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Daniel J. Epstein Department of Industrial and Systems Engineering

Parallelizing VRP post-processing

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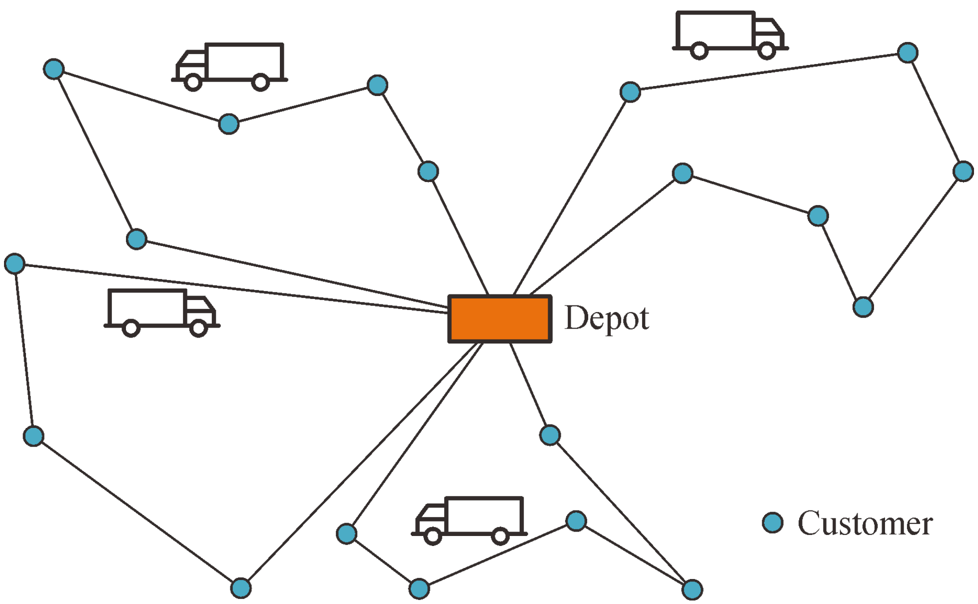
Background



1. NP-hard problem
2. Oftentimes post-processing needed

Typical Post-processing

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For each tour, we solve:

$$
\begin{aligned}
\min_{p,\epsilon} \quad & \sum_{i \in N} \epsilon_i^{IR} + \sum_{i \in N} \epsilon_i^{S} + \epsilon^{BB} \\
\text{subject to,} \quad & p_i \leq p_i^{(i,j)} + \epsilon_i^{S} \quad \forall i \in N_c \; \forall j \in (N_c \cup N_r) \\
& \sum_{i \in N_c} p_i = \mathcal{C}(N_c) + \sum_{i \in N_c} \epsilon_i^{IR} + \sum_{i \in N_c} \epsilon_i^{S} + \epsilon^{BB} \\
& p_i \leq 2c_{i0} + \epsilon_i^{IR} \quad \forall i \in N_c \\
& p_i \geq 0 \quad \forall i \in N_c \\
& \epsilon_i^{IR}, \epsilon_i^{S}, \epsilon^{BB} \geq 0
\end{aligned}
$$

Just a flavor of how complicated post-processing could get

1. Linear program
2. Parallelization

Result

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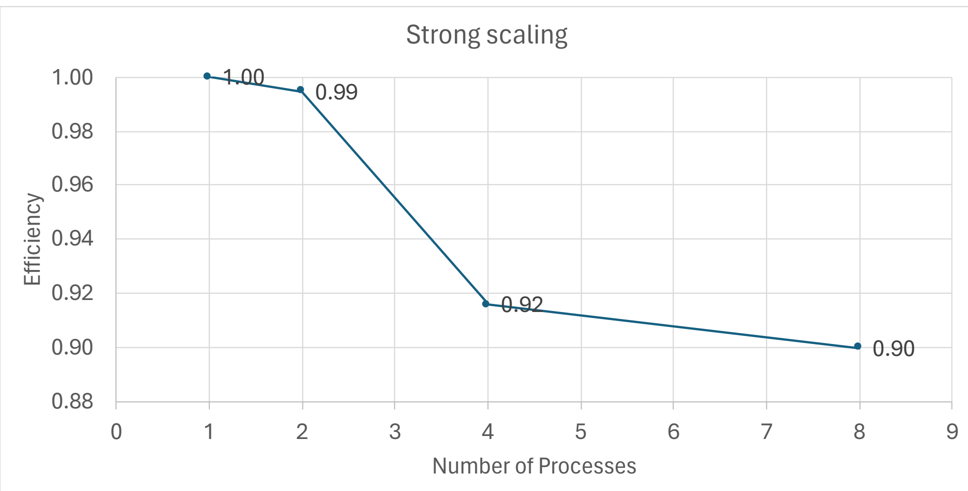
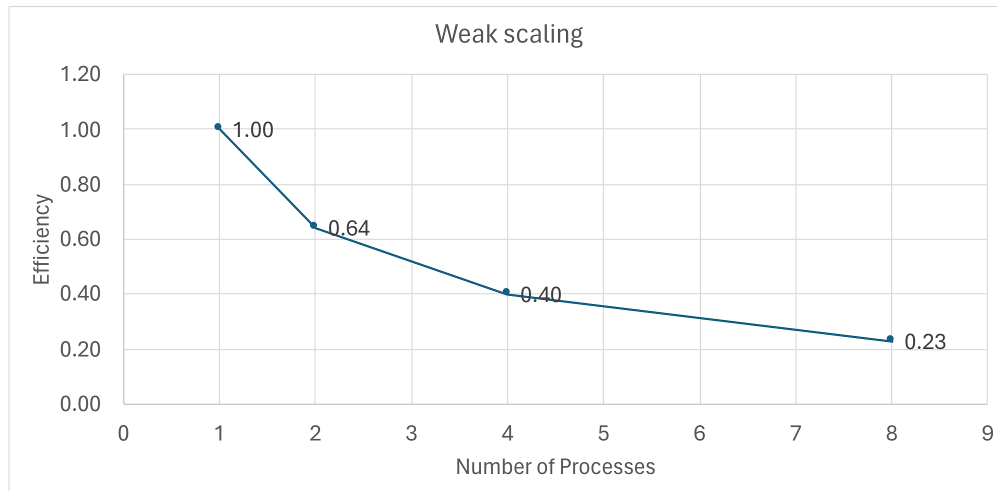
- Typical measure of workload for LP models is the **number of nodes** (not quite, as we will see later)
- Nodes: 50, 100, 200, 400
- Number of processors: 1, 2, 4, 8





Analysis

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Why weak scaling efficiency is so bad?

Change to 4

# processor	num_nodes	num_var	num_constr	factor_var	factor_constr
1	50	162	2466	1	1
2	100	328	9932	2.02	4.03
4	200	666	39870	4.11	16.17
8	400	1270	149724	7.84	60.72

- Number of constraints increases at a higher rate. For example, 400 node problem has 60 times more constraints than 50 node problem.
- We cannot know apriori how the number constraints will grow for linear programs.
- Many constraints are redundant (for example 2 < 10 and 5 < 10, only the first one suffices, but again we do not know this apriori).

Analysis

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- Adjusting for the number of constraints we get weak scaling efficiency closer to our expectation
- Unfortunately, since the factor by which the number of constraints grows is too large, and we cannot feasibly run that many processes.
- This is why, we only compare the first and the second data point. The second data point has 4 times more constraints than the first one. So, we run 4 processes for this data point.
- The resulting weak efficiency for this process is

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