Pickup and Delivery Paths of Restricted Combinatorial Structure

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The pickup and delivery problem (PDP) is a flexible model capable to cover such various applications as door-to-door transportation systems as well as managing the parcel collection and distribution of a parcel service. To the best of our knowledge, no research efforts have been undertaken in the direction of pickup and delivery paths of restricted combinatorial structure. This contrasts our experience that practically all computational experience reporting on the PDP that we are aware of is drawn from problem instances allowing only a very special structure of paths.

Certain applications in railroad traffic impose particularities on the PDP. First, vehicle capacity is very restrictive. For instance, an engine is usually not powerful enough to haul more rail cars than correspond to two or three transportation requests. Second, the loading and unloading operation itself is distinct. As a consequence of driving on railroad tracks the most reasonable loading scheme is *last-in first-out*. Clearly, deviation from this scheme incurs extra work in form of time consuming switching operations. This motivated the approach of restricting pickup and delivery paths to be built of a preselection of sensible loading/unloading sequences, leading us to the notion of precast *request patterns*. This allows for considering sequence dependent service and travel times (and cost). That is, we are able to account for the extent of work required at a particular location in dependence of the items picked up previously.

In order to exploit the additional structural knowledge, if present, we introduce the concept of *pattern concatenation*. Still, the problem of finding an optimal such concatenation is $\mathcal{NP}$-complete, but polynomially solvable special cases will be

discussed. We describe the application to a particular engine scheduling problem at industrial in-plant railroads, which originally motivated our approach. There, an especially simple family of patterns suffices to represent the practical setting. We will demonstrate that this family is a reasonable choice also from a theoretical point of view.

Key words: Pickup and Delivery Problem; Restricted Combinatorial Structure; Engine Scheduling