Optimal Decision Trees for Interpretable Clustering with Constraints

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VECTOR INSTITUTE FOR ARTIFICIAL INTELLIGENCE

CP'23 DOCTORAL PROGRAM

ORIGINALLY APPEARED AT IJCAI-23

Overview

Constrained Clustering

- Semi-supervised

Decision Trees

- Interpretable Classifiers

Decision Tree Clustering

- No constraint support
- No optimality guarantee

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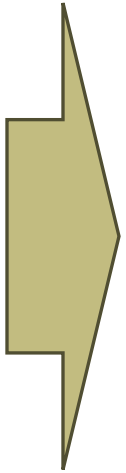
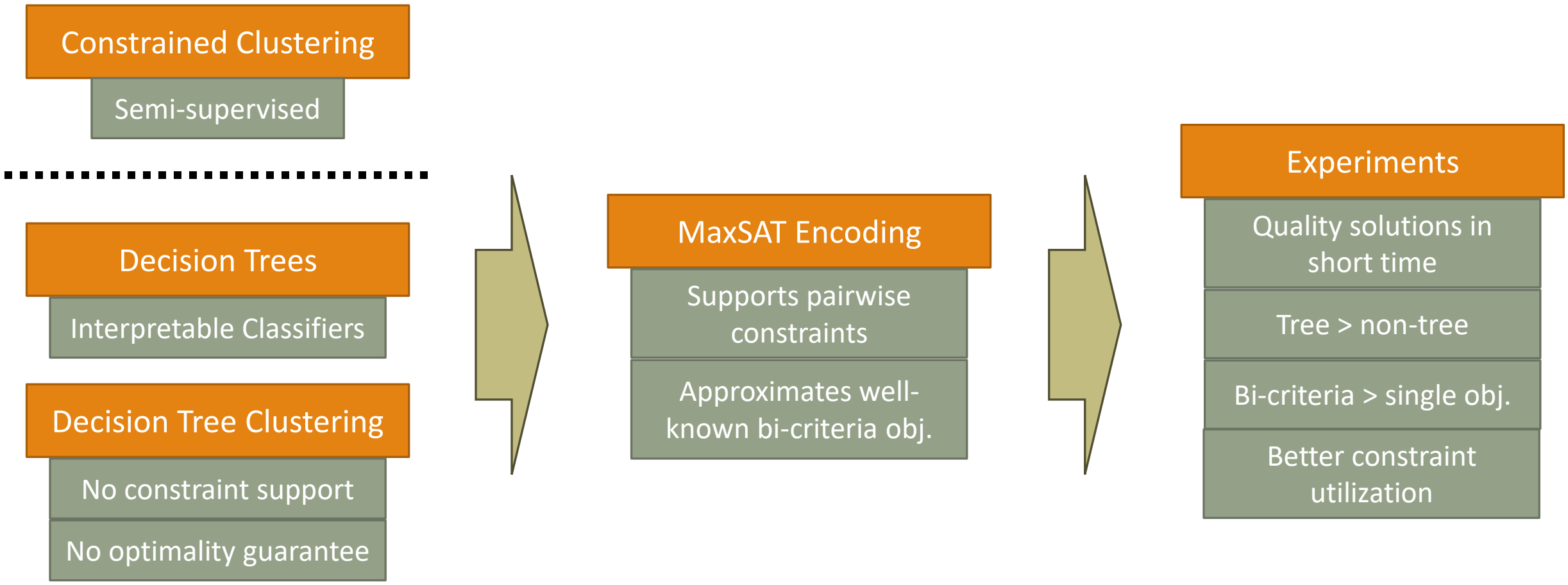


MaxSAT Encoding

Supports pairwise constraints

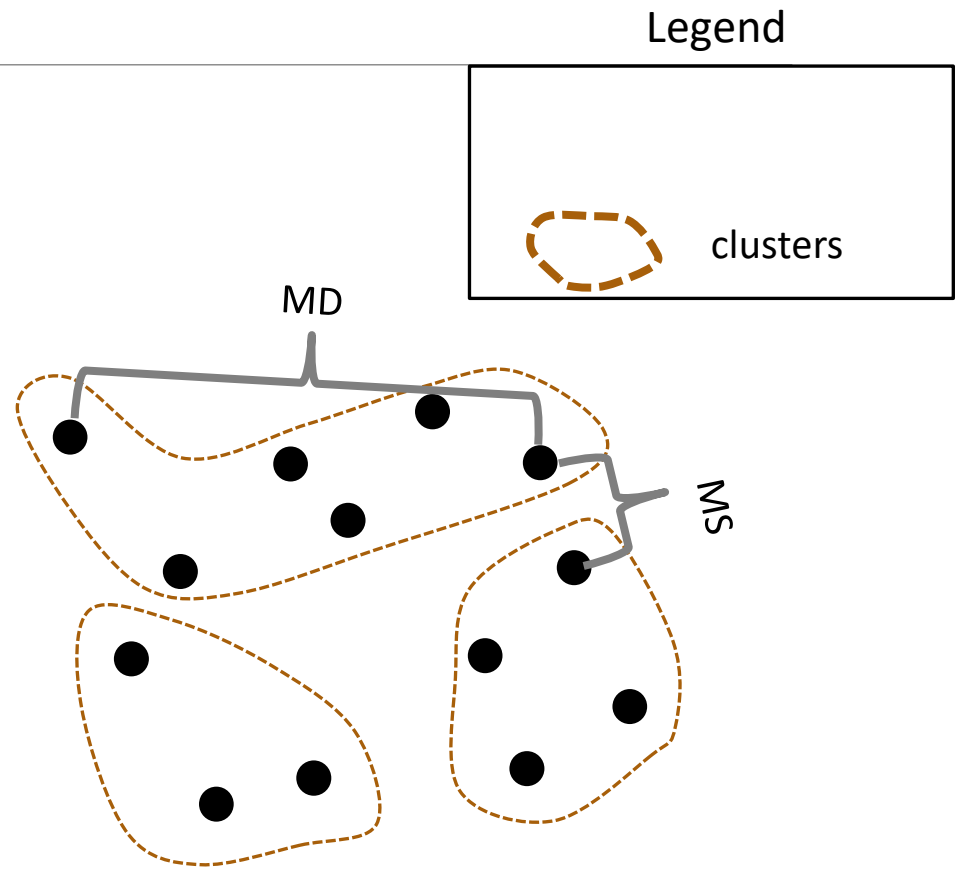
Approximates well-known bi-criteria obj.

Overview


Constrained Clustering
Semi-supervised
Decision Trees
Interpretable Classifiers
Decision Tree Clustering
No constraint support
No optimality guarantee
MaxSAT Encoding
Supports pairwise constraints
Approximates well-known bi-criteria obj.
Experiments
Quality solutions in short time
Tree > non-tree
Bi-criteria > single obj.
Better constraint utilization

Problem Definition

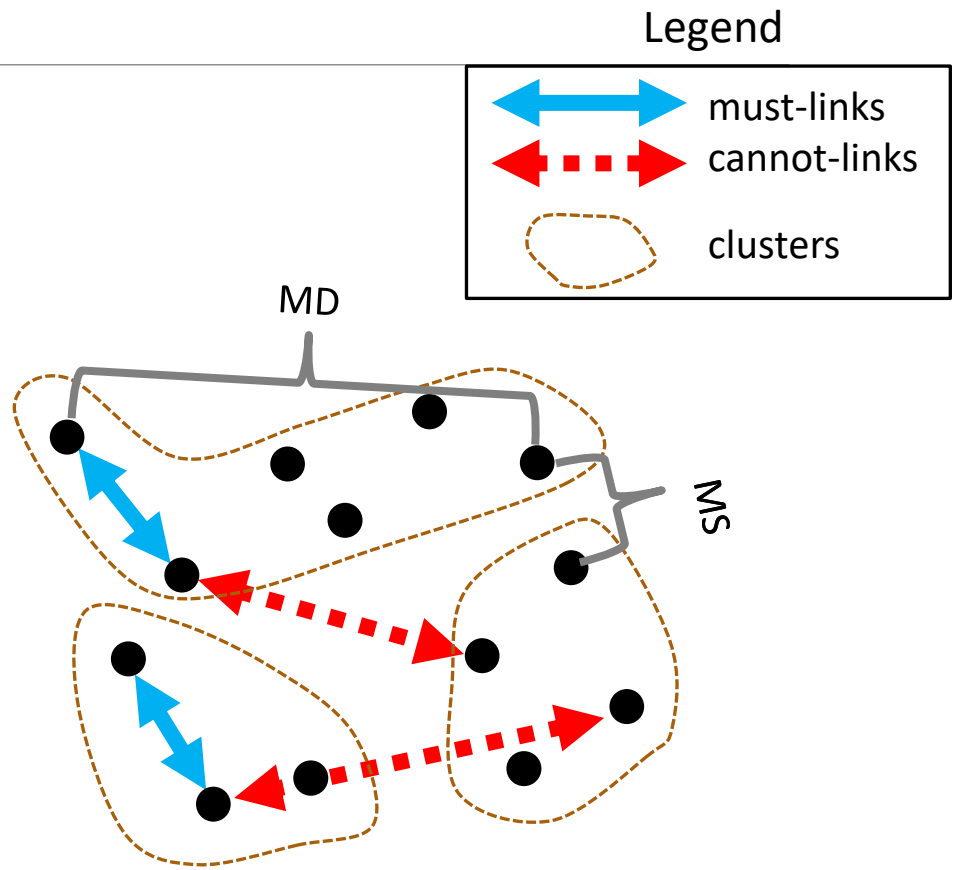
- **Bi-criteria** objective:
  - **Maximize** minimum split **(MS)** between clusters
  - **Minimize** maximum diameter **(MD)** within clusters



Problem Definition

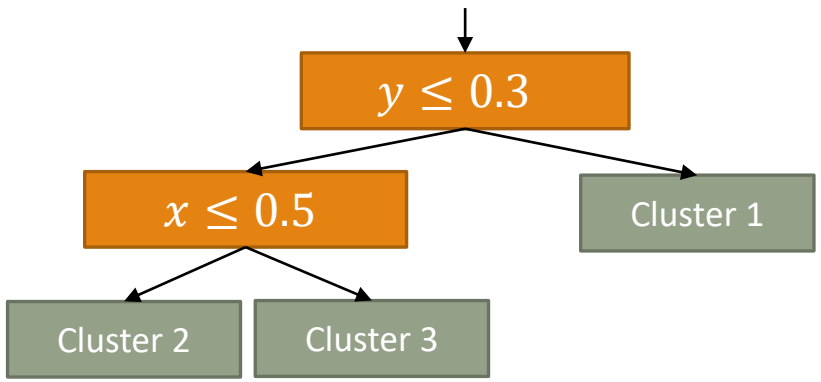
- **Bi-criteria** objective:
  - **Maximize** minimum split **(MS)** between clusters
  - **Minimize** maximum diameter **(MD)** within clusters

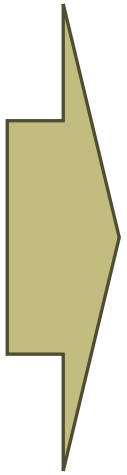
- **Pairwise** Constraints:
  - **Must-links:** pairs that should be in the same cluster
  - **Cannot-links:** pairs that should be in different clusters

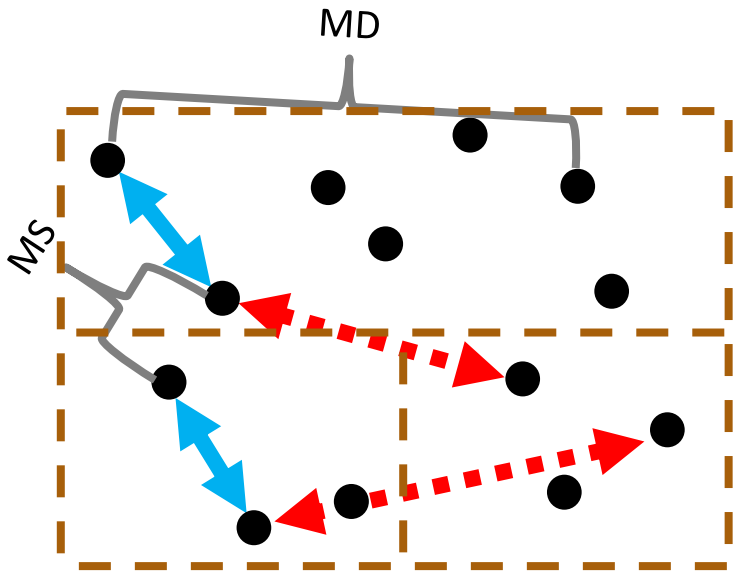


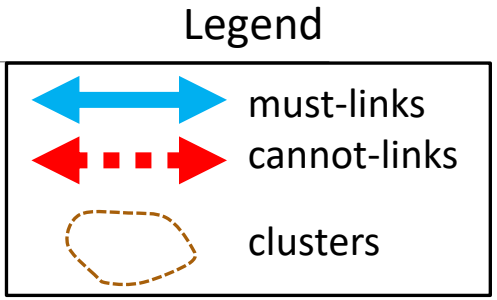
Problem Definition

- **Decision tree** clustering:



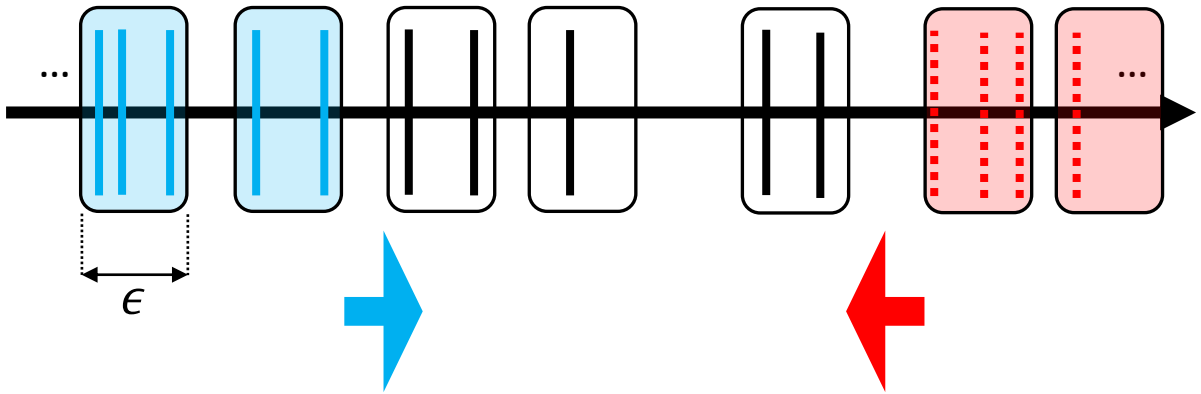






Encoding

- All distances of pairs sorted into **distance classes**



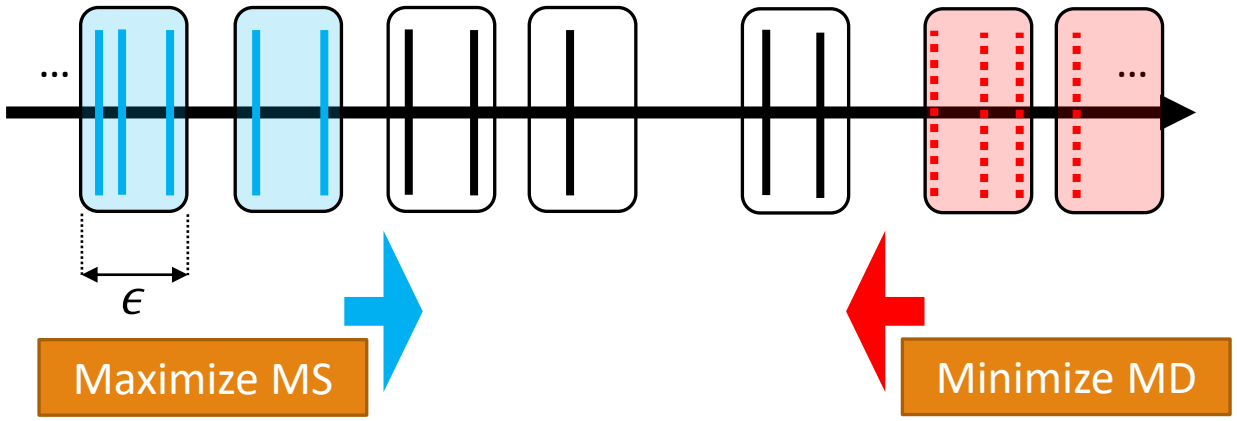
Legend

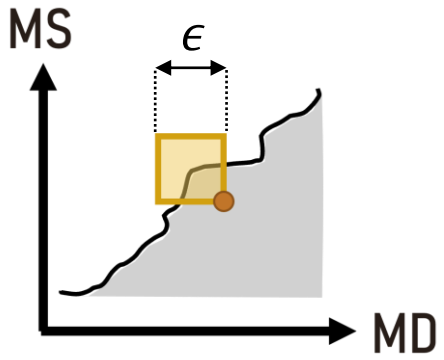
same cluster

diff. clusters

Encoding

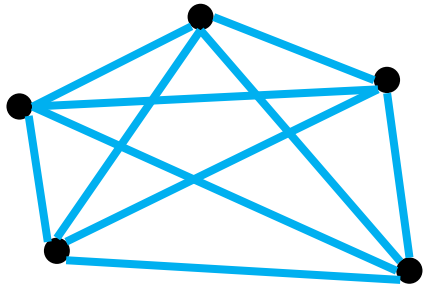
- All distances of pairs sorted into **distance classes**

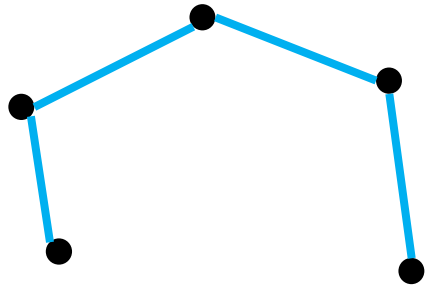




Smart Pairs

- **Linear** number of clauses enough to enforce **quadratic** number of must-links





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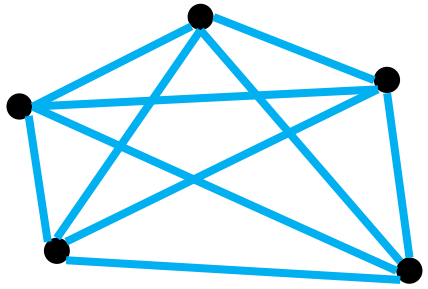
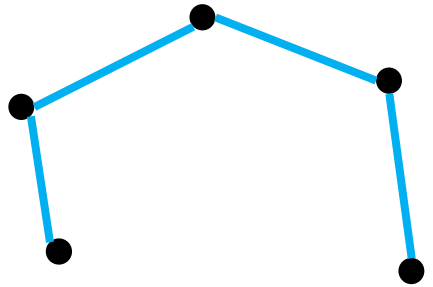




	Constraints	Conditional
Force to be in the same cluster	Must-link	MS obj.
Force to be in different clusters	Cannot-link	MD obj.

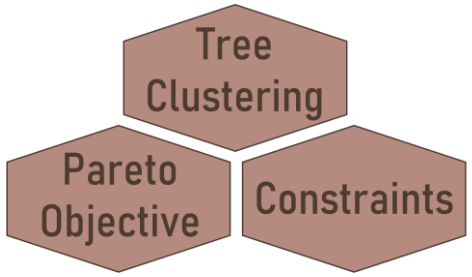
Smart Pairs

Detect **redundant** edges

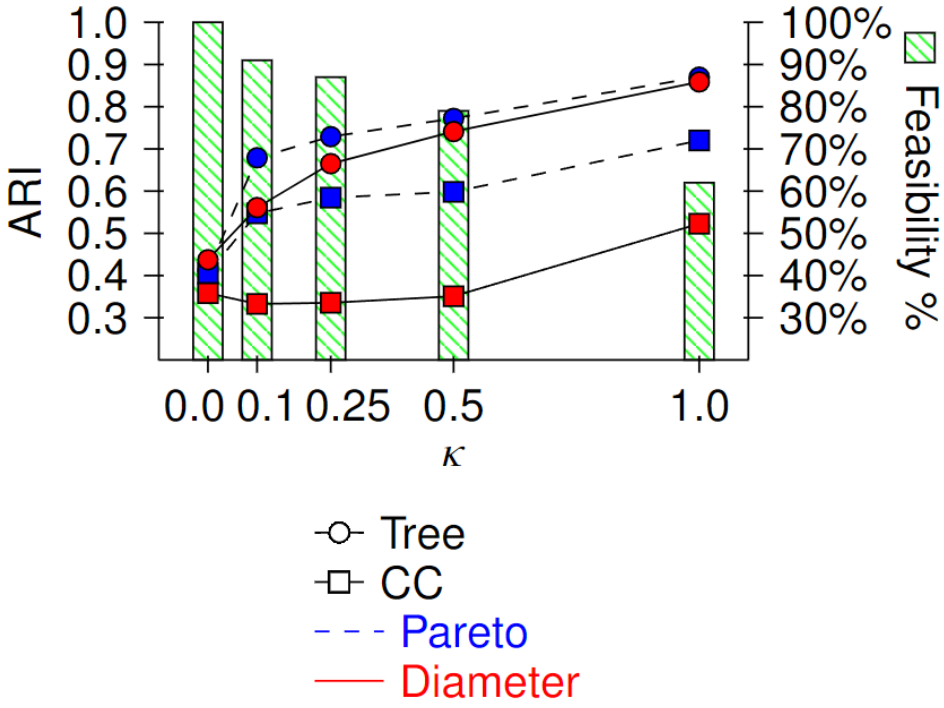
Detect **infeasible** edges

Better Score + Better Interpretability

- High quality solutions in a short time



- Improve the solution individually
- Complement each other



- Trade-off between quality and feasibility

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Thank you for your time!

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