Logistics alone accounts for up to $3,000

of a new car's price.

Logistics for Uncertain Intermodal Distribution Networks

MaHeu Project

Tom Bürskens, Nicolas Garcia,
Julian Komoßa, Raoul Luqué

15.07.2025

Problem and Objective

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- Transport cars through a logistics network from *Plant* to *Dealership*
- Transport options with costs and capacities are planned in advance
- Uncertainties are simulated through *Realizations*

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- Transport cars through a logistics network from *Plant* to *Dealership*
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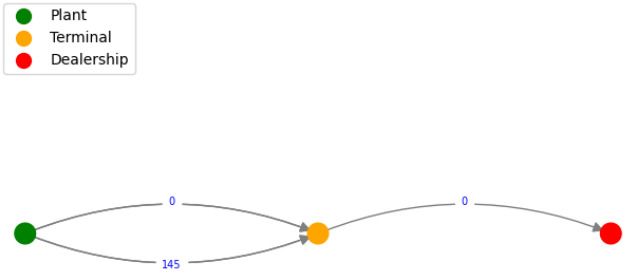
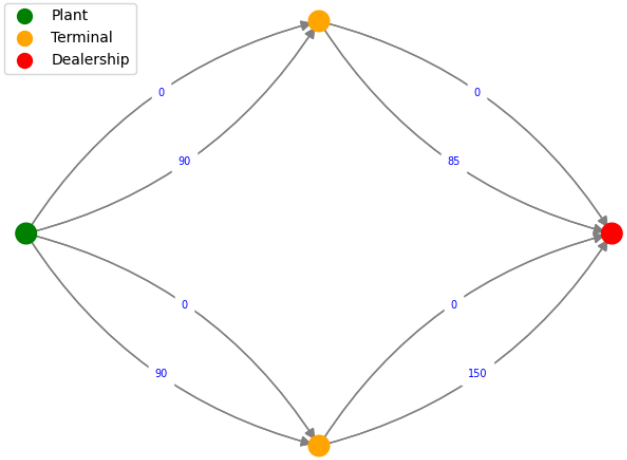
Objective

- Find a routing plan for the cars
- Minimize costs and avoid delays

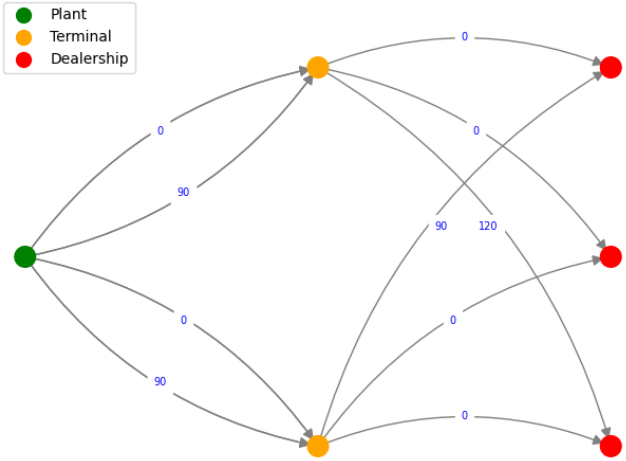
Logistics Networks – All Datasets



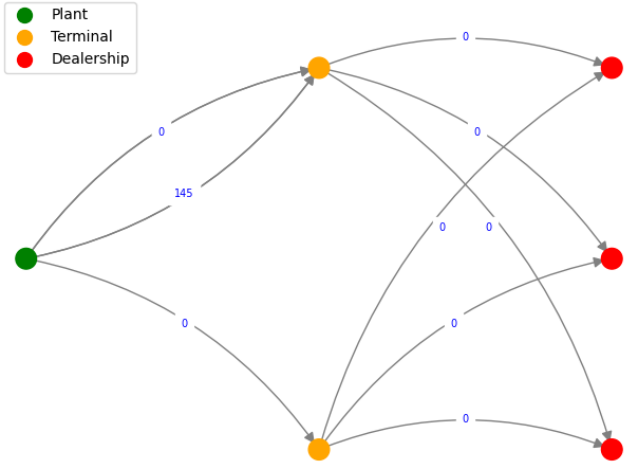
(a) Dataset 1



(b) Dataset 2



(c) Dataset 3

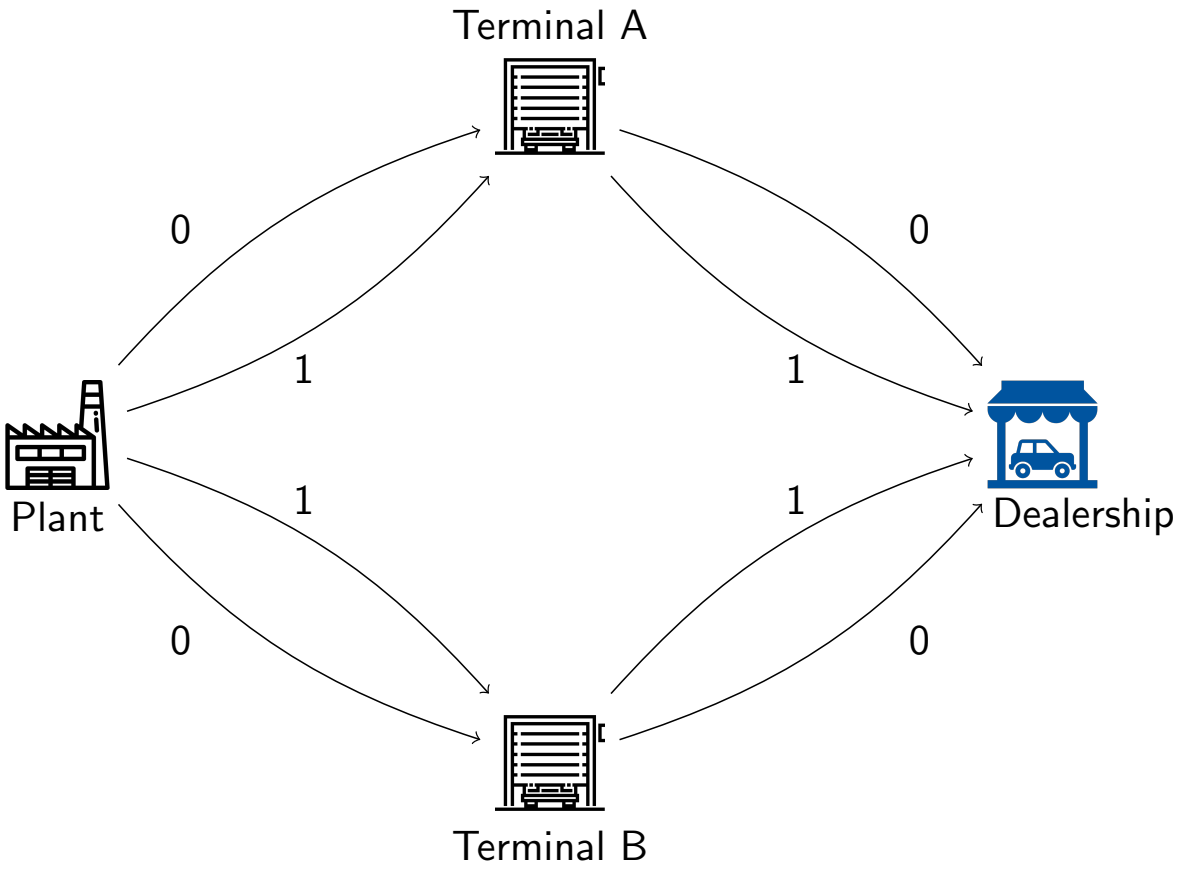


(d) Dataset 4

Base Greedy Visualization

Transport capacities: 1 vehicle

Transport durations: 1 day

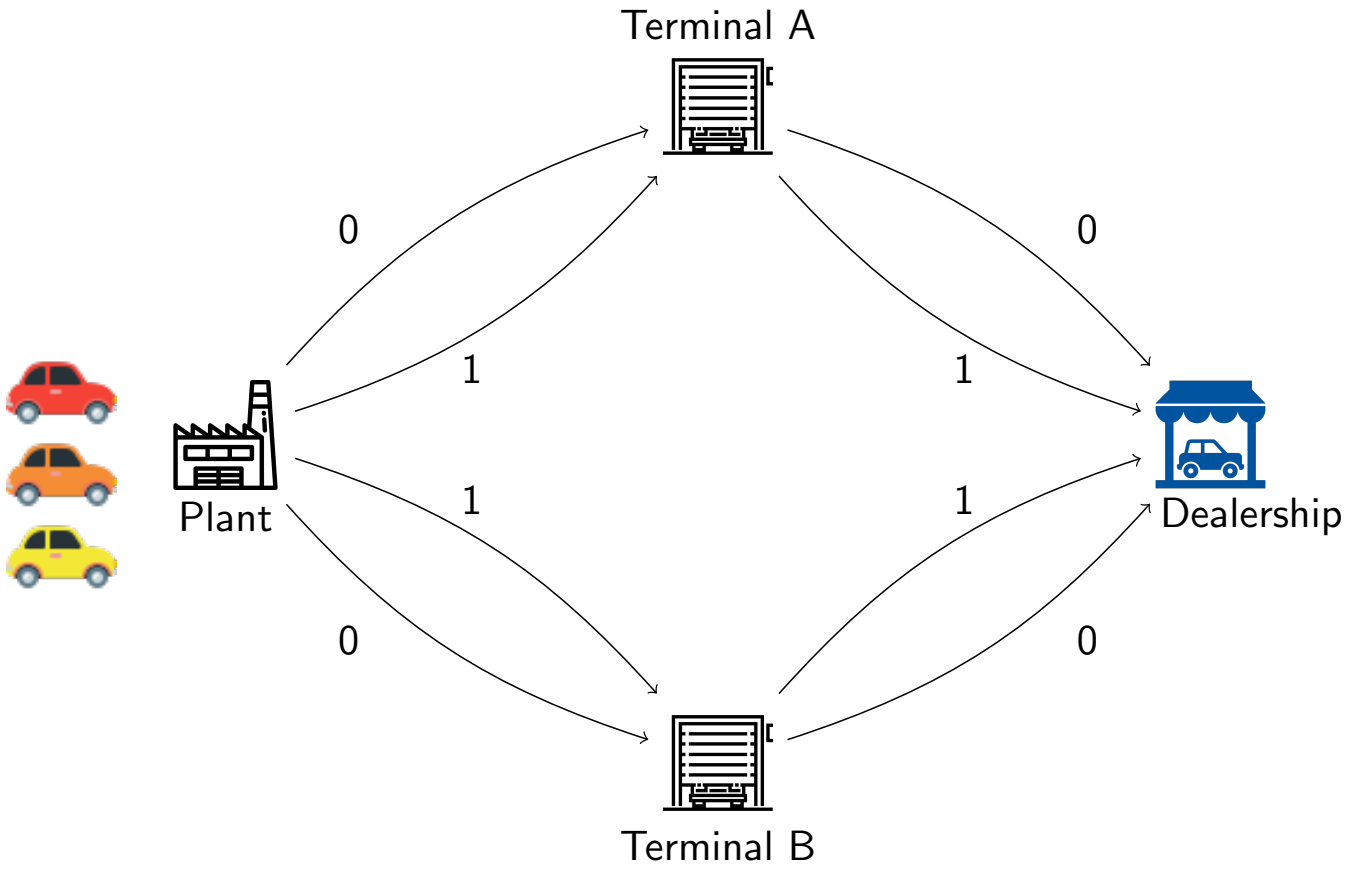


Base Greedy Visualization

Transport capacities: 1 vehicle

Transport durations: 1 day

Day: 1



Base Greedy Visualization

Transport capacities: 1 vehicle

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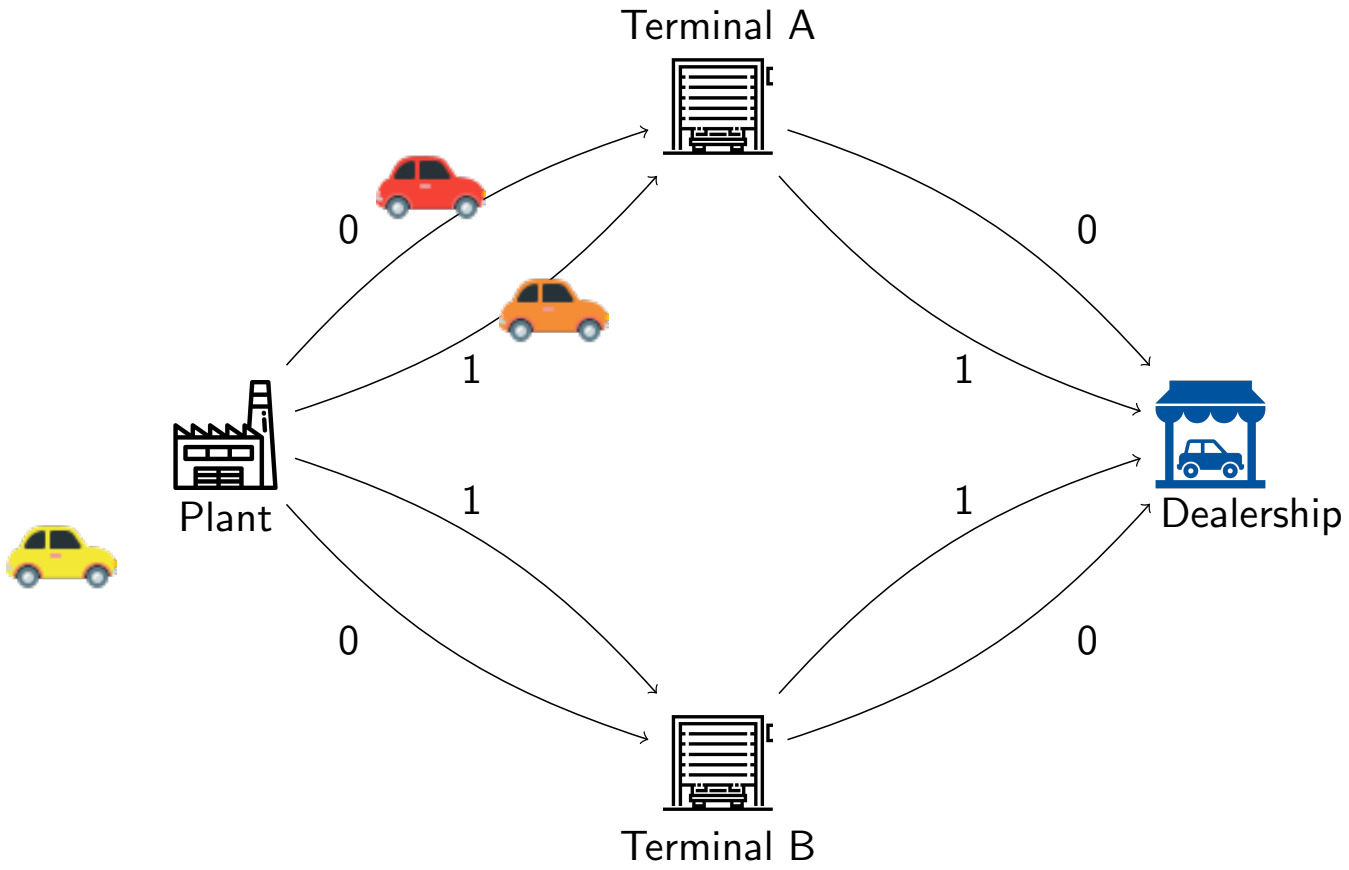
Day: 1

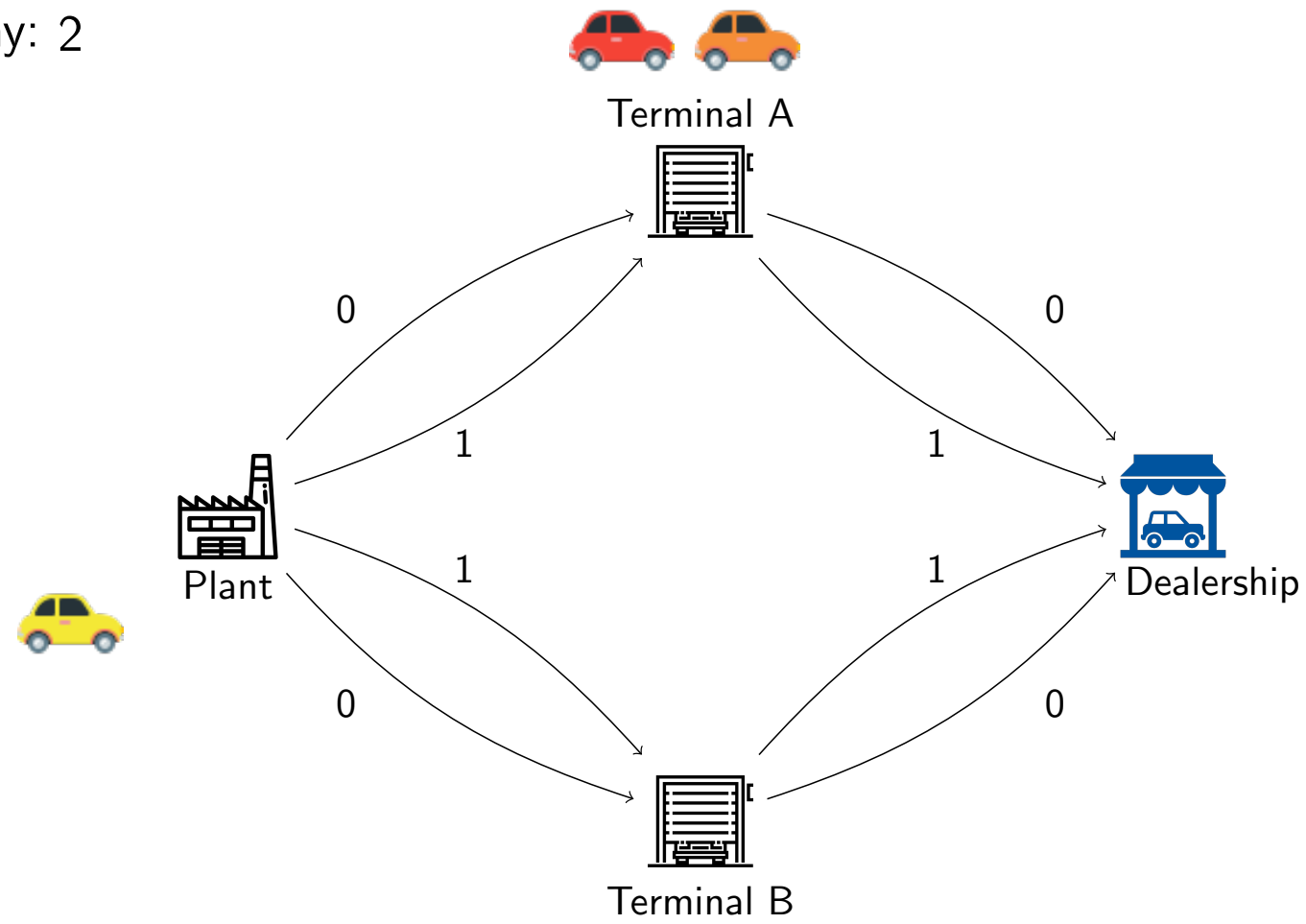


Base Greedy Visualization

Transport capacities: 1 vehicle

Transport durations: 1 day

Day: 2

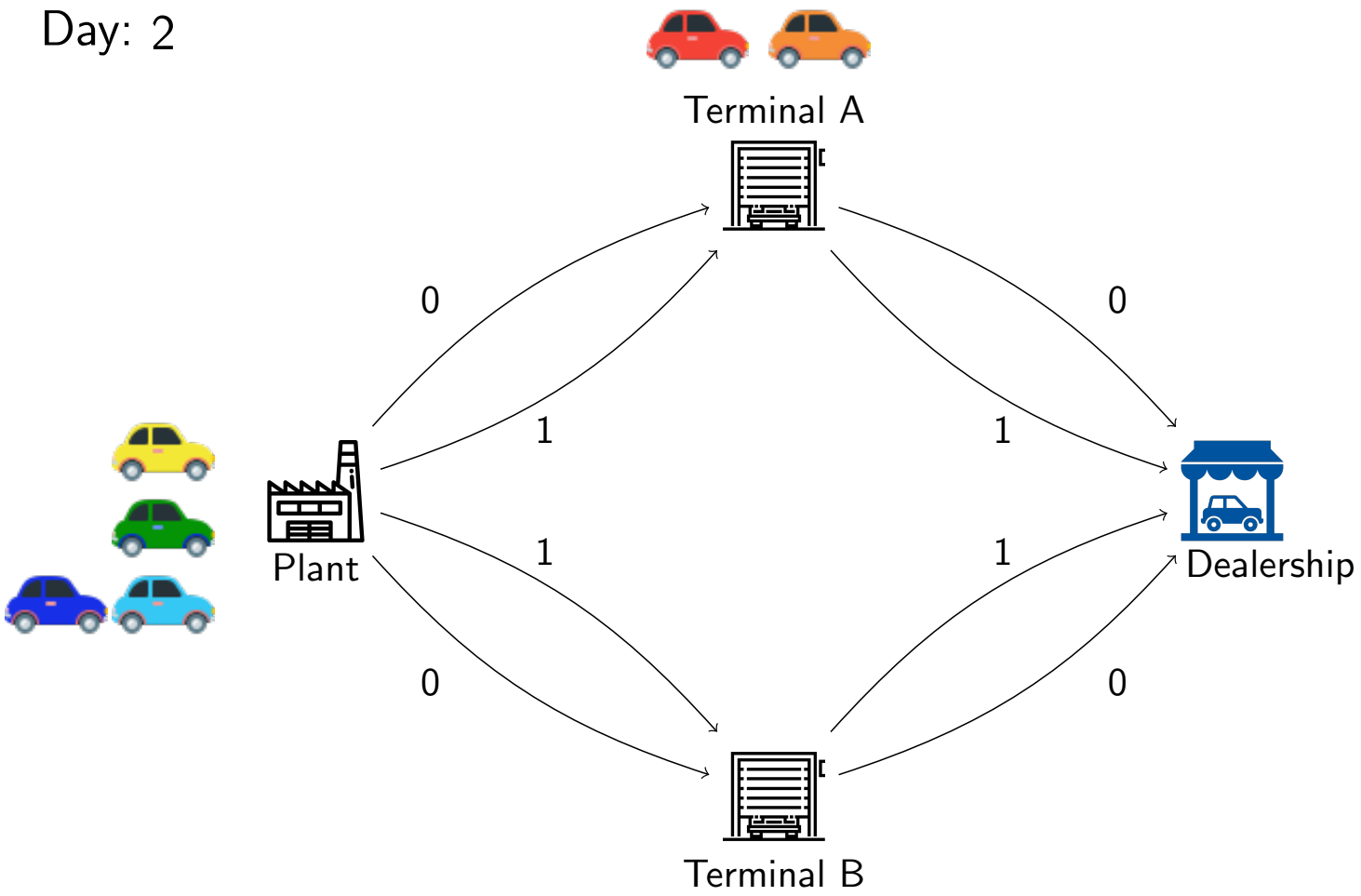


Base Greedy Visualization

Transport capacities: 1 vehicle

Transport durations: 1 day

Day: 2

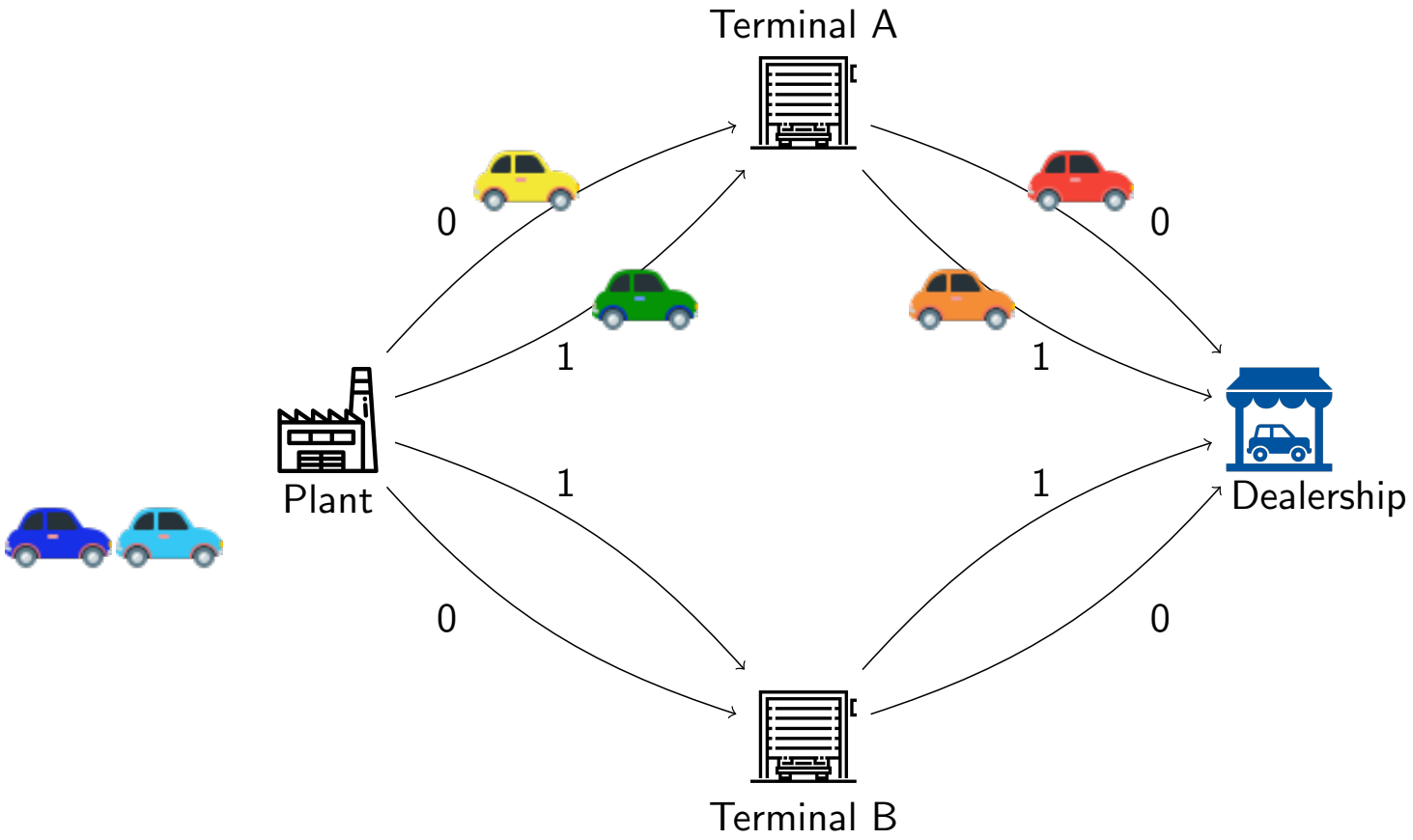


Base Greedy Visualization

Transport capacities: 1 vehicle

Transport durations: 1 day

Day: 2

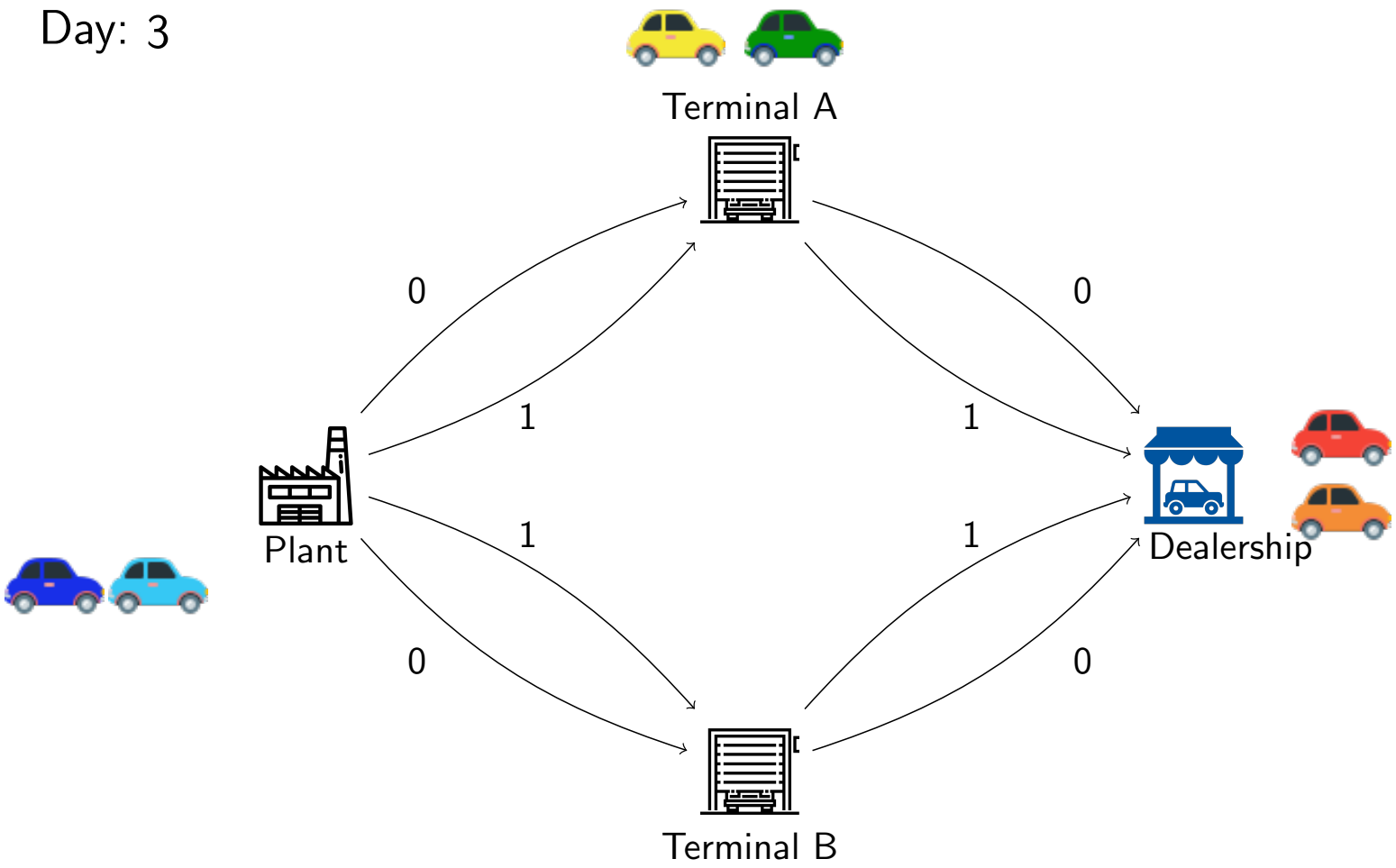


Base Greedy Visualization

Transport capacities: 1 vehicle

Transport durations: 1 day

Day: 3



Base Greedy Visualization

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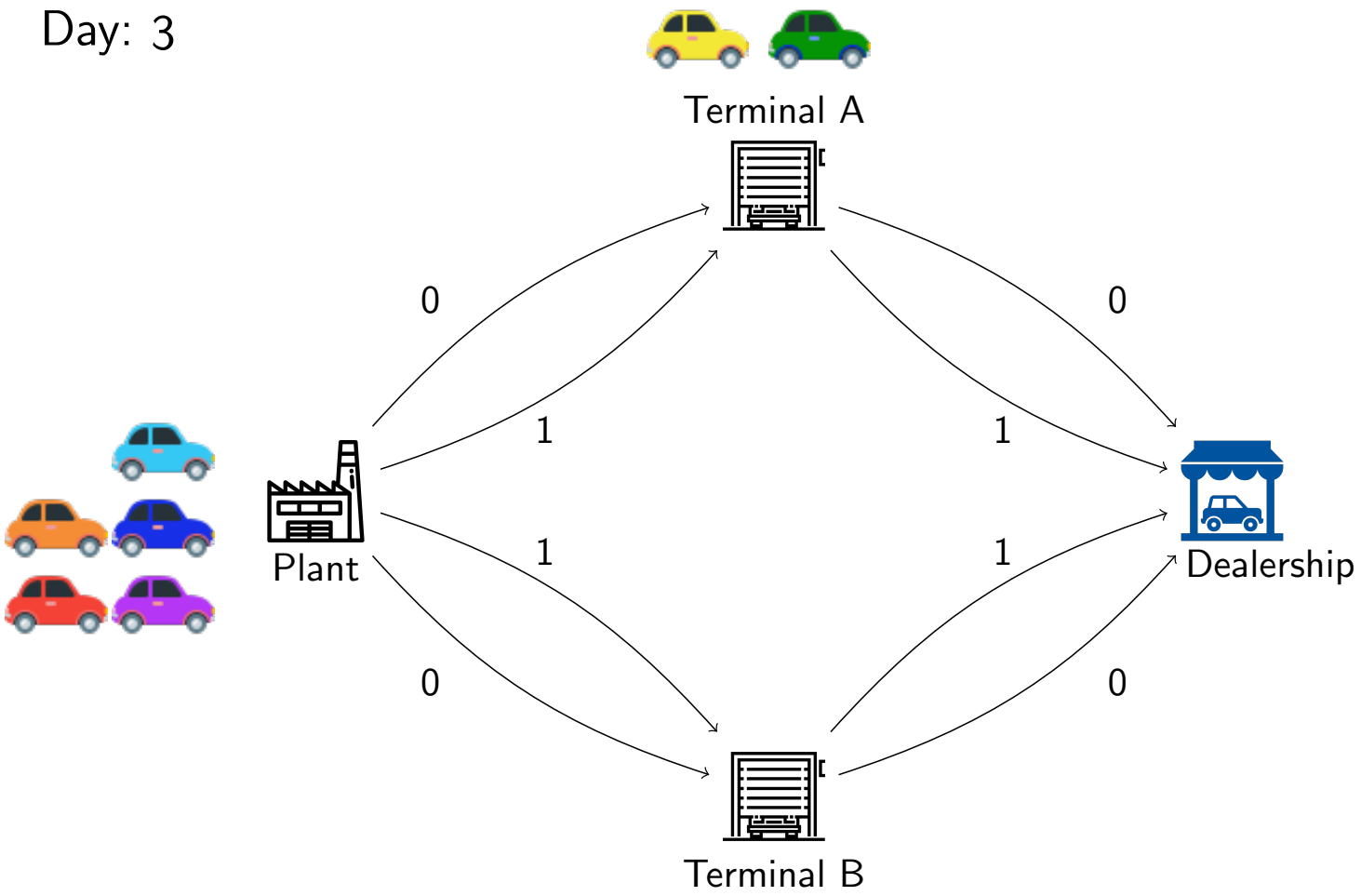

Base Greedy Algorithm

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1. Find shortest path for each vehicle

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$\Rightarrow$ Restricted in choice of path, maximally greedy in using it

Greedy in Uncertain Case

Greedy in Uncertain Case

- No difference in assigning, as we iterate over days already

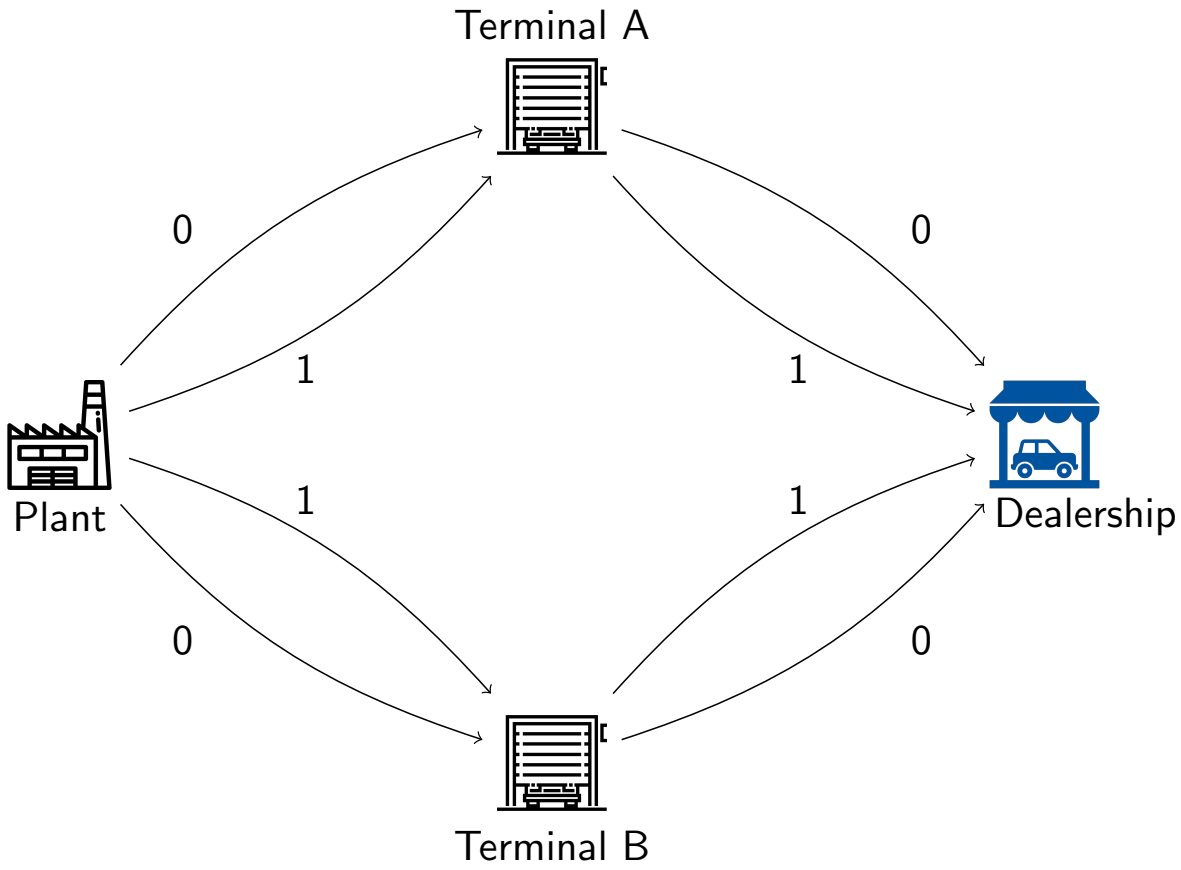
Greedy in Uncertain Case

- No difference in assigning, as we iterate over days already
- Run first on planned data to determine some vehicles which will likely be delayed

Greedy with Candidate Paths

Transport capacities: 1 vehicle

Transport durations: 1 day

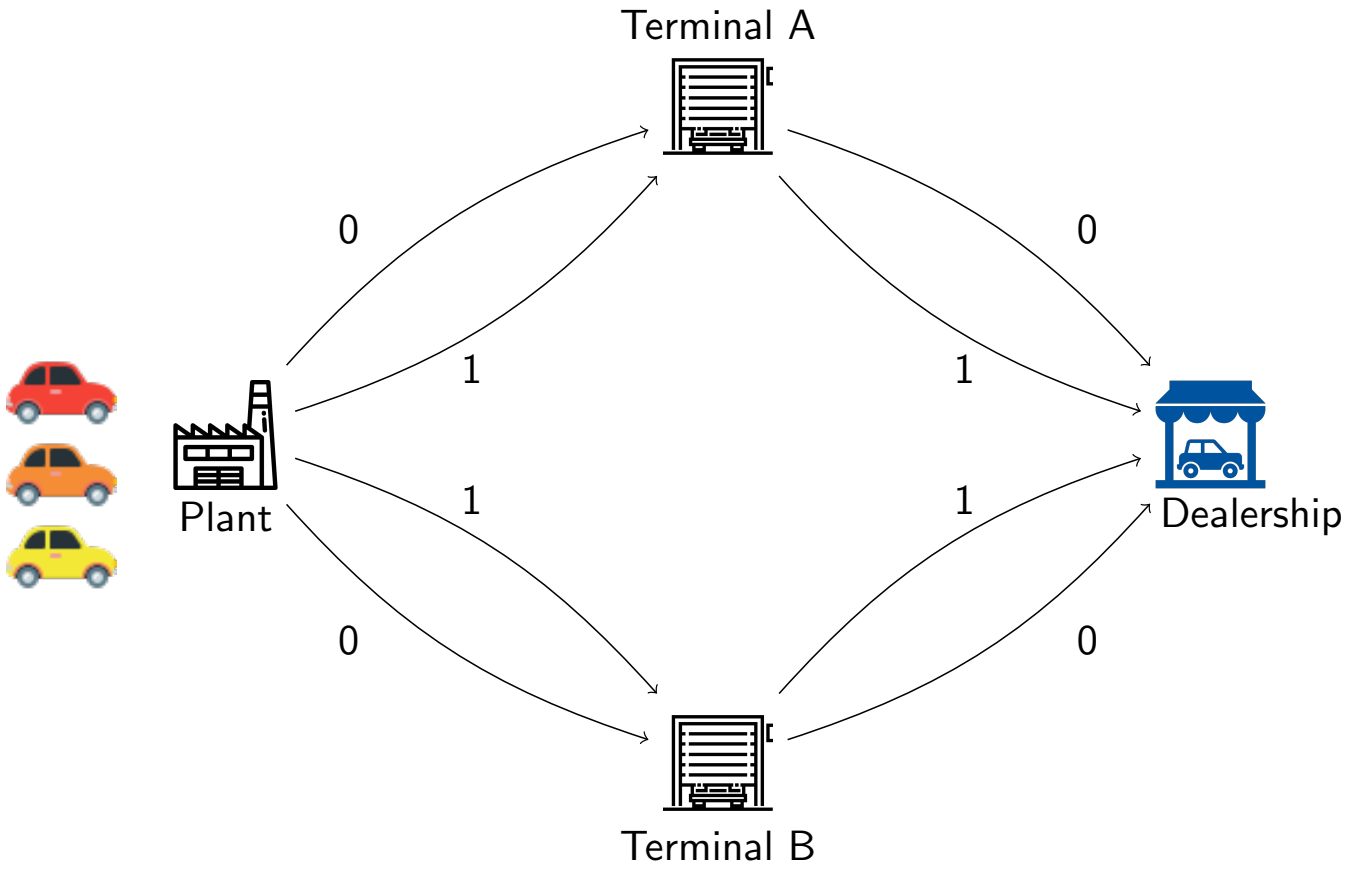


Greedy with Candidate Paths

Transport capacities: 1 vehicle

Transport durations: 1 day

Day: 1



Greedy with Candidate Paths

Transport capacities: 1 vehicle

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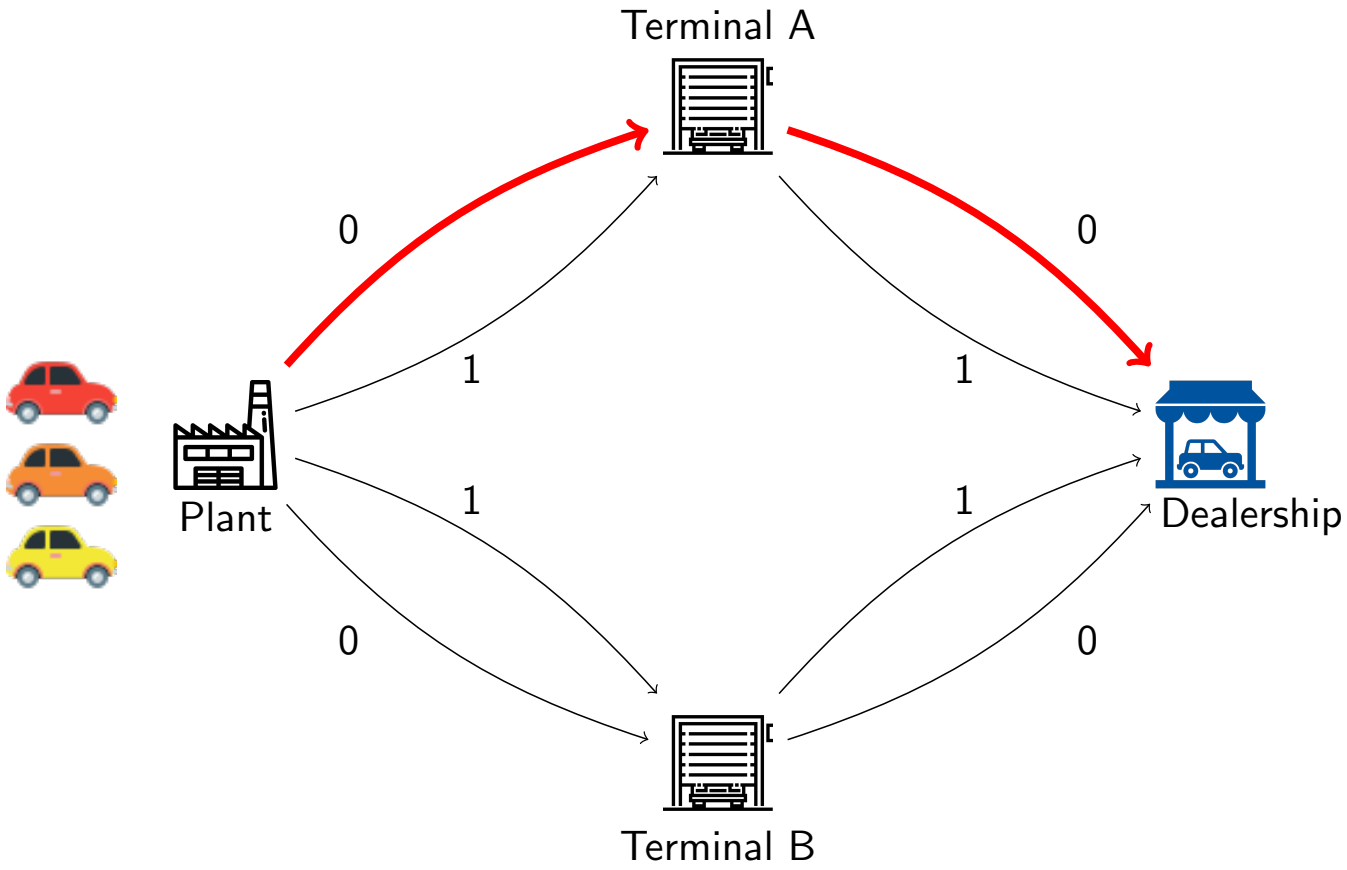

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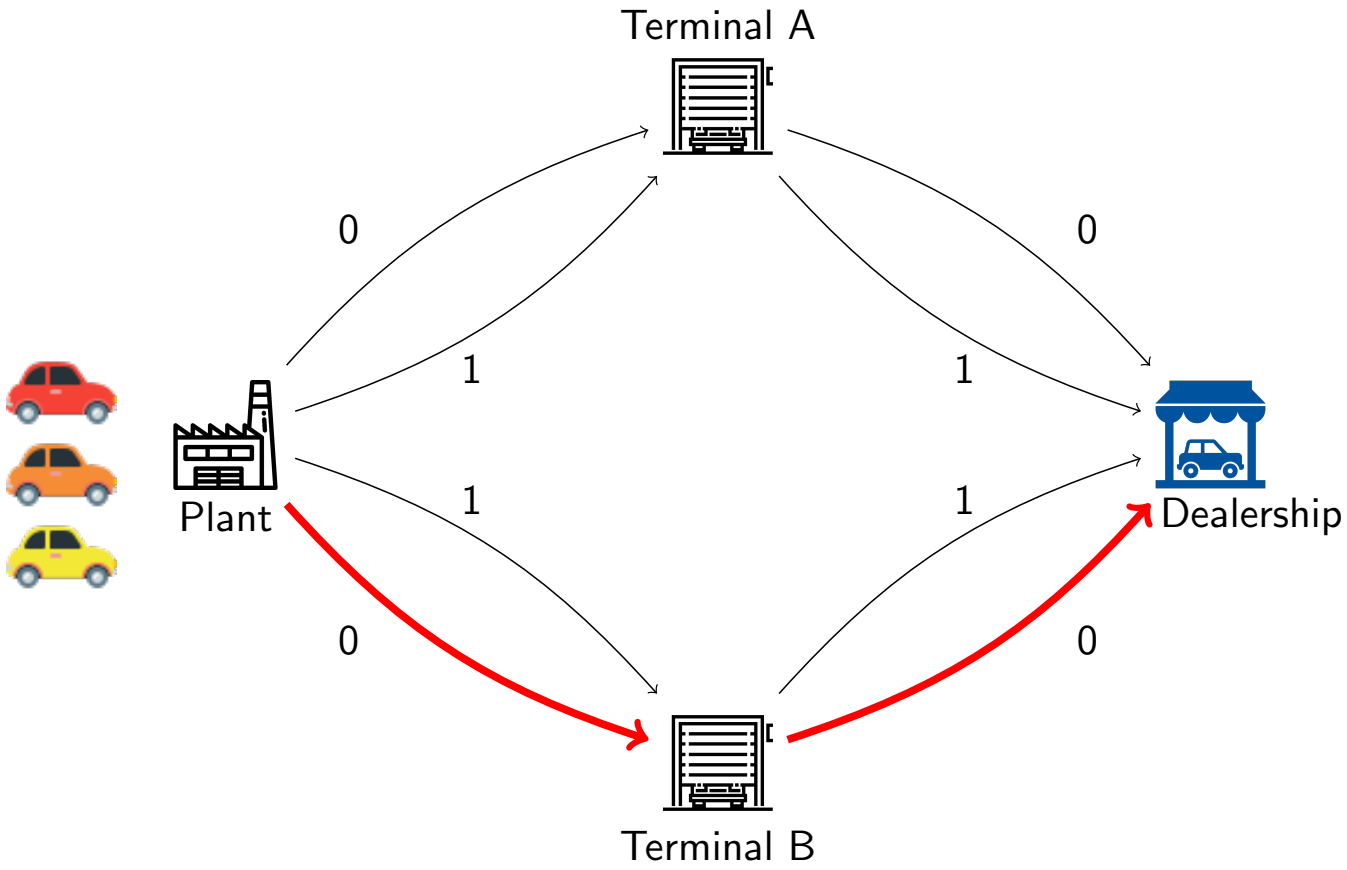

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Transport capacities: 1 vehicle

Transport durations: 1 day

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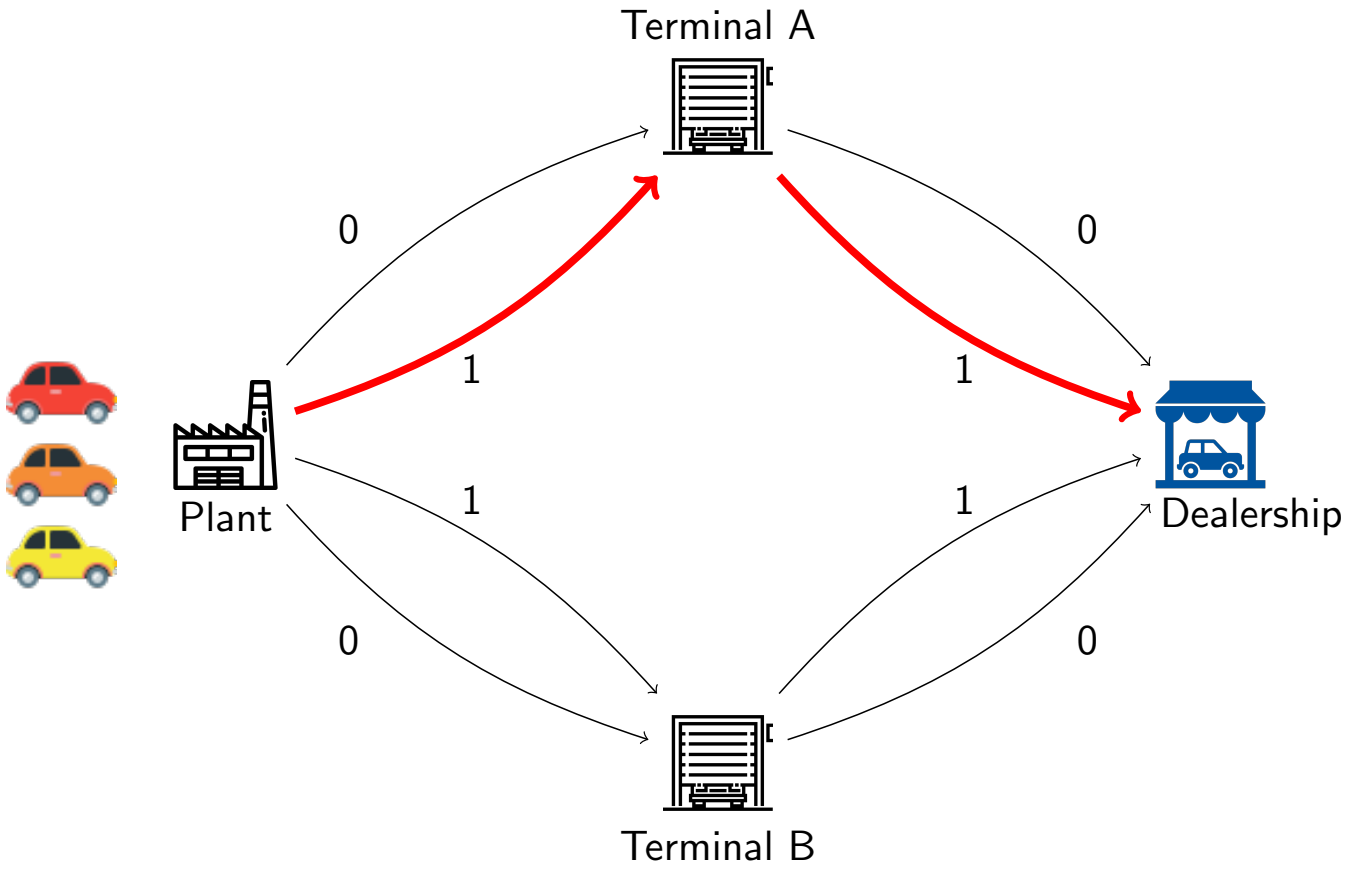

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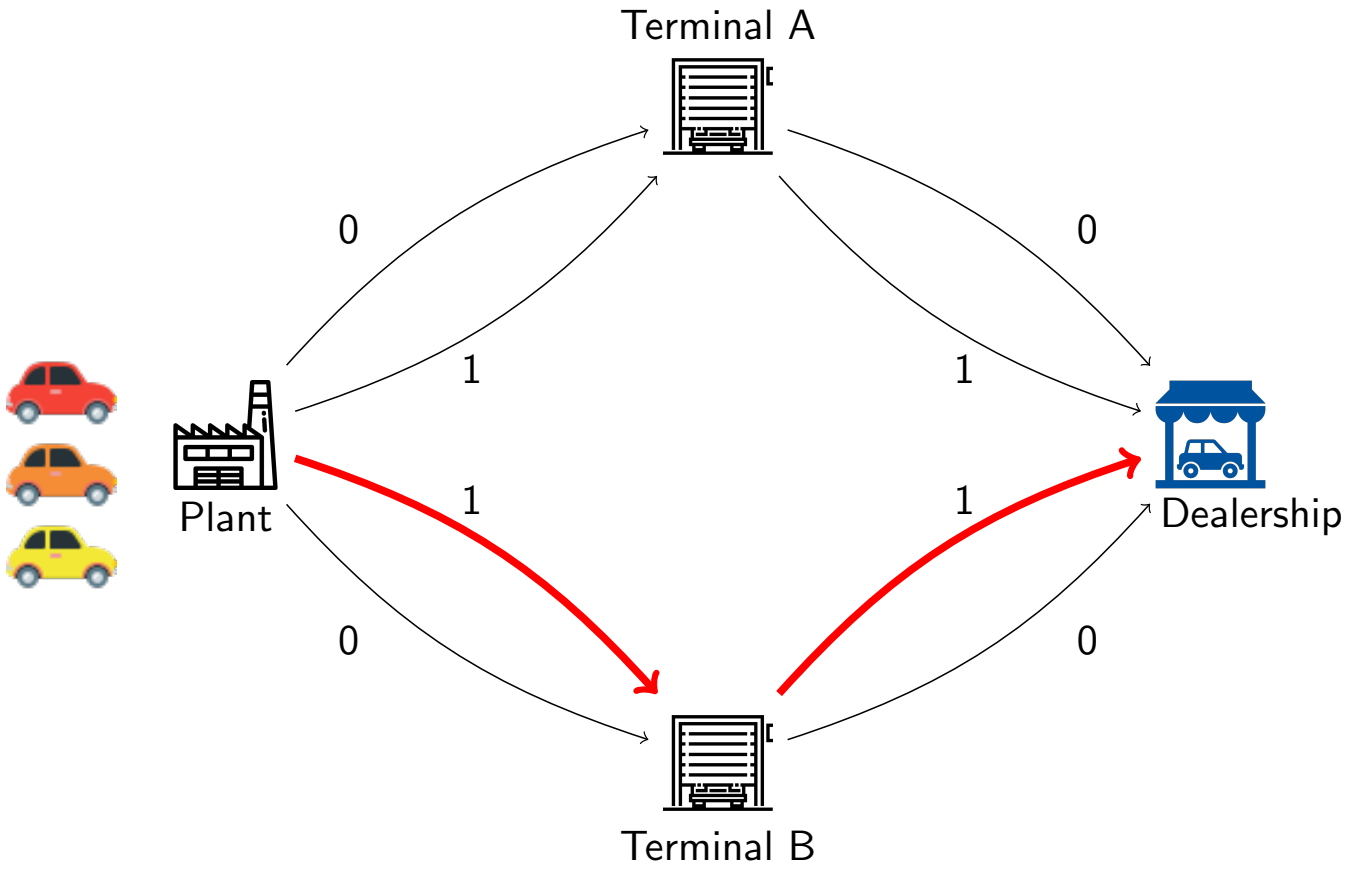

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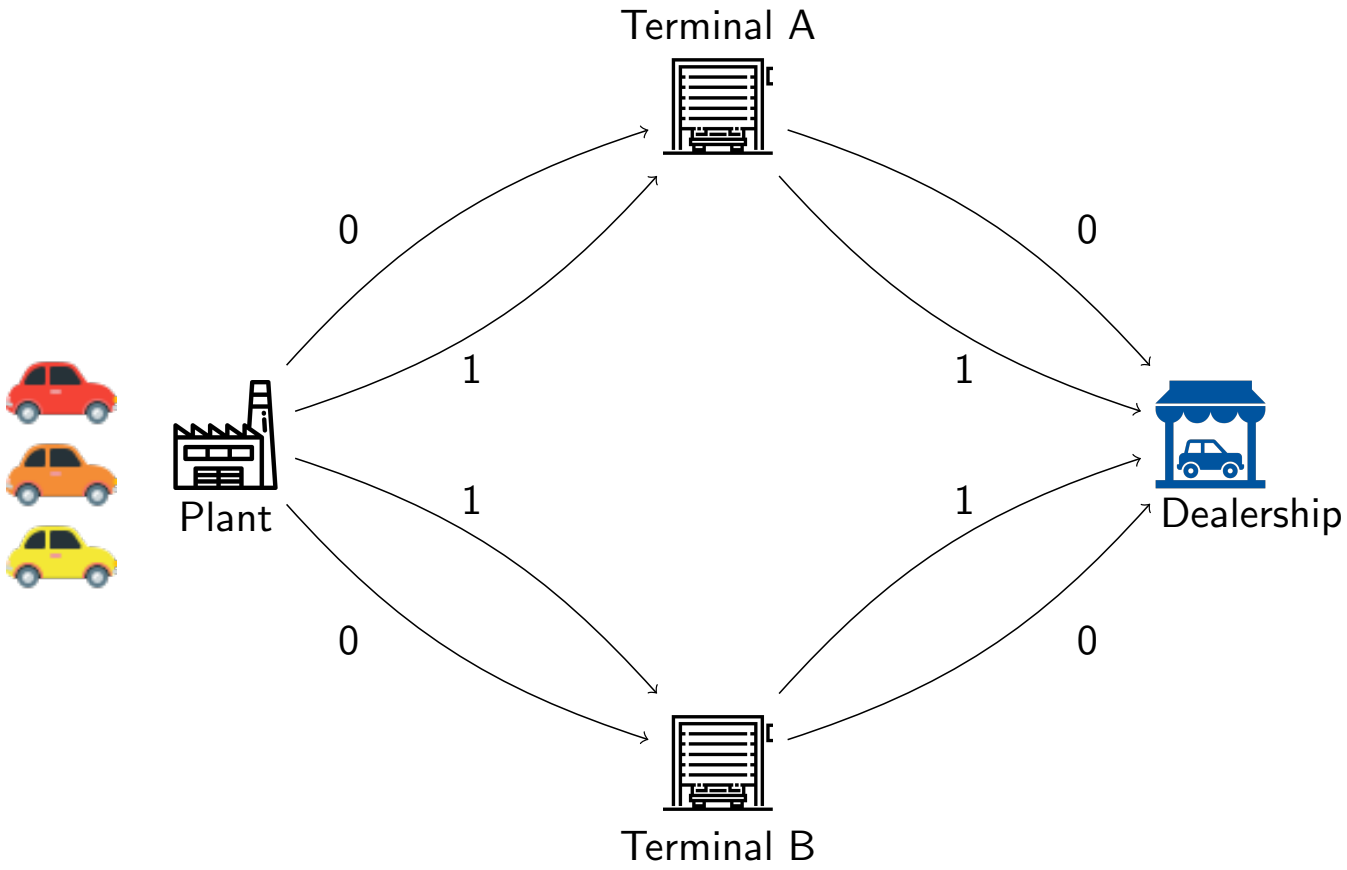

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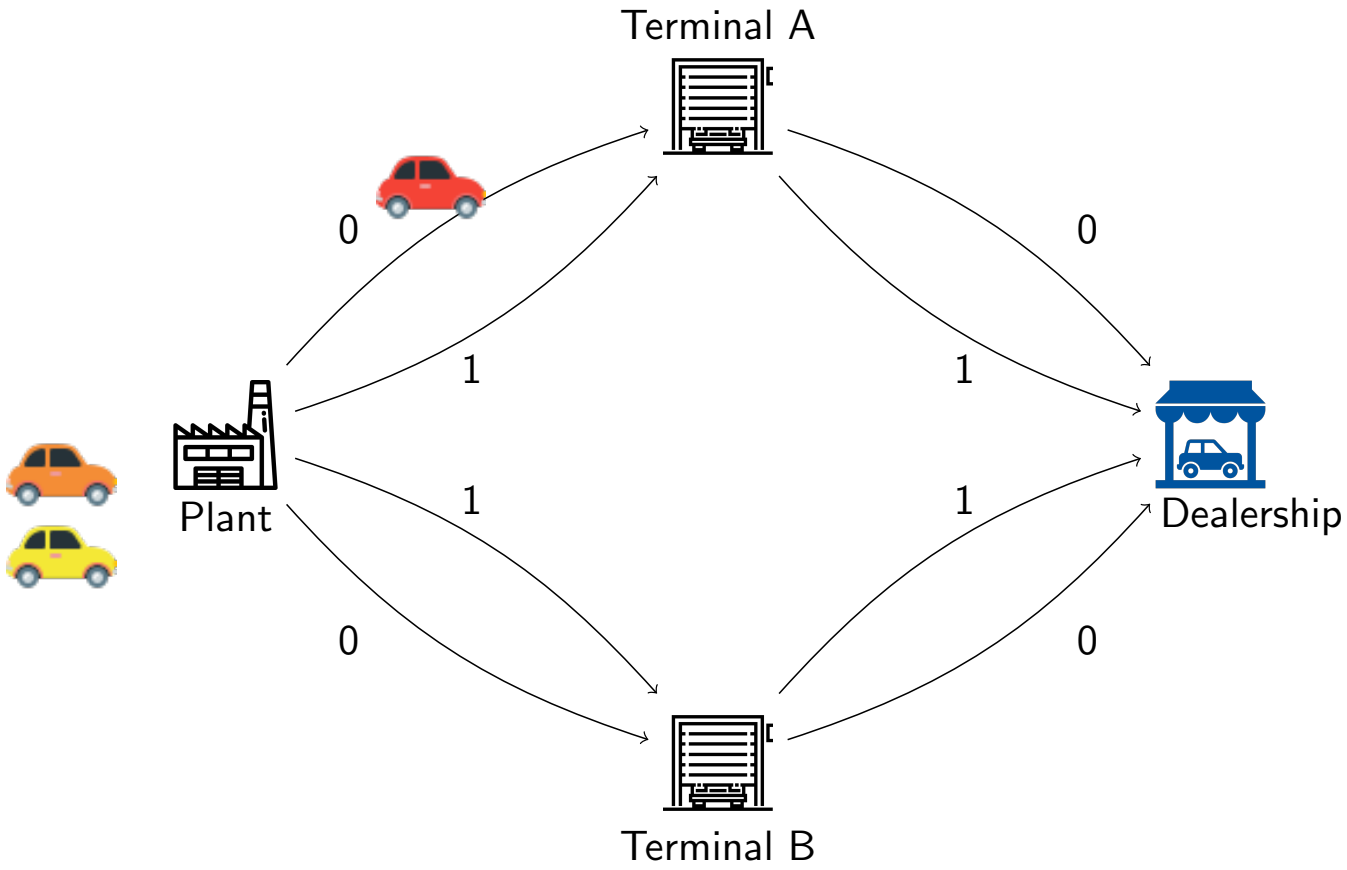

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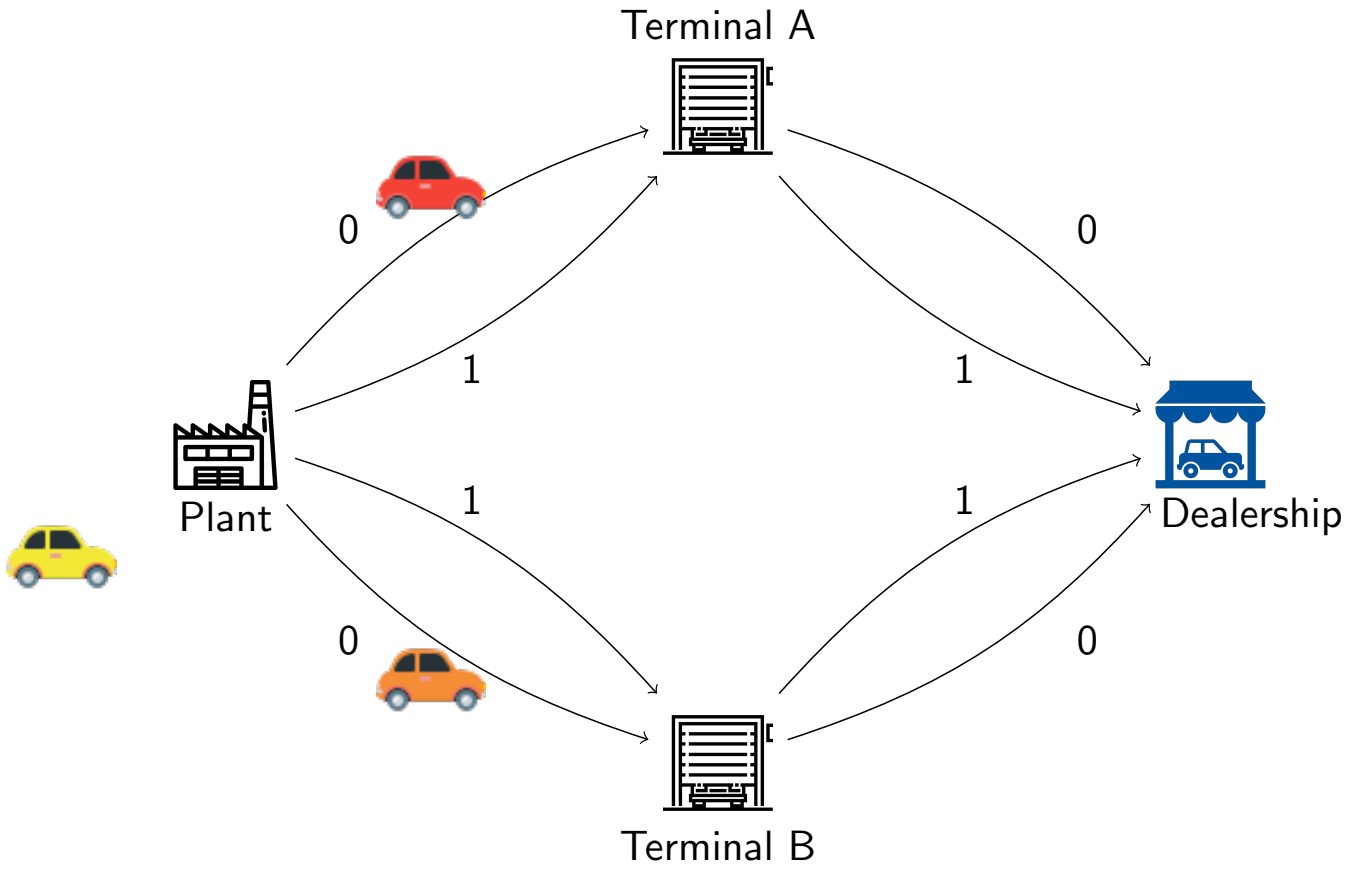
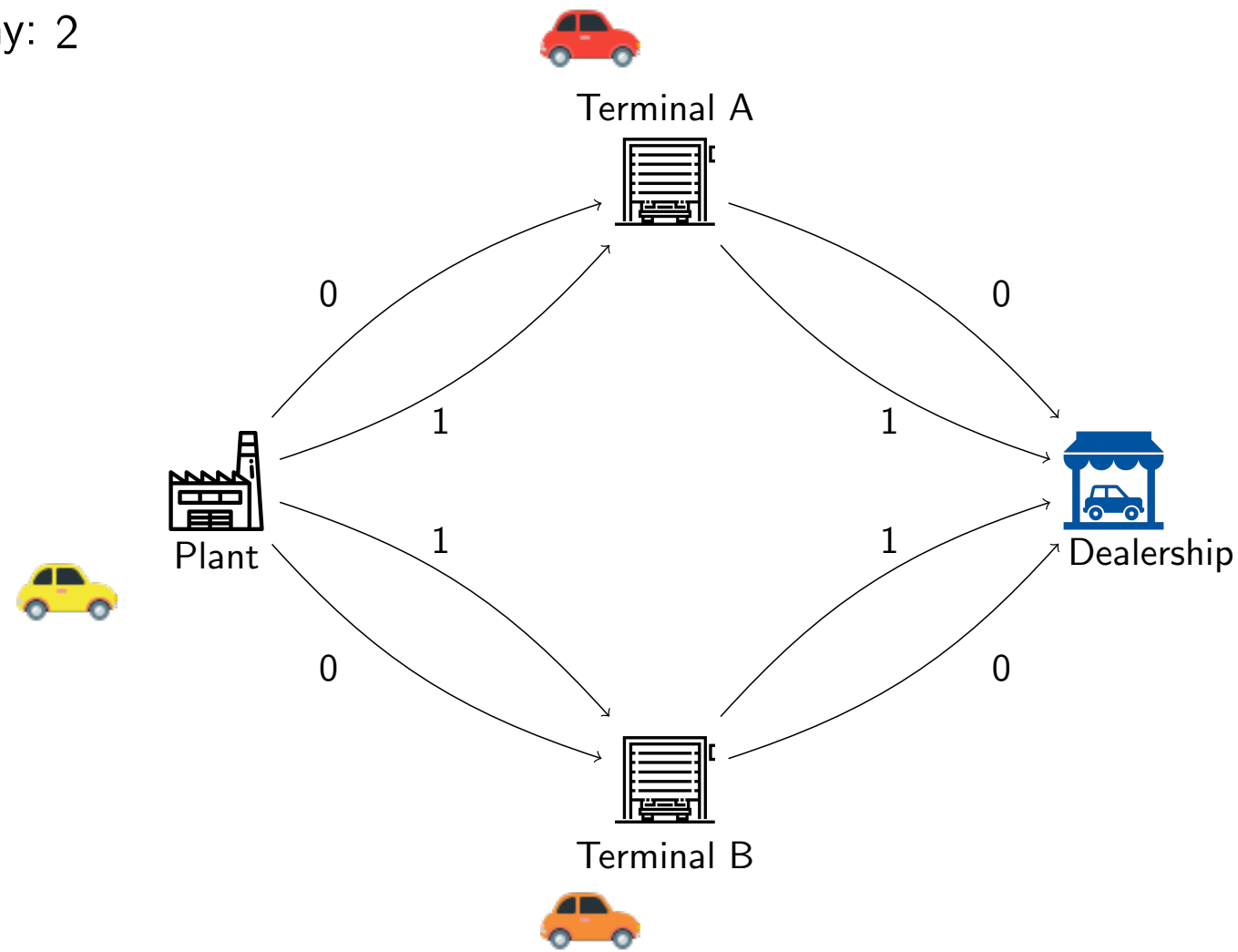


Greedy with Candidate Paths

Transport capacities: 1 vehicle

Transport durations: 1 day

Day: 2

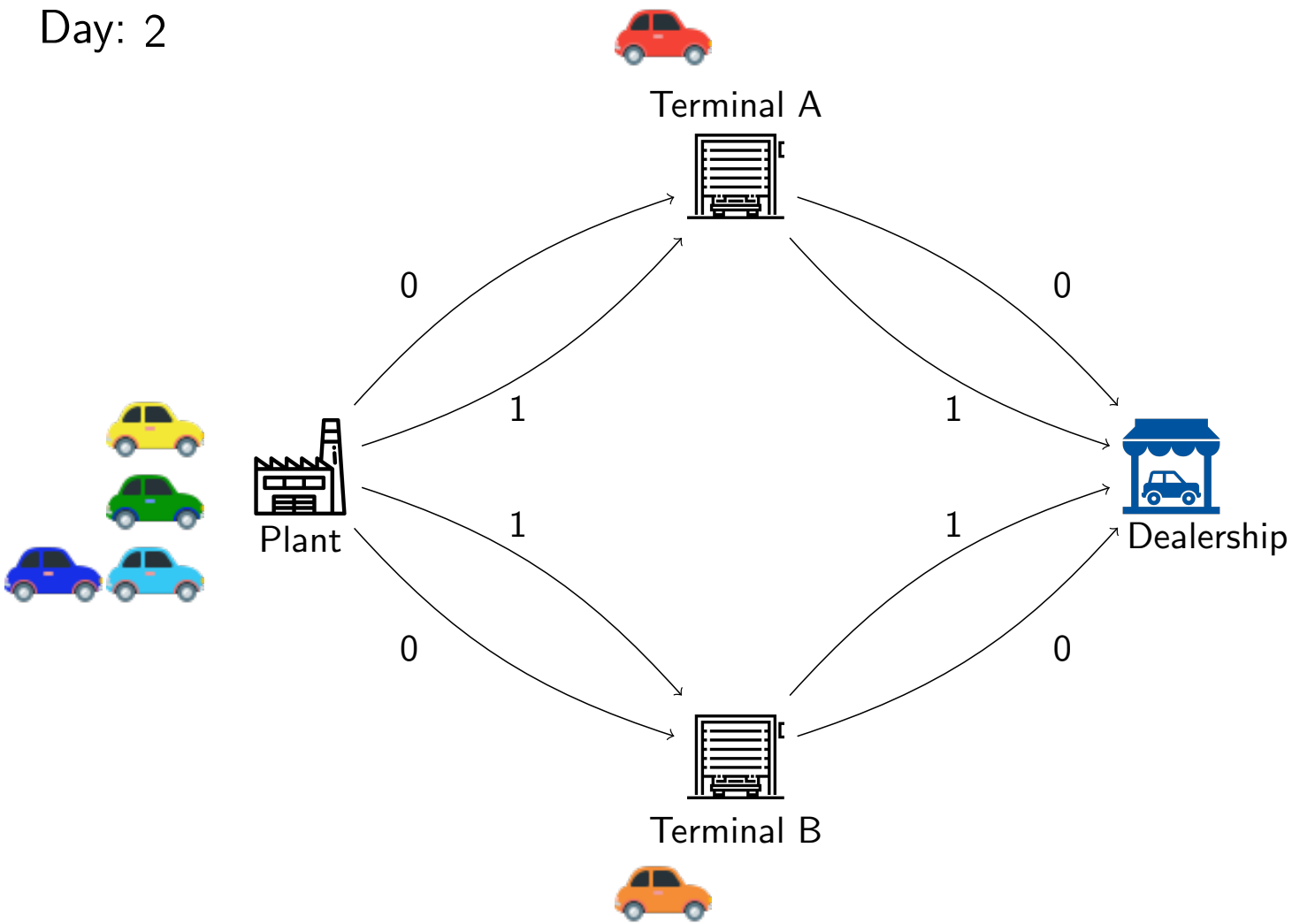


Greedy with Candidate Paths

Transport capacities: 1 vehicle

Transport durations: 1 day

Day: 2



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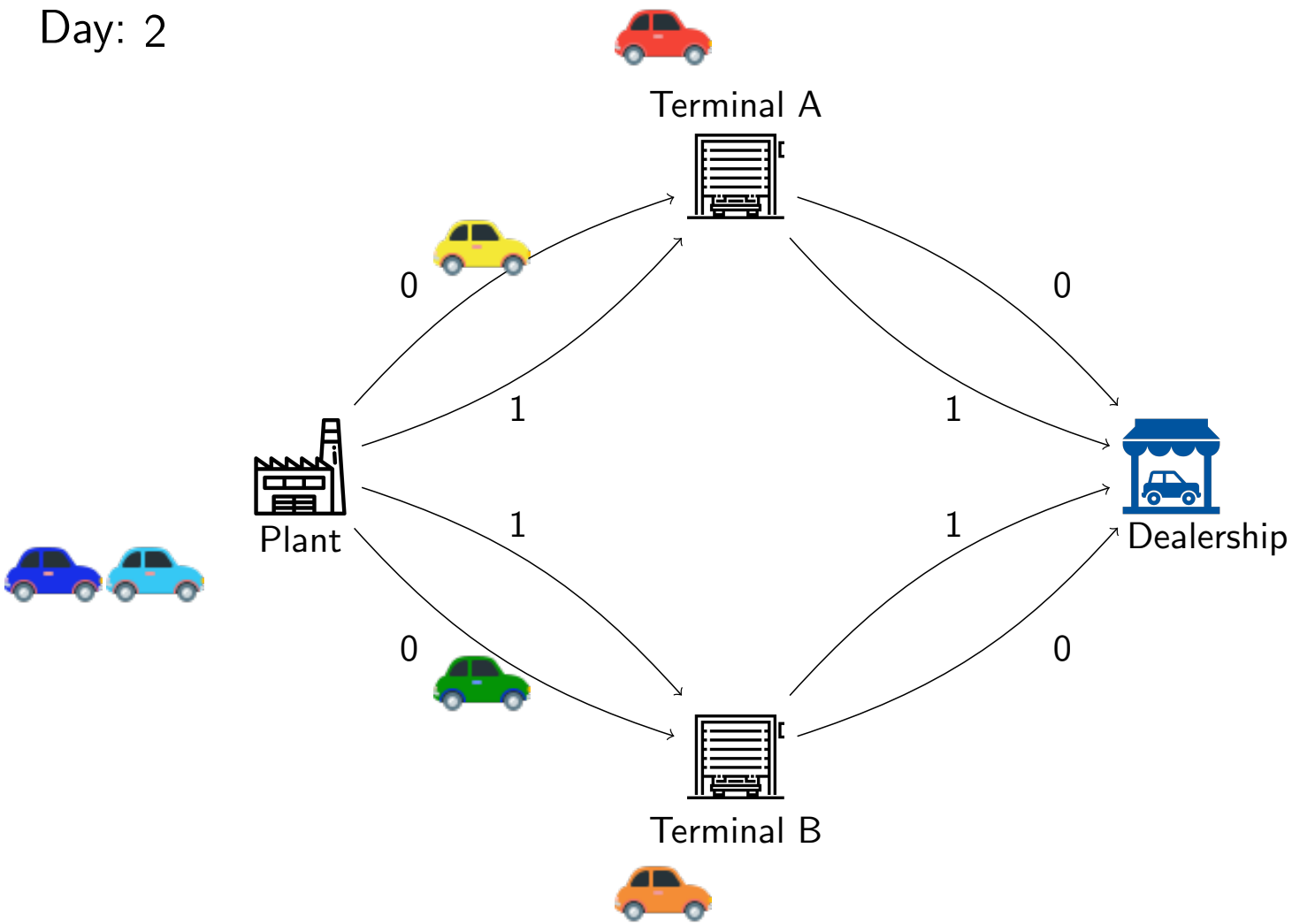

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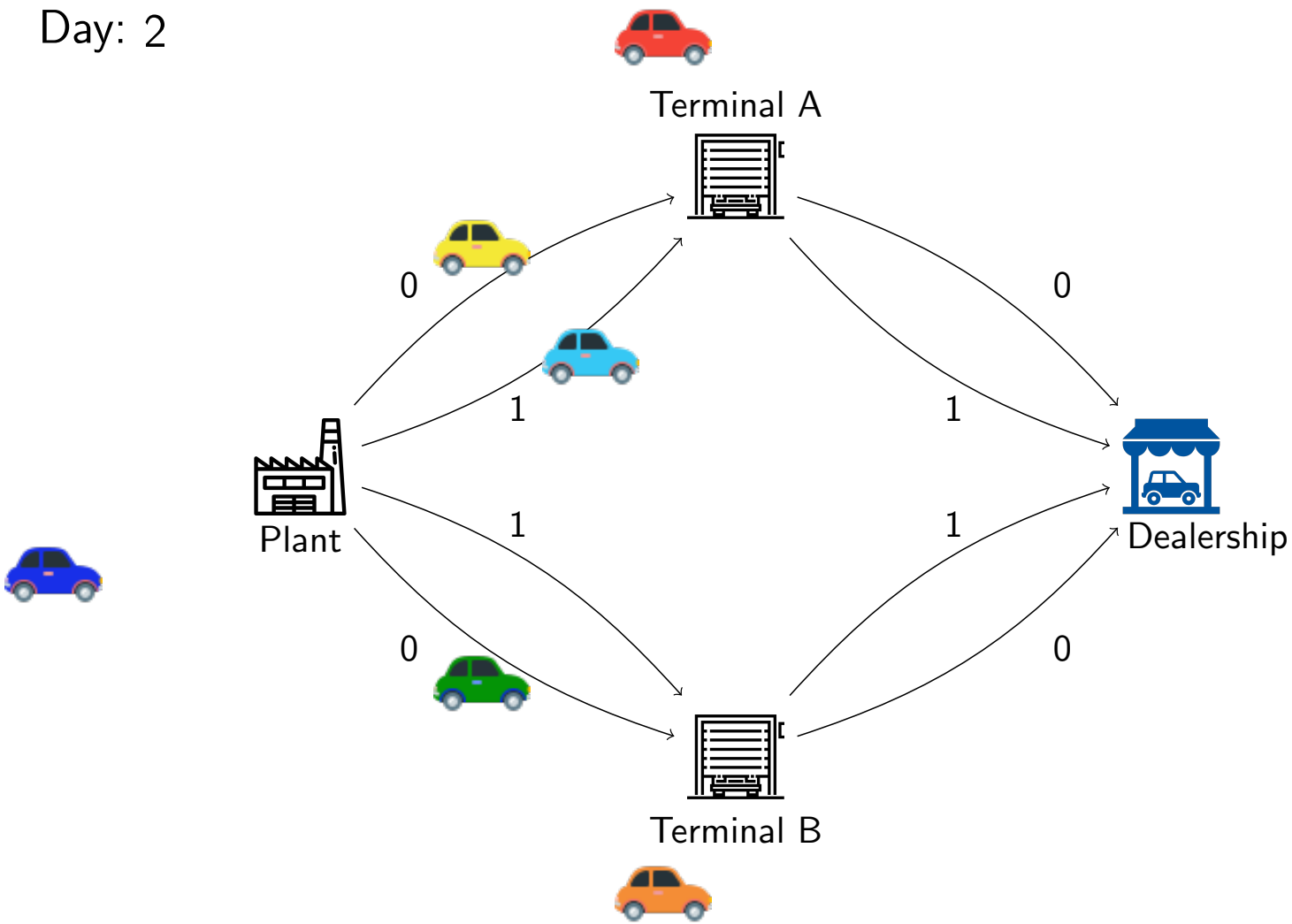
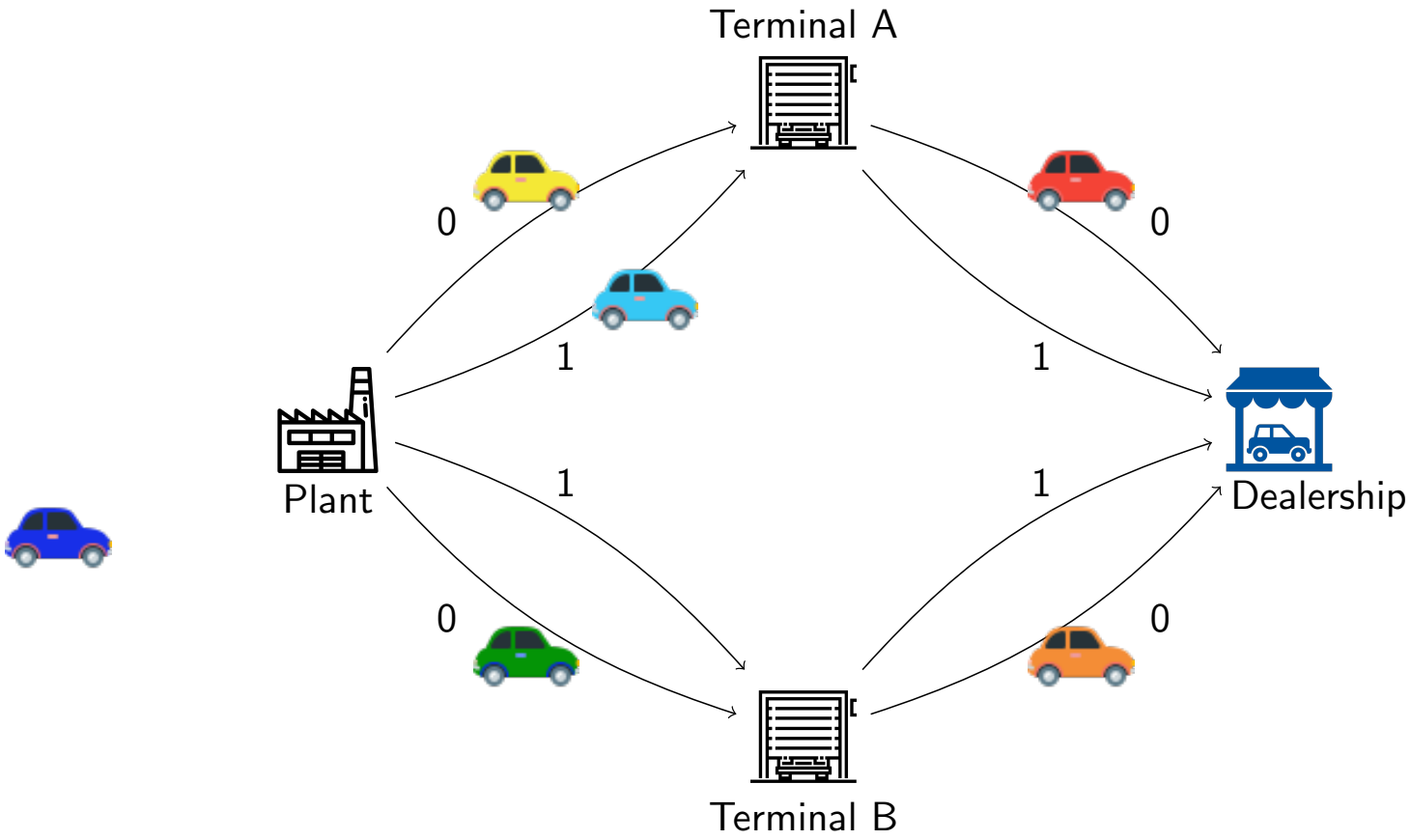


Greedy with Candidate Paths

Transport capacities: 1 vehicle

Transport durations: 1 day

Day: 2

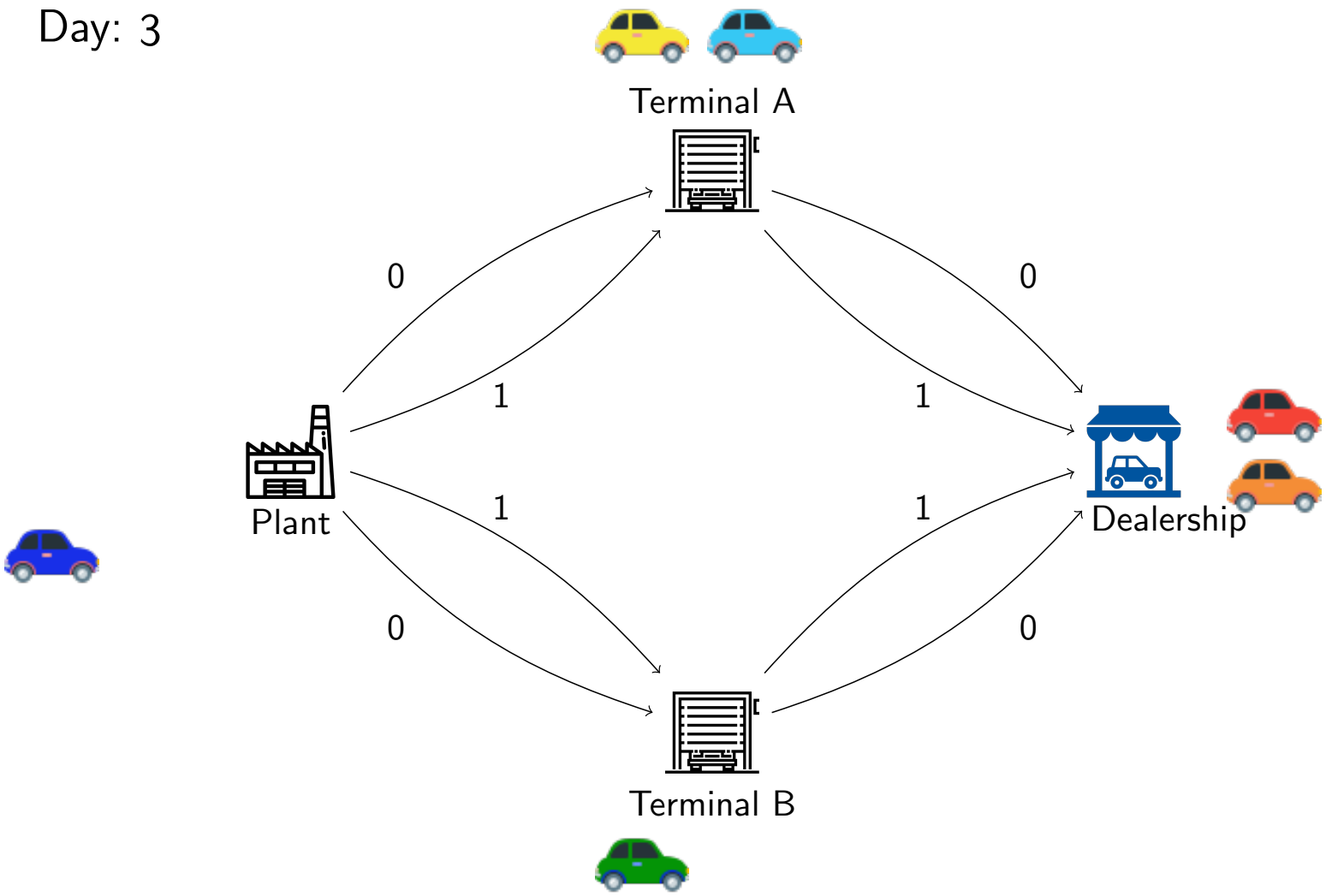


Greedy with Candidate Paths

Transport capacities: 1 vehicle

Transport durations: 1 day

Day: 3



Greedy with Candidate Paths

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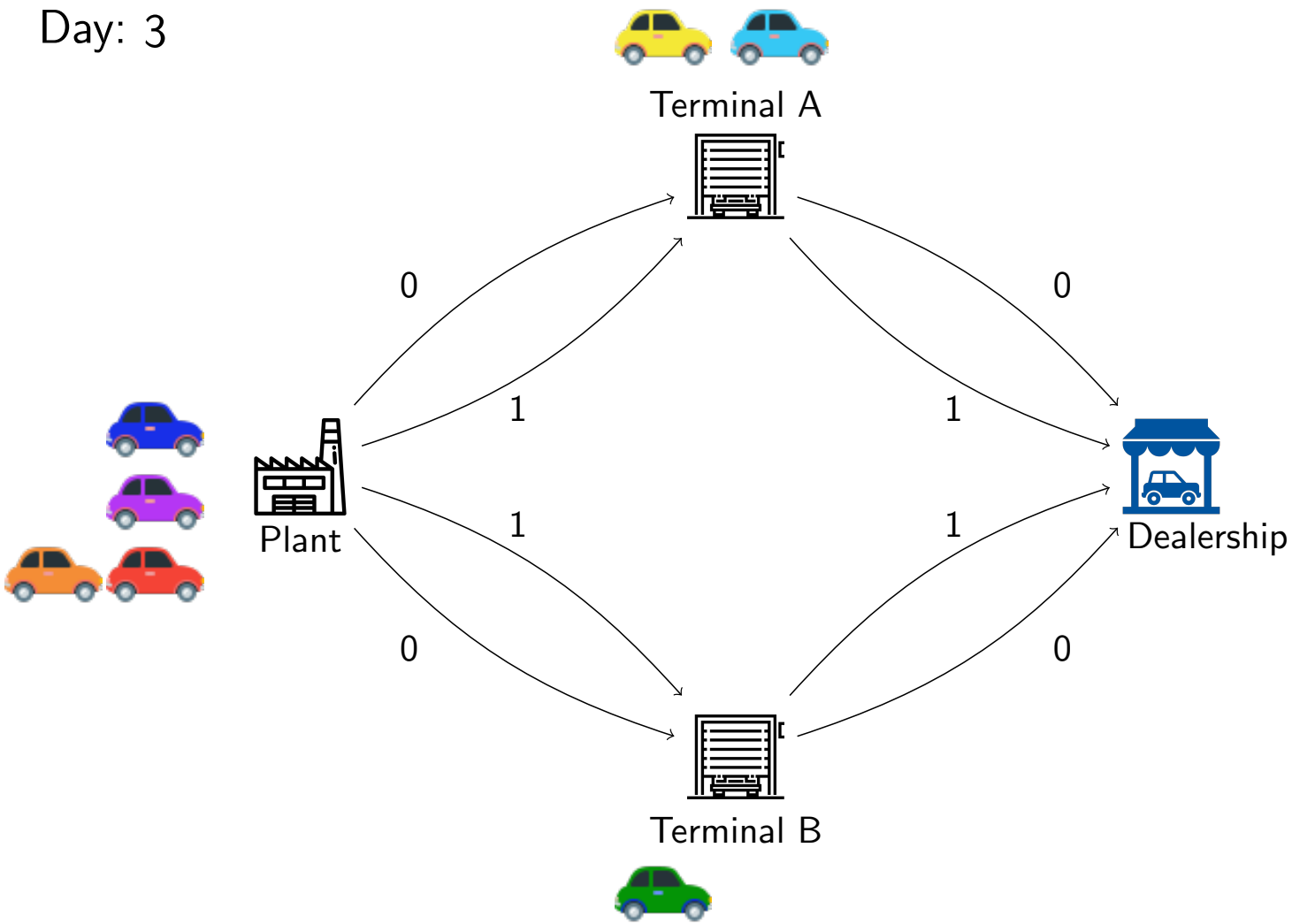
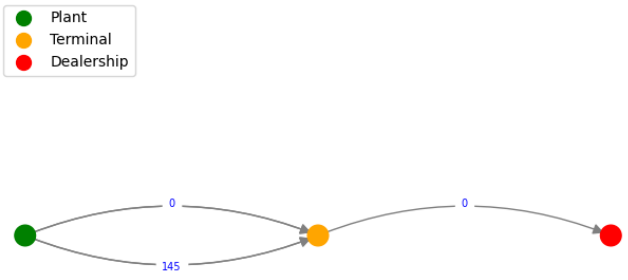
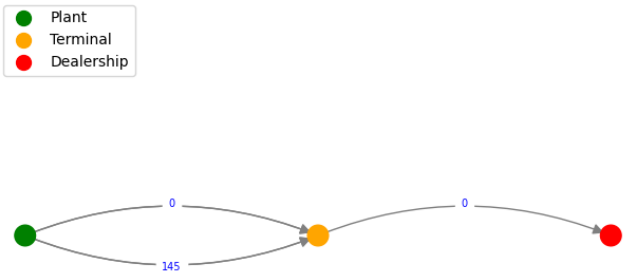
Day: 3



Modeling the Logistics Problem as a Flow Problem

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Dealership
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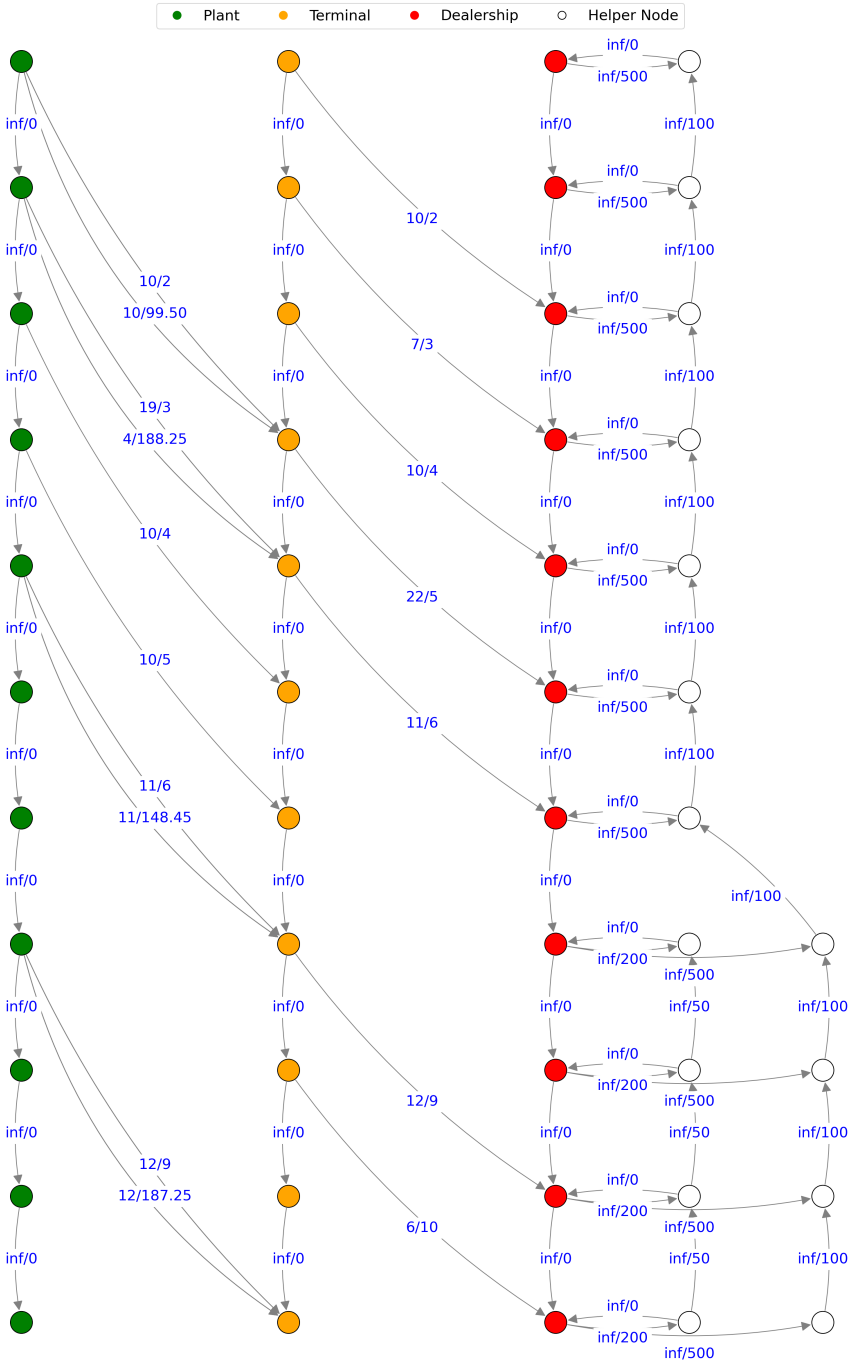
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22/5
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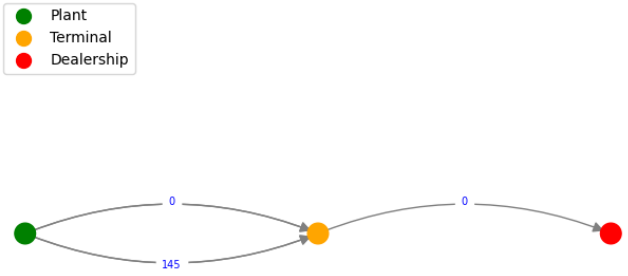
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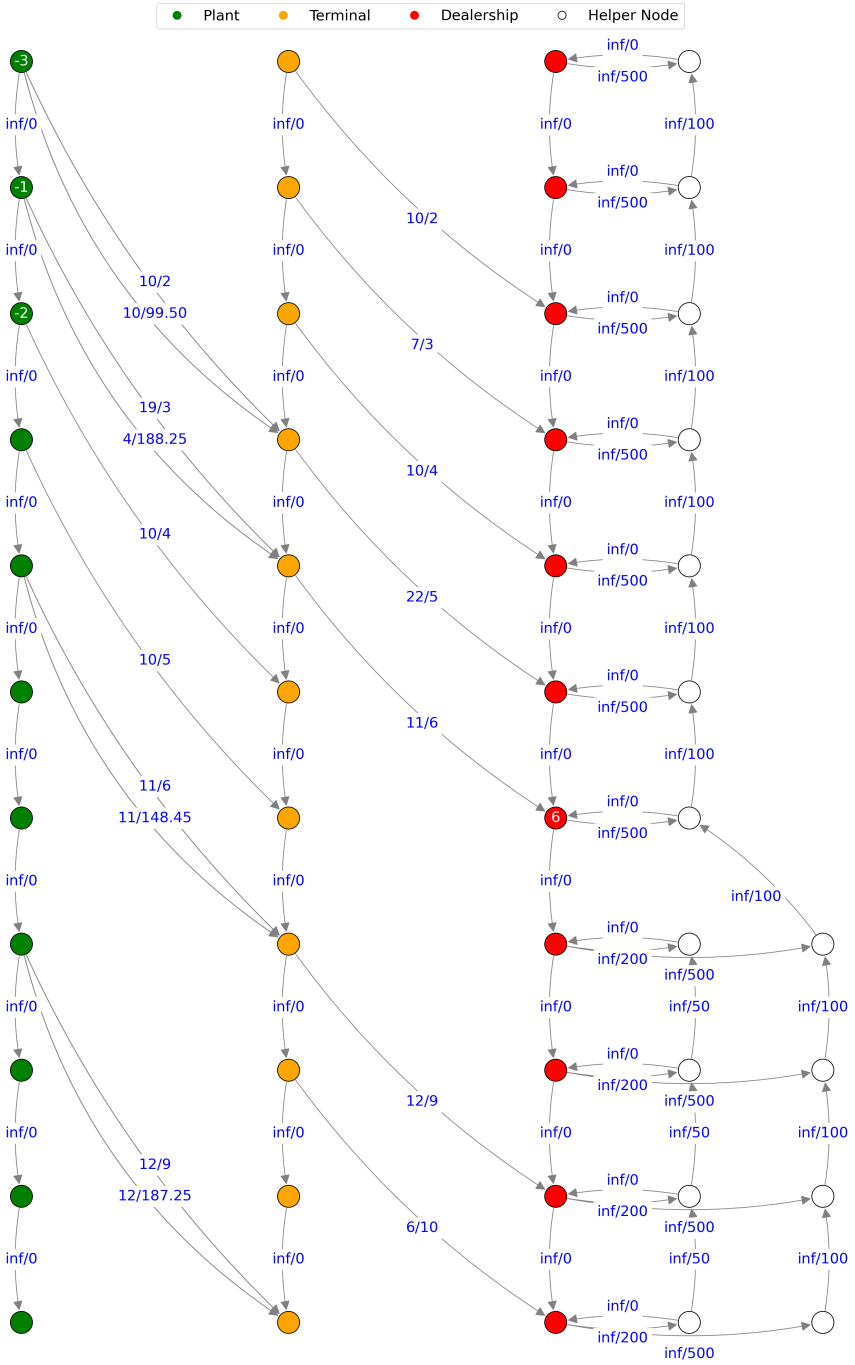
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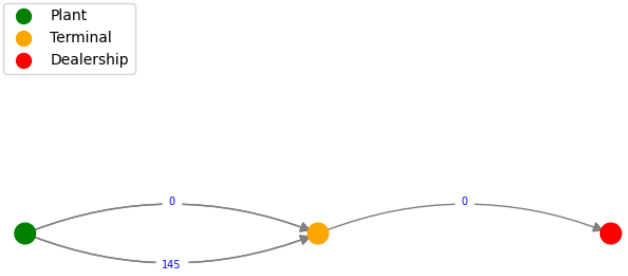
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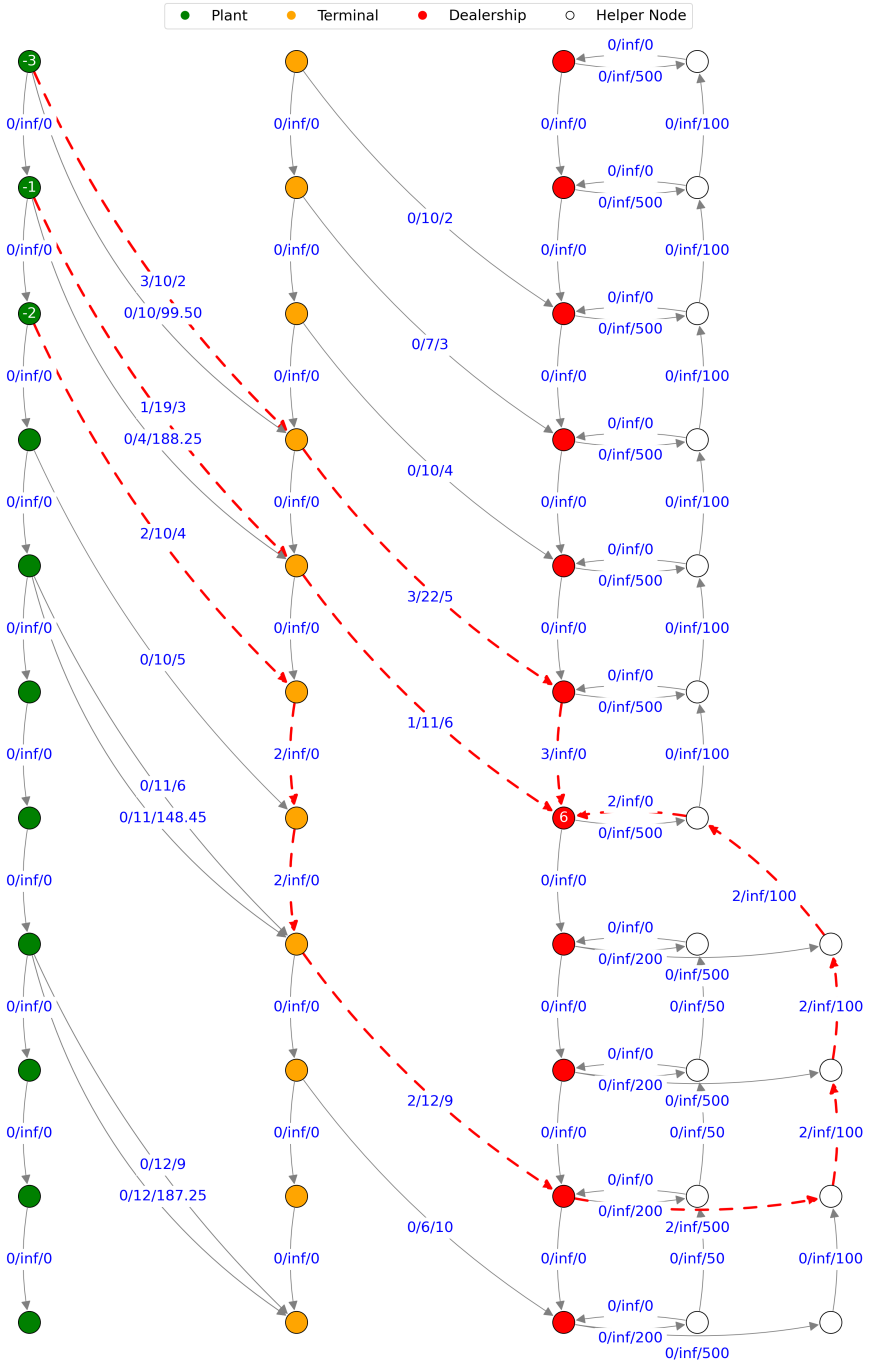
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Dealership
Helper Node
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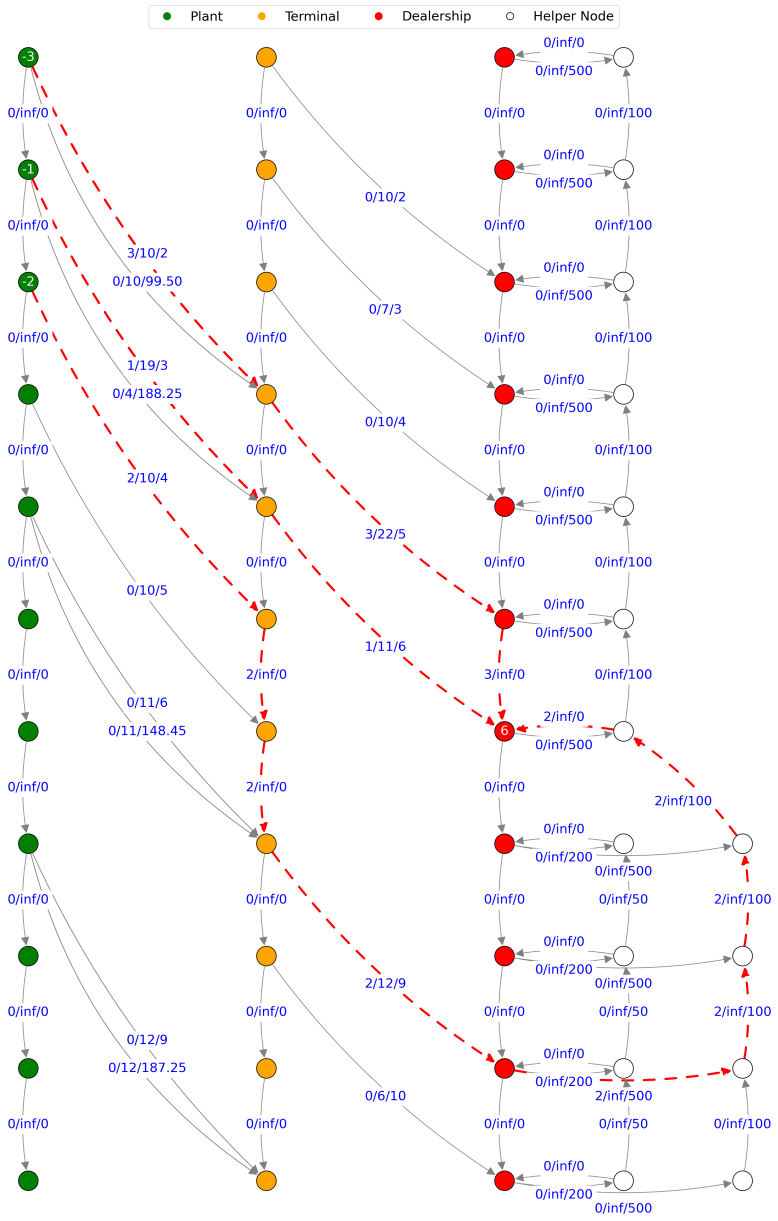
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Dealership
Helper Node
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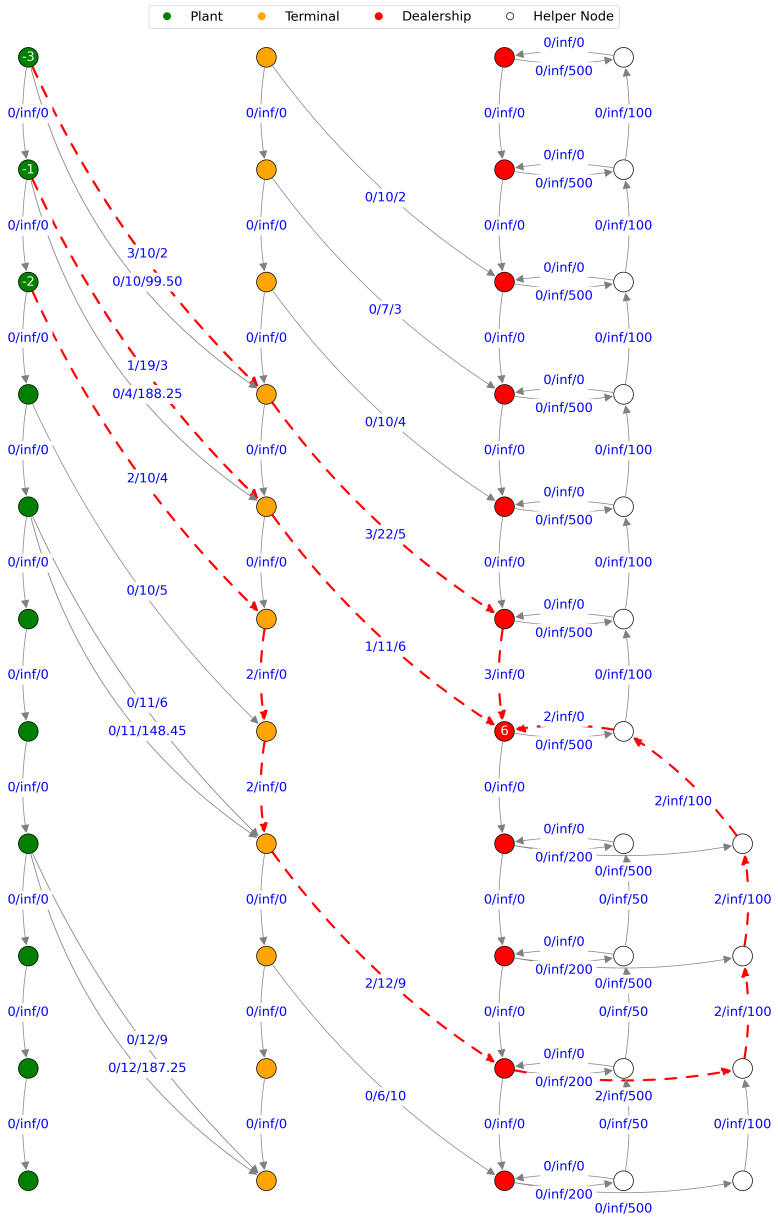
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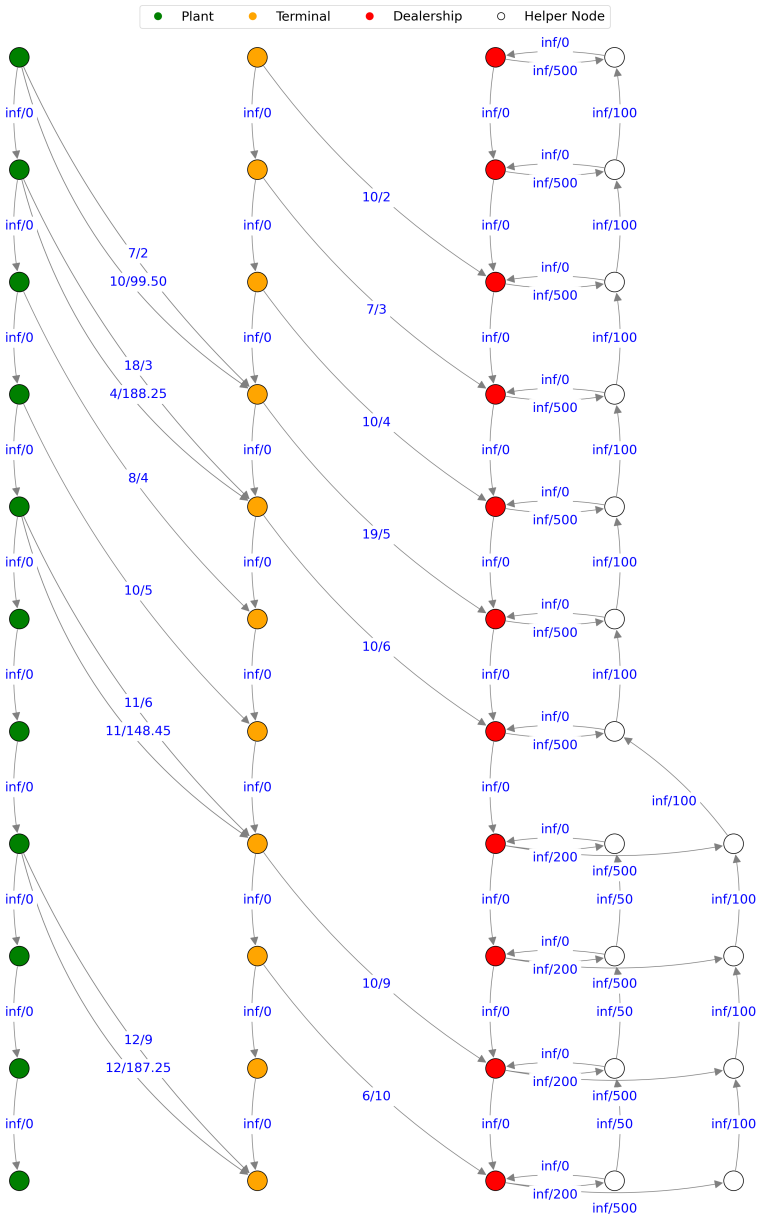
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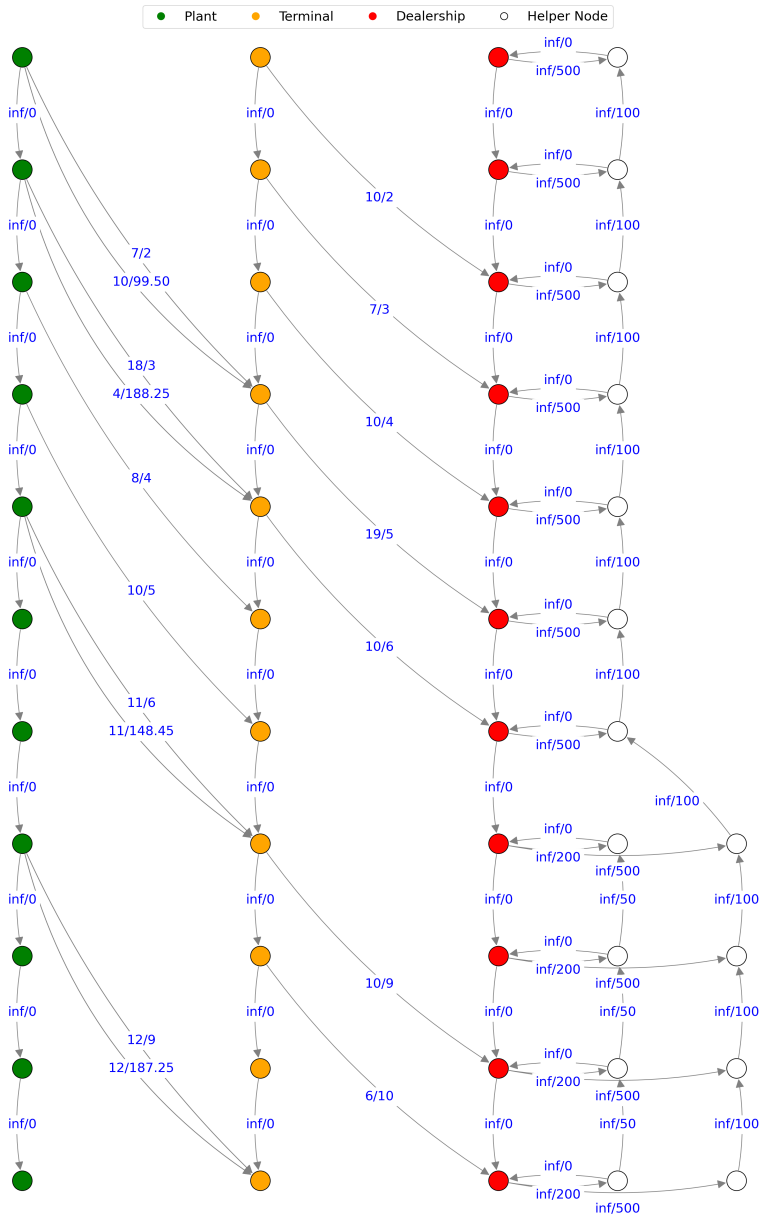
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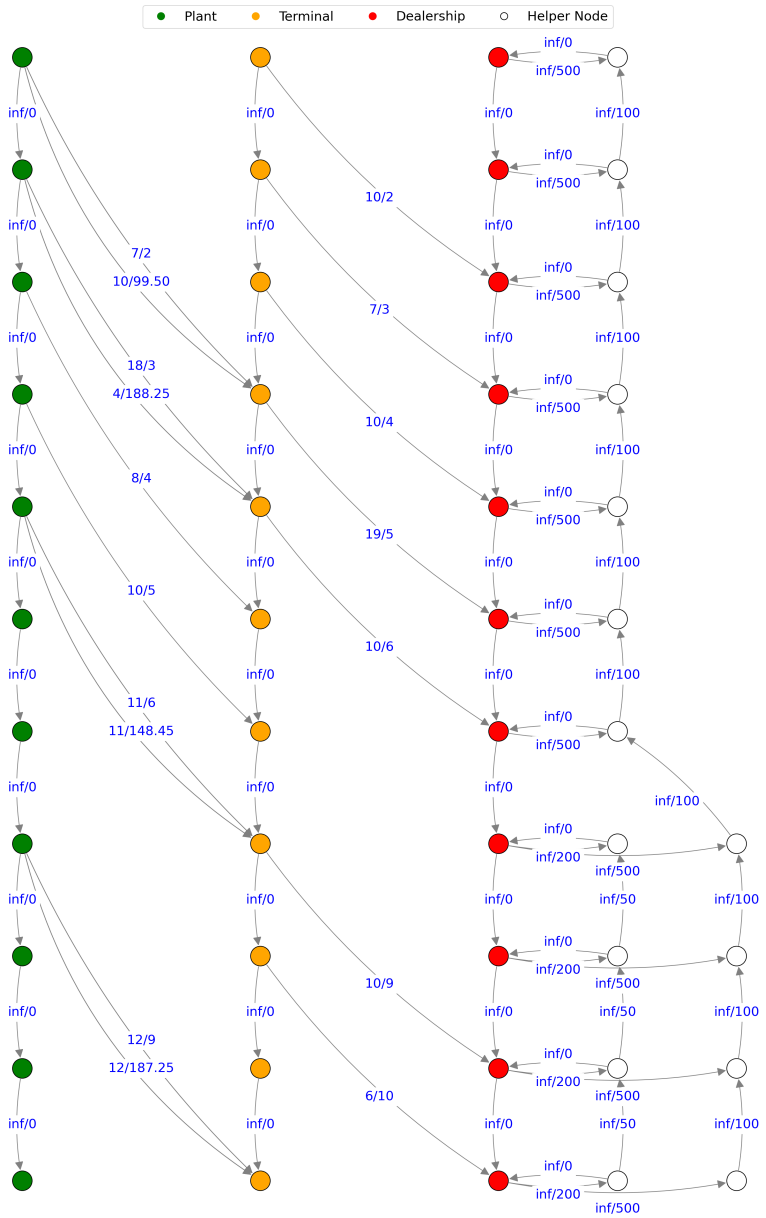
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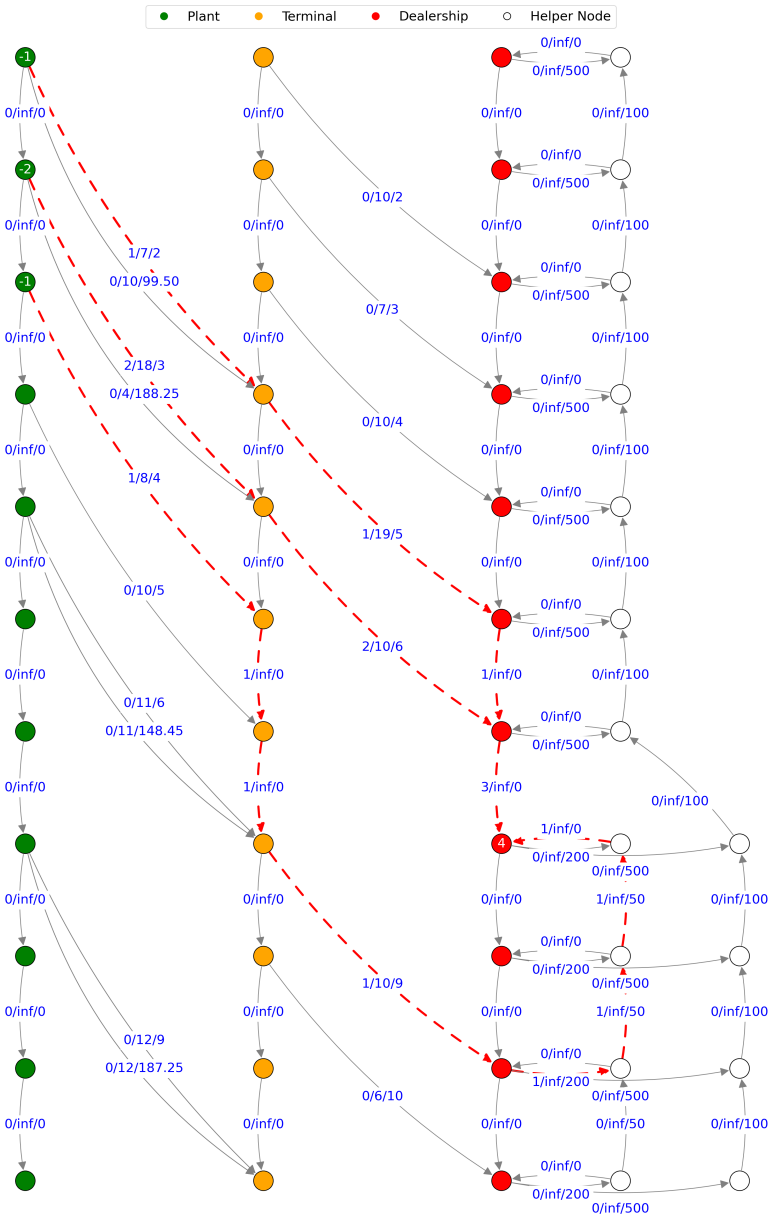
10/9
6/10


Plant
Terminal
Dealership
Helper Node
-1
-2
-1
4
0/inf/0
0/inf/500
0/inf/100
0/inf/200
1/inf/0
3/inf/0
1/inf/200
1/inf/50
1/7/2
0/10/99.50
2/18/3
0/4/188.25
1/8/4
0/10/5
0/11/6
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0/12/9
0/12/187.25
0/10/2
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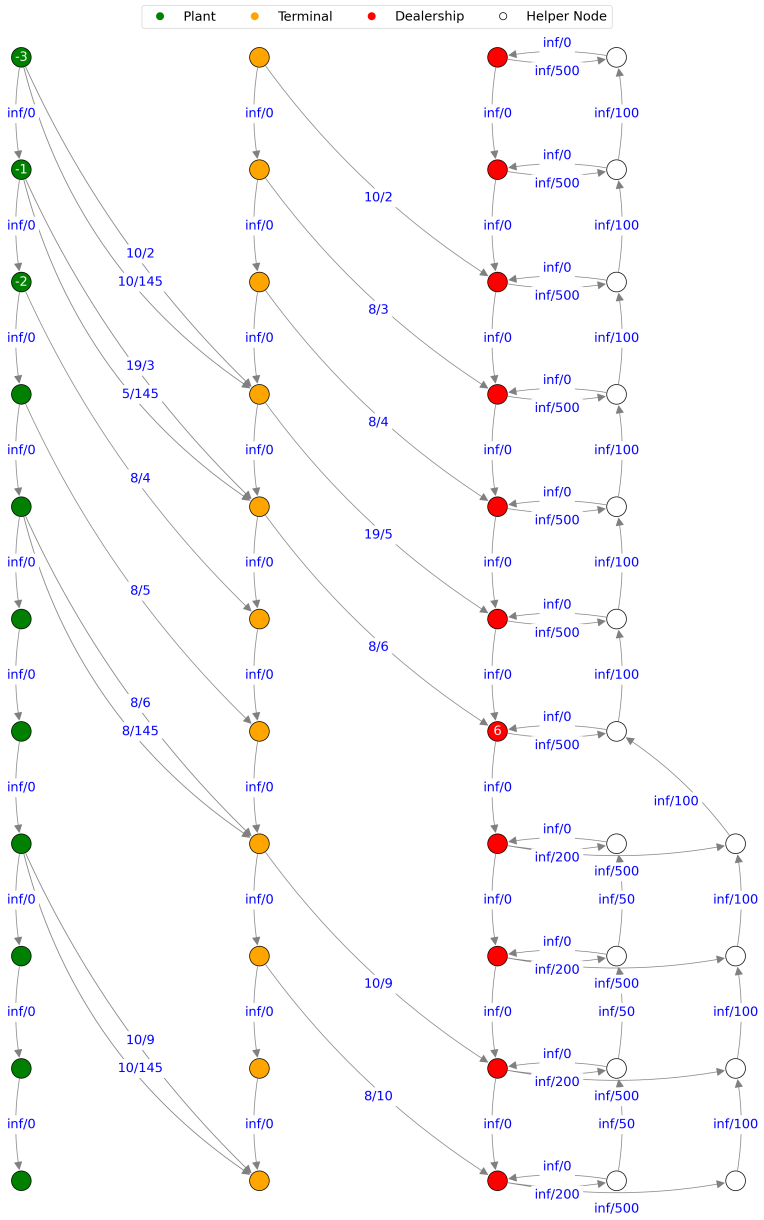
1/10/9
0/6/10

Flow approach: What to do in the uncertain setting?



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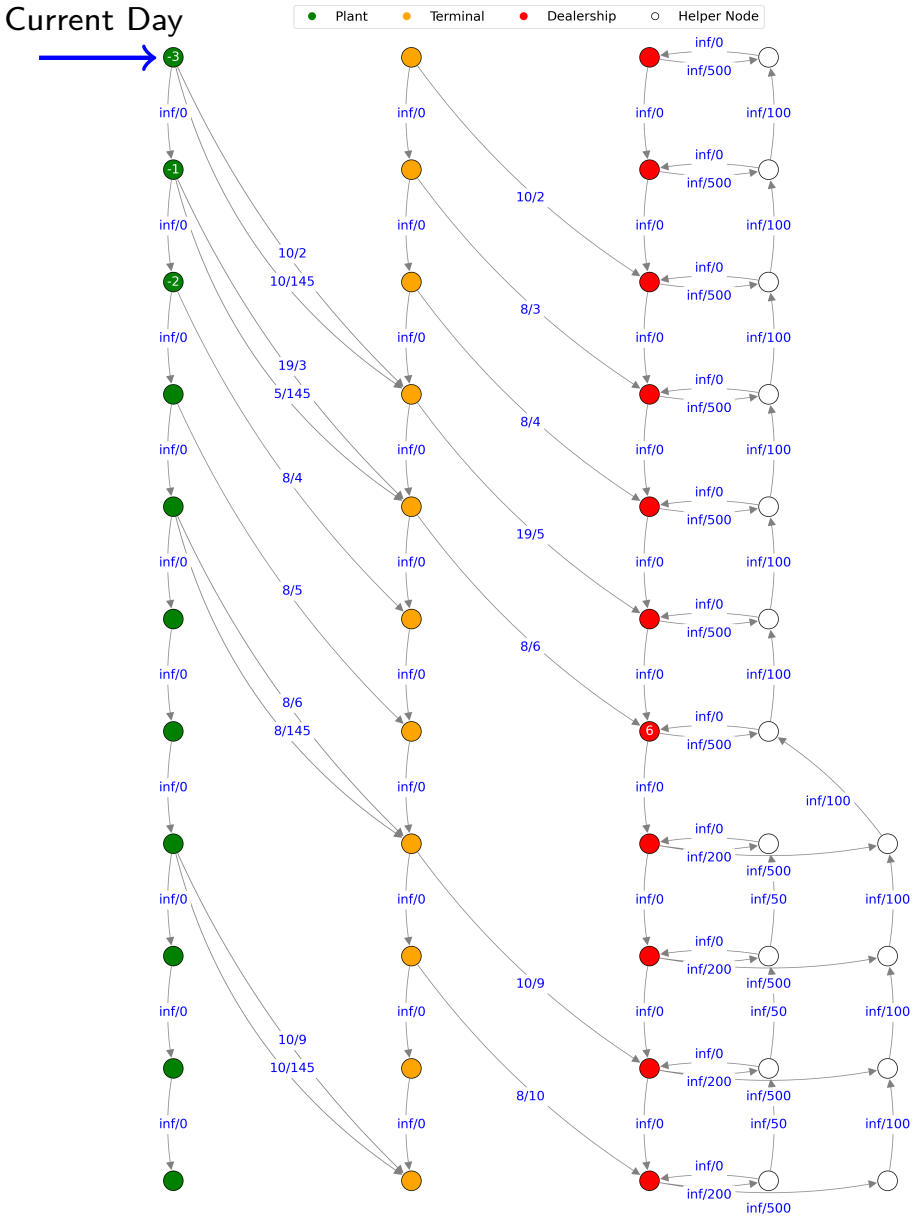

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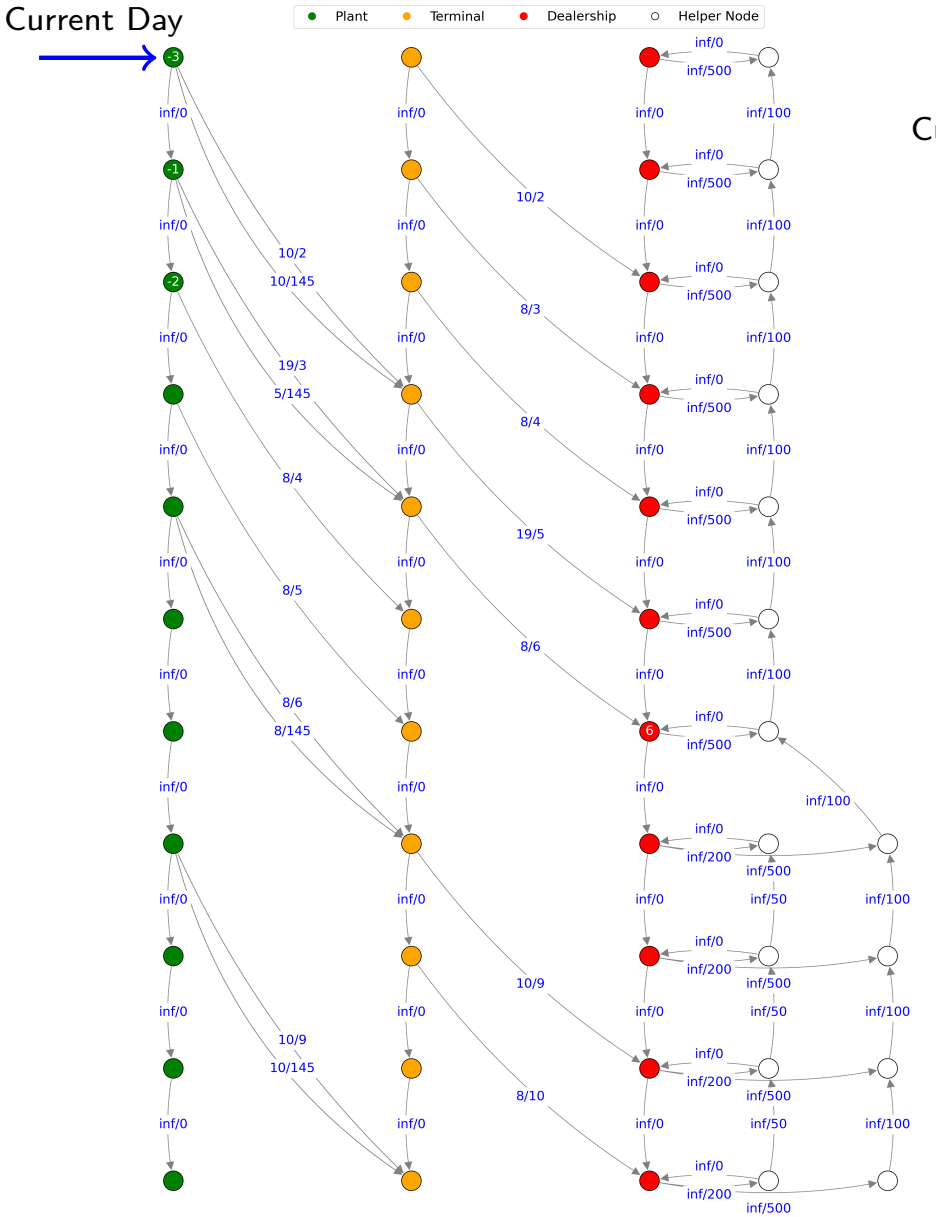
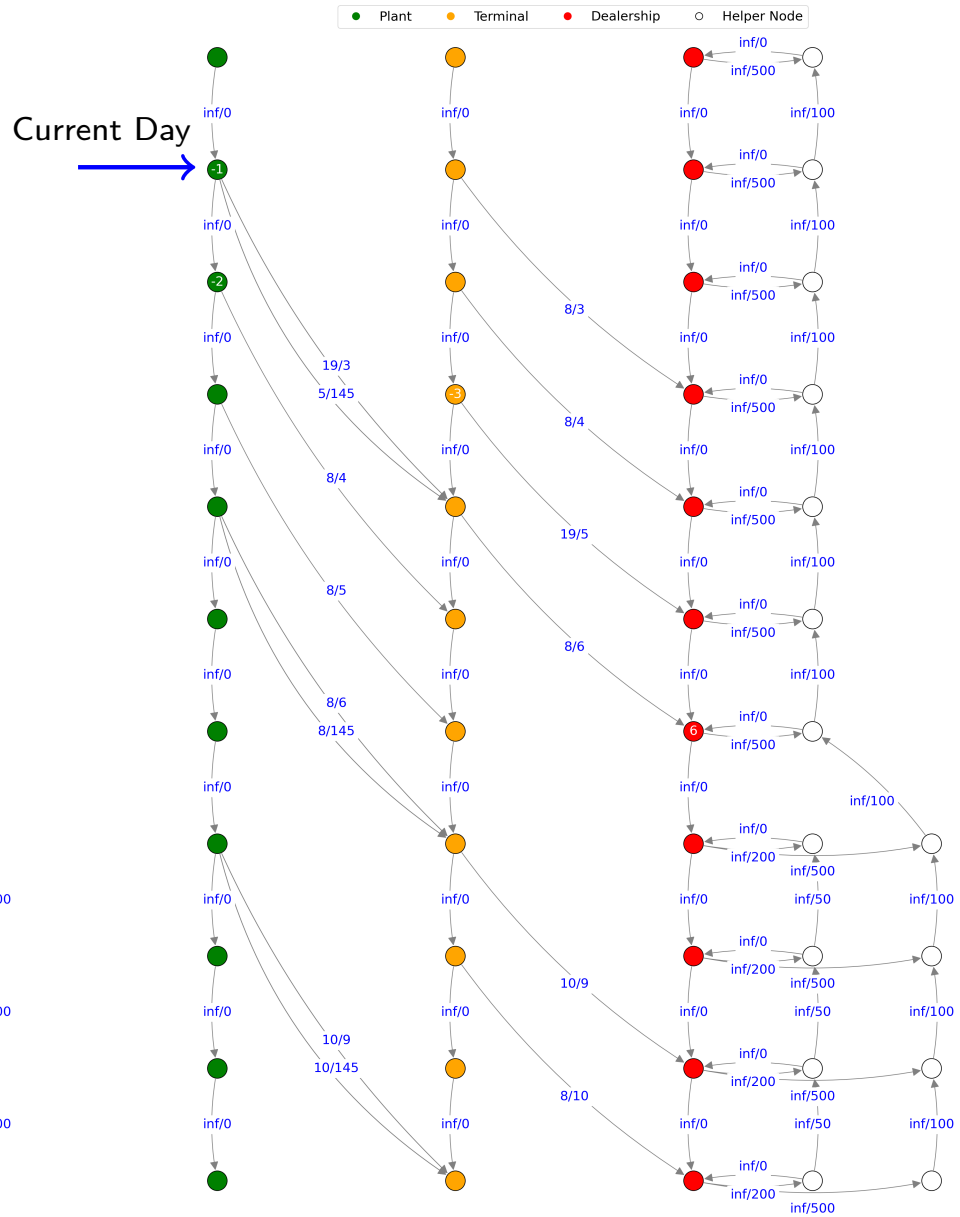
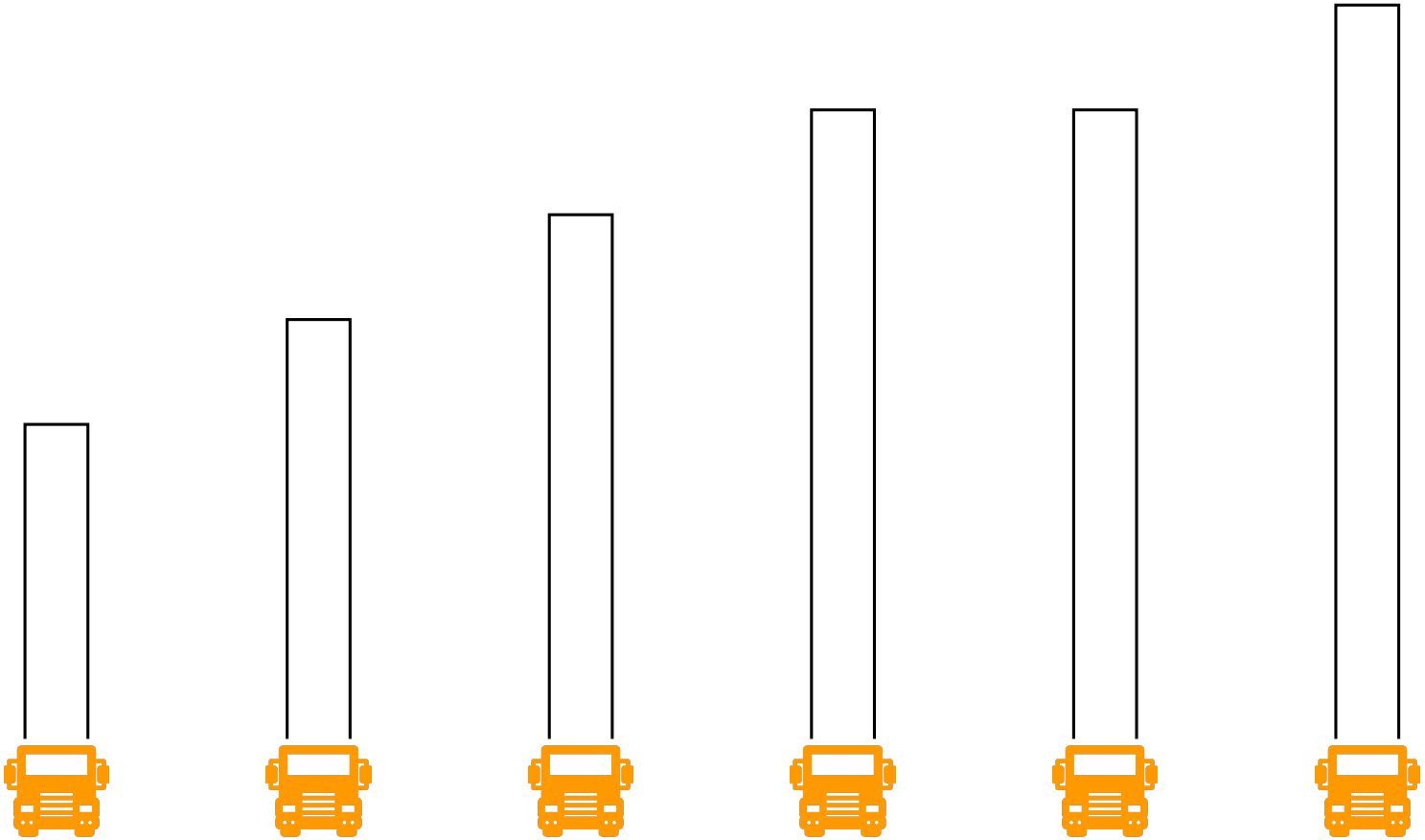




Uncertainty

Uncertainty

Planned capacities

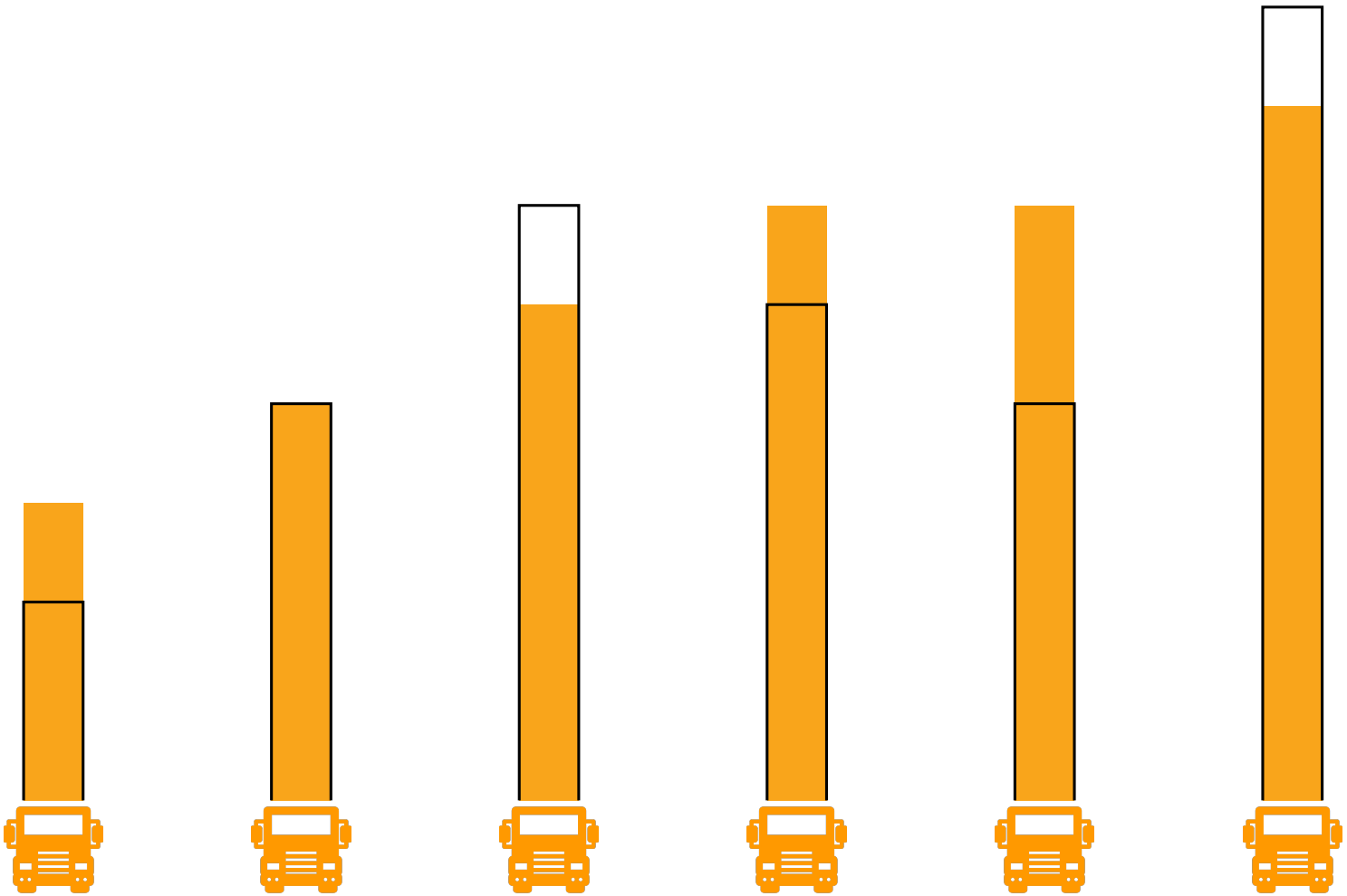


Uncertainty

Planned capacities

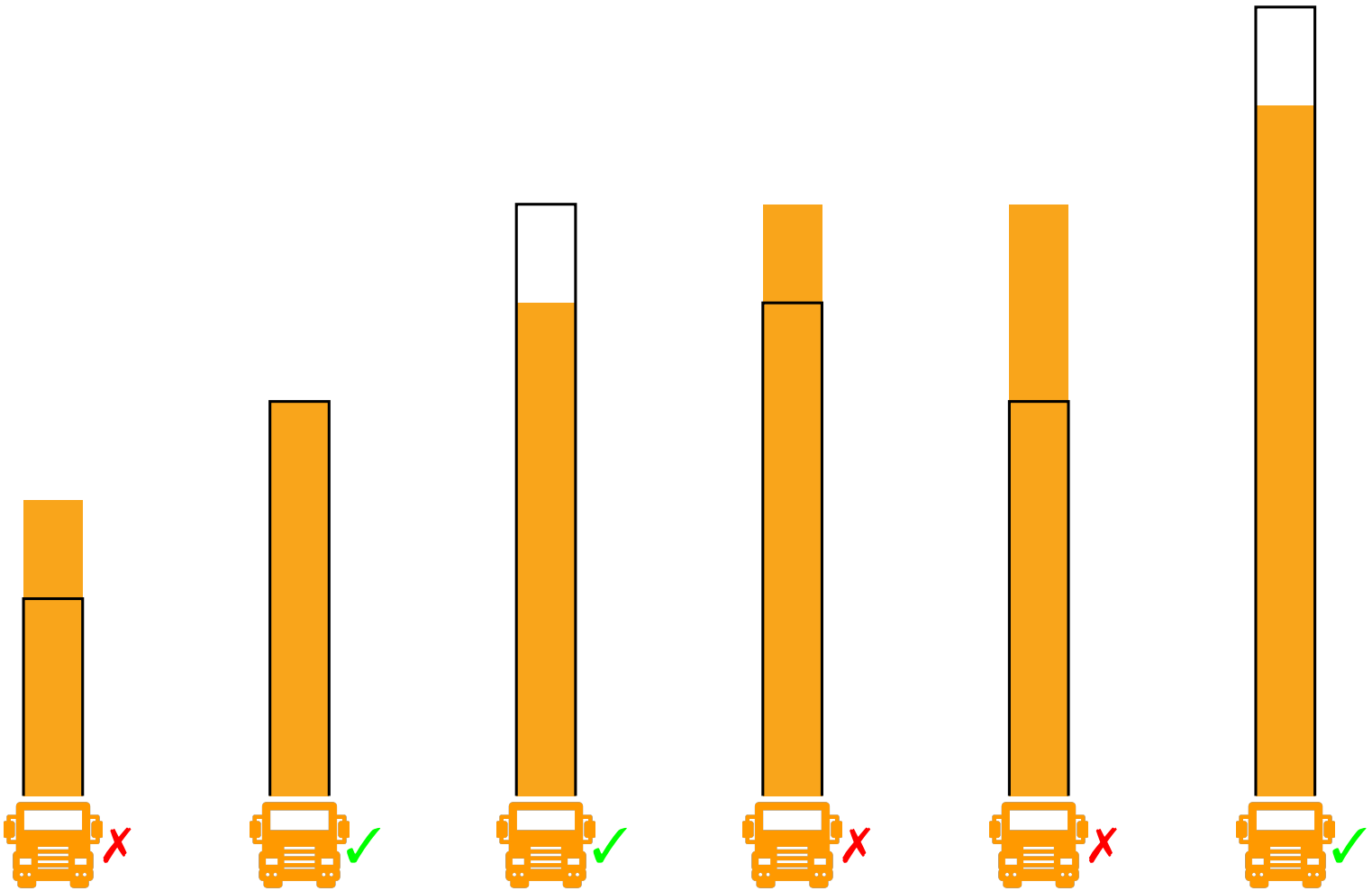
Uncertainty

Realised capacities

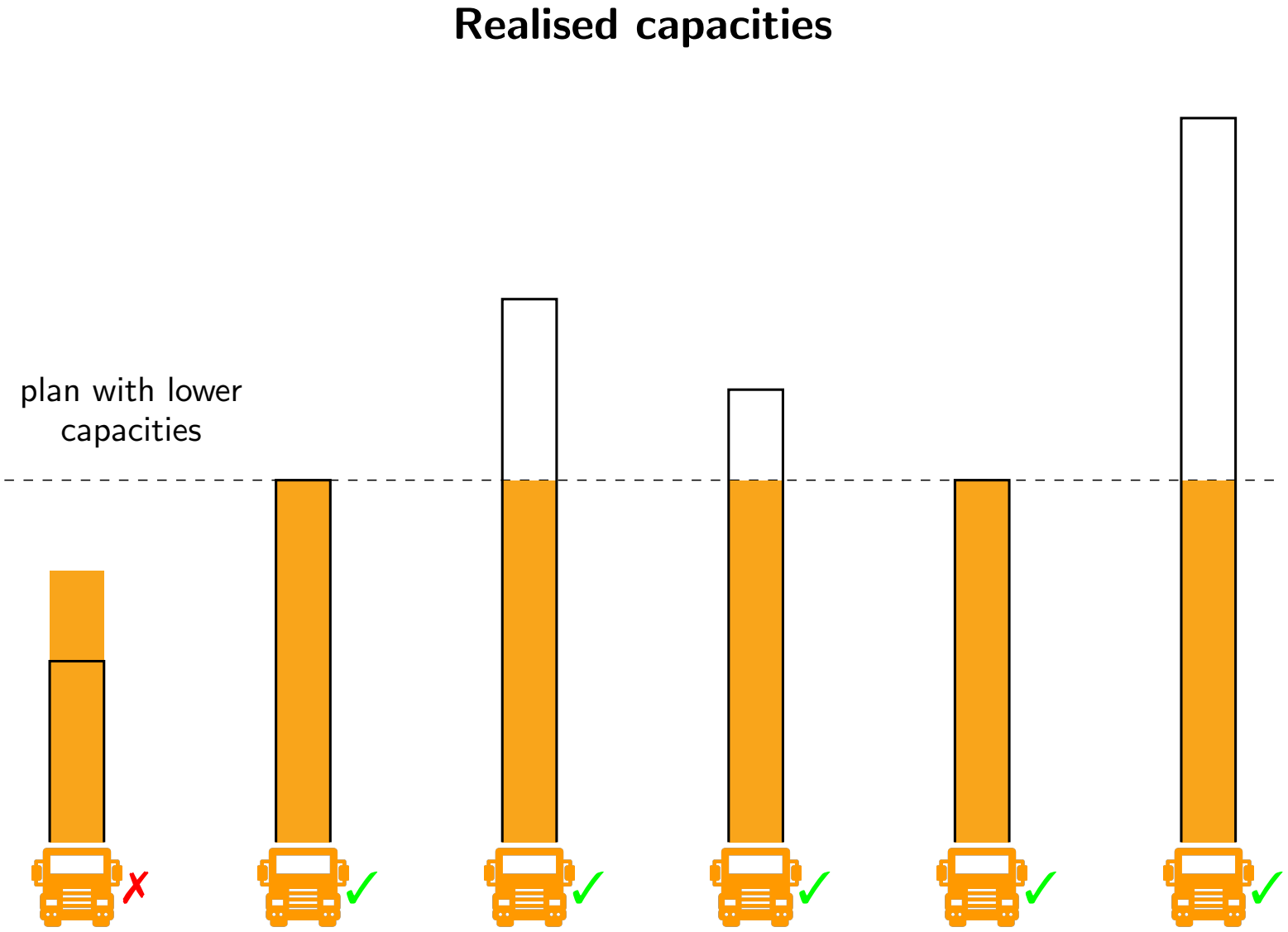


Uncertainty

Realised capacities



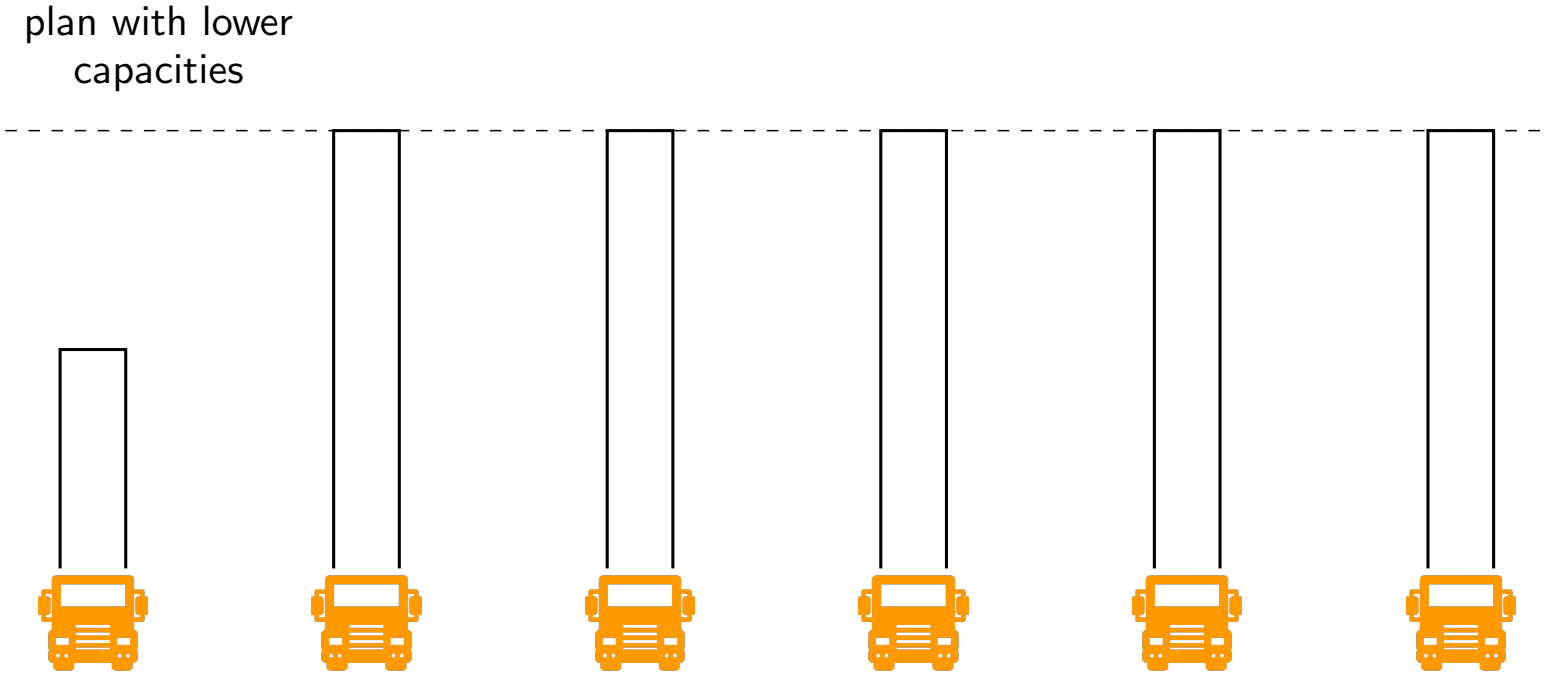
Uncertainty



Uncertainty

Adjusted capacities

By how much do we adjust?



Adjust capacities

Assumption: Future capacities are similar to those in the past

Adjust capacities

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1. Decide for a value of $p \in [0, 100]$

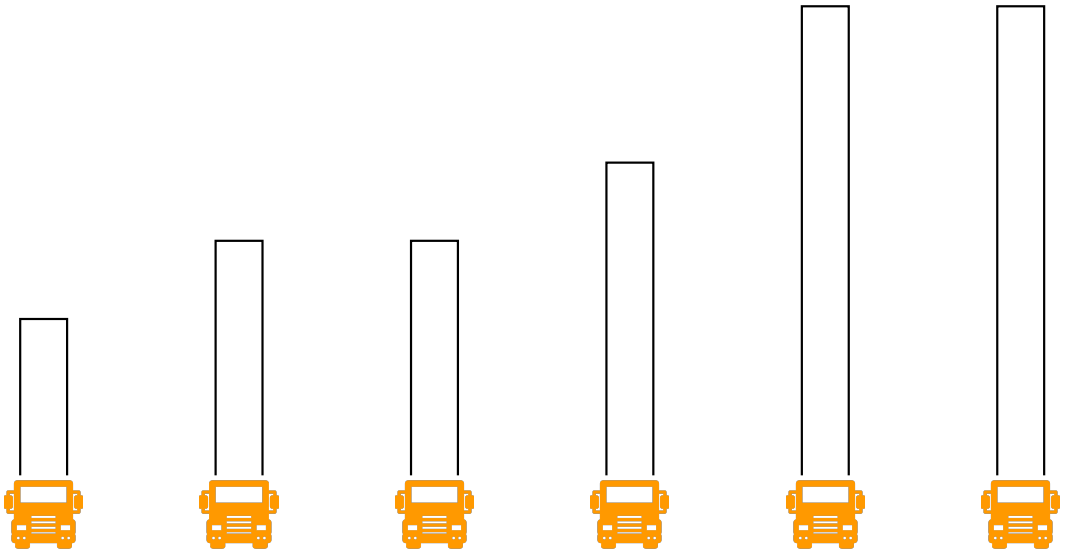
For each group of transports:

2. Find respective capacities in the past
3. Set adjusted capacity such that in $p\%$ of the cases:

$$\text{Capacity shortfall} \not\Rightarrow \text{problem}$$

Example – Adjusted Capacities for $p = 50$

Planned capacities: `[2, 3, 3, 4, 6, 6]`



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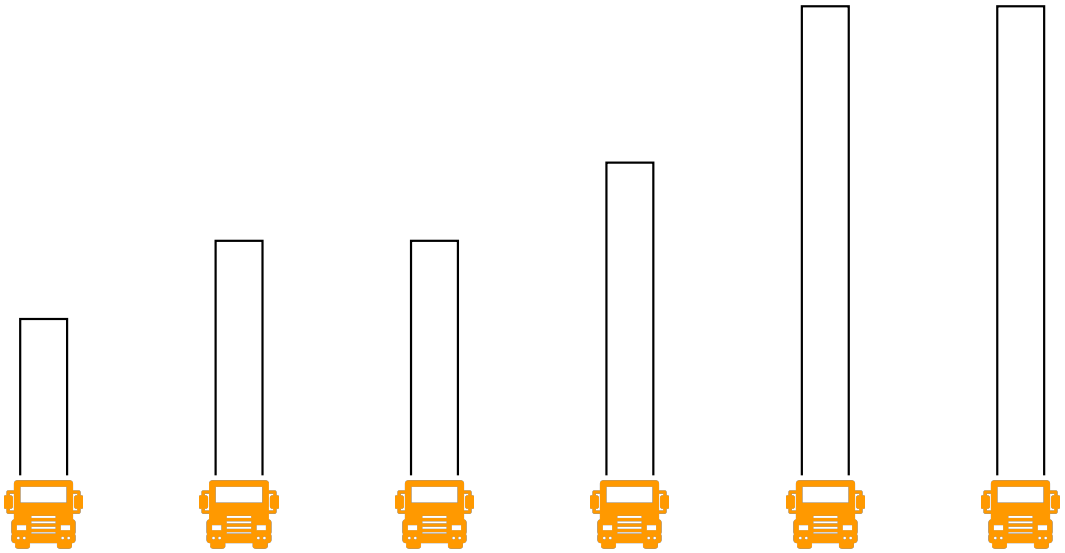

Historical capacities: `[2, 3, 3, 4, 5]`

↑

50th percentile

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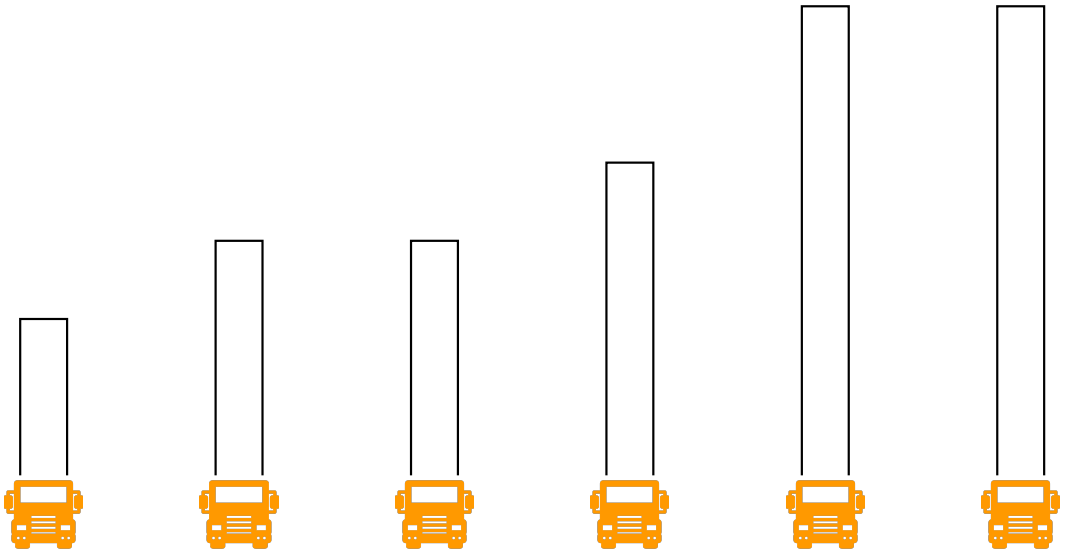
Planned capacities: `[2, 3, 3, 4, 6, 6]`



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↑

50th percentile

⇒ **Adjusted capacities:** `[2, 3, 3, 3, 3, 3]`

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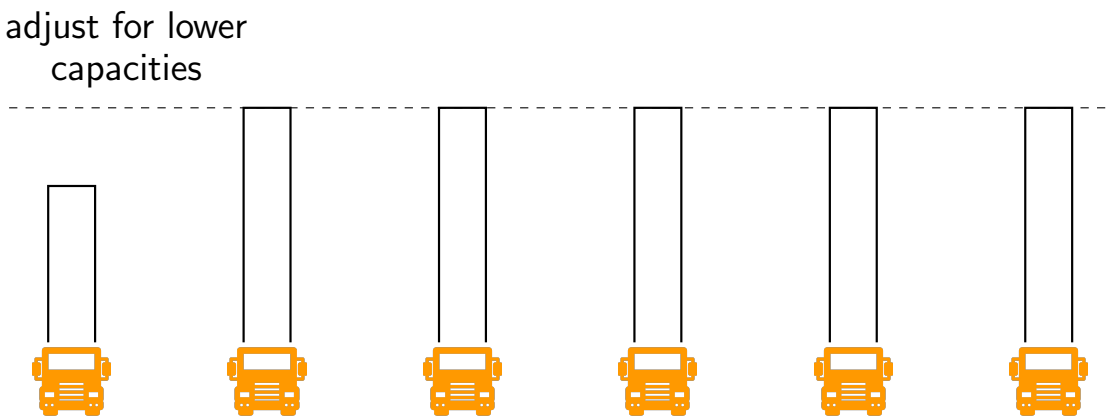

Historical capacities: `[2, 3, 3, 4, 5]`

↑

50th percentile

⇒ **Adjusted capacities:** `[2, 3, 3, 3, 3, 3]`

Results

Results

Implementation:

- Ran on high-performance computing cluster CLAIX-2023 at RWTH, with dual Intel Xeon 8468 Sapphire CPUs (48 cores per CPU) and 256 GB of memory
- Only 4 of the total cores were actually utilized

Results

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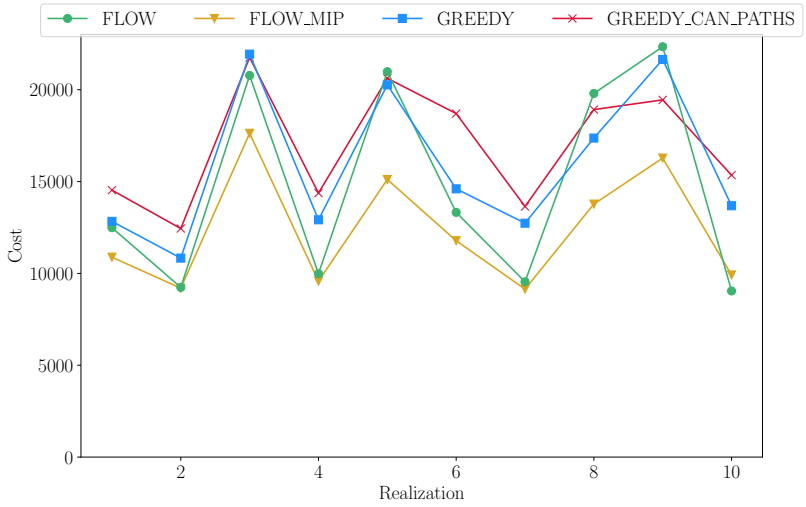
- Ran on high-performance computing cluster CLAIX-2023 at RWTH, with dual Intel Xeon 8468 Sapphire CPUs (48 cores per CPU) and 256 GB of memory
- Only 4 of the total cores were actually utilized

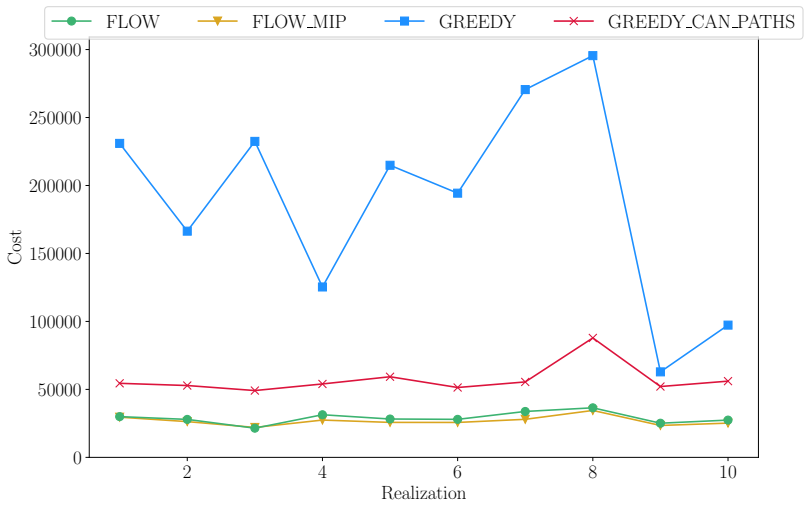
Evaluation Details:

- Account for Horizon effects in 7 first and last days of vehicle availability

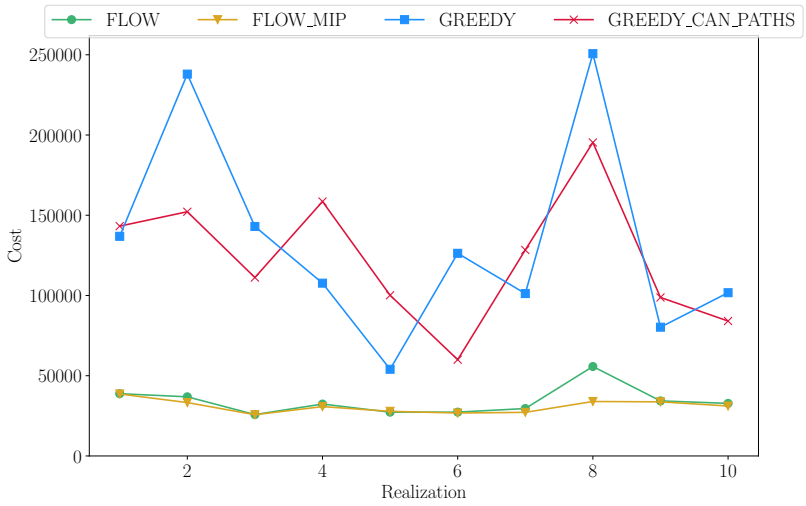
Costs – Deterministic Setting



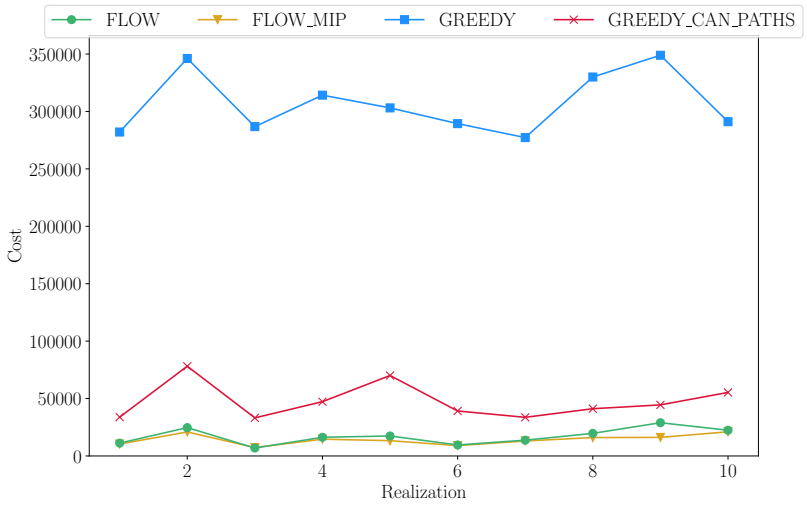
(a) Dataset 1



(b) Dataset 2

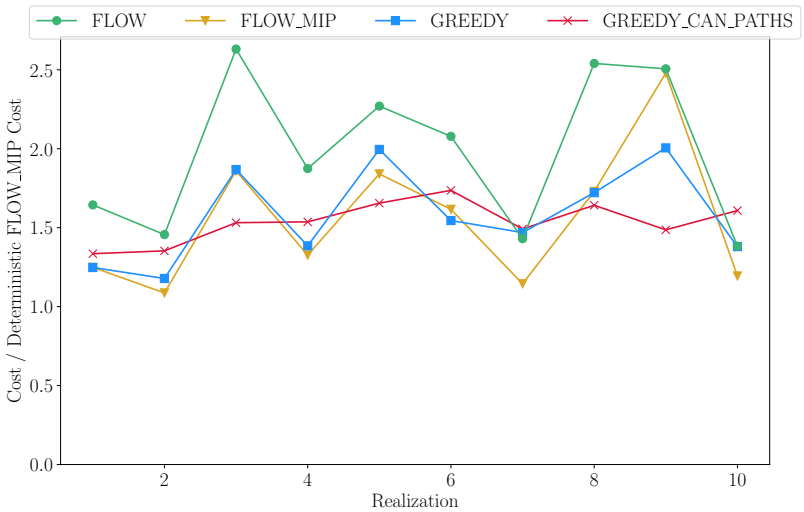


(c) Dataset 3

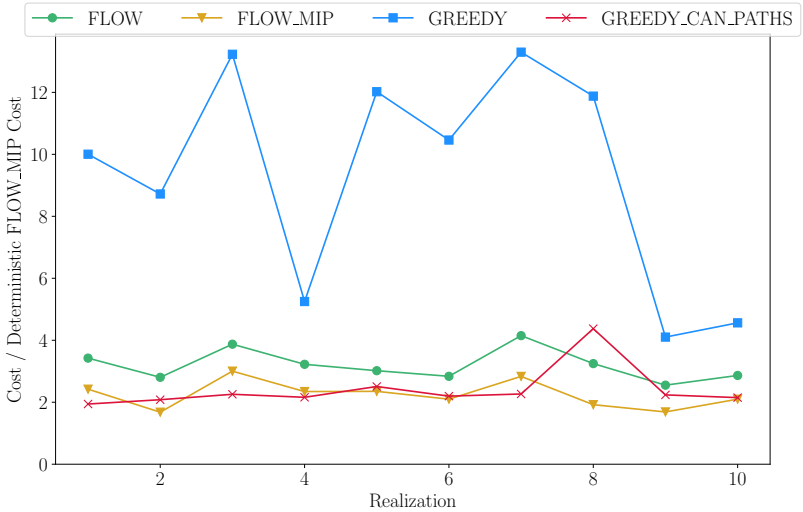


(d) Dataset 4

Costs – Uncertain Setting



(a) Dataset 1



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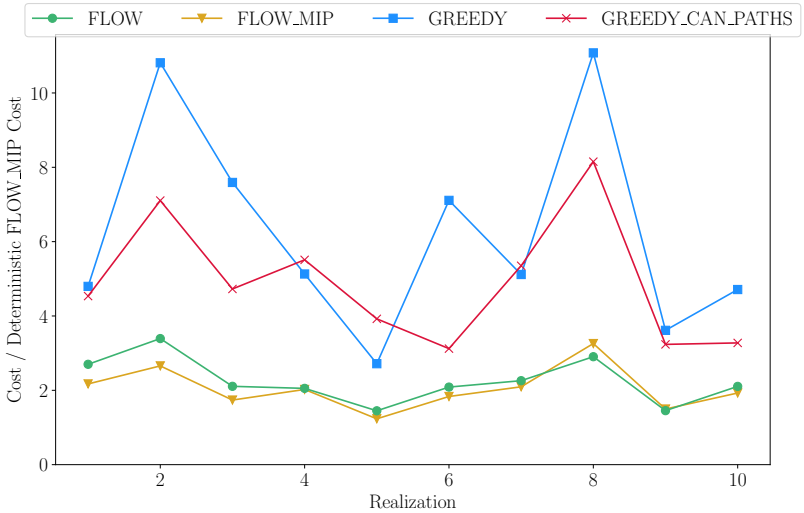

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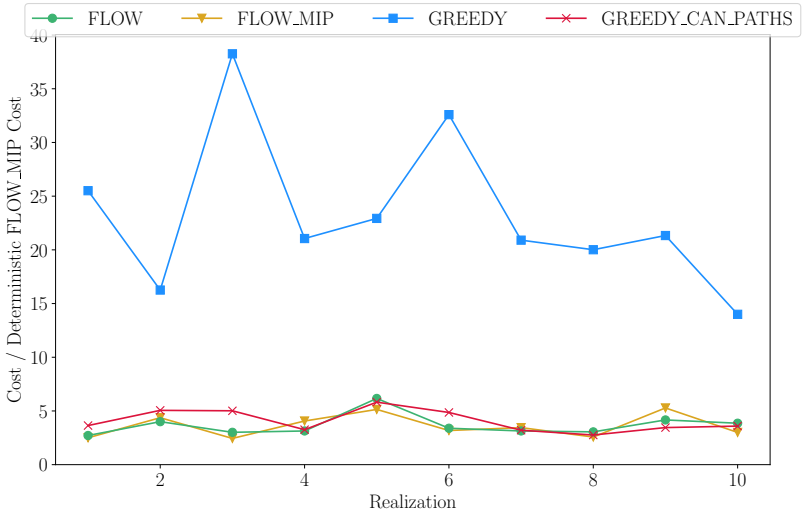
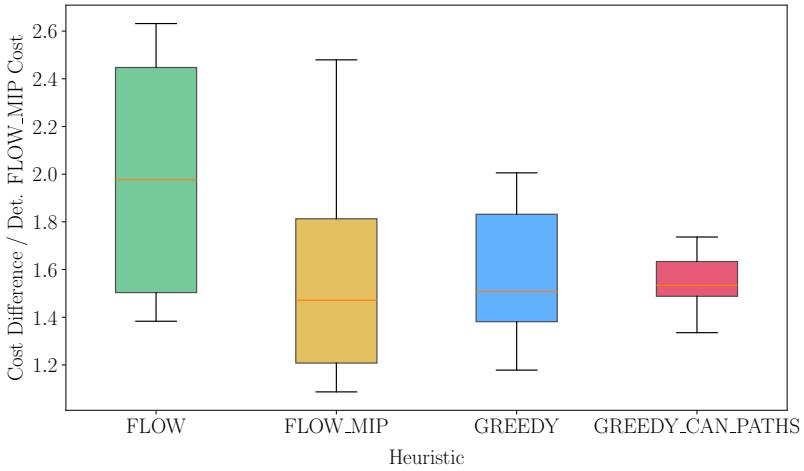
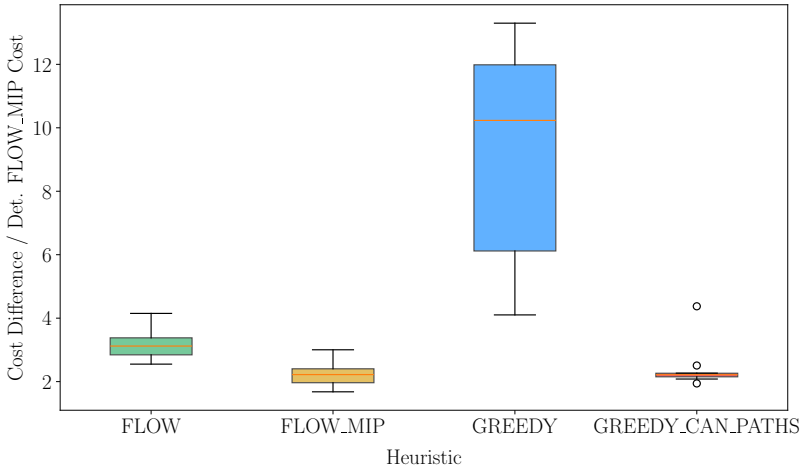


(d) Dataset 4

Difference to Optimal Solution (Uncertain)



(a) Dataset 1



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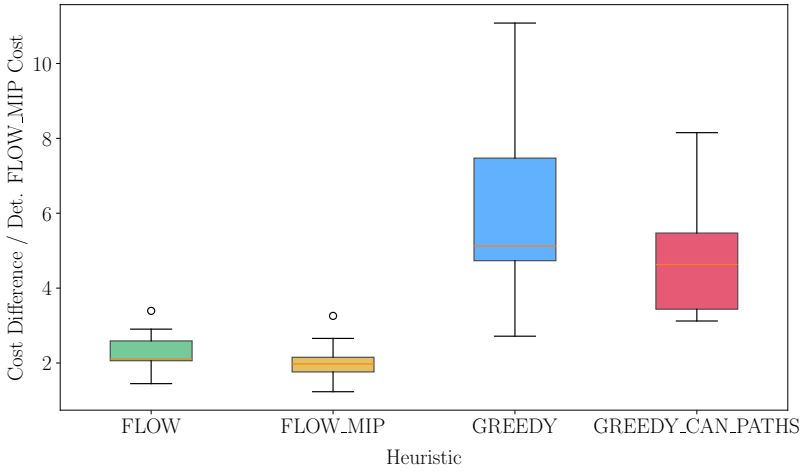

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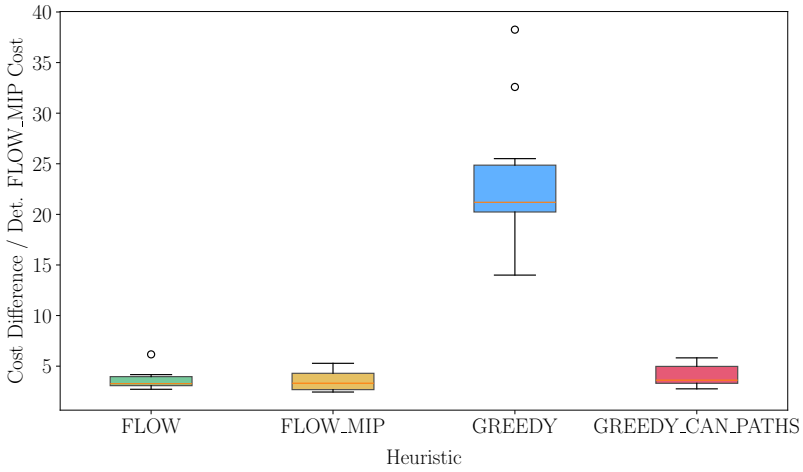
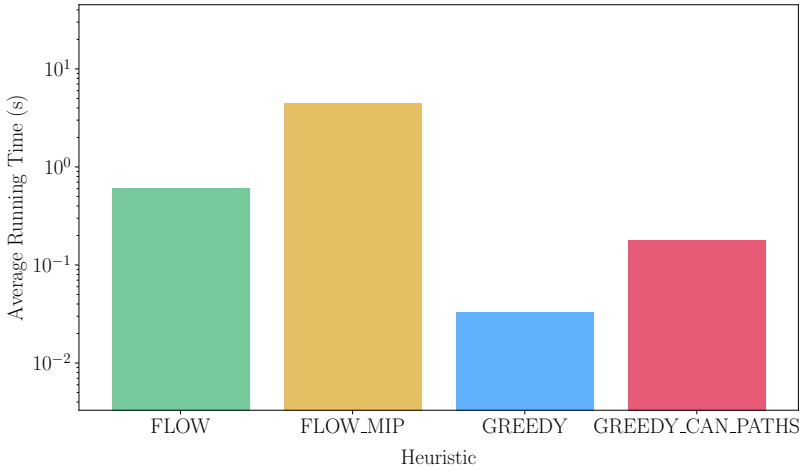
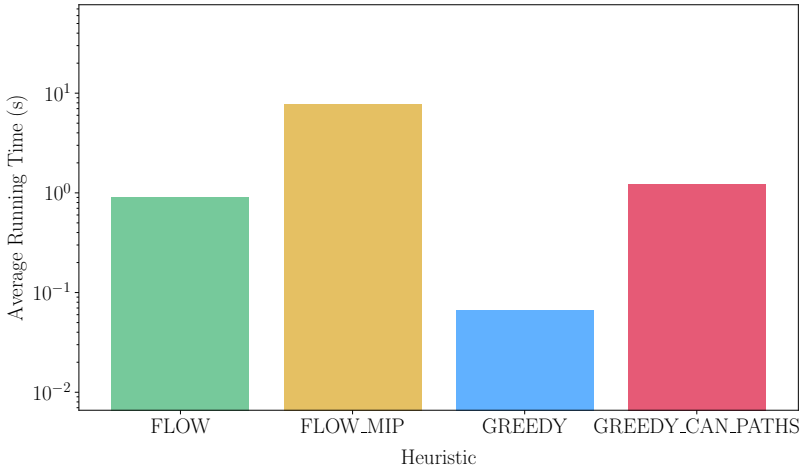


(d) Dataset 4

Runtime – Deterministic Setting



(a) Dataset 1



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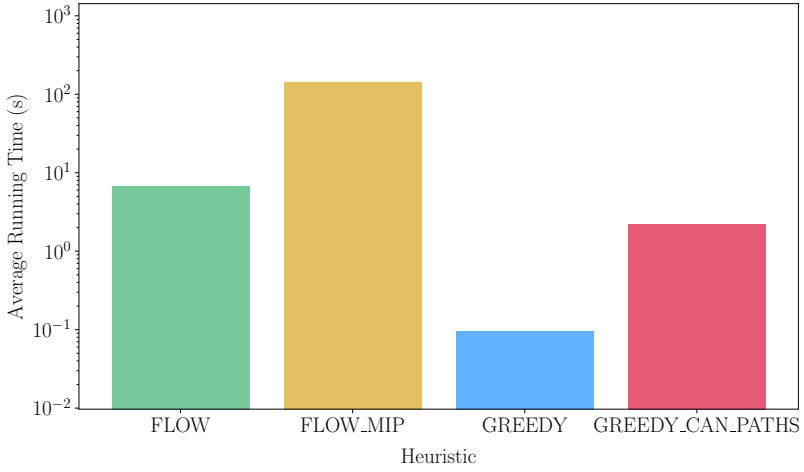

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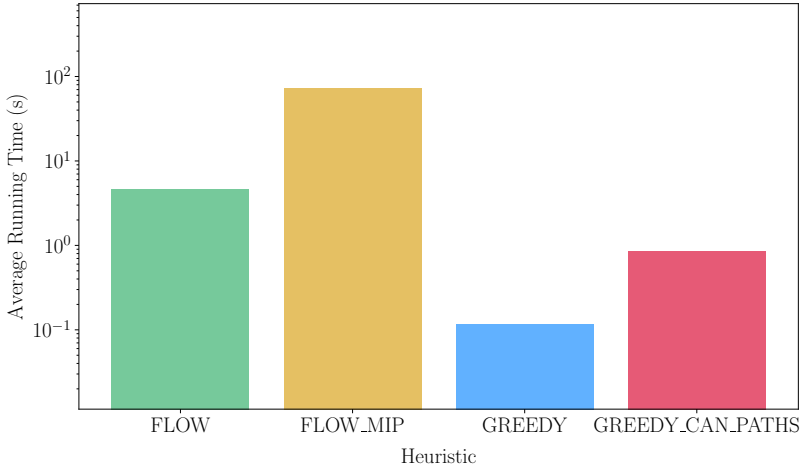

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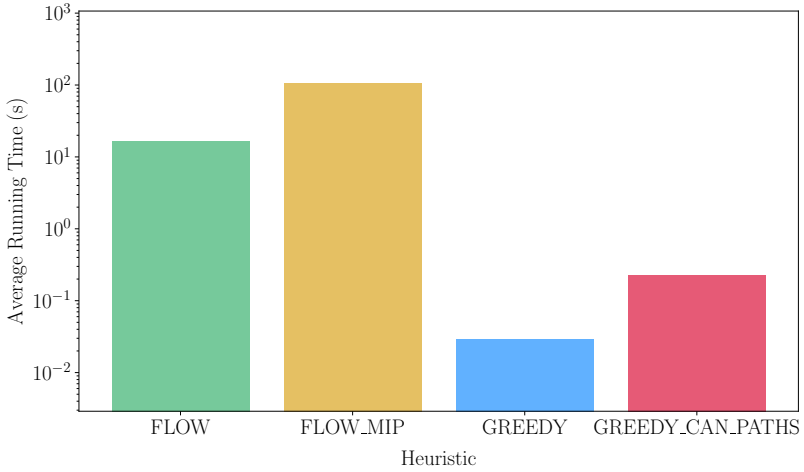

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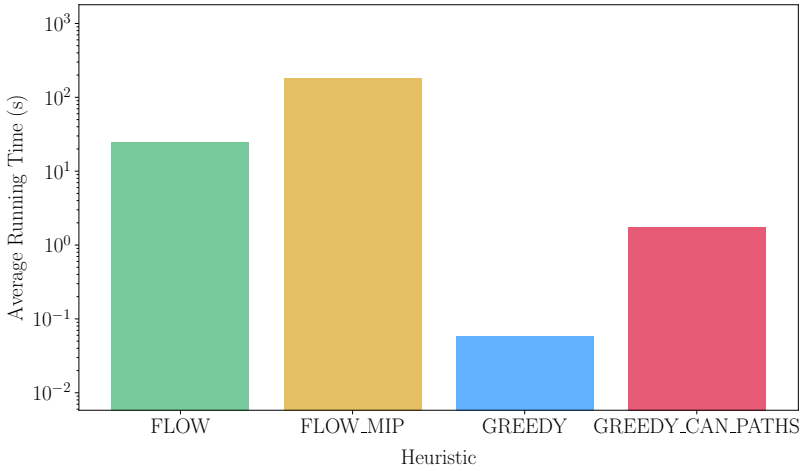

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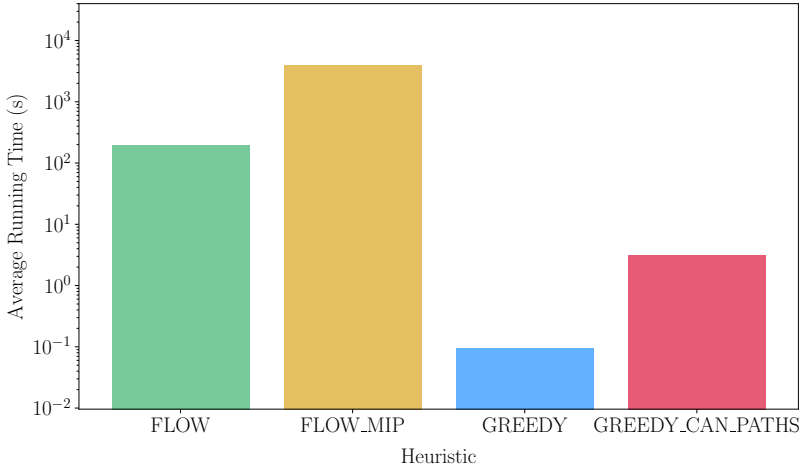

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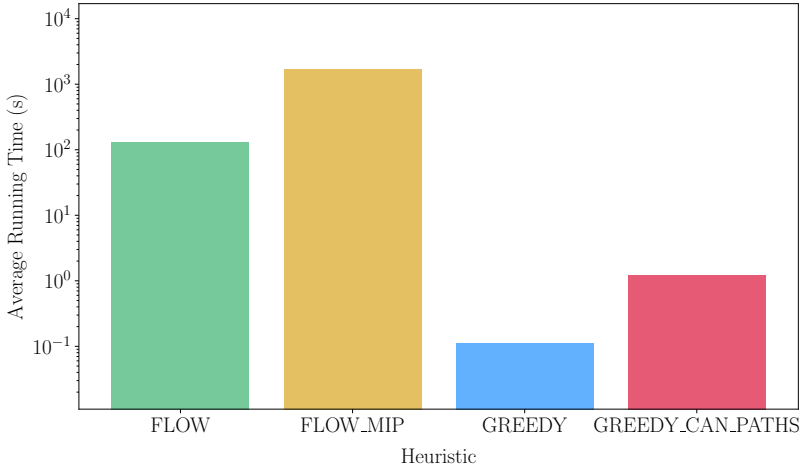
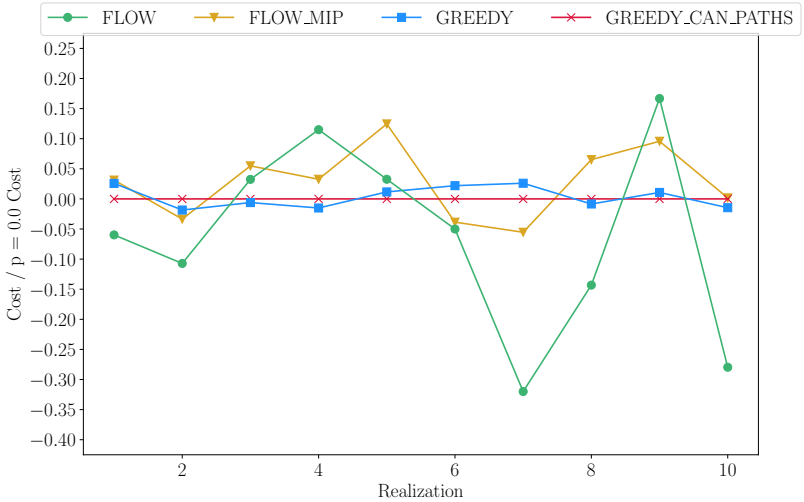
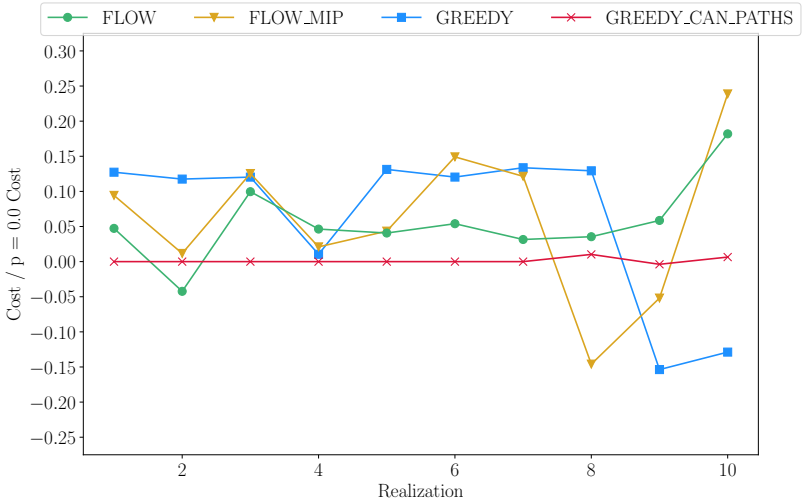


(d) Dataset 4

Robustness Improvement $p = 50$ vs $p = 0$



(a) Dataset 1



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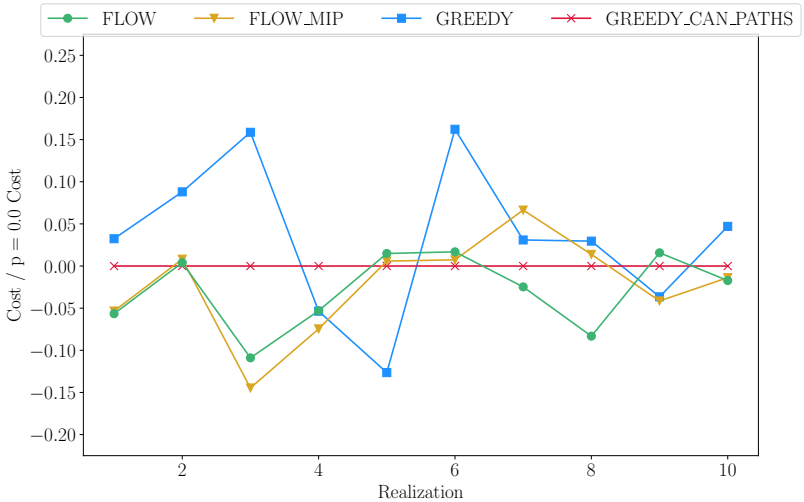

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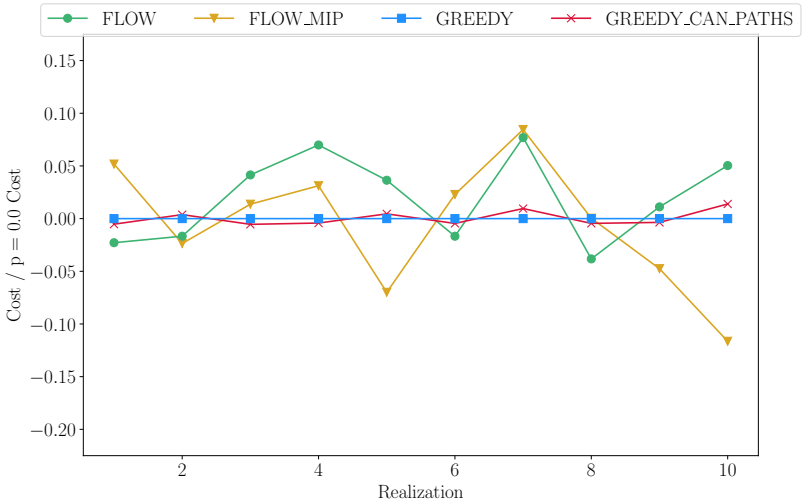
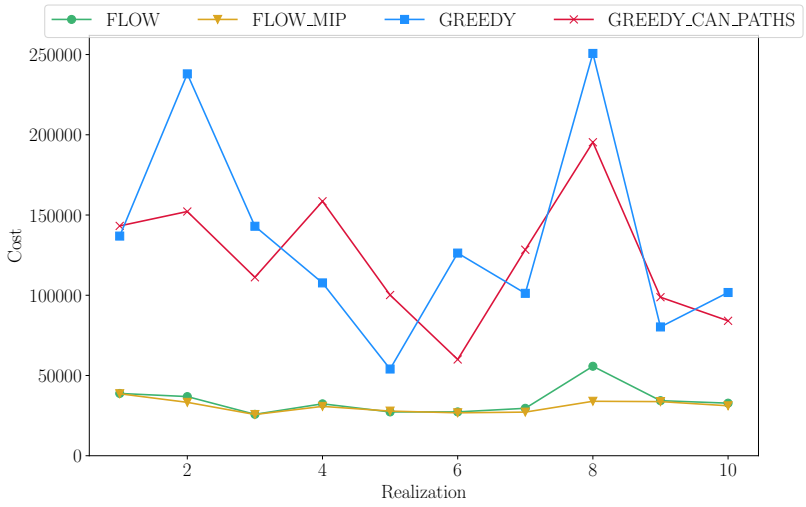
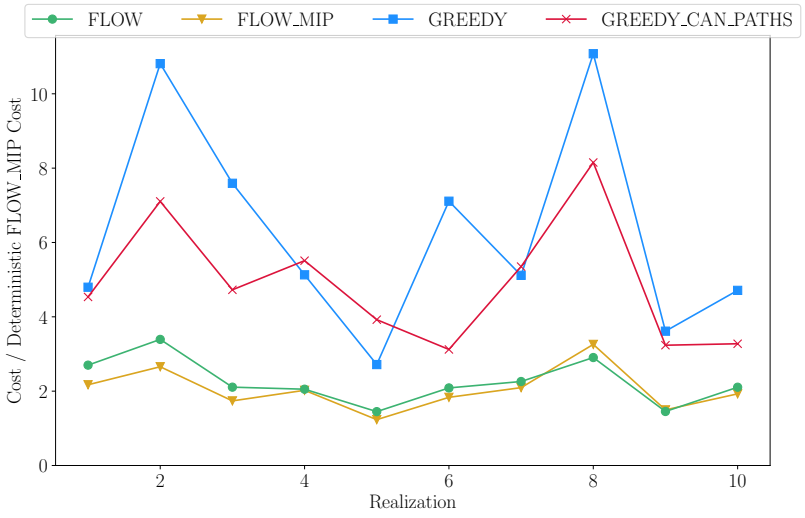
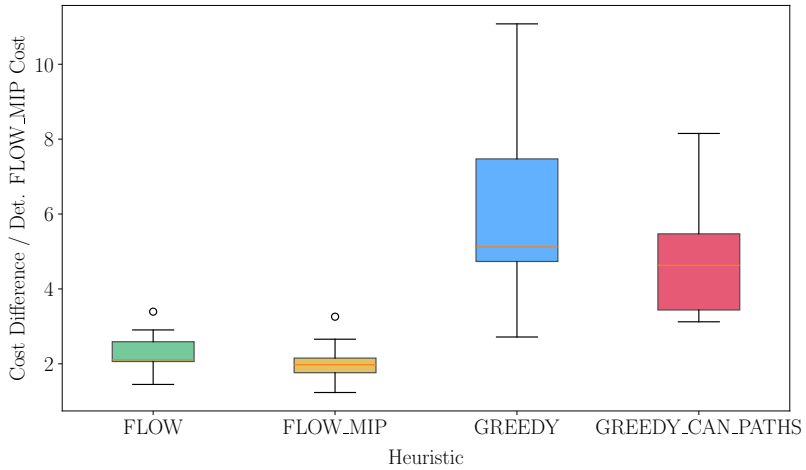


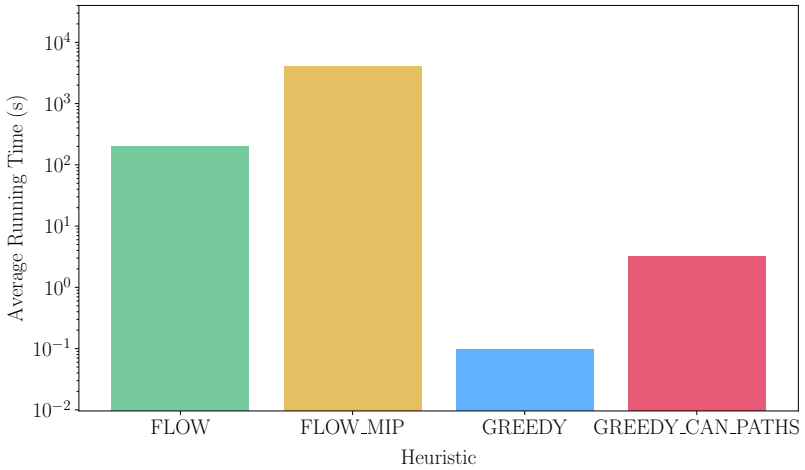
(d) Dataset 4

Conclusion

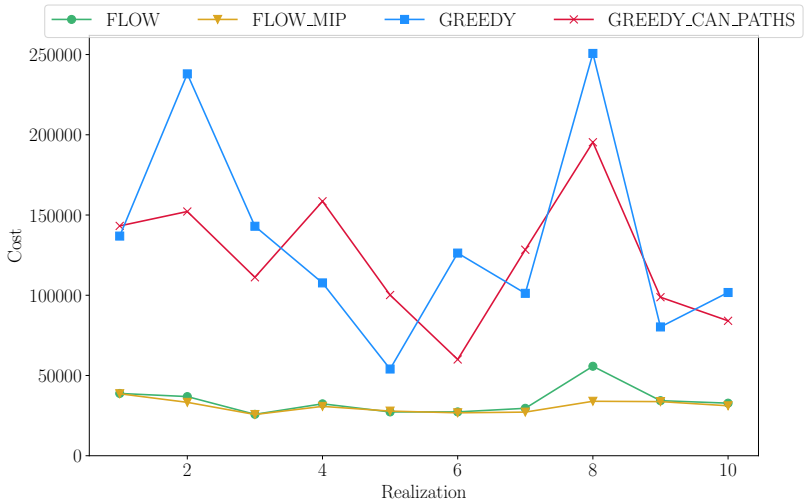

FLOW
FLOW_MIP
GREEDY
GREEDY_CAN_PATHS
Cost
Realization

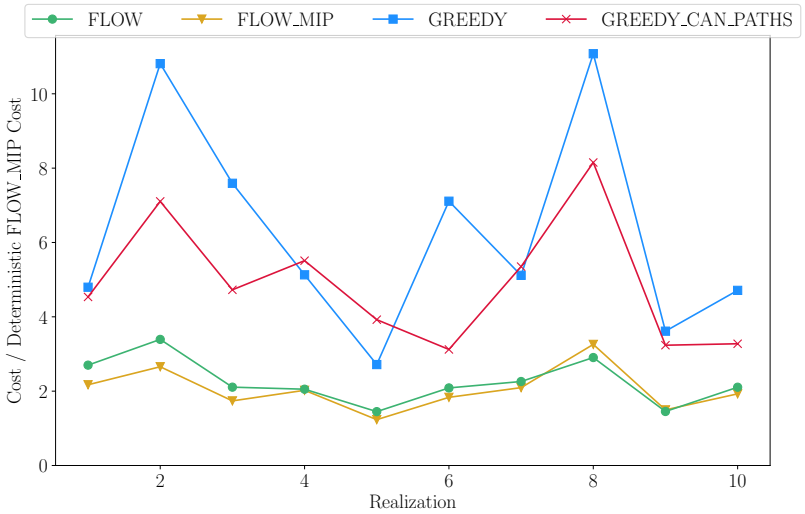

FLOW
FLOW_MIP
GREEDY
GREEDY_CAN_PATHS
Cost / Deterministic FLOW_MIP Cost
Realization


Cost Difference / Det. FLOW_MIP Cost
FLOW
FLOW_MIP
GREEDY
GREEDY_CAN_PATHS
Heuristic

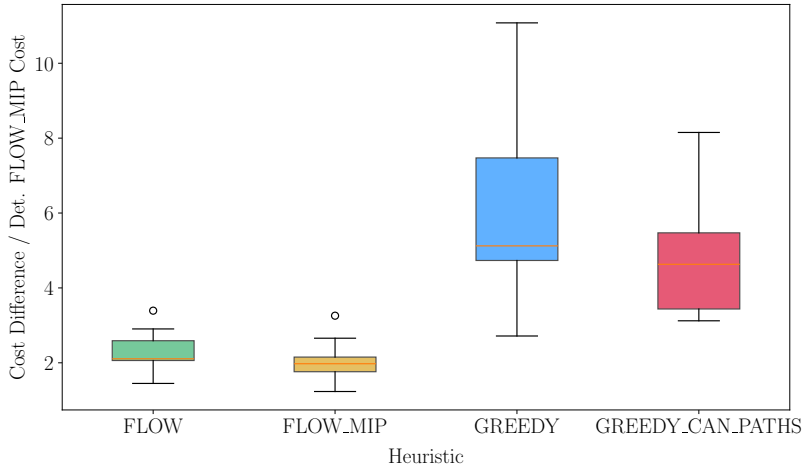

Average Running Time (s)
FLOW
FLOW_MIP
GREEDY
GREEDY_CAN_PATHS
Heuristic

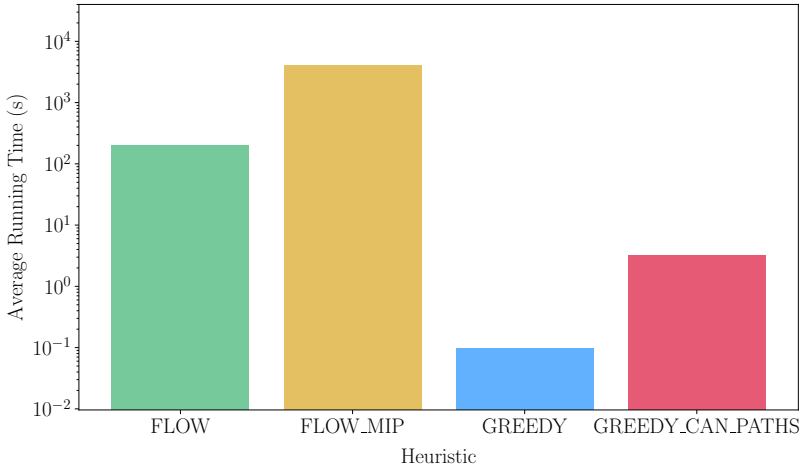
Conclusion





Thank you for your attention!





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References II

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References III

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