“The Vehicle Relocation Problem for a One-way Electric Car-sharing Service”

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Traditional car-sharing services are based on the two-way scheme, where the user picks up and returns the vehicle at the same parking station. More recently, some operators also allow one-way trips, where the user can return the vehicle in another station. Although the one-way scheme is more attractive for the users, it may pose a problem to the distribution of the vehicles, for the possible unbalancing between the user demand and the availability of vehicles or free lots at the stations. Such a problem is more complicated in the case of electric car-sharing, where the travel range depends on the level of charge of the vehicles. A new approach for the relocation of electric vehicles (EVs), where the EVs are moved by the staff of the car-sharing service to keep the system balanced, is presented. Such approach generates a challenging Paired Pickup and Delivery Problem with Time Windows that we call the Electric Vehicle RElocation Problem (EVREP). We yield a Mixed Integer Linear Programming formulation of the EVREP and some devices to speed up its solution through a state-of-the-art solver (e.g. CPLEX). Moreover, we develop a simple but effective heuristic based on such a formulation and three upper bound methods. We test the performance of both the exact and the heuristic methods on verisimilar instances built on the Milan road network also through a simulator based on the OD private car traffic matrix (yielded by the Milan transport agency, AMAT) and on the current location and capacity of docking stations (A2A).