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# Technical Report

## Channel Estimation in Vehicular Platoons

**Kai Li**

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Kai Li

*CISTER Research Centre

Polytechnic Institute of Porto (ISEP-IPP)

Rua Dr. António Bernardino de Almeida, 431

4200-072 Porto

Portugal

Tel.: +351.22.8340509, Fax: +351.22.8321159

E-mail: kaili@isep.ipp.pt

http://www.cister.isep.ipp.pt

## Abstract

In vehicular platoons, a lead vehicle broadcasts messages carrying information on its vehicle position and velocity to update the platoon 19s vehicles. The following vehicle acts as a data-forwarding node so that the messages from the leader can be disseminated to all the vehicles in the platoon. This report presents a channel estimation approach in vehicular platoons, where the channel gain between any two vehicles in the platoon can be estimated by another vehicle based on their distance gap.

# Channel Estimation in Vehicular Platoons

Kai Li
CISTER Research Centre, Porto, Portugal
kaili@isep.ipp.pt

Forming a vehicular platoon is shown in Fig. 1. At $T1$, the lead vehicle broadcasts messages carrying information on its vehicle position and velocity to update the platoon's vehicles. The following vehicle acts as a data-forwarding node so that the messages from the leader can be disseminated to all the vehicles in the platoon. In particular, the preceding vehicle disseminates the data to its following vehicle based on store-and-forward broadcasts at different time (e.g., $T2$, $T3$, and so on) without causing interference to the other vehicles.

In vehicular platoons, a large-scale path loss that has taken the average effect of multipath into account is considered to model the inter-vehicle communication channel. Let $P_i^{tx}$ denote the transmit power (in dB) of $\text{Pkt}_i$ at vehicle $v_i$. The receiving signal power at vehicle $v_j$ ($j \in [i+1, n]$) is

$$P_j^{rx} = P_i^{tx} + K_1 + K_2 - 10\eta_{PL}\log_{10}(d_{i,j}) + \phi_{i,j}, \tag{1}$$

where $K_1$ and $K_2$ are two positive fixed constants relating to the channel, and $\eta_{PL}$ is the path loss coefficient. The term $\phi_{i,j}$ denotes an independent shadow fading over different time epochs. $d_{i,j}$ in (1) is the distance between vehicles $v_i$ and $v_j$, which can be further

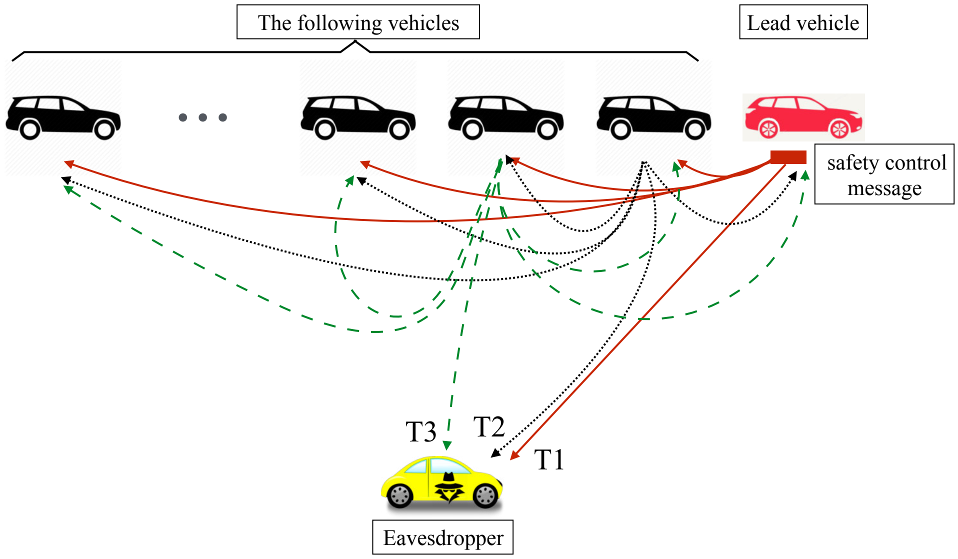


Fig. 1. A platoon of vehicles, where the vehicular information is disseminated by broadcasting over the insecure public channel.

written as

$$d_{i,j} = 10^{\frac{H_{i,j}+K_1+K_2+\phi_{i,j}}{10\eta_{PL}}}, \tag{2}$$

where $H_{i,j} = (P_i^{tx} - P_j^{rx})$ presents the channel gain of the link between sender $v_i$ and receiver $v_j$. $d_{i,j}$ can be predetermined before forming the platoon since the non-leading vehicle in the platoon is required to maintain a certain distance with the preceding one.

Table I shows $H_{i,j}$, which is obtained after Pkt$_i$ is received by $v_j$ from $v_i$. However, $v_j$ is not aware of the channels between the other vehicles in the team, e.g., $H_{i,j-1}$. Fortunately, as the inter-vehicle distance with random variance has been known before forming the platoon, the channel gain between any other two vehicles in the platoon can be estimated by $v_j$ based on their distance gap, i.e., $d_{i,j-1} = d_{i,j} - d_{j-1,j}$. Furthermore, we have $10^{\frac{H_{i,j-1}+K_1+K_2+\phi_{i,j-1}}{10\eta_{PL}}} =$

TABLE I

CHANNEL QUALITY OBTAINED AT $v_j$ AFTER PKT$_i$ IS RECEIVED FROM $v_i$.

| **Token** | $H_{i,j}$ obtained at $v_j$ | | | | | | |
|---|---|---|---|---|---|---|---|
| Pkt$_1$ | — | $H_{1,2}$ | $H_{1,3}$ | $H_{1,4}$ | ... | $H_{1,j}$ | ... |
| Pkt$_2$ | $H_{2,1}$ | — | $H_{2,3}$ | $H_{2,4}$ | ... | $H_{2,j}$ | ... |
| Pkt$_3$ | $H_{3,1}$ | $H_{3,2}$ | — | $H_{3,4}$ | ... | $H_{3.j}$ | ... |
| Pkt$_4$ | $H_{4,1}$ | $H_{4,2}$ | $H_{4,3}$ | — | ... | $H_{4,j}$ | ... |
| ... | ... | ... | ... | ... | ... | ... | ... |
| Pkt$_i$ | $H_{i,1}$ | $H_{i,2}$ | $H_{i,3}$ | $H_{i,4}$ | ... | — | ... |
| ... | ... | ... | ... | ... | ... | ... | ... |

$10^{\frac{H_{i,j}+K_1+K_2+\phi_{i,j}}{10\eta_{PL}}} - 10^{\frac{H_{j-1,j}+K_1+K_2+\phi_{j-1,j}}{10\eta_{PL}}}$ with regards to (2), which is

$$H_{i,j-1} + \phi_{i,j-1} = H_{i,j} + \phi_{i,j} + 10\eta_{PL}\log(1 - 10^{\frac{H_{j-1,j}+\phi_{j-1,j}-H_{i,j}-\phi_{i,j}}{10\eta_{PL}}}). \tag{3}$$

Therefore, $v_j$ ($j \in [i+1, n]$) can estimate the channel gain between $v_i$ and $v_{j-1}$, i.e., $H_{i,j-1}$, based on Pkt$_i$ and Pkt$_{j-1}$, using (3).