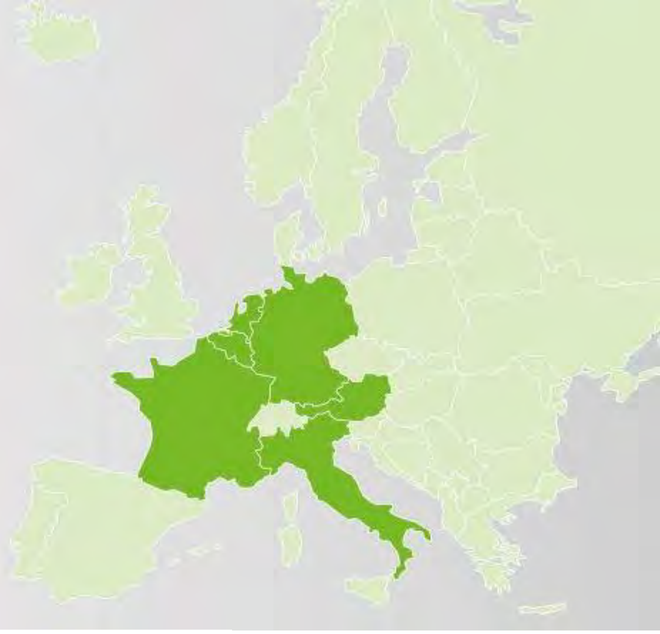
CEVOLVER

Connected Electric Vehicle Optimised for Life, Value, Efficiency and Range



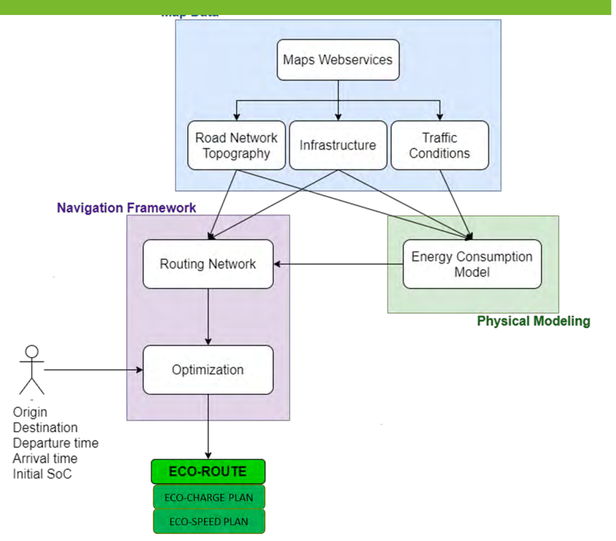
ECO-CHARGING AND ECO-DRIVING

ECO-CHARGING

For a given origin and destination, finds the optimal route, charging plan, and average speed plan

CONCEPT

- Map data
  - Road network topography (connectivity, altitude, etc.)
  - Infrastructure (signalization, charging stations, etc.)
  - Real-time traffic conditions
- Physical Modeling
  - Consider different powertrains
  - Predict energy consumption on each road segment
  - Predict travel and charging time
- Navigation framework
  - Model the road network as a directed graph
  - Find the optimal routing solution
  - Account for user's constraints



OPTIMIZATION PROBLEM

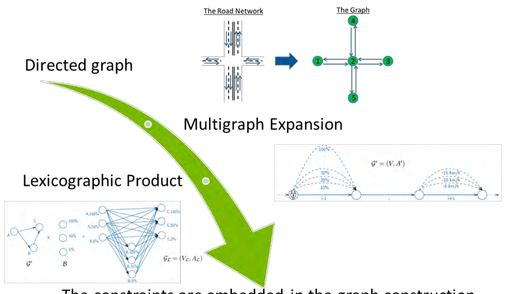
Objective

- Minimize a weighted sum (weight = λ) of total travel time (t) and energy consumption (e)
- By choosing the route segments (i) taken ($x_i = 1$ if segment i is taken, $x_i = 0$ otherwise)
- Additionally choosing the average speed (v_i) and the amount of recharge (Δ_i) on each segment

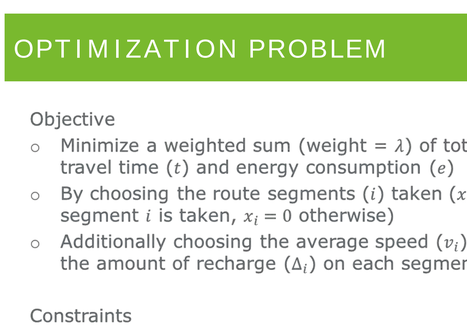
Constraints

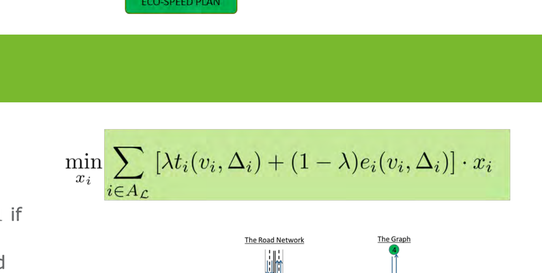
- Topology: segments i must be connected, they must go from origin O to destination D
- Physics: amounts of recharge Δ_i are limited by the capacity of the battery; net energy consumption must never exceed battery capacity
- Speed limits: average speeds v_i must respect the speed limits on segments i

$$\min_{x_i} \sum_{i \in A_{\mathcal{L}}} [\lambda t_i(v_i, \Delta_i) + (1-\lambda) e_i(v_i, \Delta_i)] \cdot x_i$$

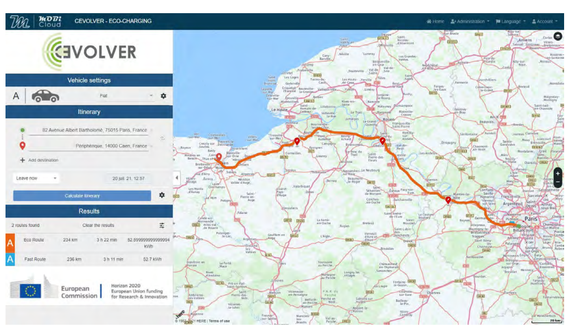


SIMULATION RESULTS





	No-speed	Speed
Graph size (arcs)	3 167 837	217 617 481
Avg. CPU Time [s]	0.7	104
Recharged energy [kWh]	153	123
Energy consumption [kWh]	181.5	152
Trip time [h]	10.7	10.3
Number of charging stops	9	6

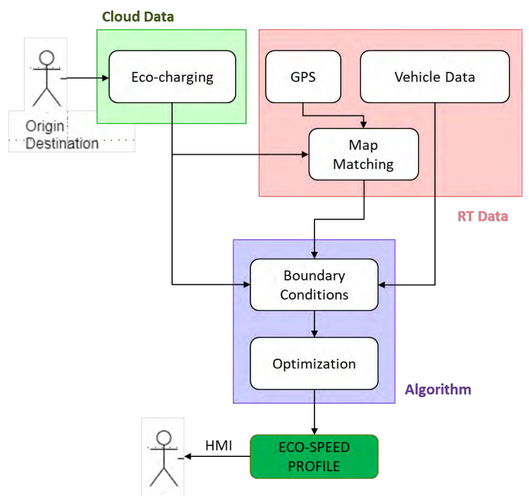


ECO-DRIVING

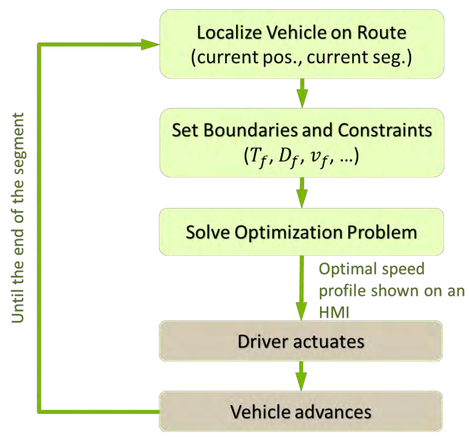
Along a given route, finds the optimal speed profiles to follow and advises the driver in real time

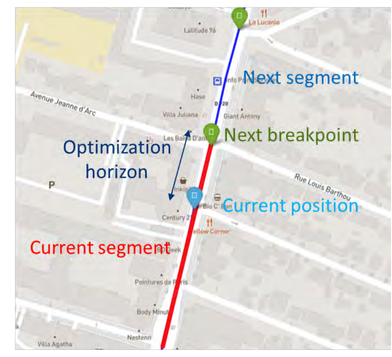
CONCEPT

- Cloud Data
  - Eco-Charging webservice (eco-route with all its attributes)
  - External webservices (traffic, weather)
- Real-Time Data
  - ADAS sensors (leading vehicle detection, traffic light) (optional)
  - In-vehicle sensors (SoC, speed, etc.)
  - GPS + Map Matching (current position, current segment on route)
- Algorithm
  - Update boundary conditions (shrinking horizon, remaining distance and time, target speed)
  - Update constraints (on speed, position)
  - Find the optimal speed profile



OPTIMIZATION ALGORITHM

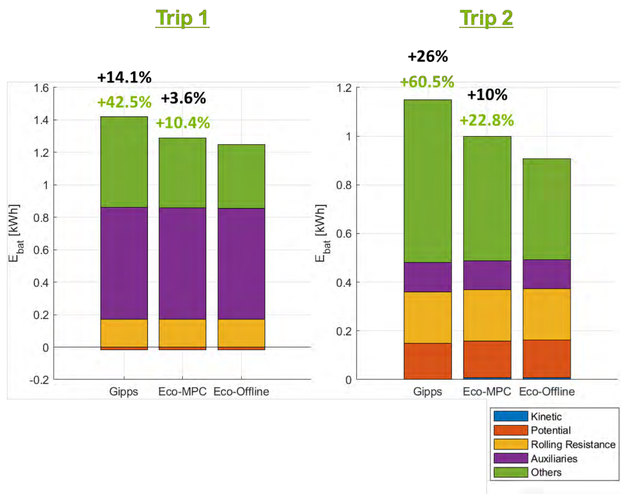




SIMULATION RESULTS

TWO TRIP SIMULATIONS

- Battery energy reduction achieved by the simulated eco-driving is of 9% and 13% compared to a standard driver model « Gipps »
- When considering only effective part (excluding noncompressible energies), reduction is of 22-23%
- Eco-driving is also reasonably close to an offline optimization (« eco-offline »), done using interior-point optimization (4% and 10%)



CLOUD AND ON-BOARD IMPLEMENTATION

Experimental results are measured within the OEM demonstrators, showing achievement of Technical Targets

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