Triple Helix Summit 2020
Designing globally connected regional innovation ecosystems

07 - Building the cities of the future trough smart infrastructures and sustainable planning

Abstract 24

GREEN-MOBILITY RESEARCH LAB: A JOINT UNIVERSITY-INDUSTRY RESEARCH PROGRAM FOR THE DEVELOPMENT OF ENVIRONMENTALLY SUSTAINABLE MOBILITY SERVICES

Academic paper

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Abstract— In the last decades, urbanization and the advance in technology led to an increasing number of vehicles on the roads, resulting in more polluted air and more congested urban centers. Time to destination or time to service accomplishment are parameters more and more considered as KPI of quality of life within cities. Waste of time, in traffic or in queue, and the associated fuel consumption and air pollution, may be mitigated thanks to the advent of Hybrid Electric Vehicles equipped with telecommunication devices. In fact, the flexibility granted by multiple sources of propulsion and the access to information on what is happening outside of the vehicle can clear the way to predictive control strategies development. Predictive control strategies, otherwise named eHorizon functions, can drive “the mobility user” to destination while optimizing energy usage and time.

The green Mobility Research Lab (GMRL), a joint research collaboration between FEV Italia and University of Bologna started in 2019, has defined a 4-years program to develop predictive control strategies for vehicles. In the first 18 months of activity, GMRL has set up an innovative development and simulation environment for the validation of predictive control strategies for connected vehicles (developend by the GMRL itself), supported by cloud-based mobility services with traffic simulation capability. The target is to ensure tests safety, repeatability and reliability to replace the expensive and time-consuming conventional road tests. The simulation environment consists of a connected Hardware-in-the-Loop (HiL) system to test the supervisory controller (Hybrid Control Unit) where the predictive functions will be implemented. In addition to all the advantages of a conventional HiL layout, it can send and receive data from cloud service providers and nearby devices (such as route data and information from infrastructures and other vehicles). The over-the-air interfaces between the powertrain controllers, the cellular network (LTE) and the Intelligent Transportation Systems (ITS-G5) is handled using a custom connectivity control unit with proprietary functionalities.

To test the data flow, the server initially provides the supervisor with route information through the internet by using the cellular network. Then, the exchange of data between the simulated vehicle and a real Intelligent Transportation System Station (ITS-S) is reproduced and verified. The supervisor, therefore, sends vehicle maintenance data to the cloud-based control function. The proposed approach makes it possible to test both short and long data exchange with real controllers, and to lay the ground for predictive control strategies testing and validation.

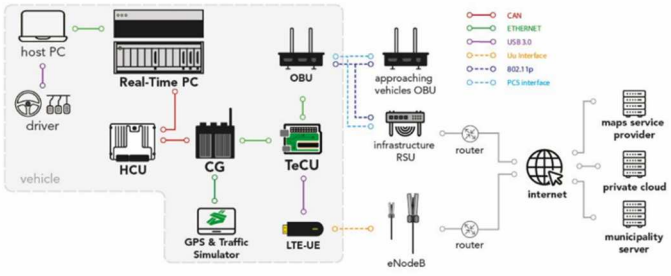

Fig. 1. - Connected HiL system representation

Within this program, the Researchers, PhD and Master's students of the Laboratory have identified and will identify several predictive functions that can enable smart city services. In particular, the Zero Emission Zone (ZEZ) function is an algorithm that identifies city zones where only electric drive is allowed and adapts the hybrid powertrain control strategies to guarantee the battery state of charge required to drive the vehicle through the ZEZ in pure electric mode. The innovative approach is based on the prediction of vehicle speed and trajectory within the ZEZ, to calculate the amount of energy needed in the battery pack to complete such mission, using a mathematical model of the vehicle dynamics. Once the expected energy consumption within the ZEZ has been estimated, the calculation of the battery state of charge to complete the city event in pure electric mode can be performed, and such value can be set as a target for the strategy that optimizes the energy consumption from the starting point of the trip to the ZEZ beginning. The developed predictive functions can be named eHorizon 2.0, functions that run in cloud with HPC (to differentiate them from the ones that run in vehicle based on traffic update information only).

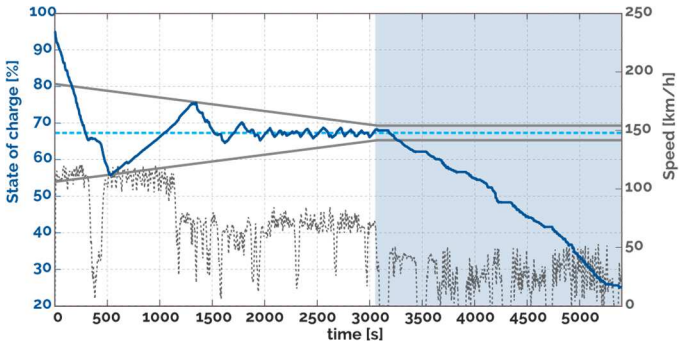

Fig. 2. - ZEZ function with predictive speed and energy management

The ZEZ function could be directly integrated within the program of the Comune di Bologna for a dynamic and environmentally protected traffic zone (dynamic ZTL). The working principle is the following: the Comune di Bologna "publishes" in a Smart City platform the data (opendata) regarding the actual dynamic ZTL and the ZEZ function, in combination with navigation route calculation, will adapt the powertrain functions to accomplish the ZTL limitation or rules. This is the only way to not "stress" the driver to collect all the necessary information of the city destination before start of the journey.

The GMRL established partner cooperation with CINECA to test ZEZ and dynamic ZTL in a cloud and HPE environment. Other cooperations are with Dedagroup, for identifications of smart city services necessity and with Carmenta for the optimization of the vehicle trip, thanks to their TraficWatch platform that communicate the optimal speed profile to the vehicle control supervisor.

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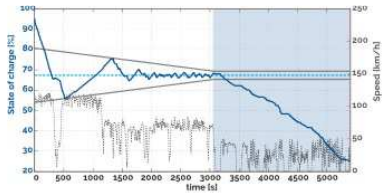
State of charge [%]
Speed [km/h]
time [s]
100
90
80
70
60
50
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30
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250
200
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500
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