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IT-Porto

An Overlay TDMA Protocol for Platooning

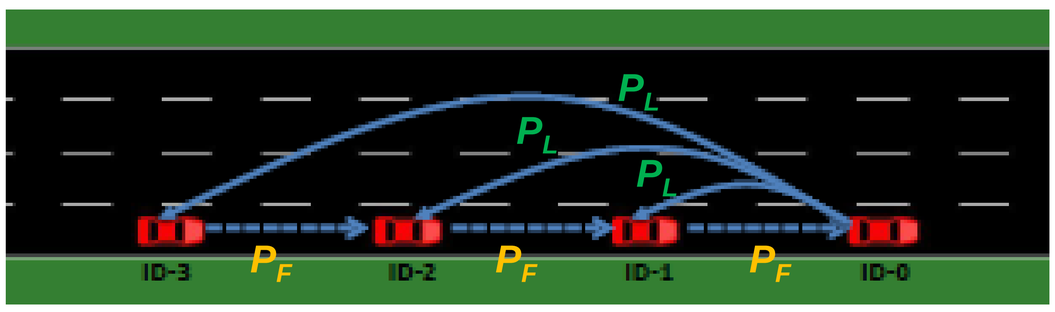
Networked Systems

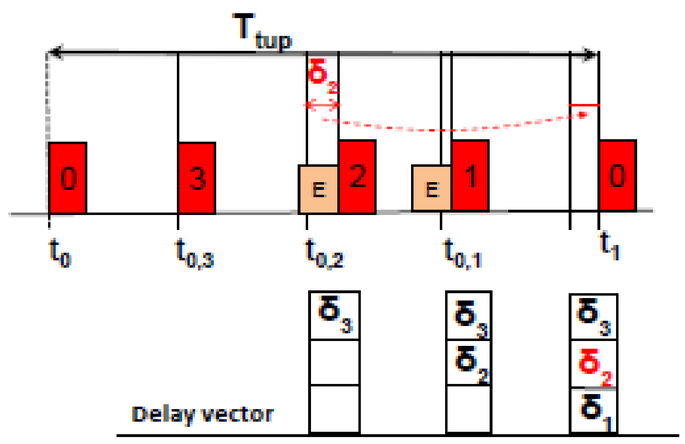
Background and challenges

- Vehicular Ad-hoc Networks (VANETs) can enable a wide range of vehicle coordination applications
  - Require **Reliable Communication Channel, Good Timeliness, Lower Latency, Less Access Collisions**
- Define **Overlay TDMA Protocol on top of IEEE 802.11p**
  - Aim to combine the benefits of both **TDMA and CSMA/CA**
    - **Collisions reduction** through **synchronization** of beacons
    - **Efficient bandwidth** usage tolerating **asynchronous** access
  - **Distributed** and **self-organizing**
    - Solution with new **RA-TDMAp** protocol which is proposed for platooning applications

Description and main innovation

- **RA-TDMAp** is an instantiation of **RA-TDMA** that was developed for teams of robot
  - Adds **transmission power** control
  - Includes **admission** control to manage platoon dynamic composition





- RA-TDMAp shifts the TDMA round escaping from periodic interferences causing delays

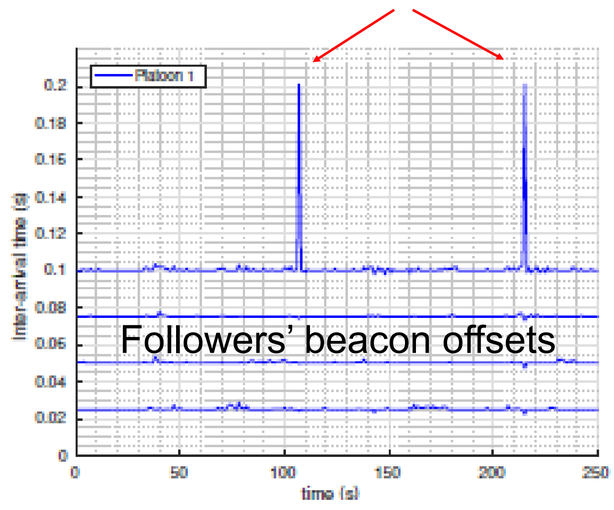
Main parameters:
The beacon interval (TDMA round period) – T_{tup}
Number of vehicles in the platoon – N
Offset between beacons in a platoon – $T_{xwin} = T_{tup}/N$
Transmission instants of follower *i* in round *n* (assuming leader transmits at $t_{n,0}$) – $t_{n,i} = t_{n,0} + T_{xwin} \times (N - i)$
Followers transmit with low power – P_F , while leader transmits with high power – P_L

Main adaptation mechanism:
Leader gets all delays that affected the platoon beacons in that round (δ_i , *i=1..N-1)*
Leader adjusts next round (up to a tolerable limit Δ) transmitting at

$$t_{n+1,0} = t_{n,0} + T_{tup} + min\left(\Delta, \max_{i=1..N-1}(\delta_i)\right)$$

δ_i is the delay between the effective and expected reception instants of the preceding vehicle(s)

Leader beacon losses



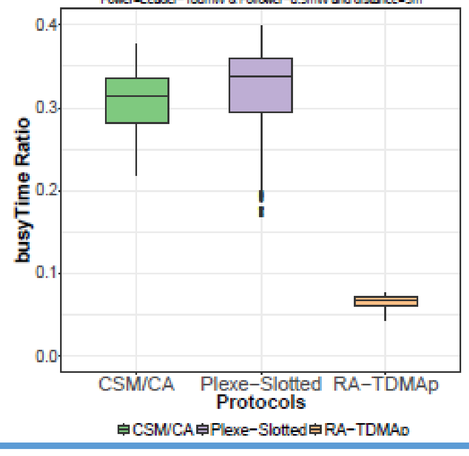
- Simulation Setup and Comparison of Protocols

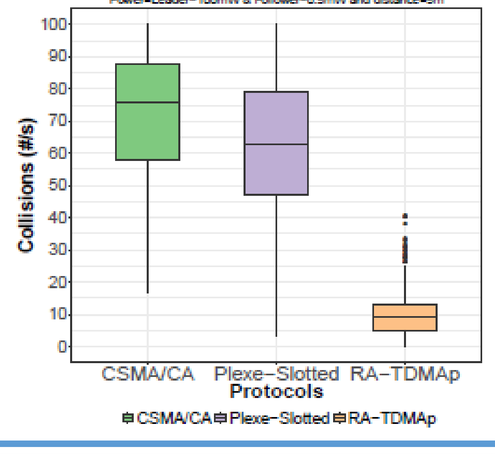
Table 1: PHY and MAC parameters

Parameter	Values
PHY/MAC model	IEEE 802.11p/1609.4 only (CCH)
Channel	5.89 GHz
Bitrate	6 Mbit/s
MSDU size	200B
Leader's Tx power	100mW
Follwer's Tx power	0.05mW, 0.5mW and 1mW

Table 2: Scenario configurations

Parameter	Values
Number of cars	160
Platoon size	10 cars
External cars	10
Inter-vehicle gap	5m
Controller	ACC





Achievements

✓Defined RA-TDMAp protocol = TDMA + external traffic handler (CSMA/CA arbitration)
  ✓Scalable = Multiple collaborative platooning applications + Fully distributed
  ✓Reduced packet collision + better channel utilization

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