Versatile Cost Partitioning with Exact Sensitivity Analysis

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Sensitivity Analysis for Linear Programs

Provides parameter ranges under which solution remains optimal.

Planning: Reuse cost partitions for other states

Exact Sensitivity Analysis

- Previous Sensitivity Analysis strategies for SPhO are approximations
- $x^*_{\mathcal{B}} + B^{-1}\Delta b \overset{?}{\geq} 0$ gives exact answer for an LP *basis*
- Problem: Basis $\neq$ Solution

Degeneracy and Non-Uniqueness

Exact sensitivity analysis is not perfect because:

- Degeneracy: multiple bases describe same solution
- Non-Uniqueness: multiple solutions are equally good

Grouping rows and columns as countermeasures

Degeneracy and non-uniqueness caused by redundancy

$\rightarrow$ group labels and abstractions

Tiebreaking $\rightarrow$ Versatile Solutions

Prefer solutions that generalize to more states:

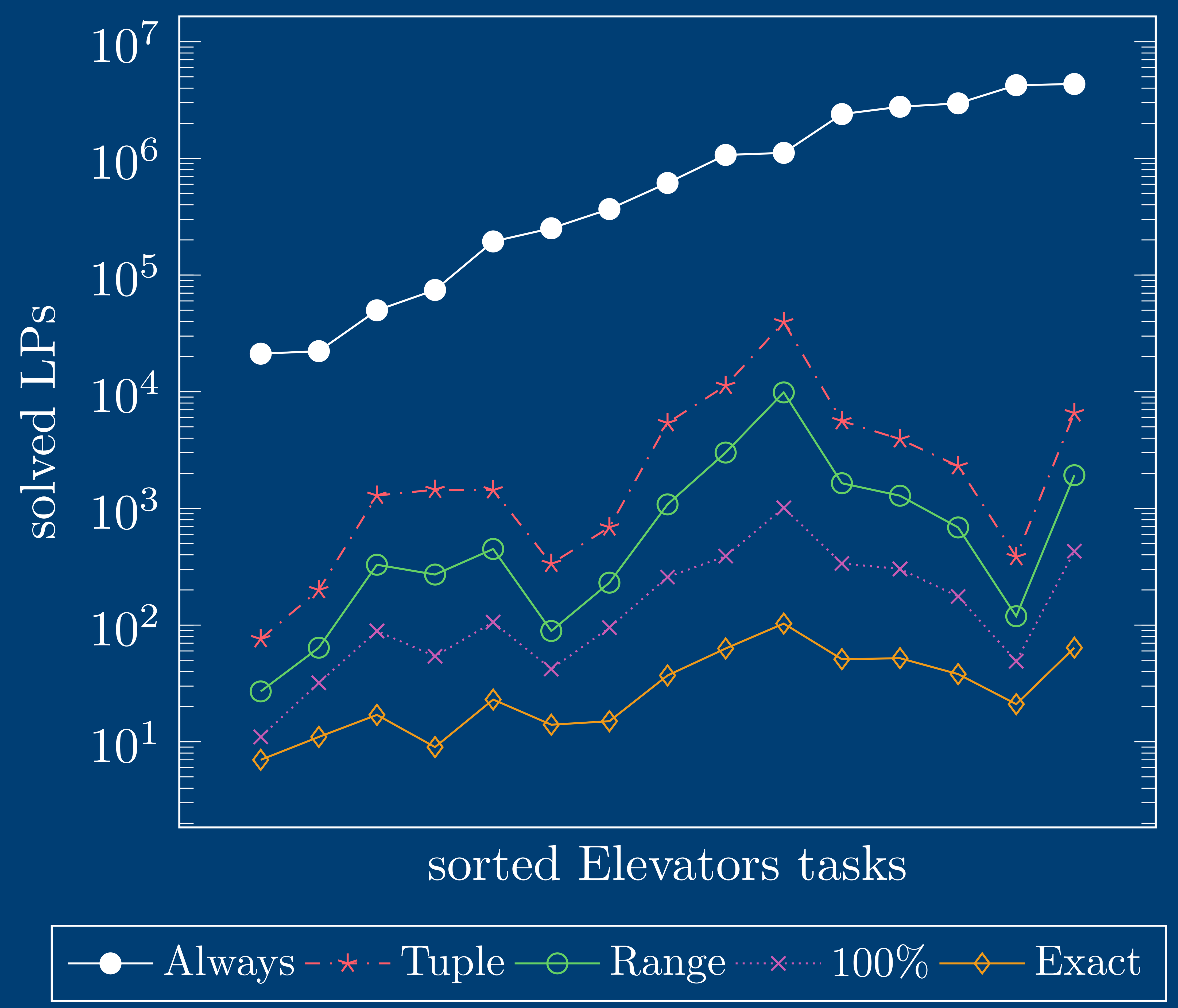
Solutions with higher coefficients

$\rightarrow$ tiebreak for higher coefficients for zero-valued heuristics

Future Work

- Further redundancy elimination
- Theoretical insights from Exact Sensitivity Analysis
- Non-redundant abstraction generator

Computing the SPhO LP in every state is unnecessary.



Cost Partitioning

If label costs $cost(\ell)$ satisfy $\sum_{h \in H} cost_h(\ell) \leq cost(\ell)$ then $\sum_{h \in H} h(s)$ is admissible

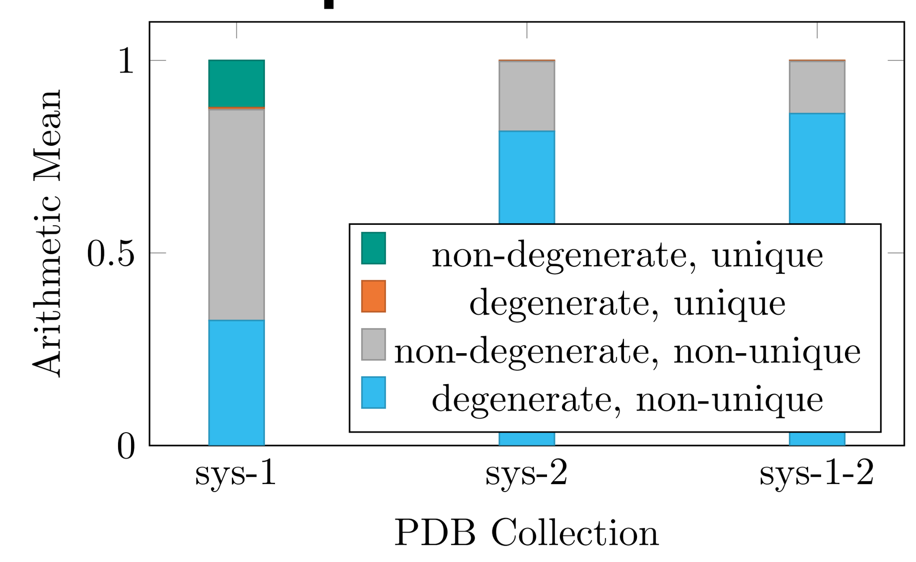
Saturated Post-hoc Optimization LP

$$\text{minimize} \sum_{\ell \in L} cost(\ell) \cdot Y_\ell \text{ s.t.}$$

$$\sum_{\ell \in L} mscf_h(\ell) \cdot Y_\ell \geq \boldsymbol{h(s)} \text{ for all } h \in H$$

$$Y_\ell \geq 0 \text{ for all } \ell \in L$$

Degeneracy and Non-uniqueness



Tiebreaking Algorithm

procedure IncreaseWeights($\mathcal{H}$, rem, s)

  for $h \in \mathcal{H}$ with $h(s) = 0$ **do**

    $\Delta w = \min_{\ell \in L} \left\{ \frac{rem(\ell)}{mscf_h(\ell)} \middle| mscf_h(\ell) > 0 \right\}$

    $w_h \mathrel{+}= \Delta w$

    for $\ell \in L$ **do**

      $rem(\ell) \mathrel{-}= mscf_h(\ell) \cdot \Delta w$