Coordination for heavy-duty vehicle platoon formation considering travel time variance

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Abstract:

Forming a platoon has the potential to reduce the overall drag, providing economic and ecological benefits such as reduced energy consumption, increased safety and a more efficient utilization of road infrastructure. Previous research on platoon coordination has mainly focused on local control of platoon formation at highway on-ramps and off-ramps, or large-network coordination strategy based on real-time vehicle-to-vehicle communication. The platoon scheduling problem, however, has been barely explored. This study investigates the optimization of platoon scheduling problem, which is defined as the minimization of the total cost of all vehicles, including travel cost, early or late penalty and fuel consumption. The travel cost is modelled as driver wage of certain travel time, which is comprised of recurrent travel time and non-recurrent delay. Non-recurrent delay is a random variable independent of departure time. If the actual arrival time is earlier than the preferred arrival time, an early penalty is incurred. Otherwise a late penalty, which has a greater weight coefficient than early penalty, is incurred. Fuel consumption is a nonlinear function of travel time and platooning state. All vehicles in the platoon except the leader will experience an air-drag reduction. The fuel cost caused by air drag only composes part of the total fuel consumption, from the perspective of energy conservation. For this nonlinear stochastic programming problem, a solution is proposed for the platoon-or-not-platoon dilemma. Moreover, the optimal departure time of the platoon is given when it is more beneficial to form a platoon than driving individually. Several numerical examples are presented to study the influences of different unit cost parameters, together with various assumptions of the distribution of non-recurrent delay, on the optimal departure time. The model enables the operator to predict the expected cost of platooning and schedule adjustment and make a reasonable decision.