

A Simple Pipeline for Orthogonal Graph Drawing

Tim Hegemann **Alexander Wolff**

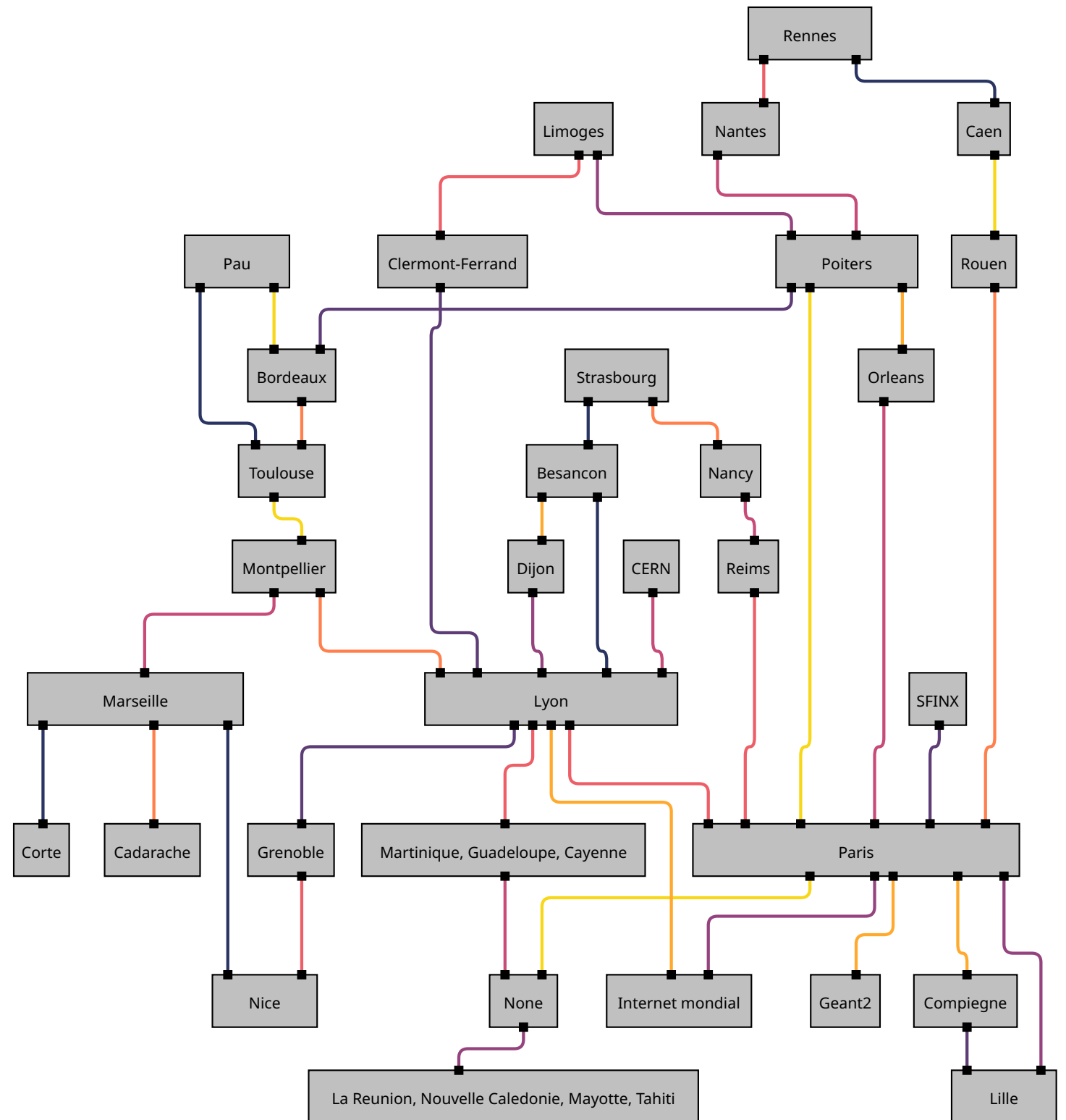
The 31st International Symposium on
Graph Drawing and Network Visualization

Motivation

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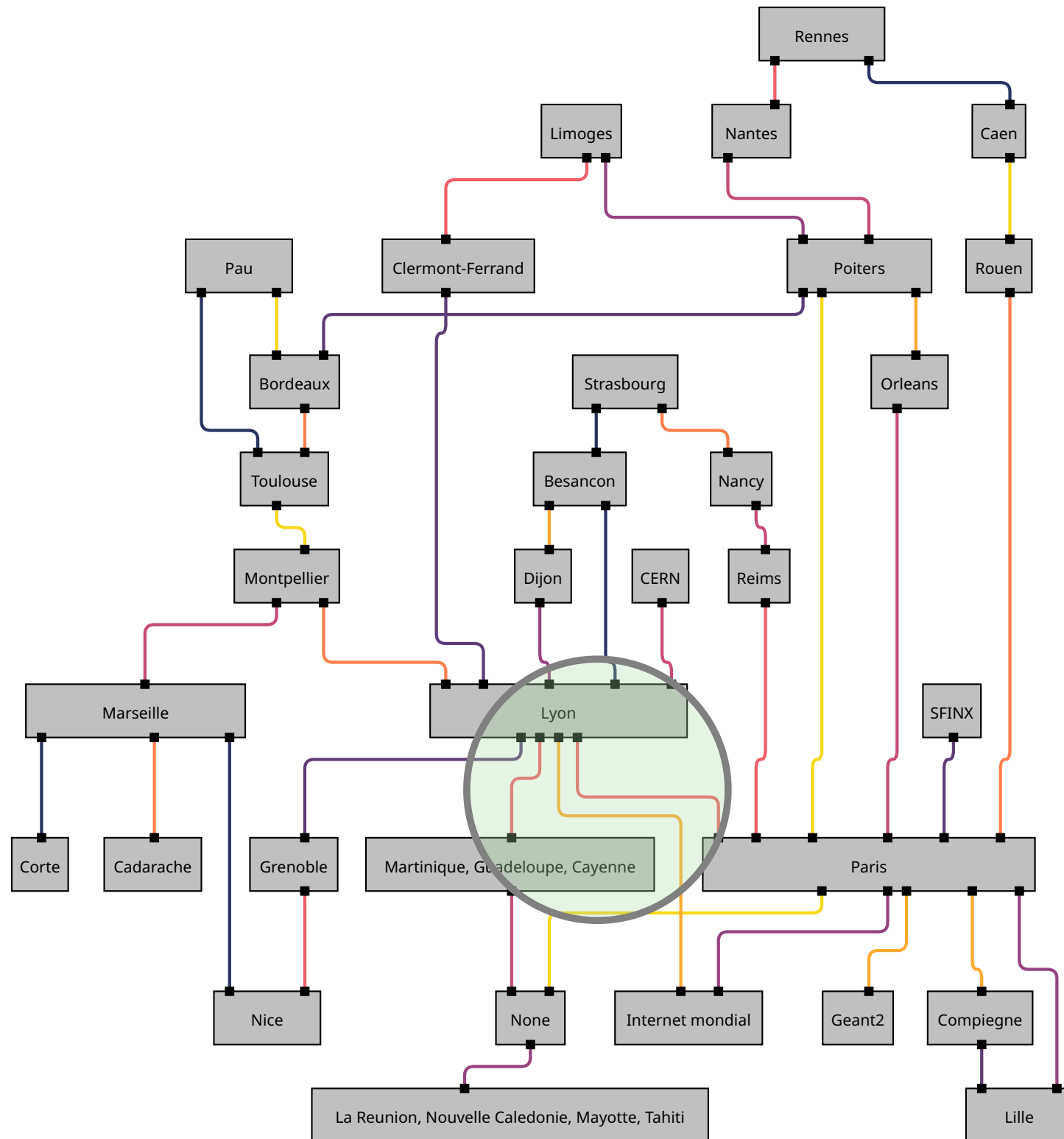
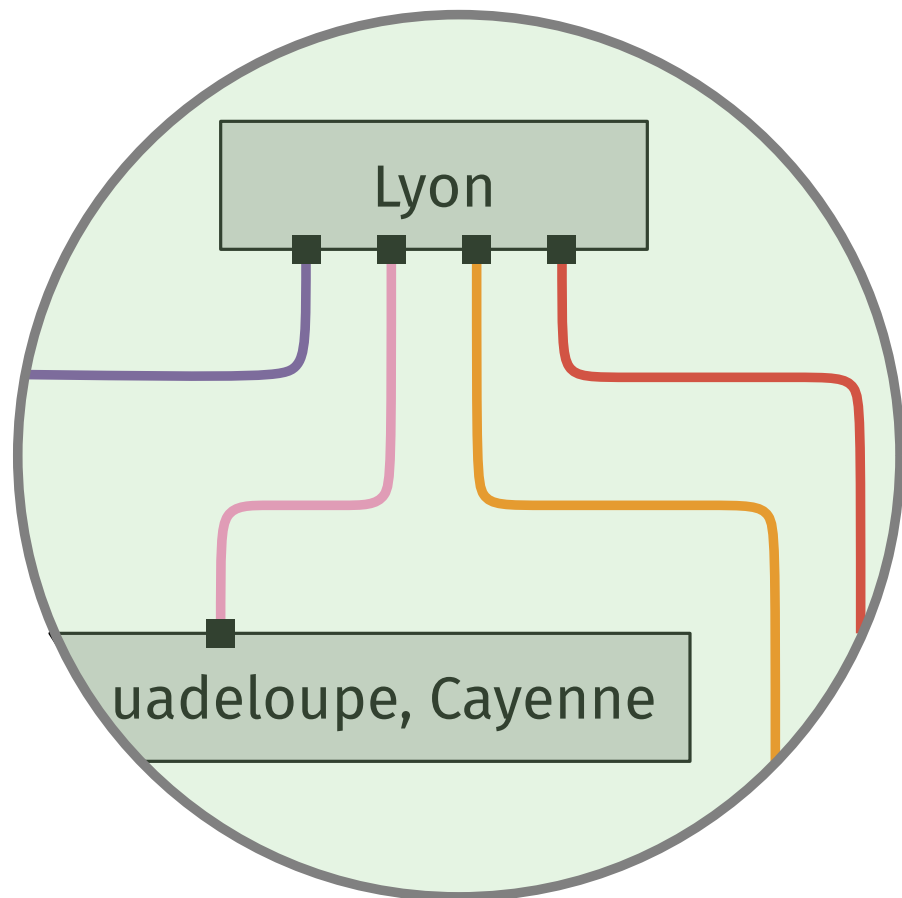


State of the Art



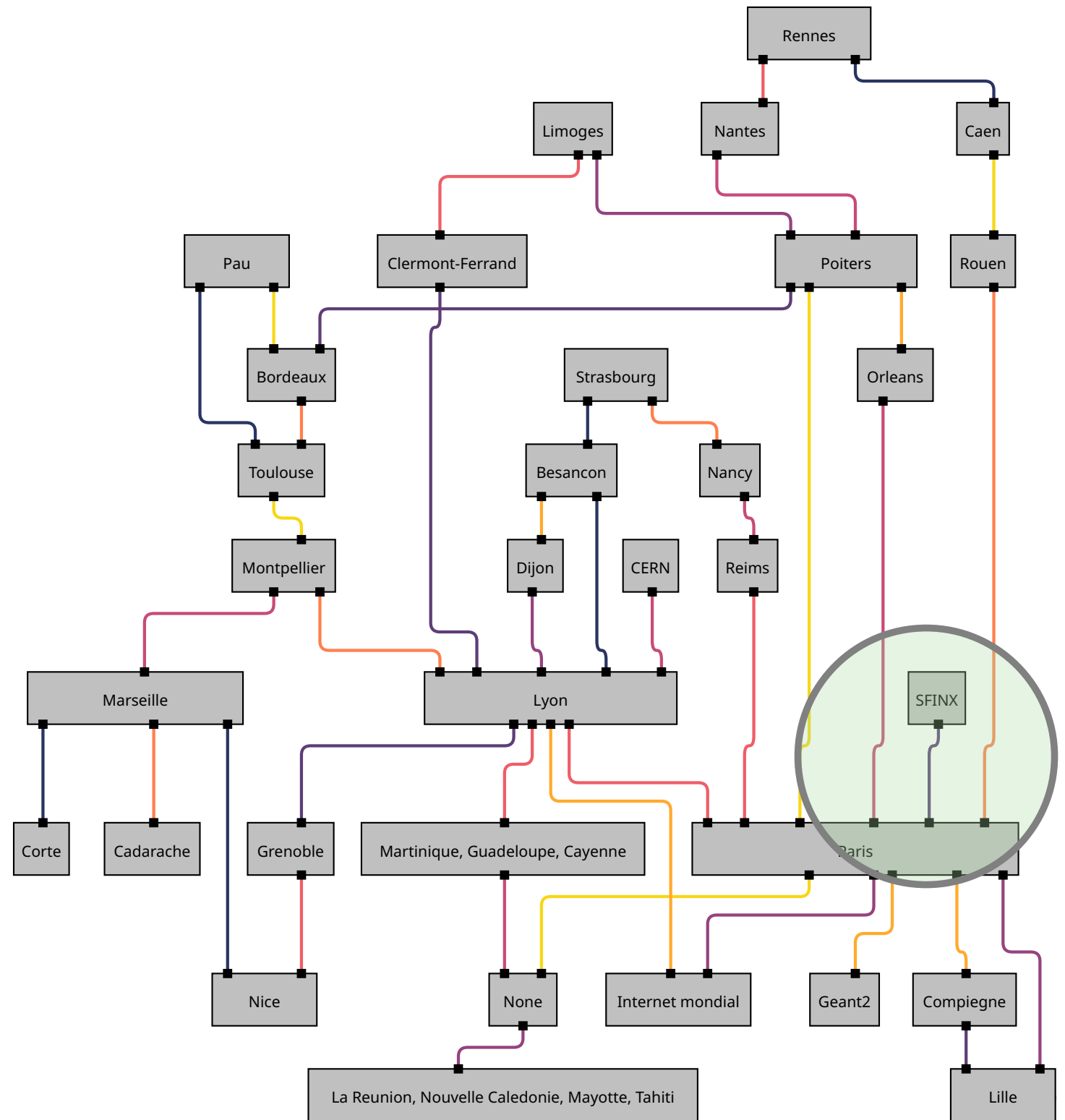
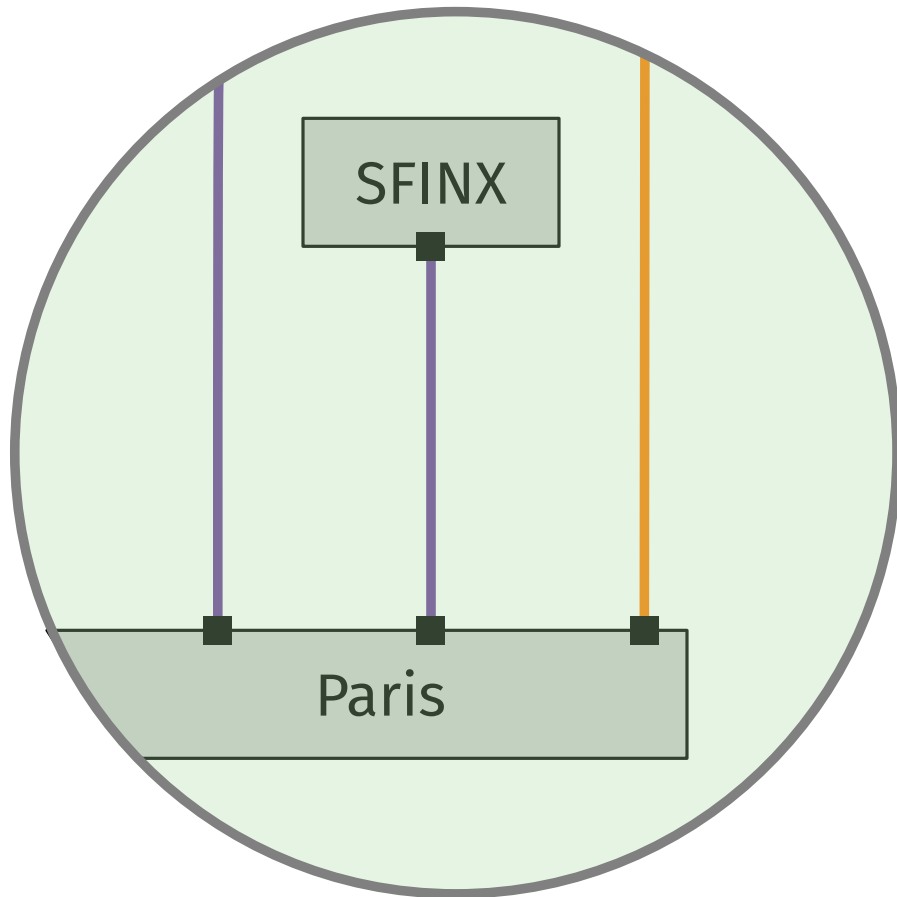
State of the Art

better:

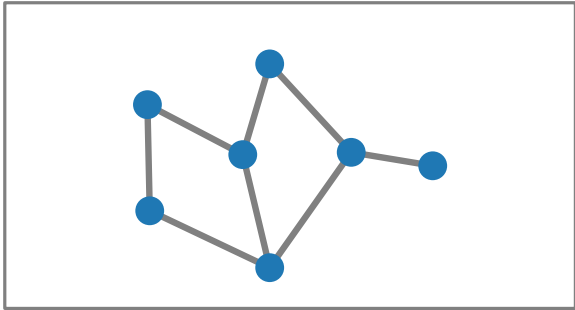


State of the Art

better:



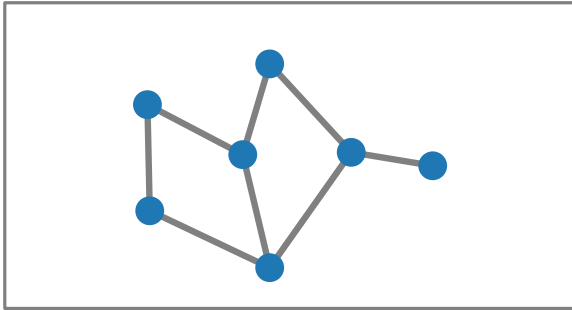
A Simple Pipeline



vertex layout

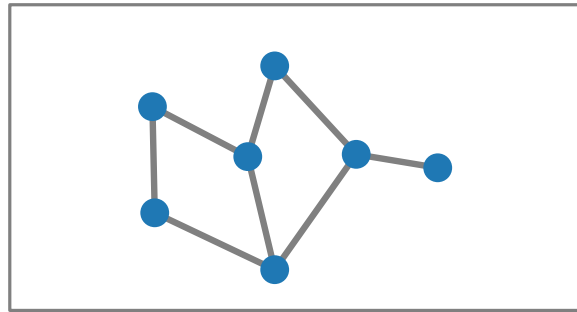
A Simple Pipeline

[Fruchtermann, Reingold 1991]

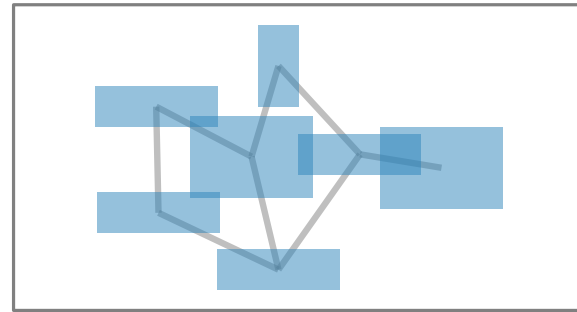


vertex layout

A Simple Pipeline

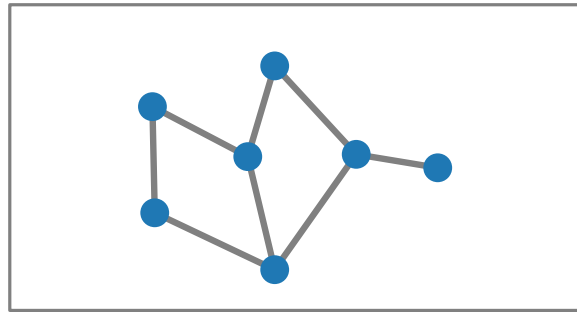


vertex layout

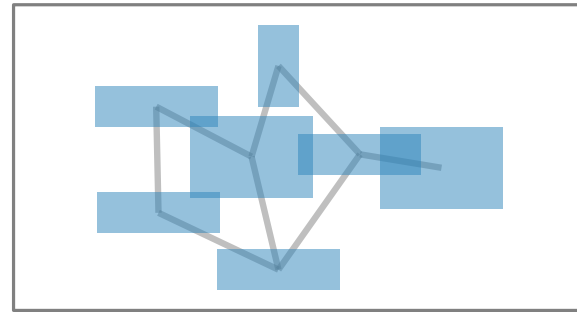


vertex boxes

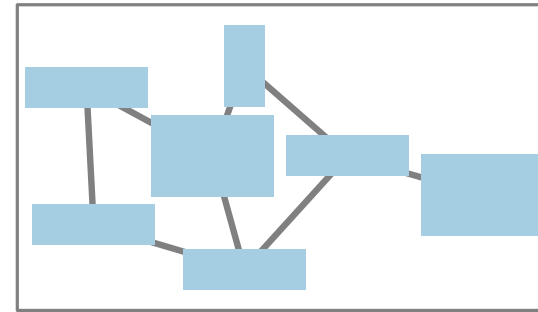
A Simple Pipeline



vertex layout



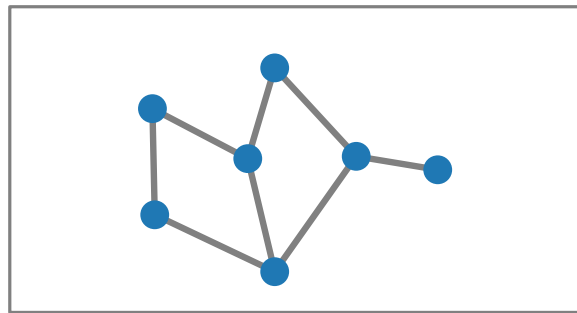
vertex boxes



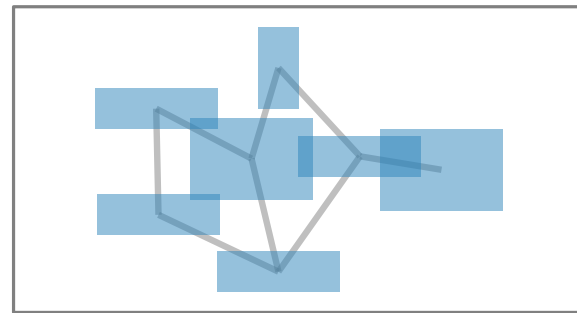
overlap removal

A Simple Pipeline

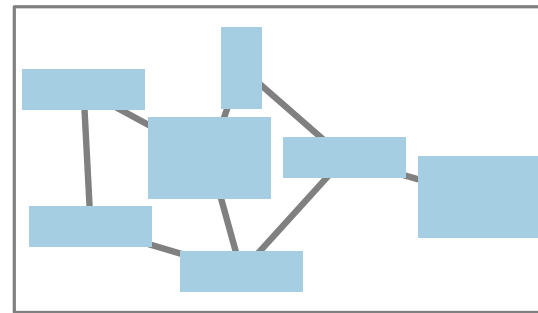
[Nachmanson et al. 2017]



vertex layout

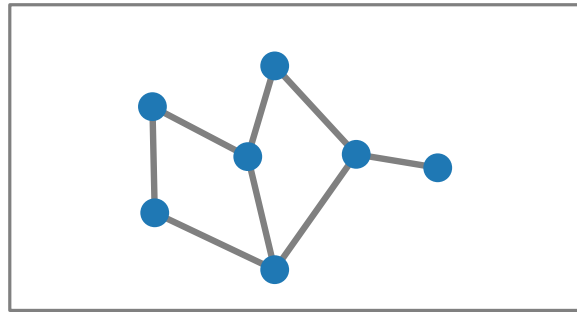


vertex boxes

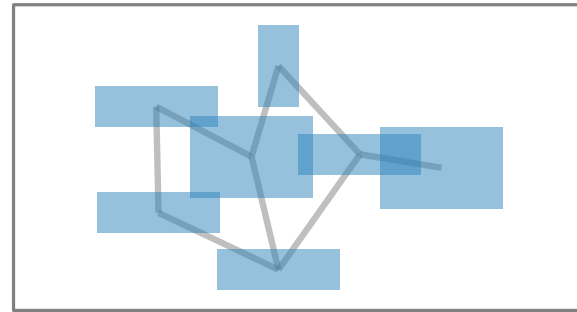


overlap removal

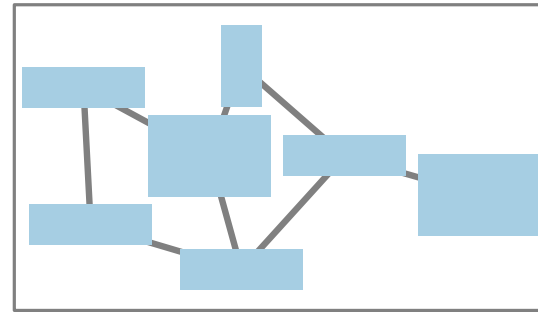
A Simple Pipeline



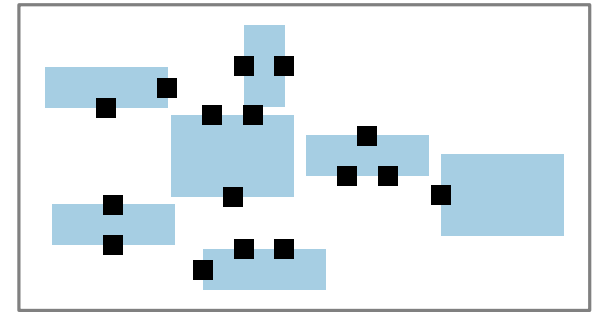
vertex layout



vertex boxes

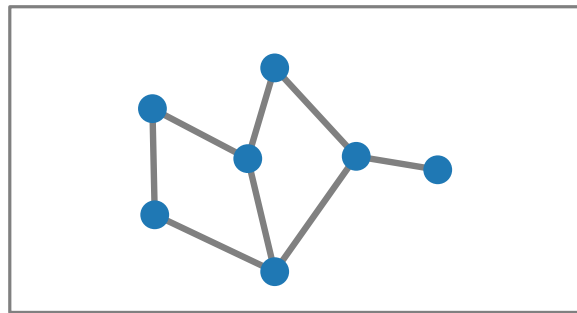


overlap removal

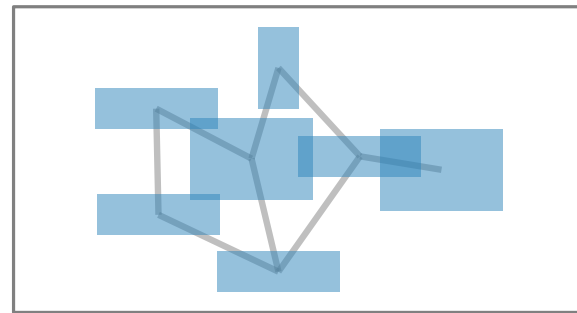


port assignment

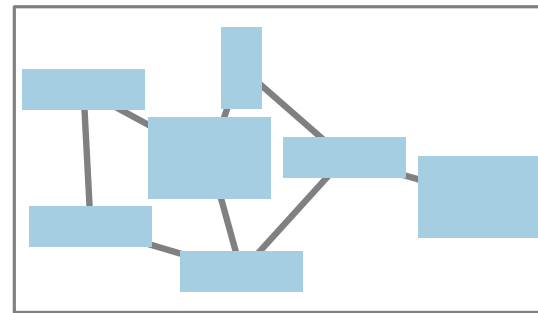
A Simple Pipeline



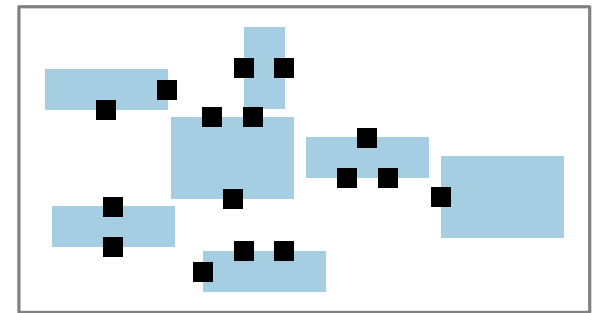
vertex layout



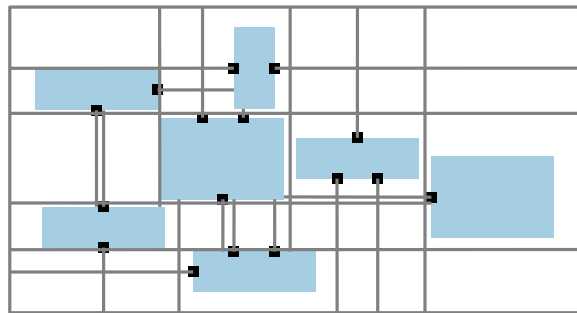
vertex boxes



overlap removal

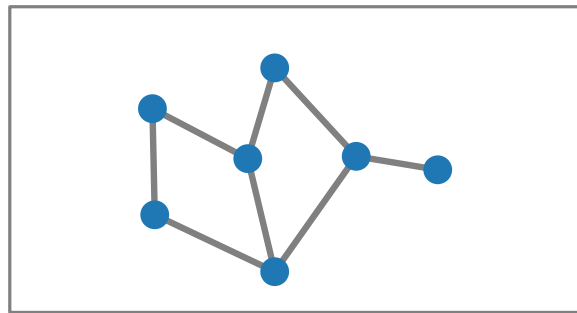


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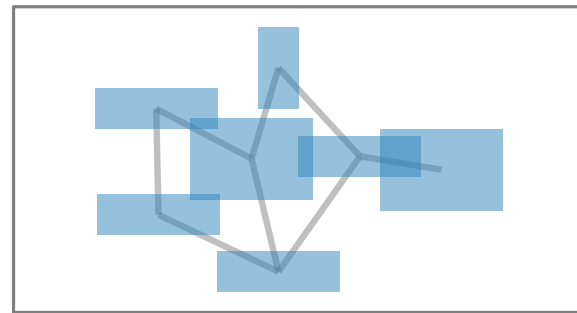


routing graph

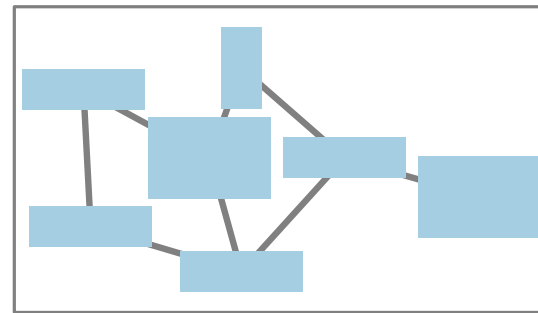
A Simple Pipeline



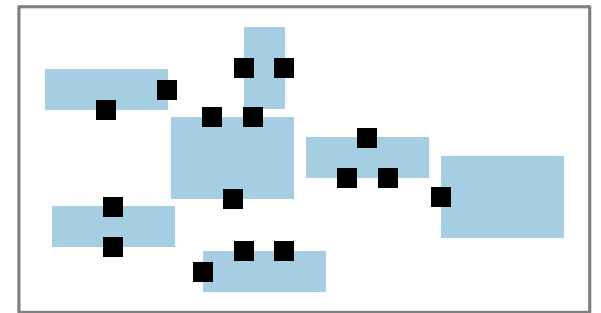
vertex layout



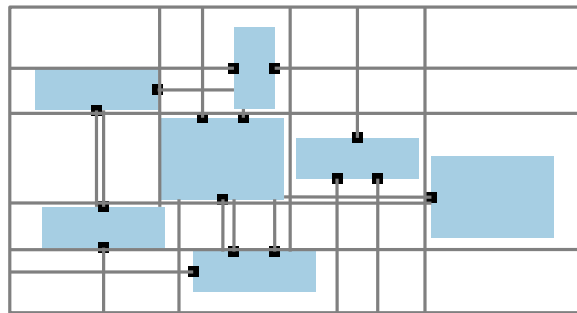
vertex boxes



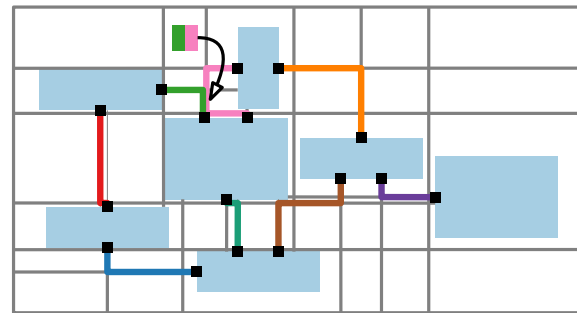
overlap removal



port assignment

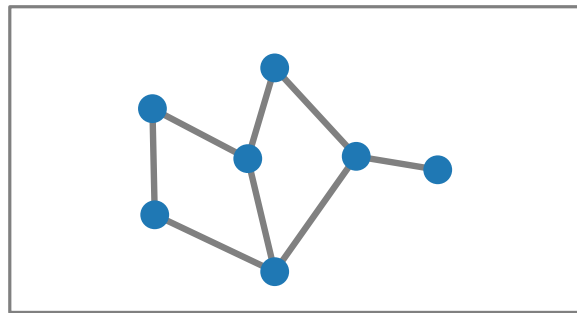


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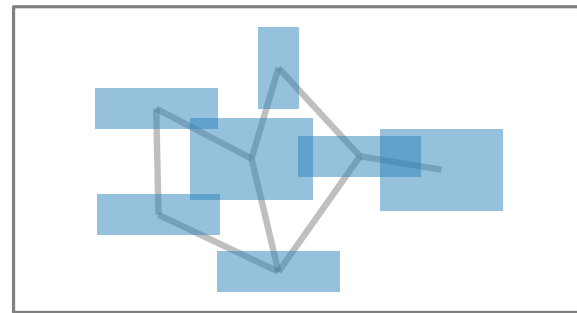


routing+ordering

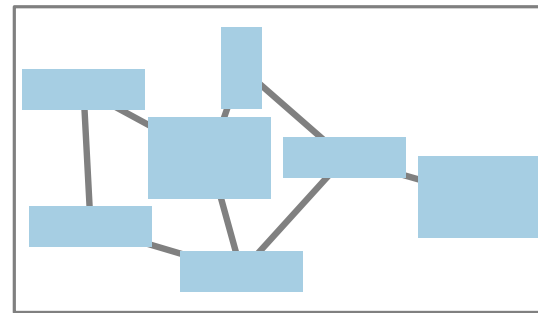
A Simple Pipeline



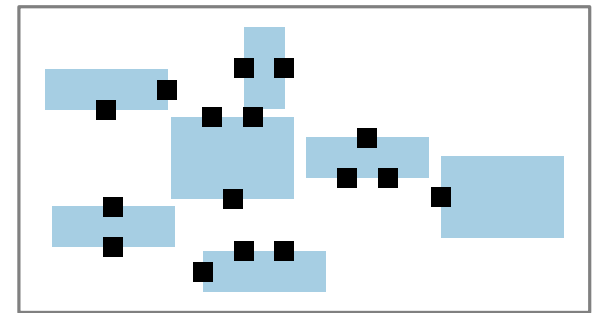
vertex layout



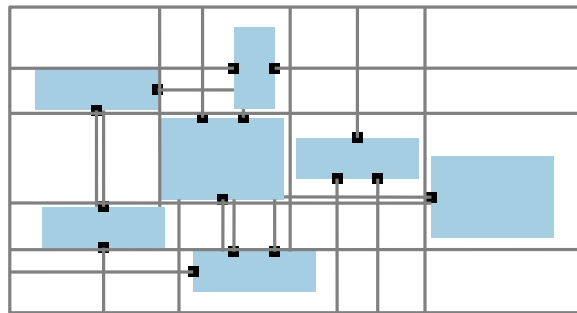
vertex boxes



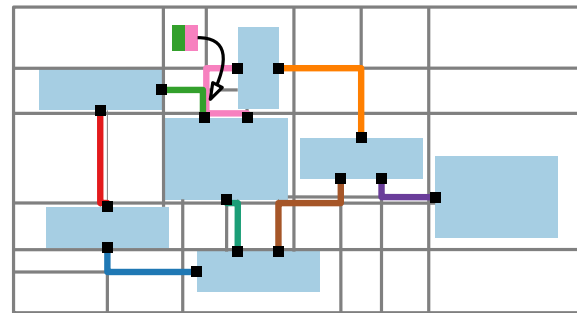
overlap removal



port assignment



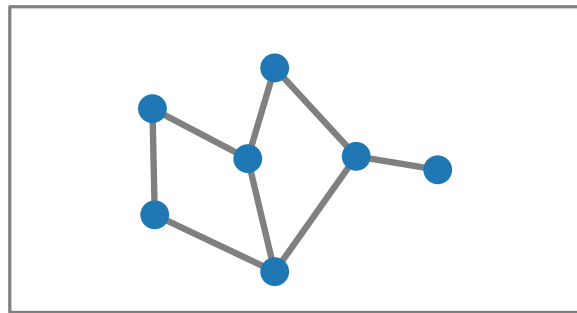
routing graph



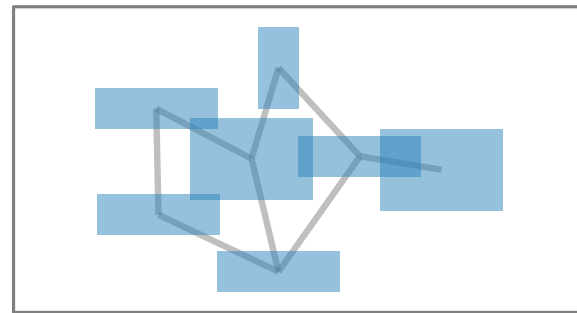
routing+ordering

[Wybrow et al. 2010, Pupyrev et al. 2016]

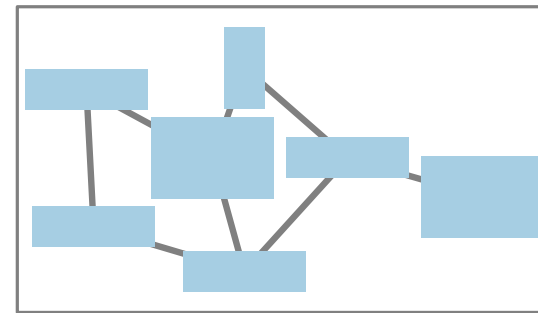
A Simple Pipeline



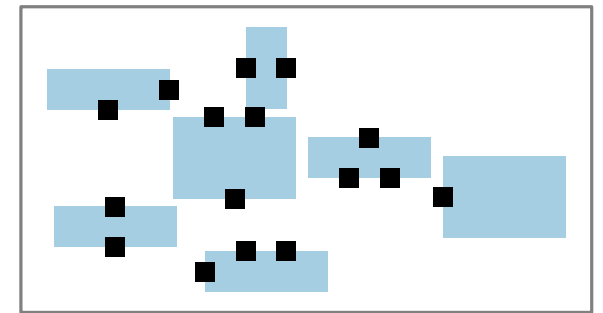
vertex layout



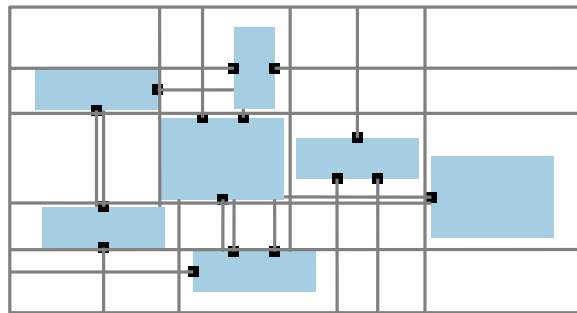
vertex boxes



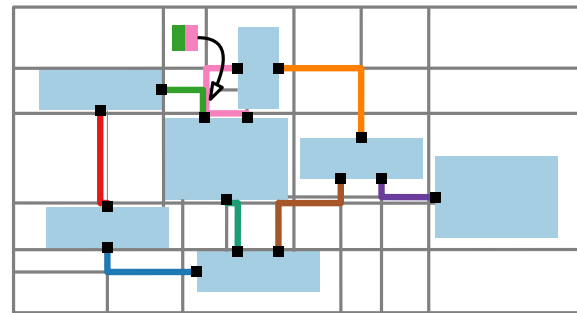
overlap removal



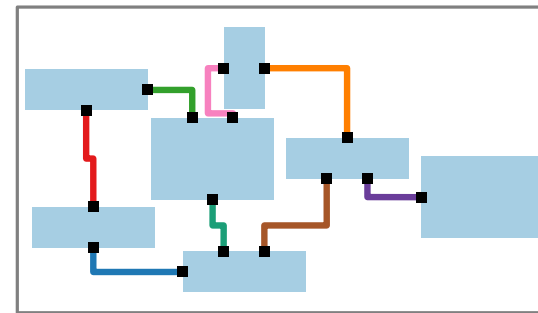
port assignment



routing graph

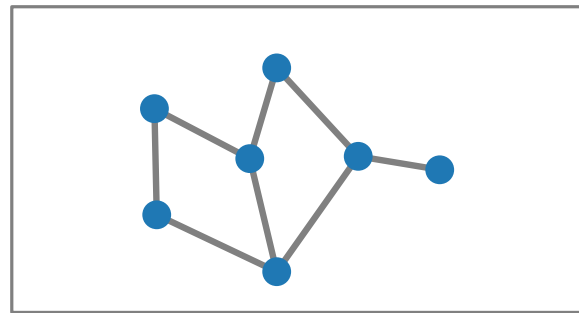


routing+ordering

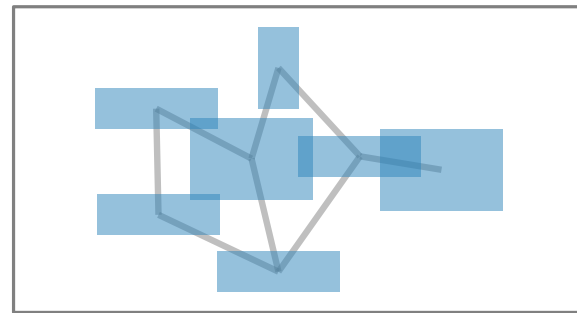


constrained nudging

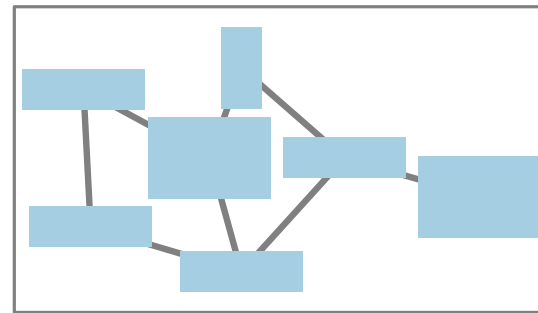
A Simple Pipeline



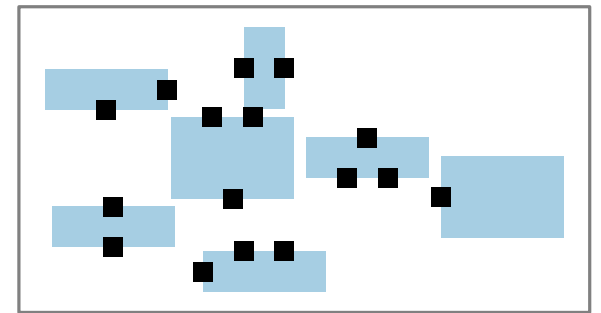
vertex layout



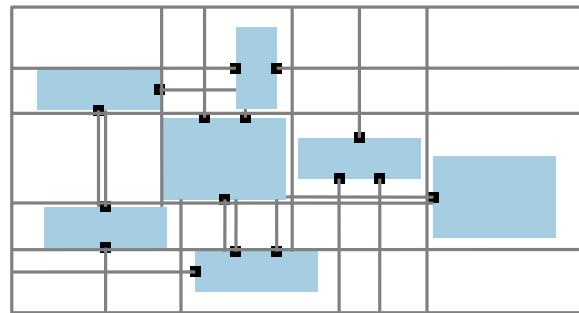
vertex boxes



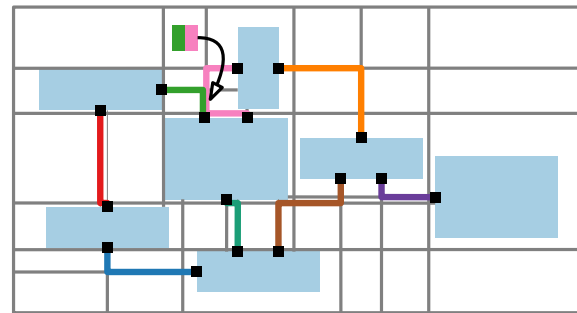
overlap removal



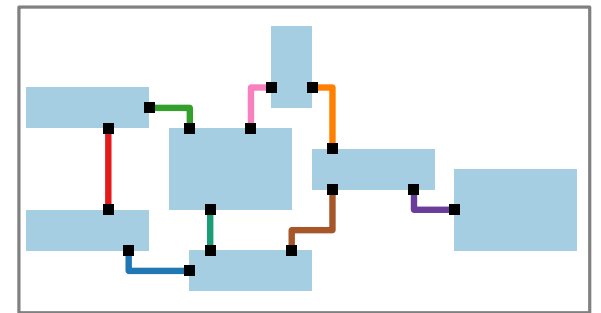
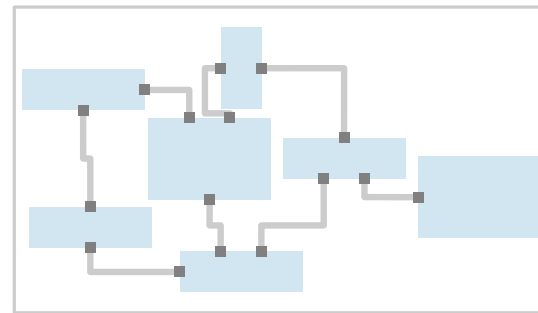
port assignment



routing graph

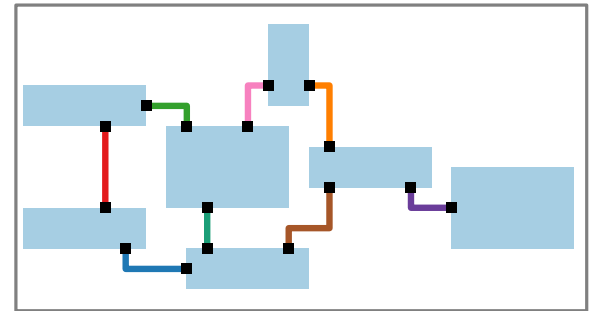
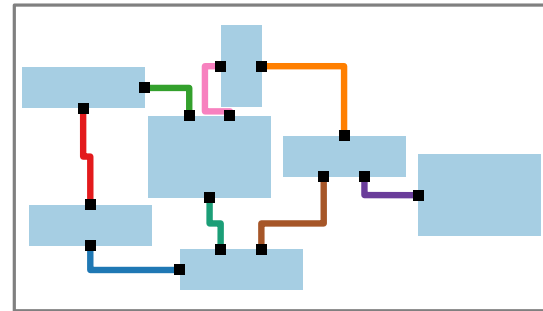
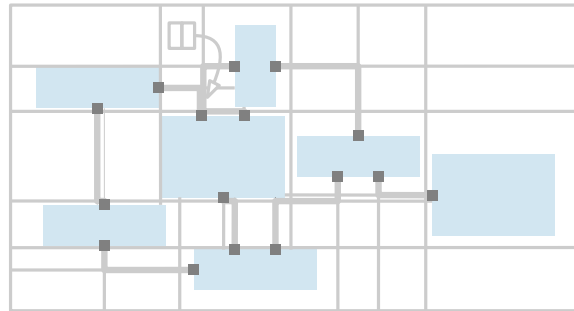
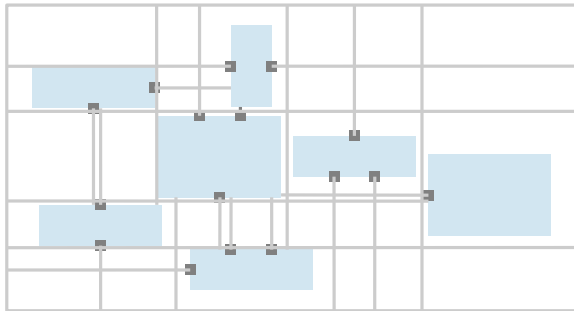
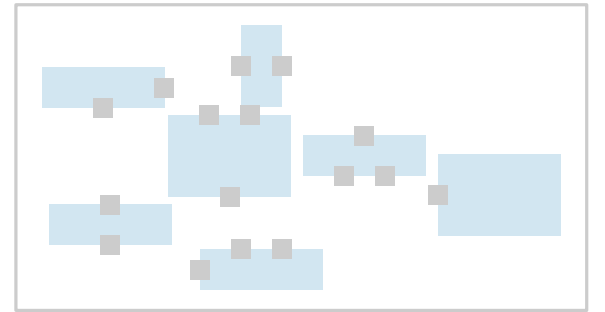
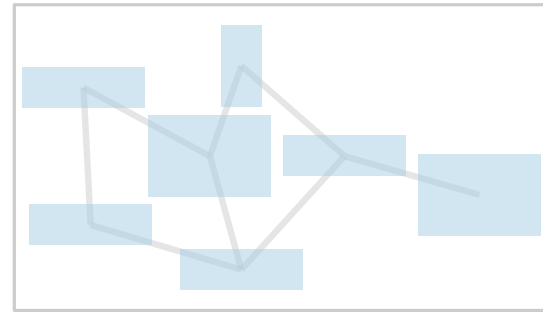
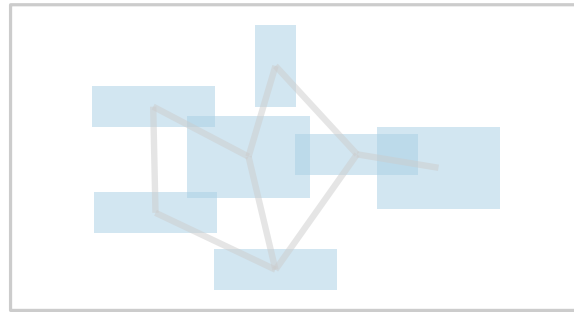
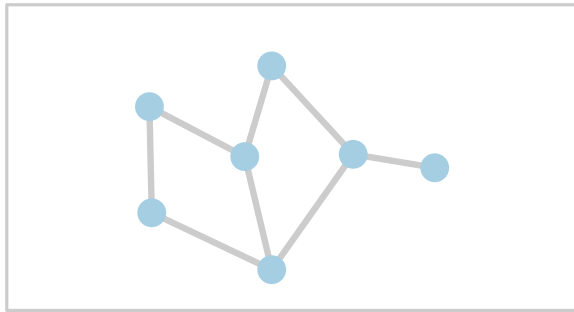


routing+ordering



full nudging

A Simple Pipeline



constrained nudging

full nudging

Contribution

- (i) The extended, LP-based nudging step with
 - a good heuristic for distributing edge segments,
 - effective compaction,
 - minimum object distance guarantees.

Contribution

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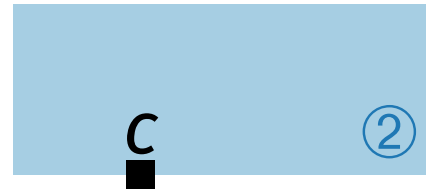
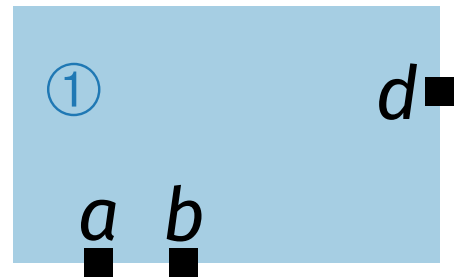
- (ii) The pipeline as a well integrated, flexible software package.

Contribution

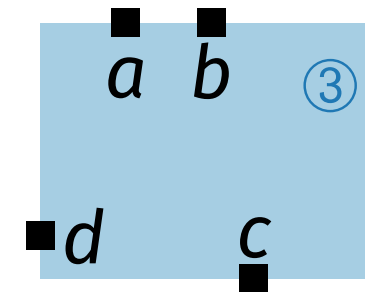
- (i) The extended, LP-based nudging step with
 - a good heuristic for distributing edge segments,
 - effective compaction,
 - minimum object distance guarantees.
- (ii) The pipeline as a well integrated, flexible software package.
- (iii) An experimental comparison with two state-of-the-art orthogonal drawing libraries.

Our Nudging Step

Input:



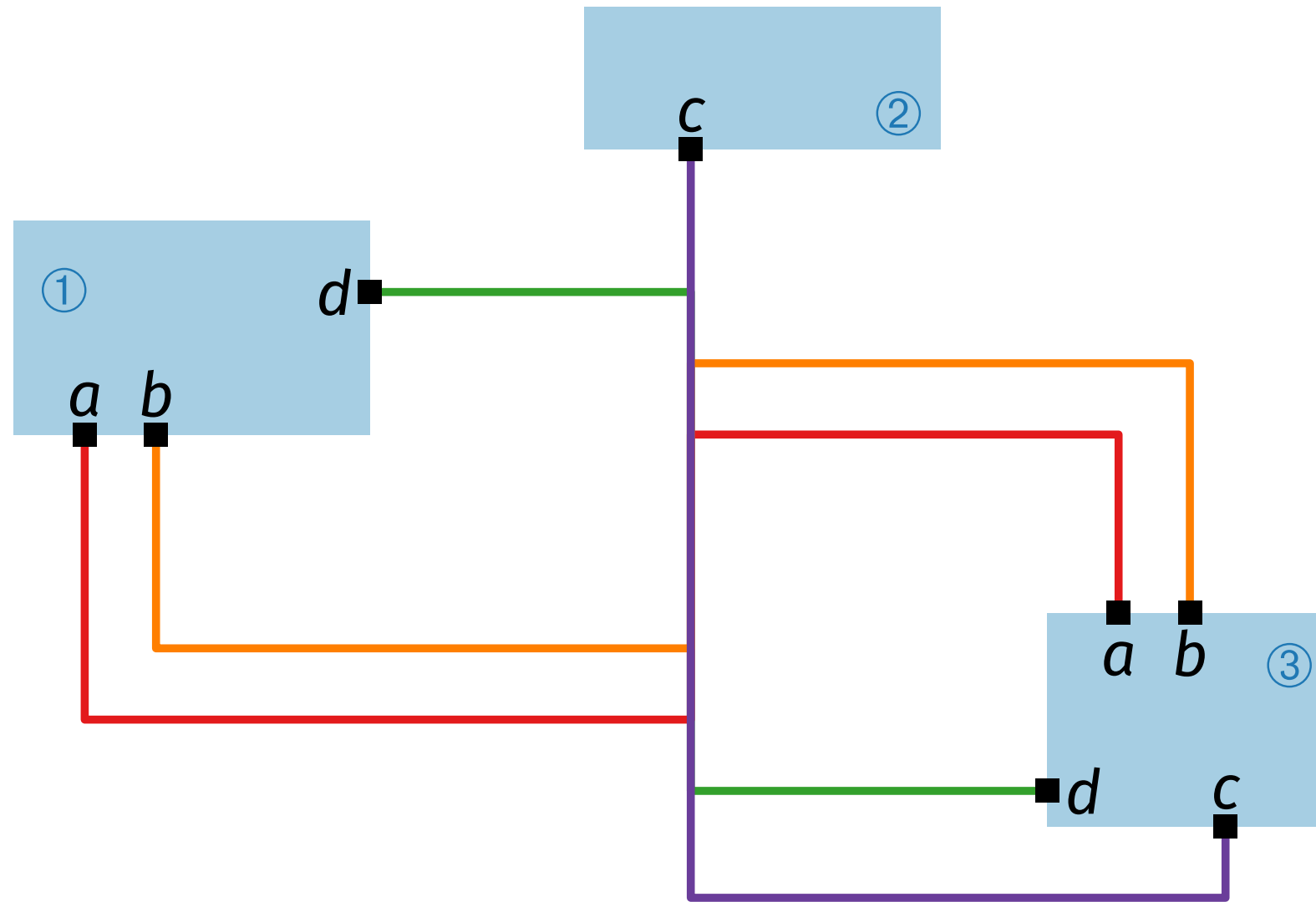
δ_{\min}



Our Nudging Step

Horizontal step

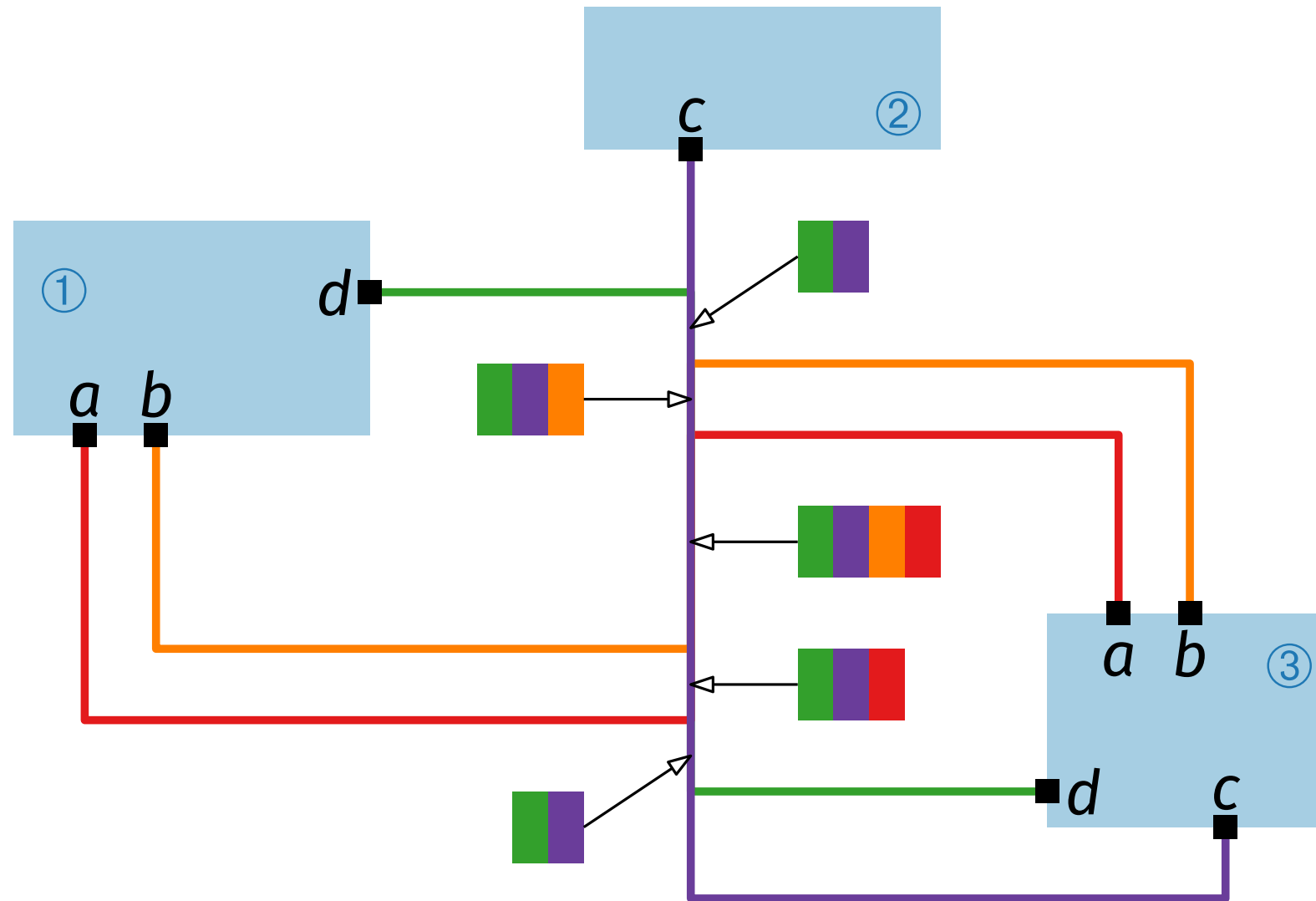
Input:



Our Nudging Step

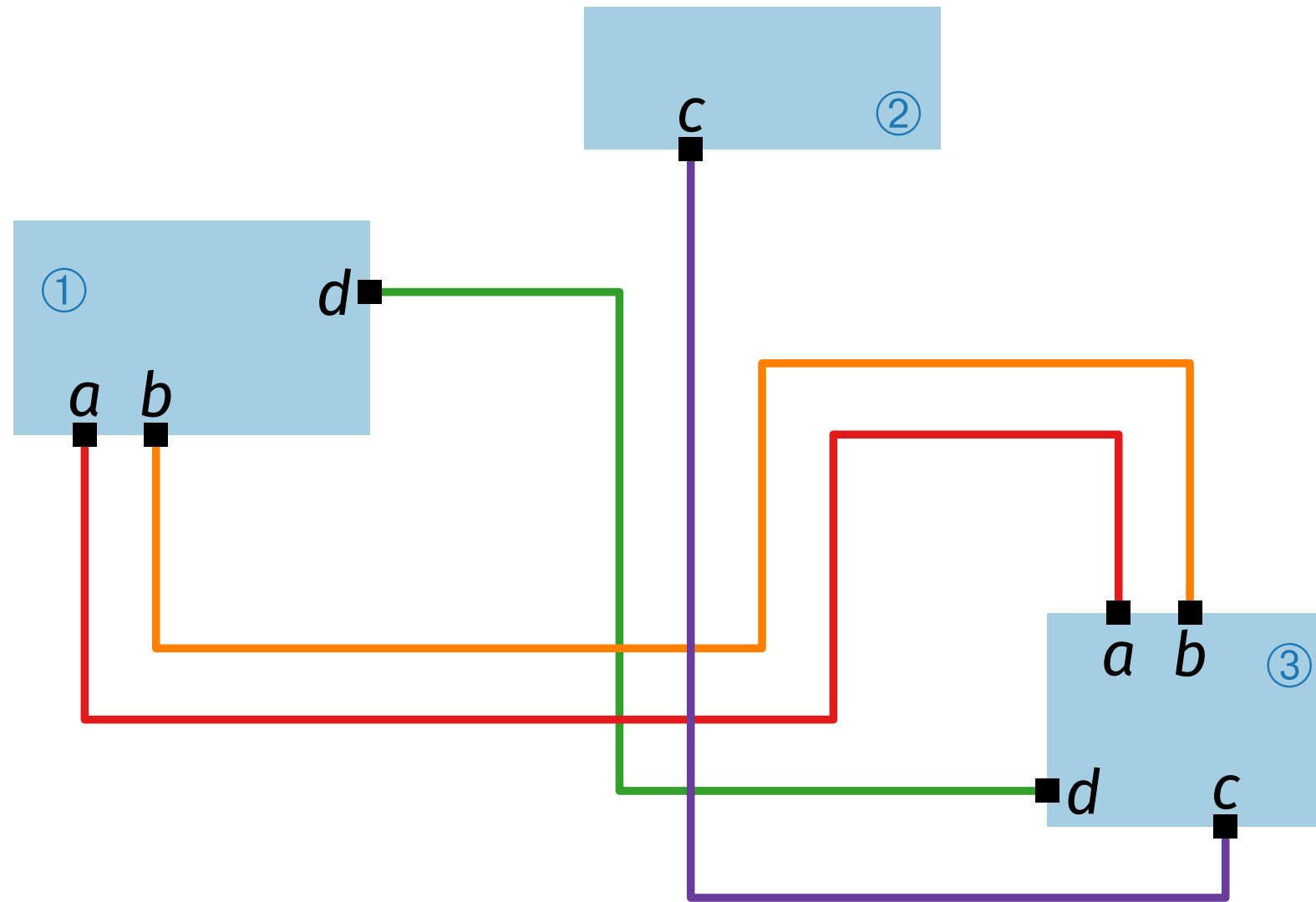
Horizontal step

Input:



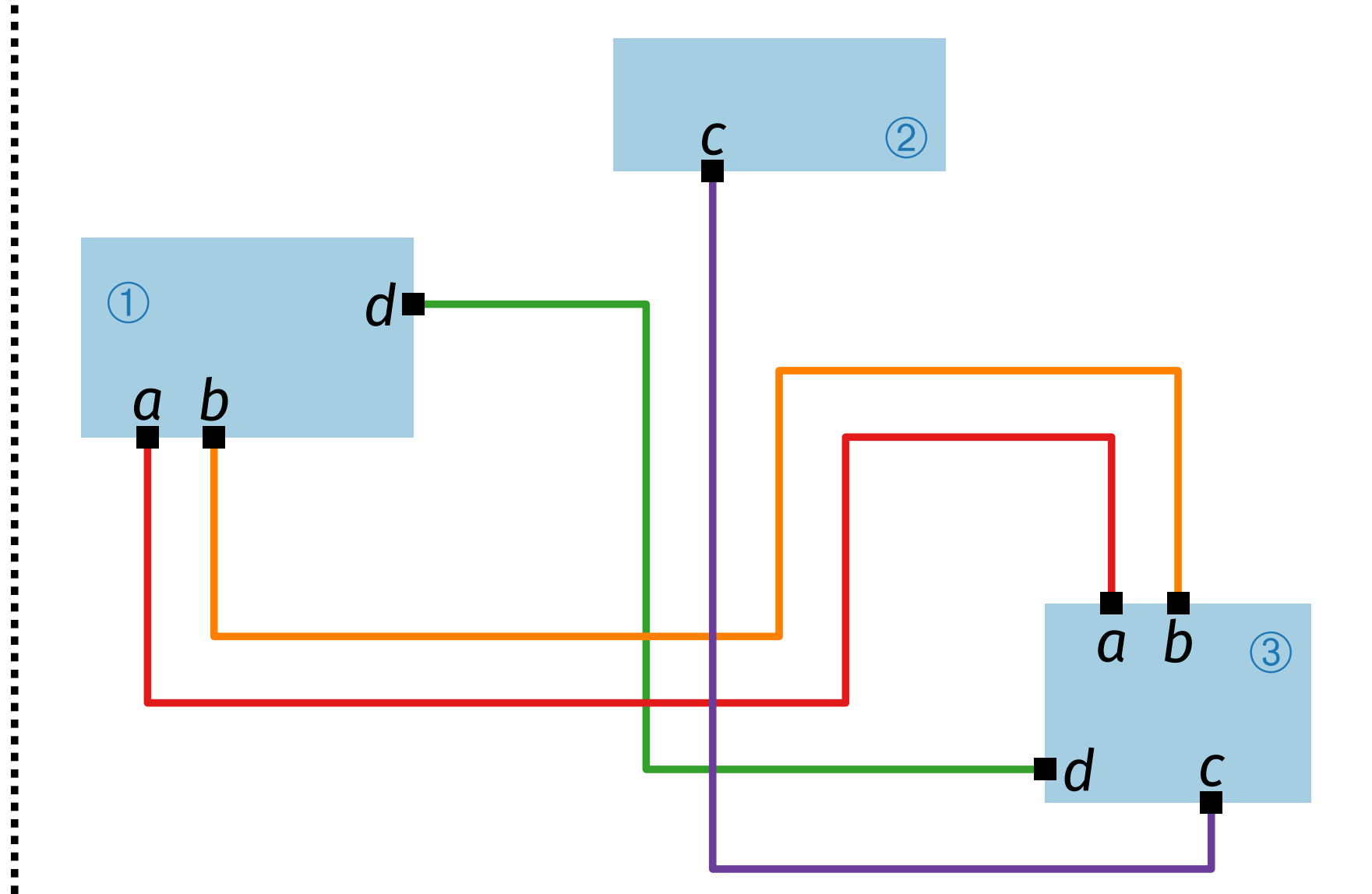
Our Nudging Step

Horizontal step



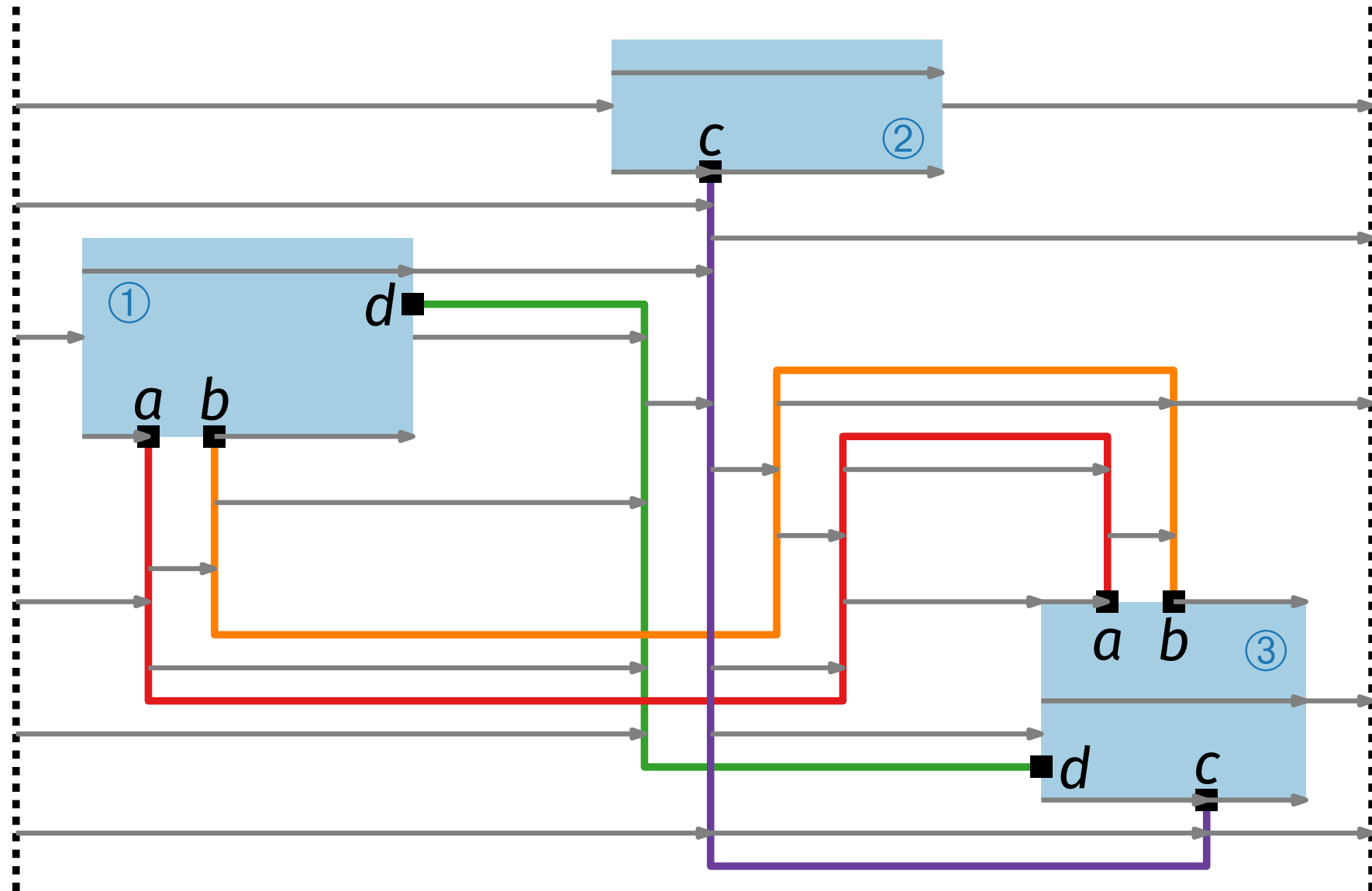
Our Nudging Step

Horizontal step



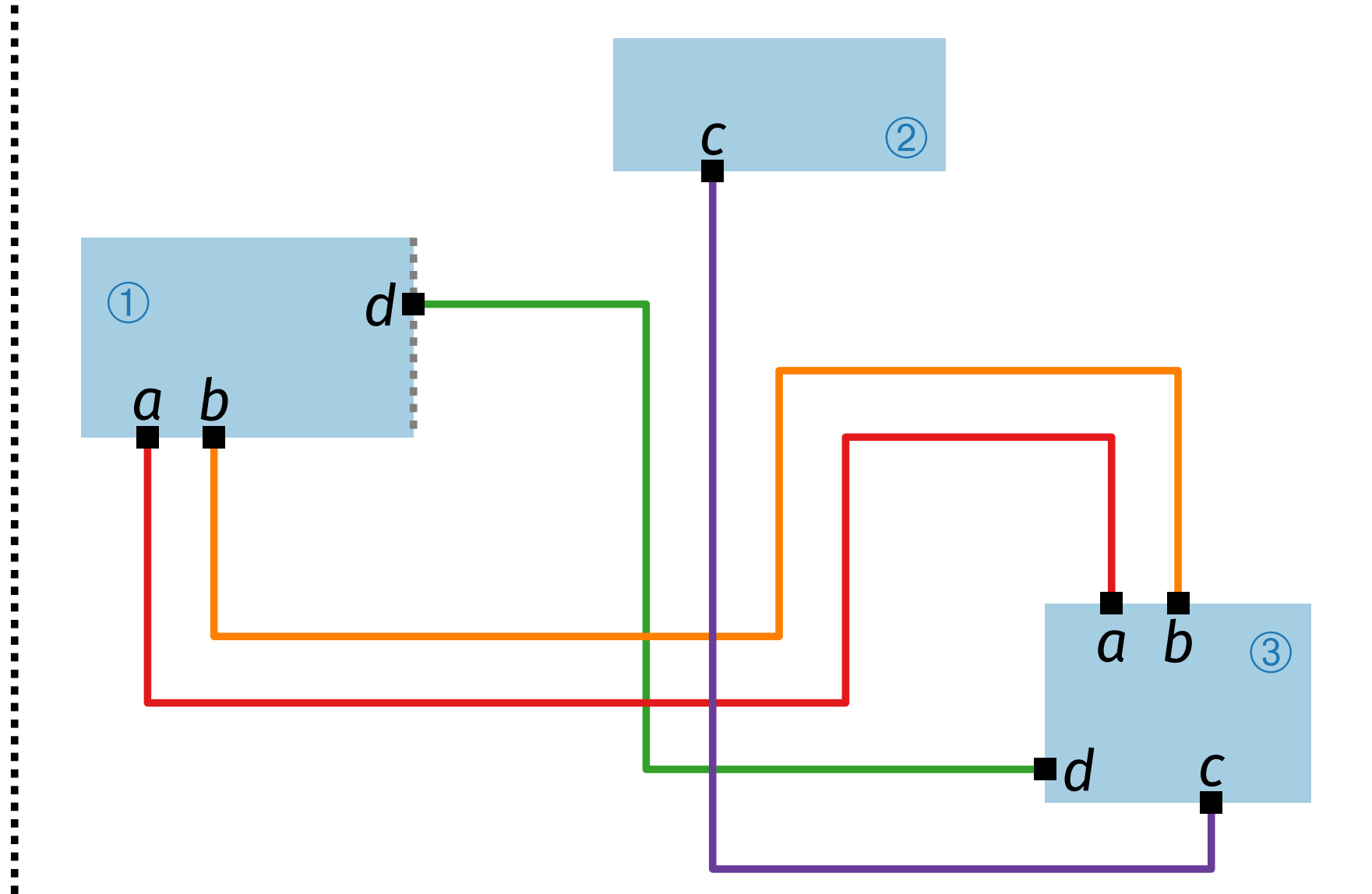
Our Nudging Step

Horizontal step



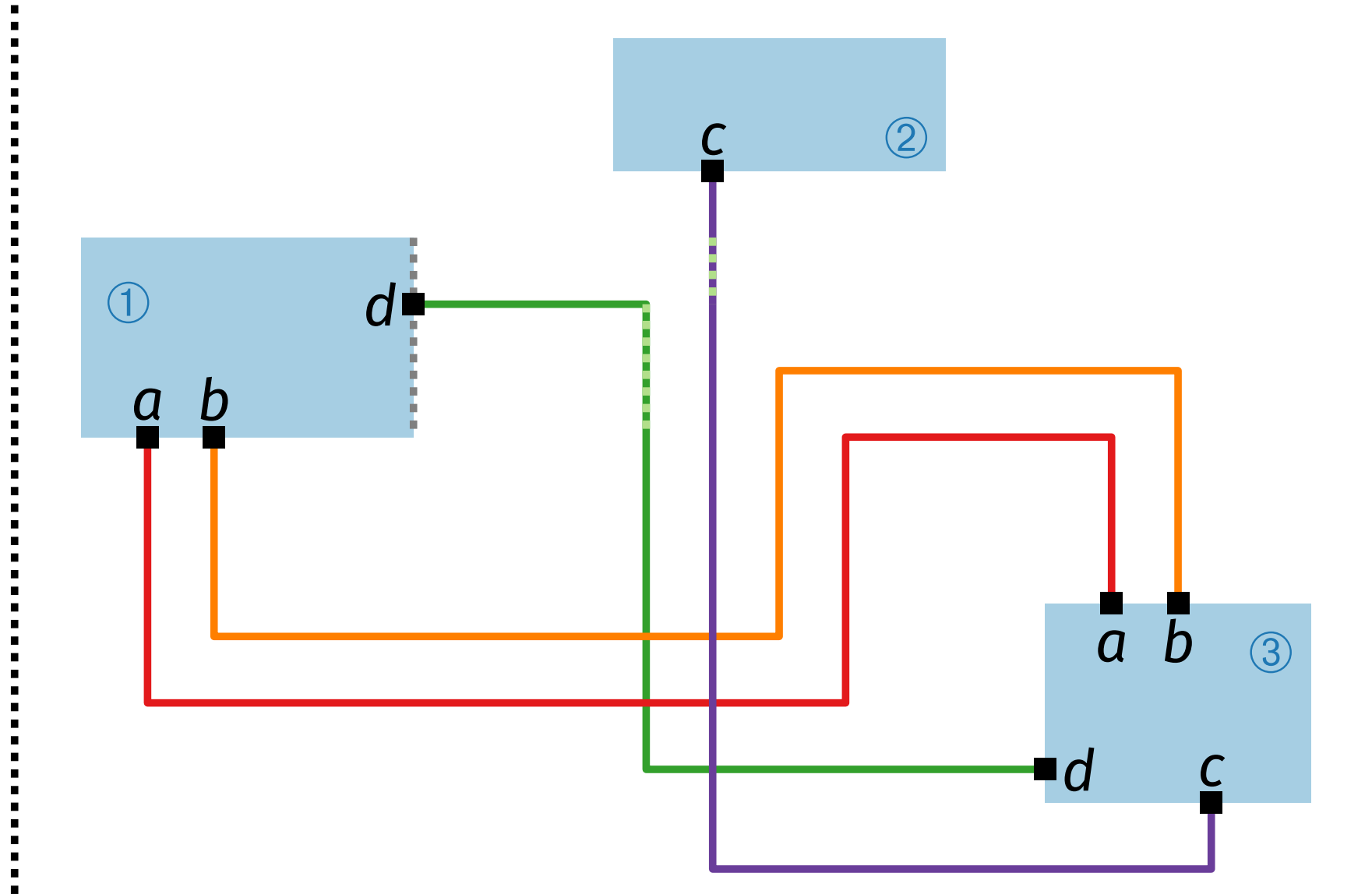
Our Nudging Step

Horizontal step



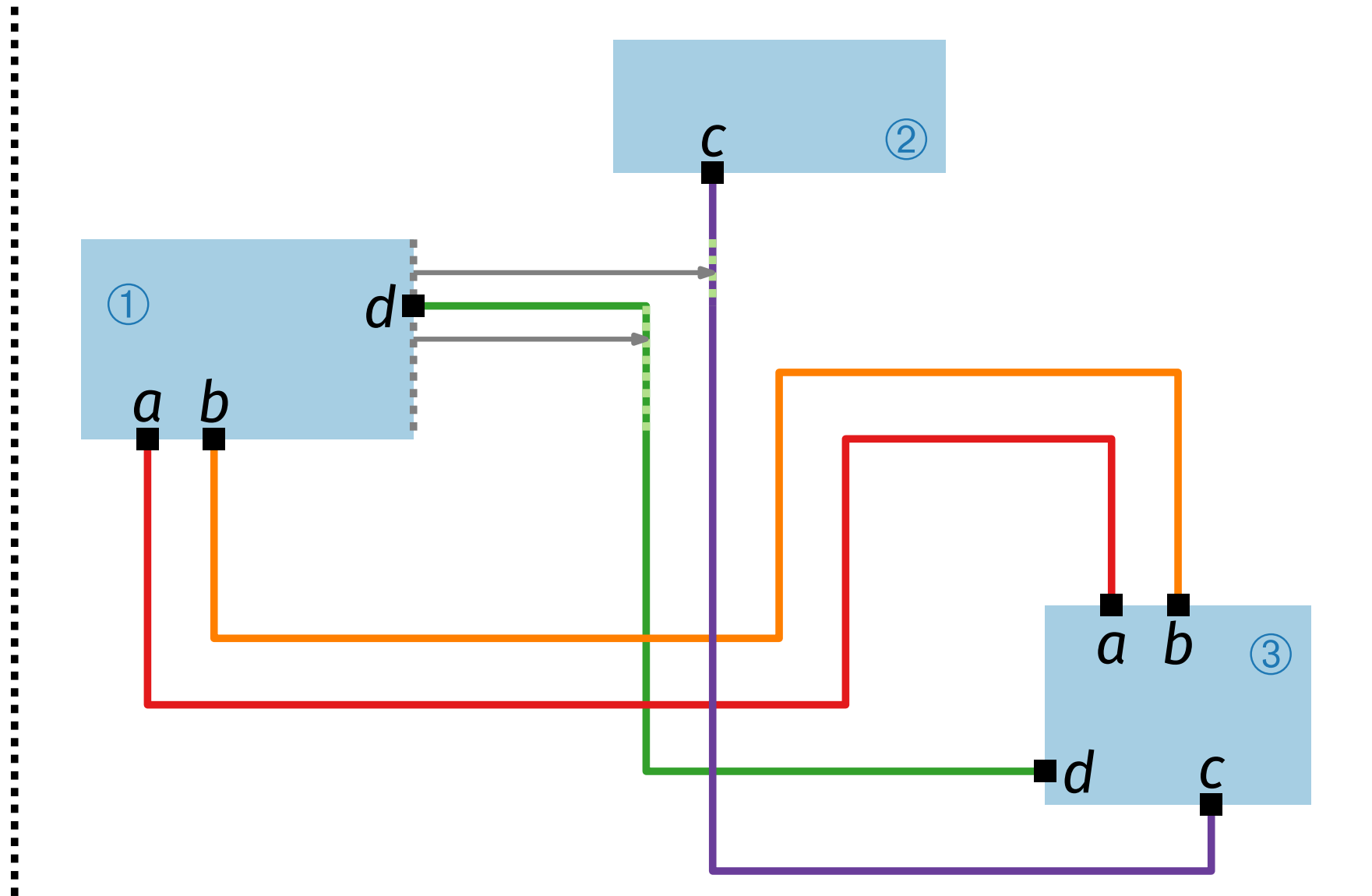
Our Nudging Step

Horizontal step



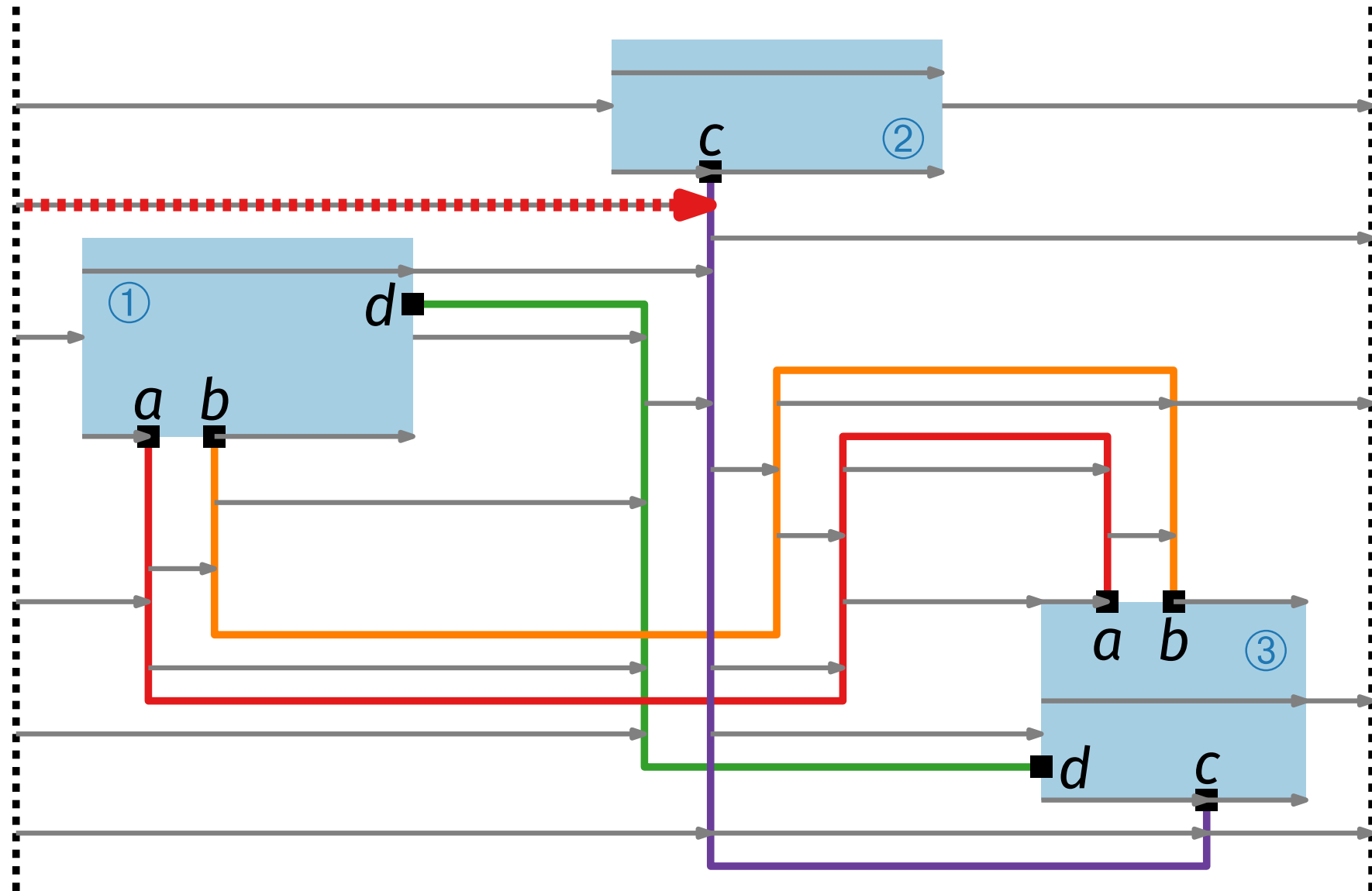
Our Nudging Step

Horizontal step



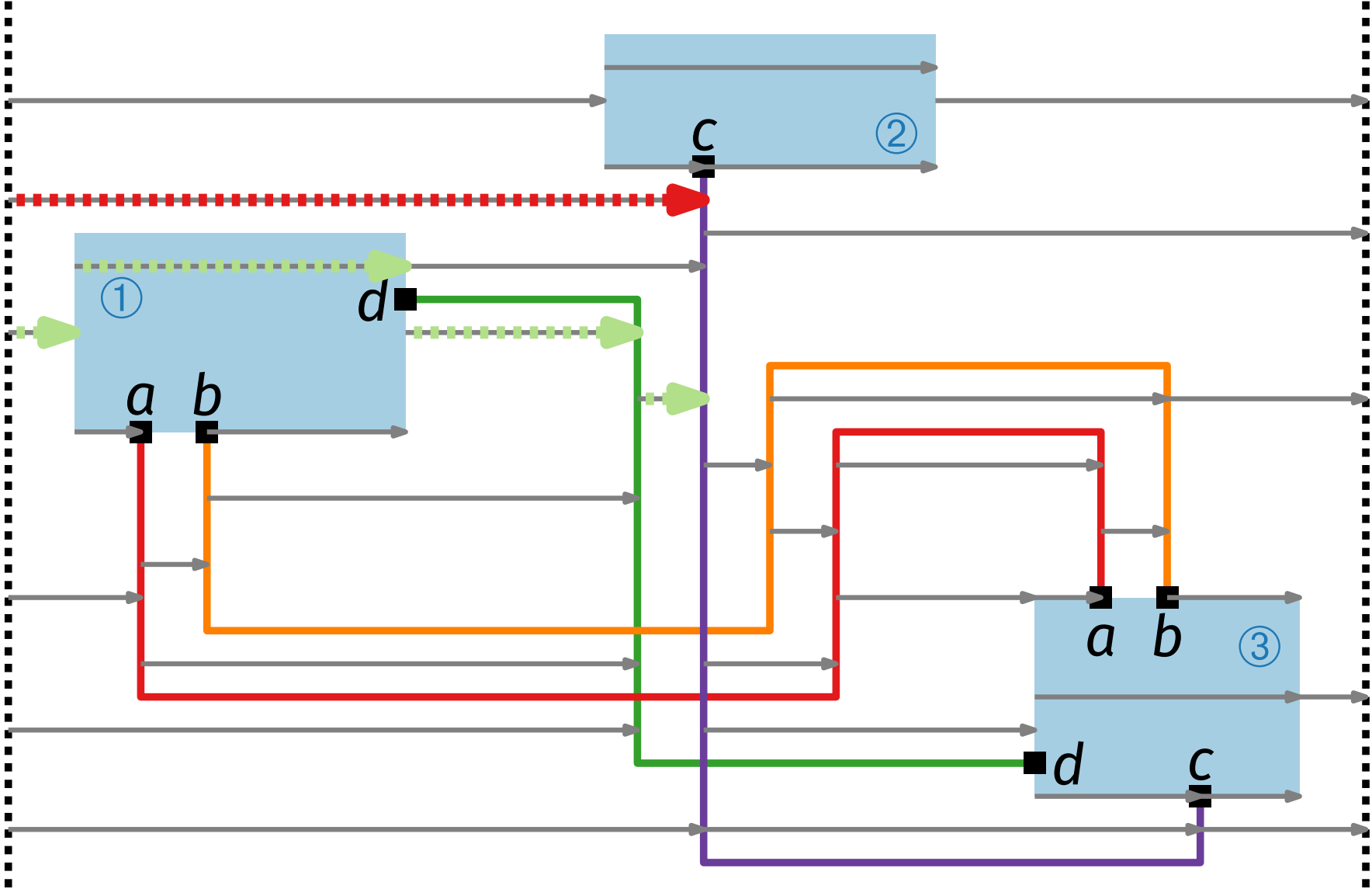
Our Nudging Step

Horizontal step



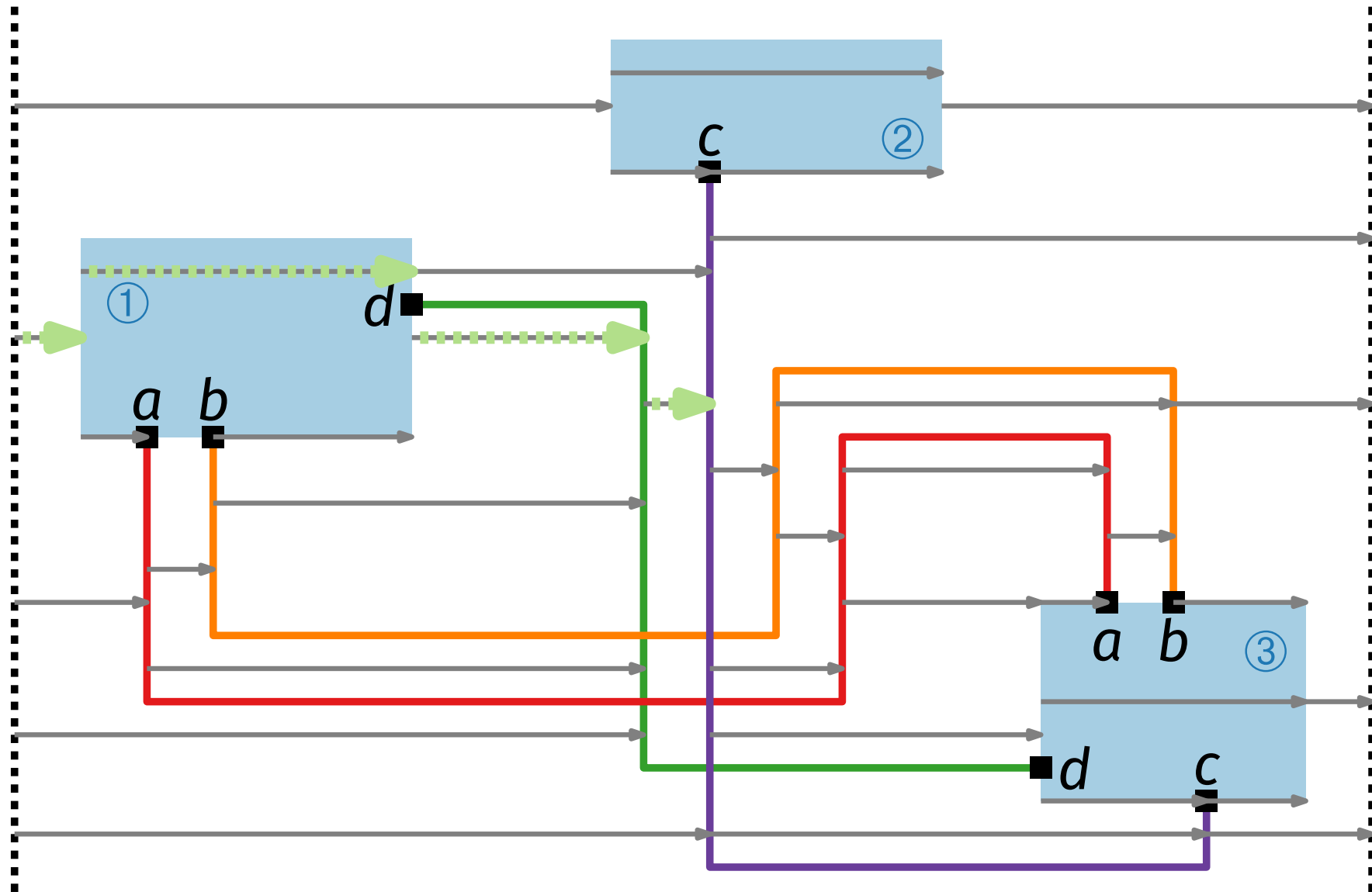
Our Nudging Step

Horizontal step



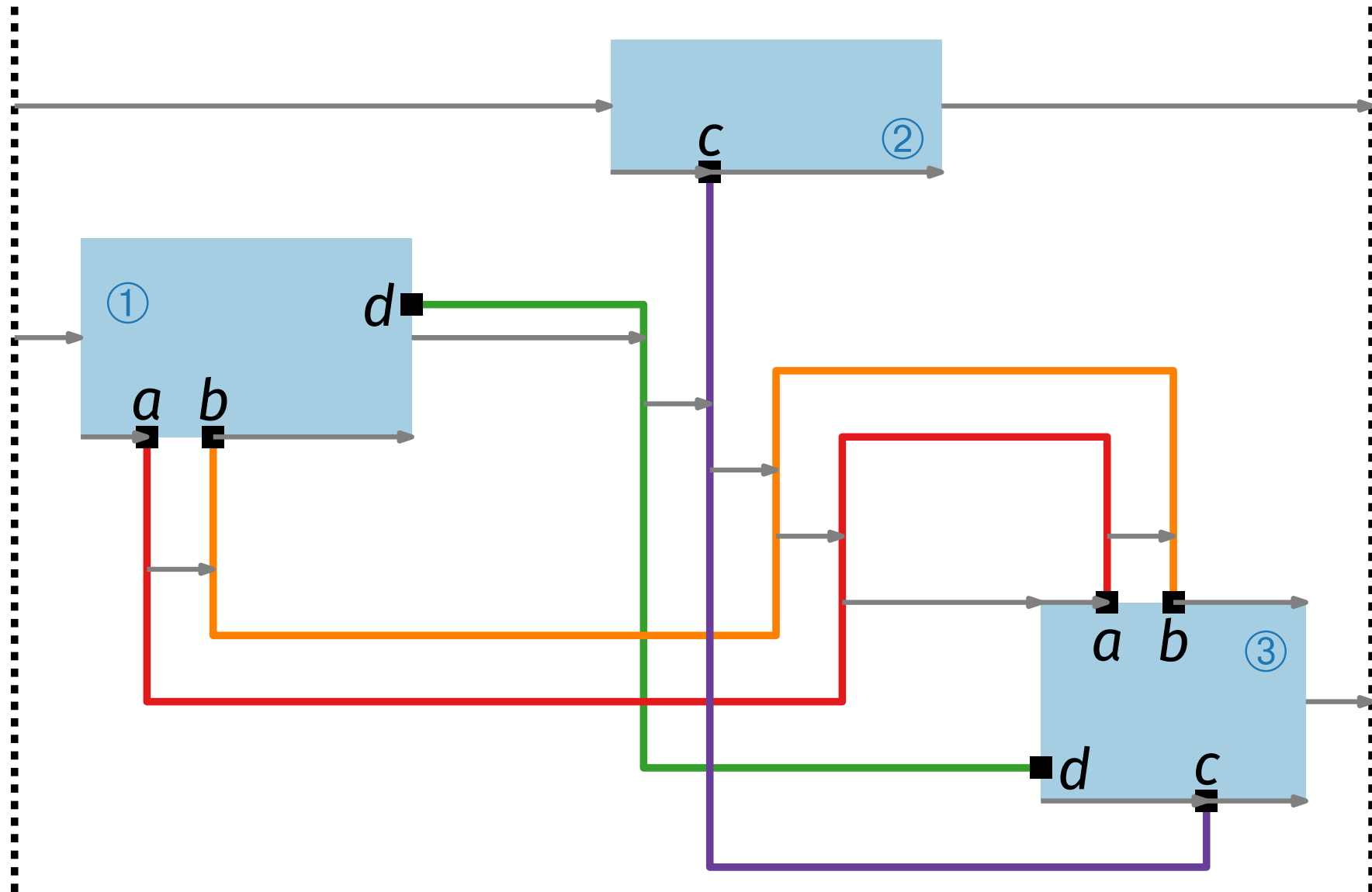
Our Nudging Step

Horizontal step



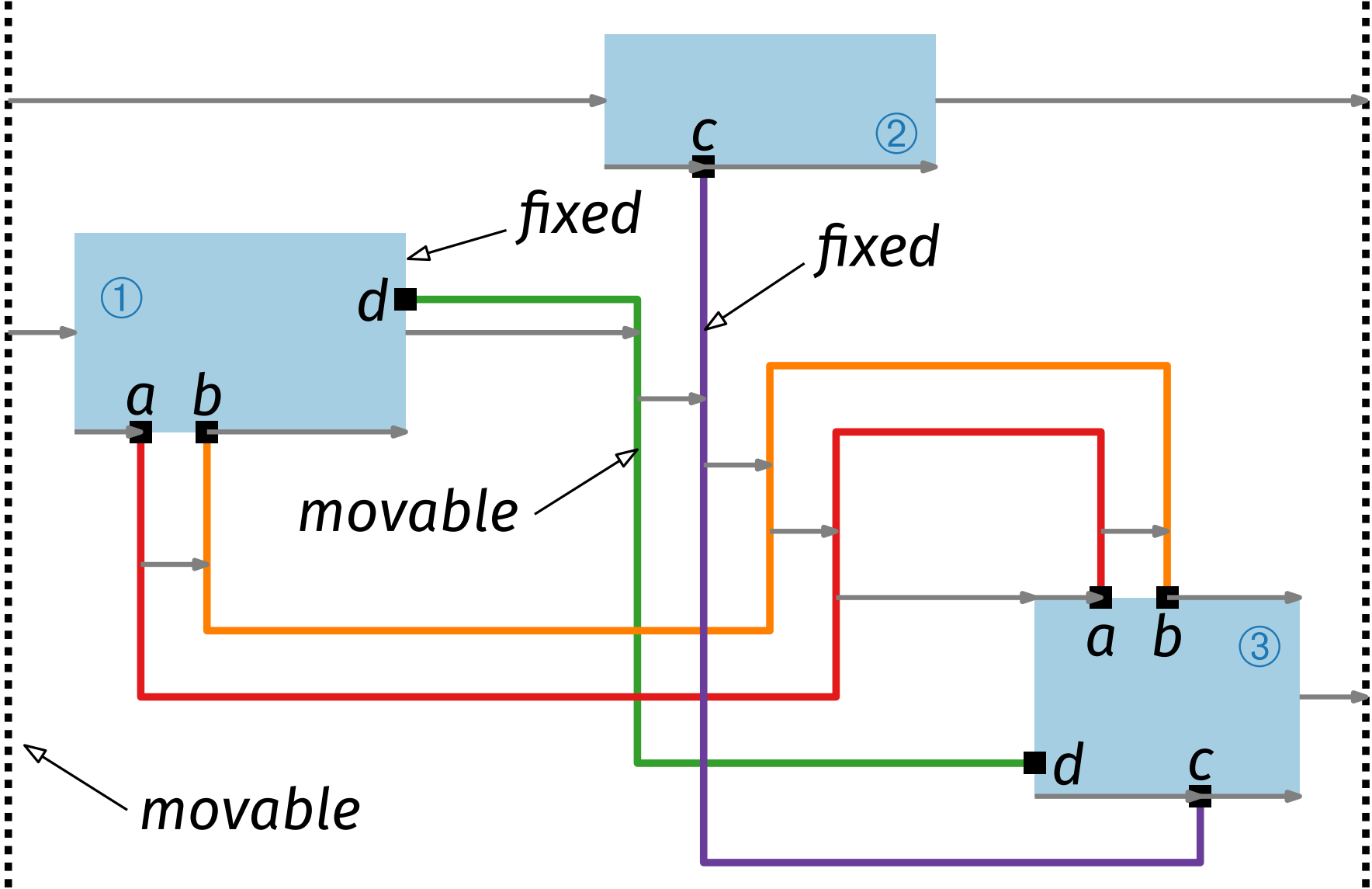
Our Nudging Step

Horizontal step



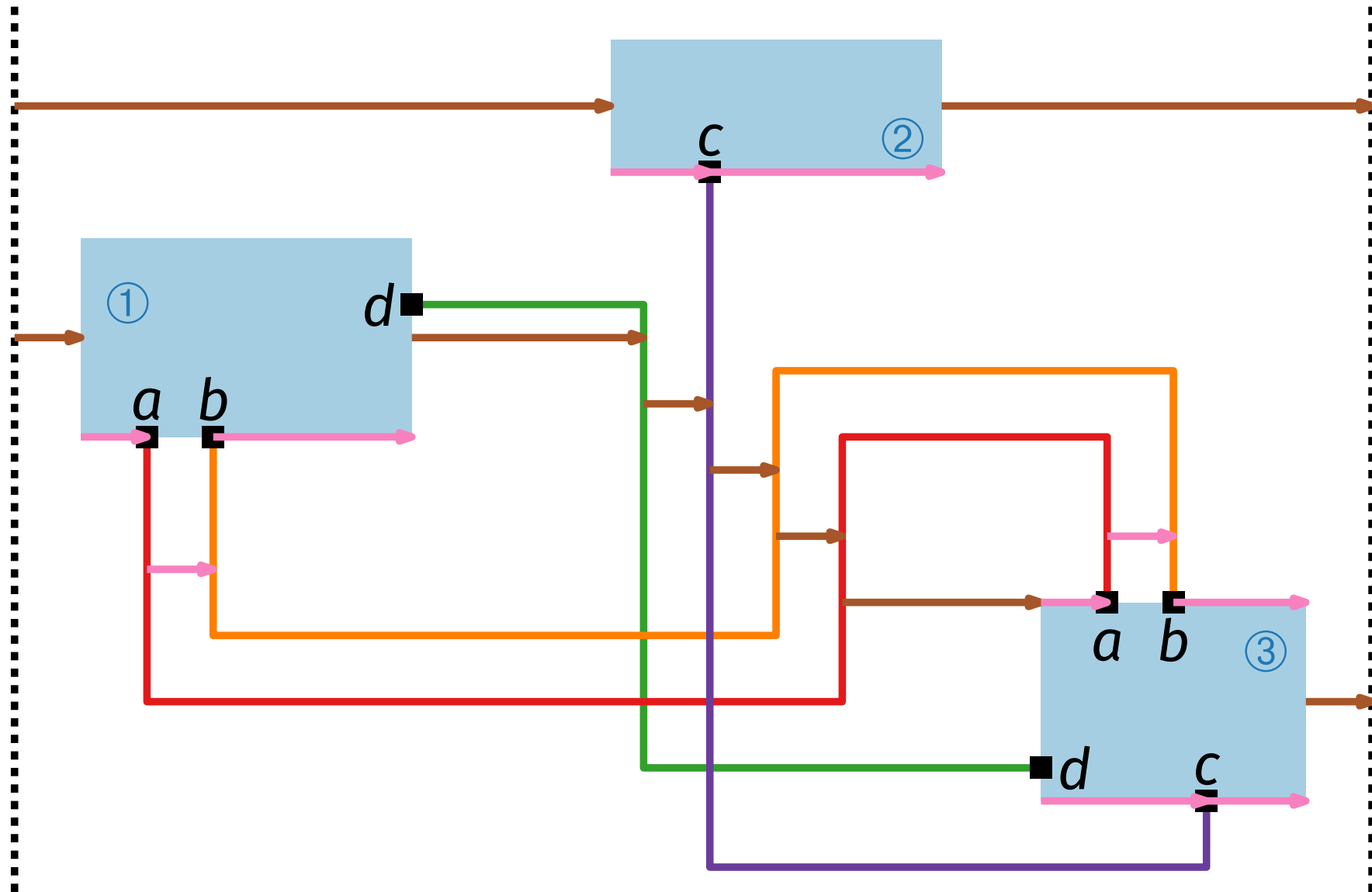
Our Nudging Step

Horizontal step



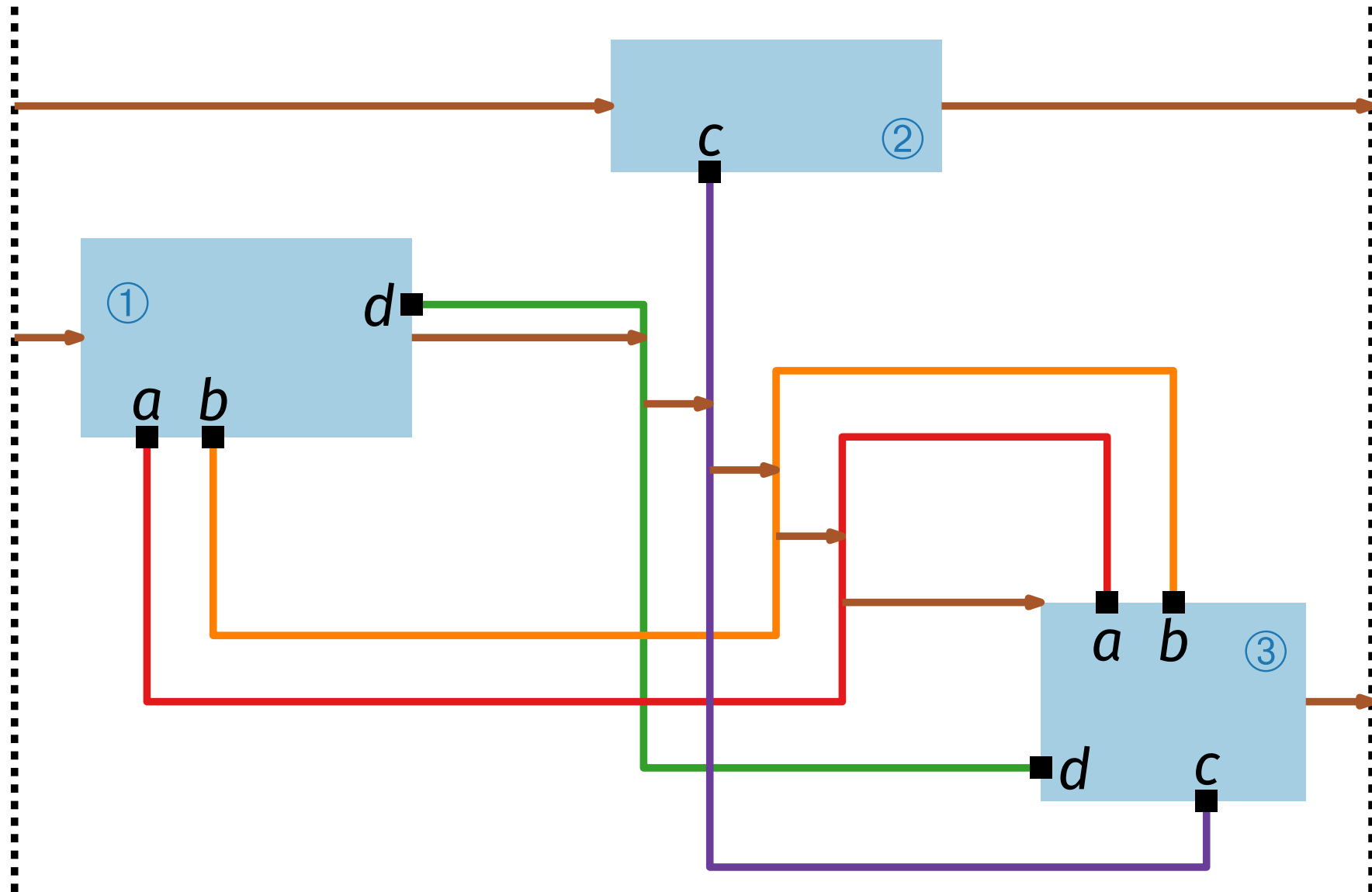
Our Nudging Step

Horizontal step



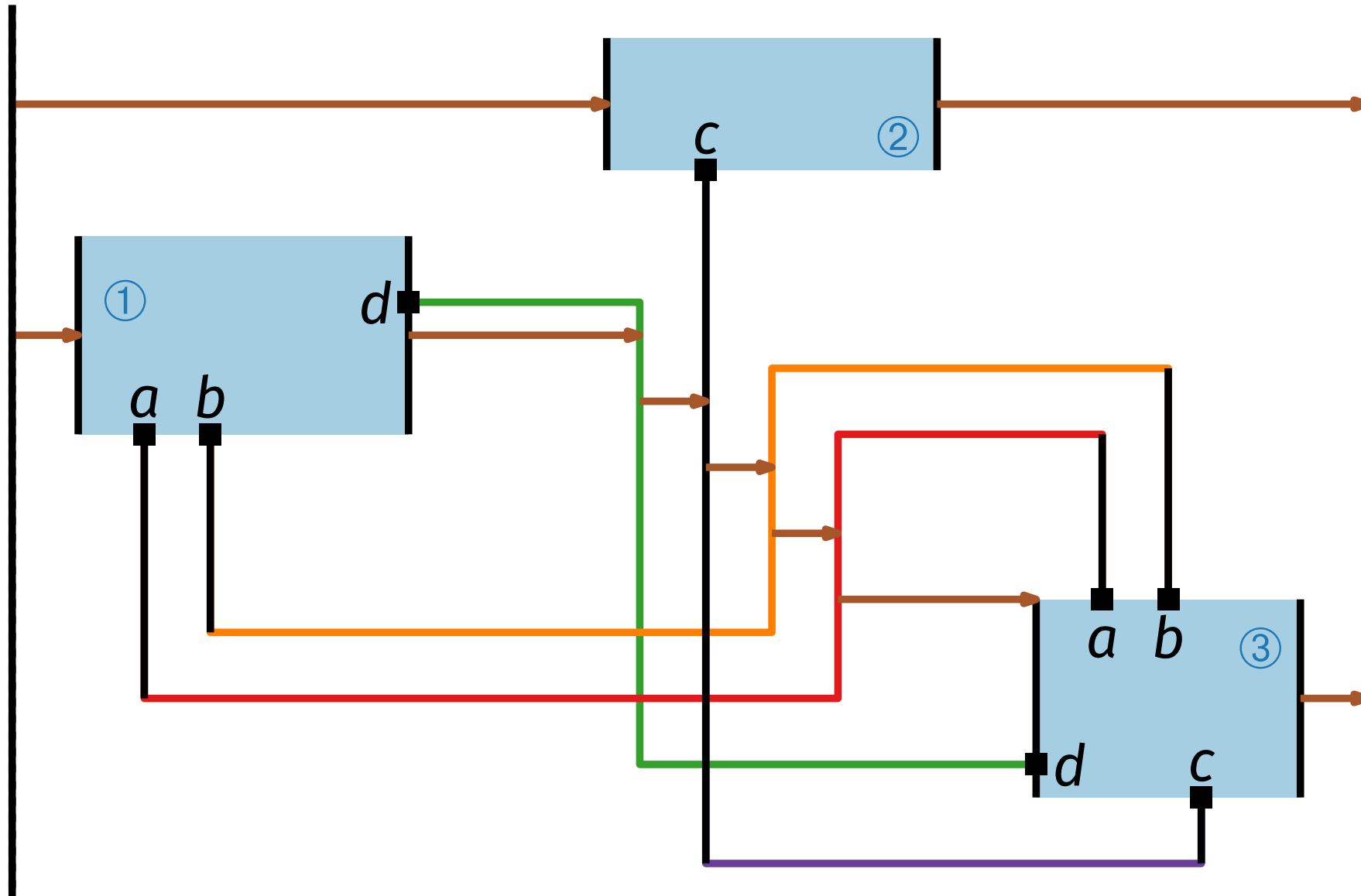
Our Nudging Step

Horizontal step



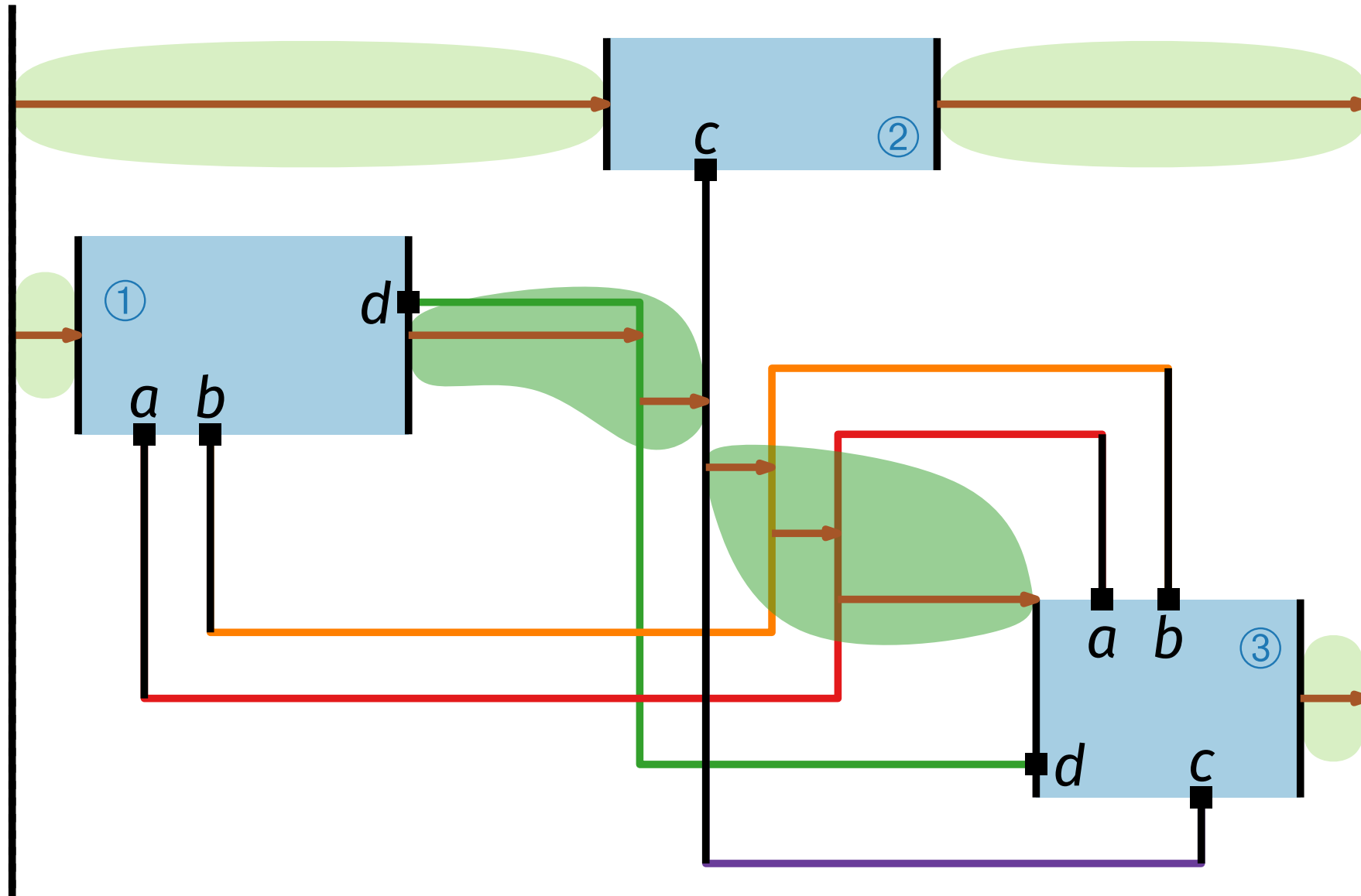
Our Nudging Step

Horizontal step



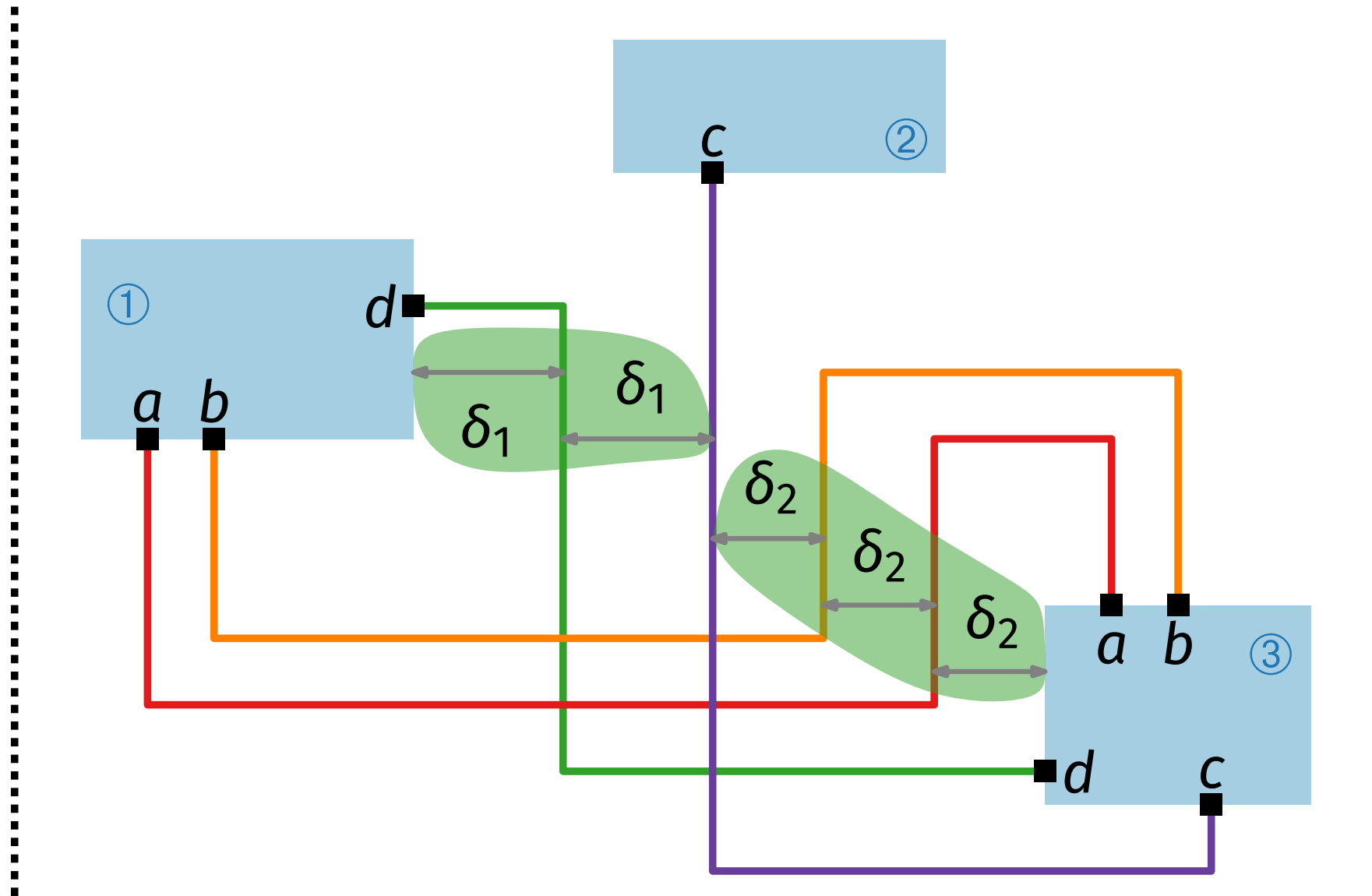
Our Nudging Step

Horizontal step



Our Nudging Step

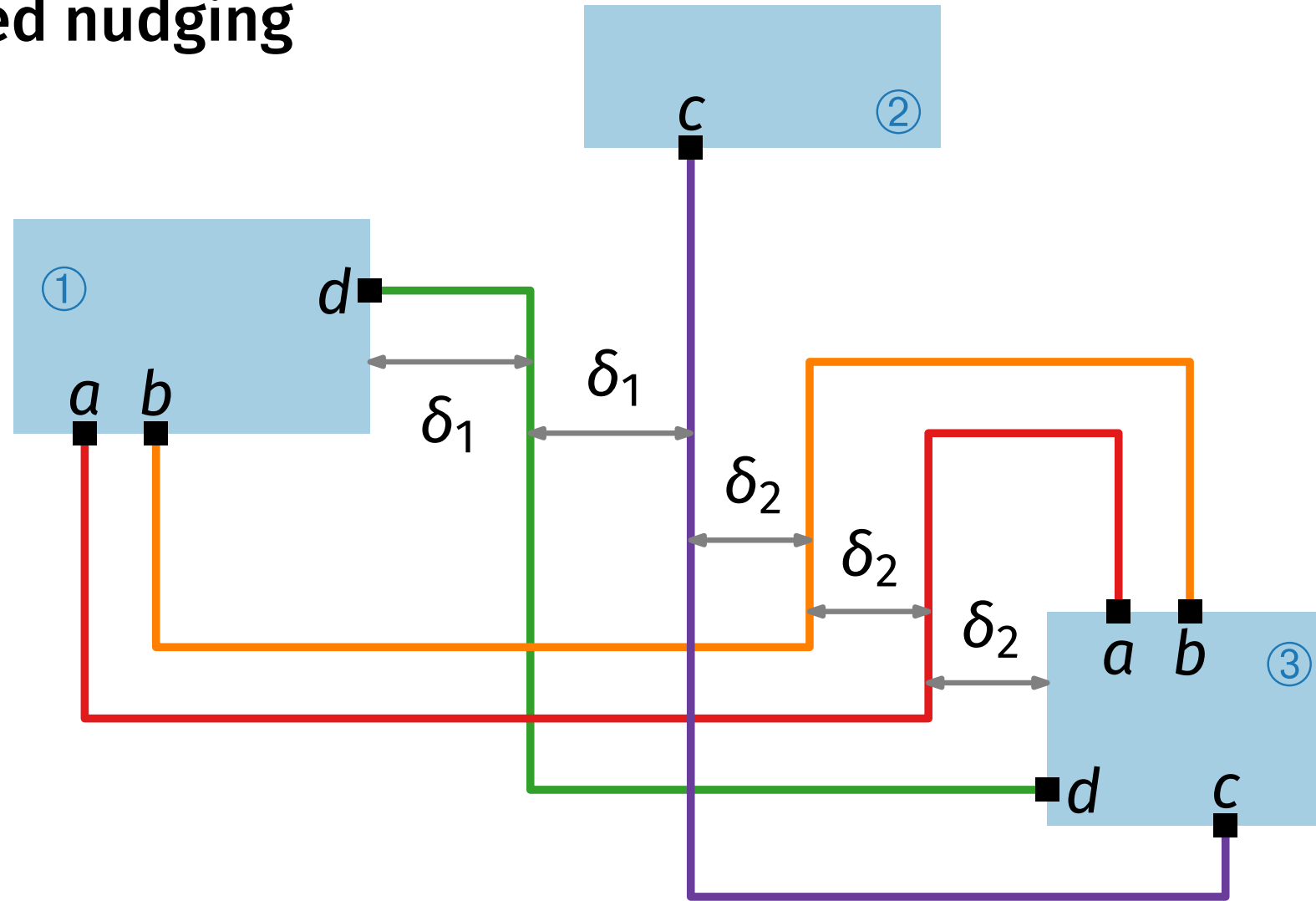
Horizontal step



Our Nudging Step

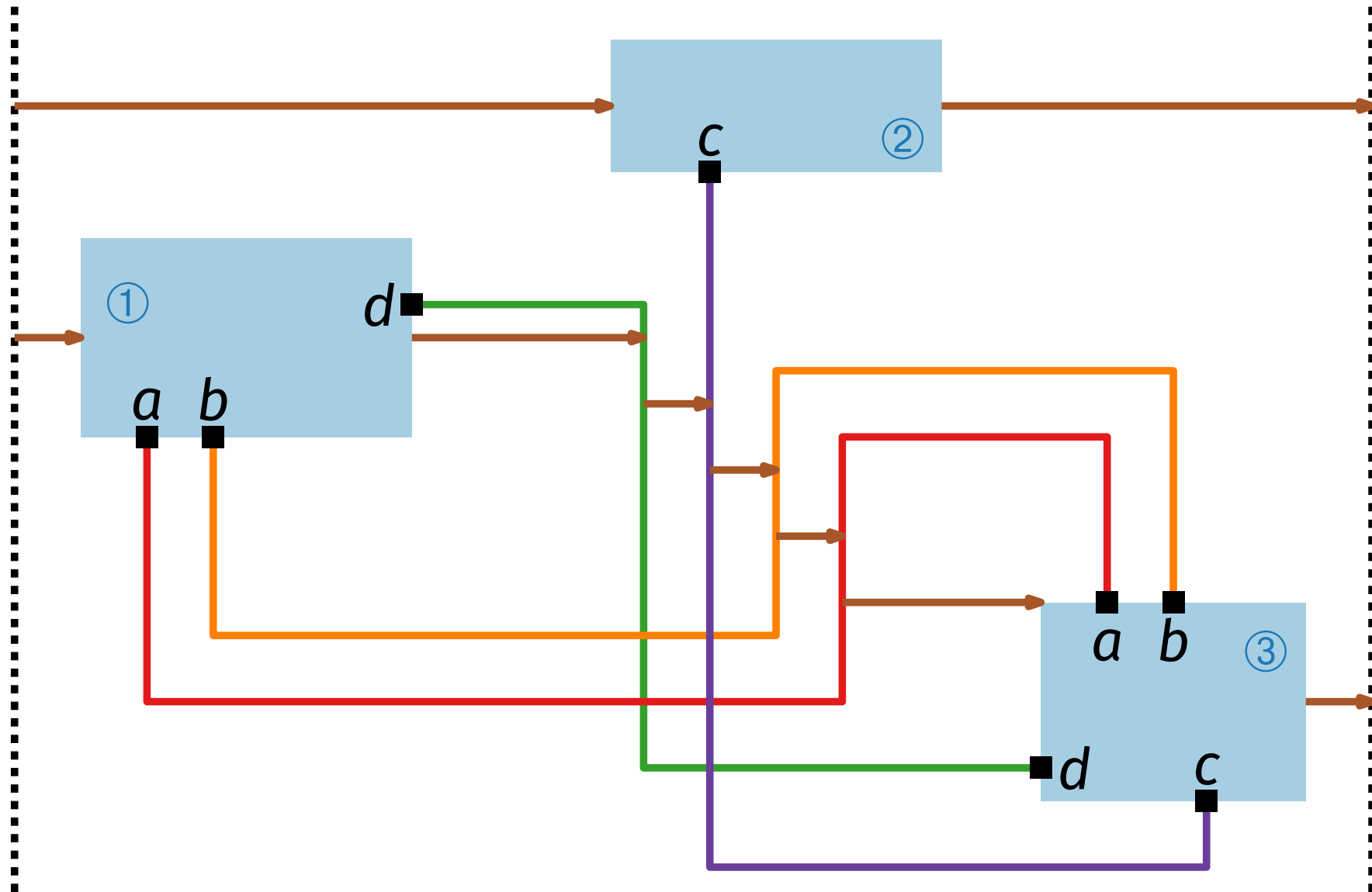
Horizontal step

Constrained nudging



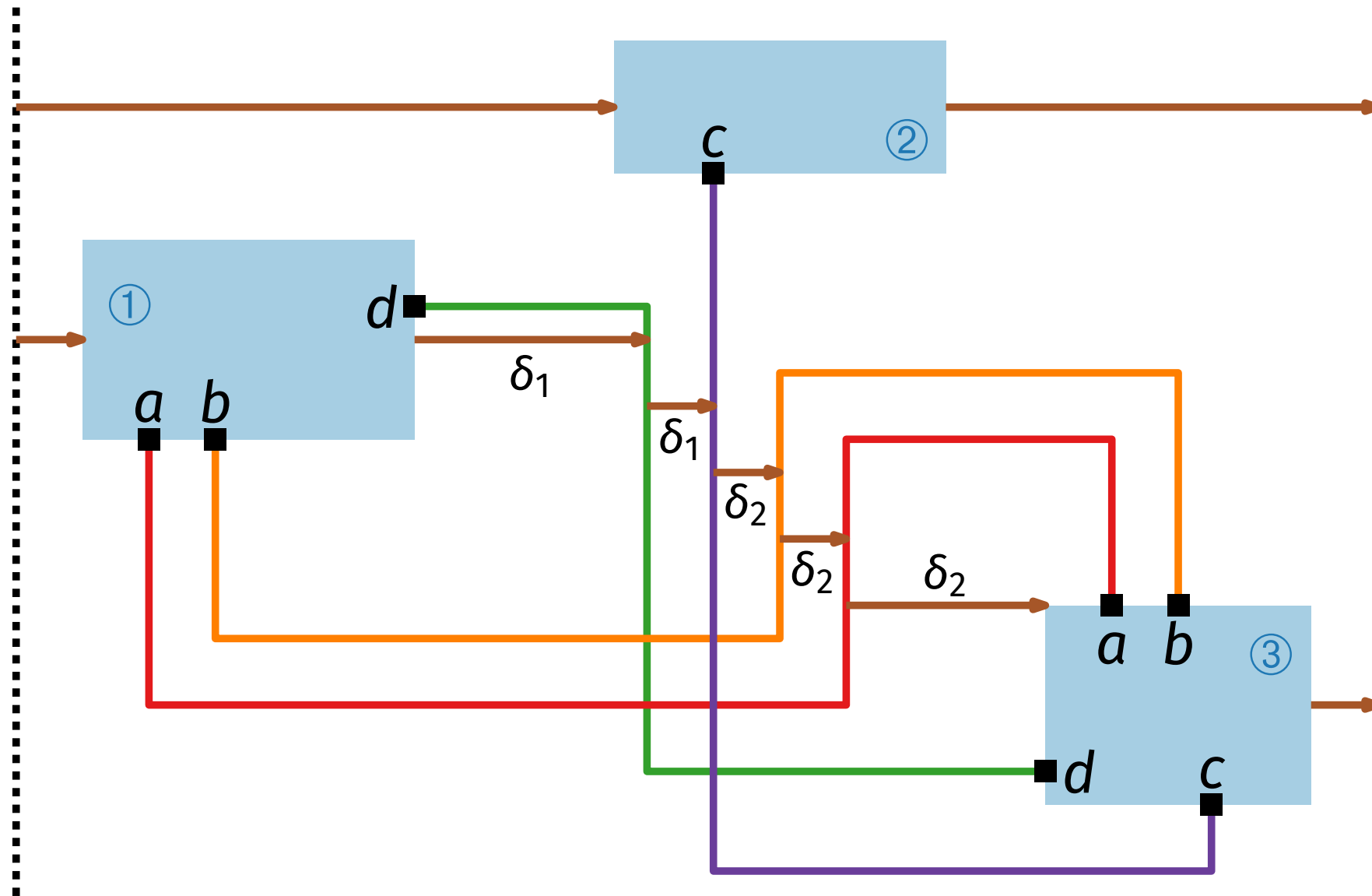
Our Nudging Step

Horizontal step



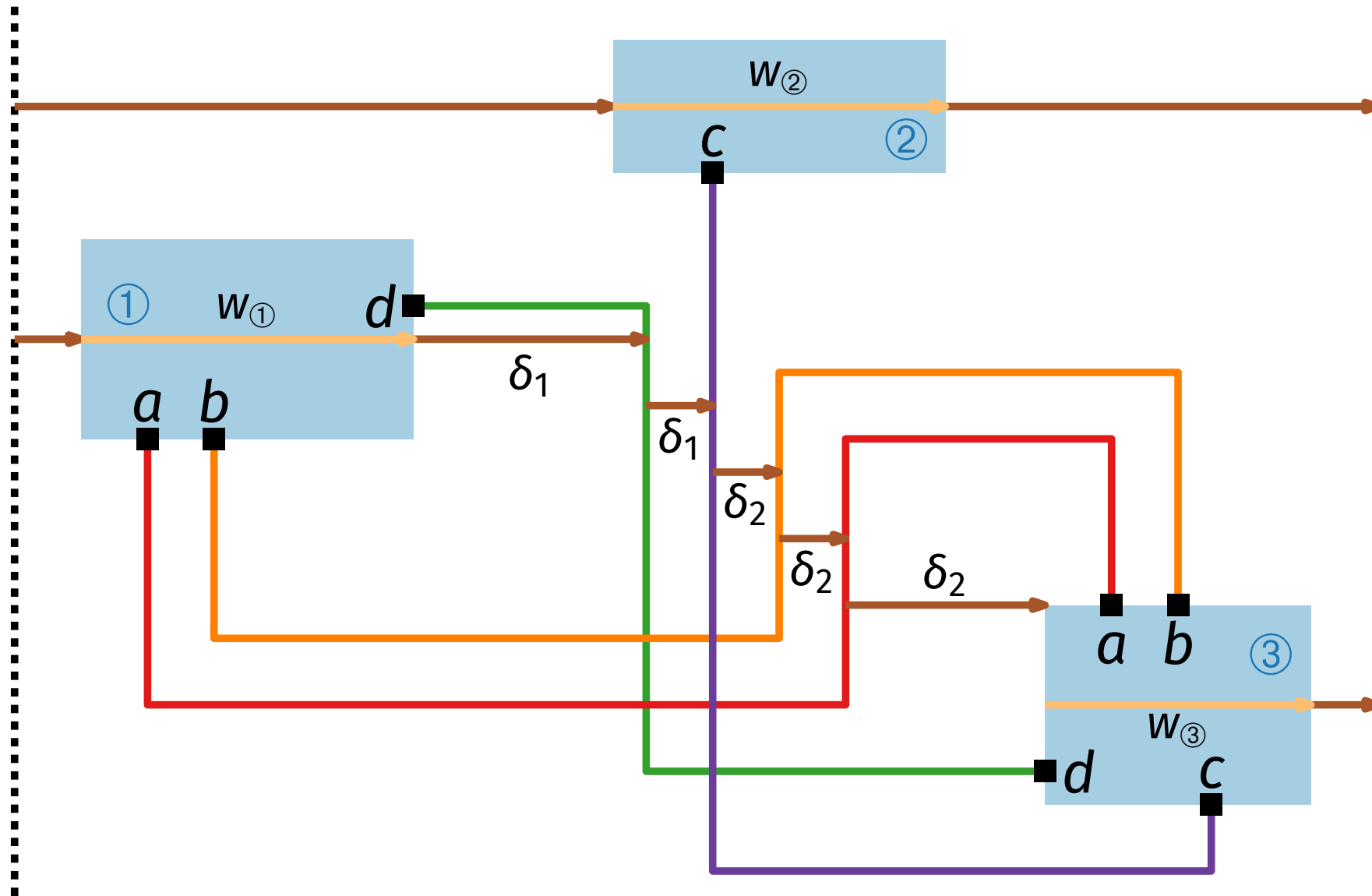
Our Nudging Step

Horizontal step



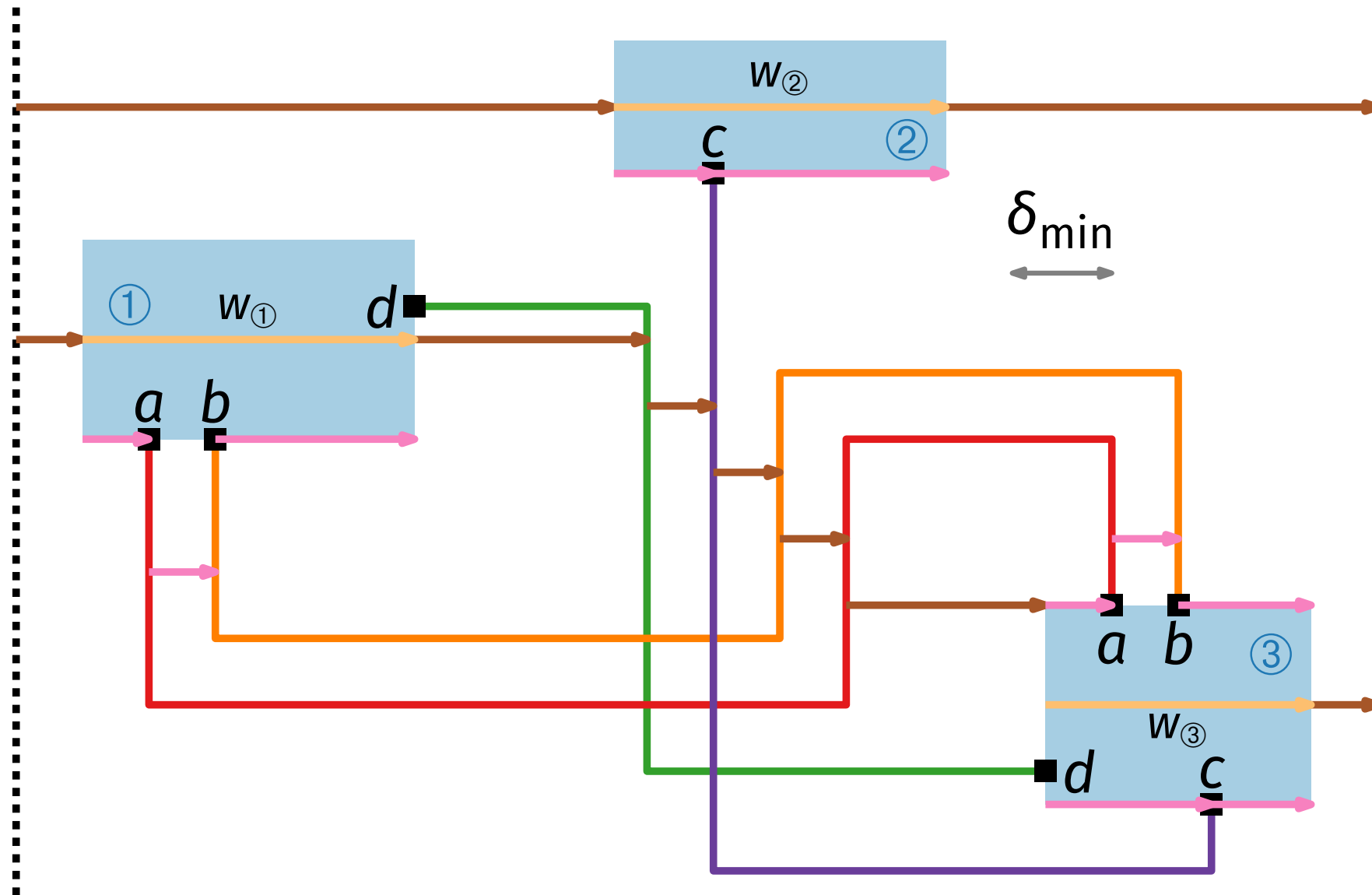
Our Nudging Step

Horizontal step



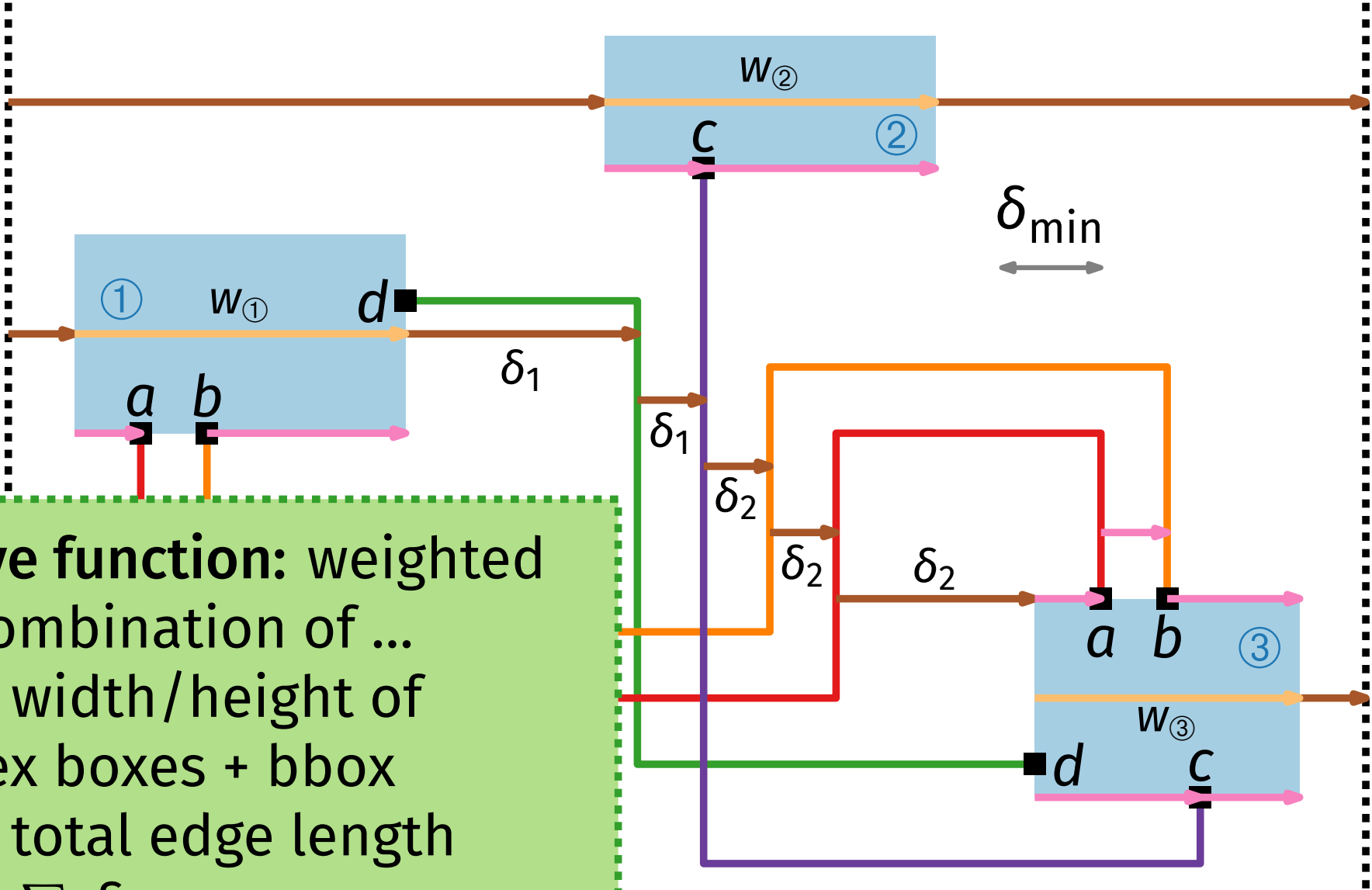
Our Nudging Step

Horizontal step



Our Nudging Step

Horizontal step



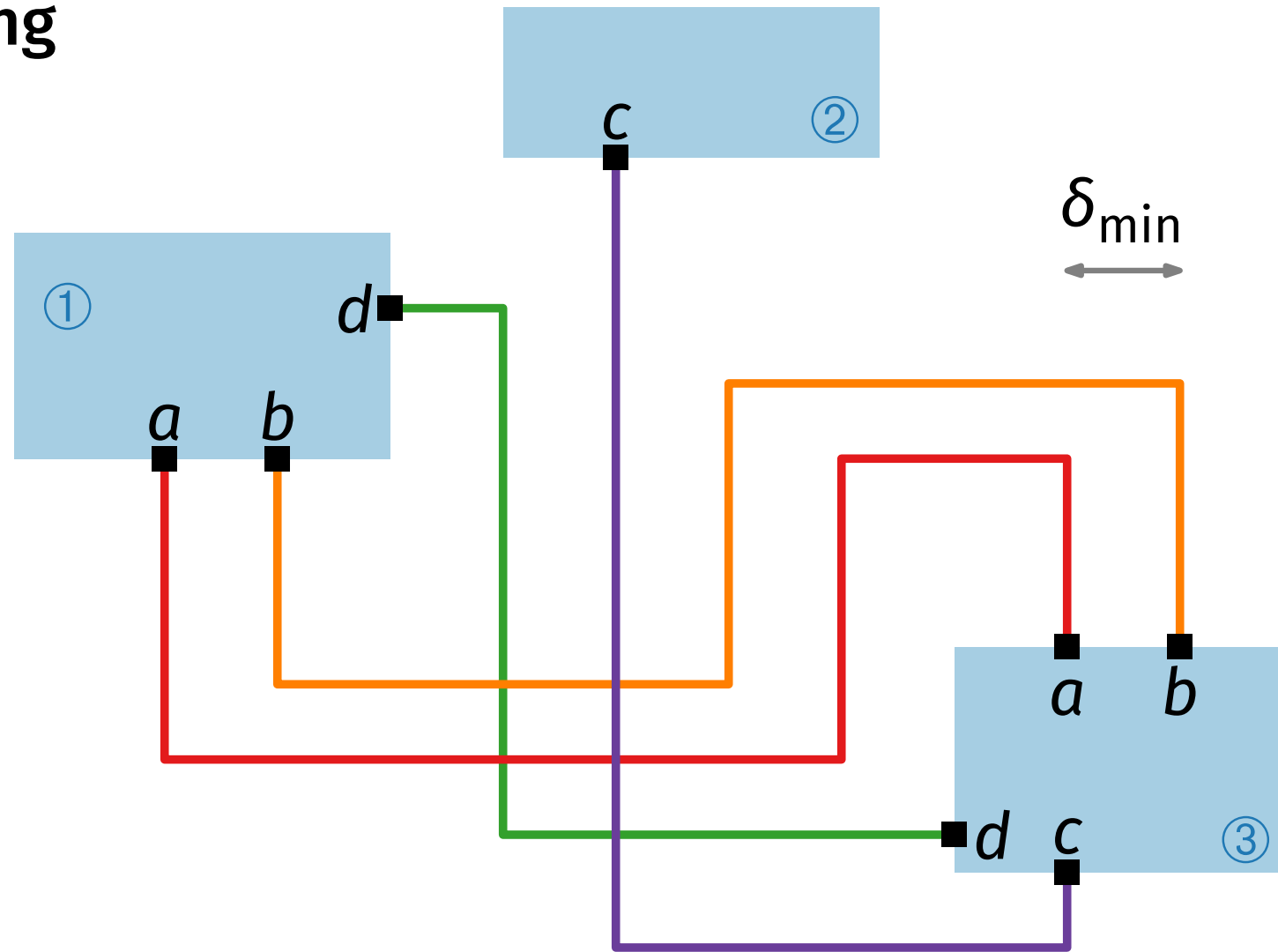
Objective function: weighted linear combination of ...

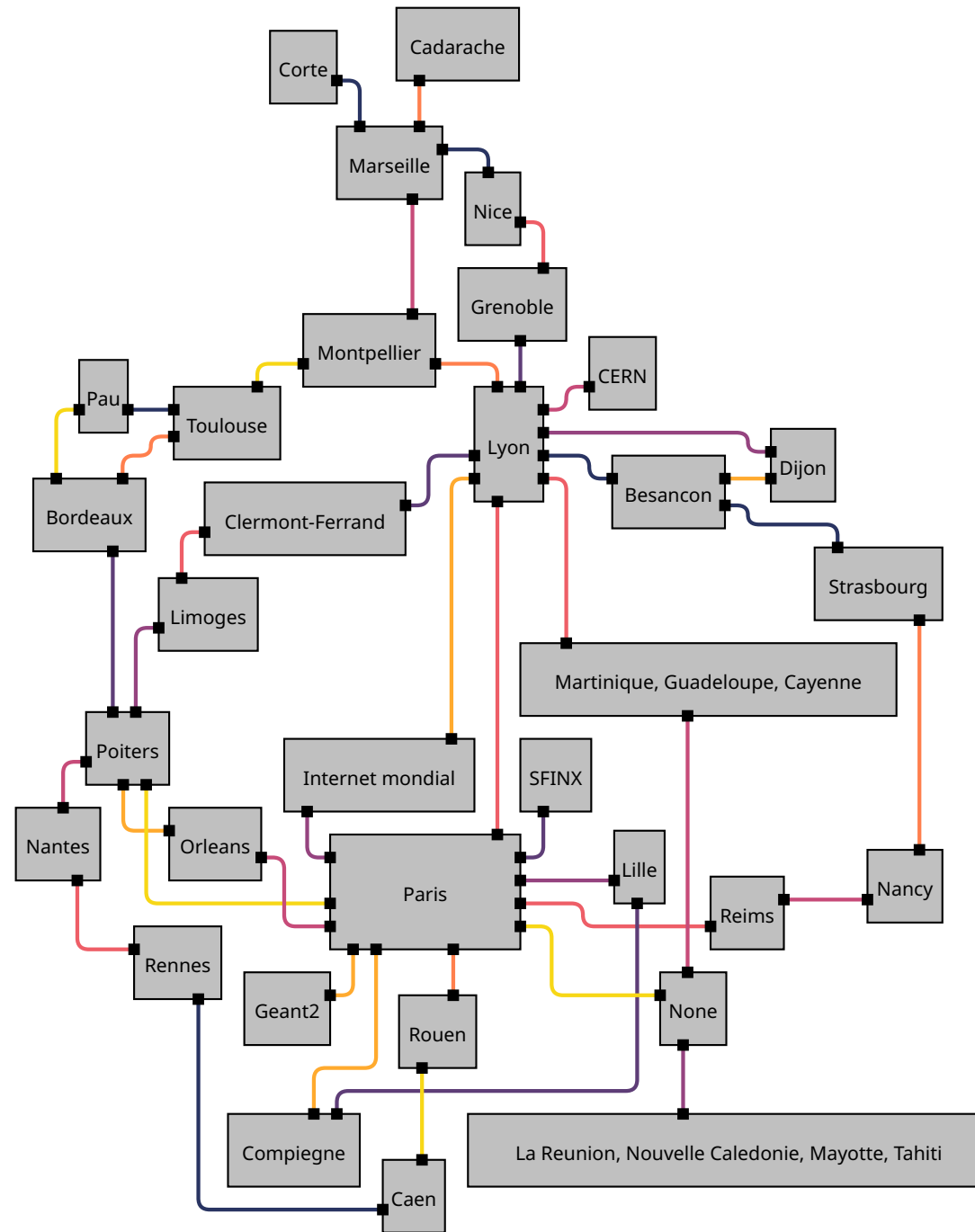
1. min. width/height of vertex boxes + bbox
2. min. total edge length
3. max. $\sum_i \delta_i$

Our Nudging Step

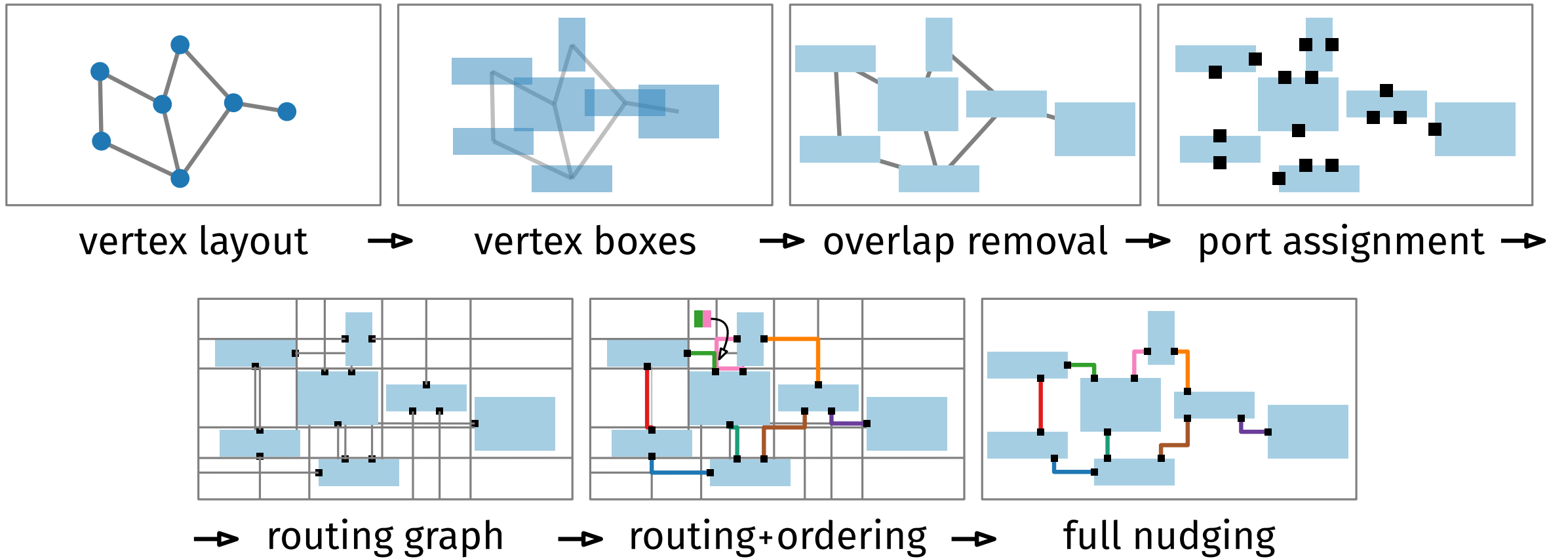
Horizontal step

Full nudging



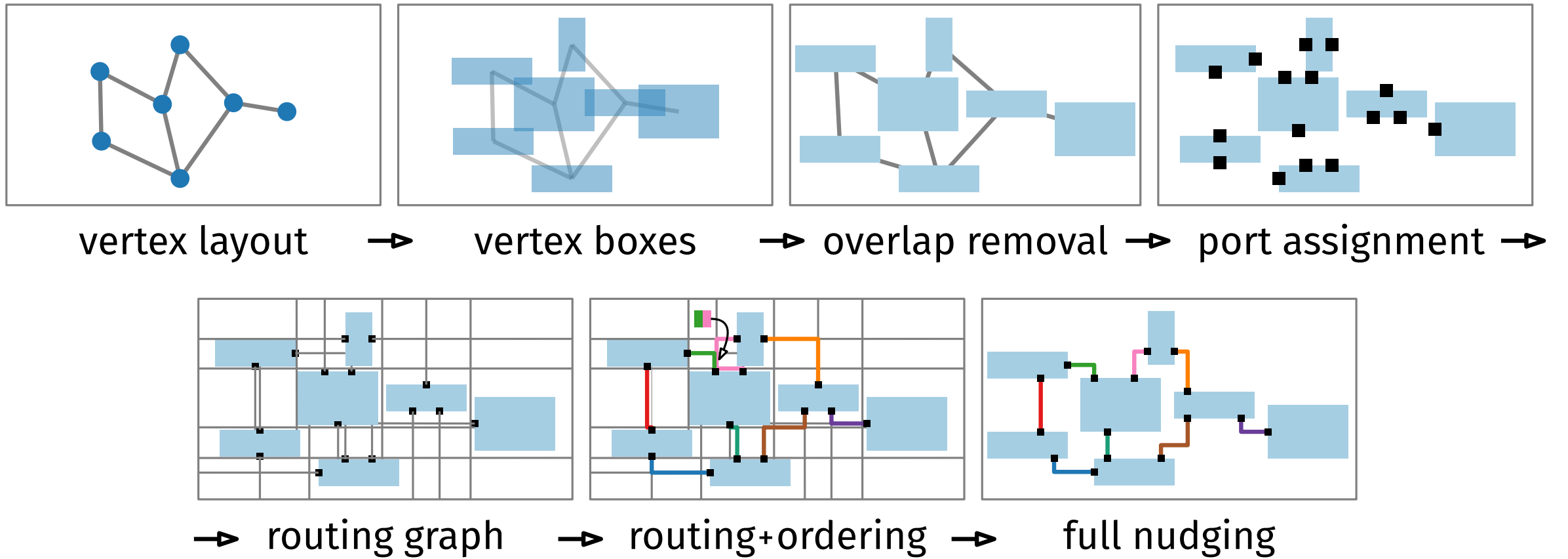


Pipeline Variants



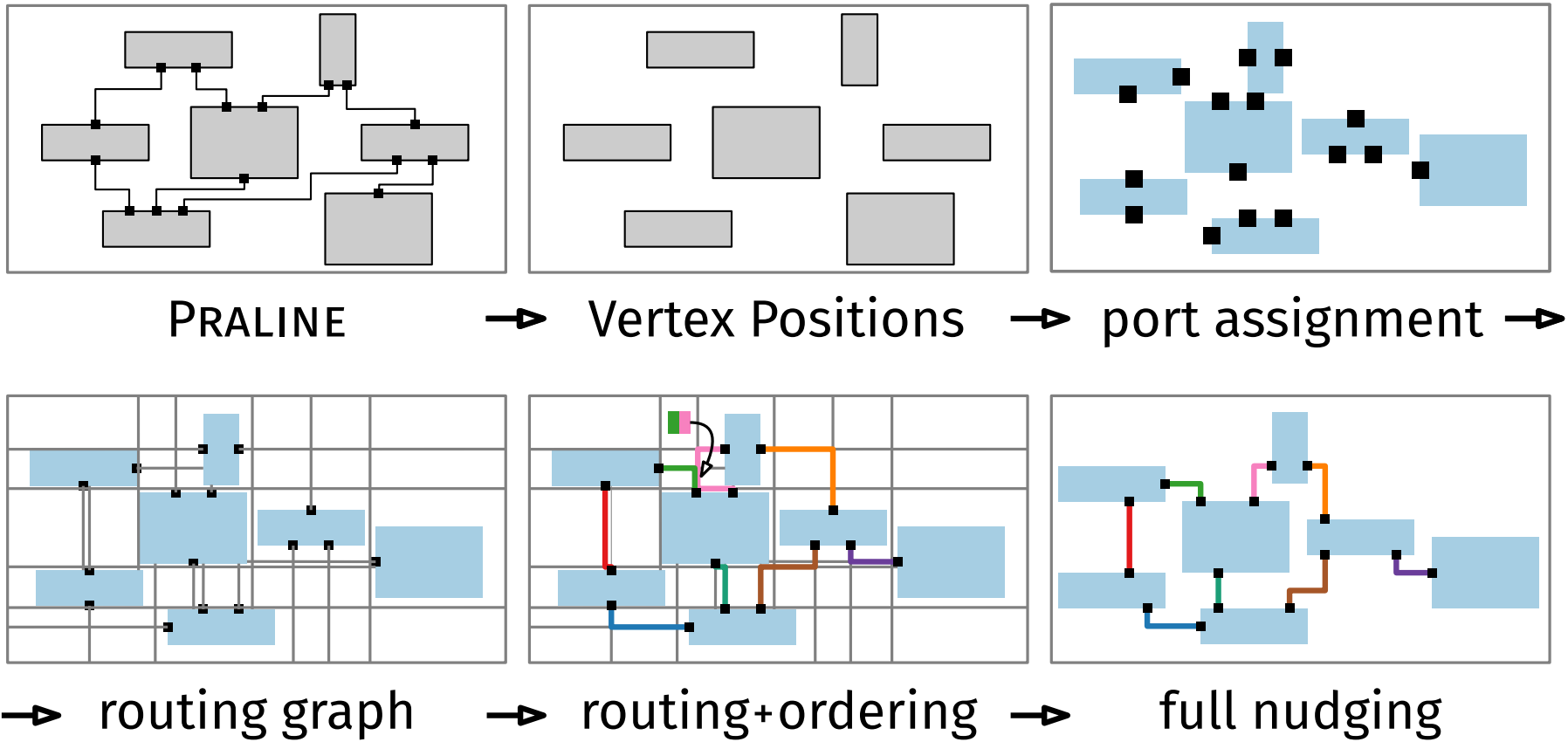
Pipeline Variants

FORCE



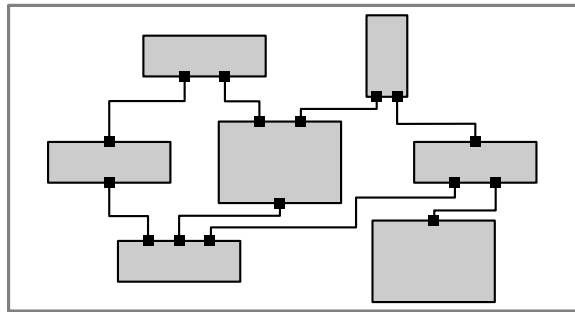
Pipeline Variants

HYBRID1

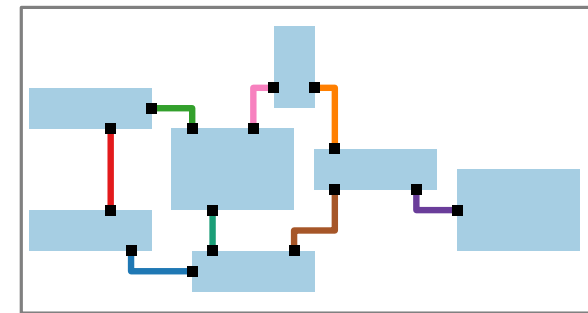


Pipeline Variants

HYBRID2

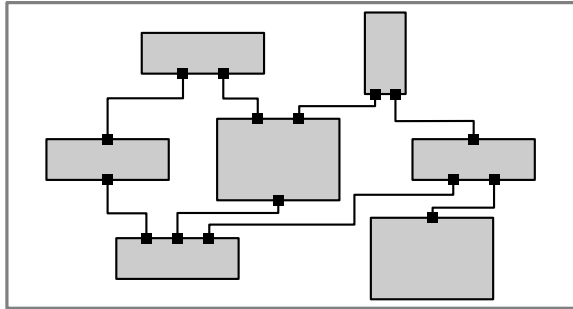


PRALINE



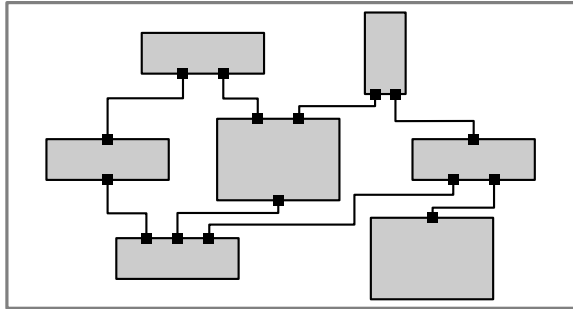
full nudging

Comparison

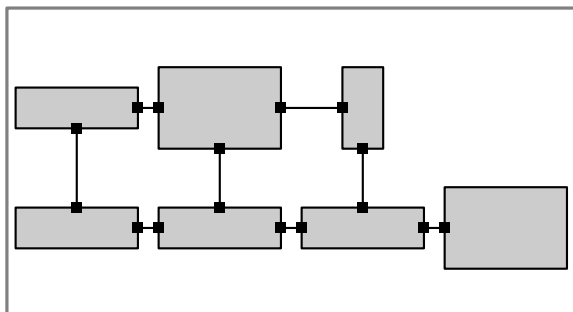


PRALINE
[Zink et al. 2022]

Comparison



PRALINE
[Zink et al. 2022]

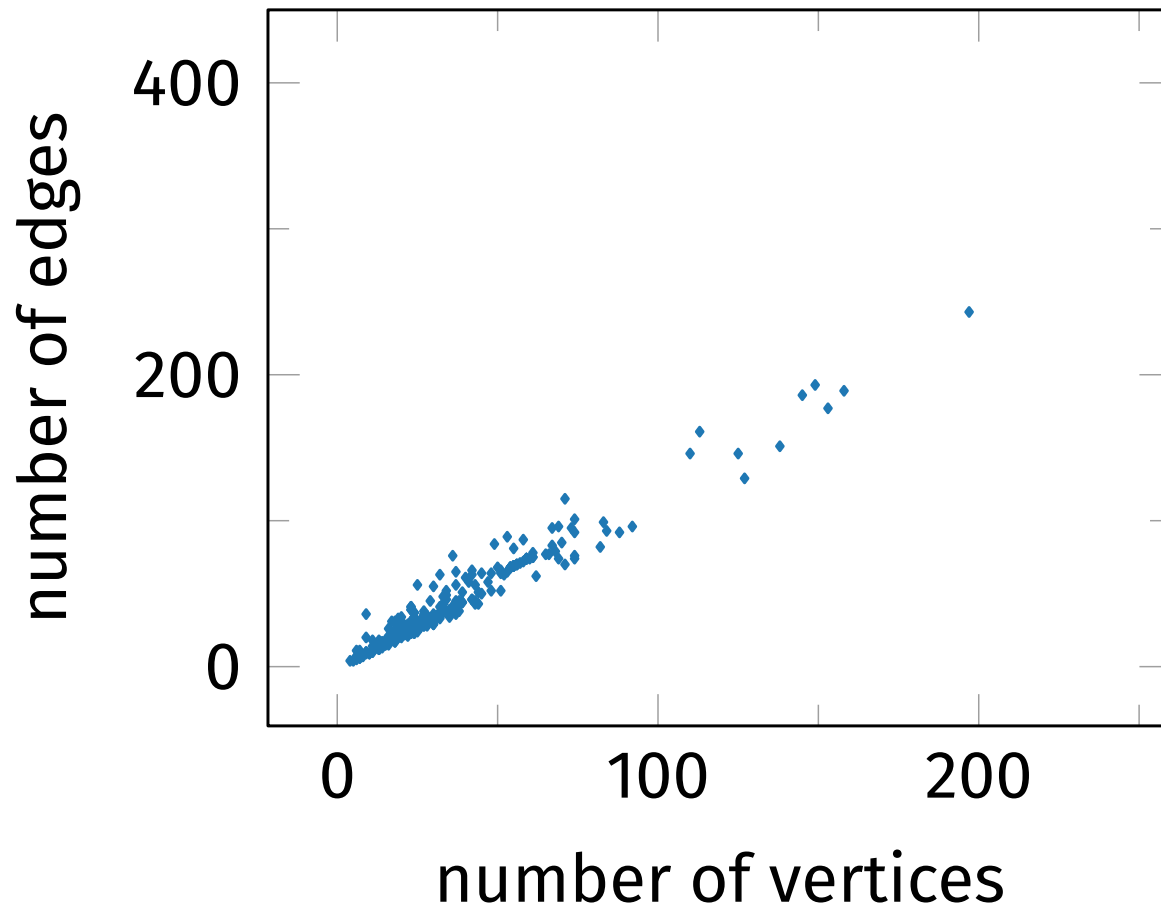


**HUMAN-LIKE ORTHOGONAL
LAYOUT ALGORITHM (HOLA)**
[Kieffer et al. 2016]

Benchmark Set

Internet Topology Zoo

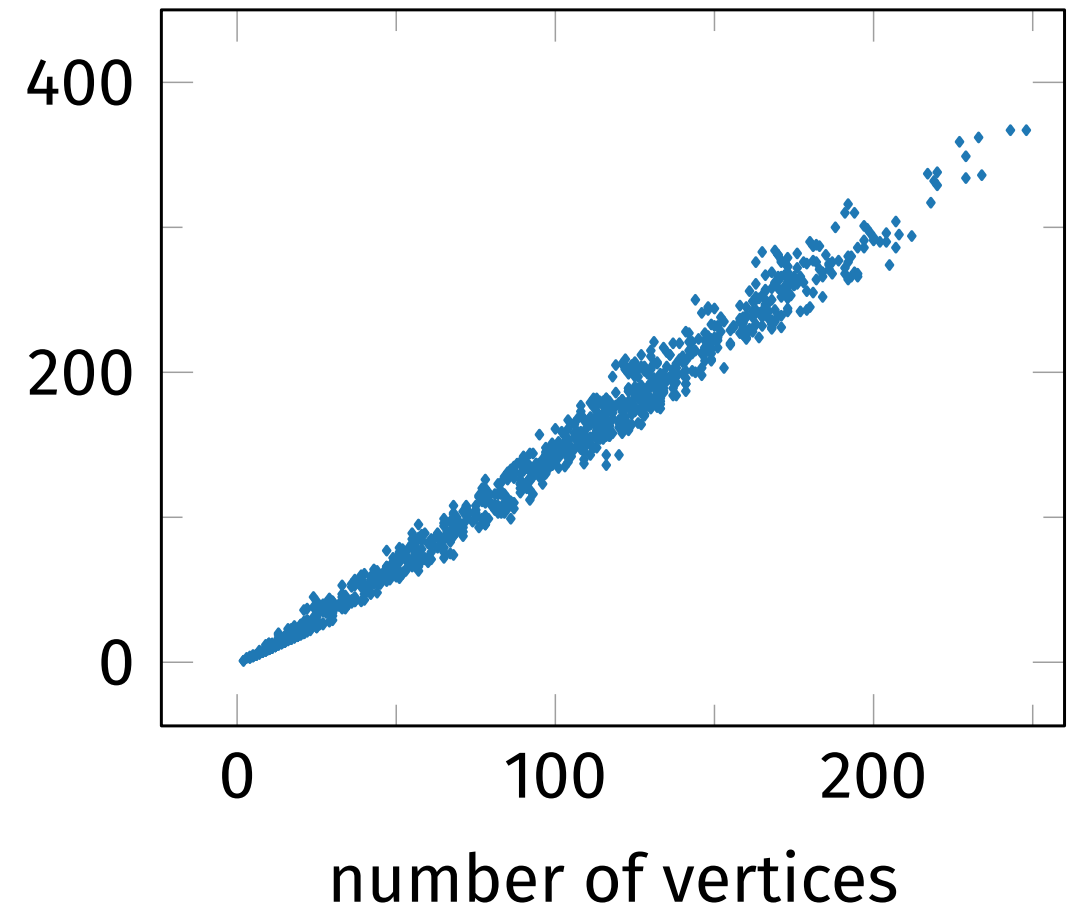
N = 260



[Knight et al. 2011]

Pseudo-Cableplans

N = 1026

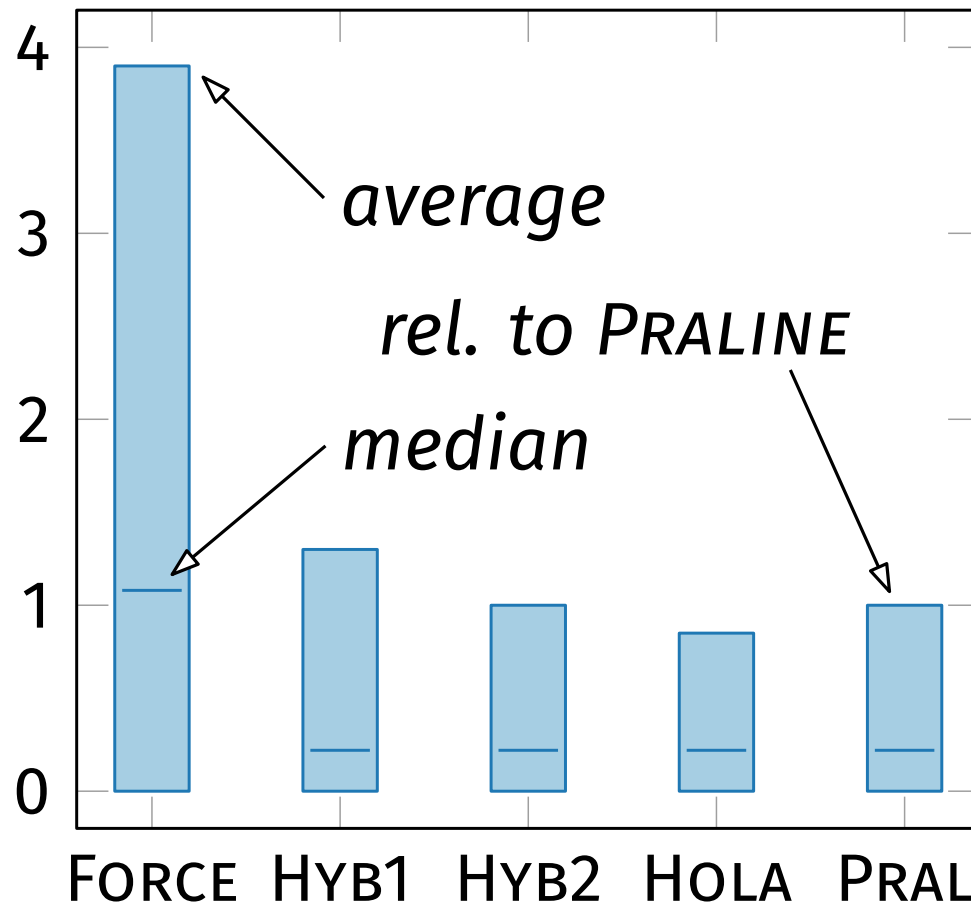


[Zink et al. 2022]

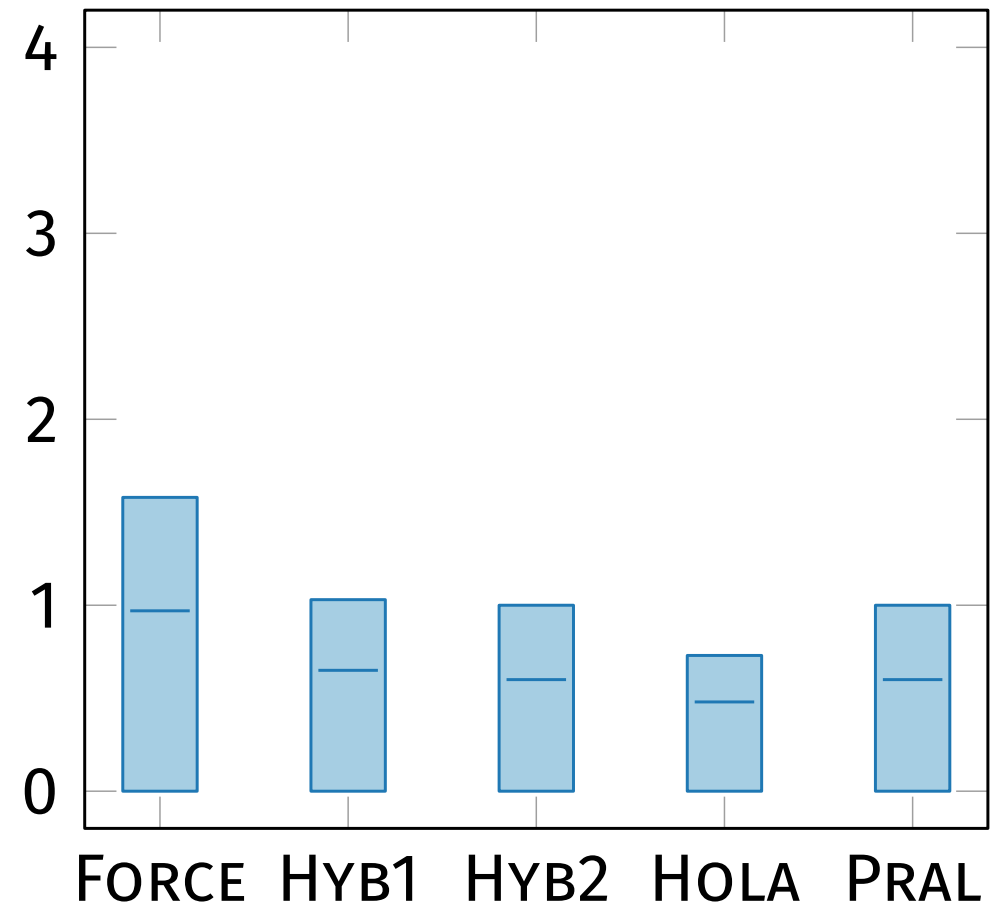
Results

Number of Crossings

Internet Topology Zoo



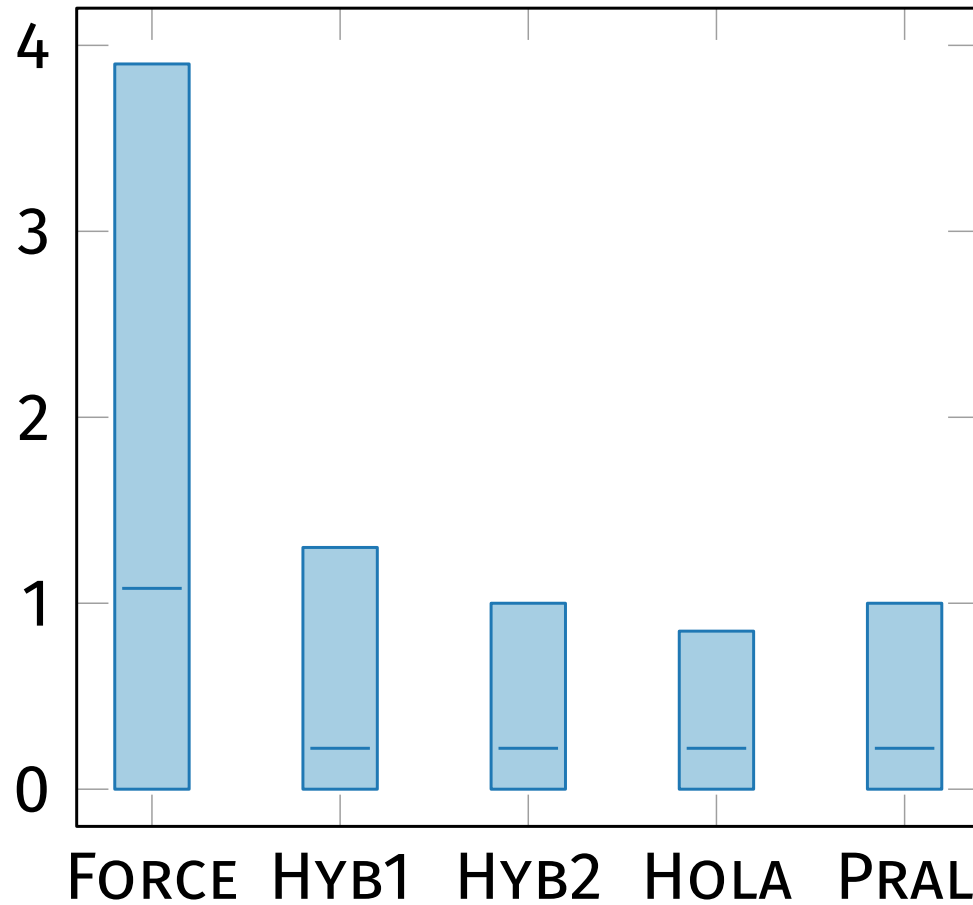
Pseudo-Cableplans



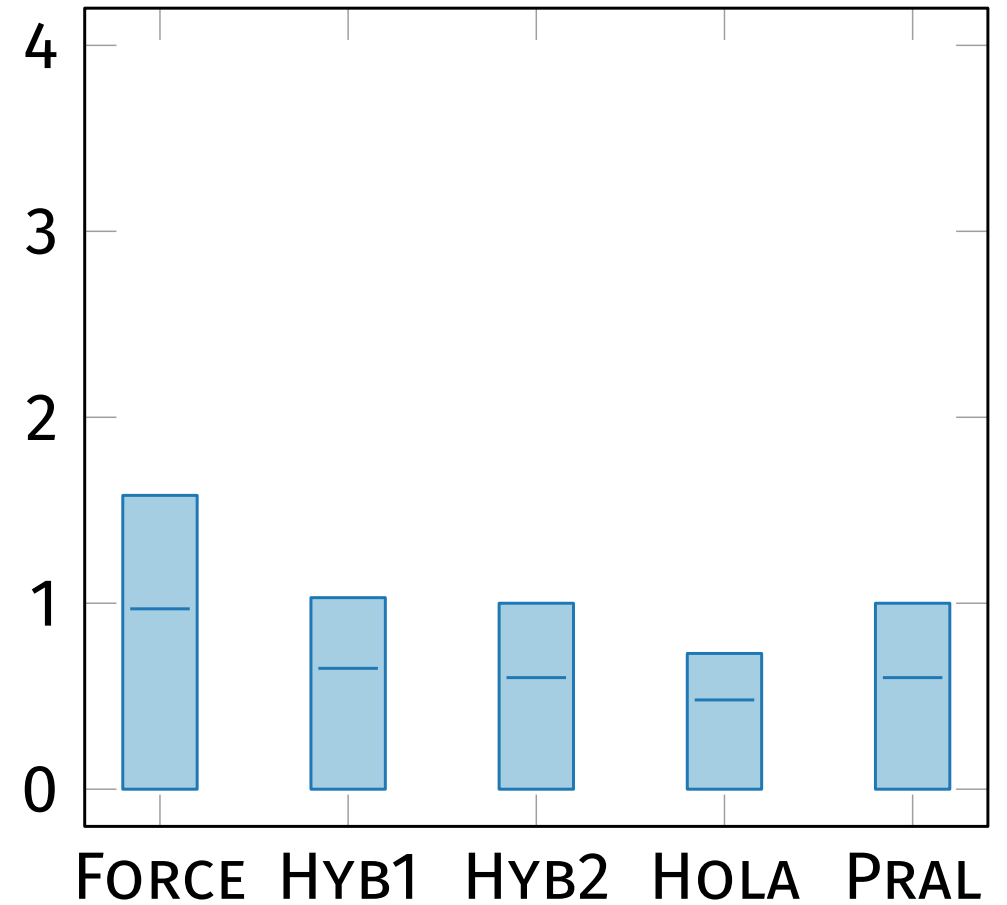
Results

Number of Crossings

Internet Topology Zoo



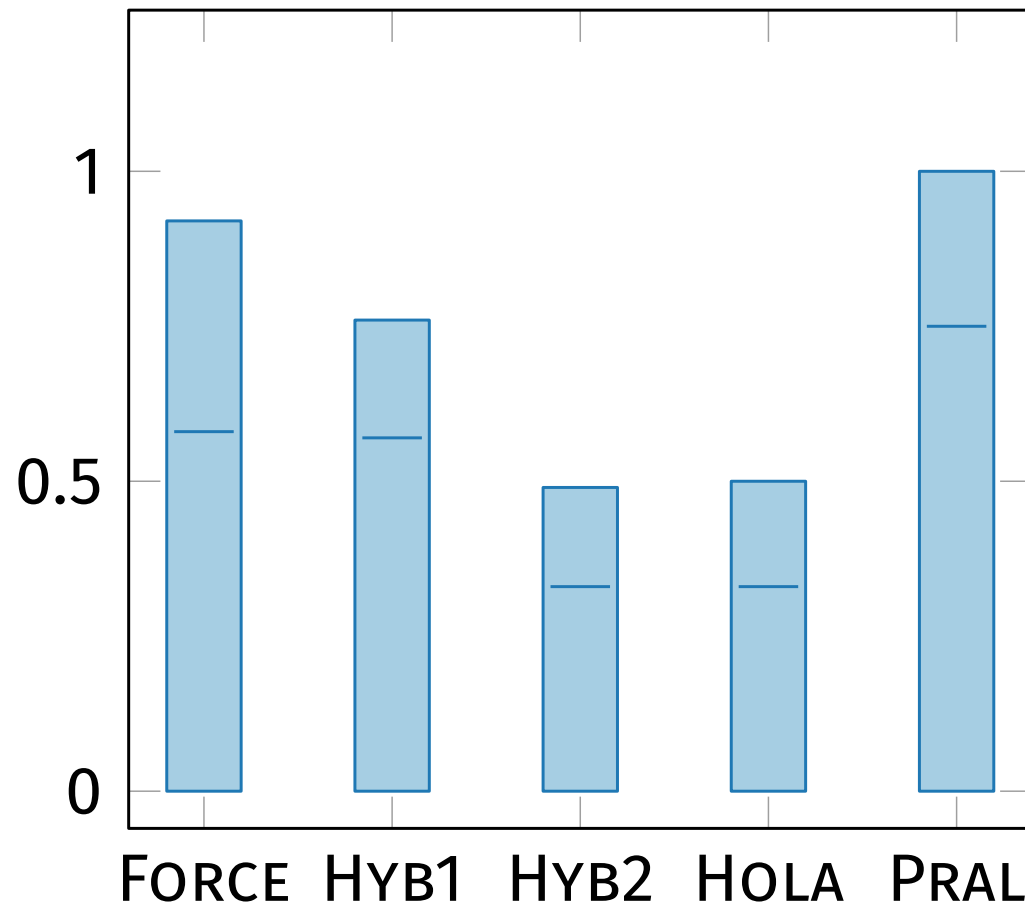
Pseudo-Cableplans



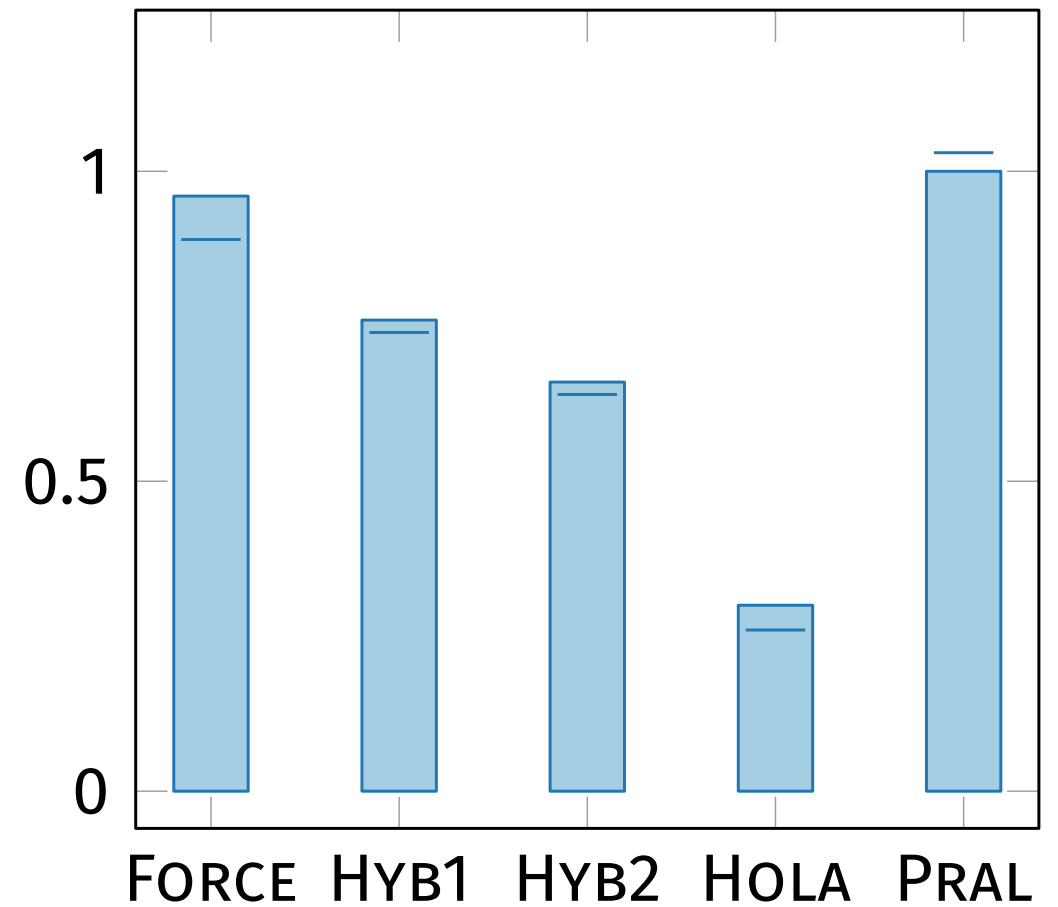
Results

Number of Edge Bends

Internet Topology Zoo



Pseudo-Cableplans

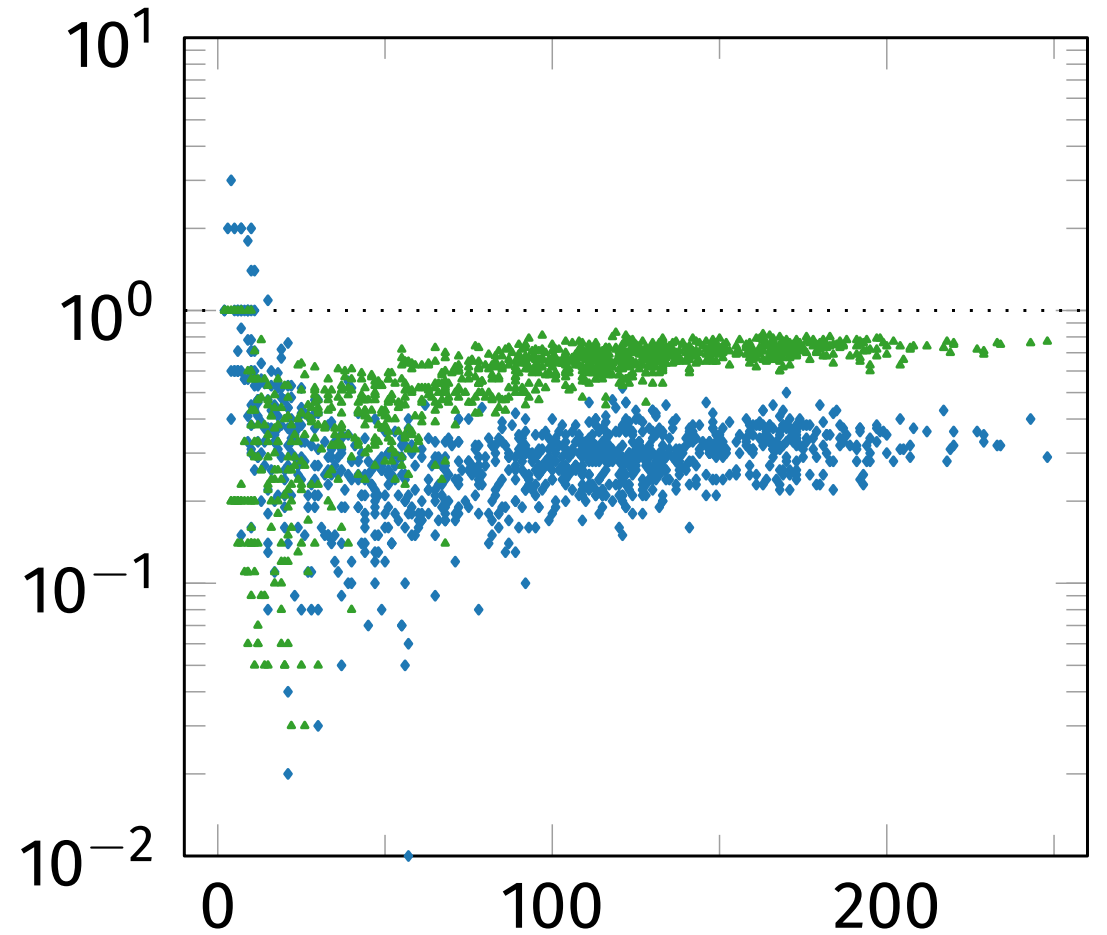
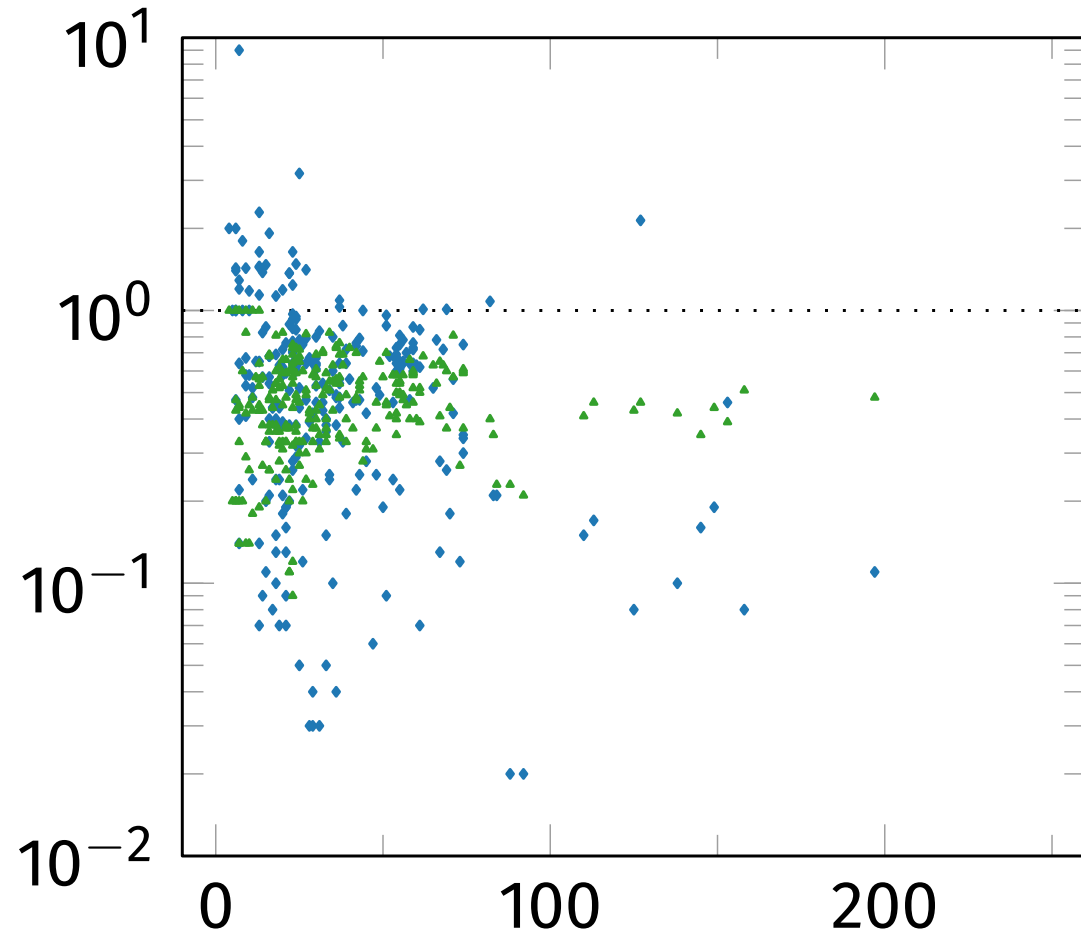


Results

Number of Edge Bends

Internet Topology Zoo

Pseudo-Cableplans



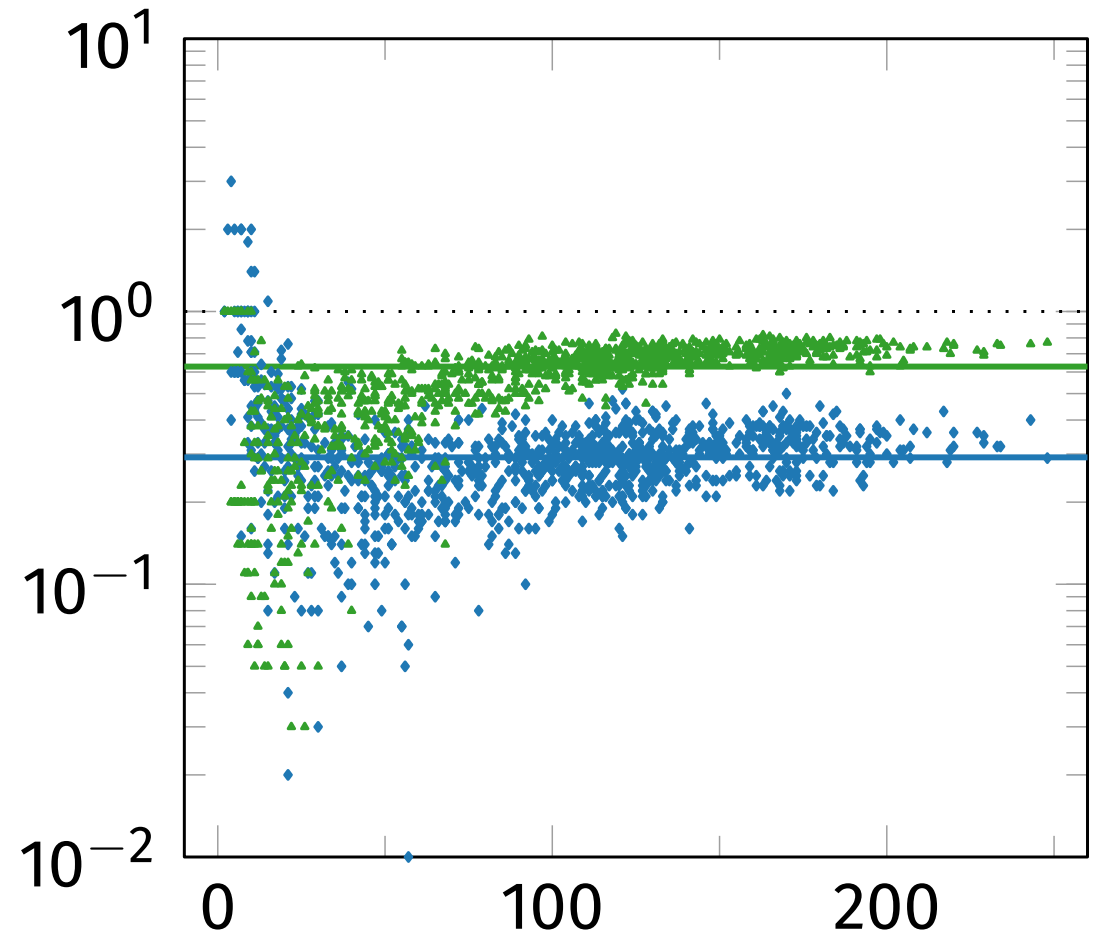
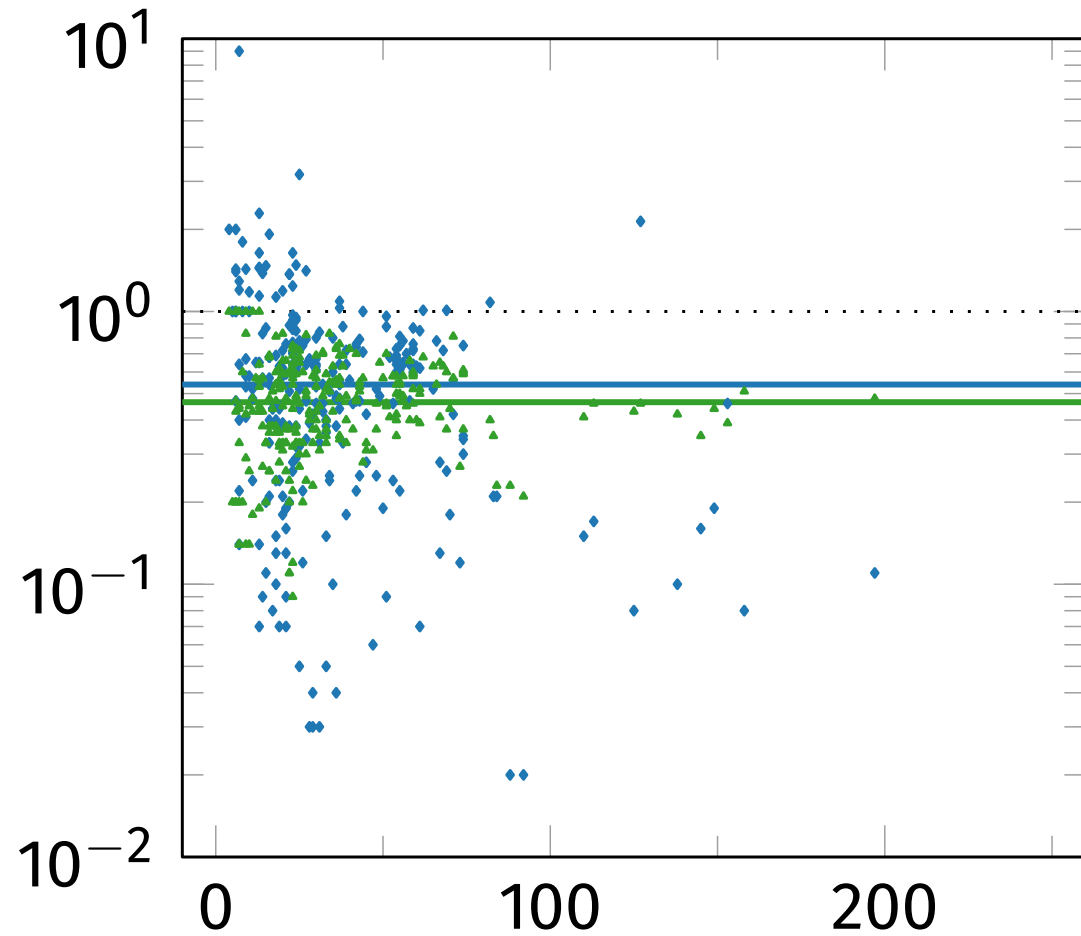
▲ HYBRID2 ◆ HOLA

Results

Number of Edge Bends

Internet Topology Zoo

Pseudo-Cableplans

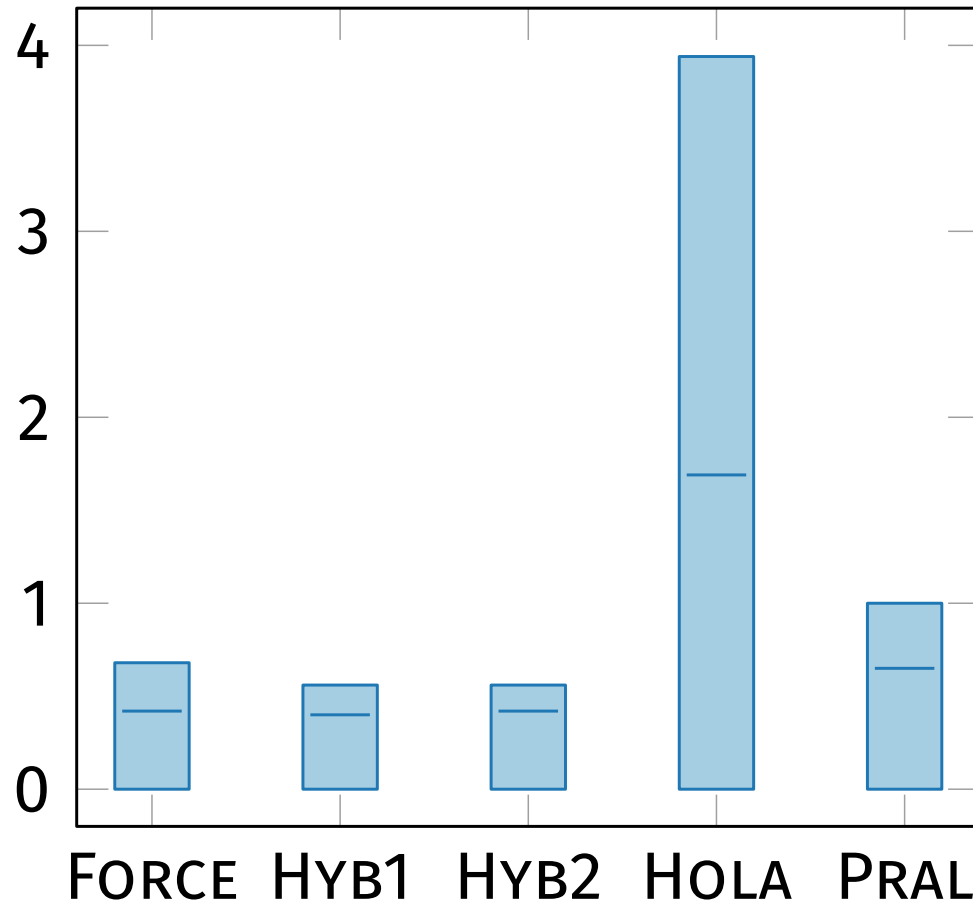


▲ HYBRID2 ◆ HOLA

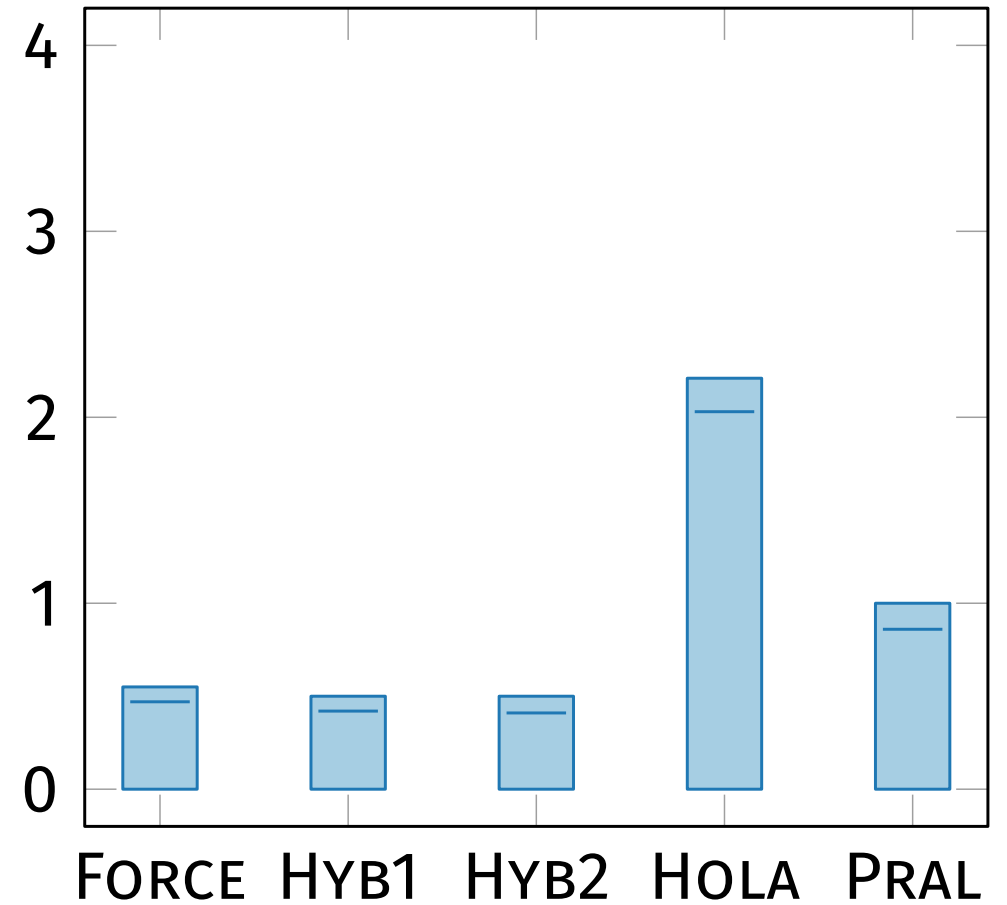
Results

Bounding Box Area

Internet Topology Zoo



Pseudo-Cableplans

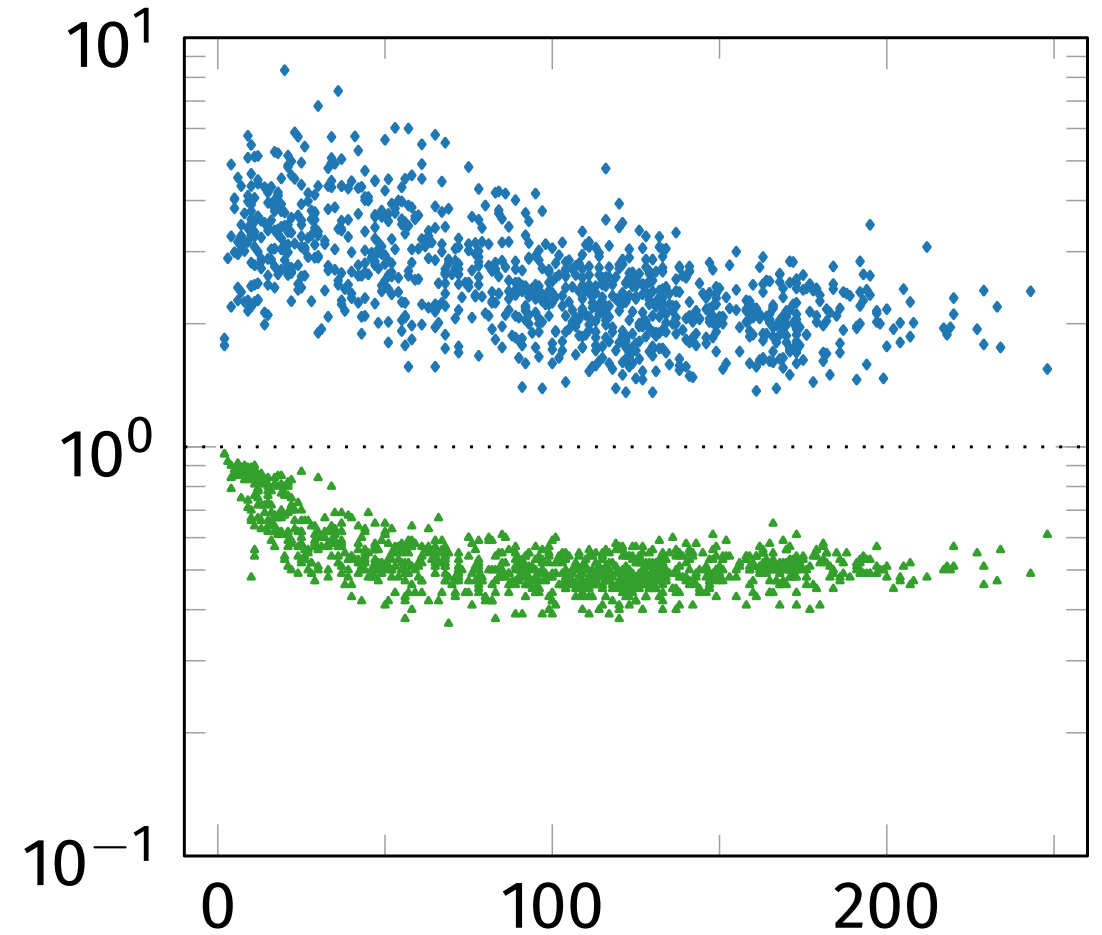
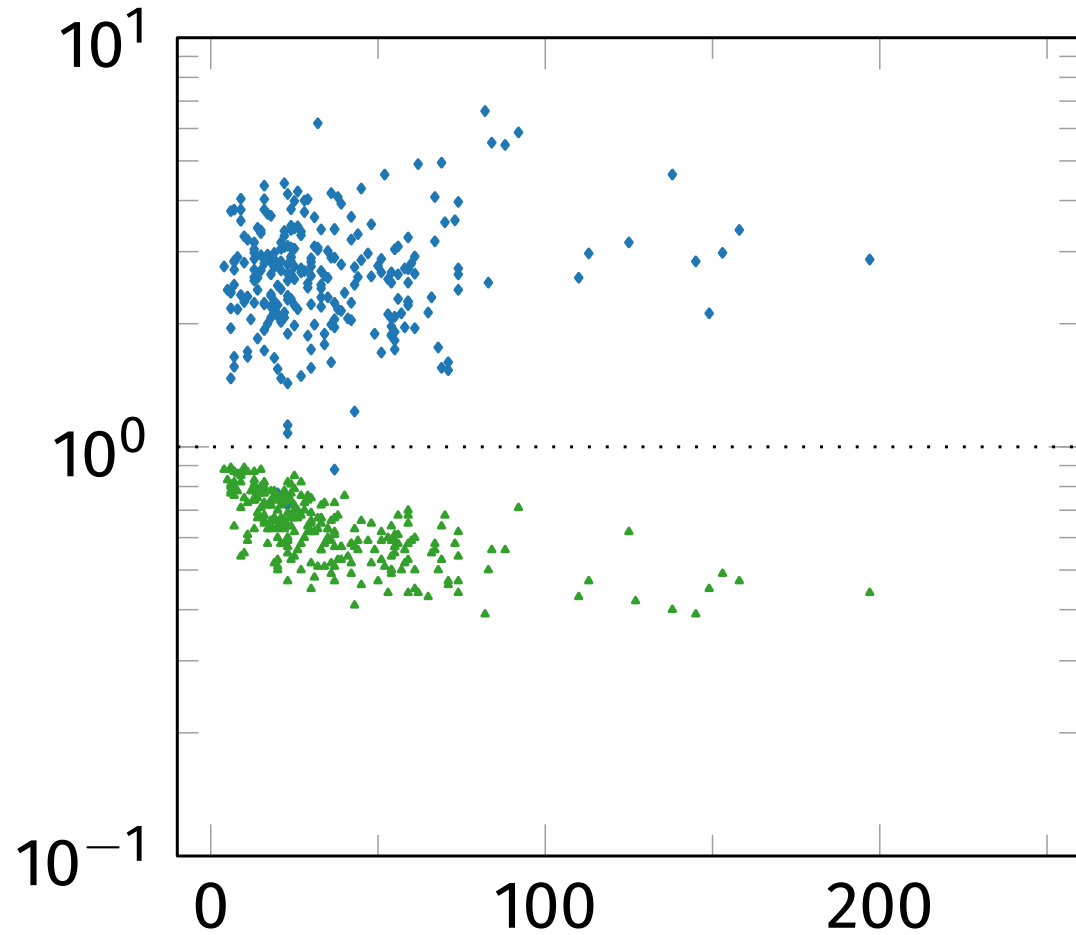


Results

Bounding Box Area

Internet Topology Zoo

Pseudo-Cableplans



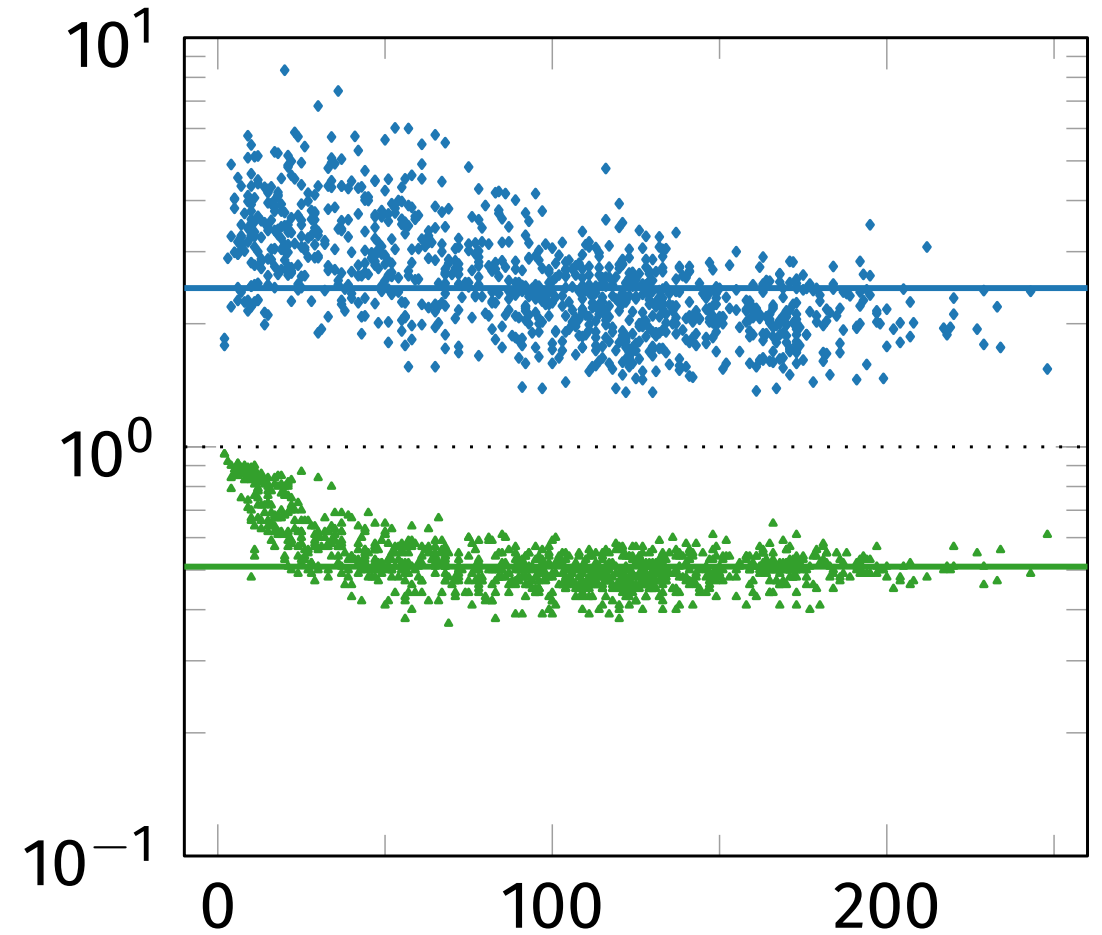
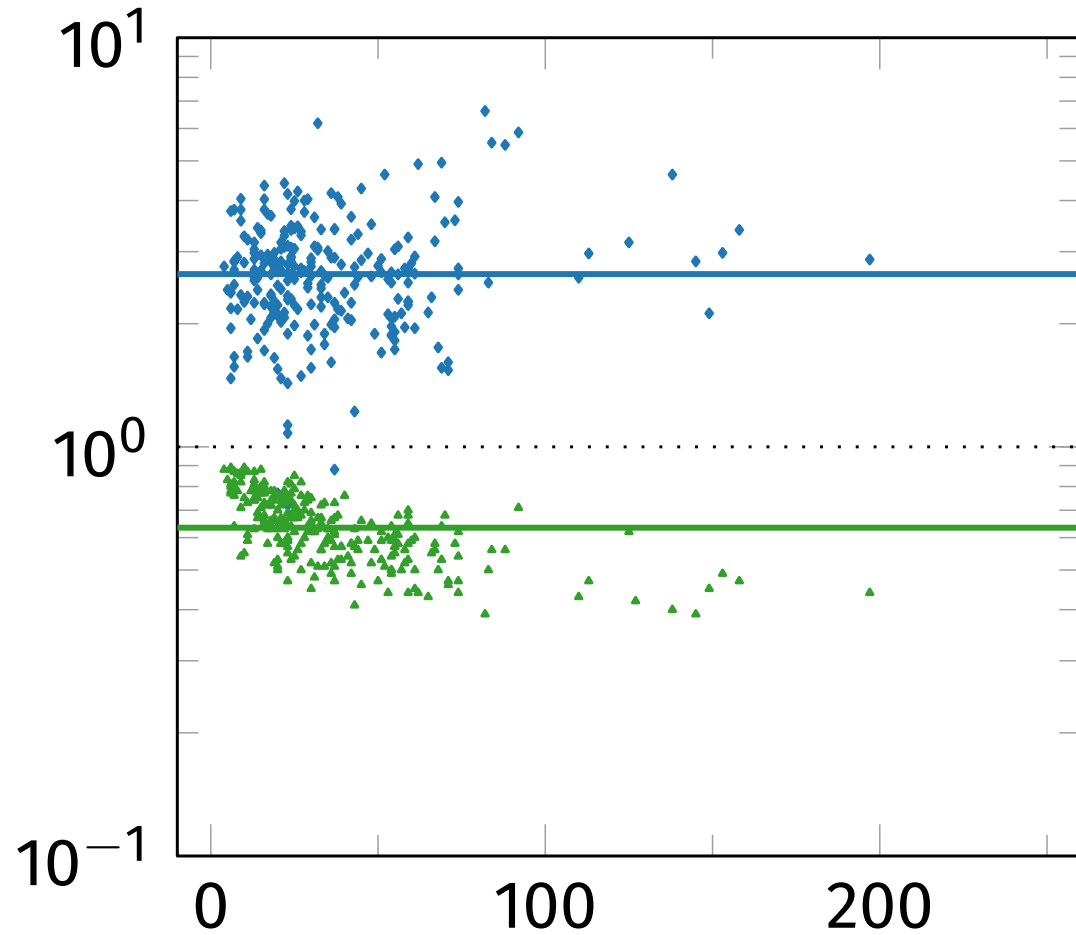
▲ HYBRID2 ◆ HOLA

Results

Bounding Box Area

Internet Topology Zoo

Pseudo-Cableplans

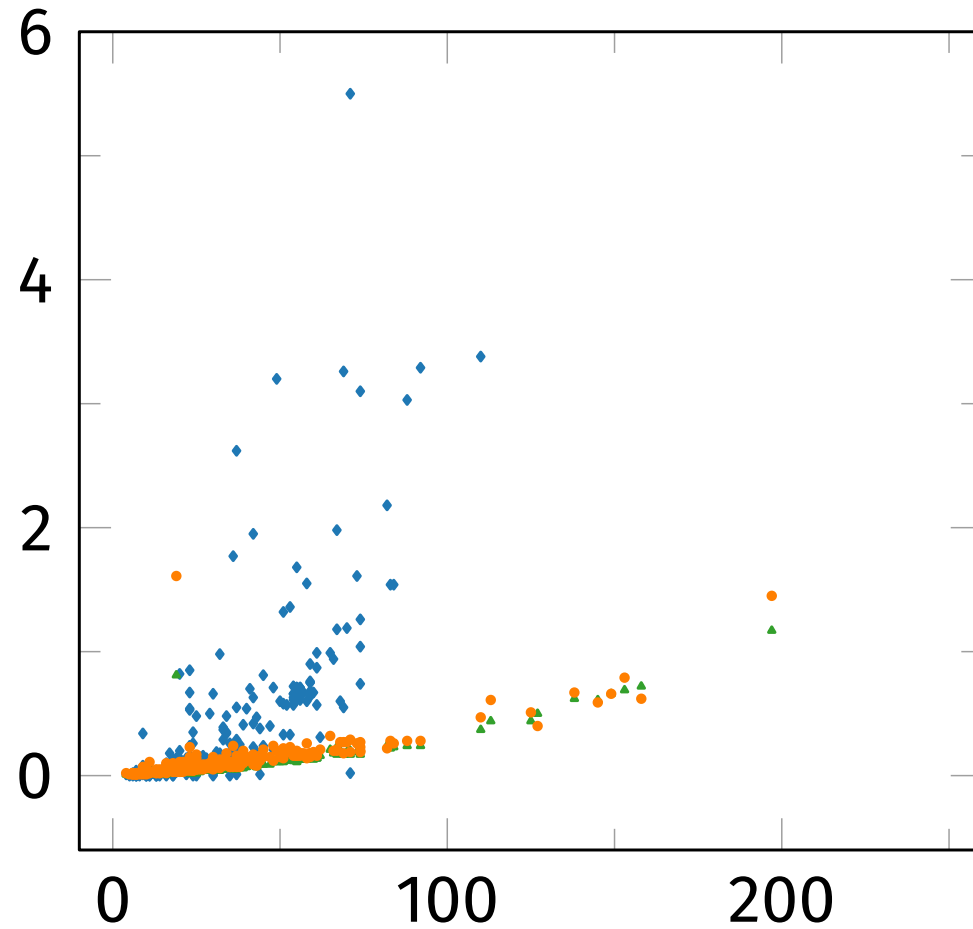


▲ HYBRID2 ◆ HOLA

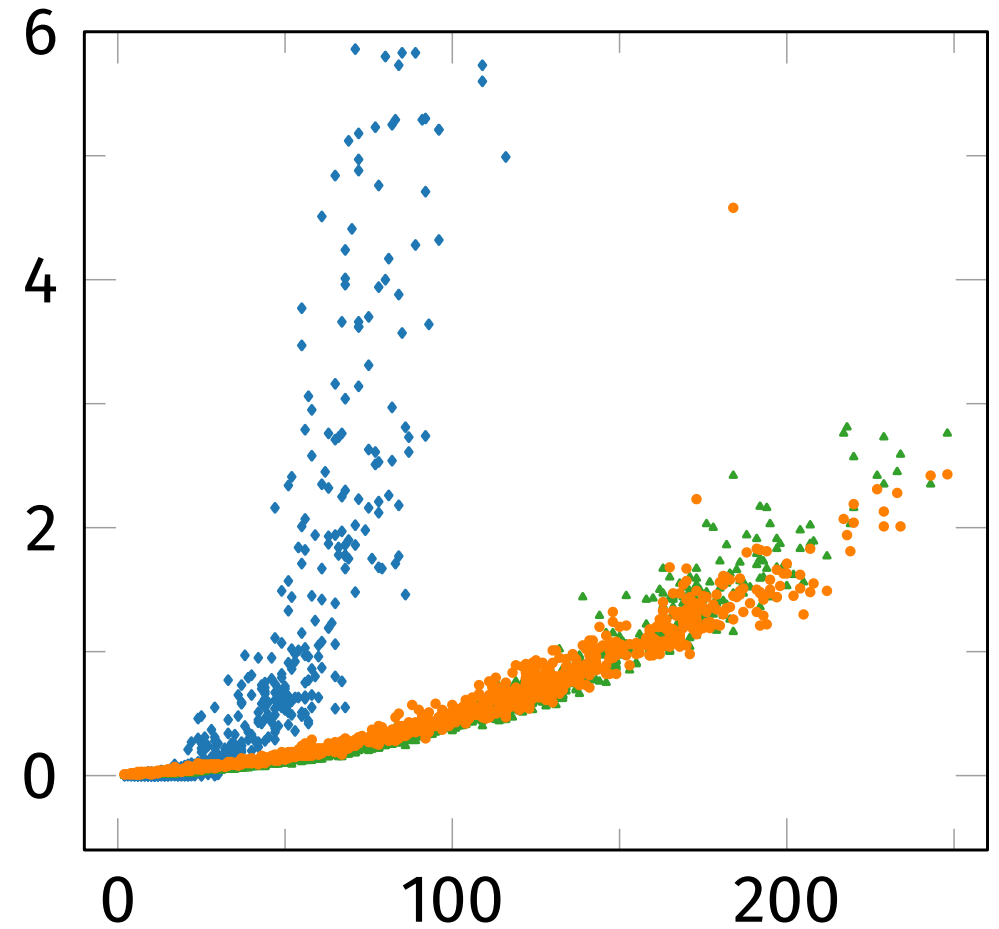
Results

Running Time [s]

Internet Topology Zoo



Pseudo-Cableplans



▲ FORCE \approx HYBRID1 ◆ HOLA ● PRALINE \approx HYBRID2

Conclusions

- Our pipeline variants turned out as good allrounders balancing different objectives.

Conclusions

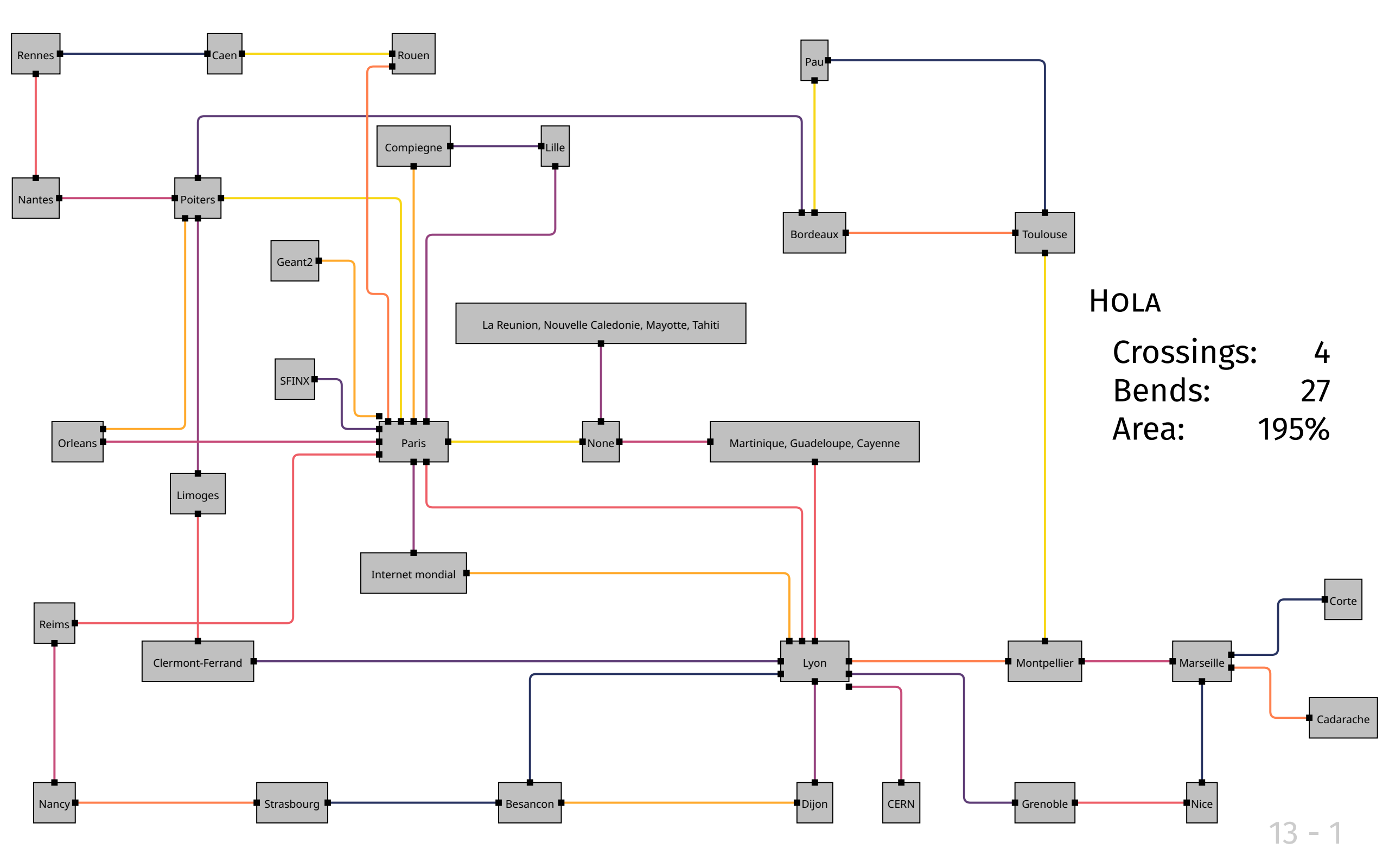
- Our pipeline variants turned out as good allrounders balancing different objectives.
- Drawings are very compact due to the effective nudging step.

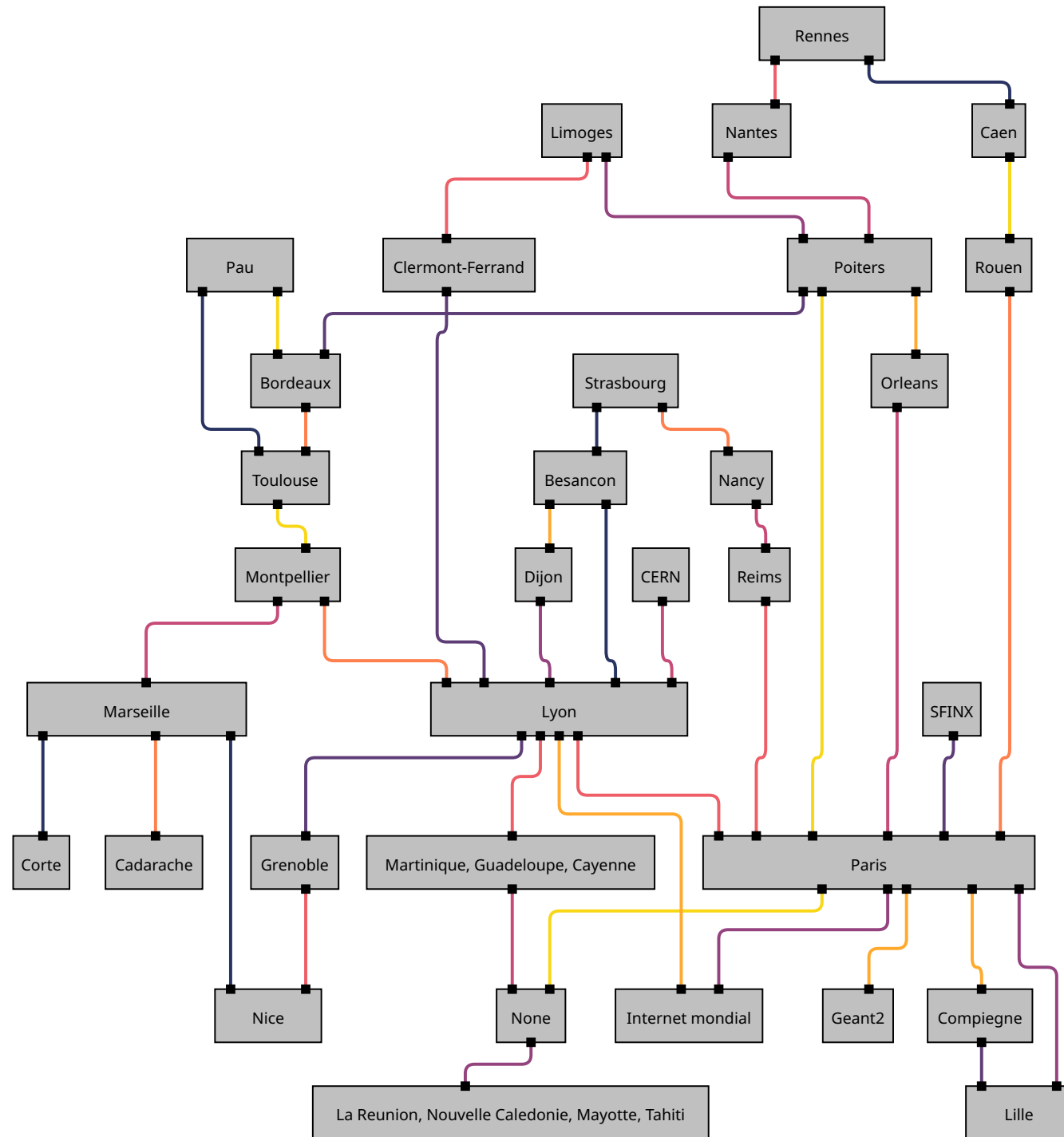
Conclusions

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- Drawings are very compact due to the effective nudging step.
- Our implementation handles multi-edges and self-loops and is sufficiently fast on real-world graphs with up to 200 nodes.

Conclusions

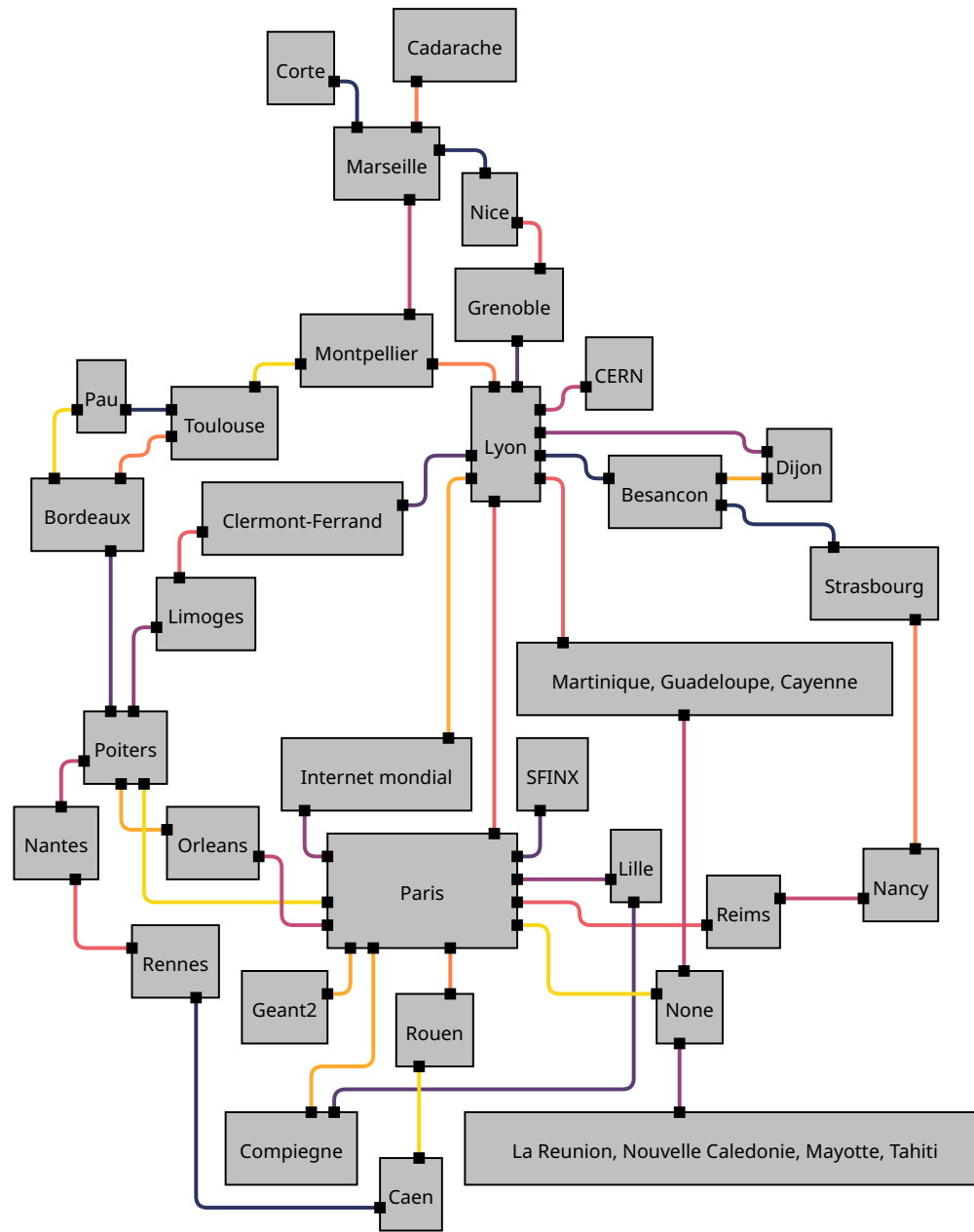
- Our pipeline variants turned out as good allrounders balancing different objectives.
- Drawings are very compact due to the effective nudging step.
- Our implementation handles multi-edges and self-loops and is sufficiently fast on real-world graphs with up to 200 nodes.
- *Future*: Better edge routing
 - Incremental crossing-aware routing (as suggested by [Wybrow et al. 2010])
 - Reordering ports in routing step





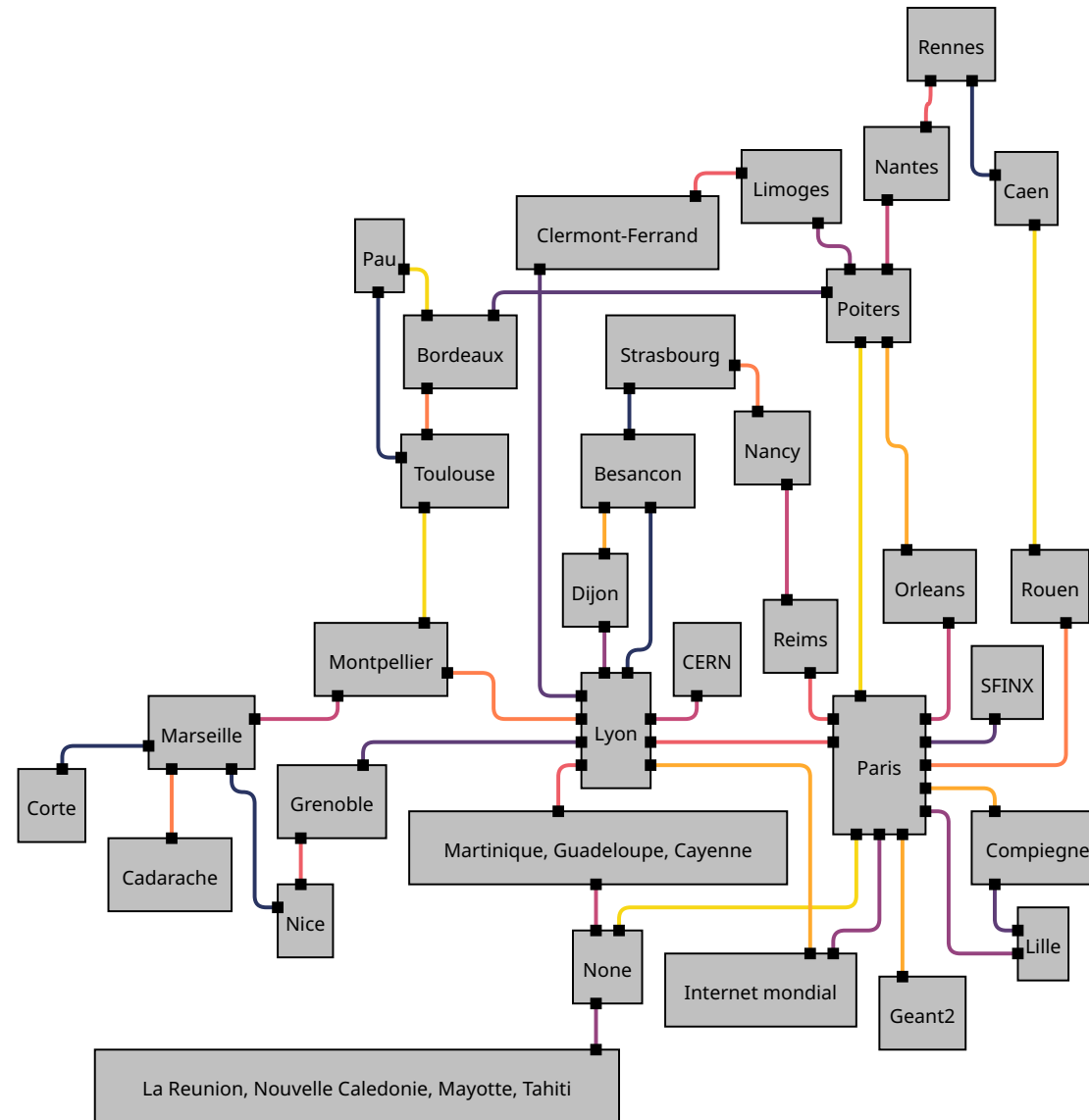
PRALINE

Crossings: 2
 Bends: 62
 Area: 100%



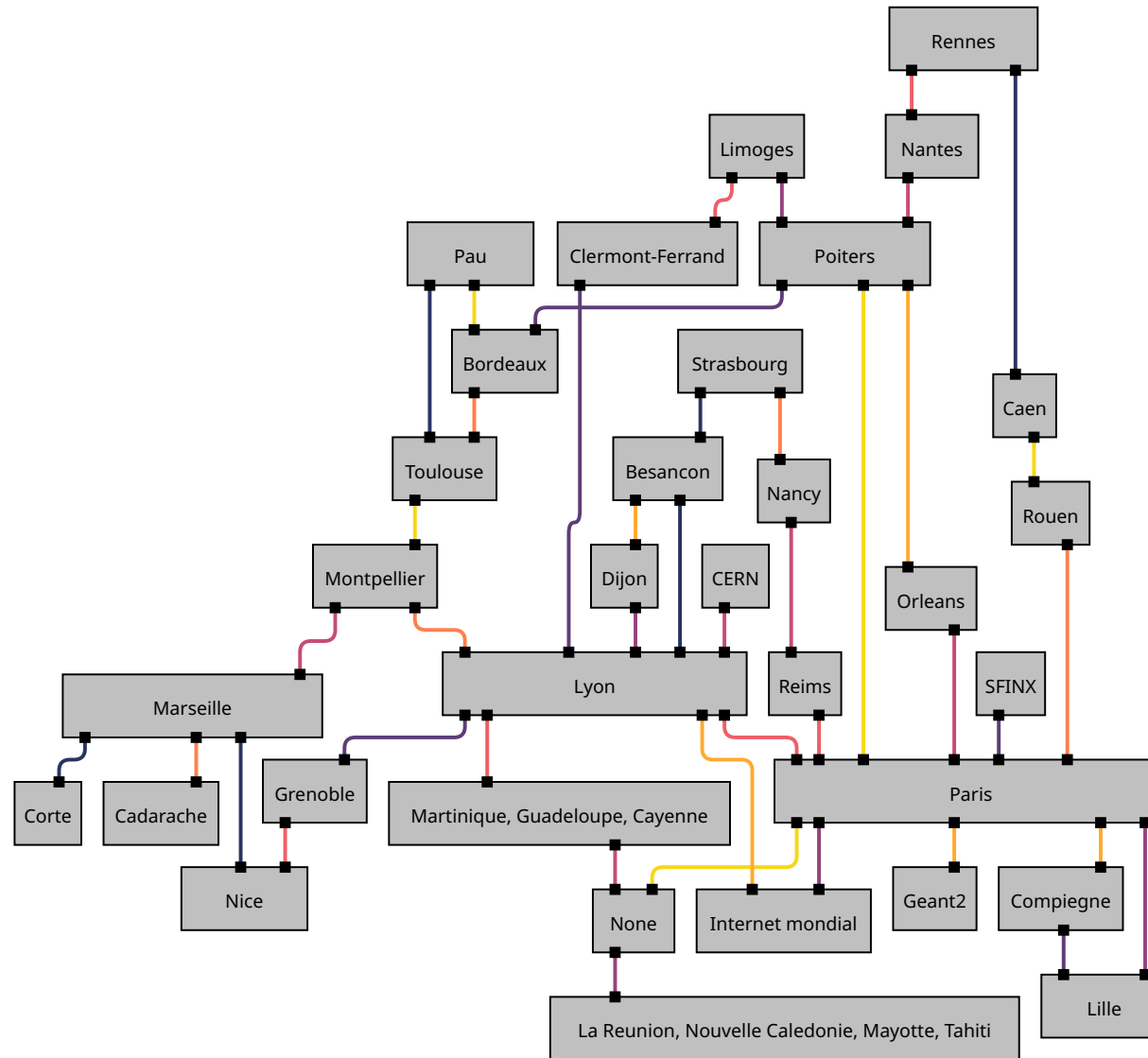
FORCE

Crossings: 6
 Bends: 42
 Area: 66%



HYBRID1

Crossings: 2
 Bends: 38
 Area: 67%



HYBRID2

Crossings: 2
 Bends: 20
 Area: 72%