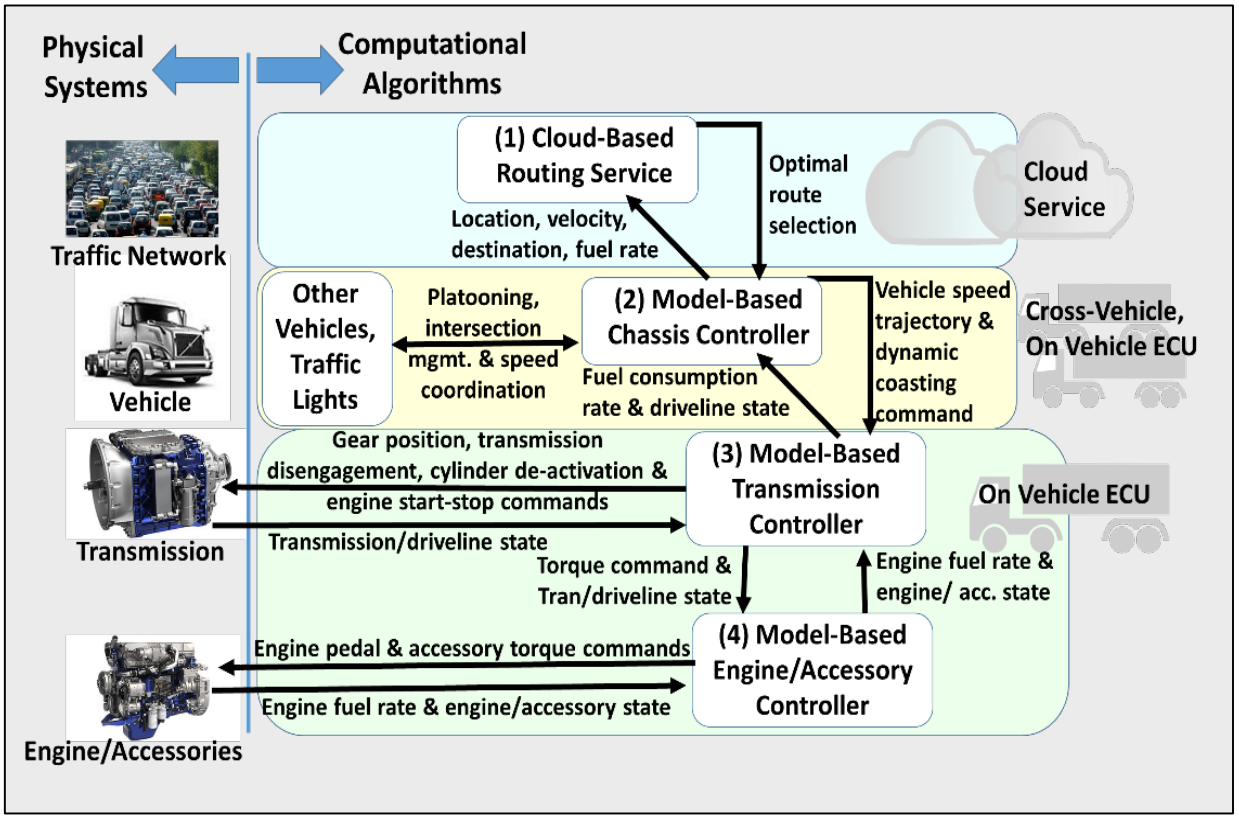


Project Innovation and Impact

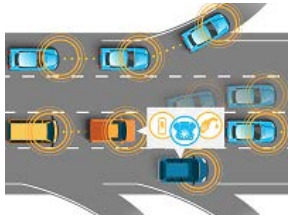




A sample of the impact of prediction and speed trajectory optimization alone **with** **and** **without** **traffic stop prediction**



Technology Impact: Reduce vehicle fuel consumption by **20%** for a broad variety of urban, suburban, and highway driving scenarios



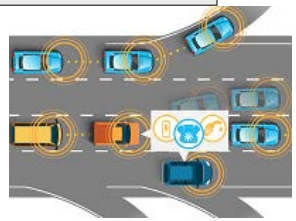
Technology-to-Market approach

- The technology will be developed in collaboration with Volvo Group North America and will be validated using a Volvo Truck.
- This technology will be valuable for different vehicle sizes and engines.

Dedicated on-vehicle **electronic control unit (ECU)** for Chassis control, transmission control, and engine/accessory control will be developed..

Optimal vehicle routing will be developed as a **cloud-based service**.

- It will allow our team to rapidly deploy different products it develops to the market independently.
- It will make it possible to distribute the cost among many potential users of the service



Key Challenges

- Need for an unified framework that enable the integrated co-optimization of powertrain and chassis functions.
- Co-optimal control is a fundamentally challenging problem because it is a **multivariable** and **multi-objective** problem.
- The combined dynamics of a vehicle's chassis and powertrain span multiple time spatial and temporal scales.
- Fuel-conscious optimal vehicle control is a fundamentally non-convex optimization problem.
- Coordinated optimization among multiple vehicles creates significant challenges from the perspective of cyber-security.