Multi-Objective Parametric Query Optimization

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Paper Goal

Generalize Query Optimization

Traditional Query Optimization

- Input: query
- One cost metric
- Plan cost known
- Goal: find optimal plan

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$$\text{Cost}(\text{Plan}) \in \mathbb{R}$$

Parametric Query Optimization

- Input: query **template**
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$$\text{Cost(Plan)} \in \mathbb{R}^N \rightarrow \mathbb{R}$$

Multi-Objective Query Optimization

- Input: query
- **Multiple** cost metrics
- Plan cost known
- Goal: find **Pareto-optimal** plans

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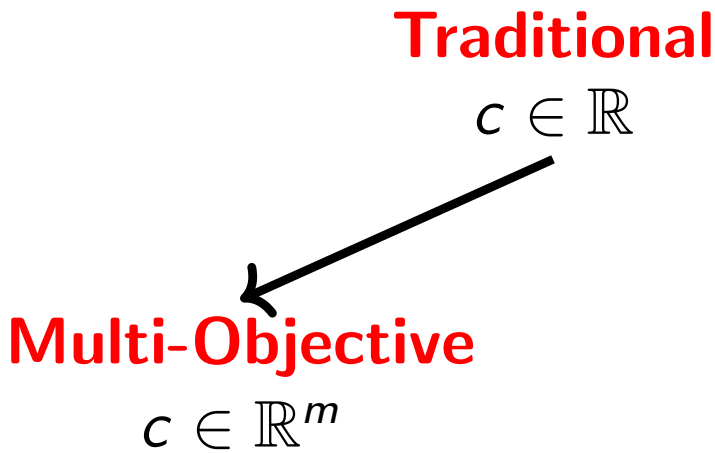
Cost Models of Query Optimization Variants

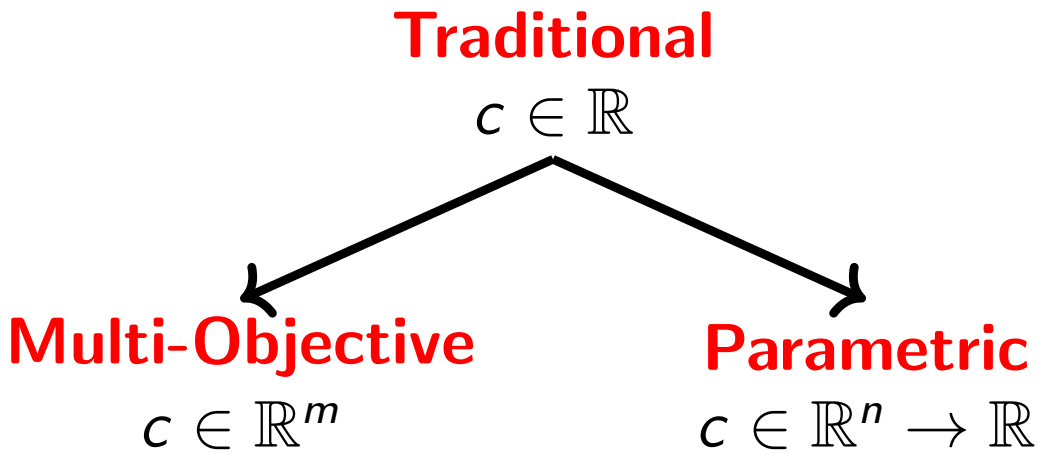
Traditional

$c \in \mathbb{R}$

Cost Models of Query Optimization Variants



Cost Models of Query Optimization Variants



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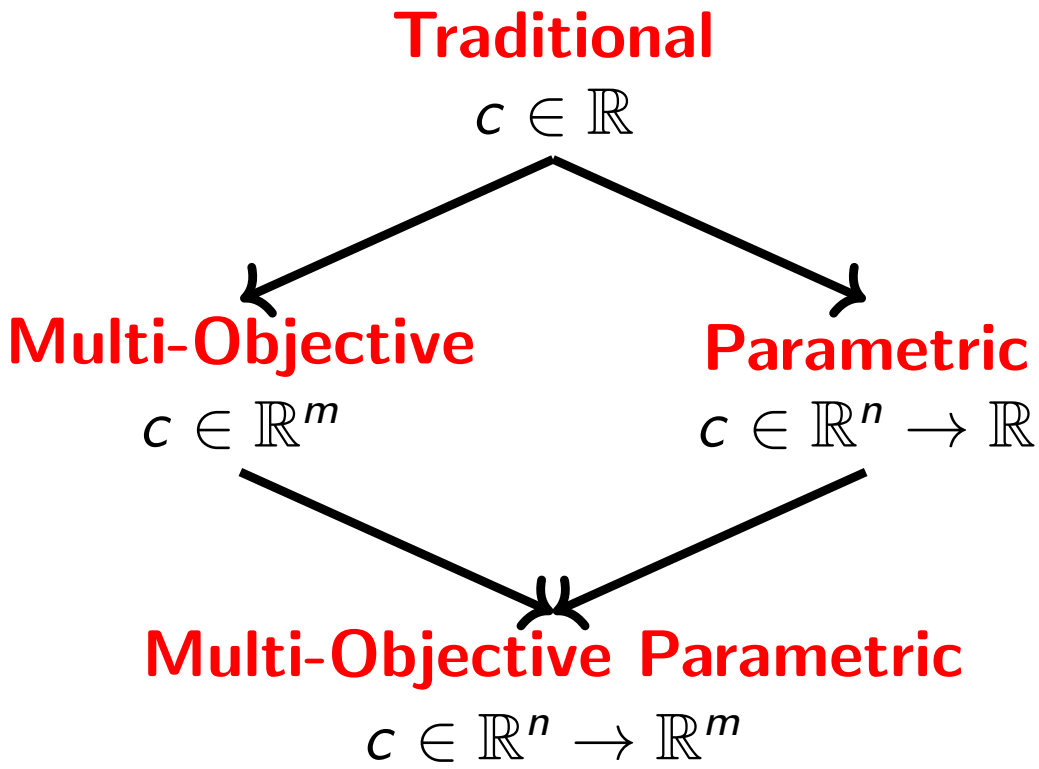
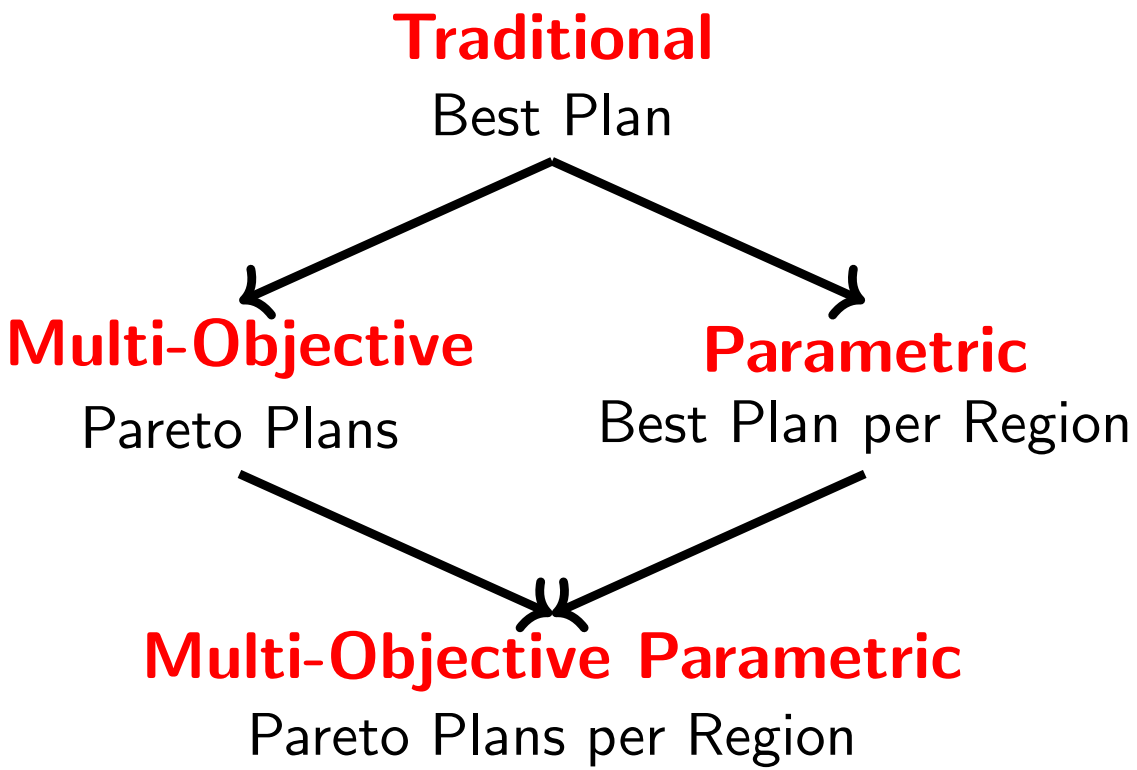
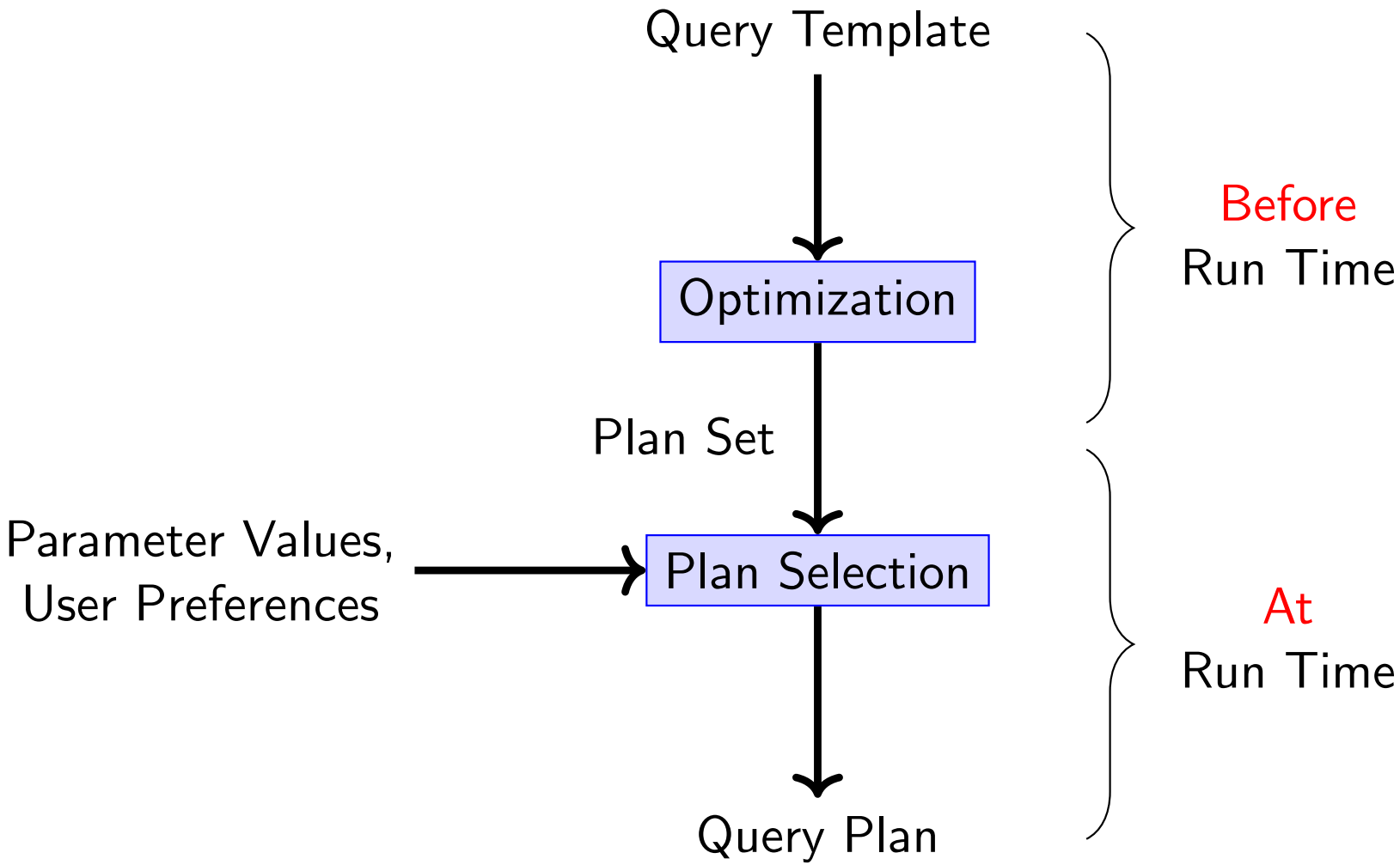


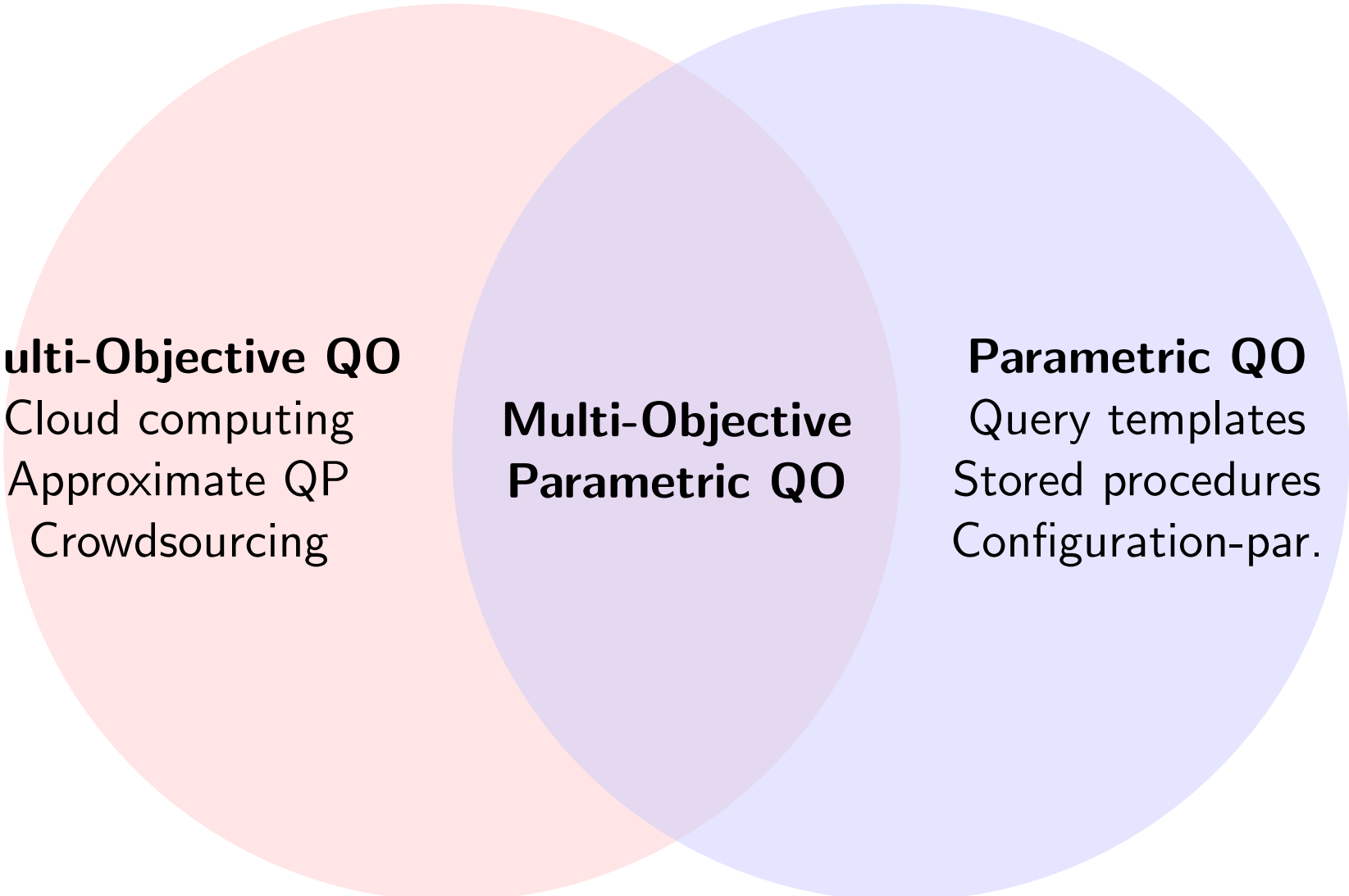
Optimization Goals



Context of MPQ



Application Scenarios



Paper Contribution Overview

- Formalize & analyze MPQ
- Propose first algorithm
- Theoretical analysis of algorithm
- Experimental evaluation

Dynamic Programming Scheme

Dynamic Programming Scheme

QUERY: $R \bowtie S \bowtie T$

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1-Table Sets	R	S	T
	Pareto Plans	Pareto Plans	Pareto Plans

Dynamic Programming Scheme

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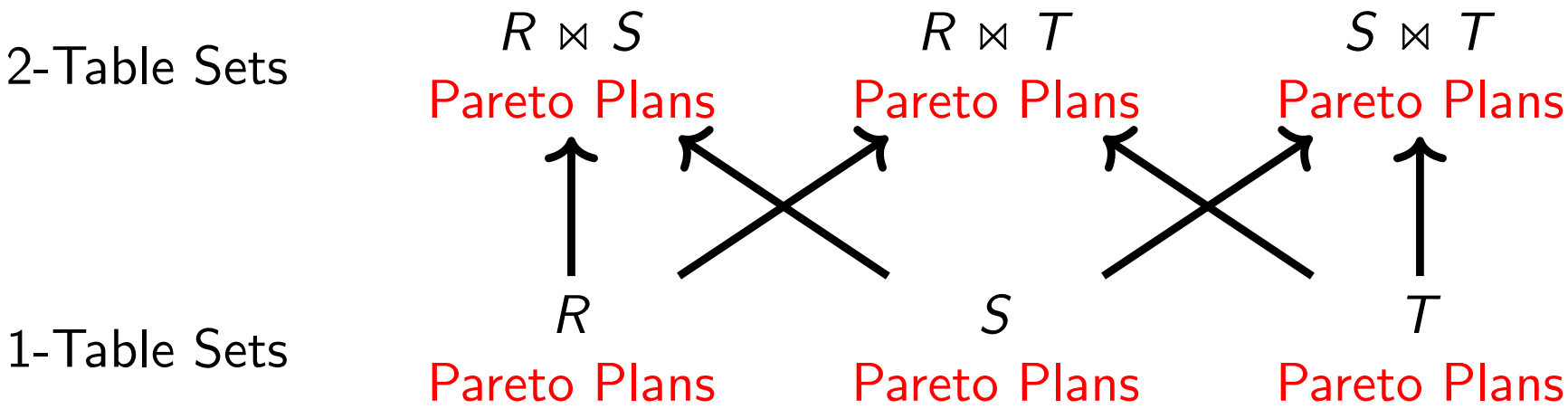

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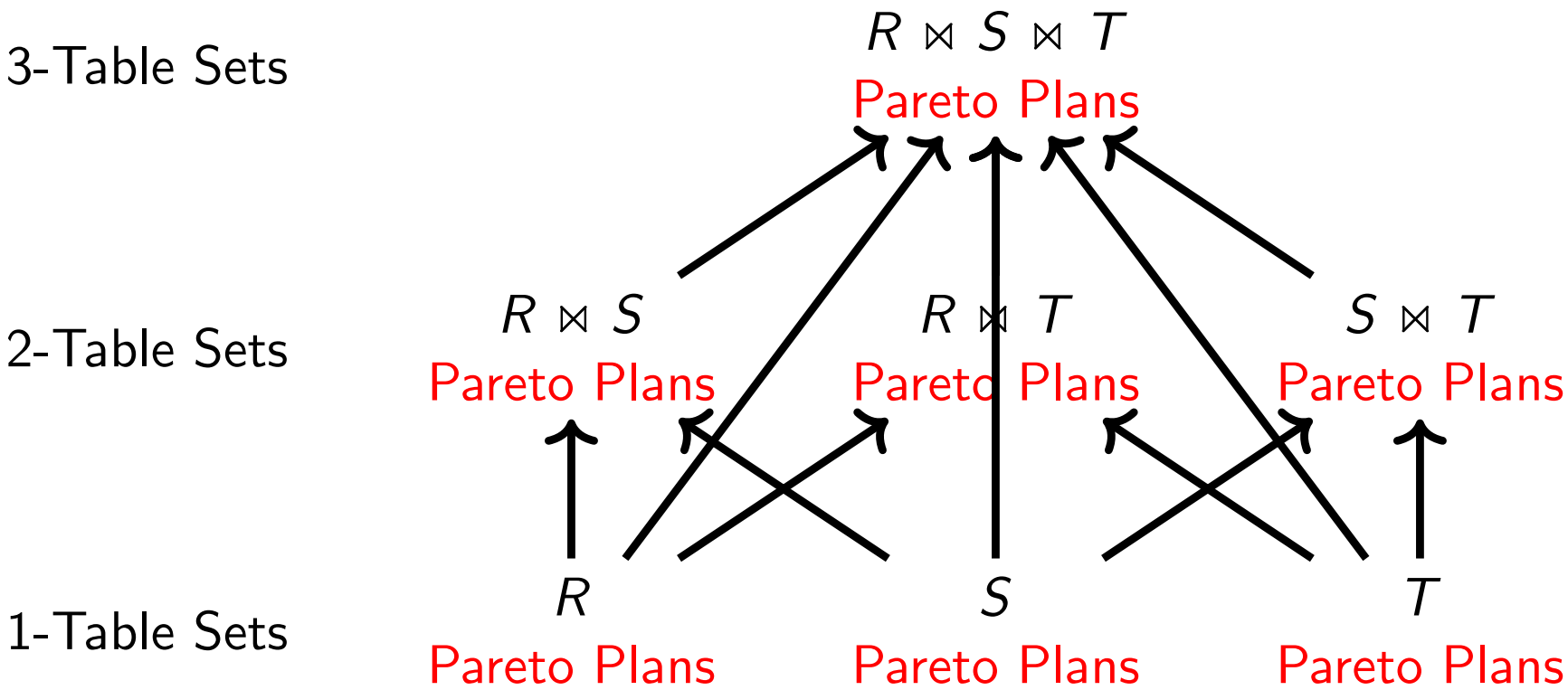

Pruning Overview

- Each query plan p maps to a Pareto region $R(p)$
- Compare plans pairwise during pruning:
  If p_1 dominates p_2 in X then $R(p_2) \leftarrow R(p_2) \setminus X$
- Plans with empty Pareto region are discarded

Questions

- Shape of Pareto regions?
- How to represent them?
- How to implement comparison, reduction, emptiness check?

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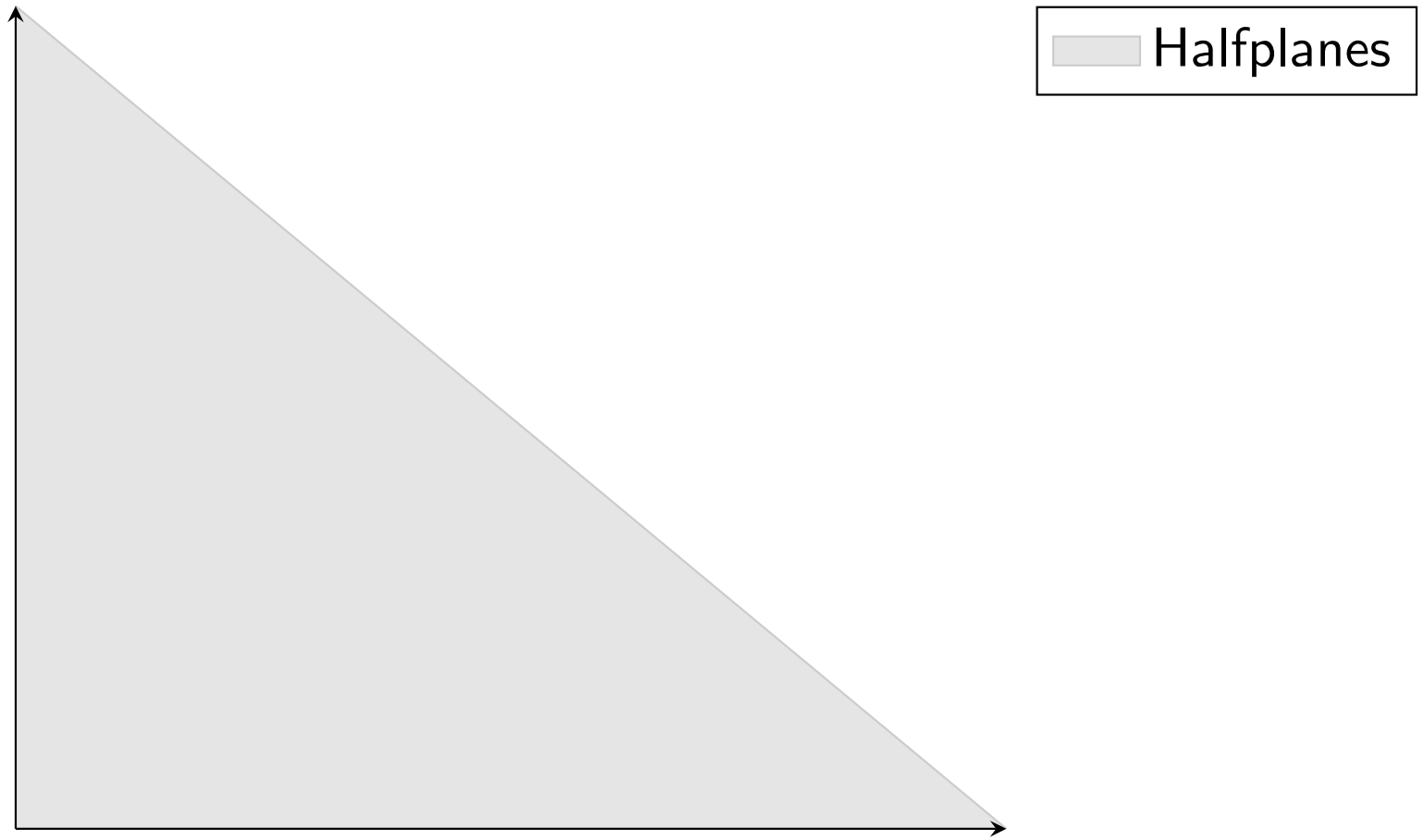
Choose: Piece-wise Linear Plan Cost Functions

Answer

- Region representation based on convex polytopes

Convex Polytopes: Intersections of Half-Planes



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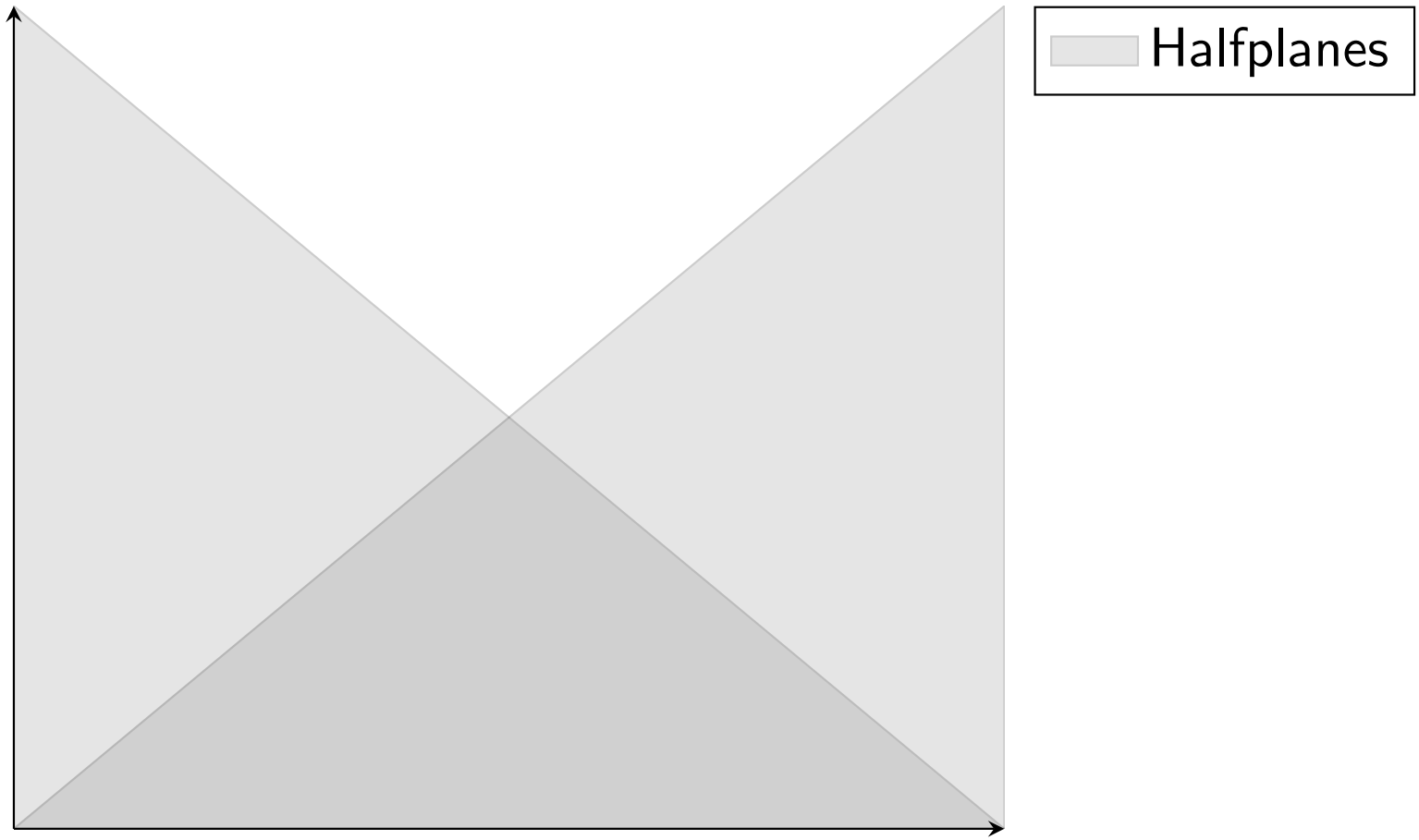

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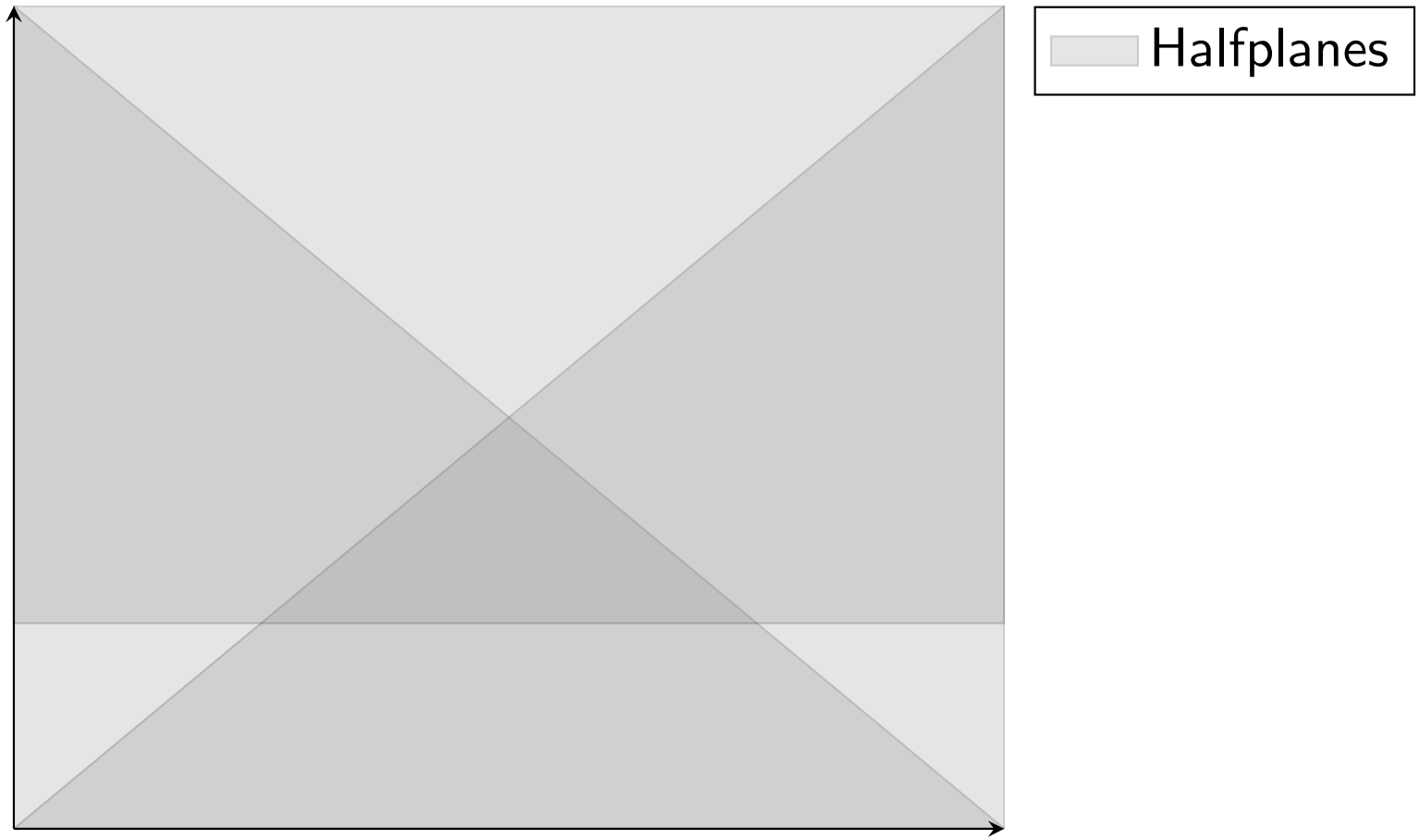

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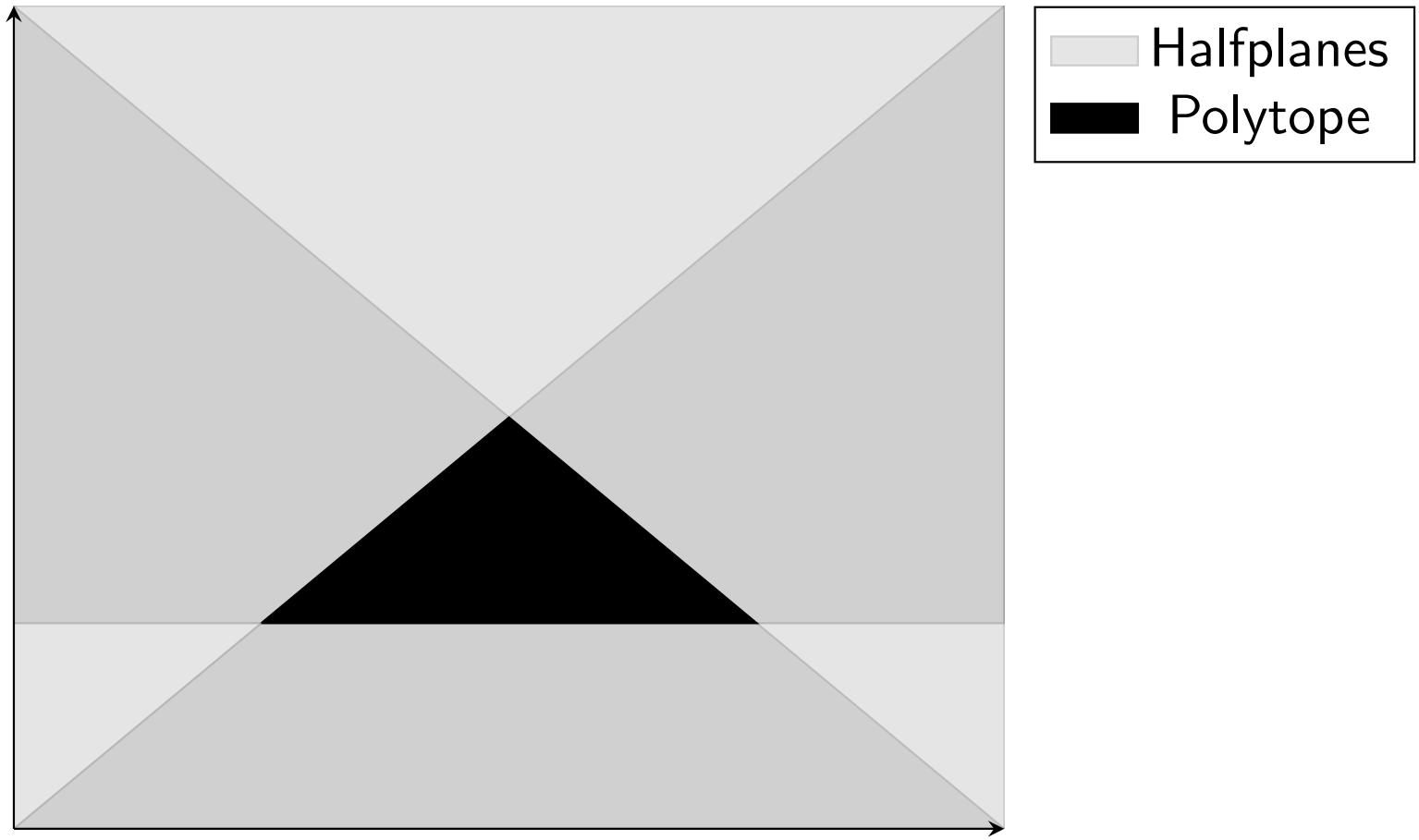

Answer

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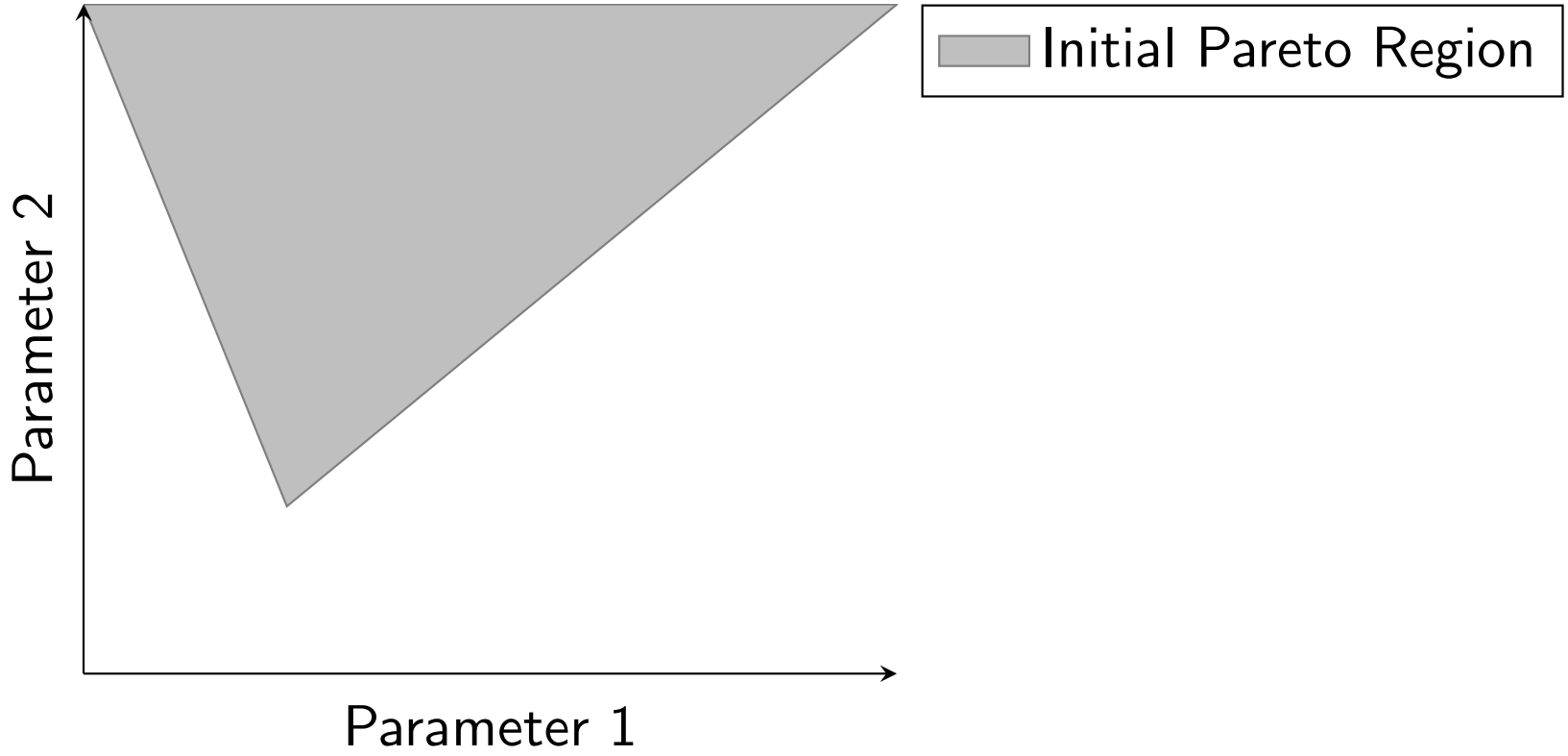
- Region representation based on convex polytopes
- Pareto region: union of sub-regions
- Sub-region: convex polytope minus union of convex polytopes
- Implement basic operations using linear programming solver

Pruning Illustration



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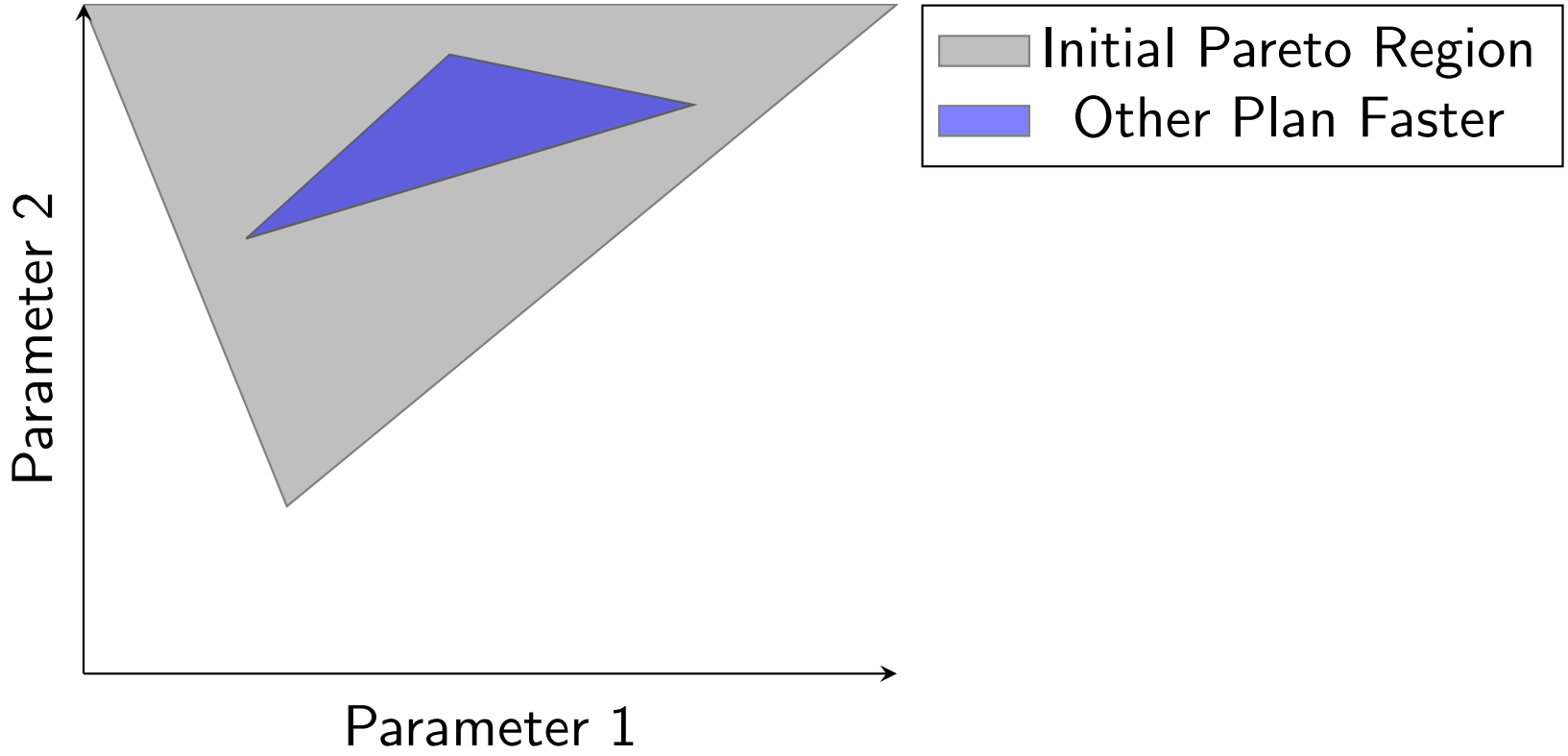

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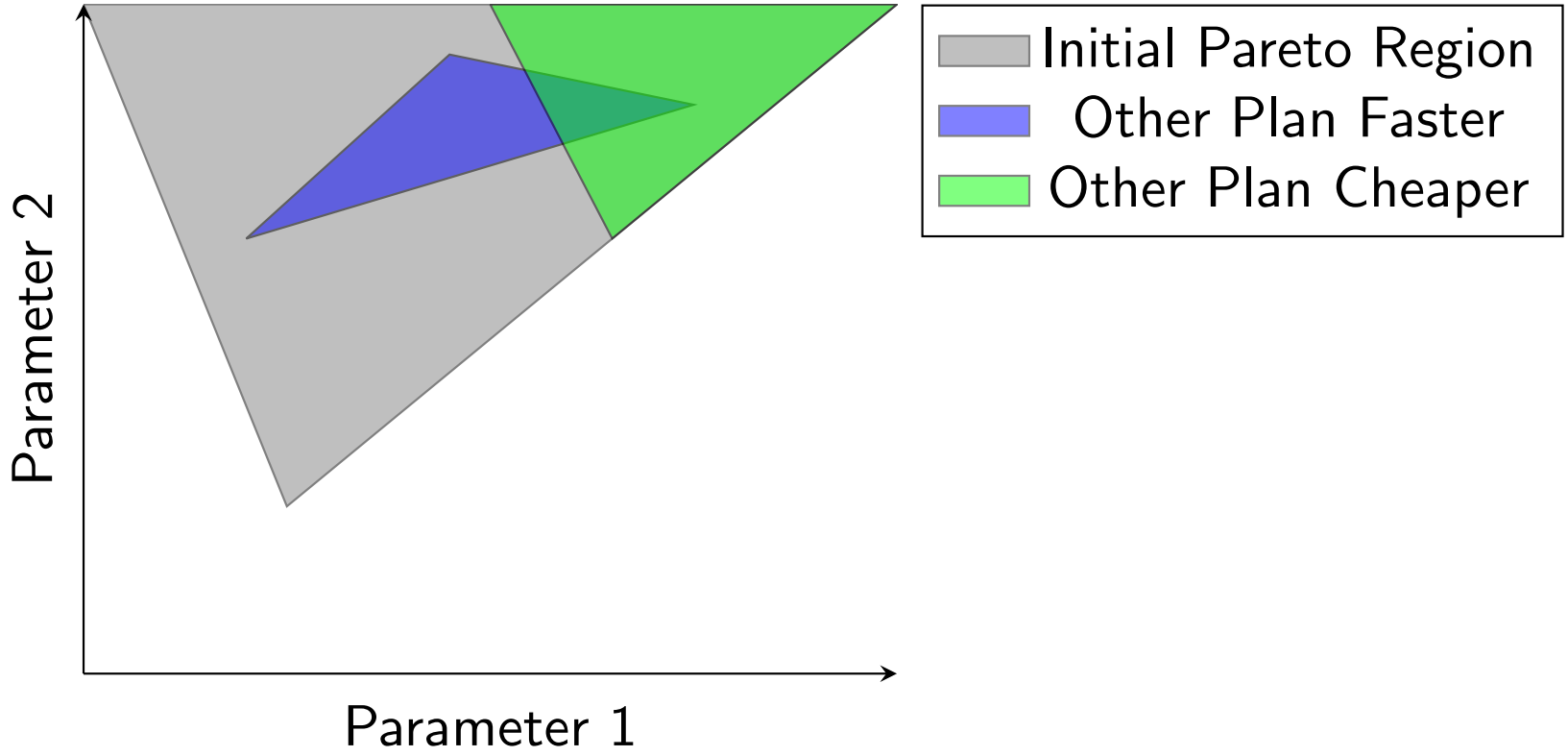

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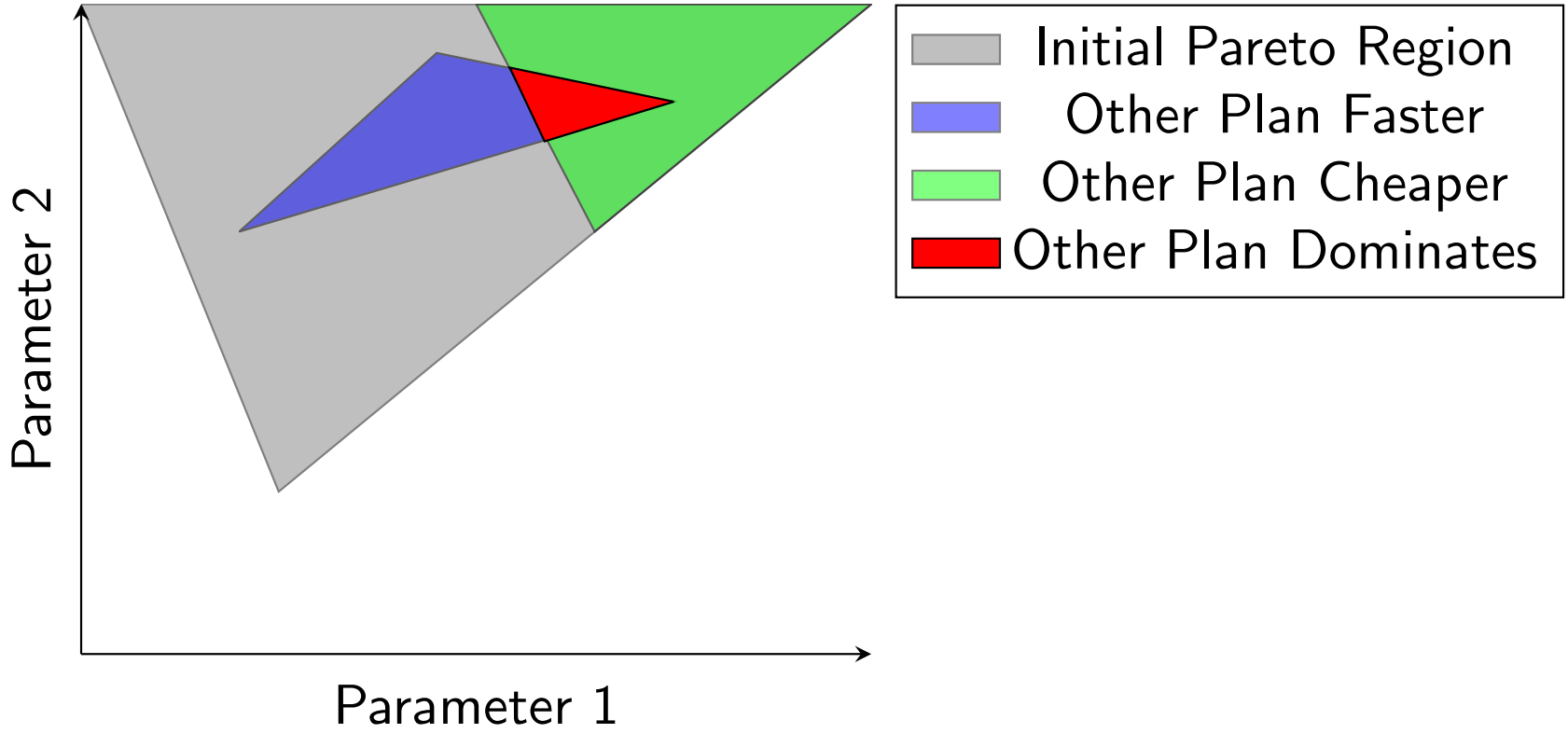

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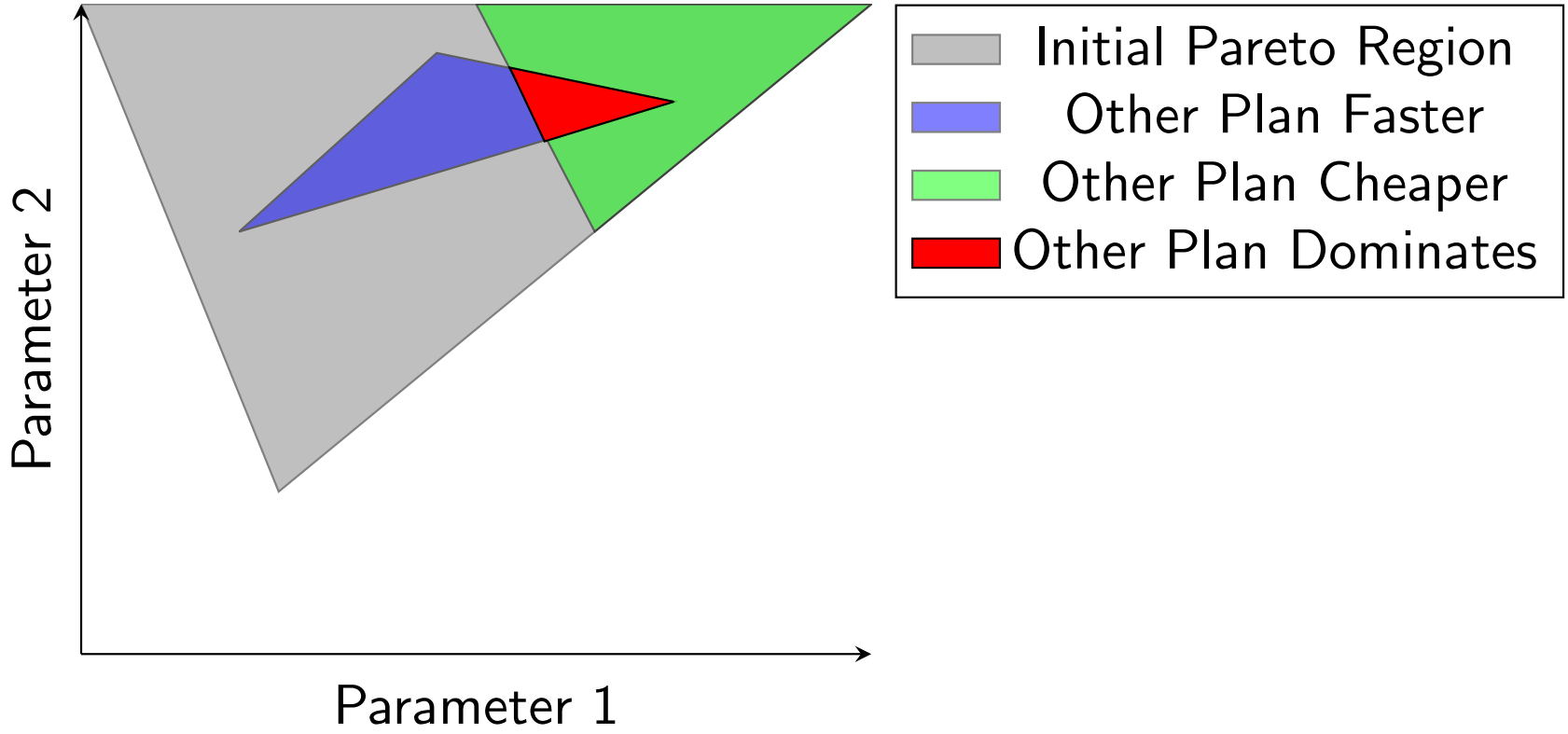
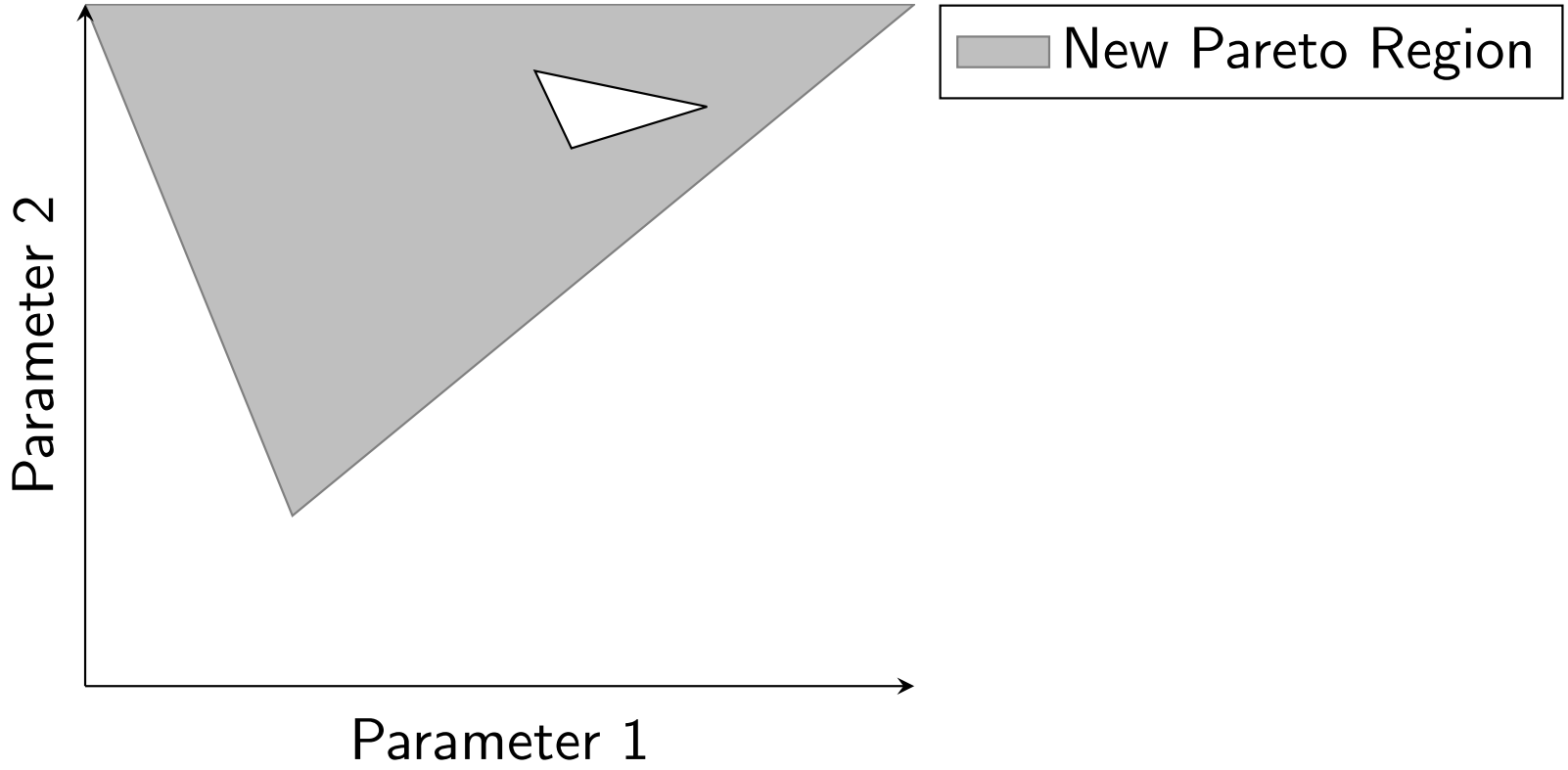


Dominated Area is Removed from Pareto Region

Pruning Illustration



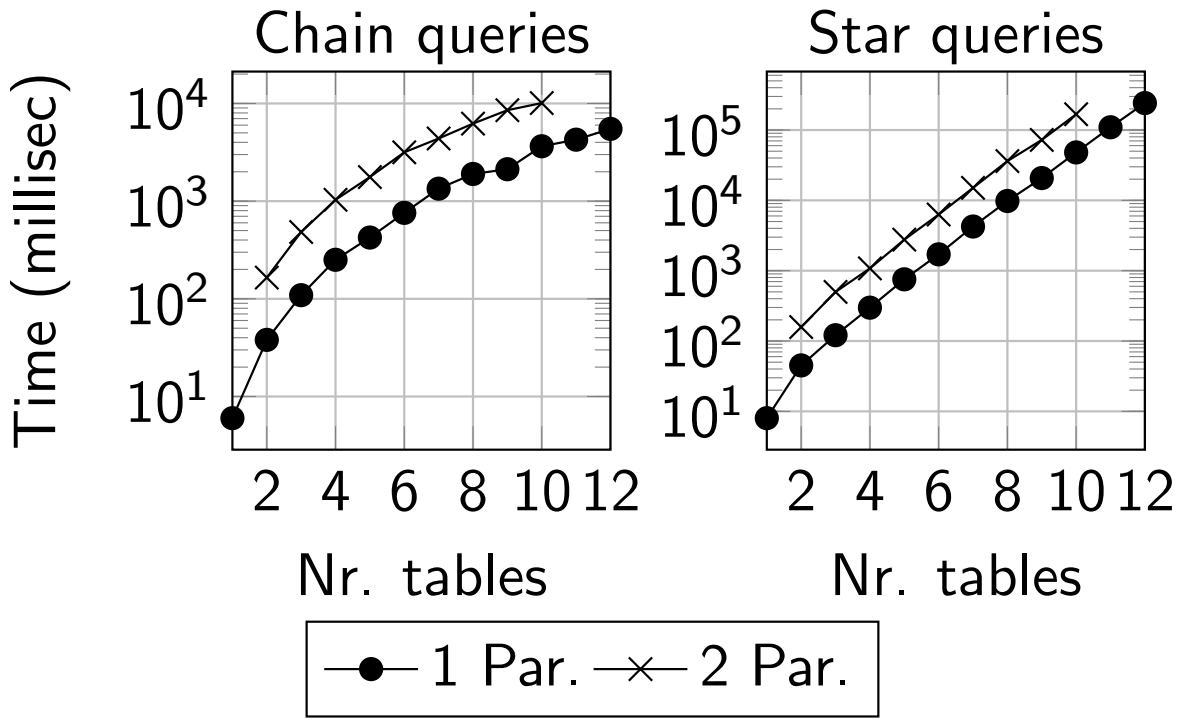
Complexity Analysis

Query Optimization Variant	**Nr. Pareto Plans per Relation**
Traditional	1
Multi-Objective	$2^{nrMetrics}$
Multi-objective Parametric	$2^{(nrParams+1)\cdot nrMetrics}$

Experimental Setup

- **Benchmark**
  - Randomly generated queries
  - Different query structures
  - Cloud scenario with two objectives
- **Algorithms**
  - Multi-objective parametric optimizer
- **Comparison**
  - Measure optimization time
  - Vary number of query tables

Experimental Results (Extract)



Conclusion

- Generalized query optimization model
- Presented first MPQ algorithm
- Future work: heuristics, approximation, ...

Thanks for your Attention!

Questions?

Slides/More on Query Optimization:
`www.itrummer.org`