

# Versatile Cost Partitioning with Exact Sensitivity Analysis

---

Paul Höft<sup>1</sup> David Speck<sup>1,2</sup> Florian Pommerening<sup>2</sup> Jendrik Seipp<sup>1</sup>

June 4, 2024

<sup>1</sup>Machine Reasoning Lab, Linköping University

<sup>2</sup>Artificial Intelligence Group, University of Basel

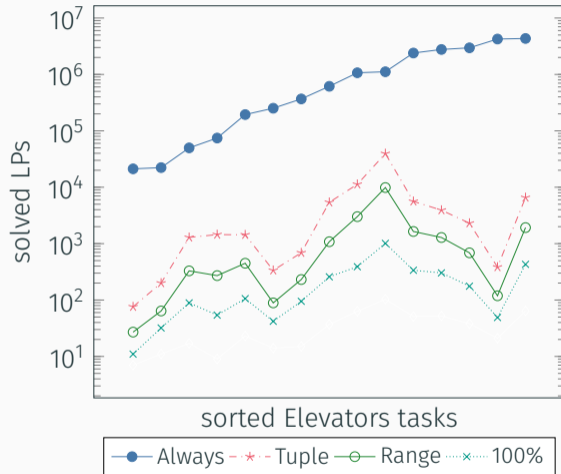


# Motivation

Lazy SPhO (Höft et al. ECAI 2023)

**Safely** reduce LP solver calls  
for SPhO

Tool: Sensitivity Analysis

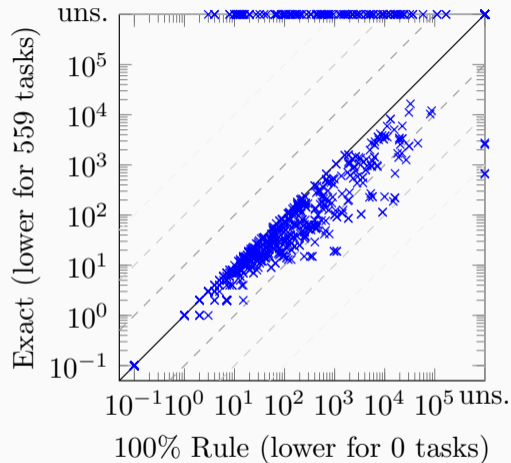


# Exact Sensitivity Analysis

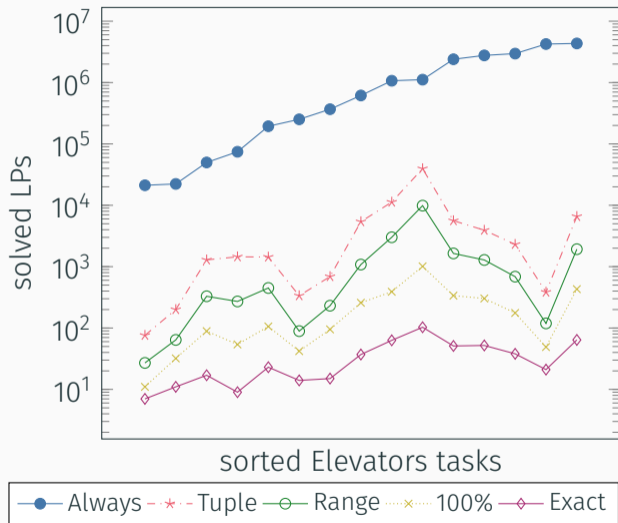
Do LP feasibility check

**Pro:** Best Sensitivity Analysis

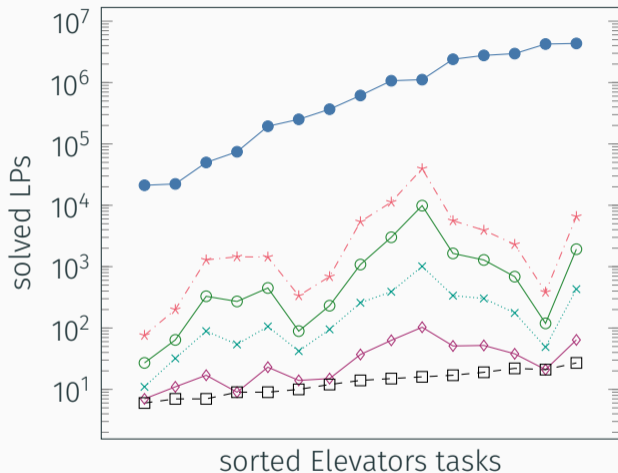
**Con:** Need to store full LP



# Is Exact Sensitivity Analysis perfect?



# Is Exact Sensitivity Analysis perfect?



## Why is Exact Sensitivity Analysis not perfect?

**Non-uniqueness:** LP solver only returns **one solution**

Alternative solution might have better reusability

## Why is Exact Sensitivity Analysis not perfect?

**Non-uniqueness:** LP solver only returns **one solution**

Alternative solution might have better reusability

**Degeneracy:** Sensitivity Analysis defined for **LP Basis**

LP Basis  $\neq$  Cost Partition/Operator Counting

# Why is Exact Sensitivity Analysis not perfect?

**Non-uniqueness:** LP solver only returns **one solution**

Alternative solution might have better reusability

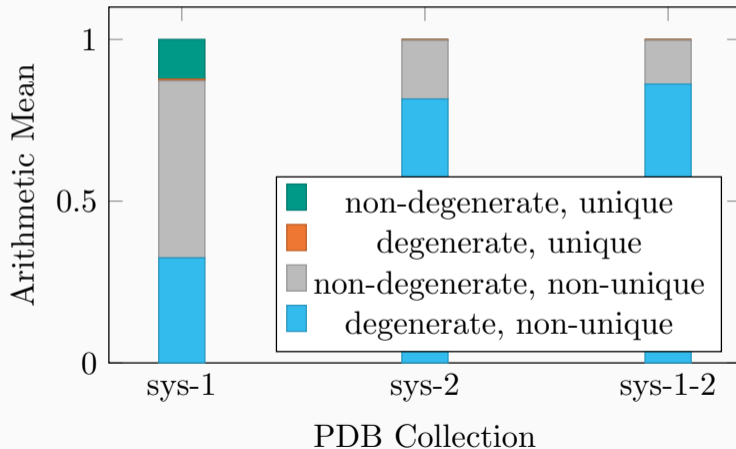
**Degeneracy:** Sensitivity Analysis defined for **LP Basis**

LP Basis  $\neq$  Cost Partition/Operator Counting

$\Rightarrow$  Both caused by redundancy

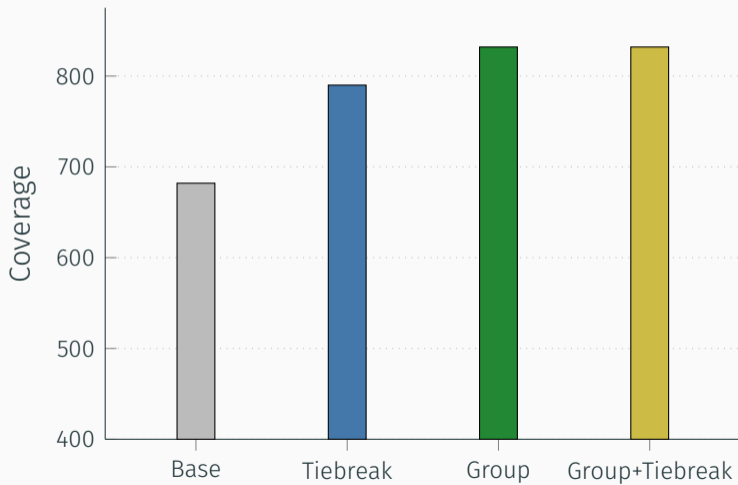


## Redundancy in LPs



- Reduce redundancy through grouping
- Tiebreaking: Prefer solutions with higher coefficients

## Exact SPhO Sensitivity Analysis



- Non-uniqueness and Degeneracy impair Exact Sensitivity Analysis
- Grouping and Tiebreaking improve the effectiveness of Sensitivity Analysis based approaches

# SPhO Linear Program

## SPhO Linear Program

$$\begin{aligned} & \text{maximize } \sum_{h \in H} h_i(s) \cdot w_h \text{ s.t.} \\ & \sum_{h \in H} mscf_h(\ell) \cdot w_h \leq \text{cost}(\ell) \text{ for } \ell \in L \\ & w_h \geq 0 \text{ for } h \in H \end{aligned}$$