A metaheuristic for the EVRPTW problem

with capacitated recharging stations

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January 30, 2019

Introduction

Problem statement

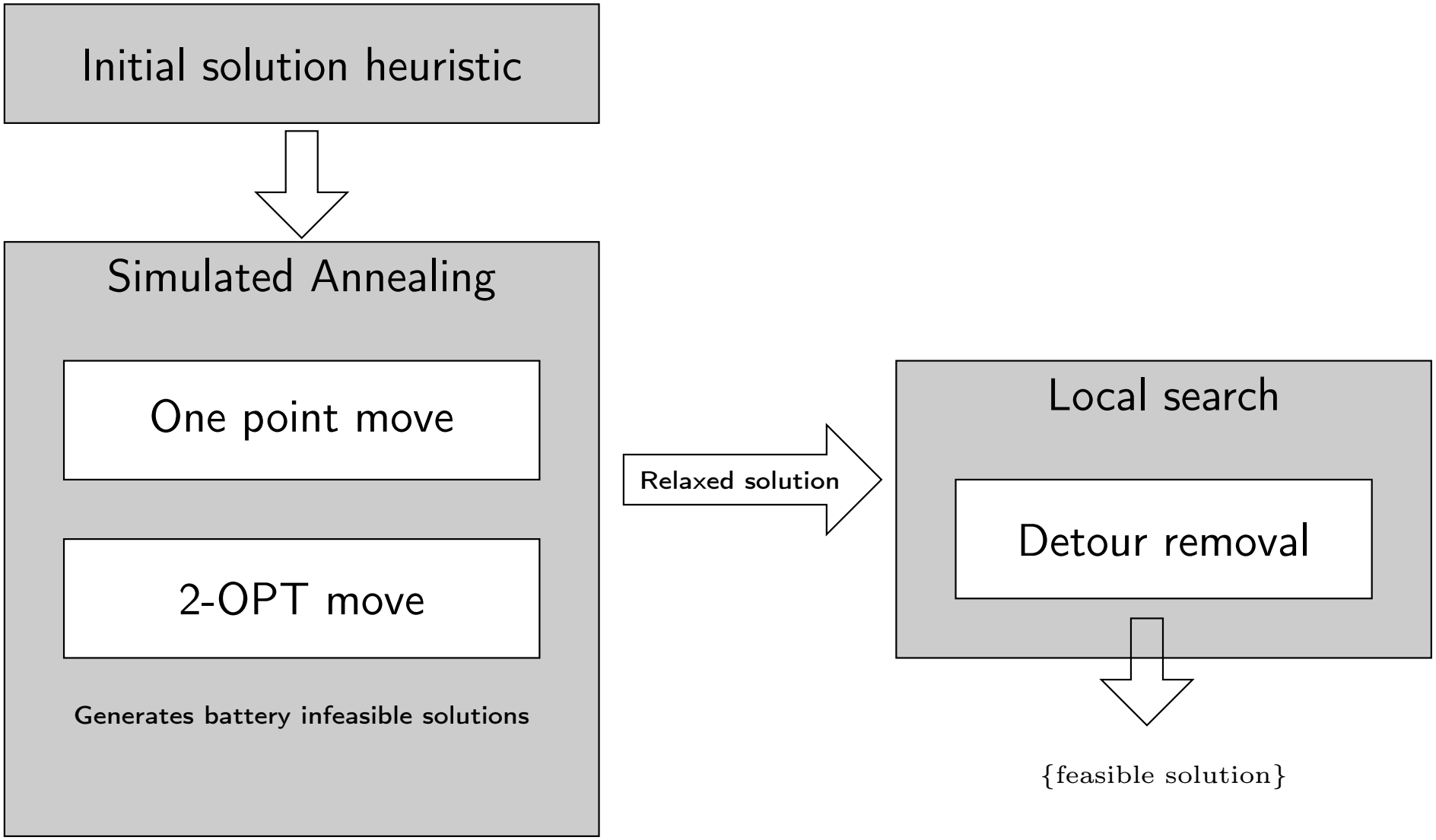
Vehicle Routing Problem with a set of constraints :

- Capacitated vehicles
- Maximum tour time
- Time windows and service times for deliveries
- Battery limitations (maximum capacty and consumption)
- Capacitated charging stations (limited number of plugs)

Property

The problem is NP-hard since it generalizes the VRP

Implemented solver



Initial solution heuristic

Route first, cluster second

- Route : TSP heuristic, nearest neighbour
- Cluster : bin packing first fit with $\sum_j d_j / n_v$

Scheduling heuristic

- EDD rule on each route, optimal for $1||\sum U_j$ (here $1|r_j|\sum U_j$)

Idea

We end up with roughly coherent routes in which we minimize the number of tardy jobs *without the release date constraint*.

Simulated Annealing with VNS

Two neighbourhoods

- One point move (both intra and inter route)
  which hopefully improves the scheduling (and optionally others)
- Two opt move (both intra and inter route)
  which hopefully keeps good scheduling while minimizing distance

Objective function

$$\text{minimize} \sum_{r \in Routes} \left(\sum_{(i,j) \in r} d_{ij} + M \times (overcapactitated_r + overtime_r + nb\_tardy\_jobs_r) \right)$$

$\rightarrow$ With linear cooling schedule, empirical parameters

Charging decisions

Local search

- Start with the hypothesis that we make a detour on every arc at the closest station
- Local Search by randomly removing detours

Objective

- $$\sum_{r \in Routes} \left(\sum_{(i,s,j) \in Detours_r} (d_{is} + d_{sj}) + M \times nb\_under\_battery\_node_r \right)$$
- if do not have enough time to make the detour because it would make the delivery tardy, we skip this detour (thus we do not recharge) but we still count the distance it would have cost to go to the station

Idea

A detour which does not improve the number of under battery nodes can be removed (thus minimizing the number of detours and travelled distance)

Critical points

- The charging decision is a critical point since we may take a lot of time trying to charge a relaxed solution which cannot be charge
- Would be good to have *a piori* criterias which disclaims some solutions which cannot be charged in any way
- Starting by assuming that the vehicle makes a detour on every arc of the route and removing them instead of assuming that the vehicles make no detour and add ones seems more efficient (experimental) but is way more costly in time