

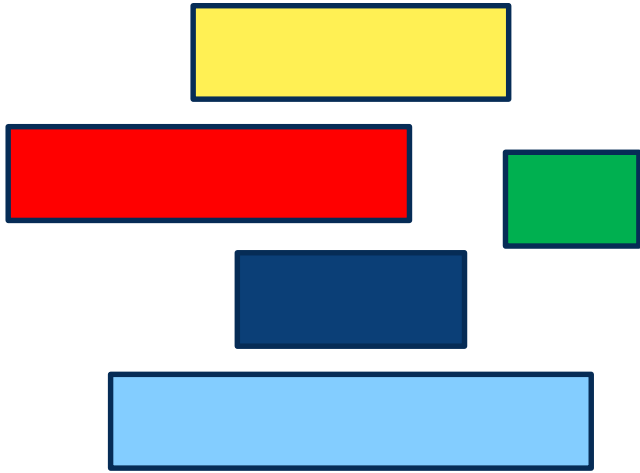


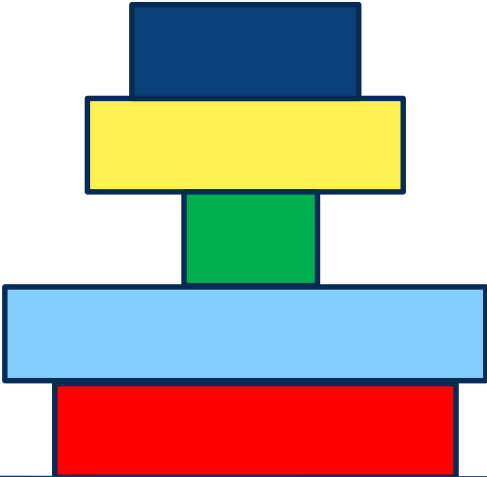
3DEXPERIENCE®

IMPROVING SOLUTIONS USING MACHINE LEARNING

DS DASSAULT
SYSTEMES | The 3DEXPERIENCE® Company

Seppo Pieterse
Willem Feijen





Agenda

1. Why is improvement so important for real world optimization algorithms?
2. What are we researching?
3. How do we do that?
4. Does it work?

Real world optimization puzzles





Decision variables:
Quantity(P, T)

Constraints:
 $5 * \text{Quantity}(P1, T1) + 1.25 * \text{Quantity}(P1, T2) \leq 60$
 $4 * \text{Quantity}(P2, T2) + 0.83 * \text{Quantity}(P2, T2) \leq 60$

Goal:
Maximize $5 * \text{Quantity}(P, T1) + 1 * \text{Quantity}(P, T2)$



Optimal Solution:
Quantity(P1, T1) = 12
Quantity(P1, T2) = 0
Quantity(P2, T1) = 9.1
Quantity(P2, T2) = 28.8

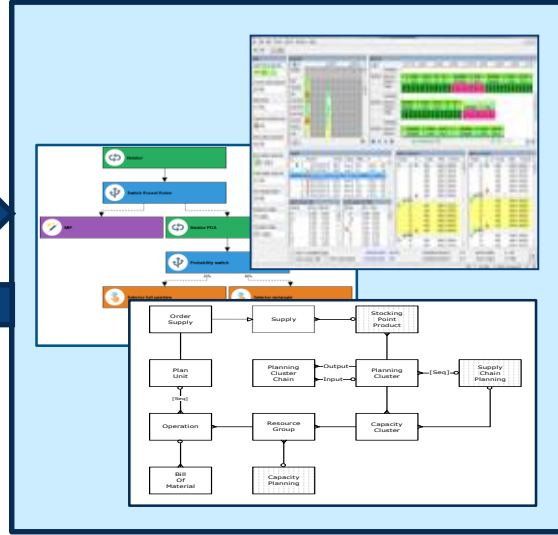
The 1-2-3 Approach: (1) Model, (2) Solve, (3) Apply

“Successful problem solving requires finding the right solution to the right problem. We fail more often because we solve the wrong problem than because we get the wrong solution to the right problem.”

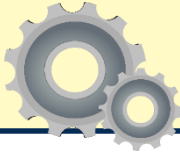
Russell Ackoff (1974)

The Real World

The Virtual Twin



Optimizers



Human
Planners

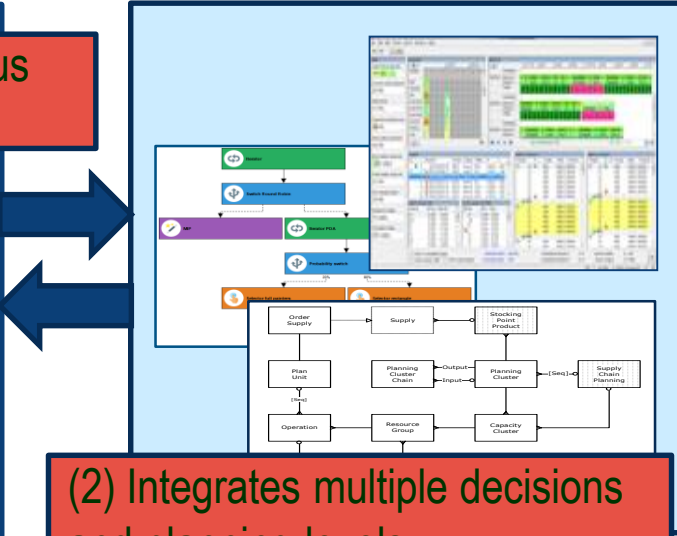


The Real World

The Virtual Twin



(1) Real-Time Continuous Synchronization

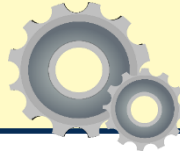


(2) Integrates multiple decisions and planning levels

(3) Realistic and Unbiased

(4) Continuous Optimization

Optimizers



Human Planners



(5) Visualization, Interaction, Workflow & Explainability

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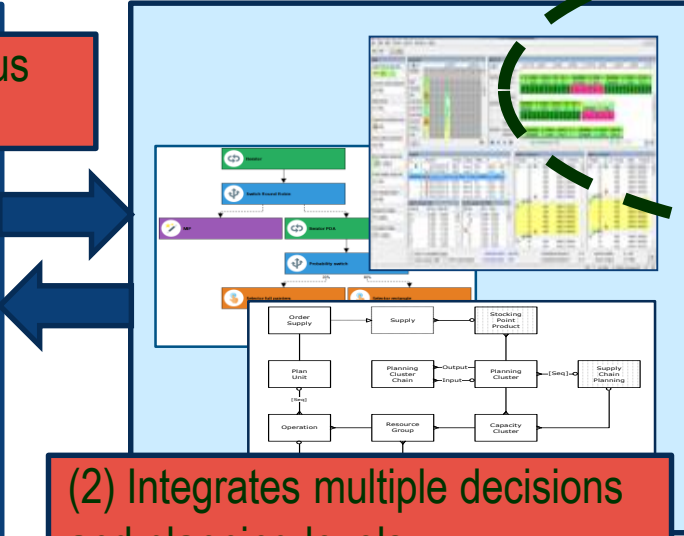
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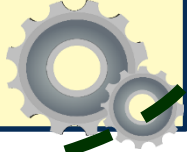


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Optimizers



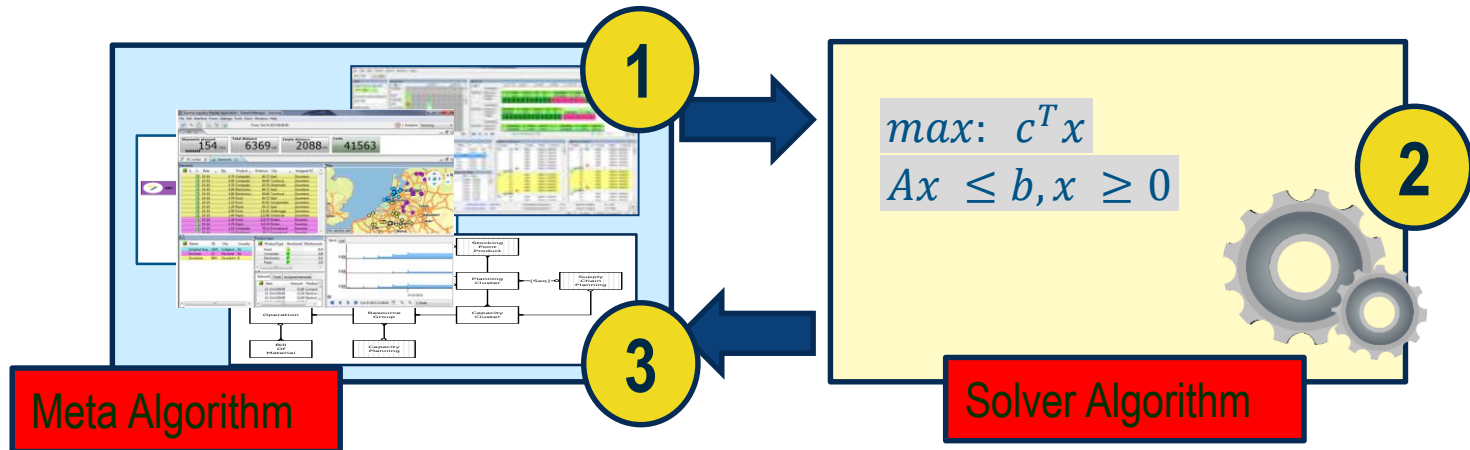
Human Planners



(5) Visualization, Interaction, Workflow & Explainability

The Virtual Twin

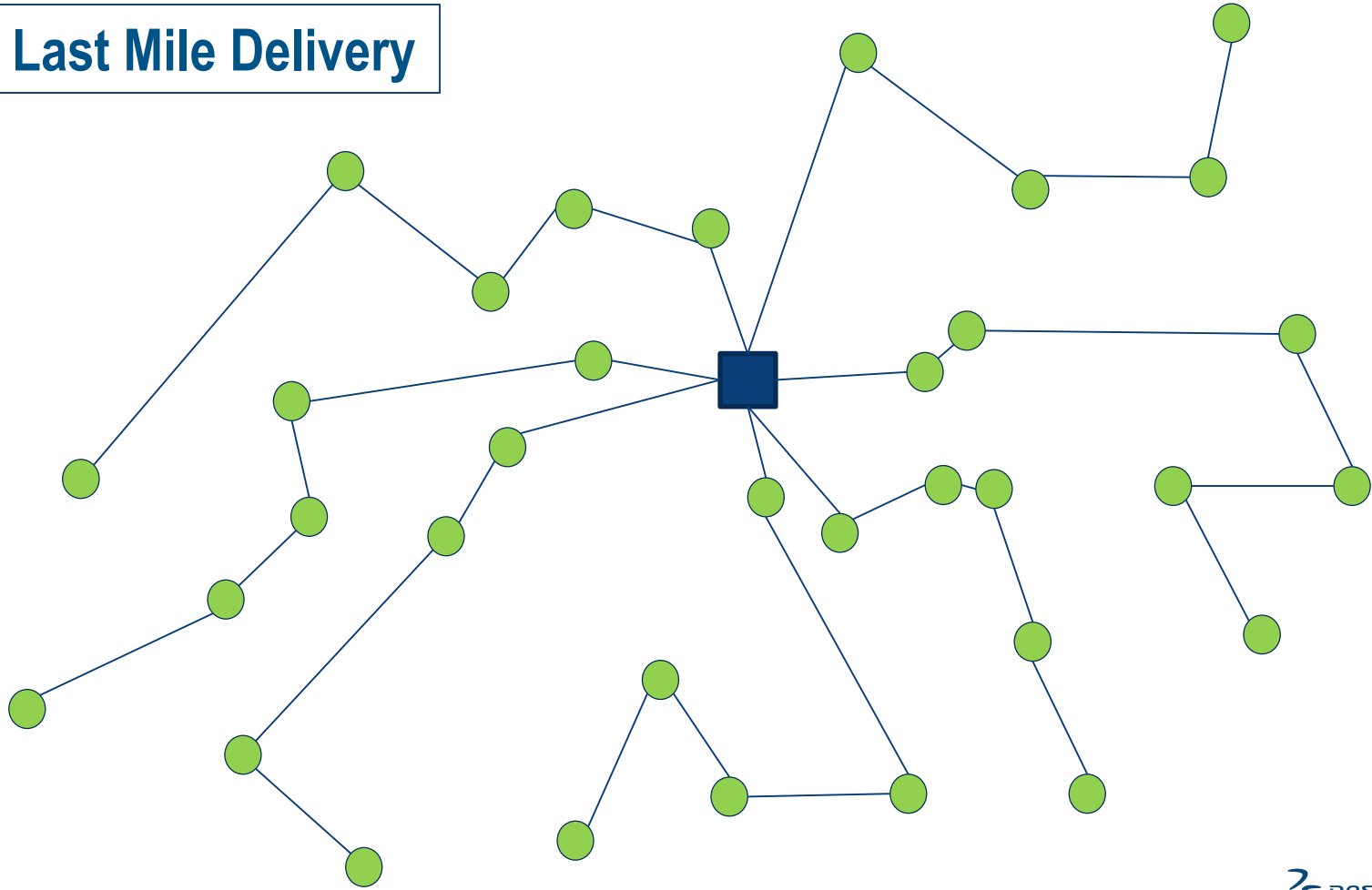
Optimization Solver



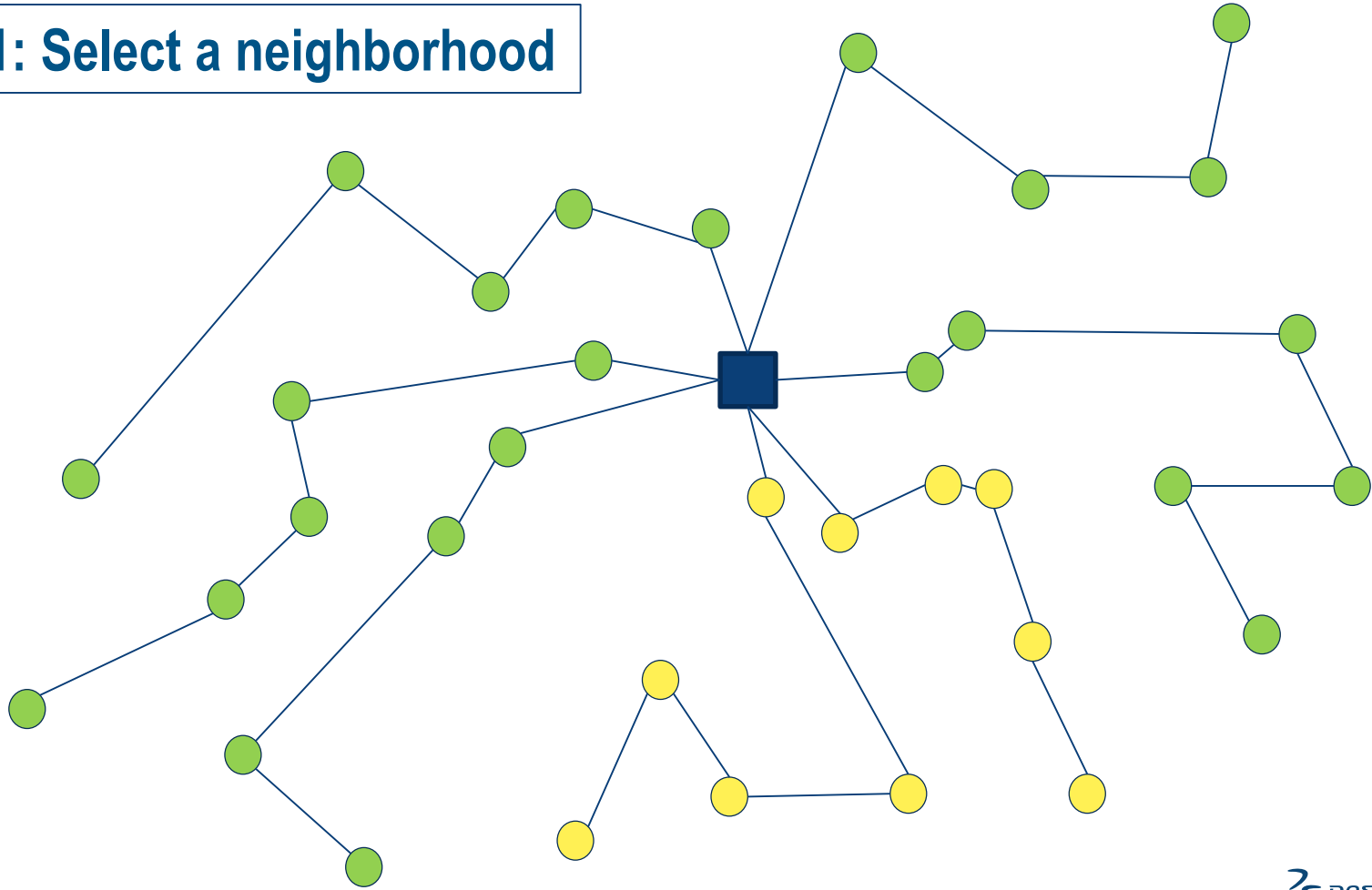
The Virtual Twin does a Meta Large Neighborhood Search:

1. Select a neighborhood
2. Send this neighborhood to a mathematical solver and look for a better solution
3. Transfer the solution of the mathematical solver back to the virtual twin

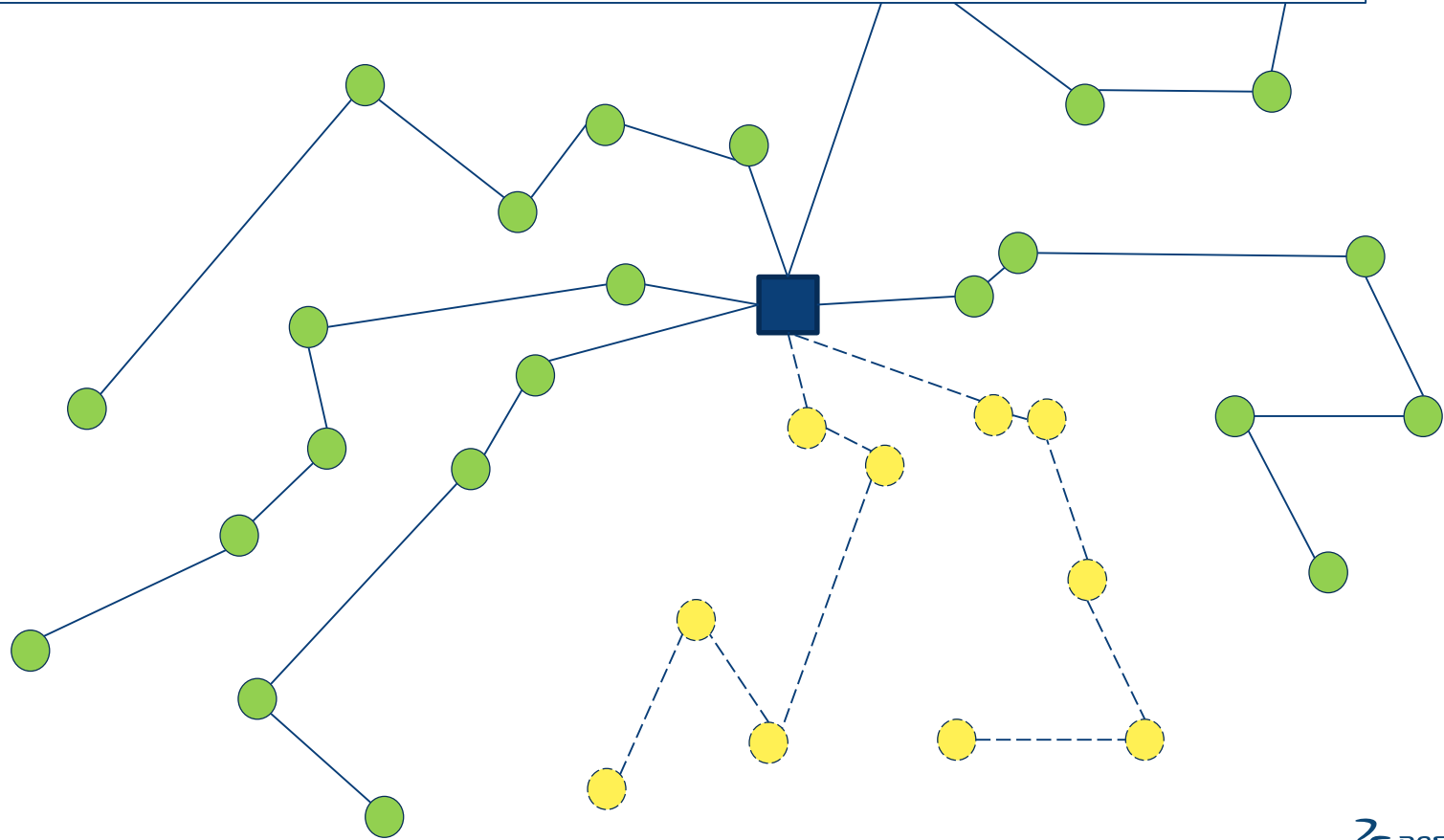
Case: Last Mile Delivery



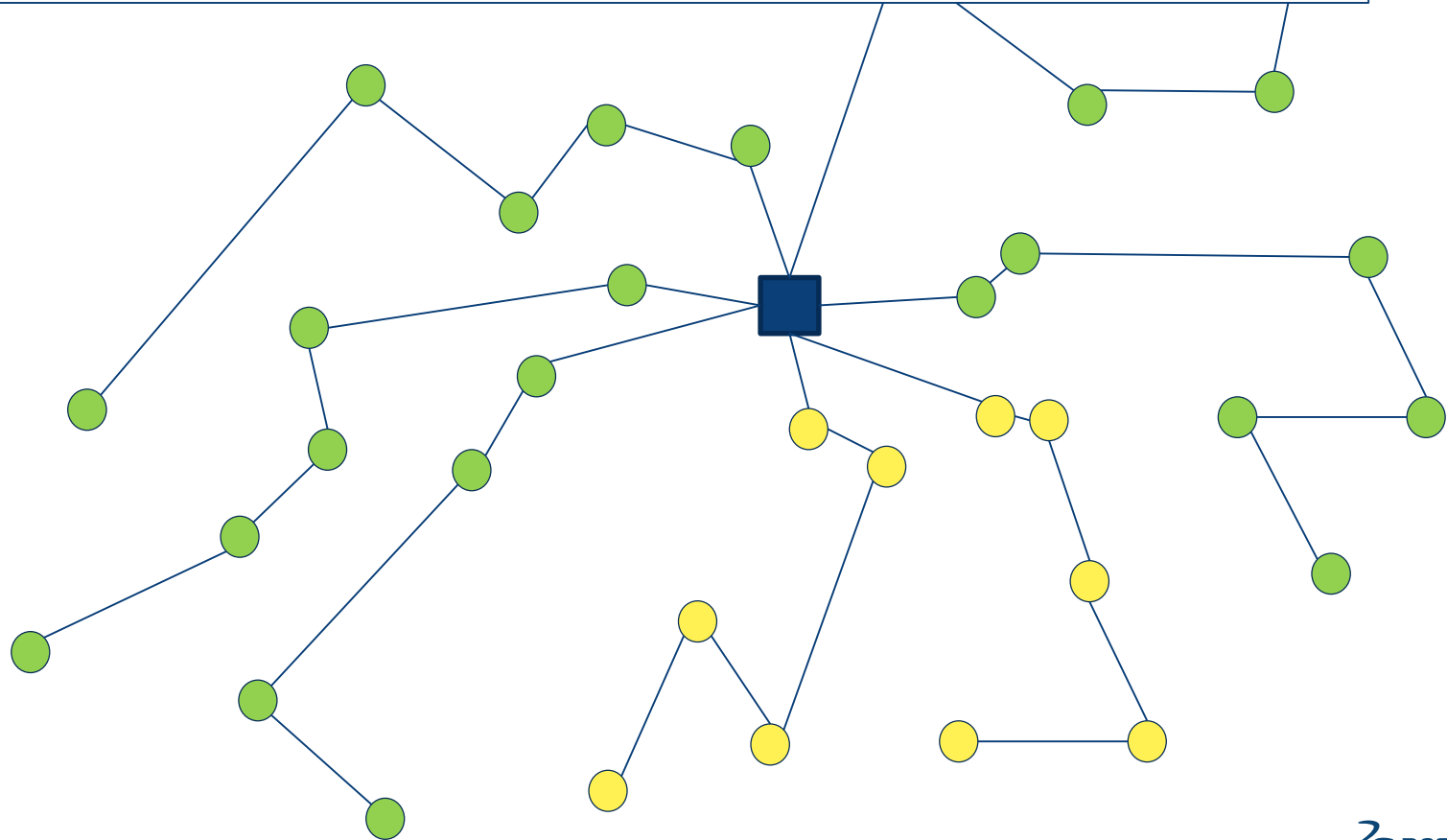
Step 1: Select a neighborhood

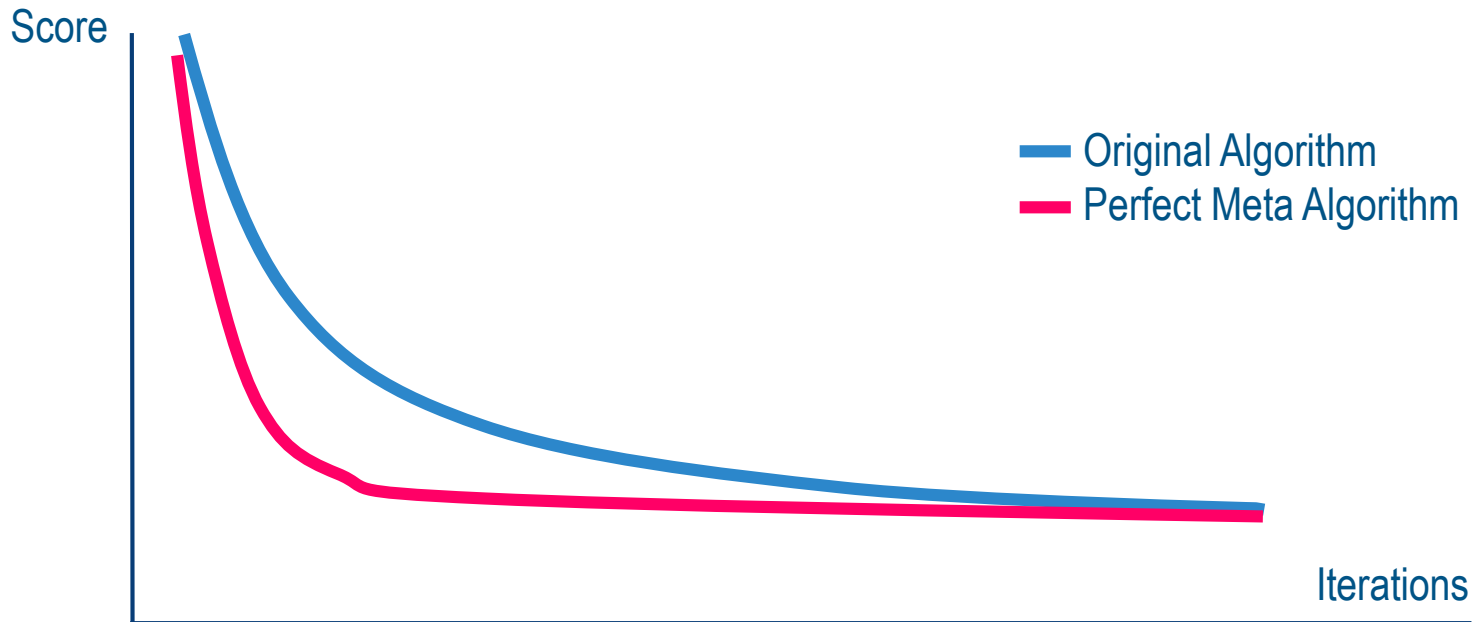


Step 2: Look for better solution with a mathematical solver



Step 3: Accept (or reject) the solution in the virtual twin





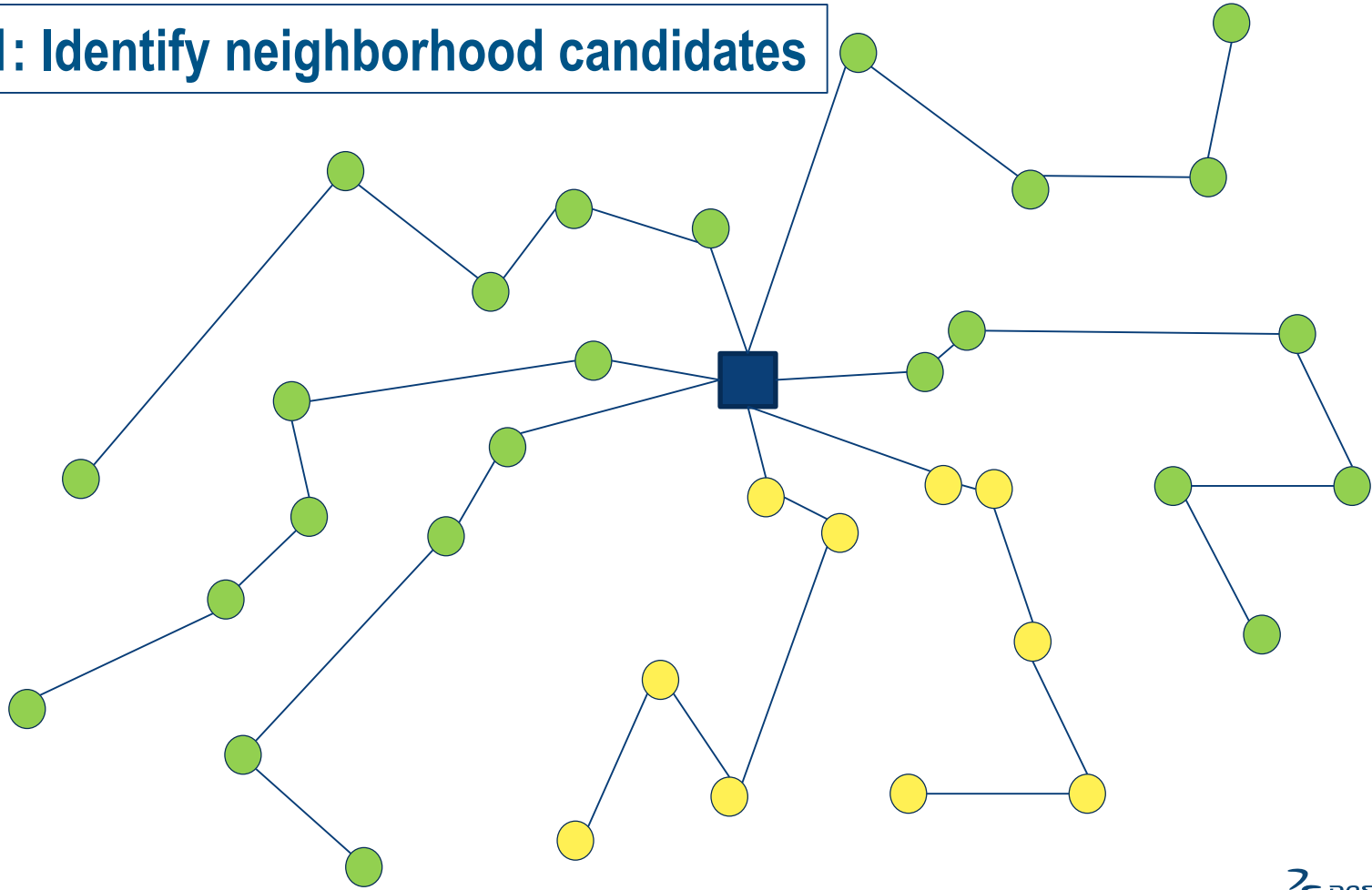
Our Research:

Can Machine Learning help us to select the most promising neighborhoods?

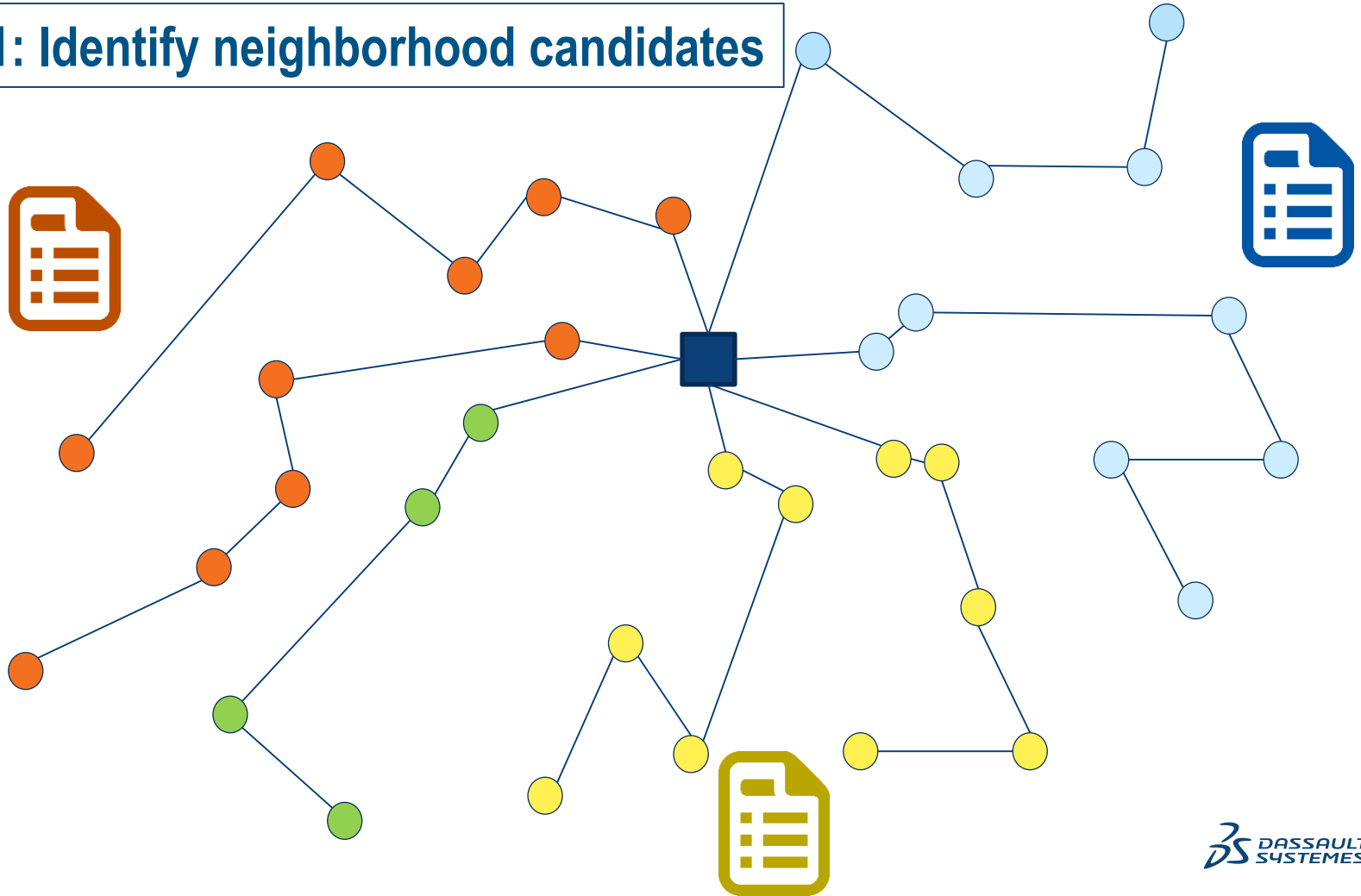
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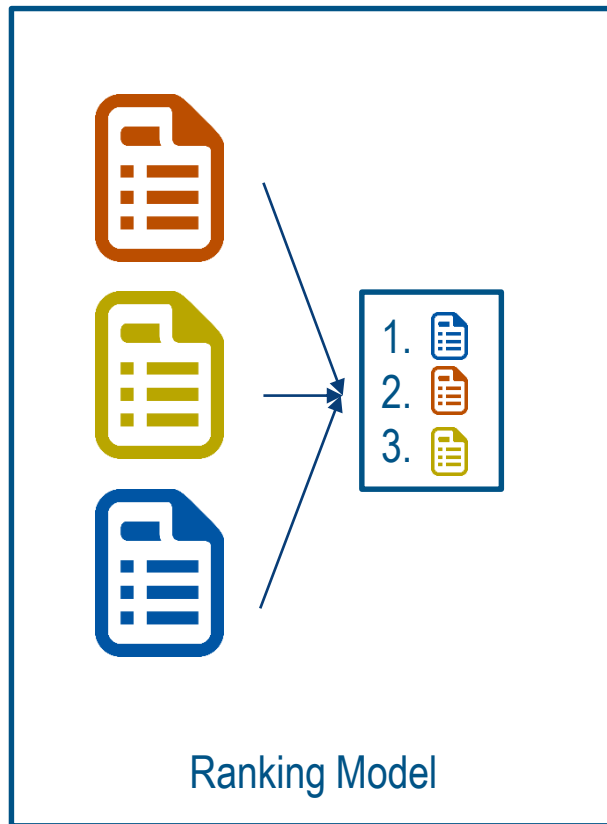
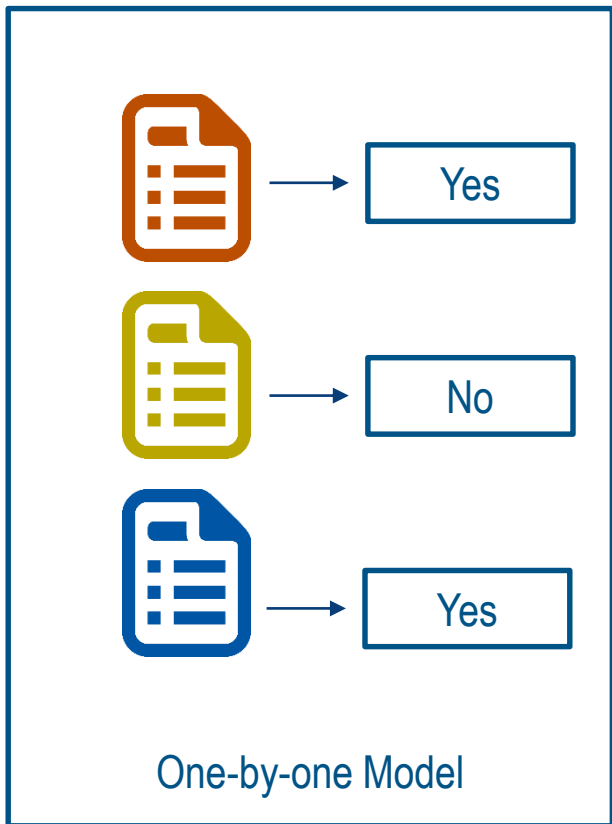
Step 1: Identify neighborhood candidates



Step 1: Identify neighborhood candidates



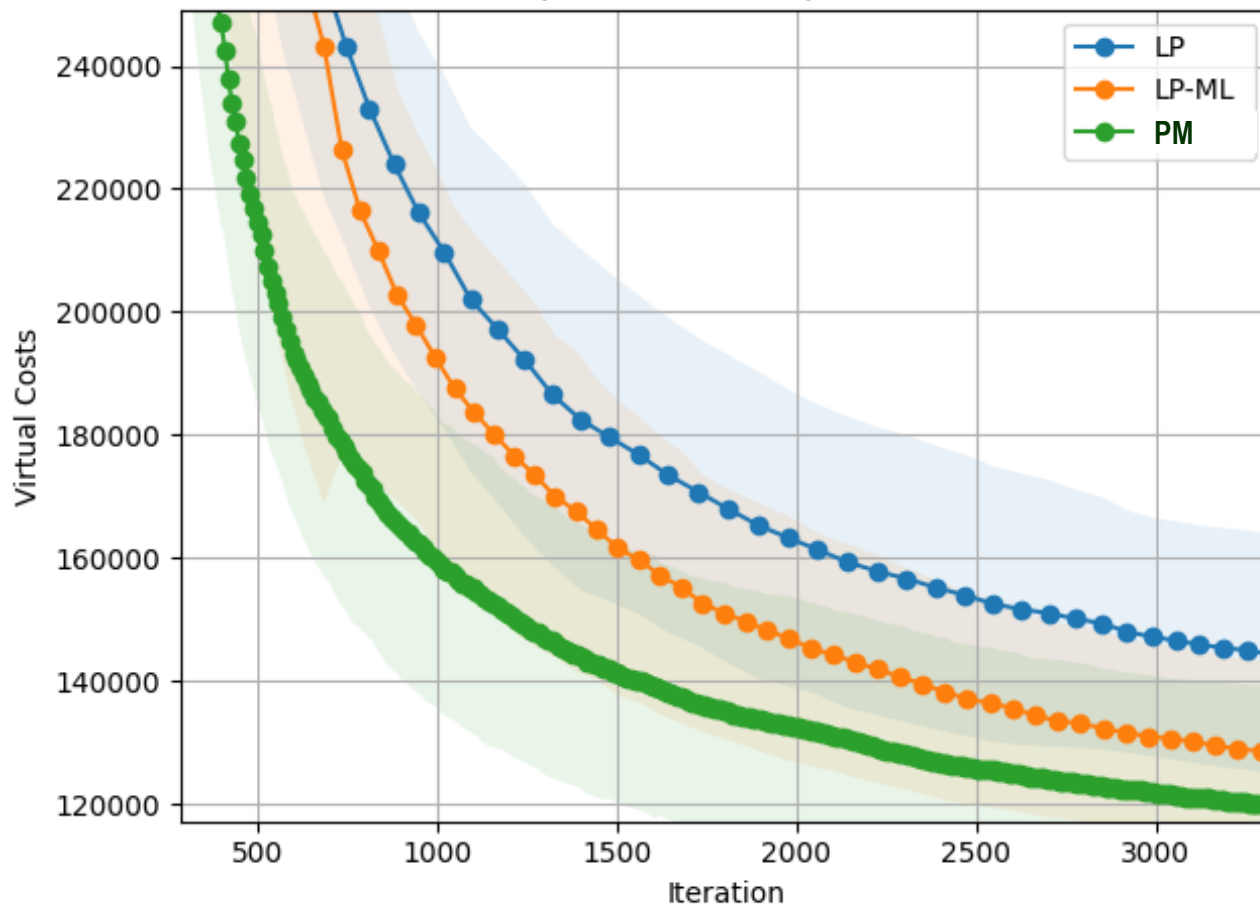
Step 2: Machine Learning Models



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4. **Does it work?**

Comparison of multiple models



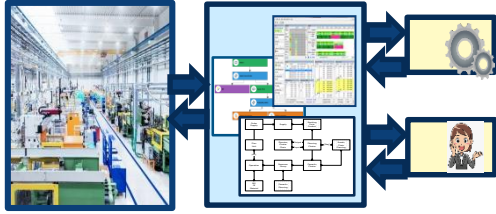
Challenges

- ▶ Feature definition and selection
- ▶ Need for real-world test case (Data + Optimizer)
- ▶ Randomness in optimization

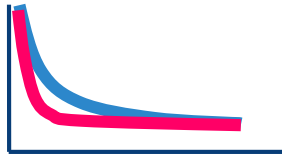
Future Research

- ▶ Online Learning
- ▶ Work-flow embedding with customers
- ▶ Neighborhood creation

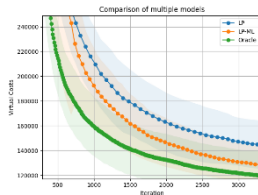
Summary



1. Improvement algorithms are important for solving real world puzzles using a virtual twin



2. Selecting optimal neighborhoods can increase the quality of LNS significantly



3. ML can predict the improvement potential of neighborhoods

