Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG

Lehrstuhl für
INFORMATIK I
Algorithmen & Komplexität

Institut für Informatik

Layered Drawing of Undirected Graphs with Generalized Port Constraints

Julian Walter, **Johannes Zink**,
Joachim Baumeister, Alexander Wolff

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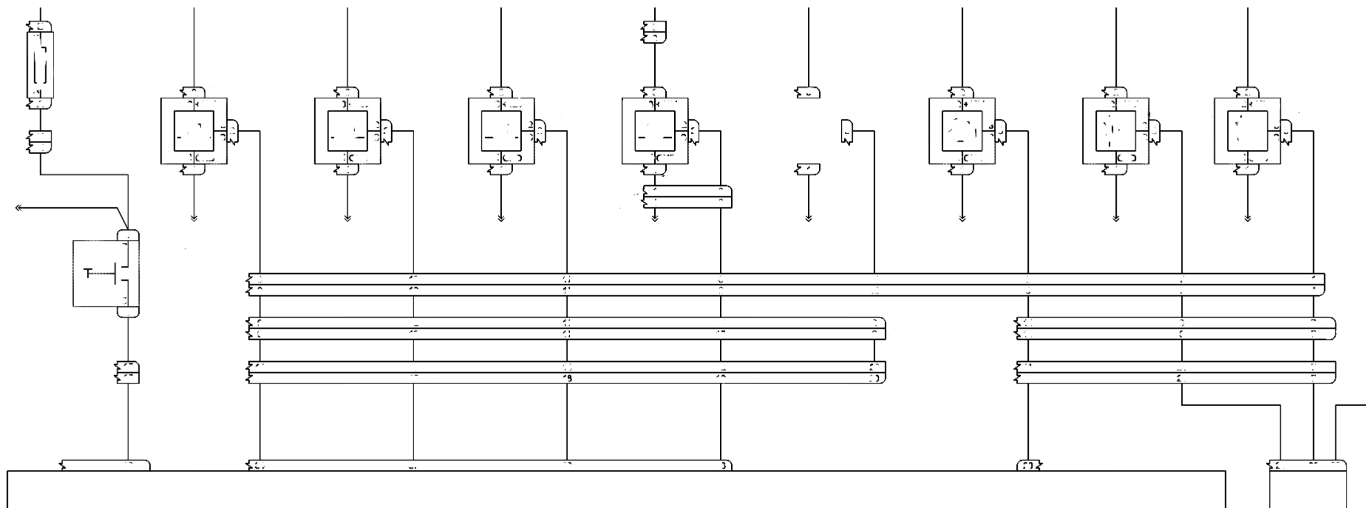

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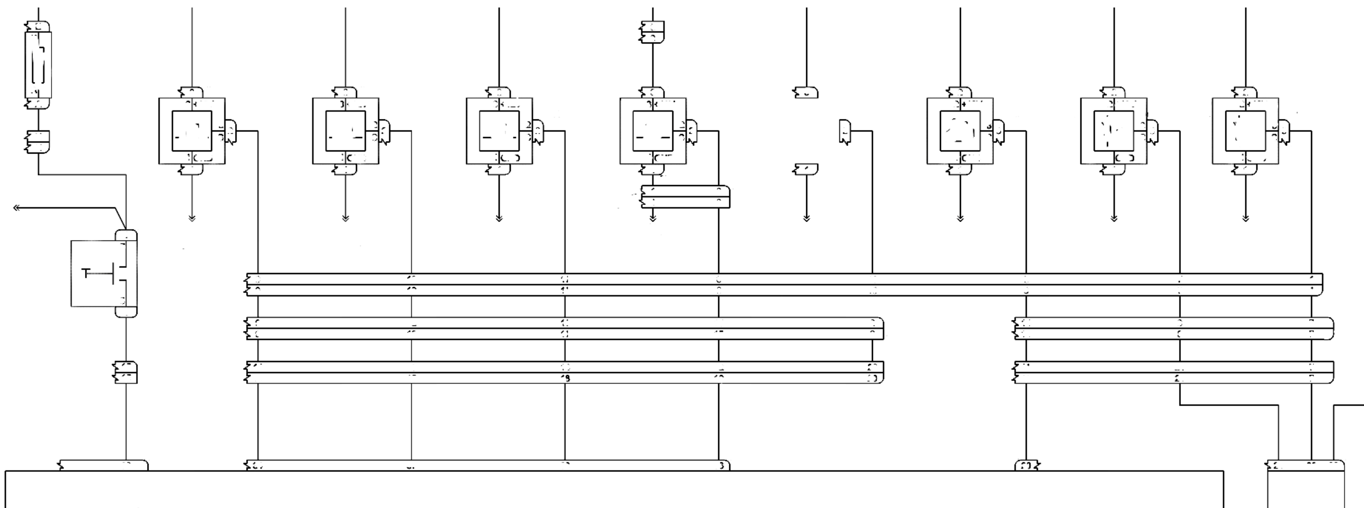

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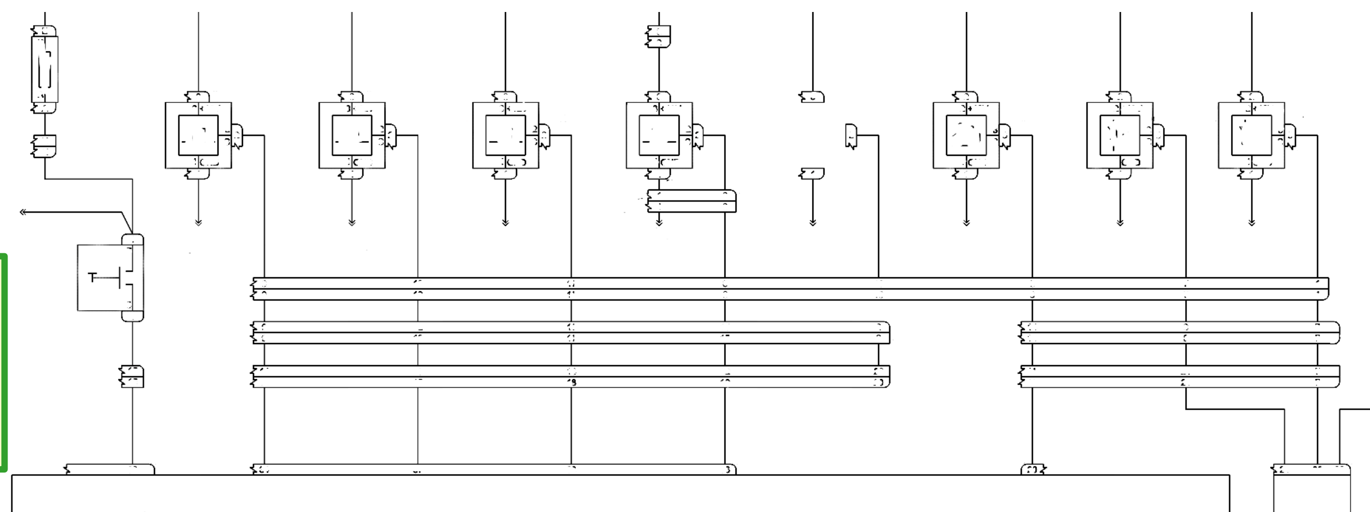

$\Rightarrow$ **use layered graph drawing algorithm**

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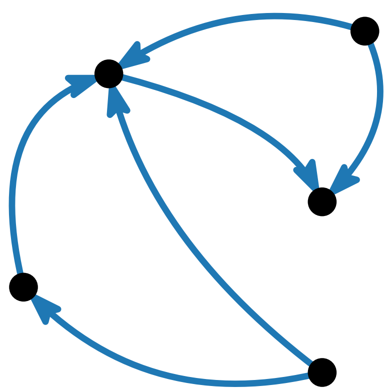

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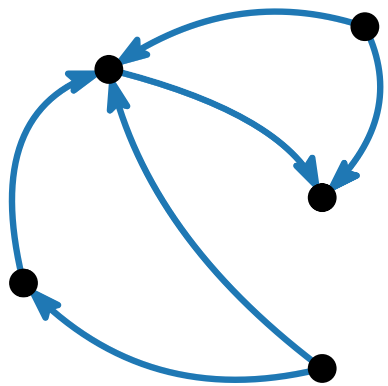

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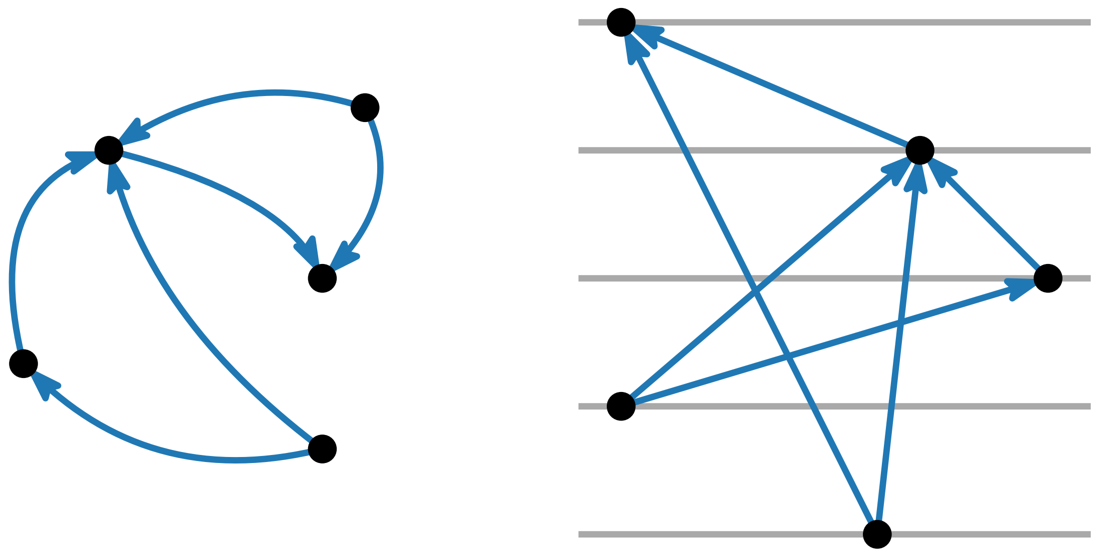

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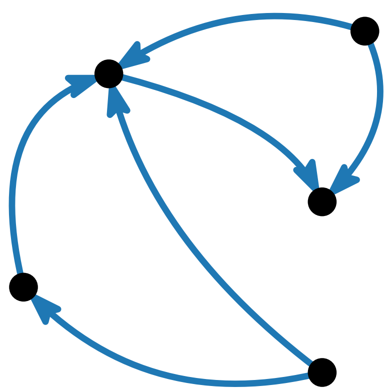

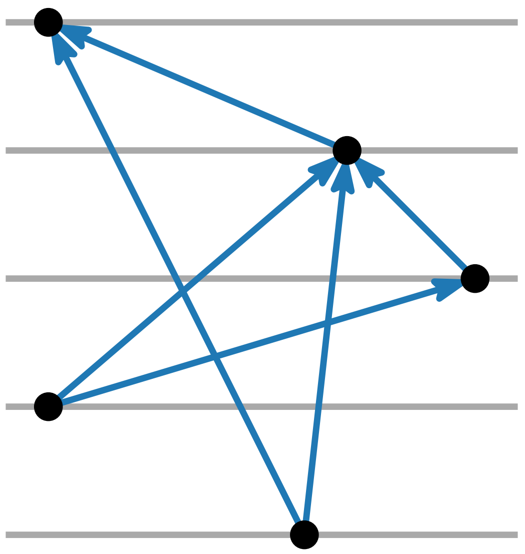

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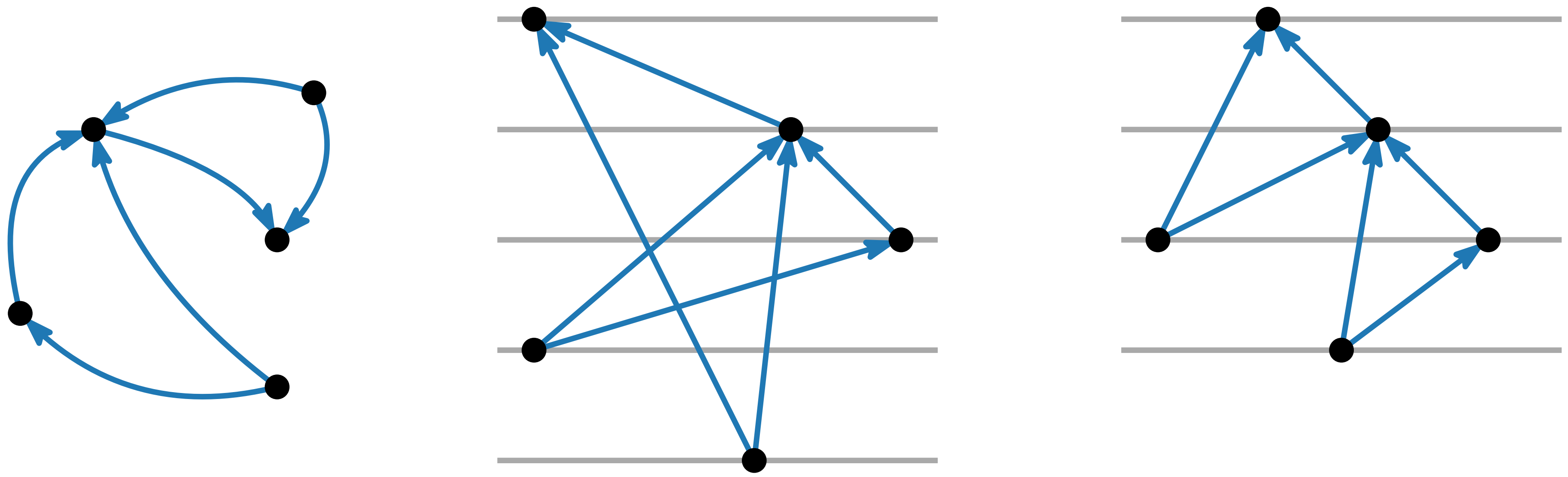

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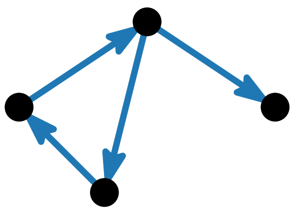

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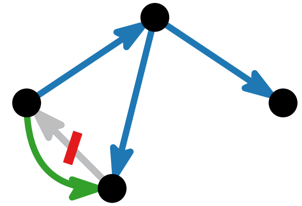

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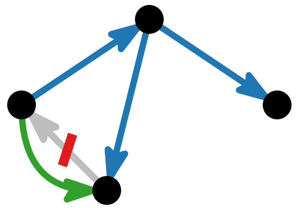

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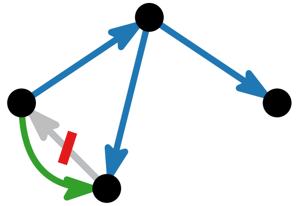

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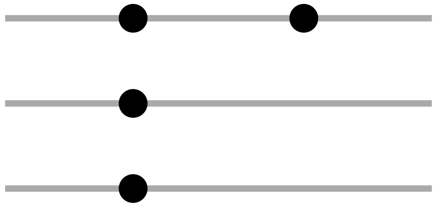

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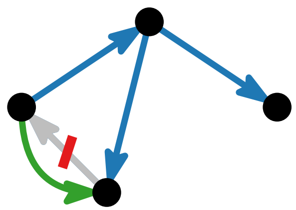

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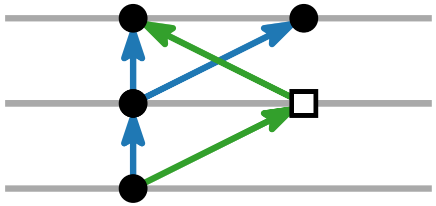

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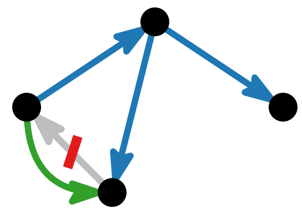

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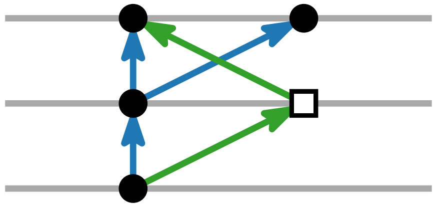

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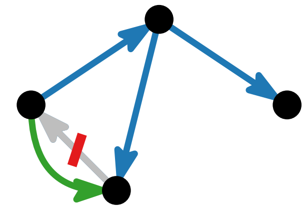

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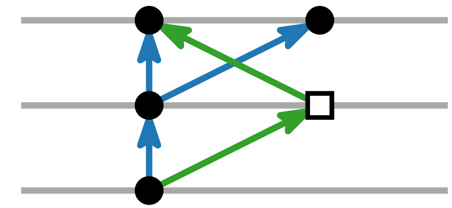

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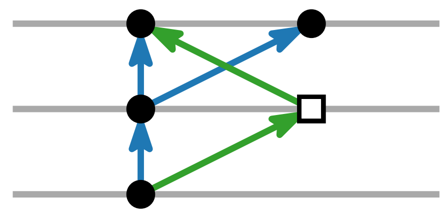

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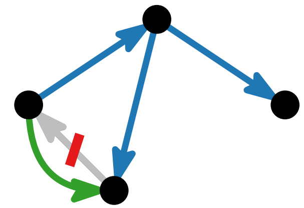

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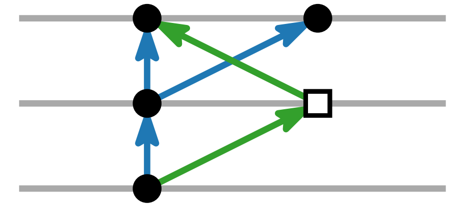

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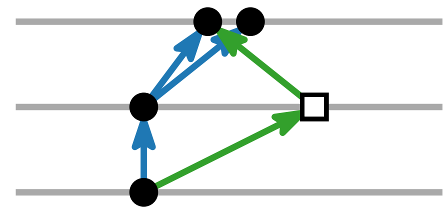

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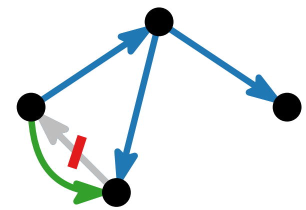

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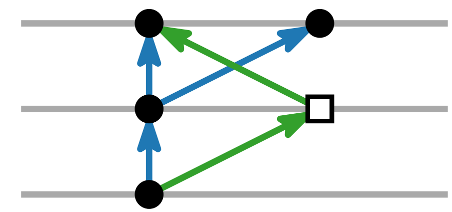

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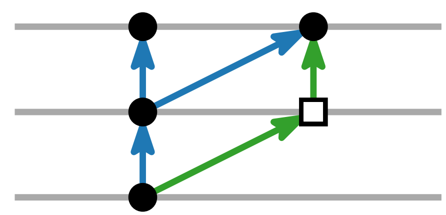

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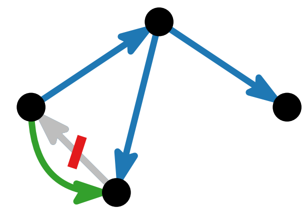

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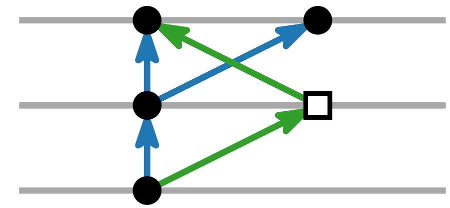

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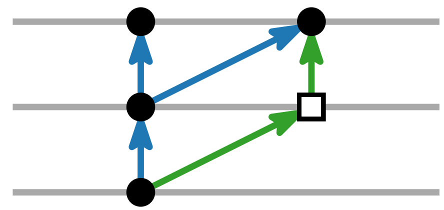

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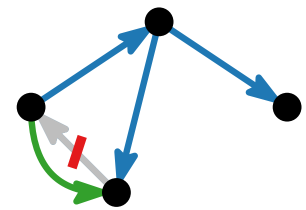

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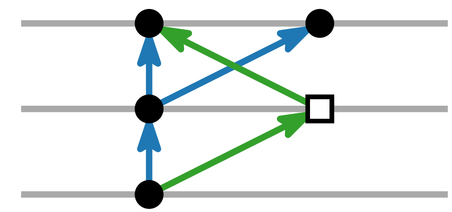

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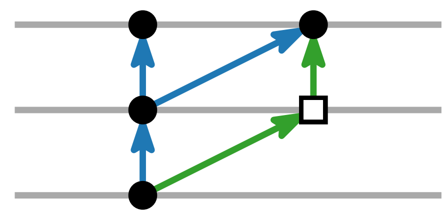

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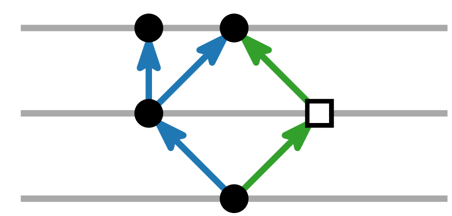

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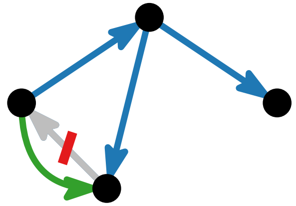

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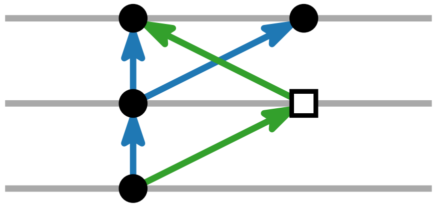

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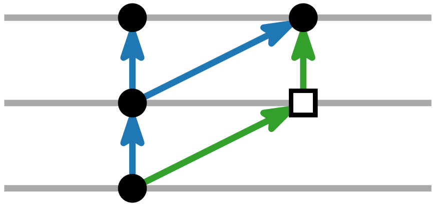

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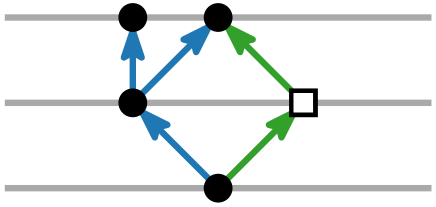

5. edge routing

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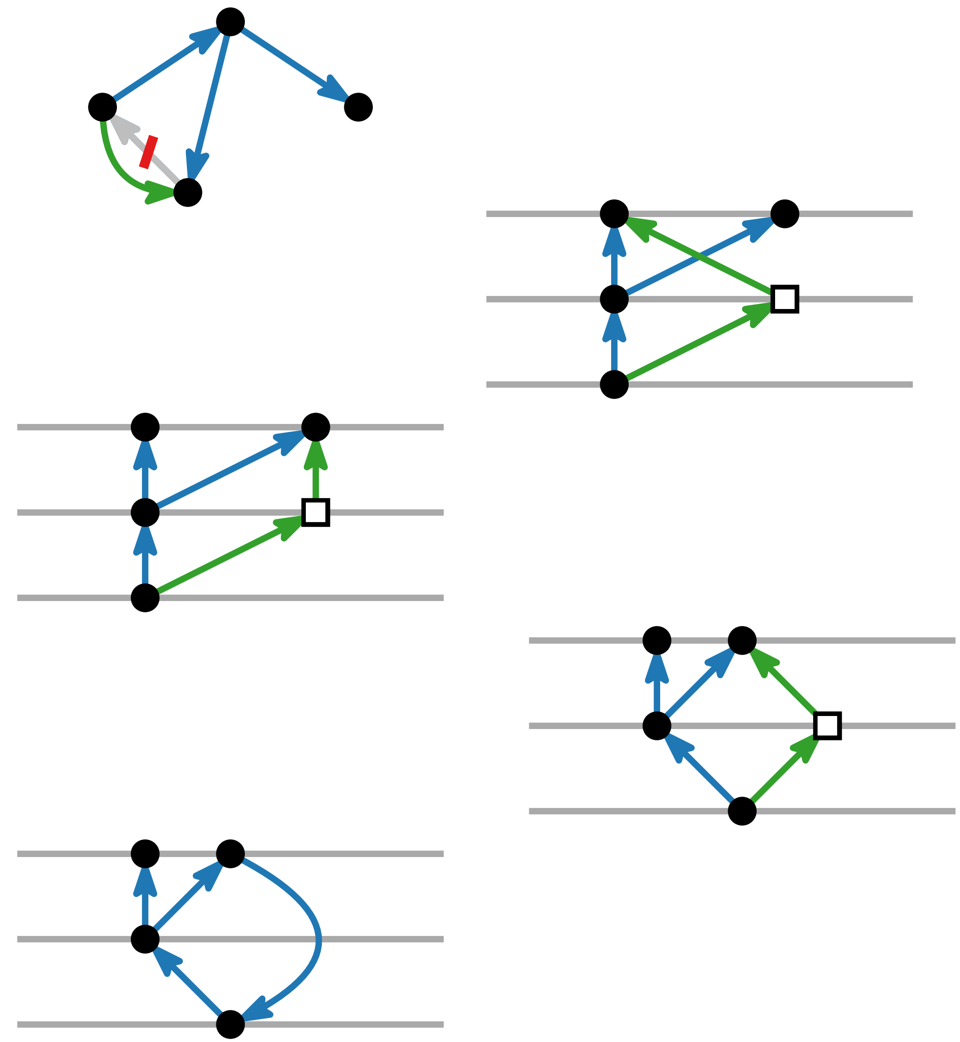

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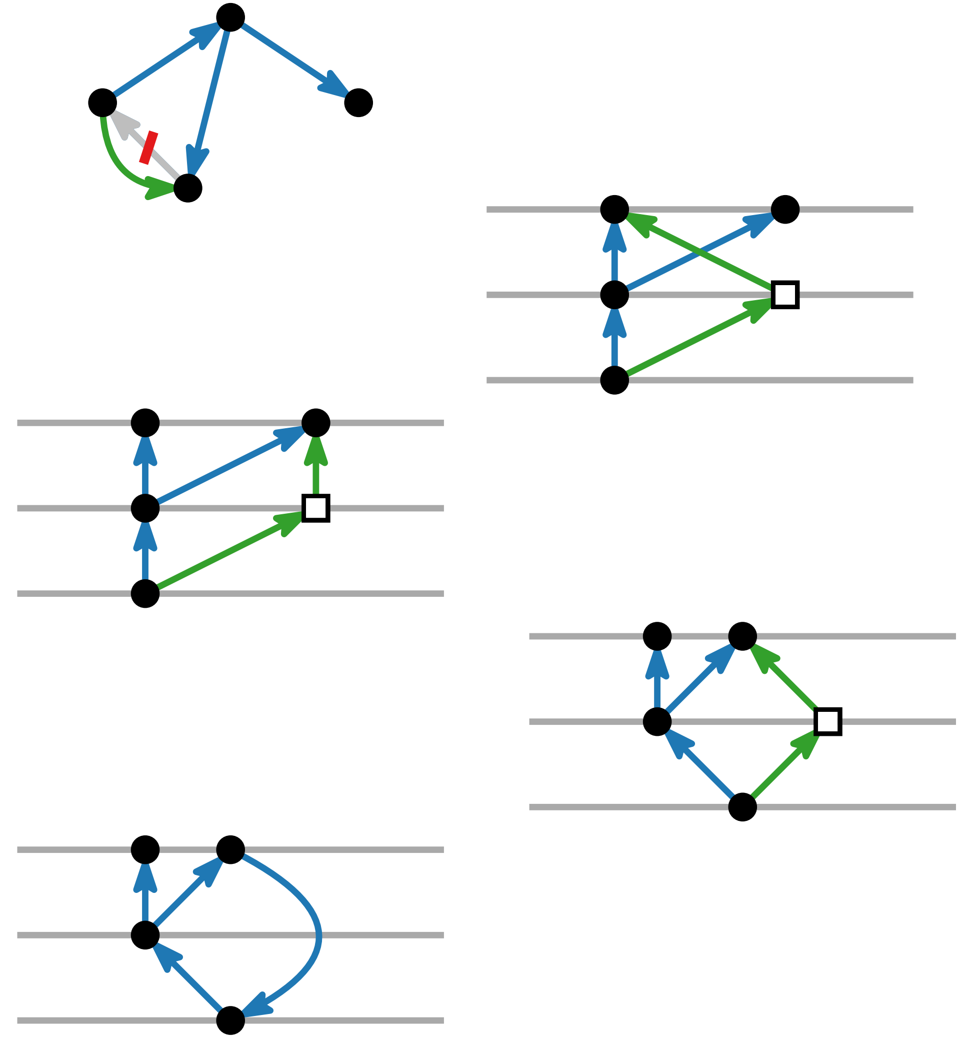

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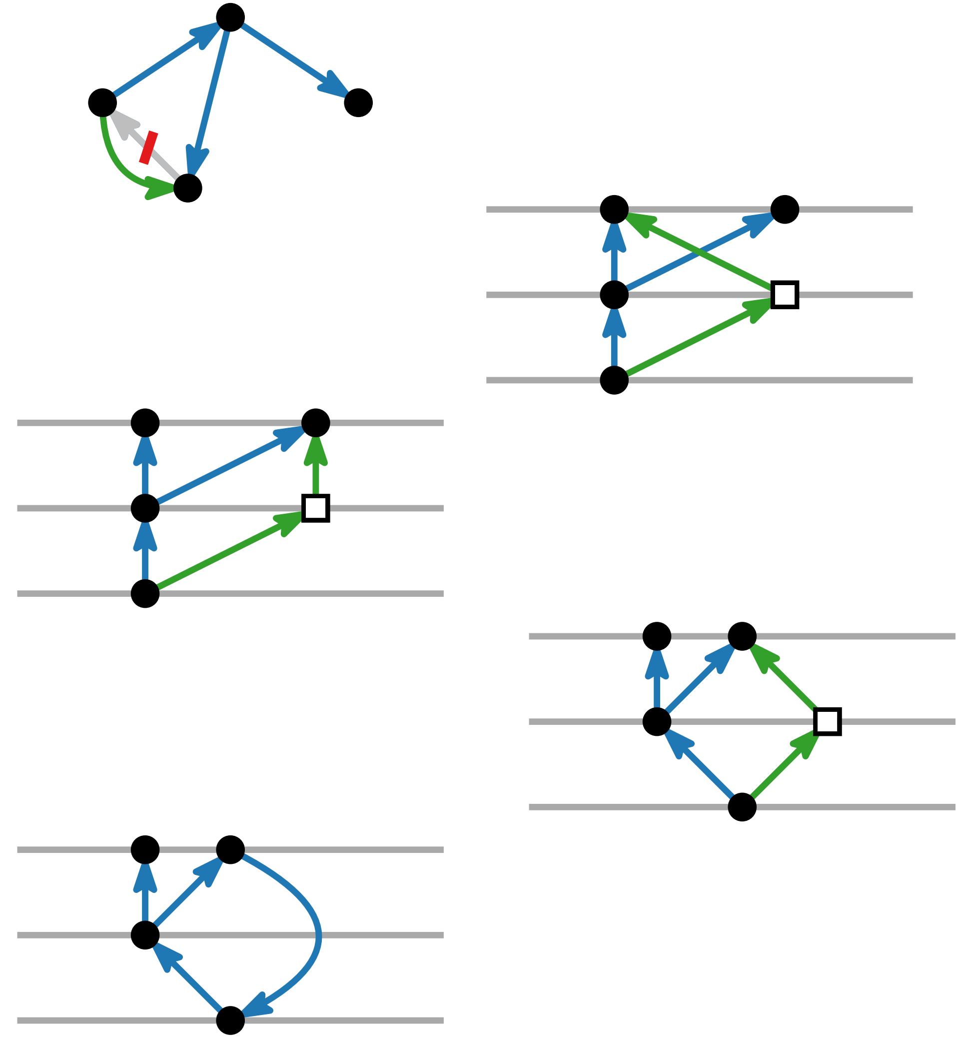

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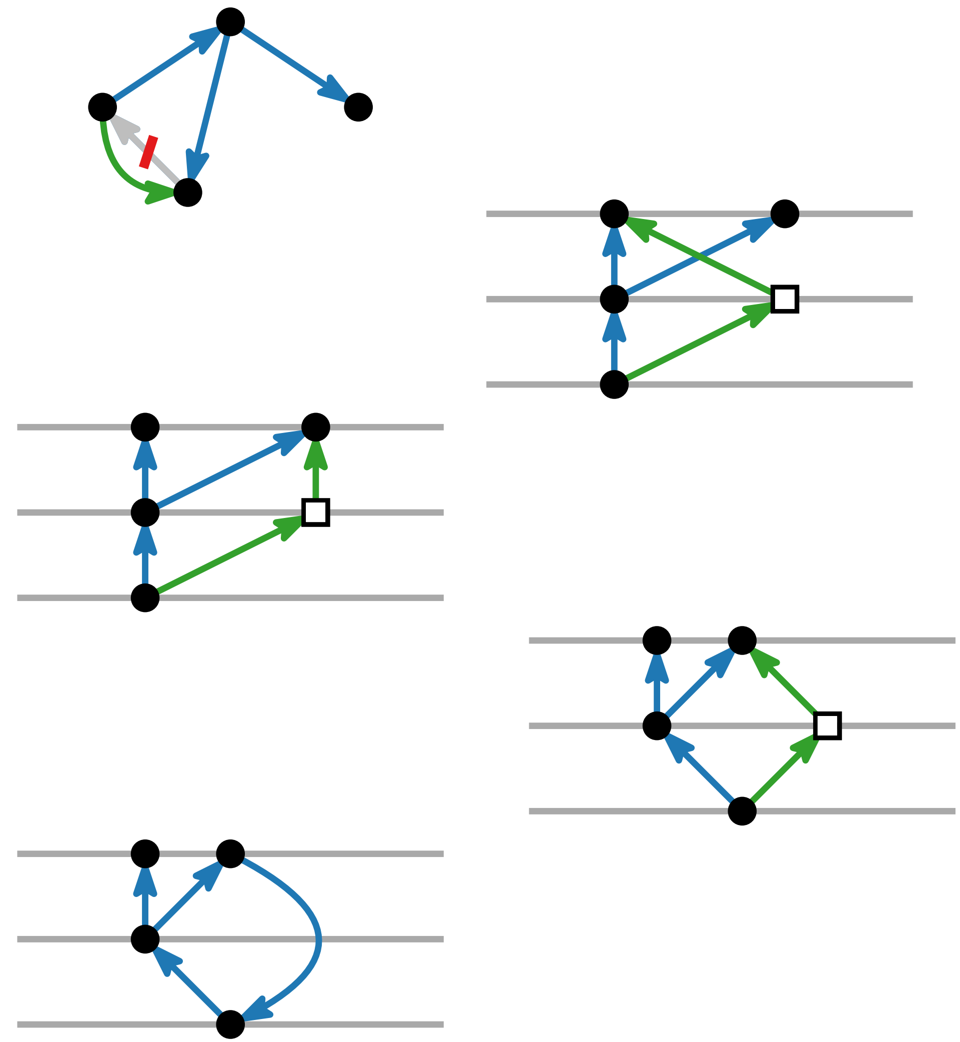

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⇒ use heuristics

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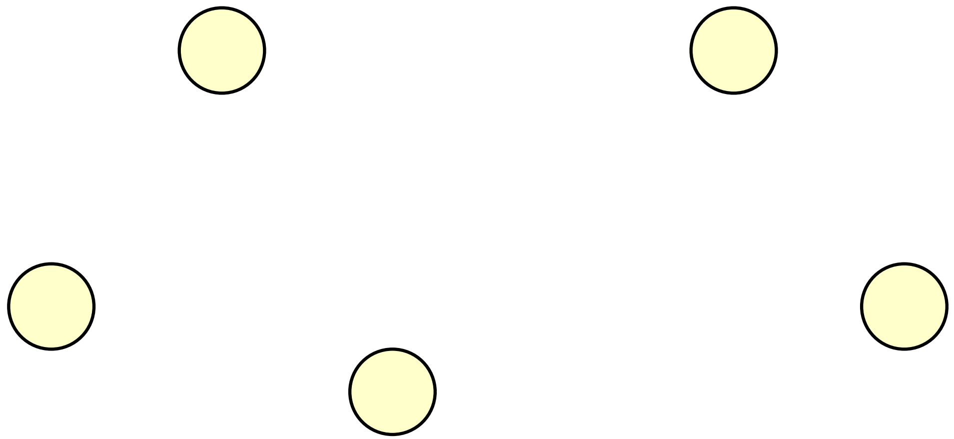

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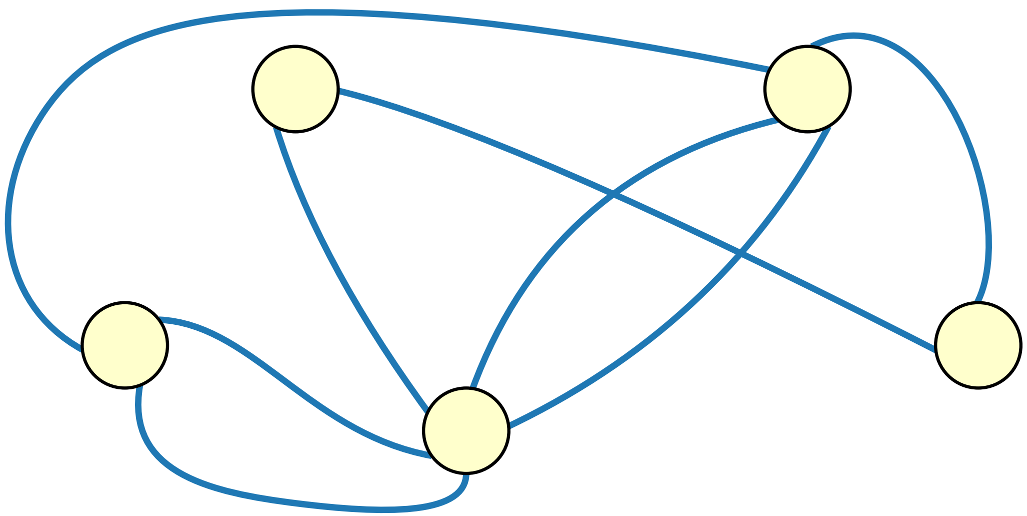

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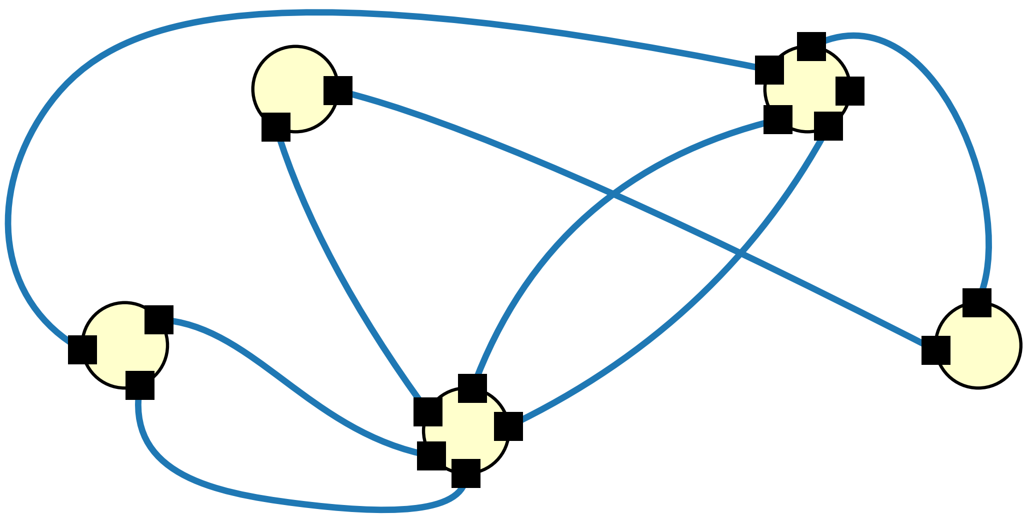

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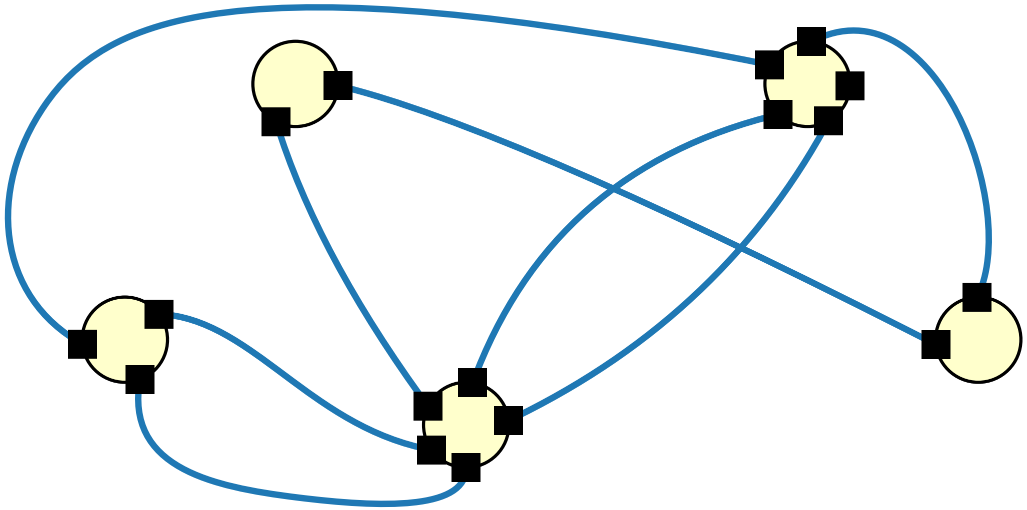

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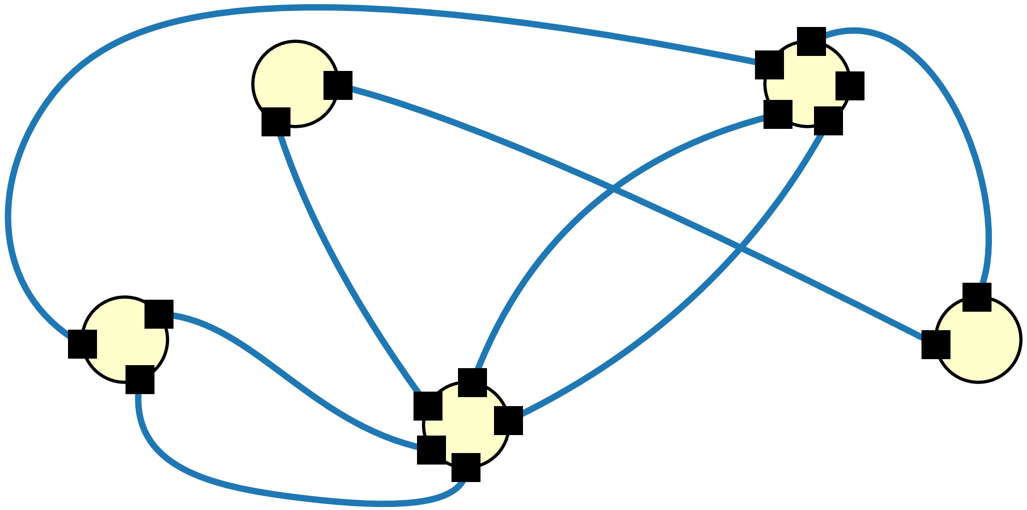

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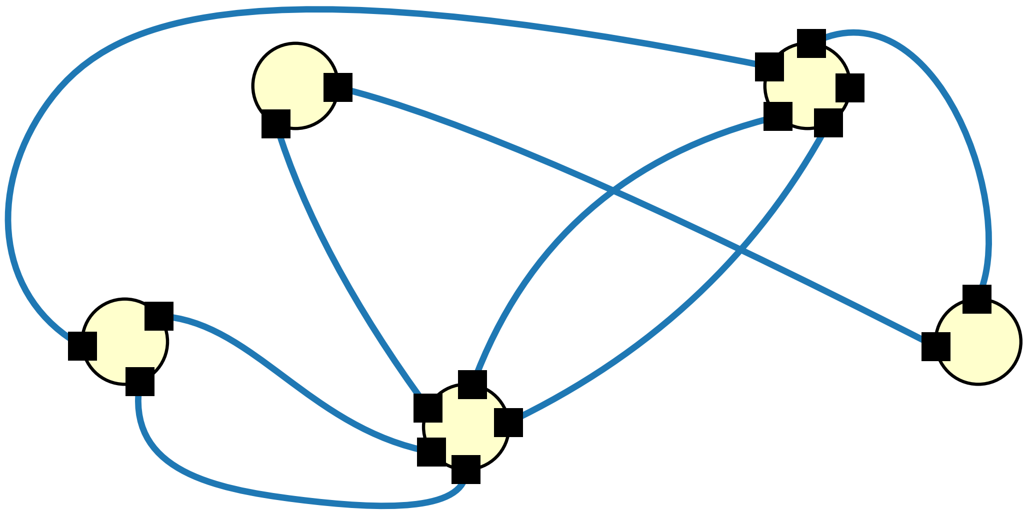

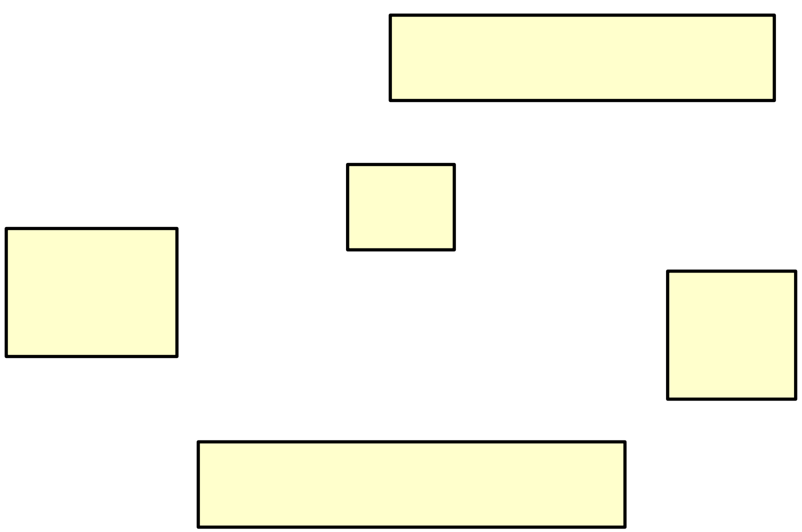

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- $v \in V$: axis-aligned rectangle of width $\geq w(v)$, height $\geq h(v)$

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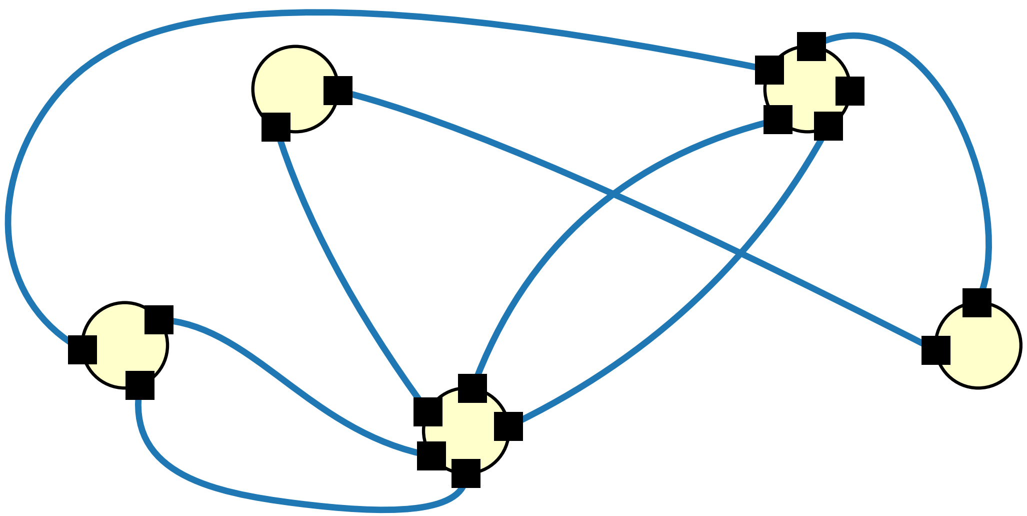

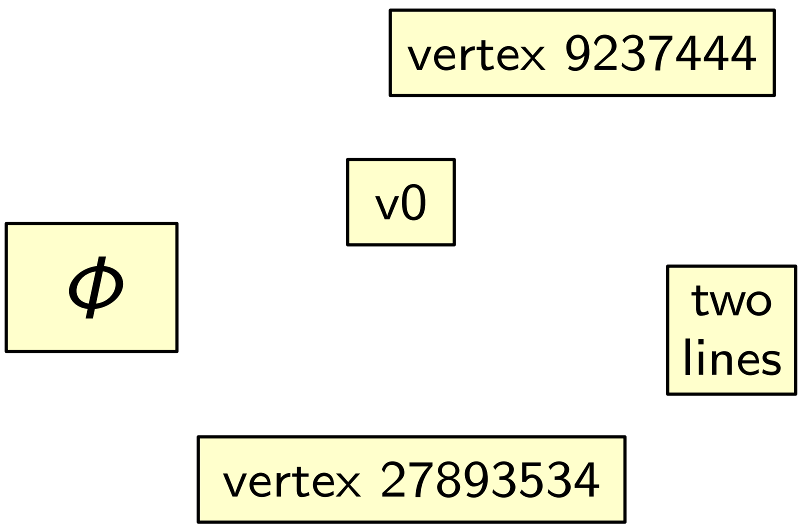

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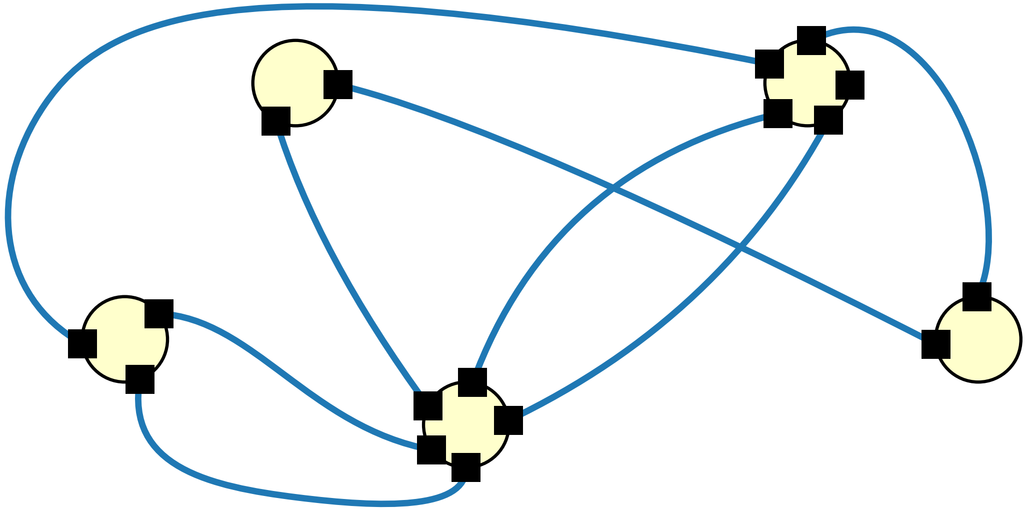

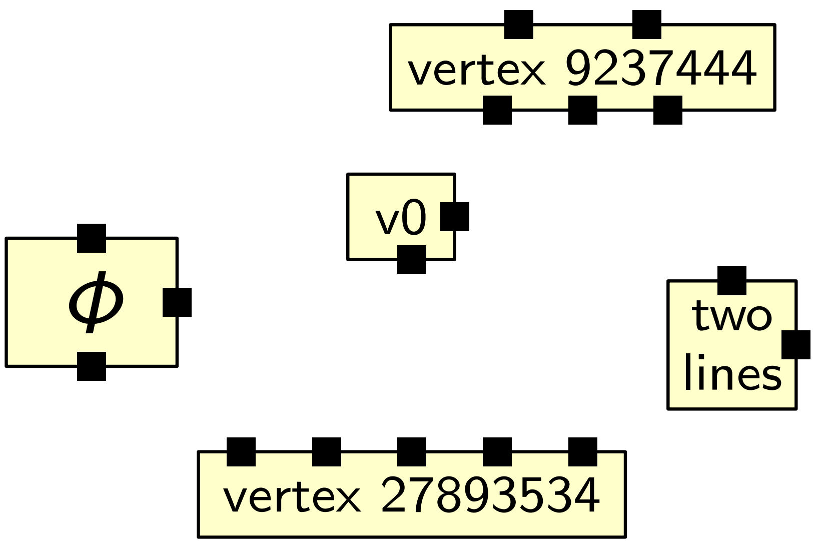

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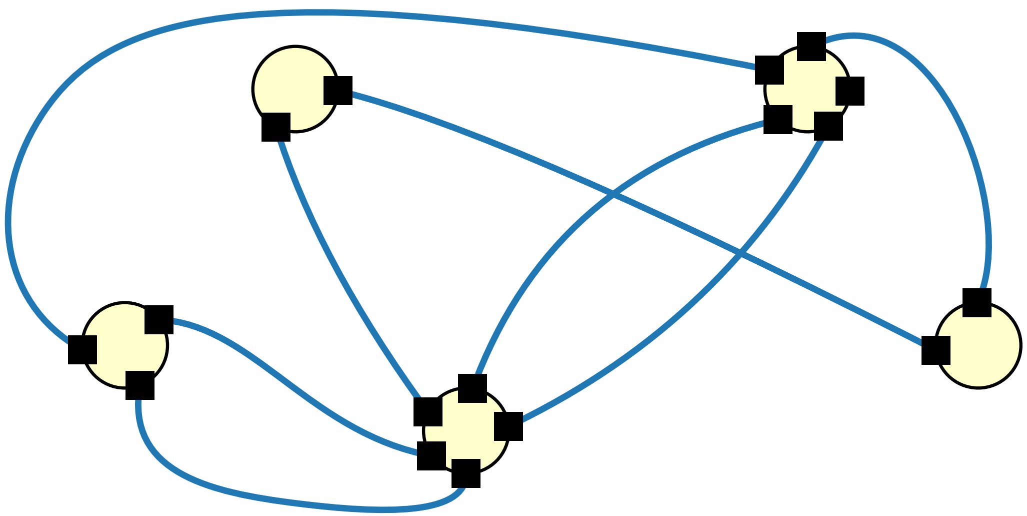

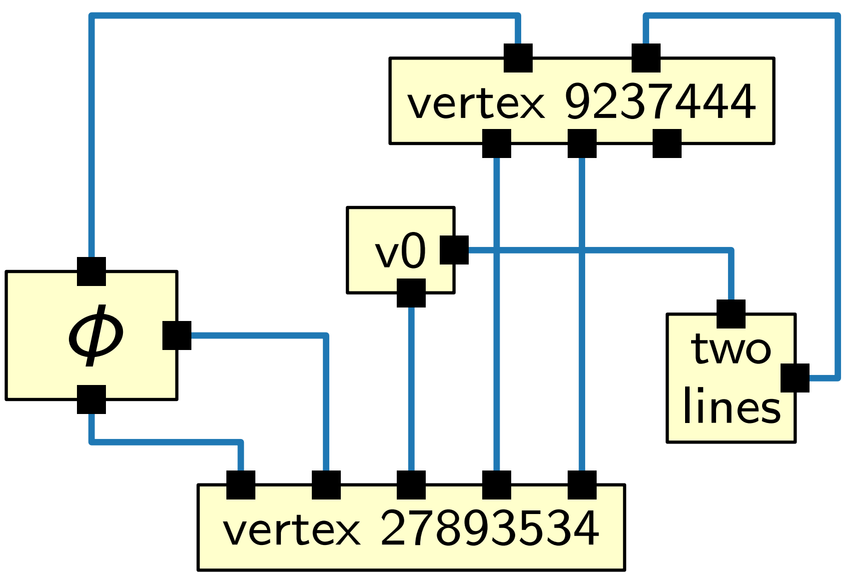

Orthogonal drawing style:

- $v \in V$: axis-aligned rectangle of width $\geq w(v)$, height $\geq h(v)$
- $p \in P$: small box on the boundary of its vertex
- $e \in E$: polyline of horizontal & vertical line segments

Previous Work

- Spönemann et al. (2009, 2014) consider graph drawing with port constraints in the Sugiyama framework.

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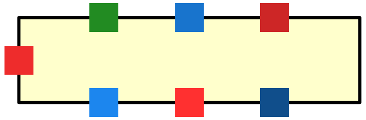

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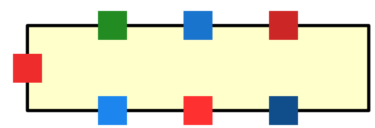
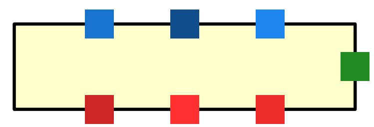


  - FIXEDSIDE



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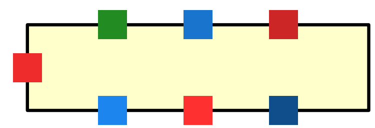
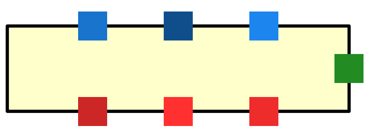
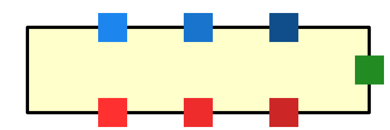
  - Free 
  - FixedSide 
  - FixedOrder 

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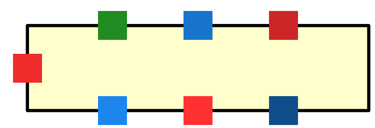
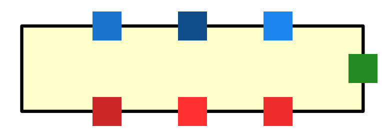
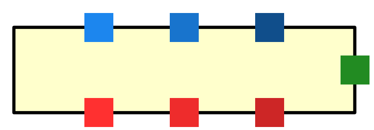
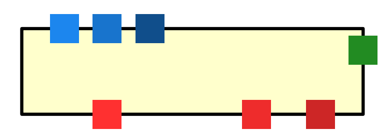
  - FREE 
  - FIXEDSIDE 
  - FIXEDORDER 
  - FIXEDPOS 

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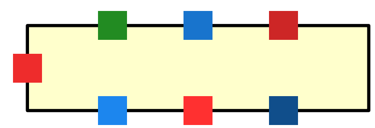
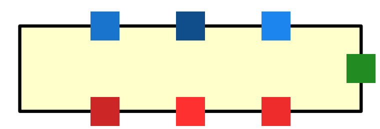
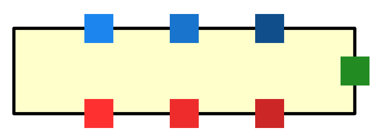
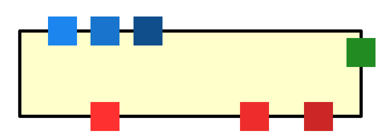
  - Free 
  - FixedSide 
  - FixedOrder 
  - FixedPos 

- Open source implemenation in Java as *KIELER* (later: *eclipse.elk*) available

Contribution

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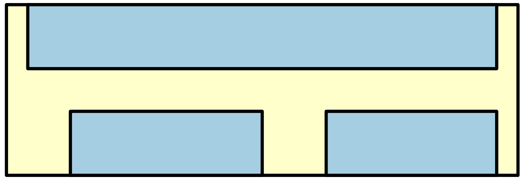

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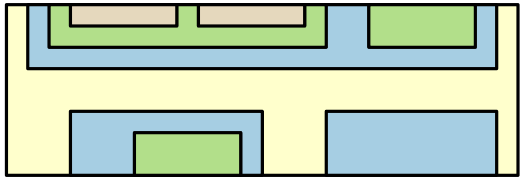

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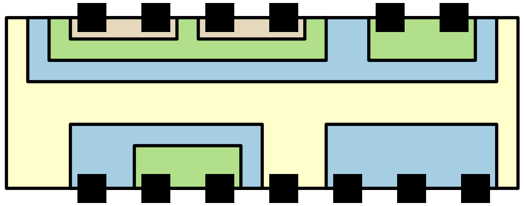

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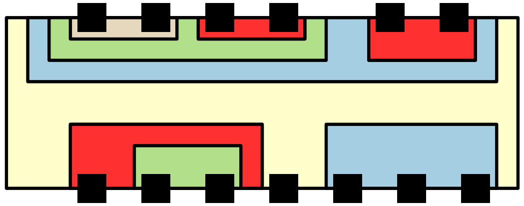

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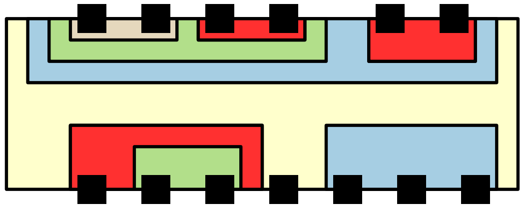

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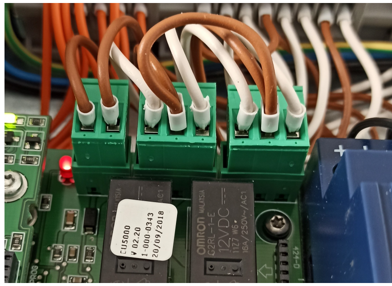

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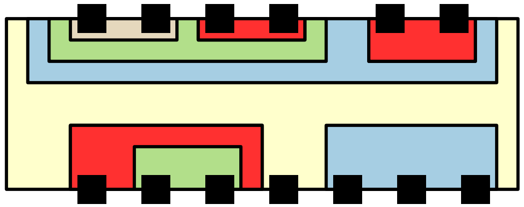

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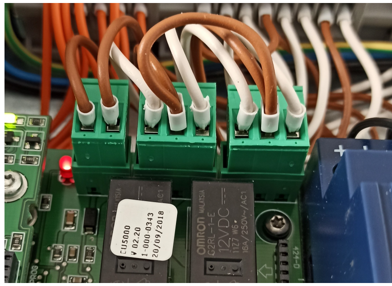

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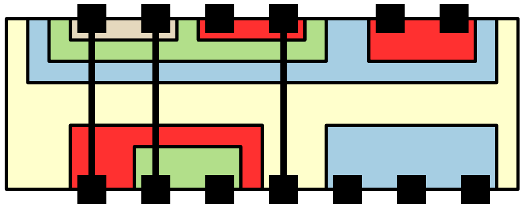

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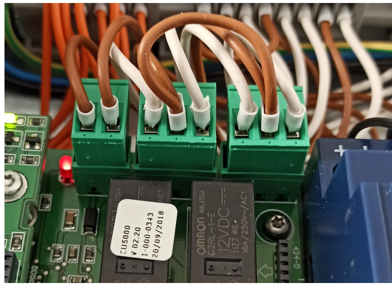

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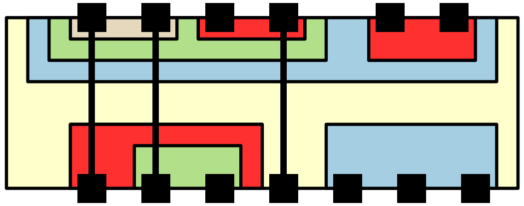

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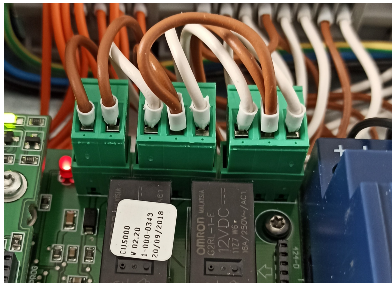

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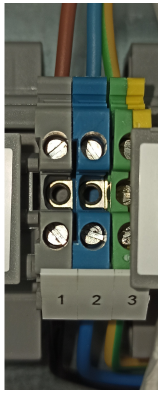

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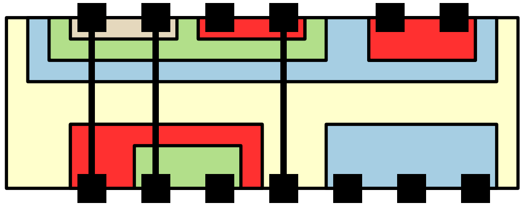

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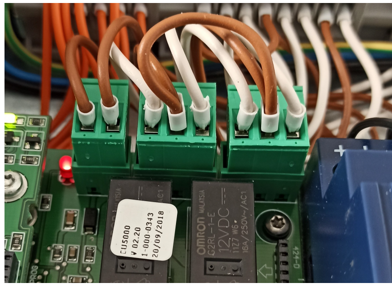

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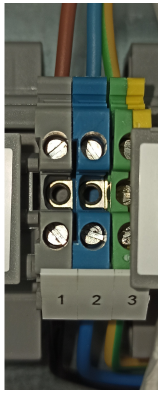

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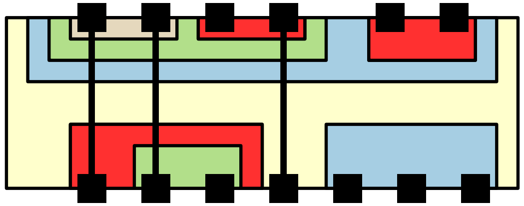

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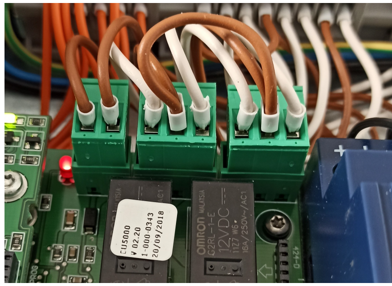
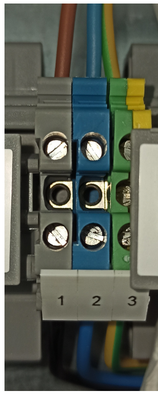


- Port pairings: require 2 ports to be on an axis-parallel line
- Draw undirected graphs by orienting the edges using
  - breadth-first search (orient in direction of discovery)



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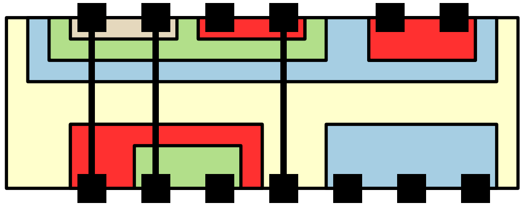

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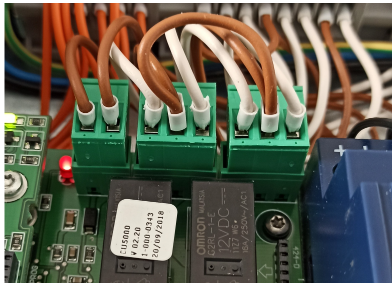

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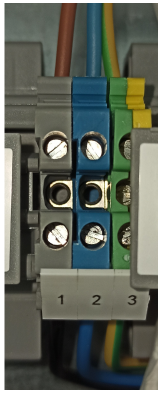

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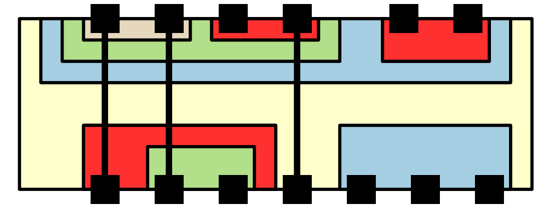

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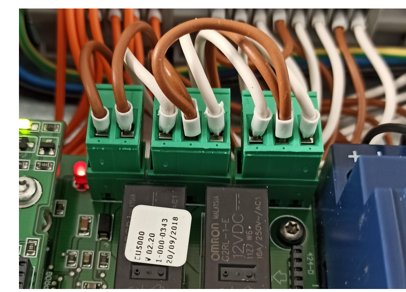

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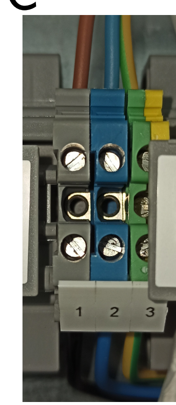

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We experimentally evaluate our variants on real cable plans and pseudo plans (we describe how we generate them from real data)

Our Extensions to the Sugiyama Framework

1. cycle elimination
2. layer assignment
3. crossing minimization
4. node placement
5. edge routing

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1. ~~cycle elimination~~
   1. Orient undirected edges (w/o creating cycles)
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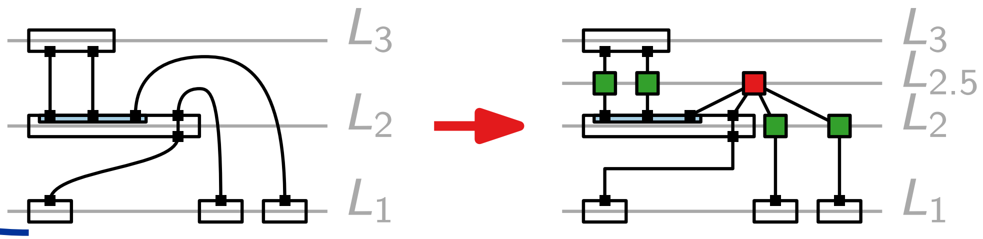

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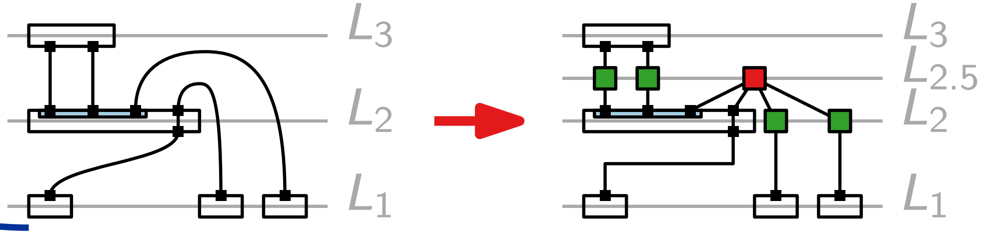

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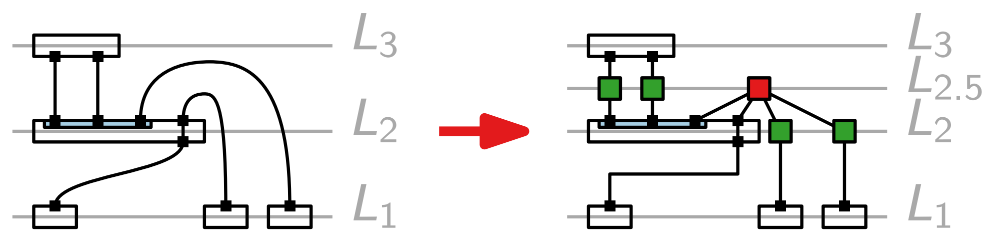

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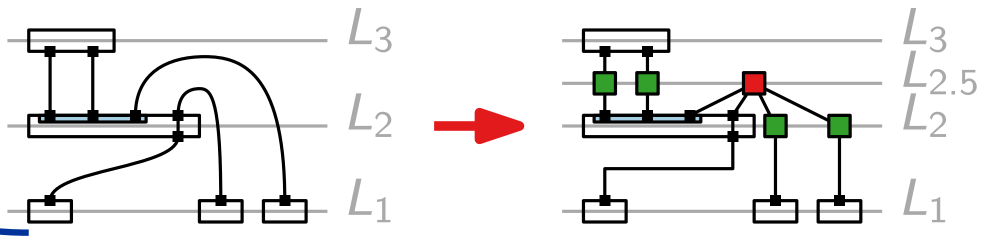

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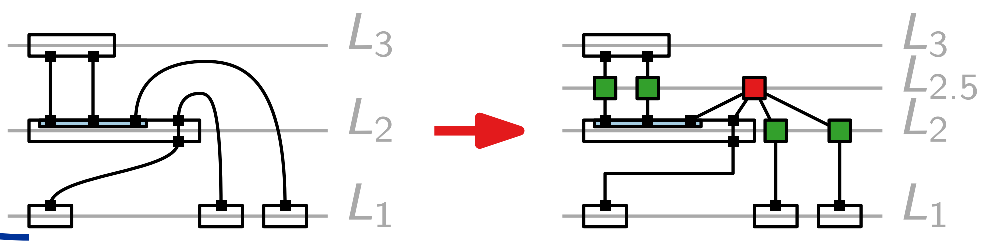

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orthogonal

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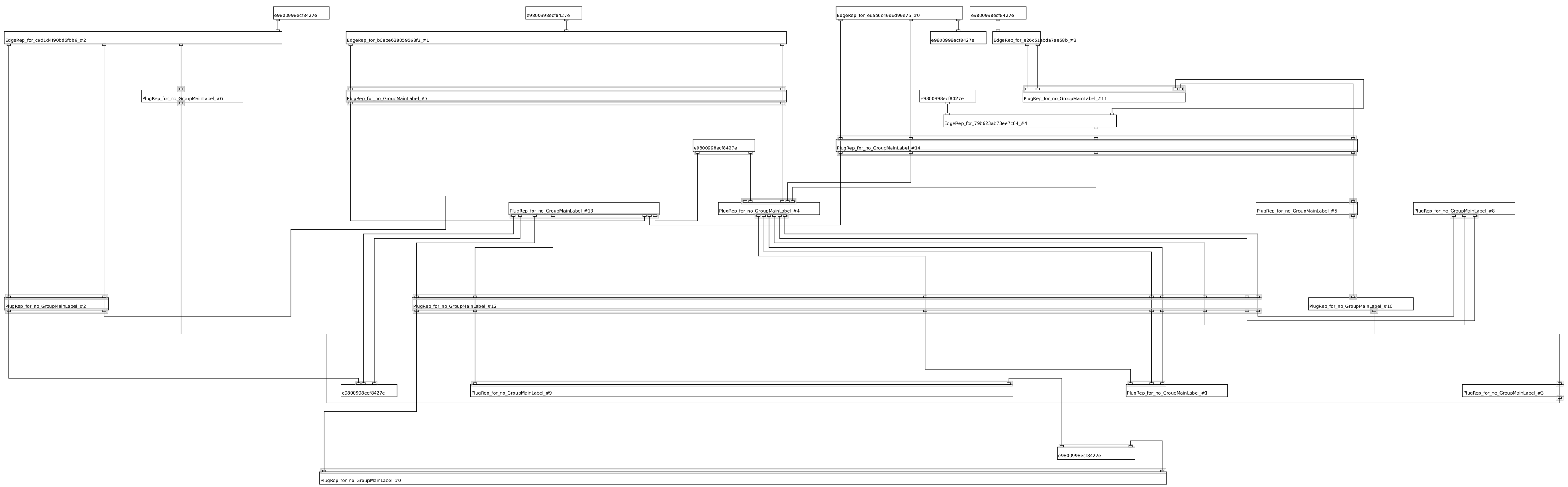
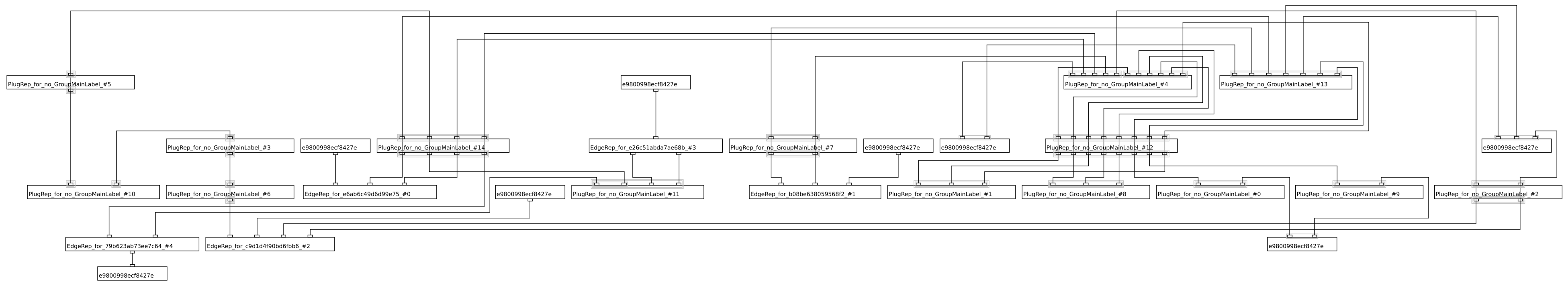
- Took best of 5 executions for each plan & variant
- Our implementation in Java is available on github:
  `github.com/j-zink-wuerzburg`
  `.../praline`
  `.../pseudo-praline-plan-generation`

Example: (anonymized) plan from REAL



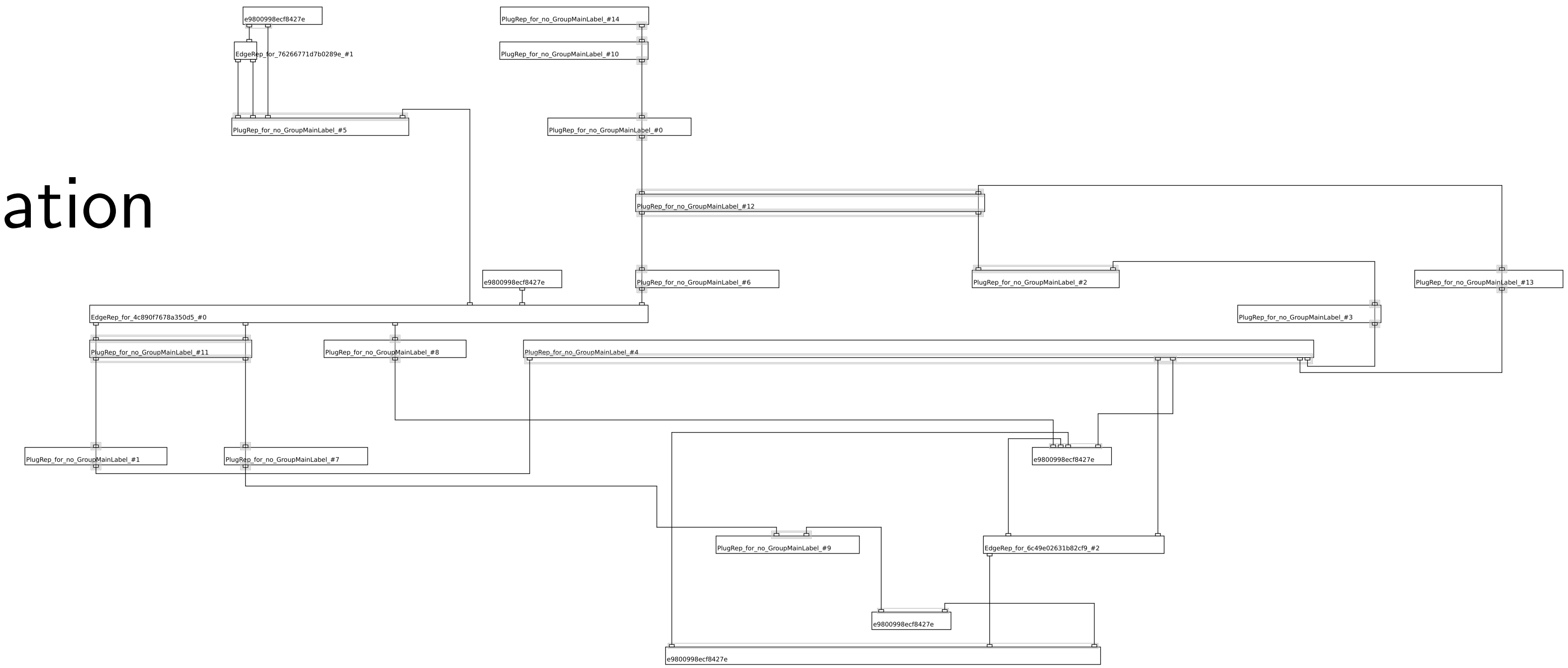
our implementation

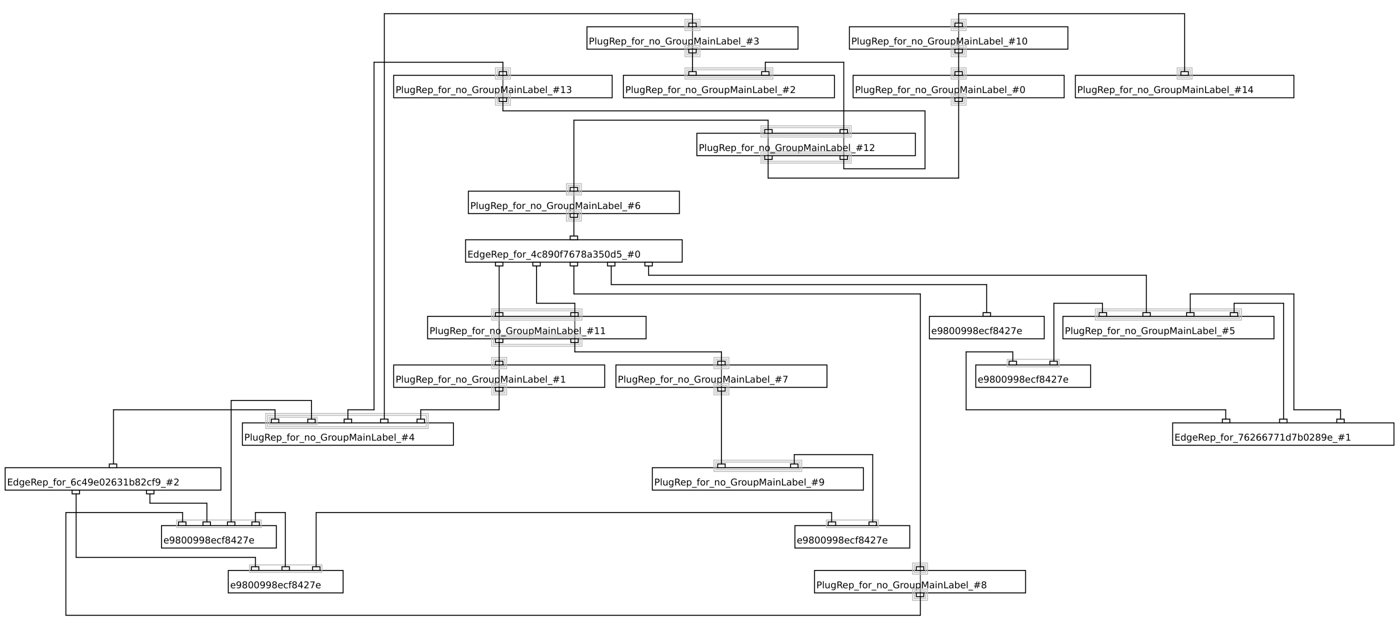


KIELER

Example: plan from PSEUDO

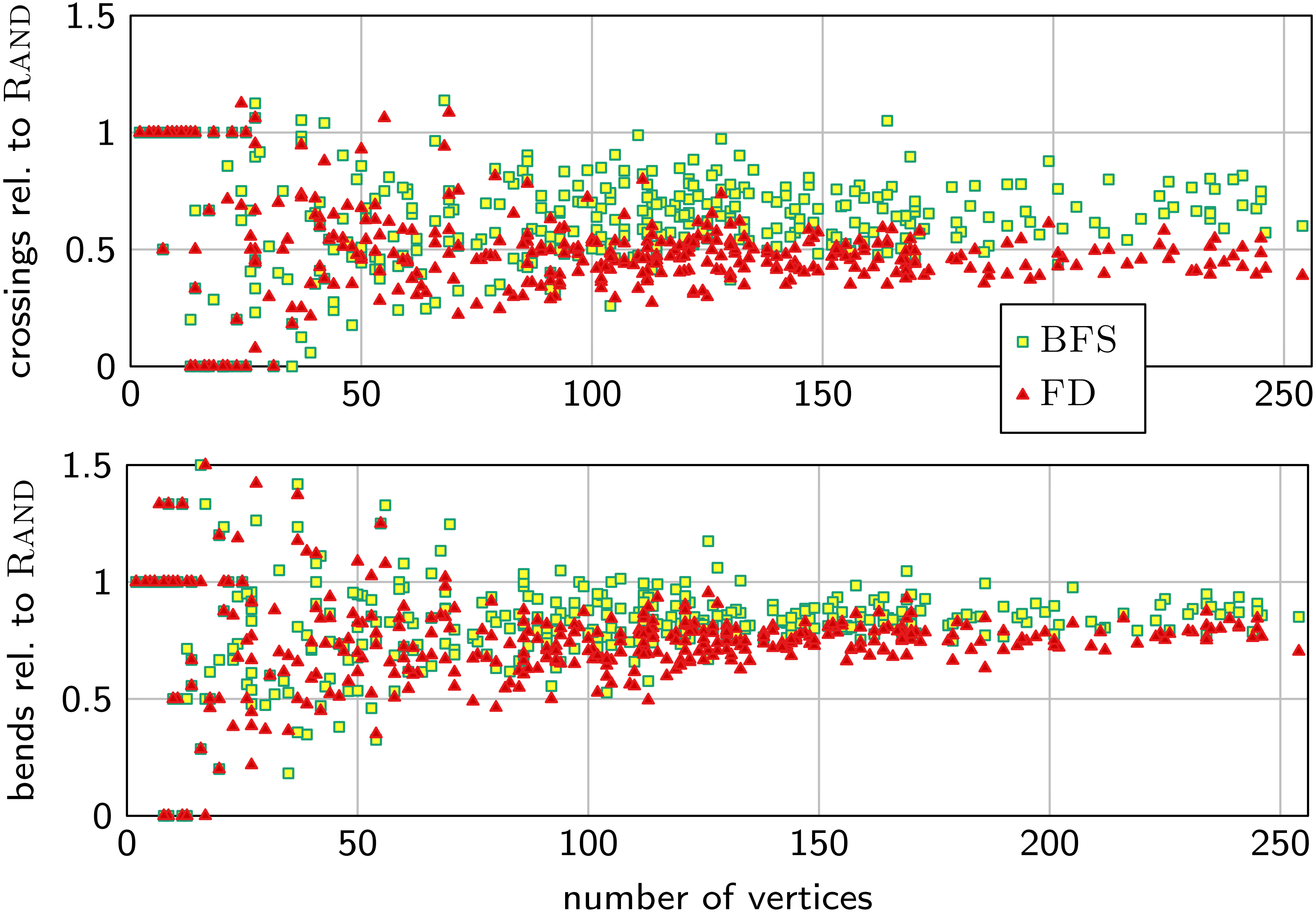
our implementation



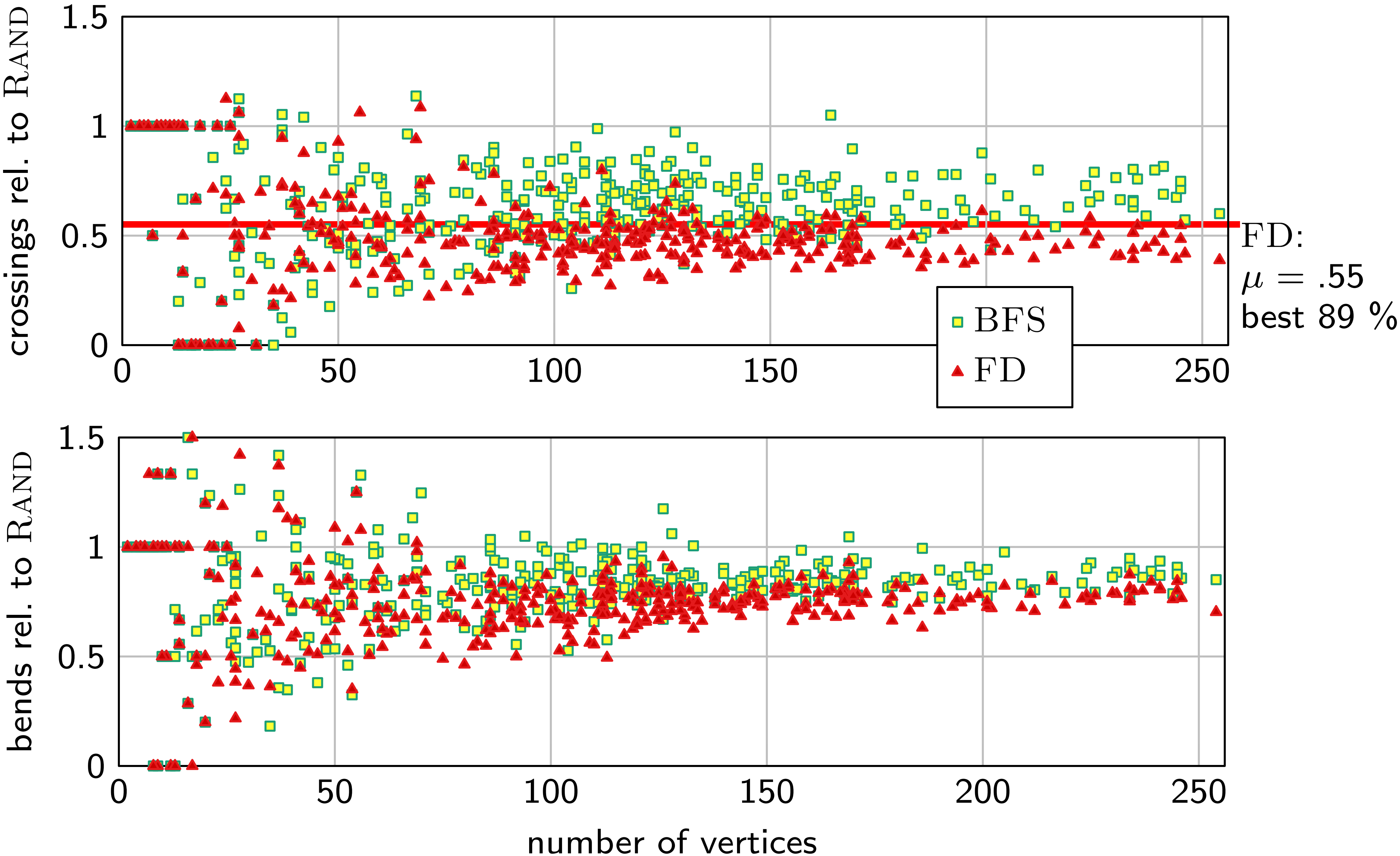


KIELER

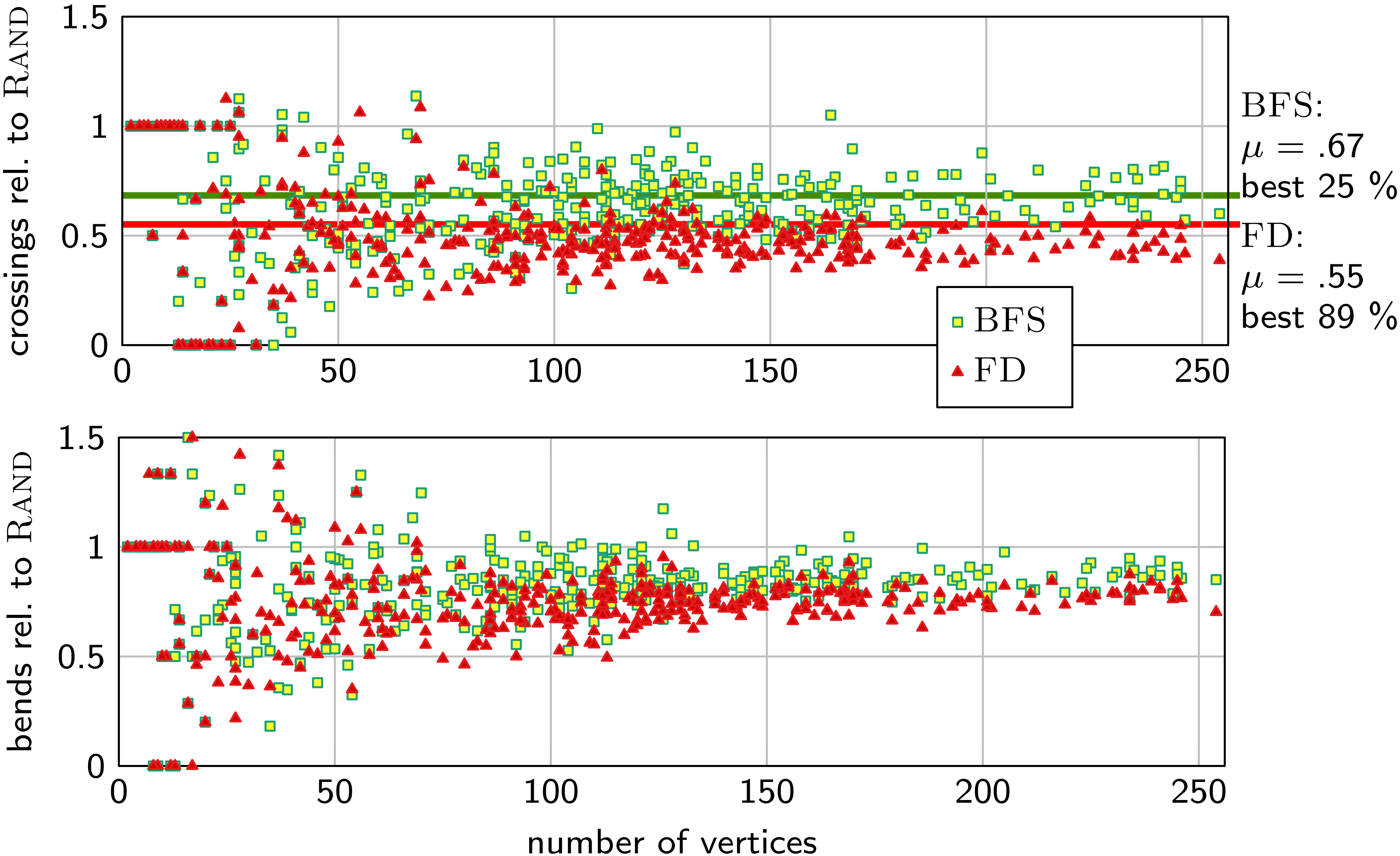
Results: Orienting Edges (Real)



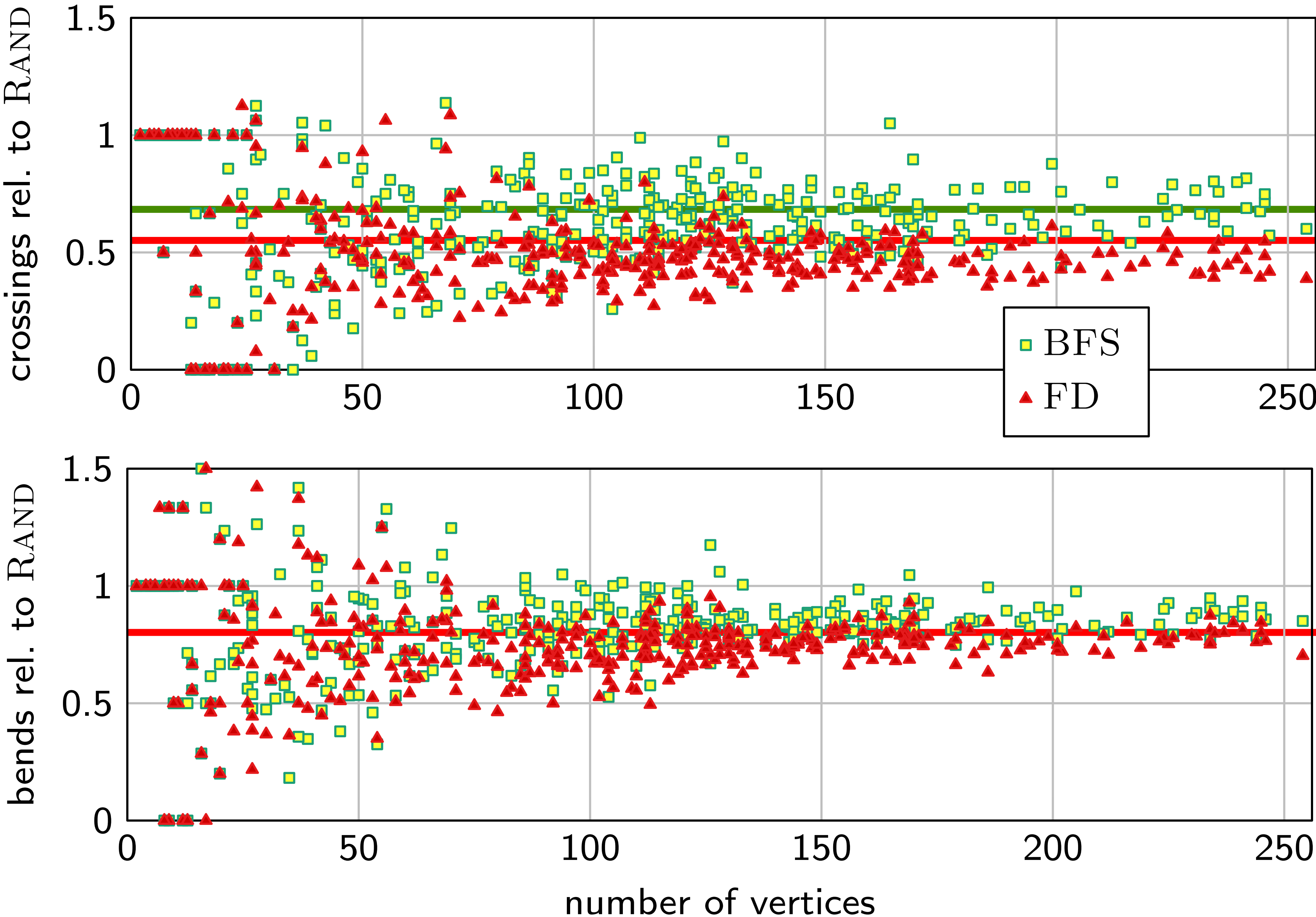
Results: Orienting Edges (Real)



Results: Orienting Edges (Real)



Results: Orienting Edges (Real)

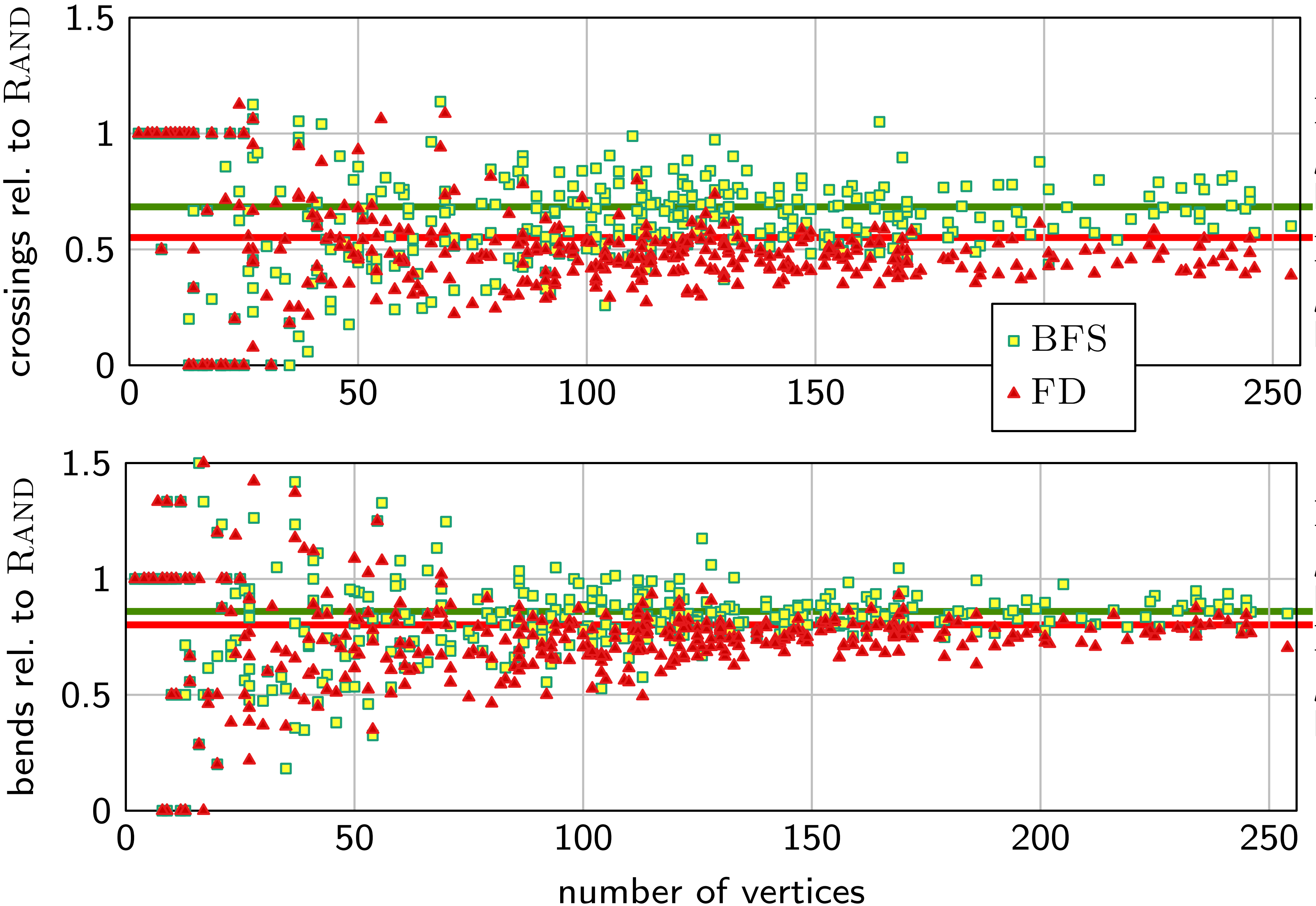


BFS:
$\mu = .67$
best 25 %

FD:
$\mu = .55$
best 89 %

FD:
$\mu = .80$
best 85 %

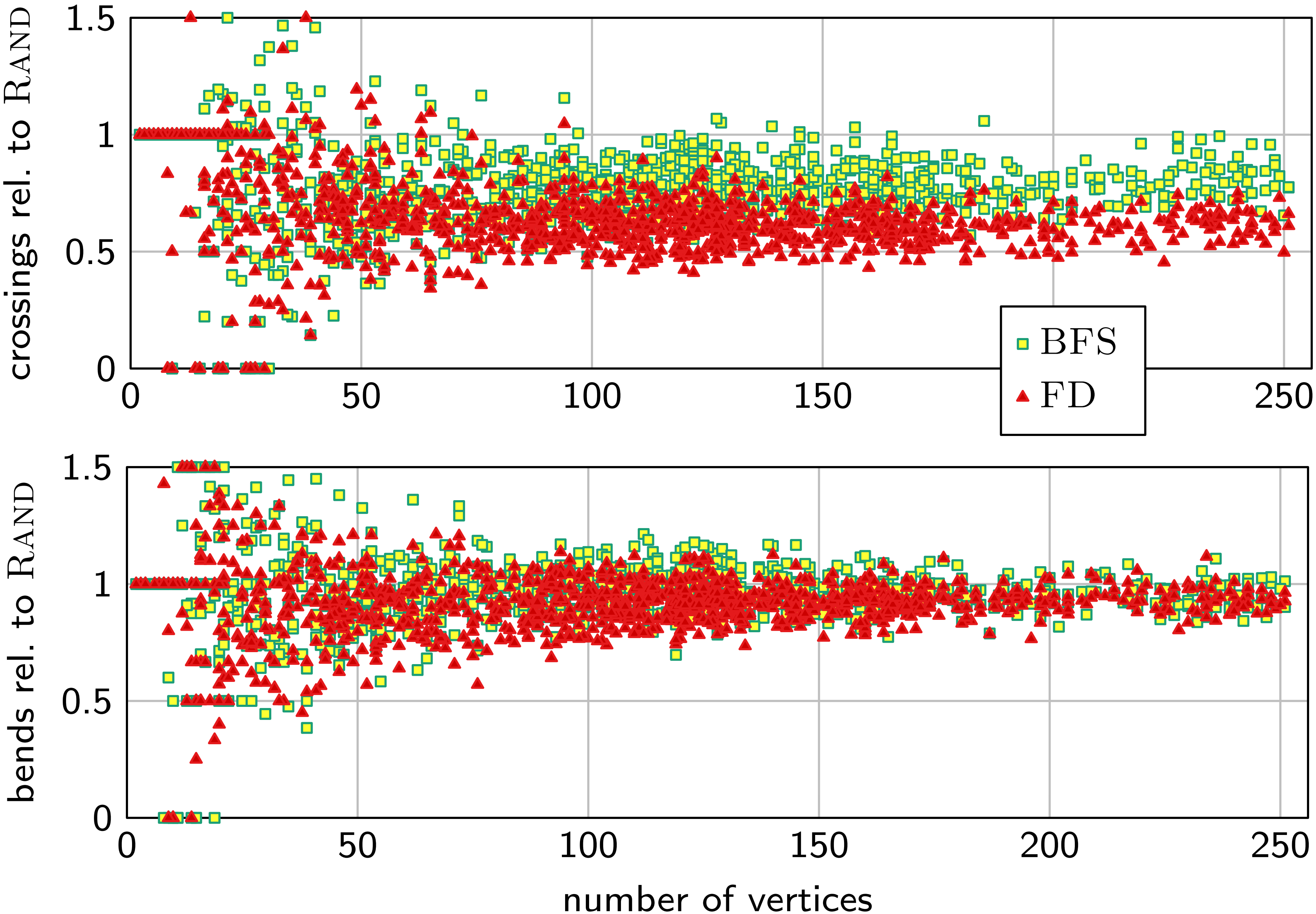
Results: Orienting Edges (Real)



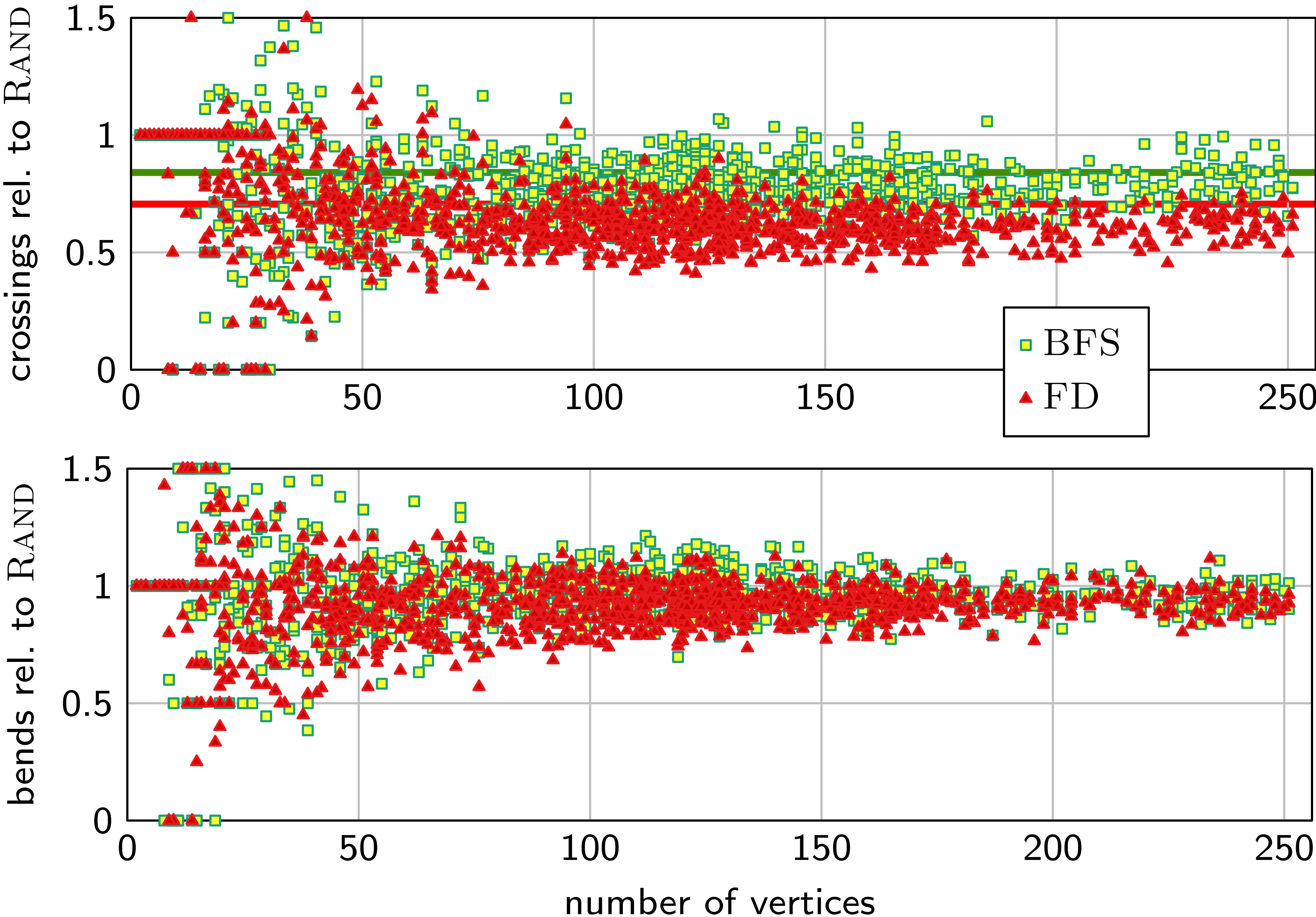
BFS:
$\mu = .67$
best 25 %
FD:
$\mu = .55$
best 89 %

BFS:
$\mu = .86$
best 20 %
FD:
$\mu = .80$
best 85 %

Results: Orienting Edges (PSEUDO)



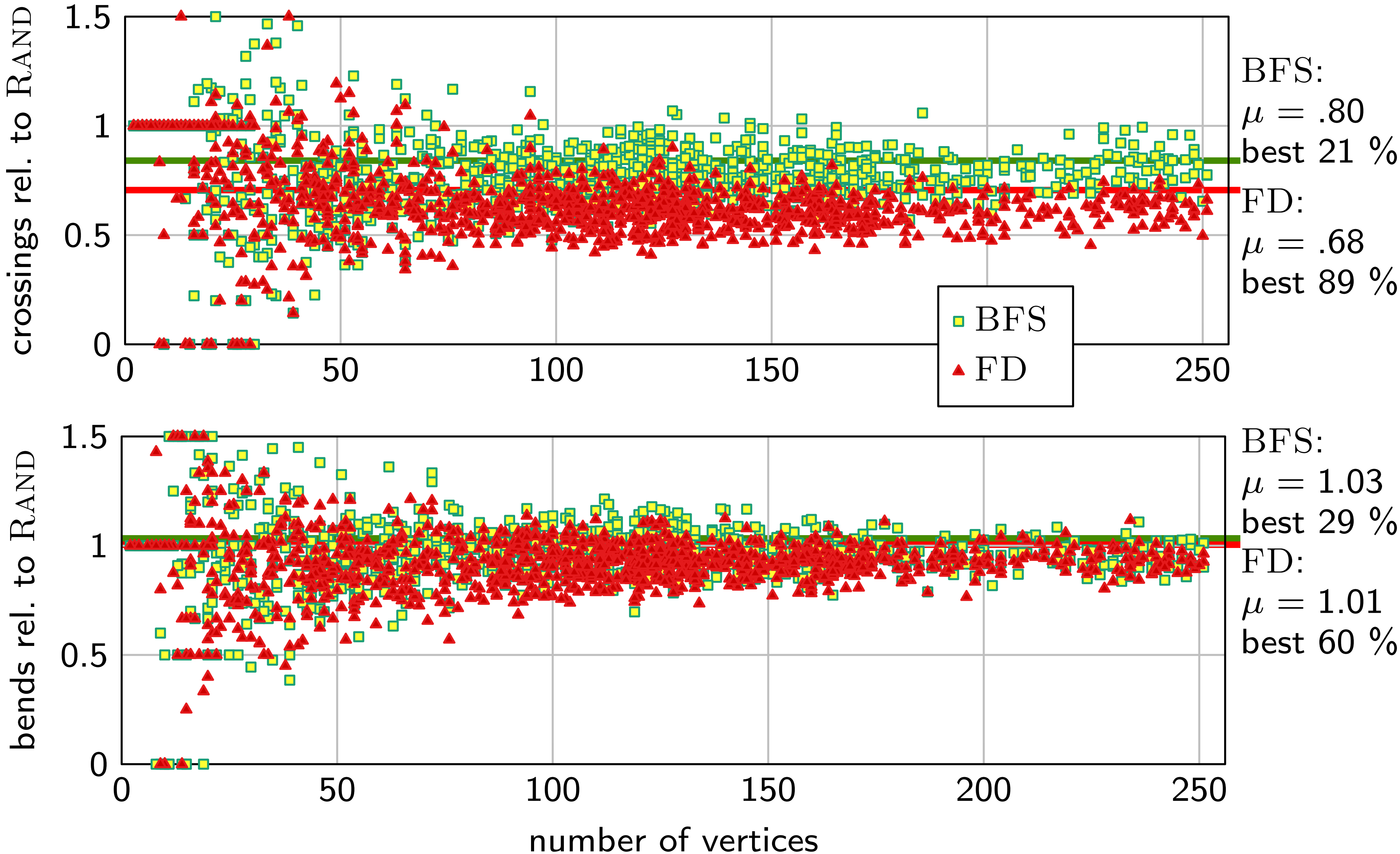
Results: Orienting Edges (PSEUDO)



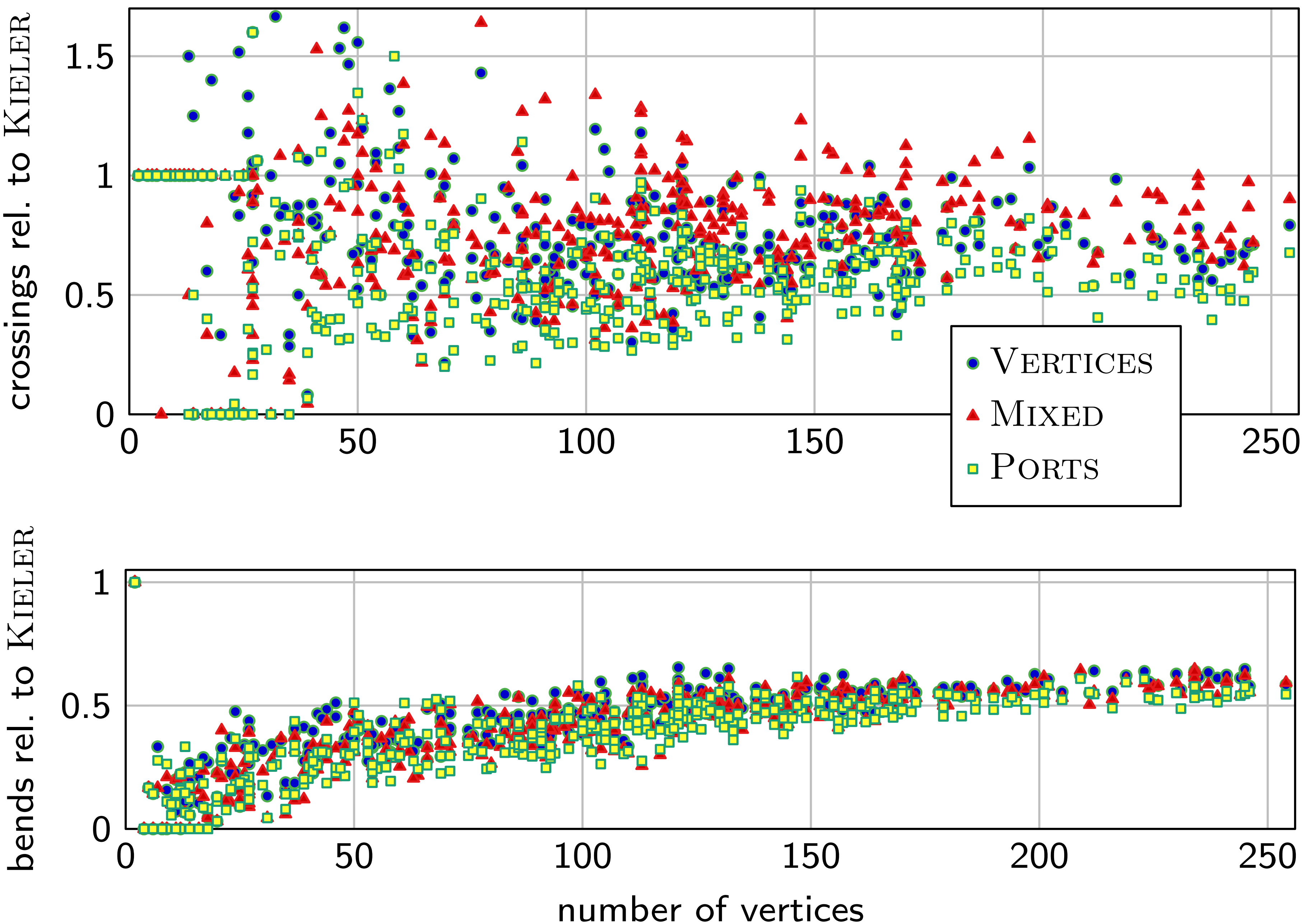
BFS:
$\mu = .80$
best 21 %

FD:
$\mu = .68$
best 89 %

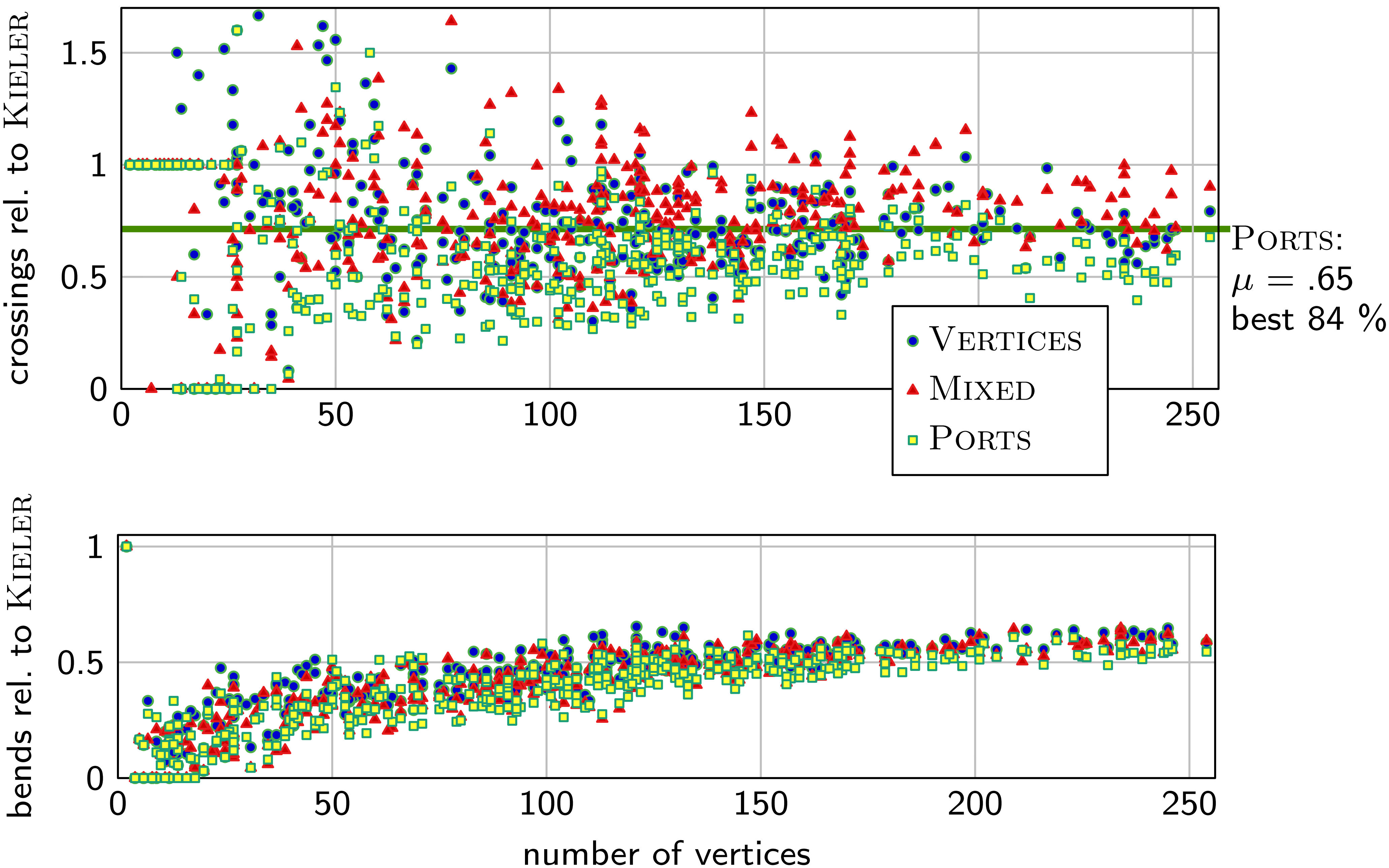
Results: Orienting Edges (PSEUDO)



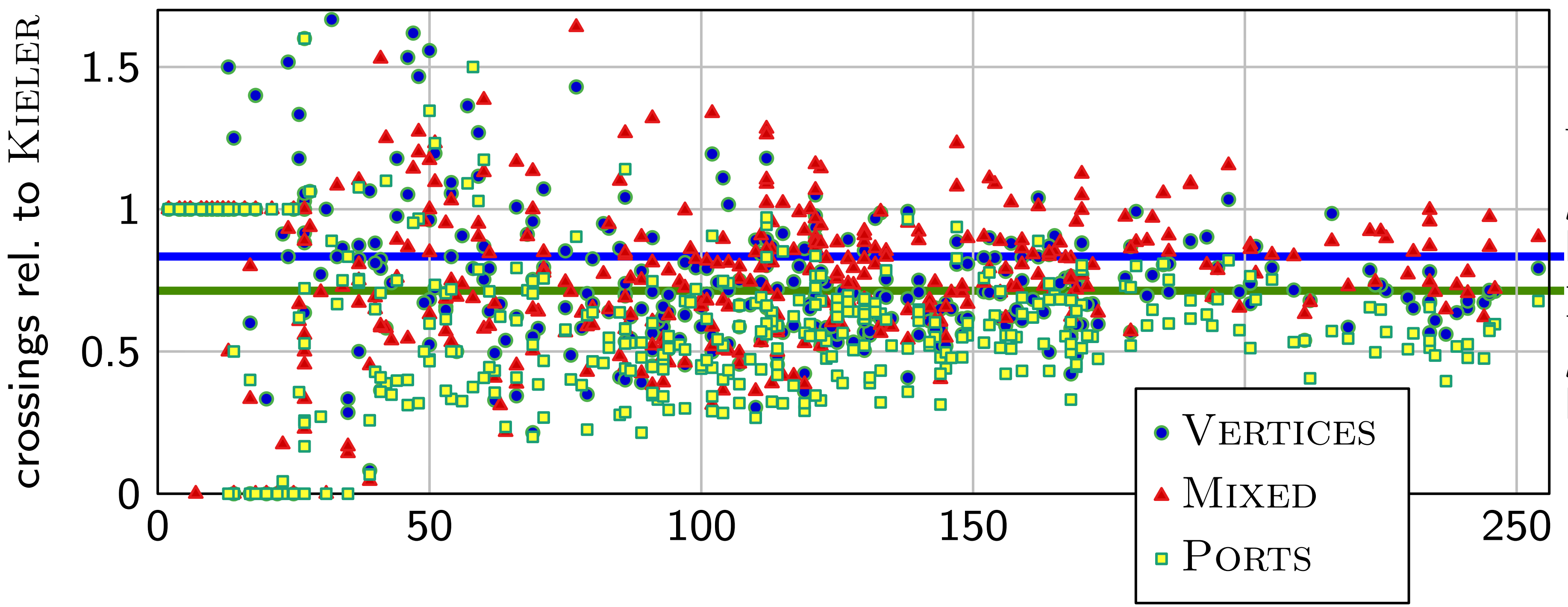
Results: Crossing Minimization (Real)



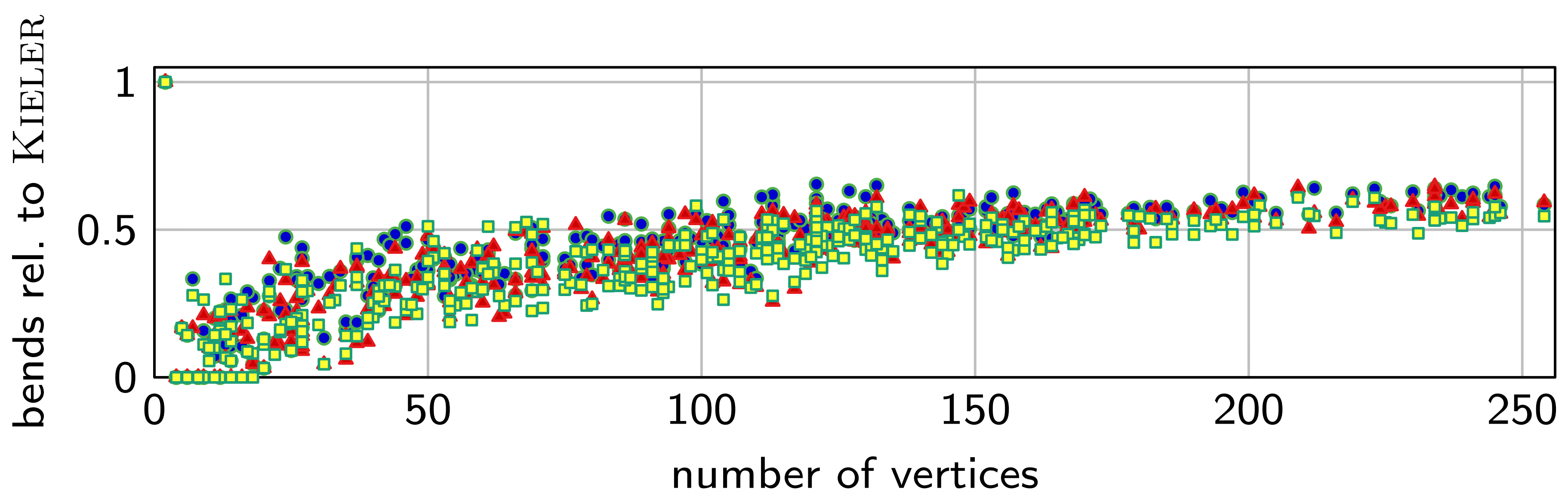
Results: Crossing Minimization (Real)



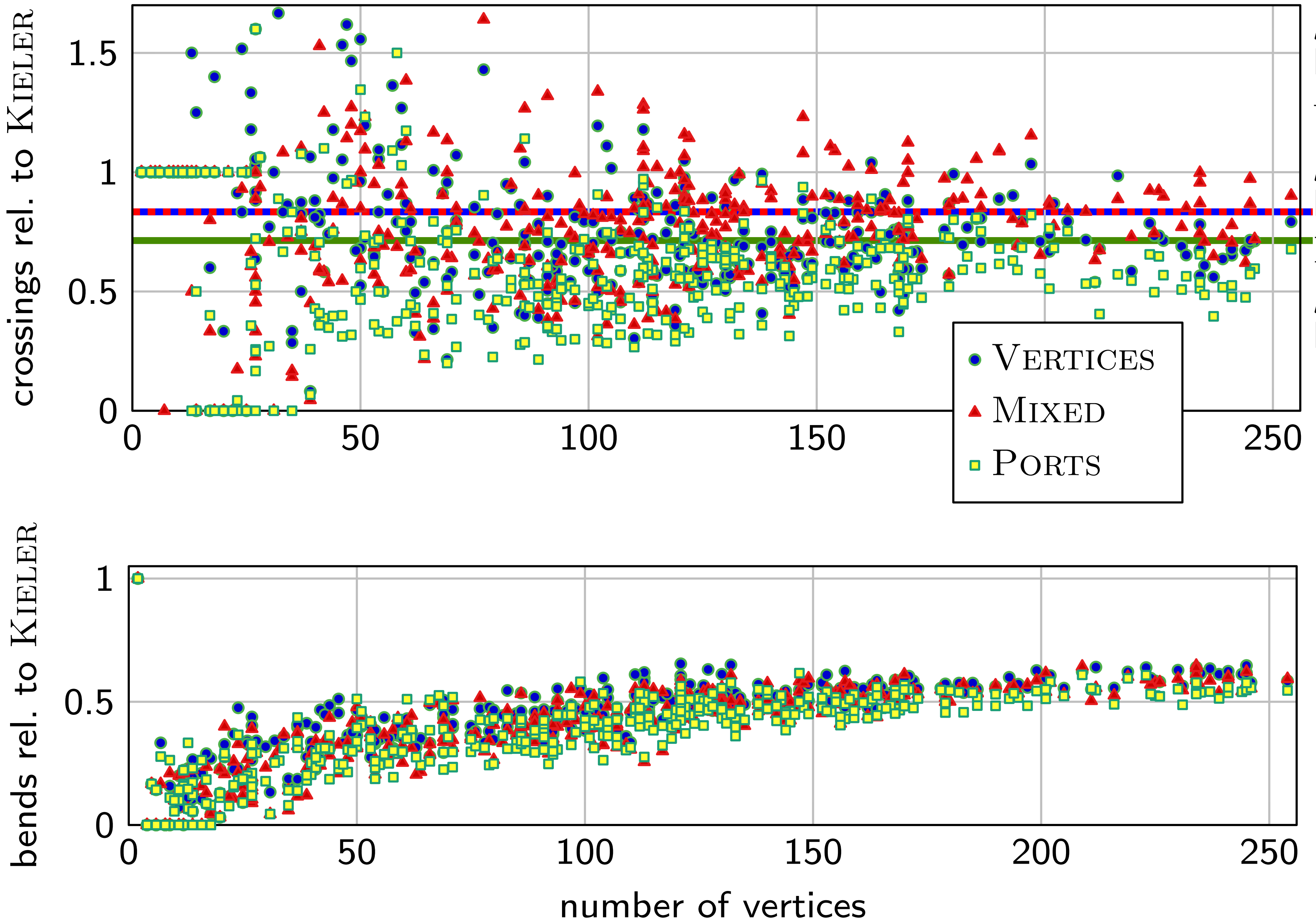
Results: Crossing Minimization (Real)



Vertices:
$\mu = .83$
best 19 %
Ports:
$\mu = .65$
best 84 %



Results: Crossing Minimization (Real)

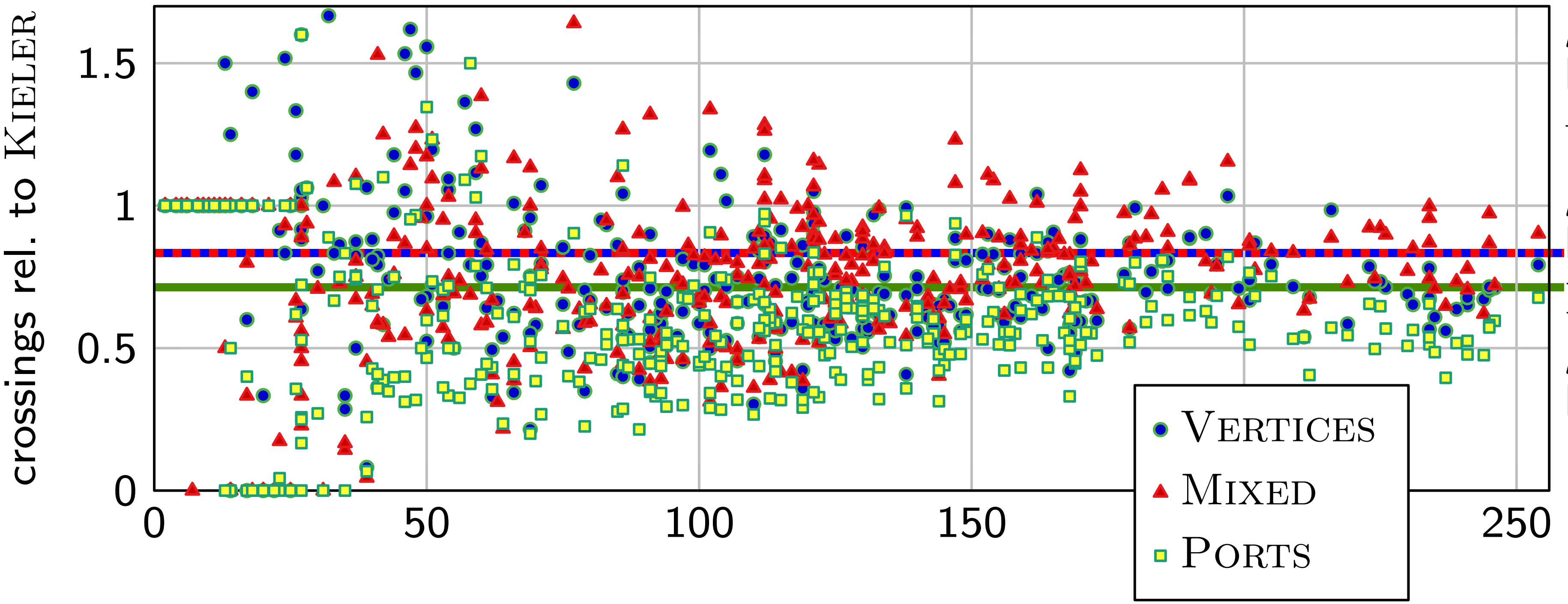


Mixed:
$\mu = .83$
best 16 %

Vertices:
$\mu = .83$
best 19 %

Ports:
$\mu = .65$
best 84 %

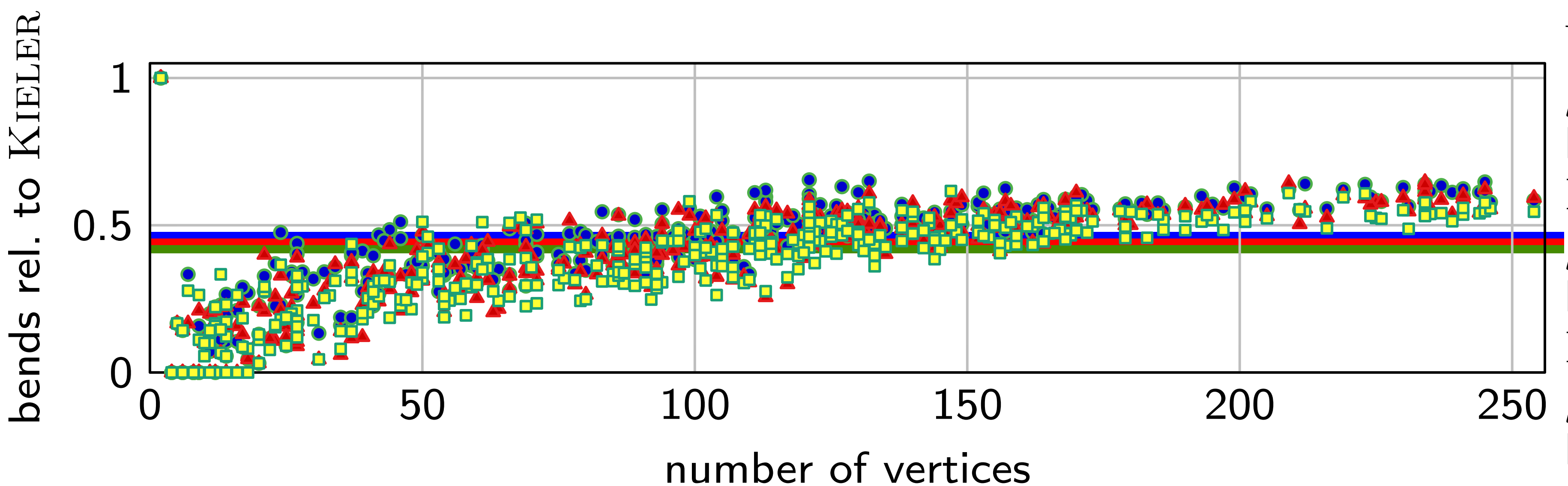
Results: Crossing Minimization (Real)



Mixed:
$\mu = .83$
best 16 %

Vertices:
$\mu = .83$
best 19 %

Ports:
$\mu = .65$
best 84 %

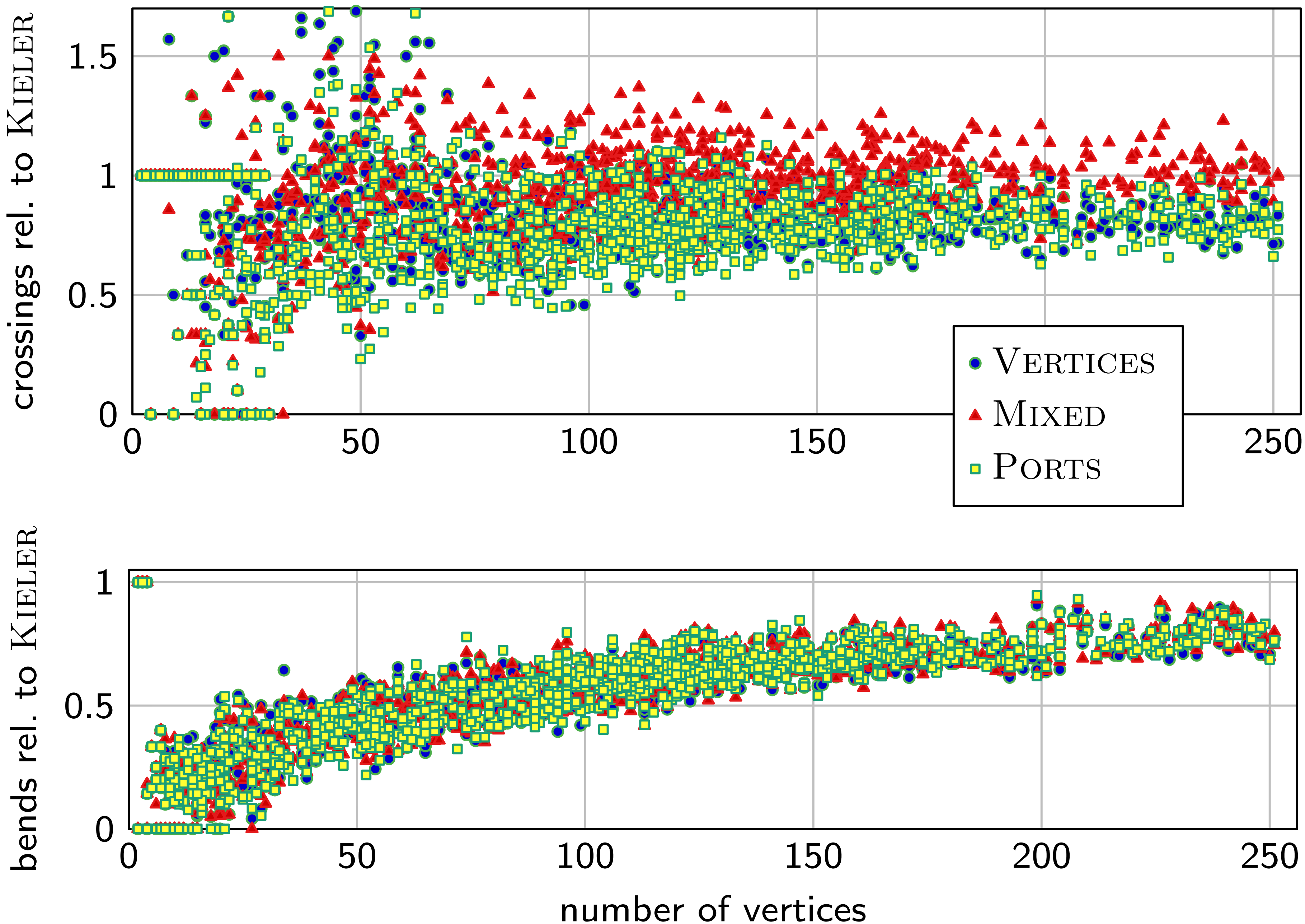


Vertices:
$\mu = .46$
best 13 %

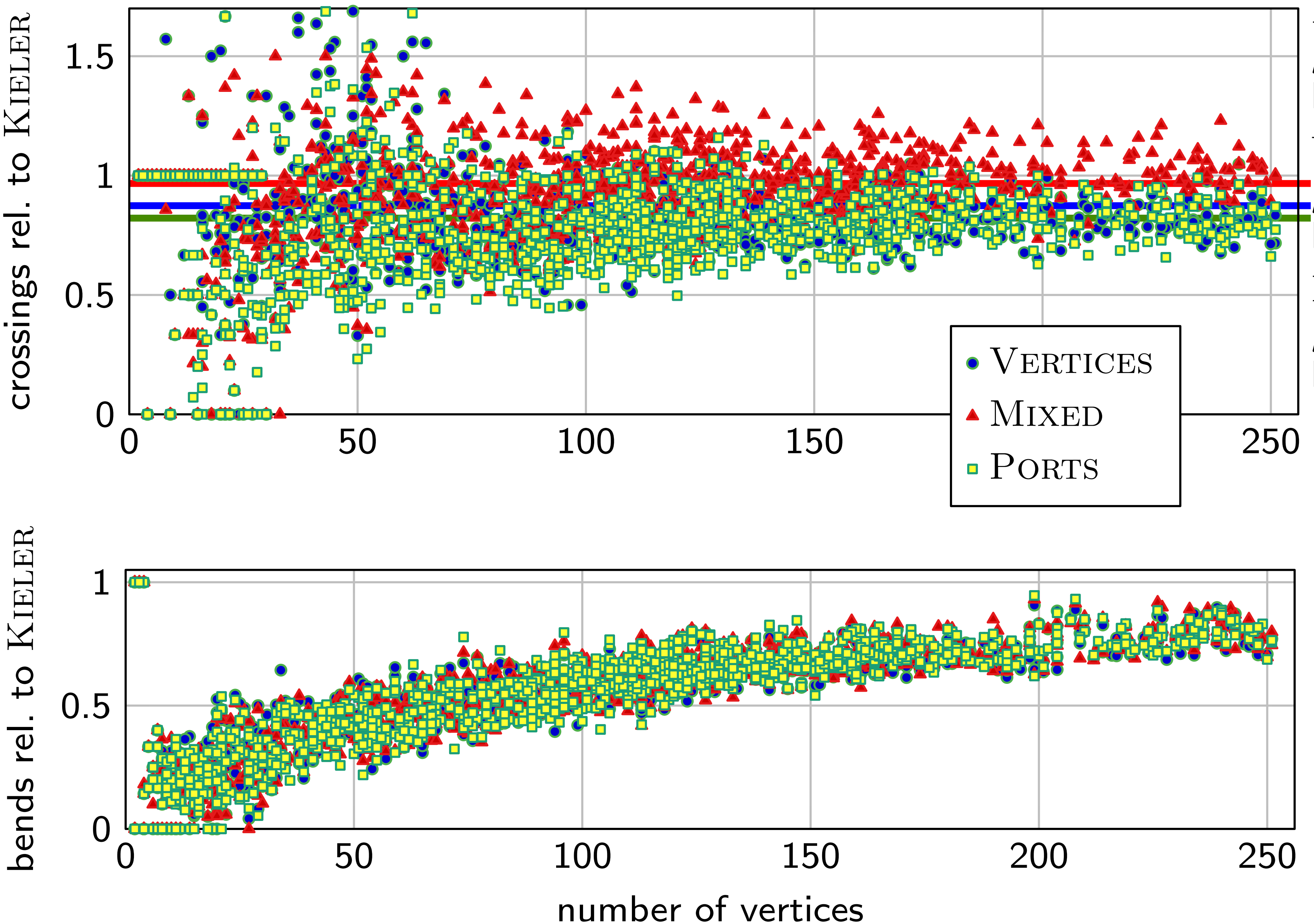
Mixed:
$\mu = .44$
best 29 %

Ports:
$\mu = .42$
best 72 %

Results: Crossing Minimization (Pseudo)



Results: Crossing Minimization (Pseudo)

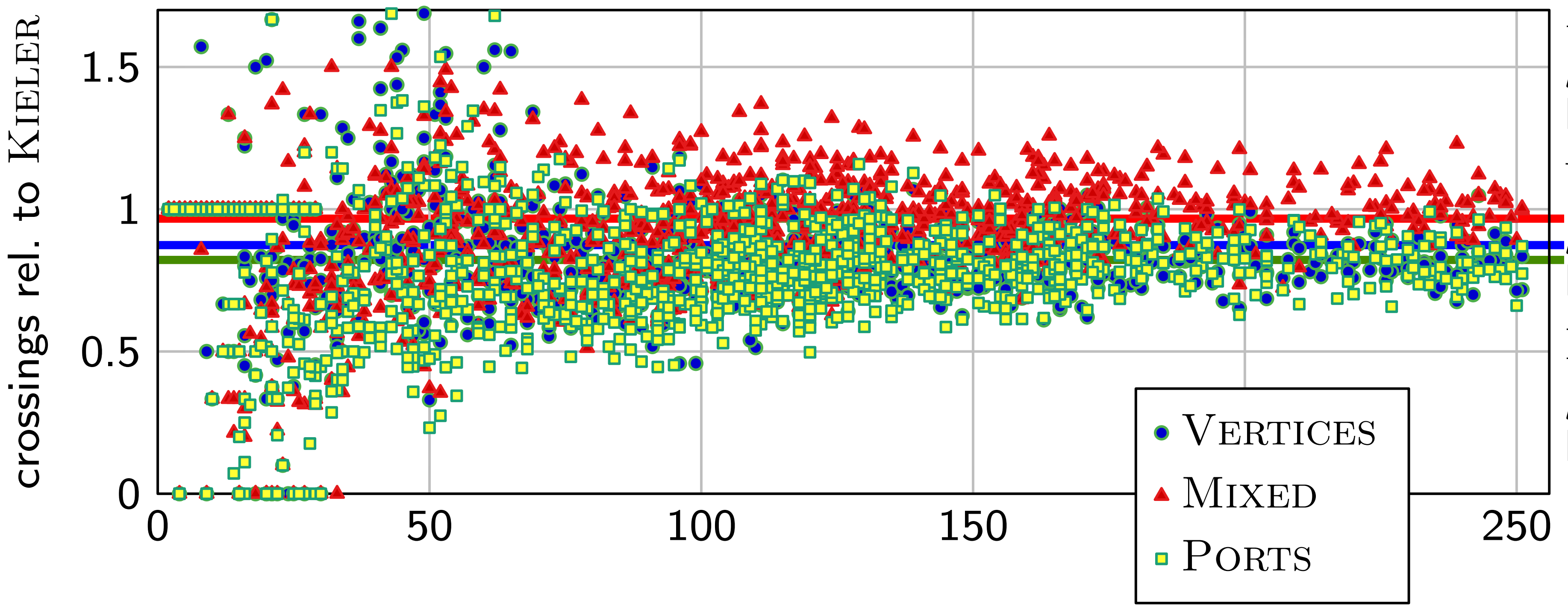


Mixed:
$\mu = .96$
best 15 %

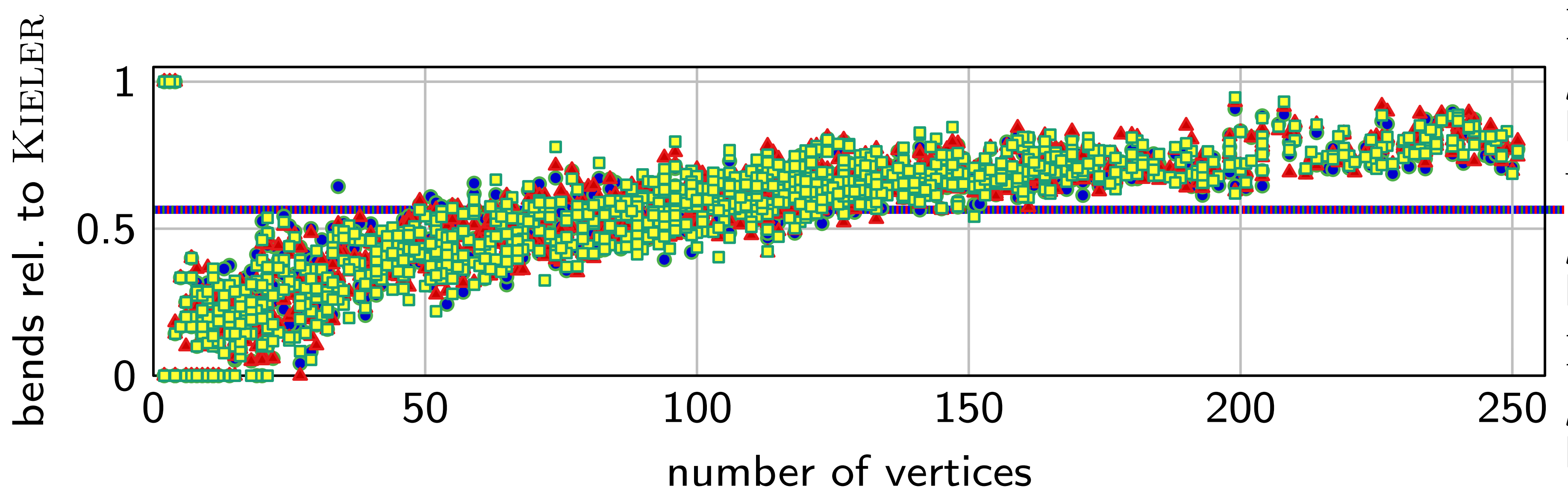
Vertices:
$\mu = .87$
best 39 %

Ports:
$\mu = .82$
best 62 %

Results: Crossing Minimization (Pseudo)

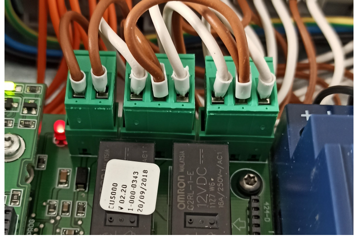


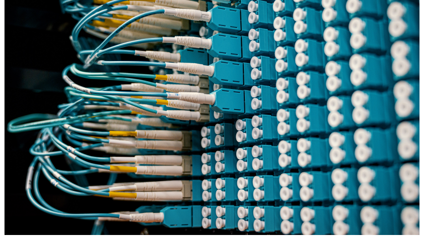
Mixed:
$\mu = .96$
best 15 %
Vertices:
$\mu = .87$
best 39 %
Ports:
$\mu = .82$
best 62 %



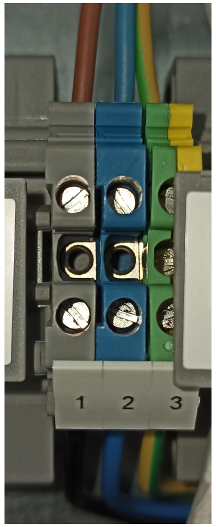
Mixed:
$\mu = .56$
best 34 %
Vertices:
$\mu = .56$
best 40 %
Ports:
$\mu = .56$
best 41 %

Conclusions

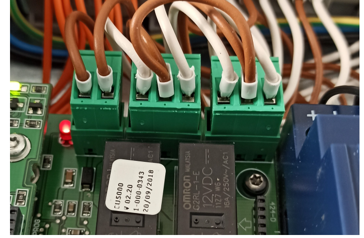


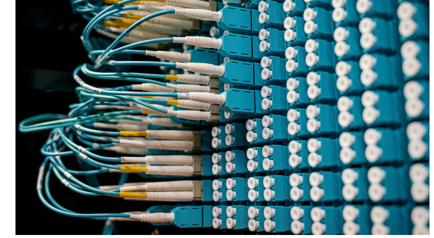


- We have extended the well-known Sugiyama framework to draw technical plans (like cable plans) that are undirected, have ports contained in (nested) port groups and plugs.



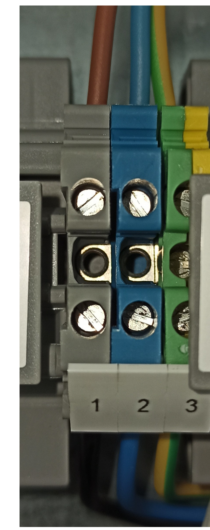
Conclusions



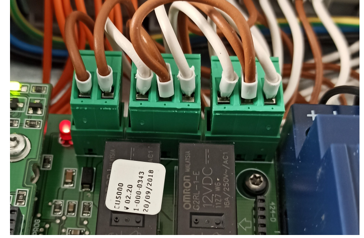


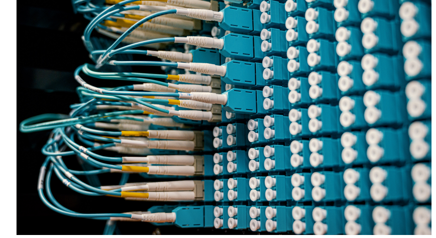
- We have extended the well-known Sugiyama framework to draw technical plans (like cable plans) that are undirected, have ports contained in (nested) port groups and plugs.

- We have implemented and experimentally evaluated our algorithm on real and on synthetic data.



Conclusions





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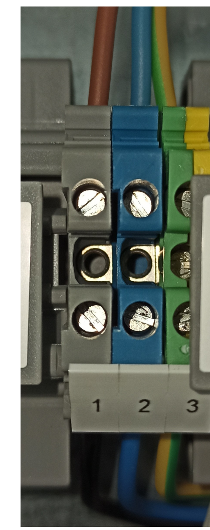
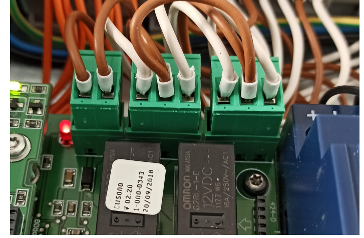
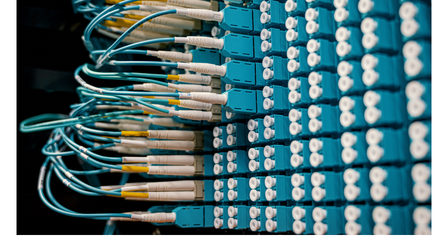


- We have implemented and experimentally evaluated our algorithm on real and on synthetic data.

- FD was best for orienting undirected edges; PORTS was best for reducing crossings.

Conclusions





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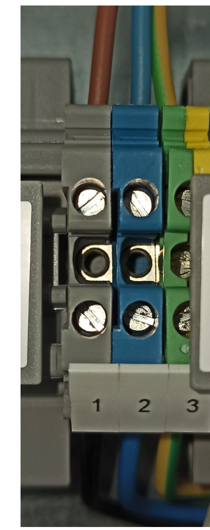

- We have implemented and experimentally evaluated our algorithm on real and on synthetic data.

- FD was best for orienting undirected edges;
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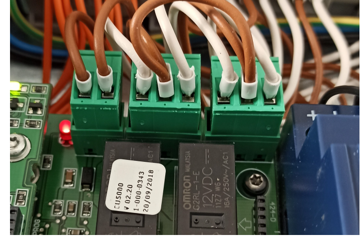
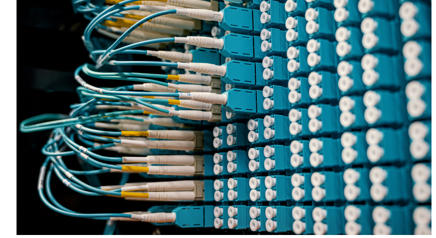
- Our variants compare well with existing implementation (KIELER) in terms of #crossings and #bends (but slower).

Conclusions





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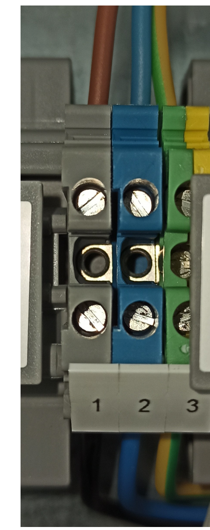

- We have implemented and experimentally evaluated our algorithm on real and on synthetic data.
- FD was best for orienting undirected edges; PORTS was best for reducing crossings.
- Our variants compare well with existing implementation (KIELER) in terms of #crossings and #bends (but slower).
- We intend to integrate our algorithm into the software of our industrial partner to see whether this statistical improvement yields advantages in practice.