Presentation Title

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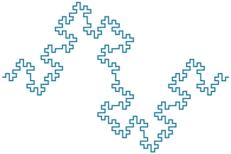
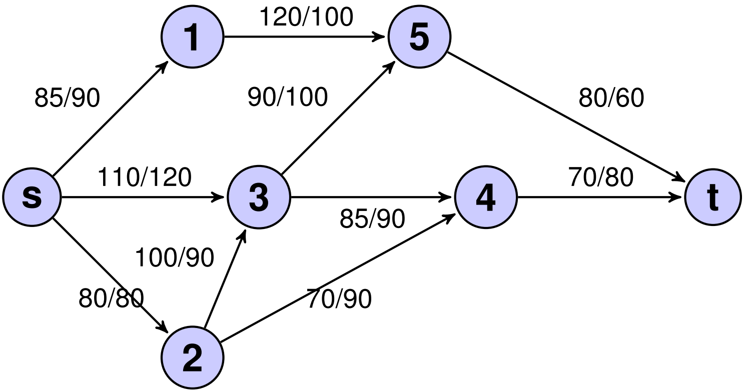


June 18, 2014

INTRODUCTION

EXAMPLE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Physical system

Modeling the physical system, of an EV and a path.

$$u_1 \xrightarrow{e_1} u_2 \xrightarrow{e_2} \cdots \xrightarrow{e_{n-1}} u_n$$

- Path
  - Charging stations, with charging rate ($R_{CH}(u_i)$)
  - Road segments, with speed limit ($v_{min}(e_i)$, $v_{max}(e_i)$) and distance ($D(e_i)$)
- EV
  - Driving consumes energy accordingly to the speed of the EV, defined by: ($R_{CO}(e_i)$)
  - Further two constants from the EV are important to model, namely, battery capacity (B_{max}) and initial battery (B_{cur})

OPTIMISATION PROBLEM

Formulating a optimization problem, which when solved will yield a optimal solution.

- Objective: Move from u_1 to u_n using minimum time .
  - + Time can be used driving or charging.
    - min: $\sum_{i=1}^{n-1} \left(\frac{D(e_i)}{v_{e_i}} + CT_{u_i} \right)$
- Physical constraints:
  - + Each edge must be driven at a speed within the speed limit:
    - $\forall_{i \in 1 \ldots n-1} : \; v_{min}(e_i) \leq v_{e_i} \leq v_{max}(e_i)$
  - + Time can only be positive.
    - $\forall_{i \in 1 \ldots n} : \; 0 \leq CT_{u_i}$
  - + The energy is the battery must alway be between 0 and B_{max}

BATTERY CONSTRAINT

The battery constraint of the optimization problem can be split into two parts

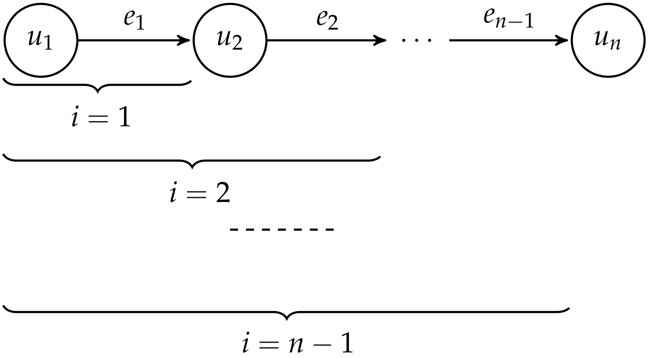
- No road segment can be passed without having the required energy
- No overcharging at any charging station.

Energy can be..

- Spend: $\forall_{i \in 1 \dots n-1} : \; ES(e_i) = D(e_i) \times R_{CO}(v_{e_i})$
- Acuried: $\forall_{i \in 1 \dots n} : \; EA(u_i) = R_{CH}(u_i) \times CT_{u_i}$
- Already in the battery: B_{cur}

BATTERY CONSTRAINT

No road segment can be passed without having the required energy



- $\forall_{i \in 1 \ldots n-1} : \; 0 \leq B_{cur} + \sum_{j=1}^{i} EA(u_j) - \sum_{j=1}^{i} ES(e_j) \leq B_{max}$

BATTERY CONSTRAINT

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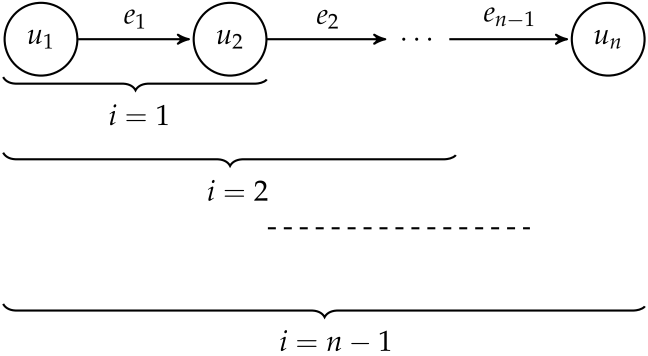


- $\forall_{i \in 1 \ldots n-1} : \; 0 \leq B_{cur} + \sum_{j=1}^{i+1} EA(u_j) - \sum_{j=1}^{i} ES(e_j) \leq B_{max}$

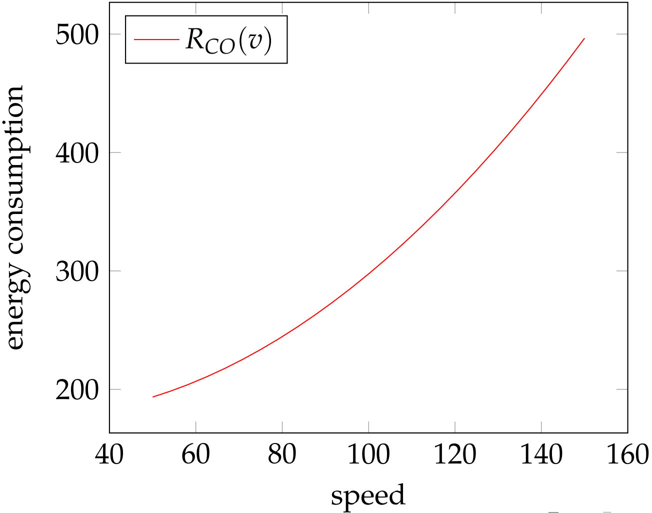
LINEAR PROGRAMMING

NP-complete problem.
Linearization and linear programming for approximate solution.
Two functions of the optimization problem are non linear functions.

- Consumption rate ($R_{CO}(v_{e_i})$)
- Driving time ($\frac{D(e_i)}{v_{e_i}}$)

LINEARIZATION EXAMPLE

Function for energy consumption before linearization.
$R_{CO}(v) = 0.019 * x^2 - 0.770 * x + 184.4$



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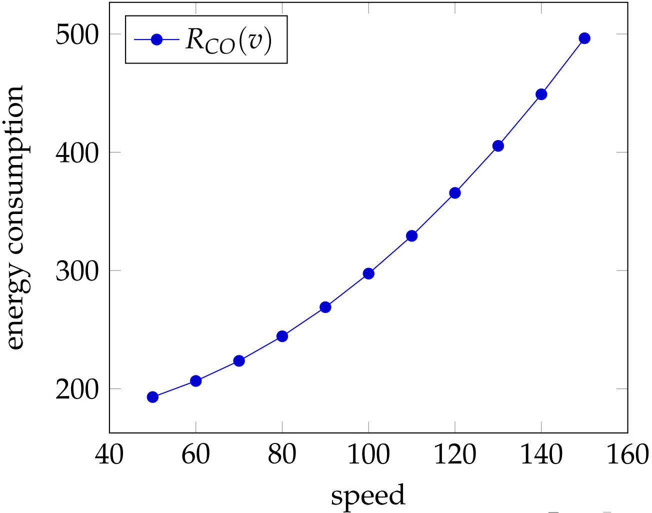

LINEARIZATION

- For all linear function their slope and the y-intercept is precomputed.
- For every edge in the path exactly one line segment needs to be chosen. Thus a binary matrix i introduced of size $n \times m$, where $n =$edges in the path and $m =$linear pieces of each line.