

Constraint Programming for ATHN

— Autonomous Transfer
Hub Network —



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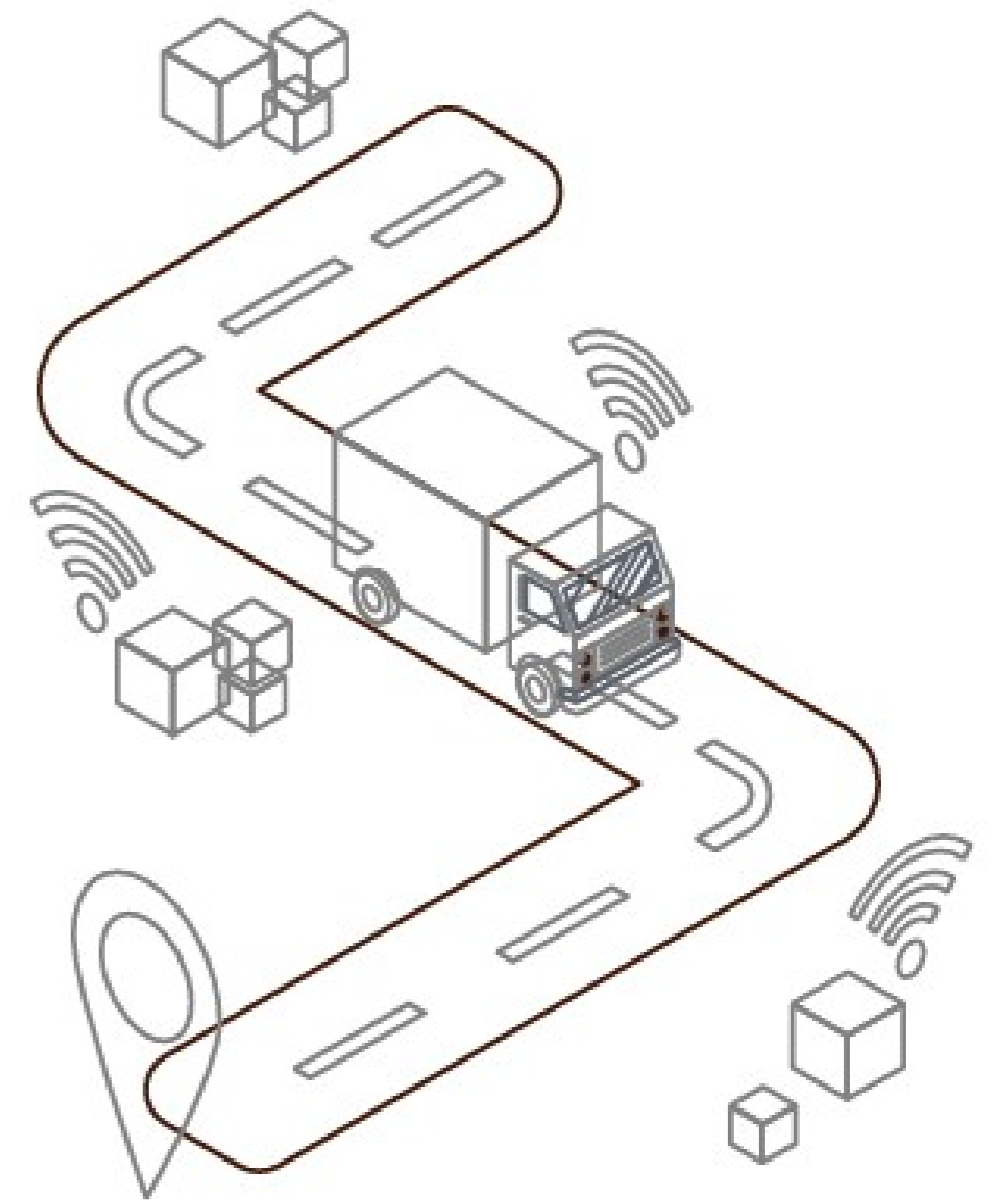
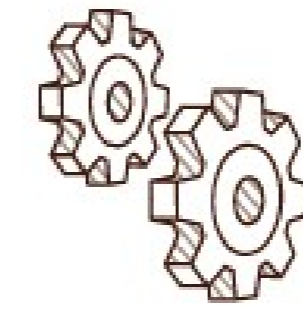
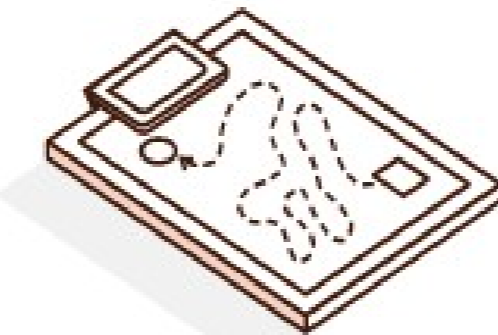
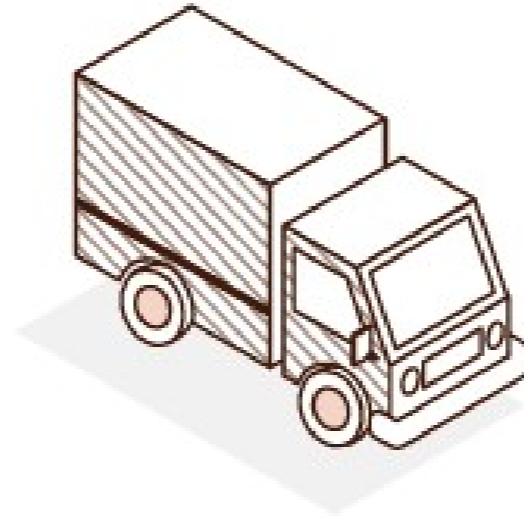
2. Methodology

a) MIP

b) CP

3. Results

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Introduction

"Constraint Programming to Improve Hub Utilization in Autonomous Transfer Hub Networks"

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- Kevin Dalmeijer
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The paper

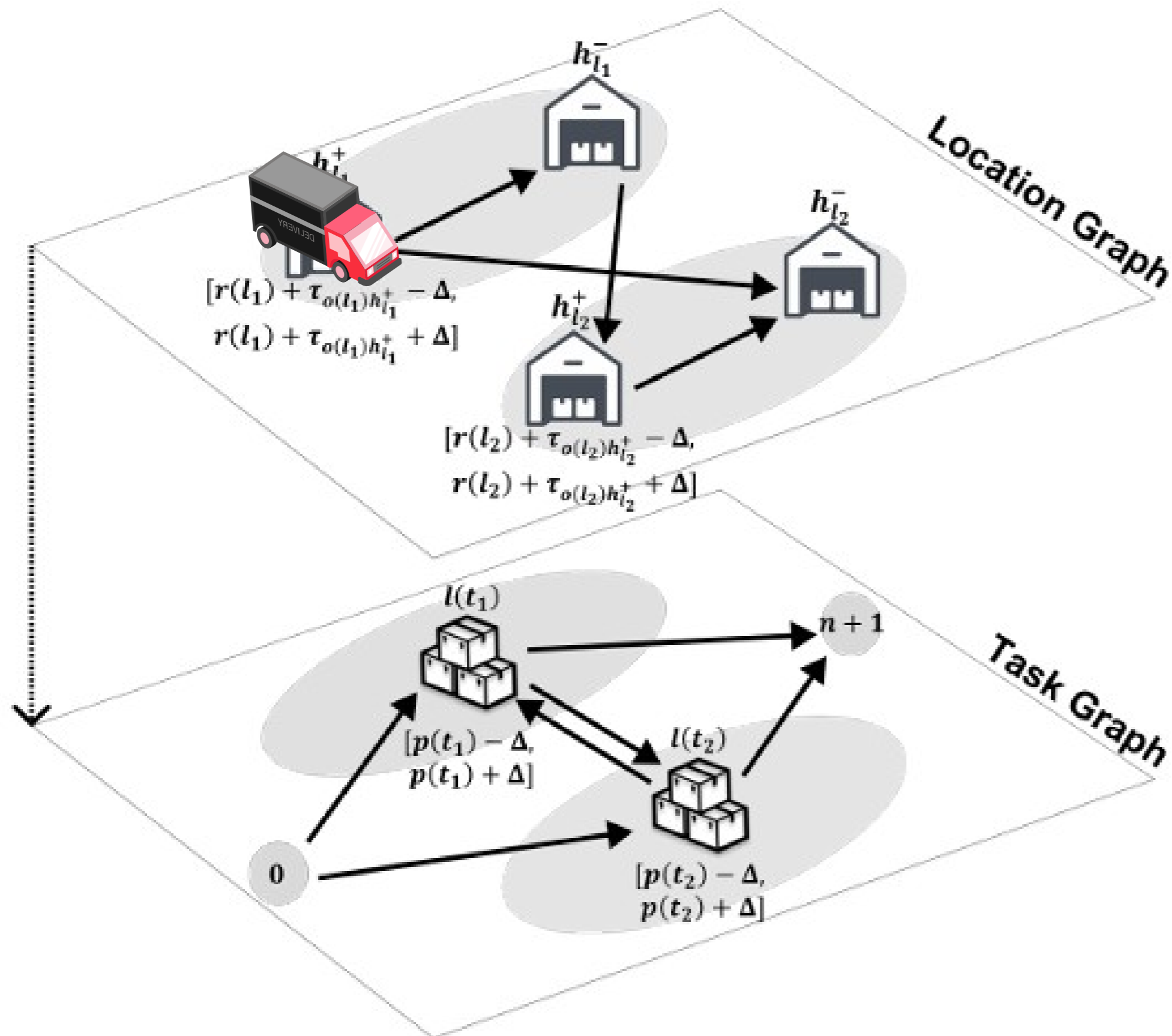
- Base of research :
«Optimizing Autonomous Transfer Hub Networks : Quantifying the Potential Impact of Self-Driving Trucks.»
- Motivation :
Industrial impact is strong, easy big scale testing, new approach
- Contribution :
Utilization of MIP and CP for automation and scheduling of freight problems

The problem

- Methodology :
In 2 parts : MIP and CP.
- MIP :
Scheduling problem with hubs and use of a clever formulation
- Contribution :
Capacity minimization at the hubs



MIP - Example



- Simplistic example:
4 hubs and 2 tasks

- MIP :
Task Graph $G = (V, A)$
Min-cost flow problem

- 3 possibilities for a truck:

1. No automation
2. Only one automated task
3. Several consecutive tasks

CP

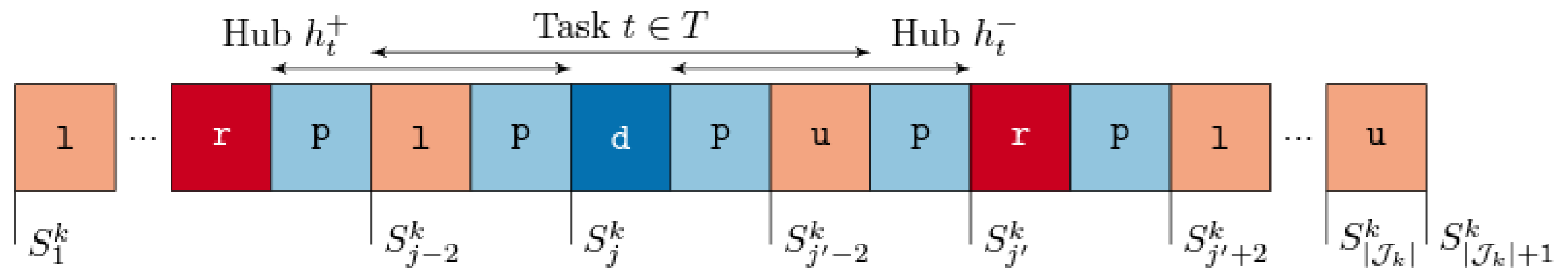
Variables and parameters

- The 4 properties of jobs :
 - Type(j) $\in \{l, d, u, r, p\}$
 - Duration(j) : job duration
 - Task(j) (only for l, u, d): associated task
 - Hub(j) (only for l, u, p) : associated hub
- s_j^k = start time of job j on route k
- c_h = unloading/unloading capacity required by hub $h \in H$

Modeling

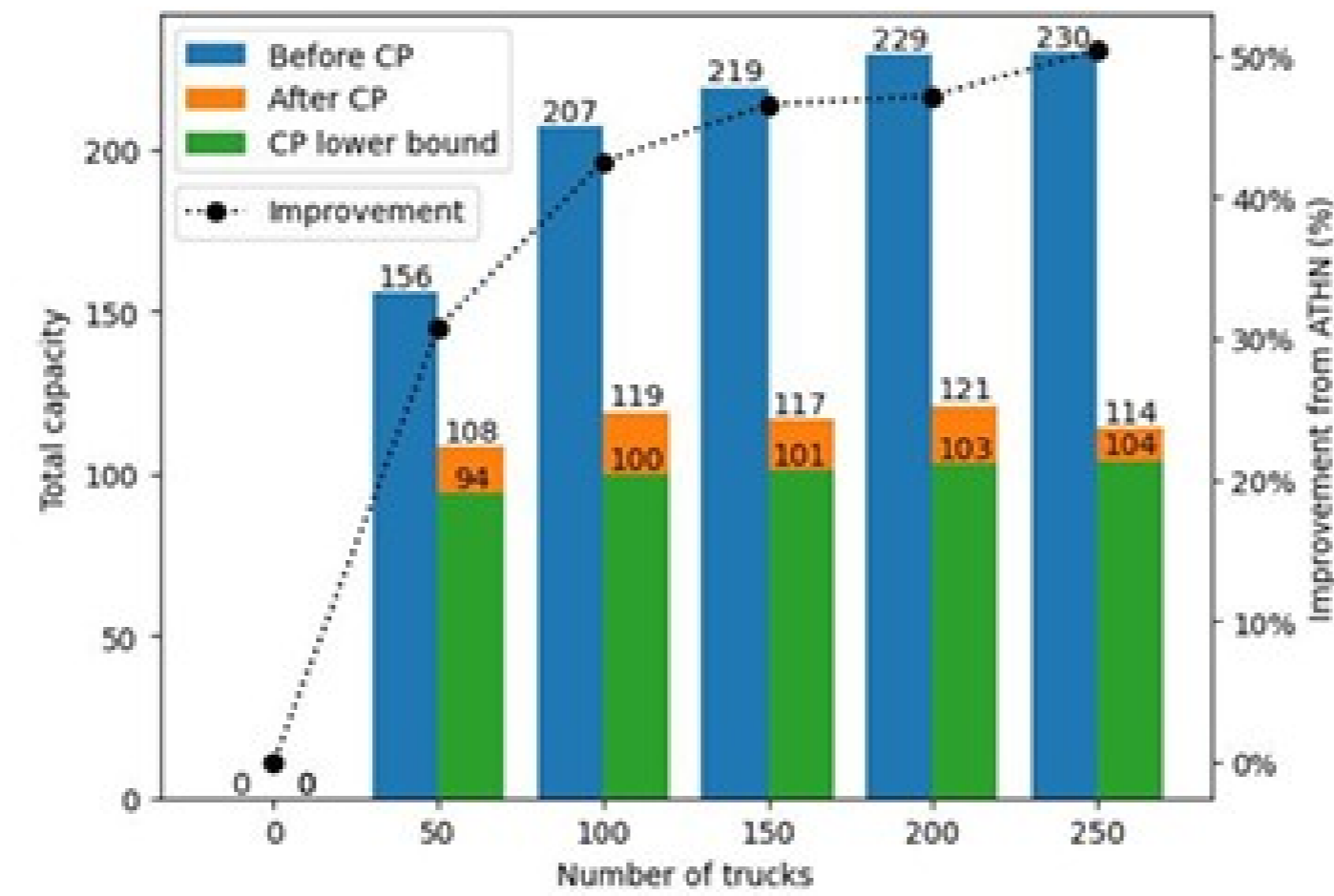
- Jobs are used instead of tasks
- Numbering in order of performance

$$\begin{aligned}
 \min \quad & \sum_{h \in H} C_h, \\
 \text{s.t.} \quad & I_j^k = \text{Interval}([s_j^k, s_{j+1}^k]) \quad \forall k \in \mathcal{K}, j \in \mathcal{J}_k, \\
 & \text{Cumulative}([I_j^k \mid k \in \mathcal{K}, j \in \mathcal{J}_k, \text{type}(j) \in \{1, u\}, \text{hub}(j) = h], C_h) \quad \forall h \in H, \\
 & s_{j+1}^k = s_j^k + \text{duration}(j) \quad \forall k \in \mathcal{K}, j \in \mathcal{J}_k, \text{type}(j) \in \{1, d, u, r\}, \\
 & \text{dom}(s_j^k) = [g_j^k, \bar{g}_j^k] \quad \forall k \in \mathcal{K}, j \in \mathcal{J}_k.
 \end{aligned}$$



Case study - Results

Comparison

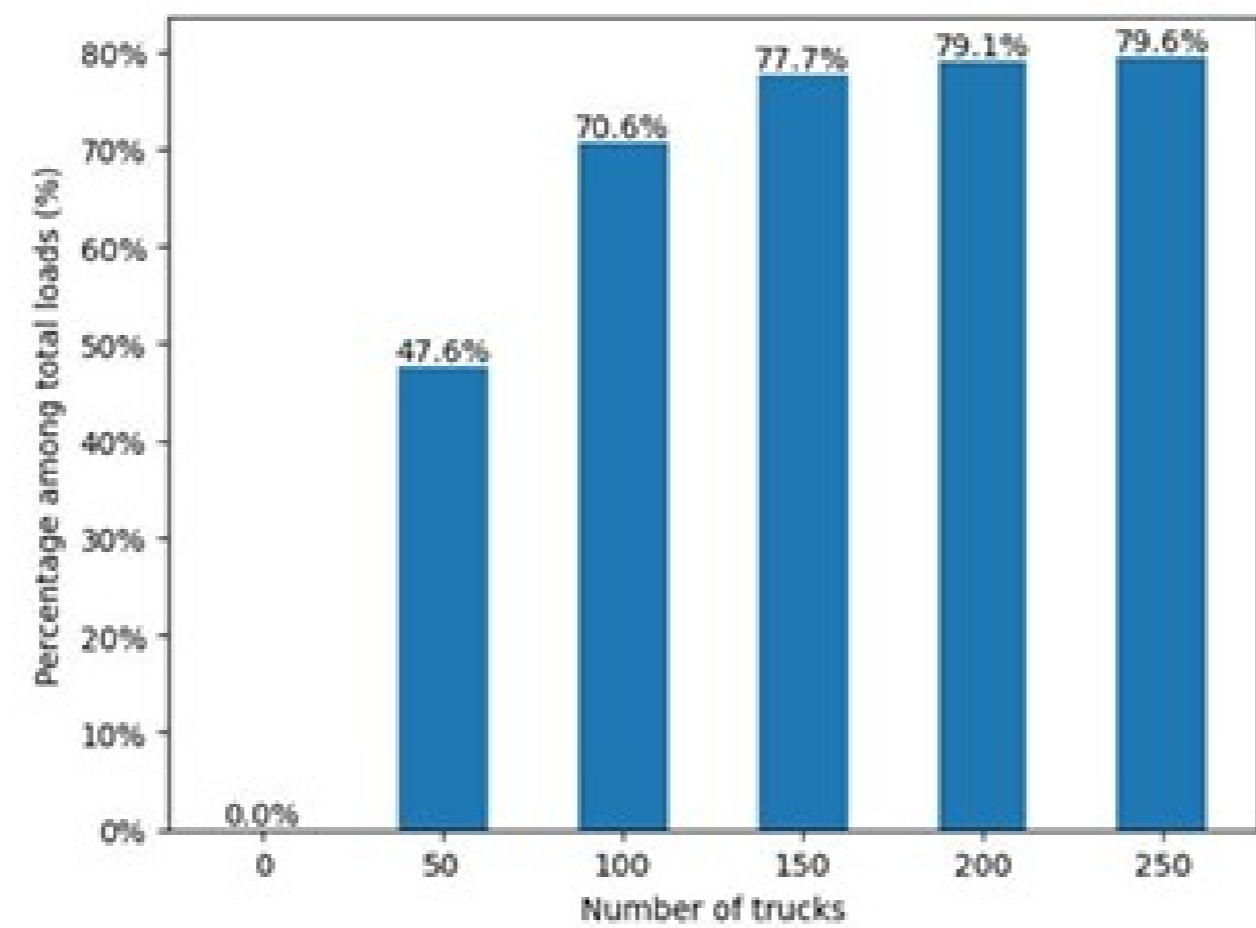


Hub capacities

MIP



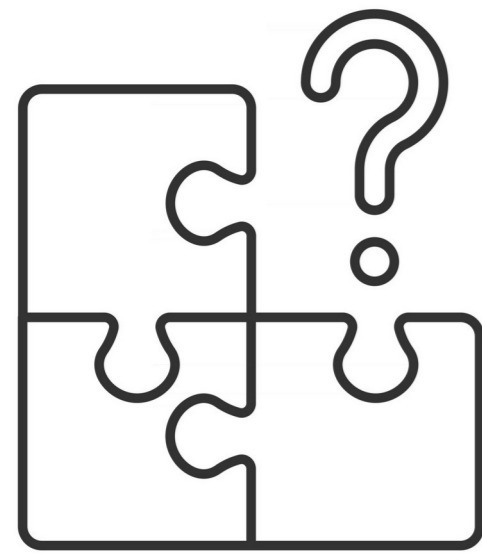
Automation



CP



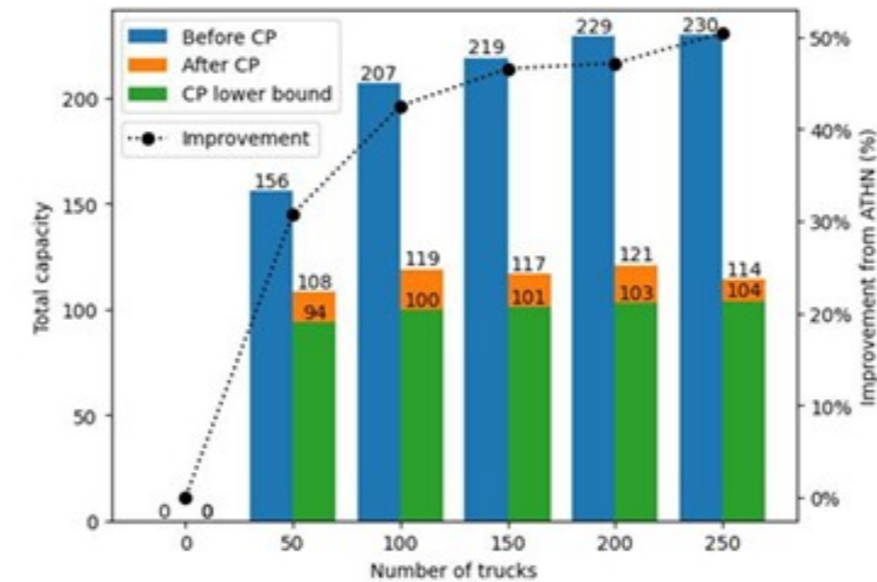
Conclusion – Questions ?



Initial work



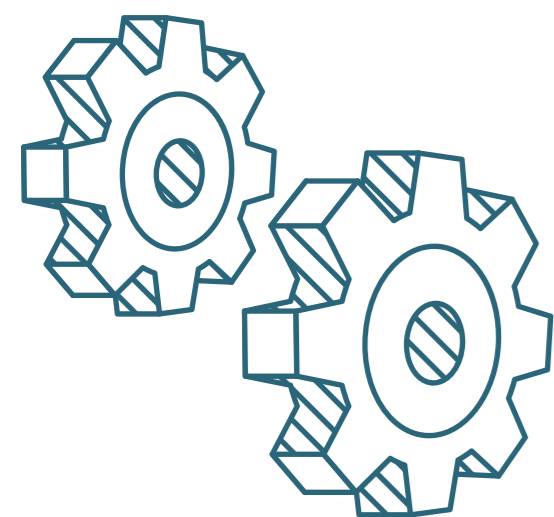
CP Modeling



Results



Future work



Autonomous transfer hub networks – Your Name Here :)



THANK YOU FOR LISTENING!



Credits

Font

- Josefin Sans: <https://fonts.google.com/specimen/Josefin+Sans>

Illustration + animation

- Slidenest : <https://slidenest.com/>
- Images :
 - <https://unblast.com/problem-solving-illustration-ai/>
 - <https://www.vecteezy.com/vector-art/2766892-mosaic-linear-icon-search-for-missing-piece-challenge-for-logic-solving-maze-jigsaw-thin-line-customizable-illustration-contour-symbol-vector-isolated-outline-drawing-editable-stroke>

Scientific article

- Constraint Programming to Improve Hub Utilization in Autonomous Transfer Hub Networks
- Optimizing Autonomous Transfer Hub Networks : Quantifying the Potential Impact of Self-Driving Trucks