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VEHICLE PLATOONING SCHEMES CONSIDERING V2V COMMUNICATIONS: A JOINT COMMUNICATION/CONTROL APPROACH

Tiago ROCHA GONÇALVES[1]

Salah E. Elayoubi [1], Vineeth S. Varma[2]

[1] CentraleSupélec, L2S laboratory [2] Université de Lorraine, CRAN

Abstract

The main objective is to provide a dynamic control mechanism where the parameters of the well-known Predicted Cooperative Adaptive Cruise Control (PCACC) are adapted based on the observed quality of the V2V (Vehicle-to-Vehicle) communication links. We evaluate our platooning scheme in a highway scenario and show the gains obtained by the dynamic adaptation of the control parameters.

1 CONTEXT

- Platooning system is designed to increase road capacity and to decreased fuel consumption.

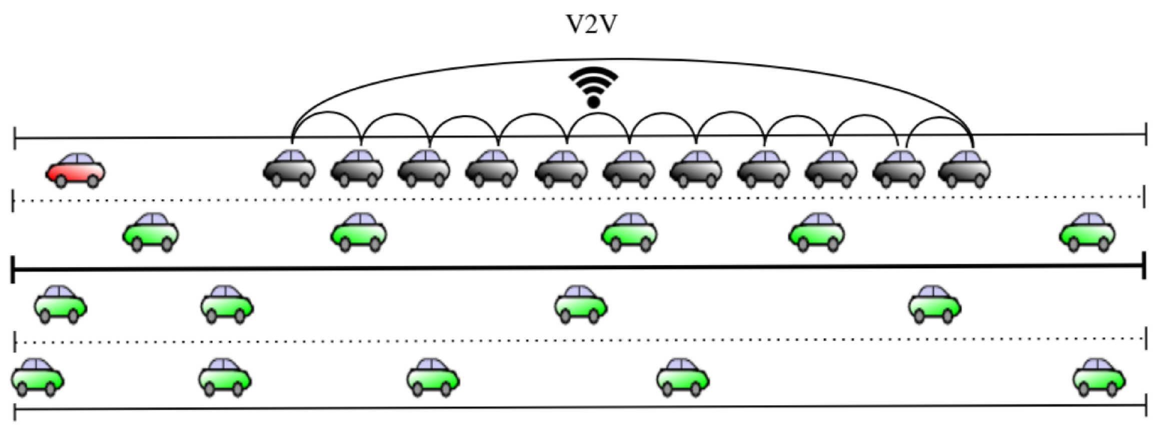

Figure 1: Traffic scenario with V2V.

Control law is given by:

$$\ddot{x}_{i\_des} = (1 - C_1)\ddot{x}_{(i-1)\_des} + C_1\ddot{x}_{l\_des} - (2\xi - C_1(\xi + \sqrt{\xi^2 - 1}))\omega_n\dot{\epsilon}_i - (\xi + \sqrt{\xi^2 - 1})\omega_n C_1(\dot{x}_i - \dot{x}_l) - \omega_n^2\epsilon_i \quad (1)$$

where

$$\epsilon_i = x_i - x_{i-1} + L_i + D_{des} \quad (2)$$

$$\dot{\epsilon}_i = \dot{x}_i - \dot{x}_{i-1}. \quad (3)$$

2 CHALLENGES AND OBJECTIVES

- The overlap of communication and control aspects introduces many challenges such as: latency, packet dropouts and string stability.
- Our main design goal is the minimization of inter-vehicular distance while being robust.

3 CONTRIBUTION

- Evaluation of the robustness of the platooning mechanism, under long bursts of losses.
- Adoption of safety as a primary performance metric, quantified in terms of avoiding emergency braking.
- Offline optimization of the parameters of the controller, for different communication link qualities expressed in terms of Packet Error Rate (PER). Extensive simulations give the pair of optimal $(C_1(PER), D_{des}(PER))$ for each link quality.
- Online adaptation of the control parameters (C_1, D_{des}), based on the observed PER.

4 RESULTS

- We performed an offline optimization of the control parameters (C_1, D_{des}).

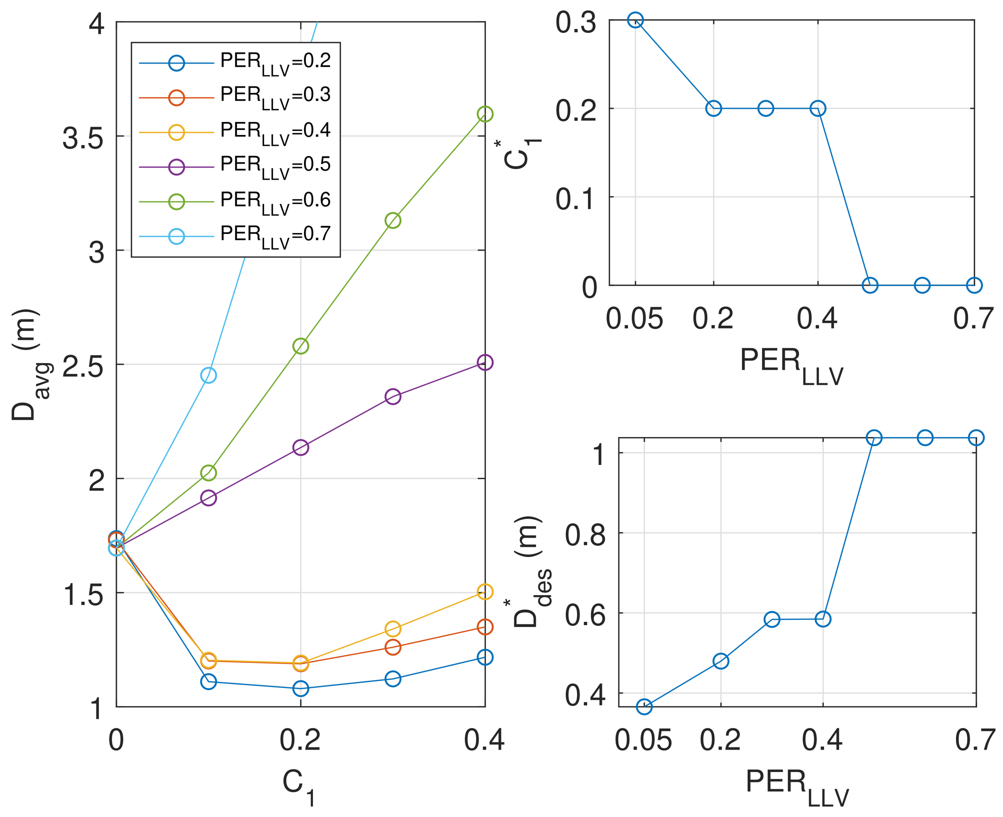

Figure 2: Offline optimization.

- We applied an online adaptation of the control parameters based on the observed link.

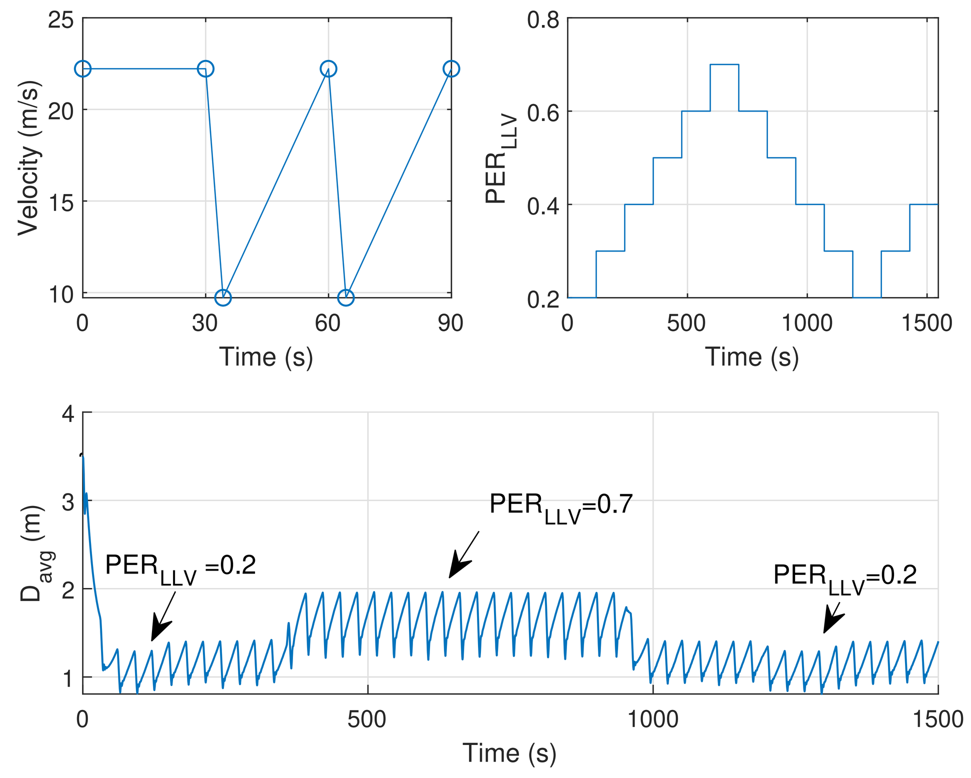

Figure 3: Jammer profile, traffic setup and online adaptation.

- For comparison purposes we also simulated cases with fixed control parameters.

Table 1: Case comparison for the online implementation.

	Parameters	Case 1	Case 2	Case 3
Controller	C_1	0.2	0	Dynamic
	D_{des} (m)	0.5847	1.0375	Dynamic
Outputs	D_{avg} (m)	1.2103	1.6785	1.3823
	D_{min} (m)	0.2537	0.6297	0.5233
	Collisions	8	0	0

- The proposed method reduced the inter-vehicular distance by 21% and is demonstrated to be the best option in terms of both performance as well as safety.

5 FUTURE WORK

- Combining V2N (Vehicle-to-Network) and VLC (Visible Light Communication) is a promising means for enhancing the robustness of the platoon while reducing the inter-vehicle distance.

STIC
CentraleSupélec
Tiago Rocha Gonçalves-
tiago.rochagoncalves@centralesupelec.fr