Generalizing JPS Symmetry Detection: Canonical Orderings on Graphs

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Background

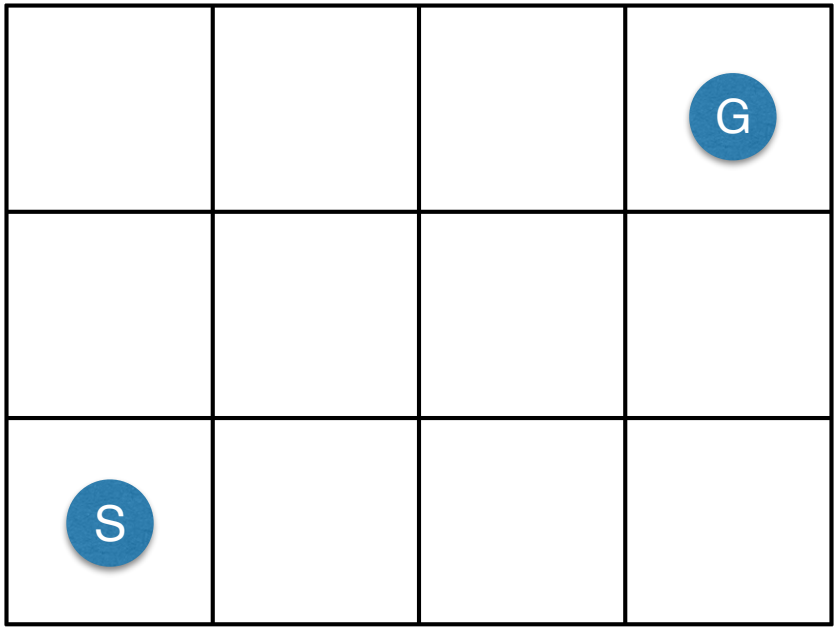
- Jump Point Search has been a popular technique for improving grid-based search
- It is one of the few techniques that requires no pre-processing
  - Pre-processing can improve speed

IJCAI 2016

- Canonical Orderings on Grids
- Reformulations JPS as:
  - Canonical ordering of states
  - Jumping policy
  - Best-first search

Canonical ordering of paths

- Order all **optimal** paths:
  - Path p_1 is preferred over path p_2 if
    - p_1 has diagonal actions prior to p_2



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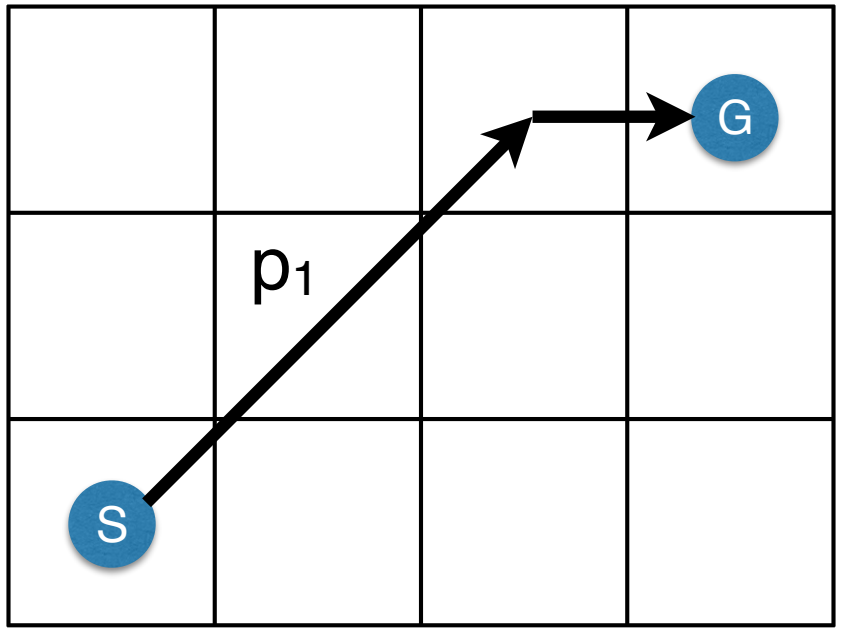

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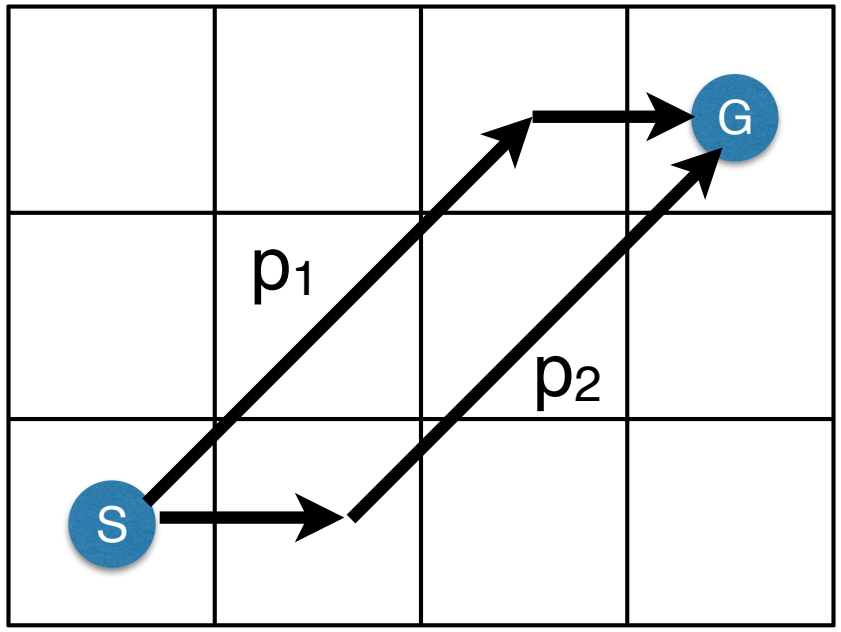

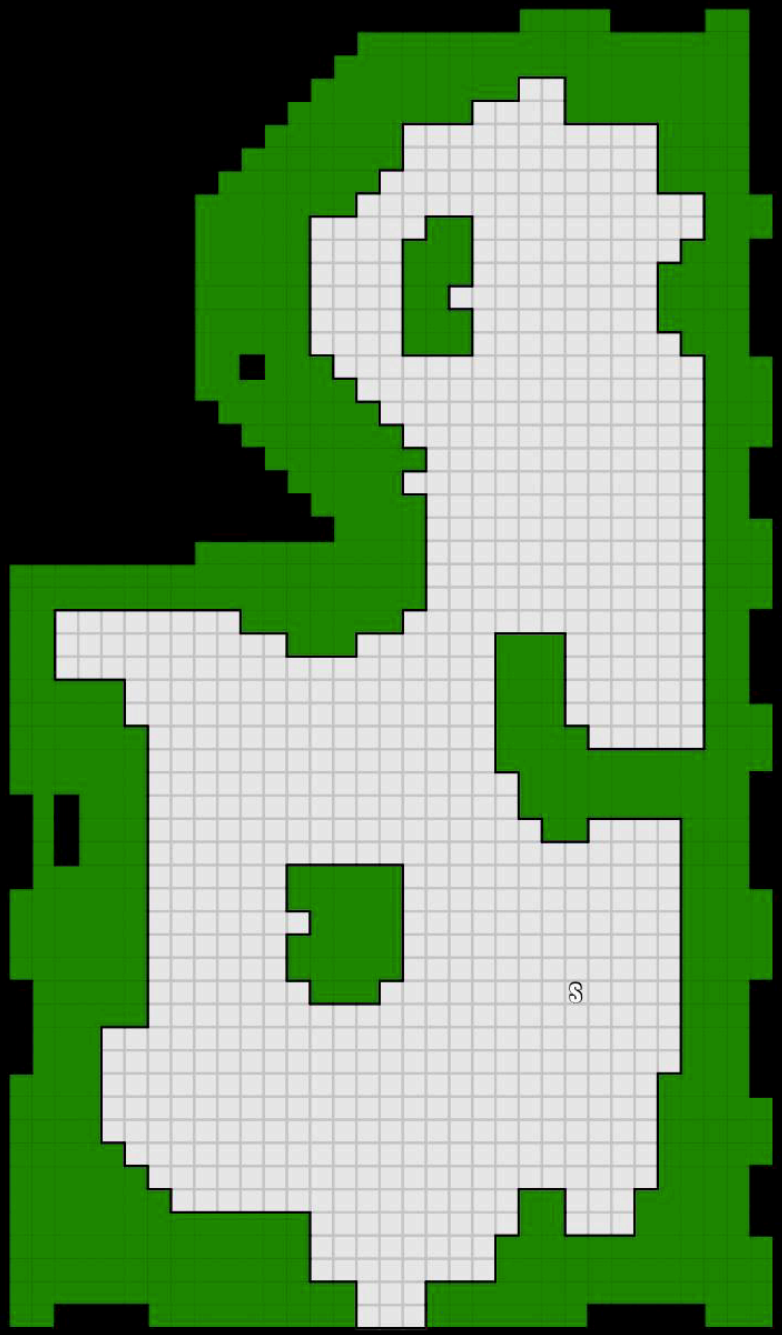

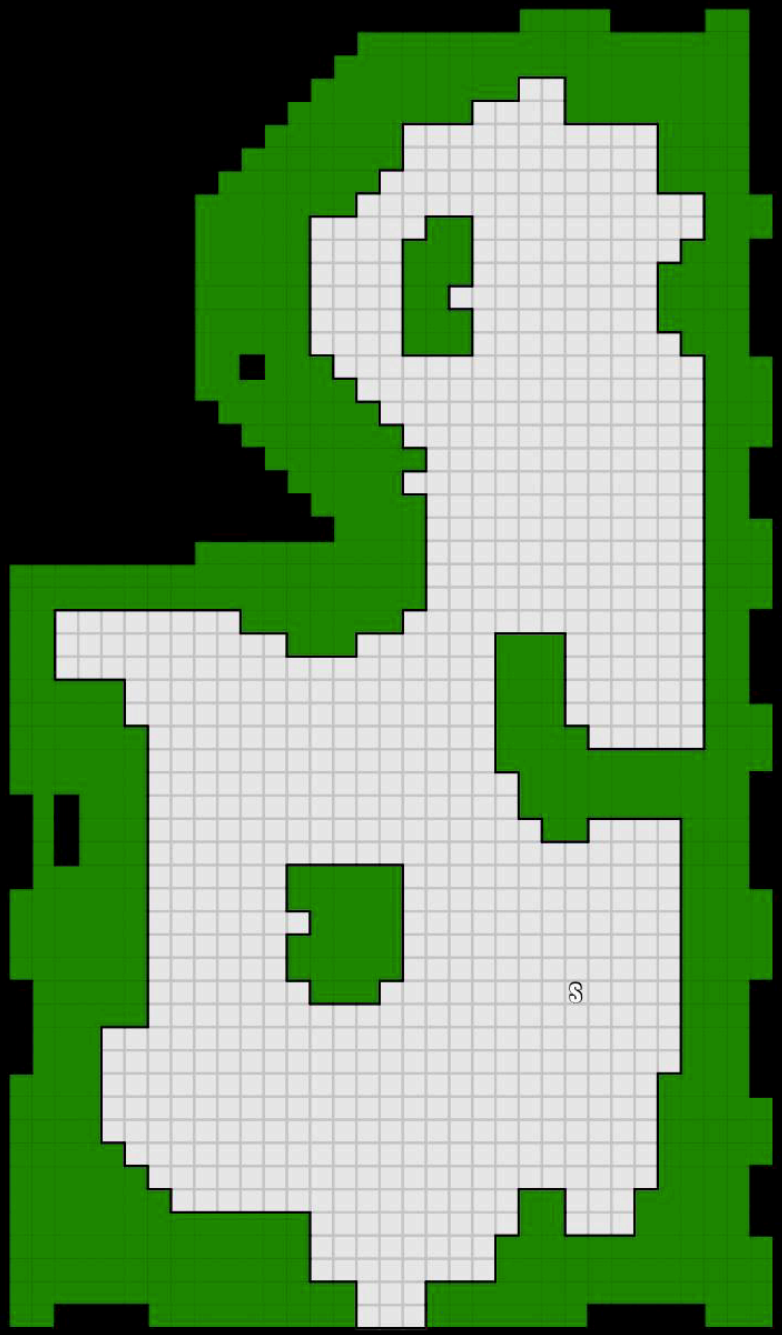

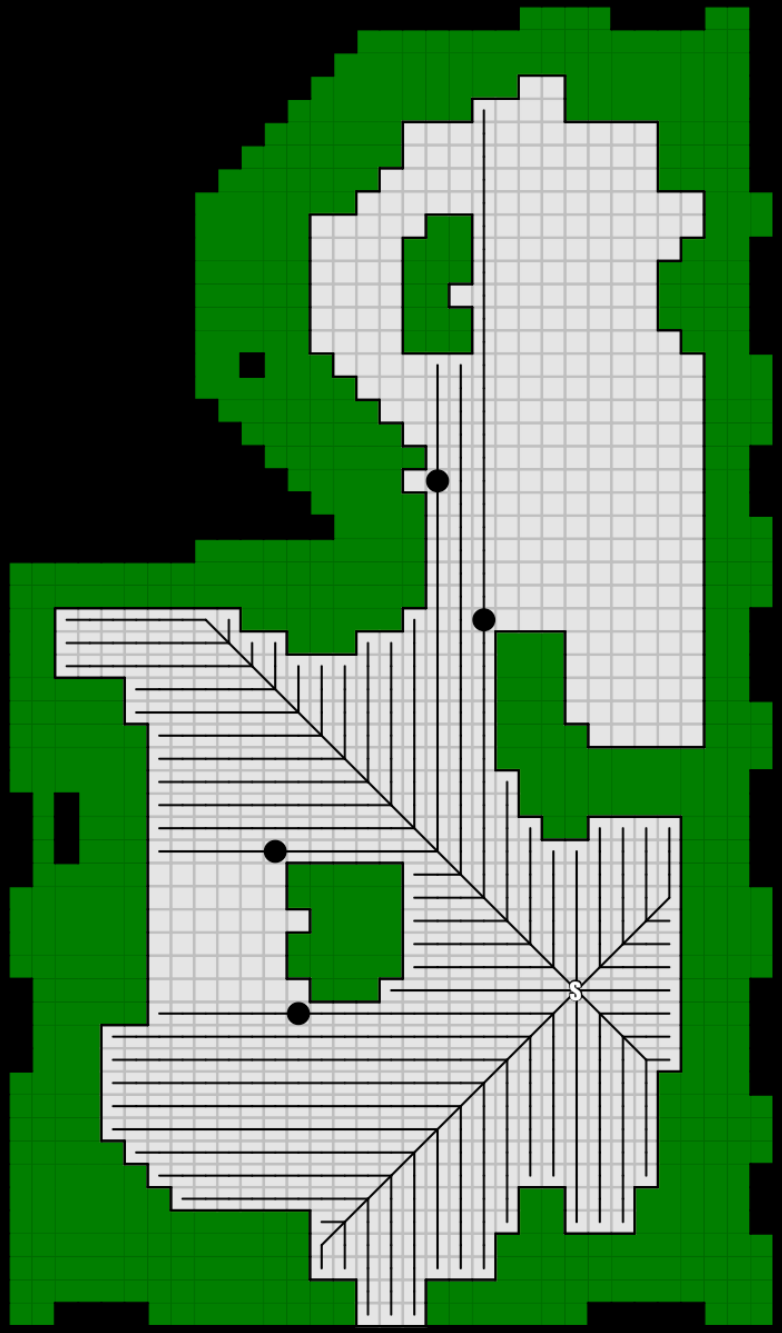
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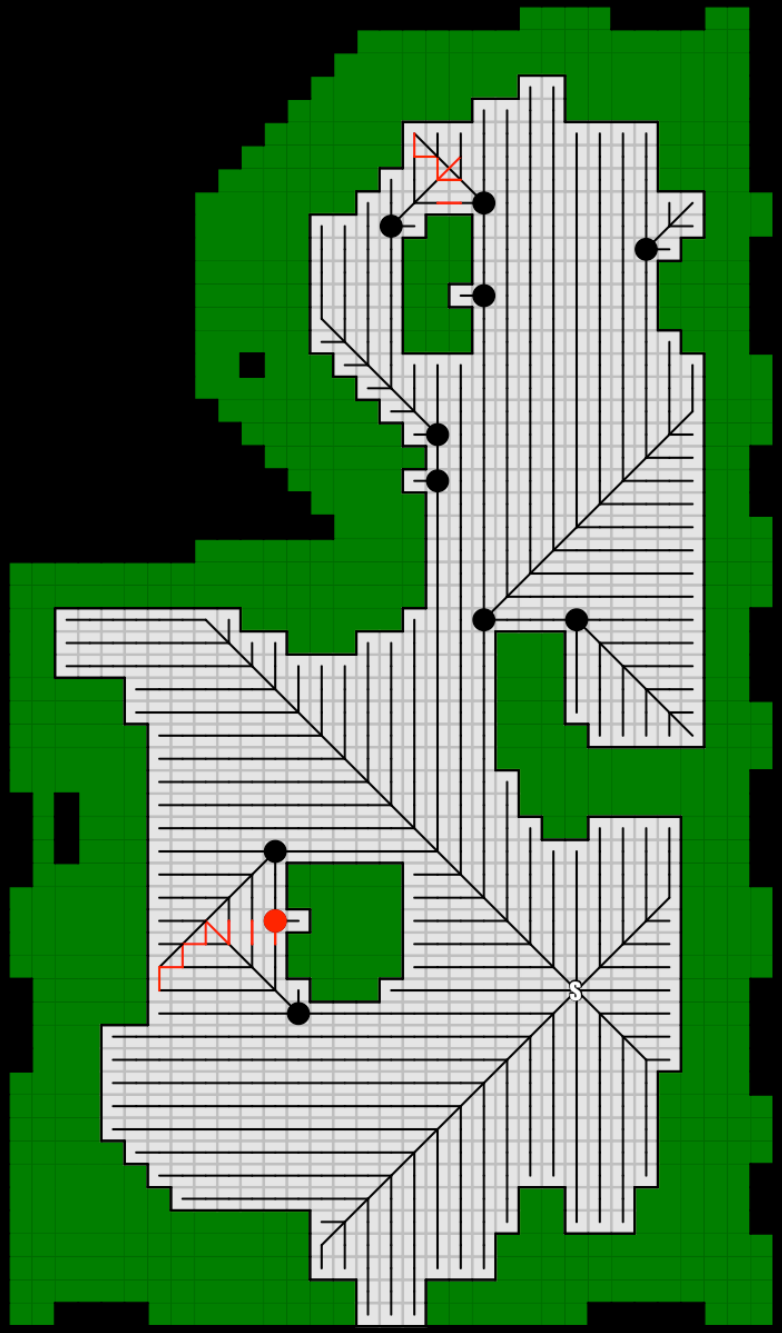
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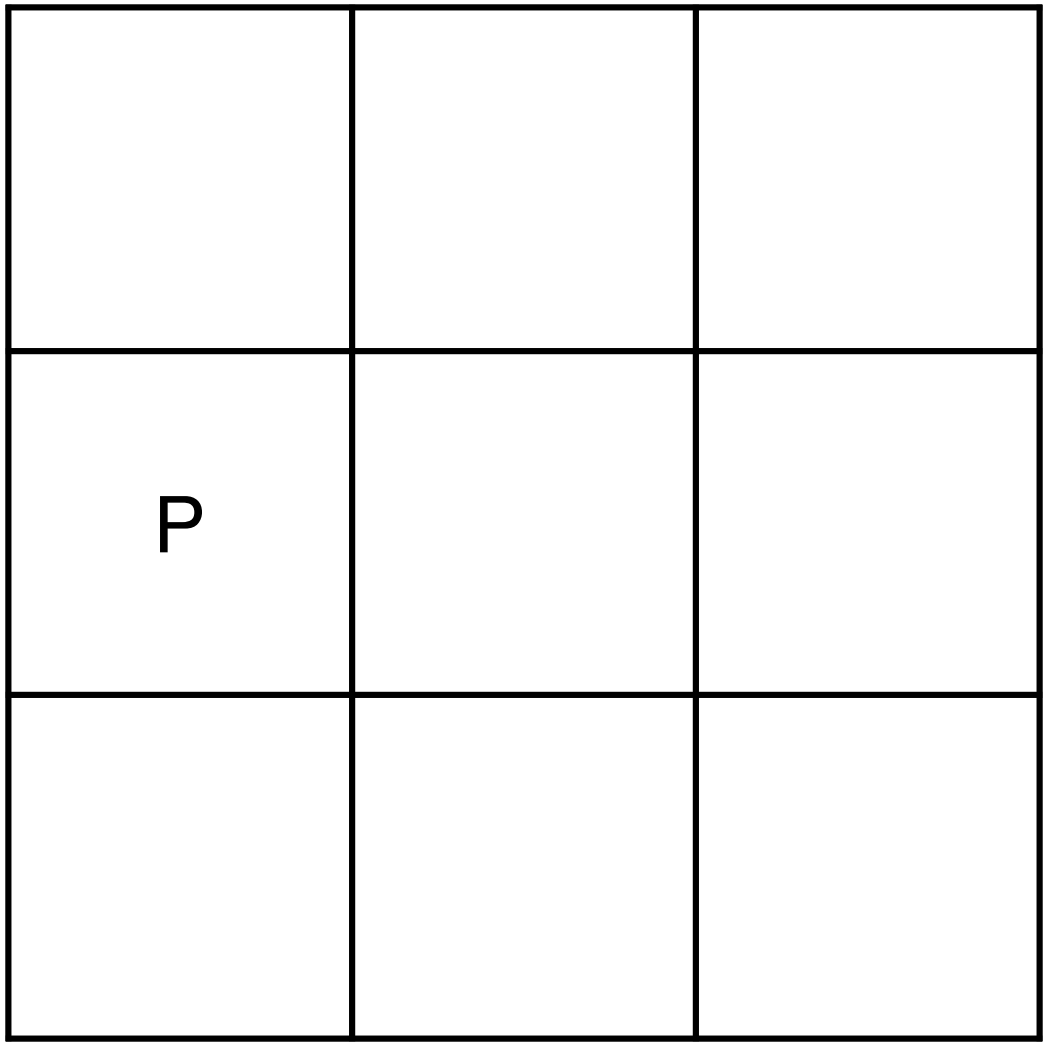
Canonical Neighbor Rule

- If this state was reached from a parent via:
  - A cardinal action
    - Only 1 successor in the same cardinal direction
  - A diagonal action
    - 2 children from component cardinal actions
    - 1 diagonal child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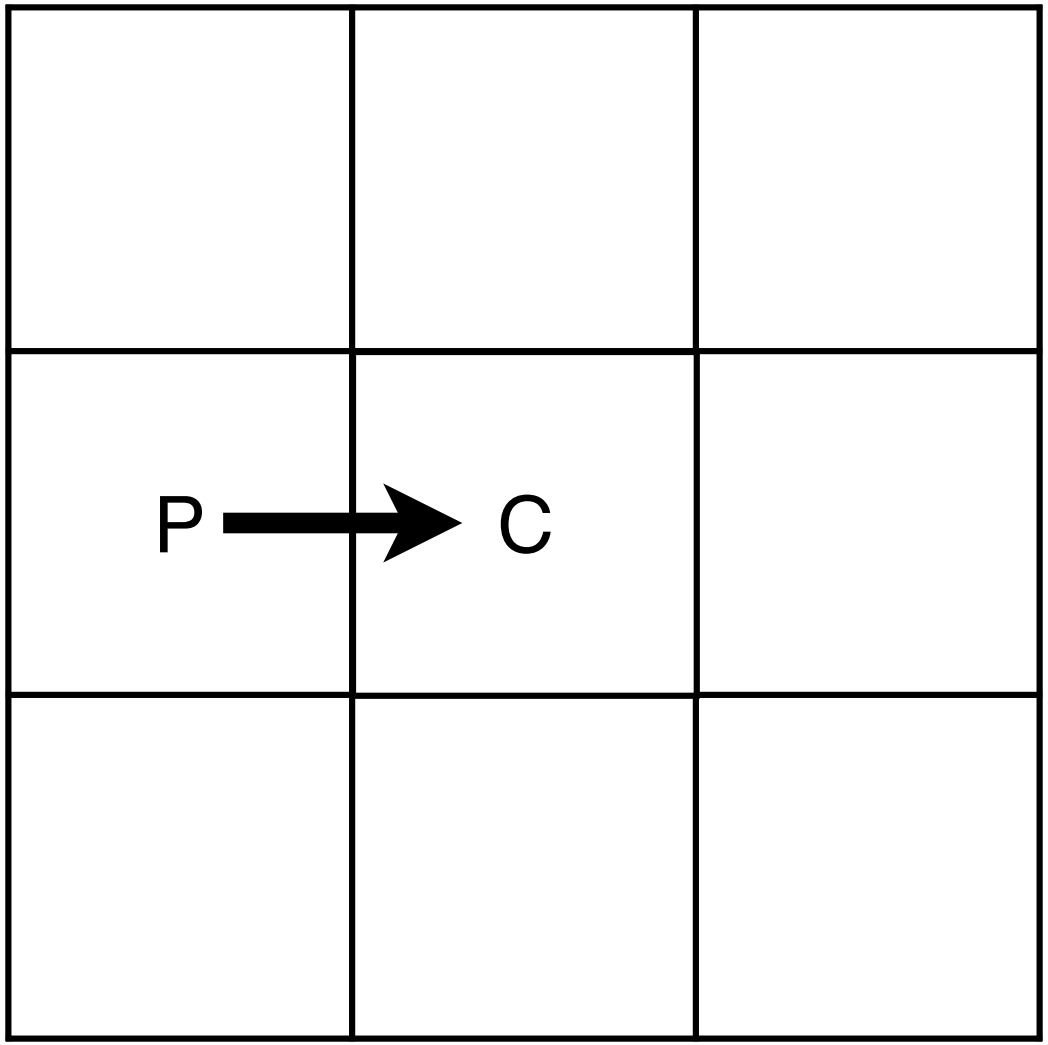
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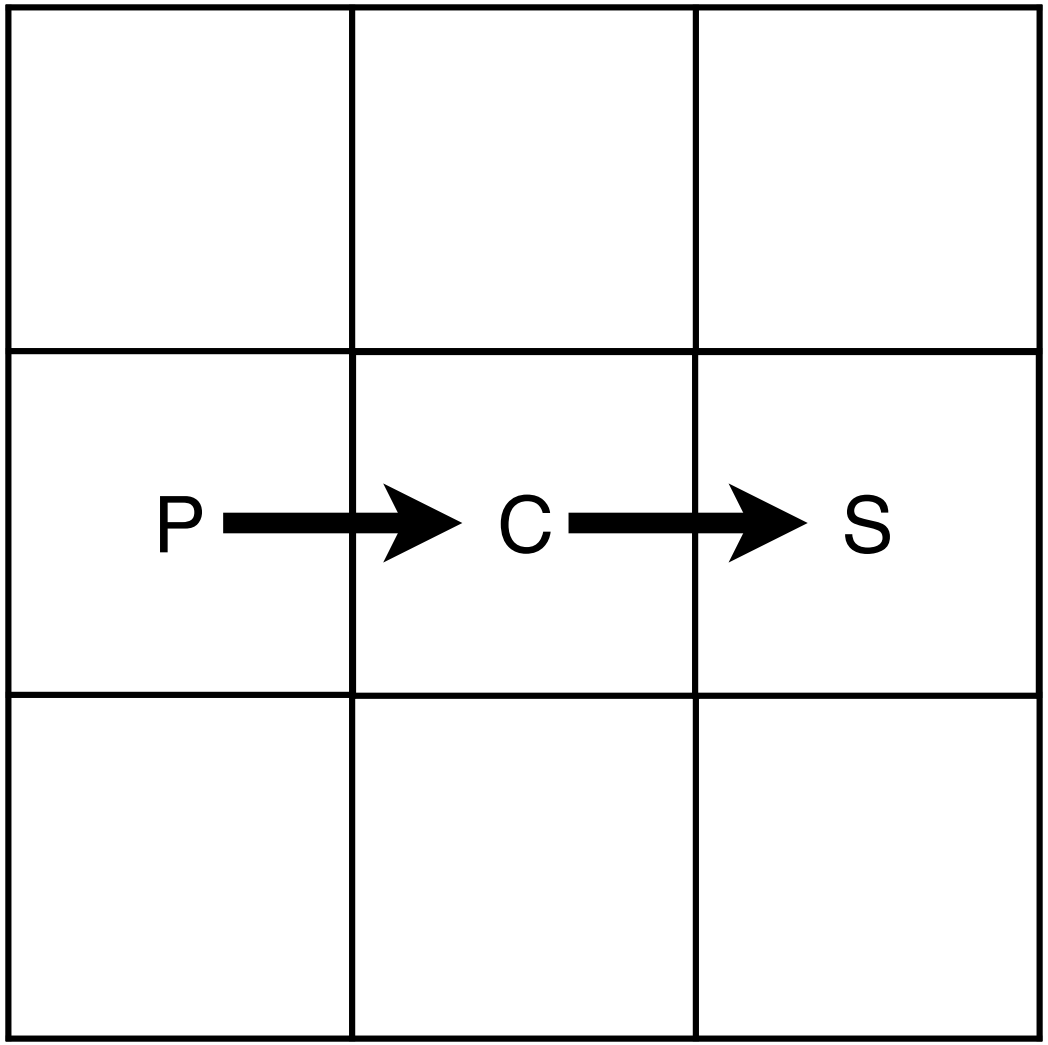
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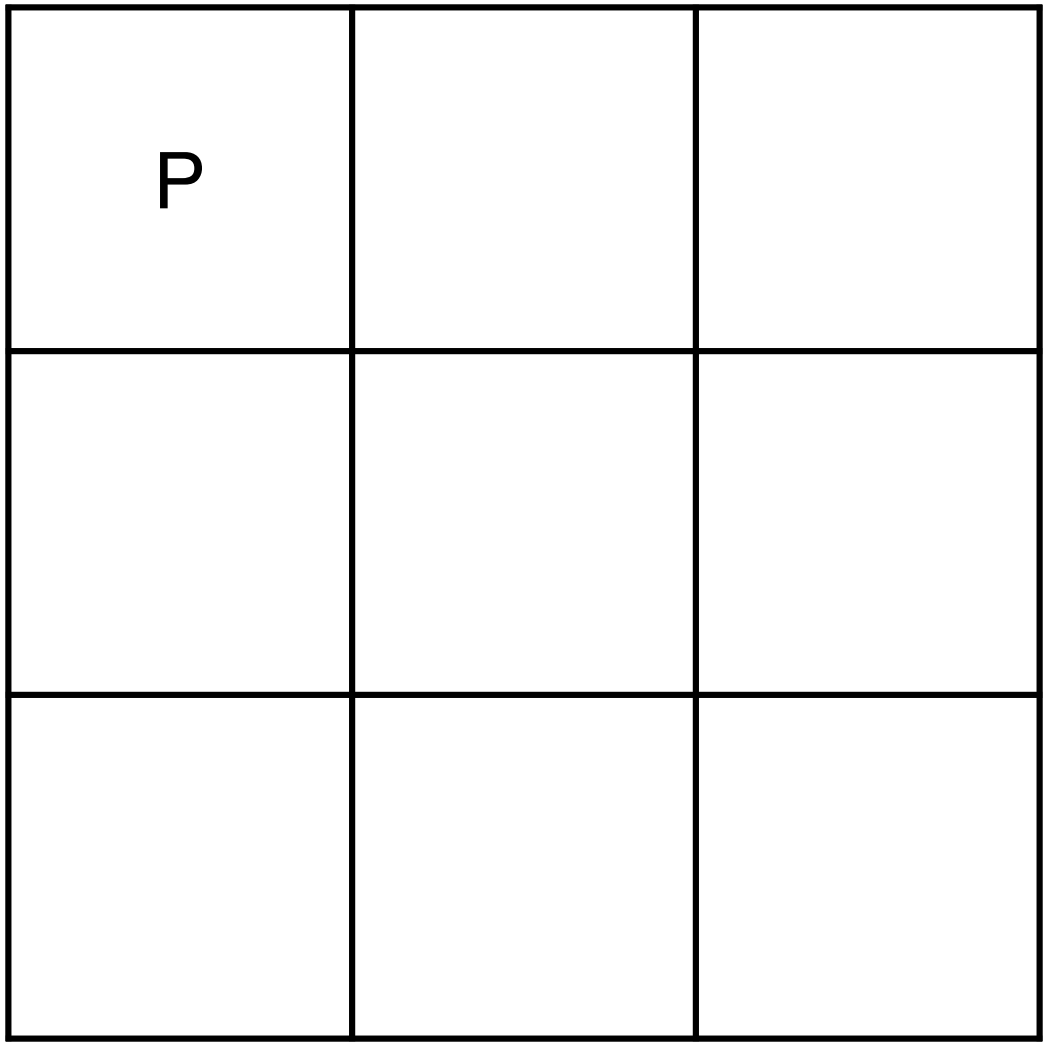
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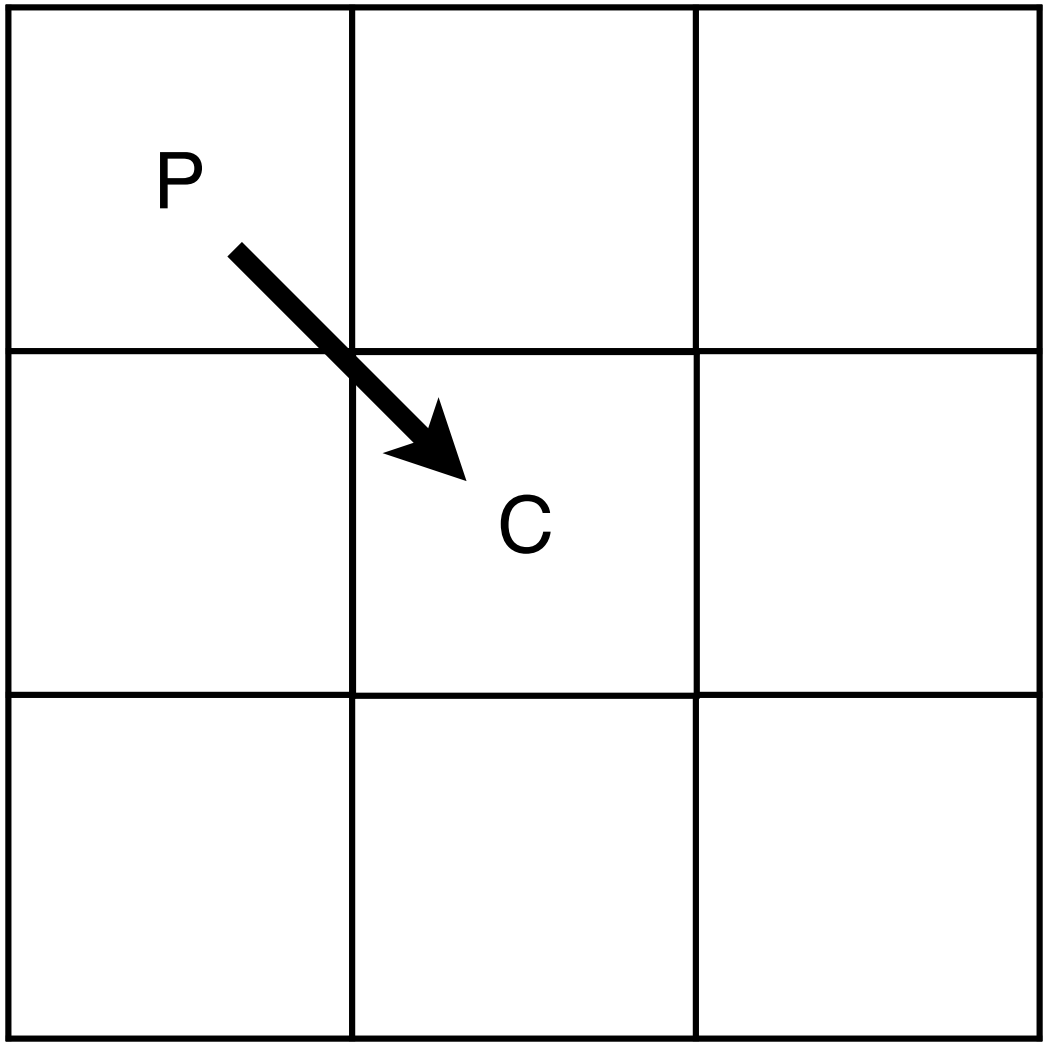
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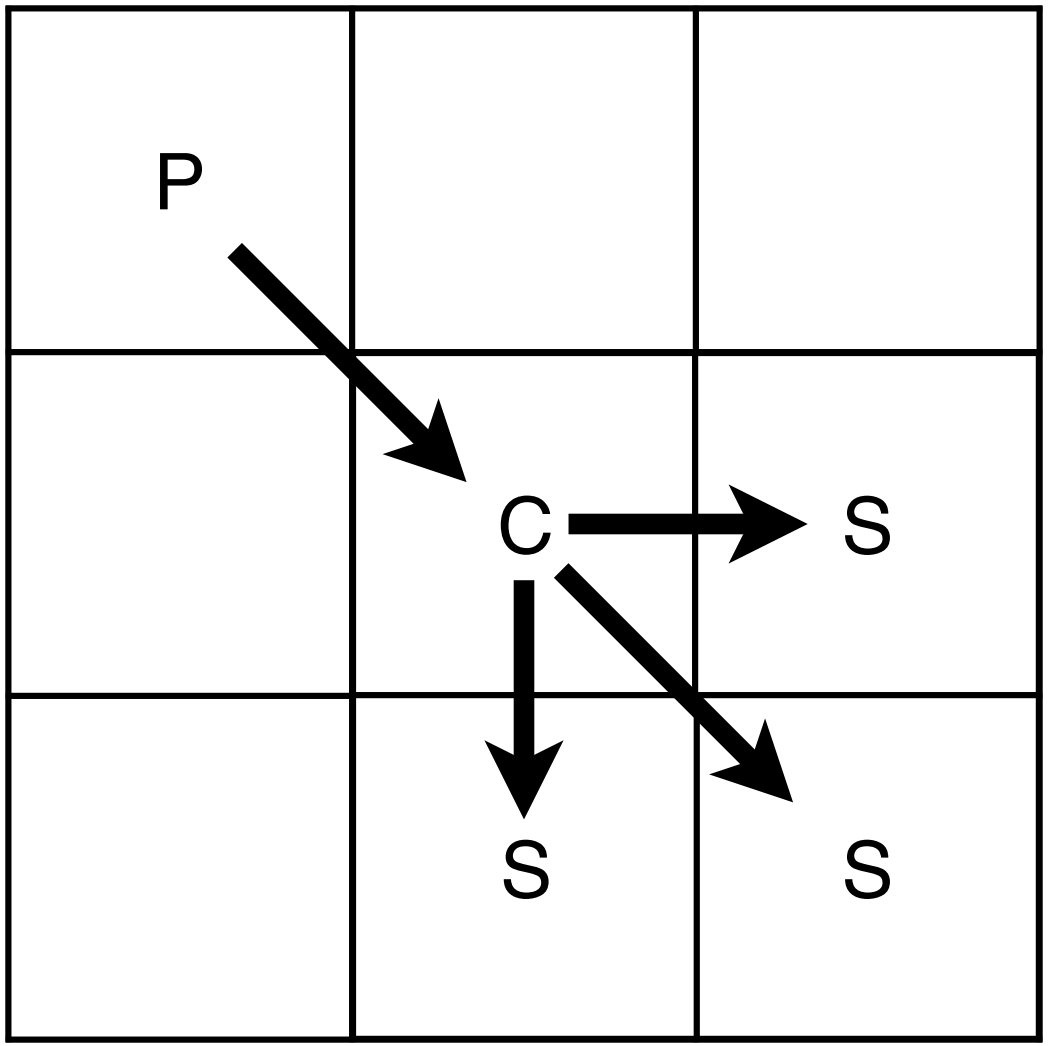
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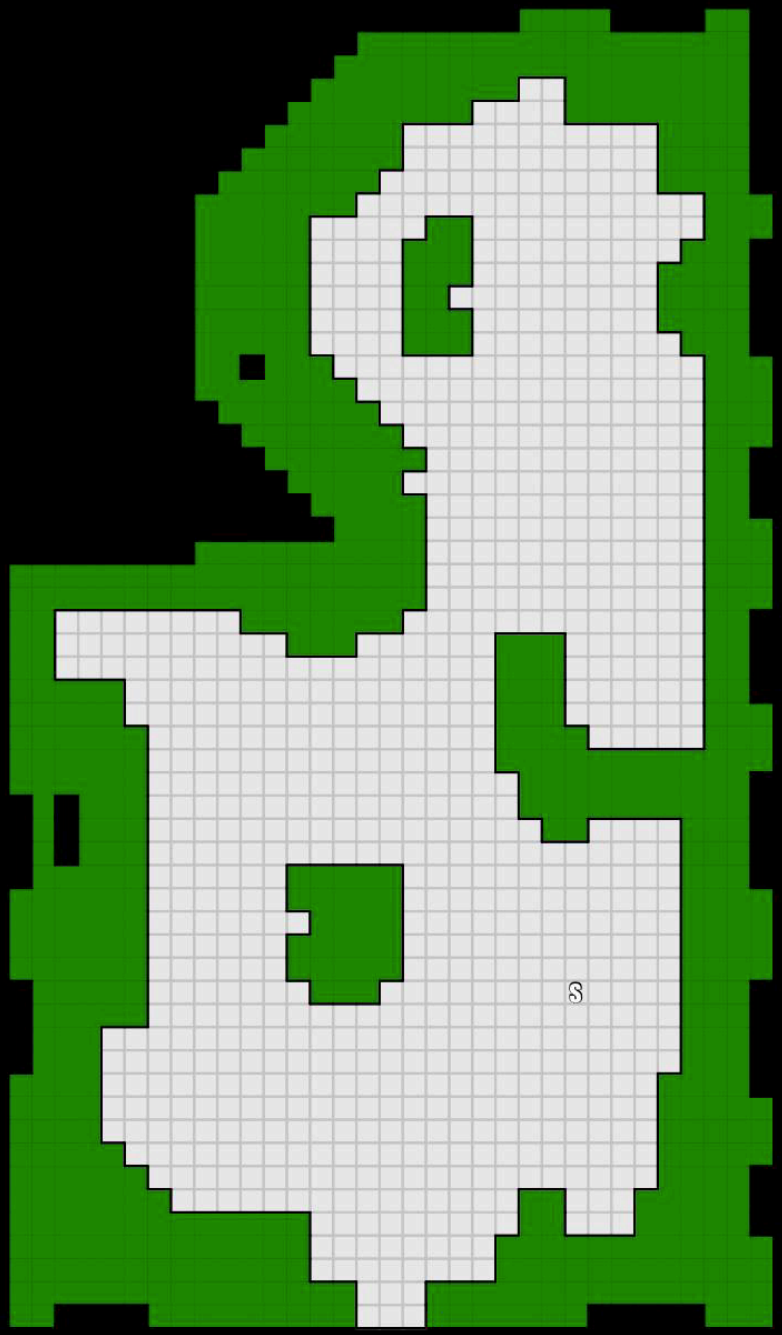

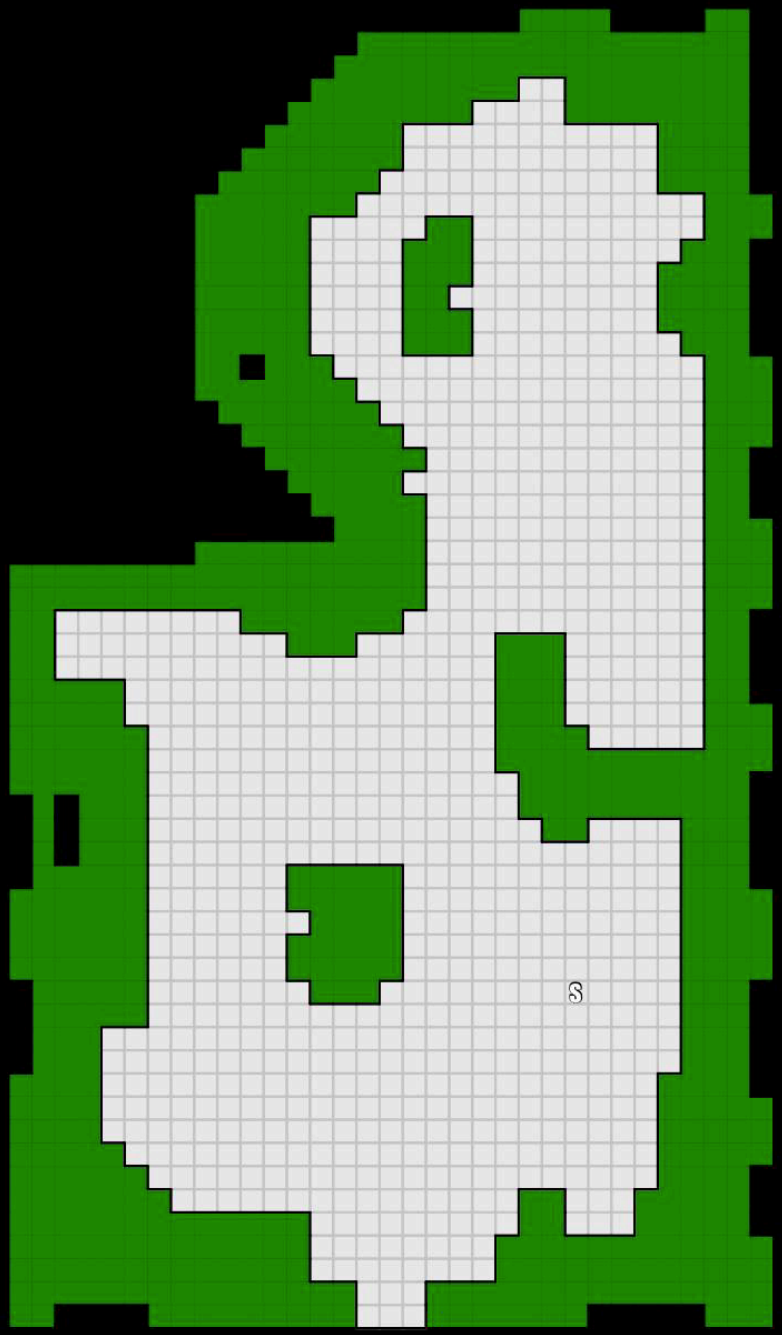

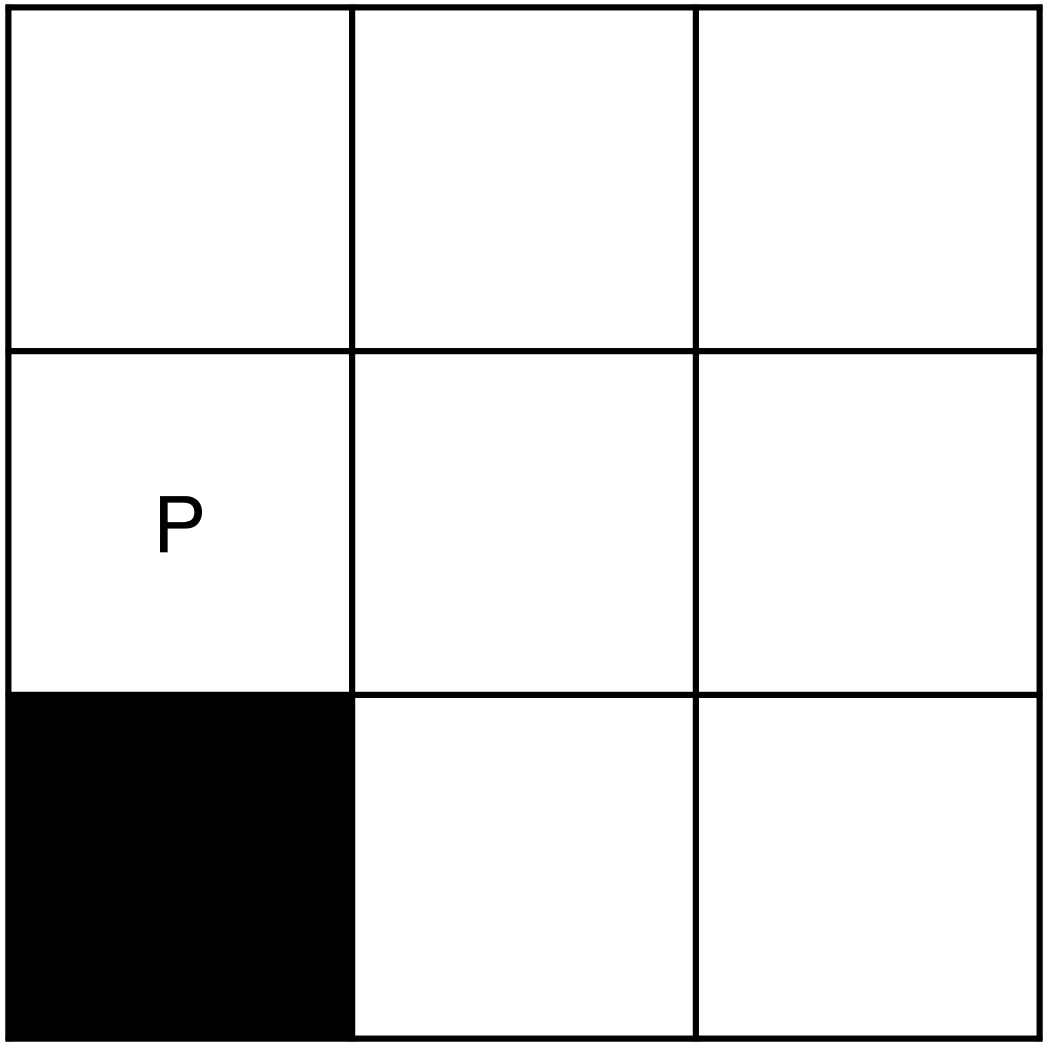
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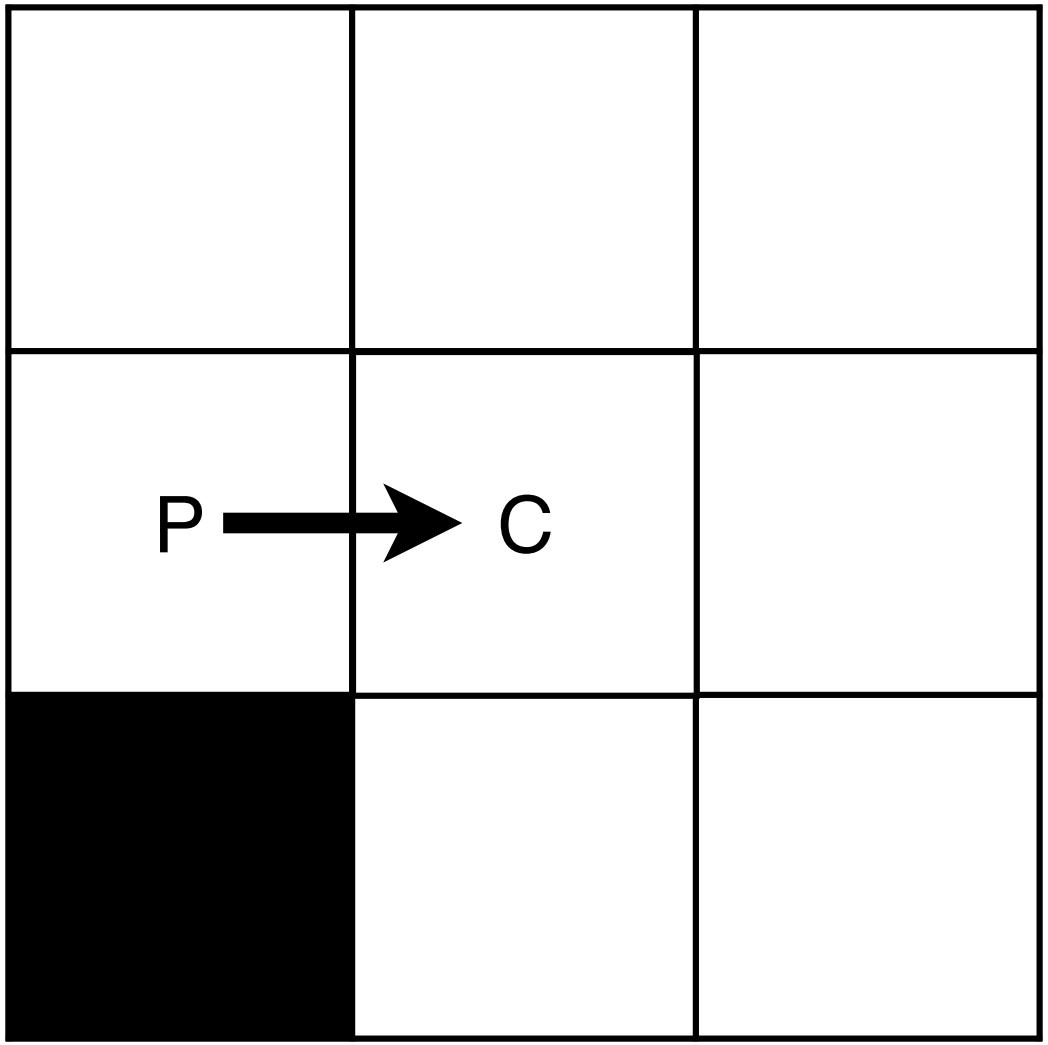
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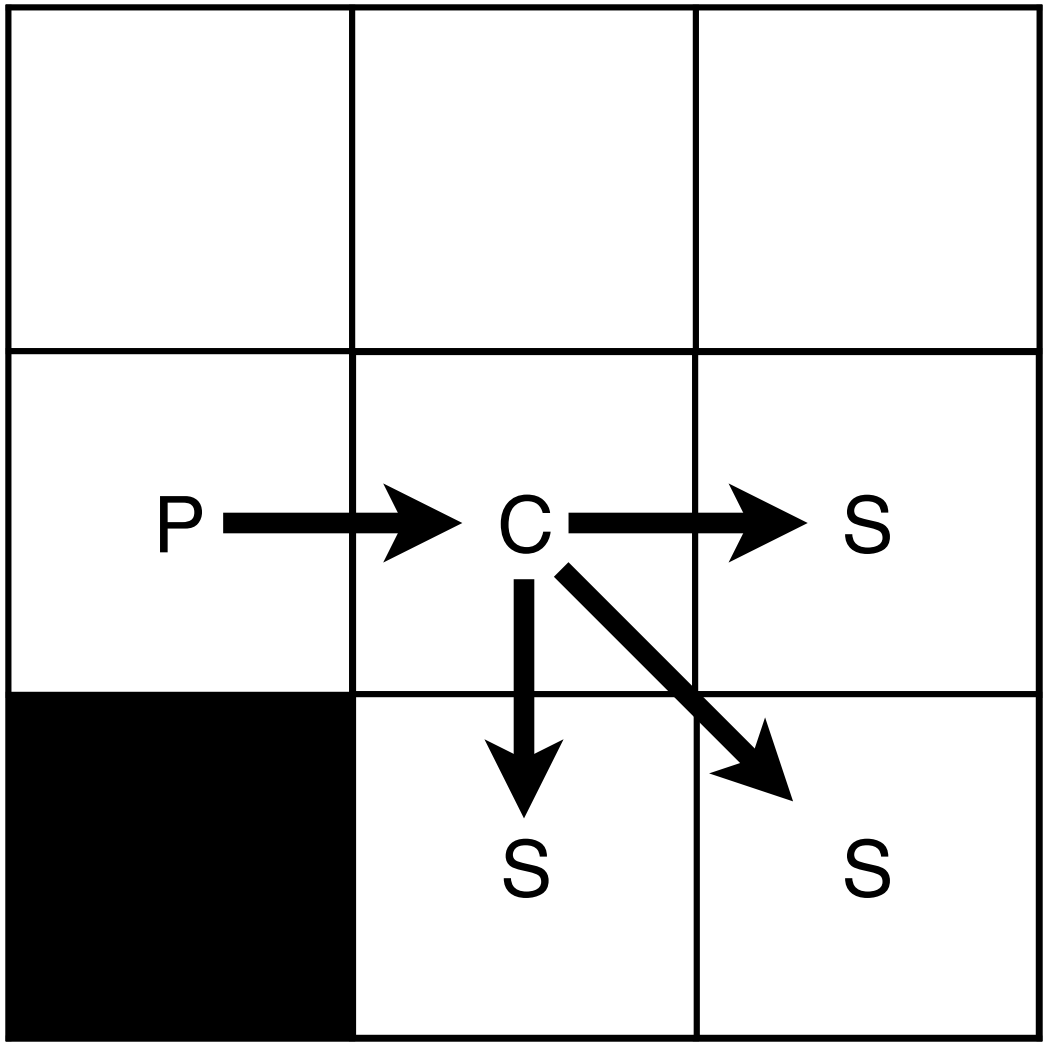
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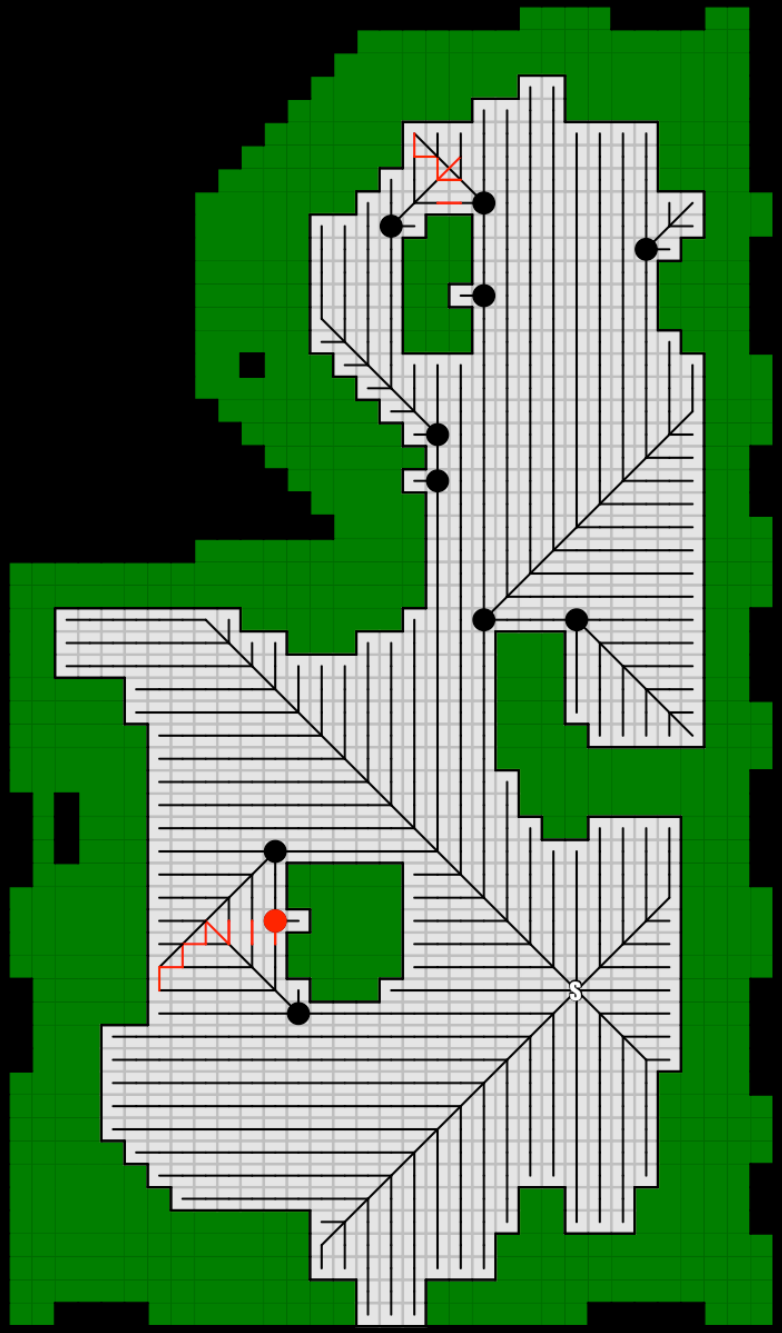
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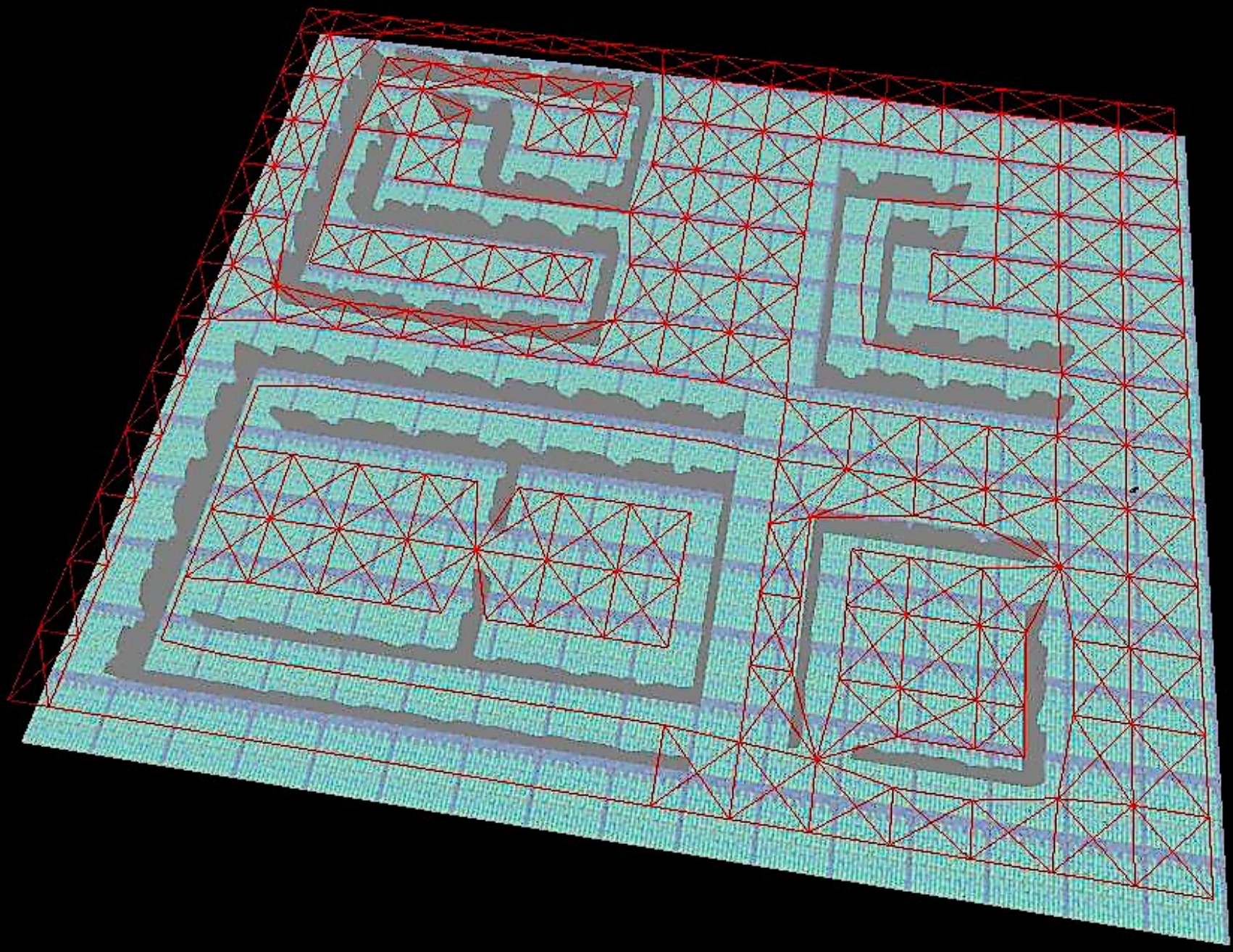
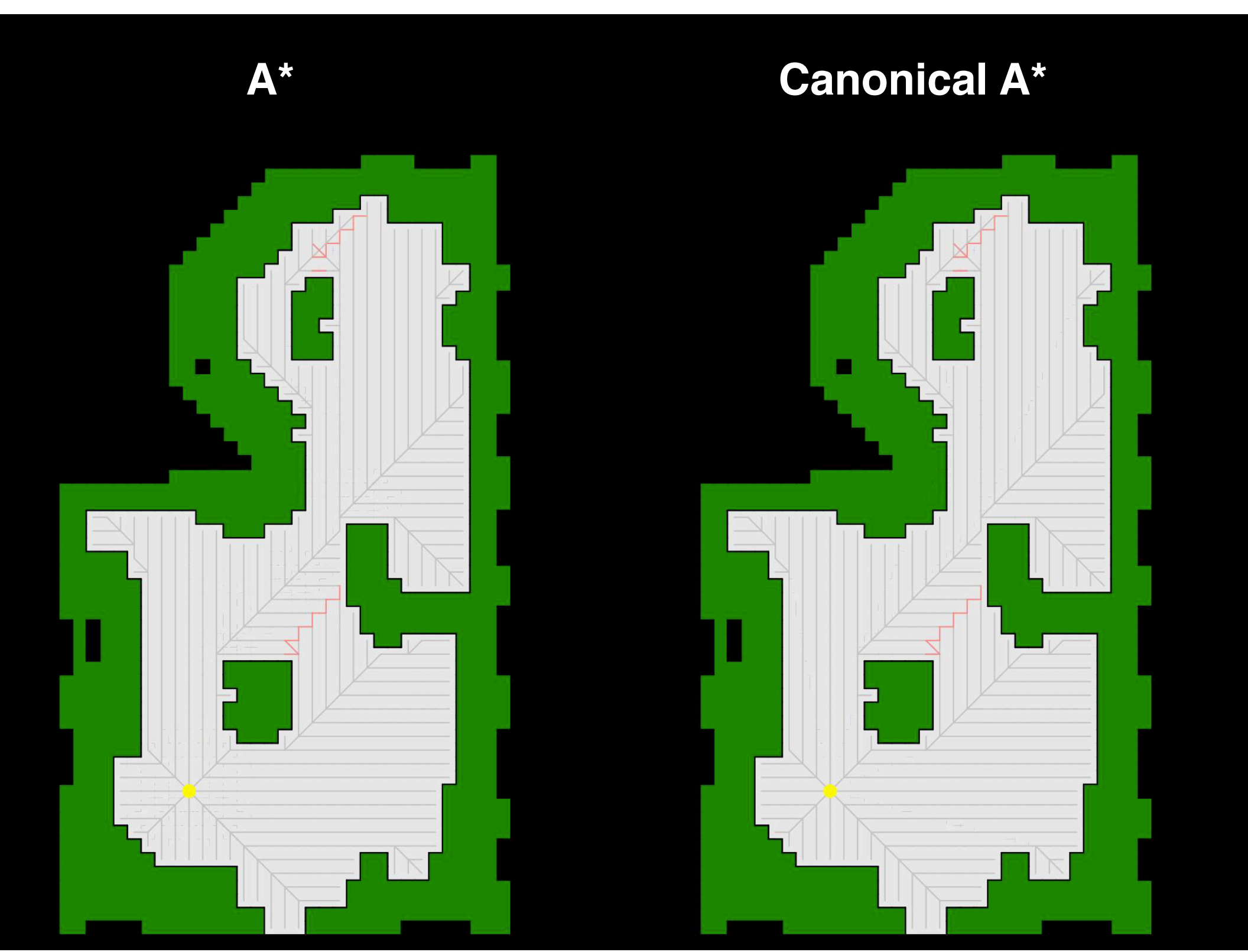
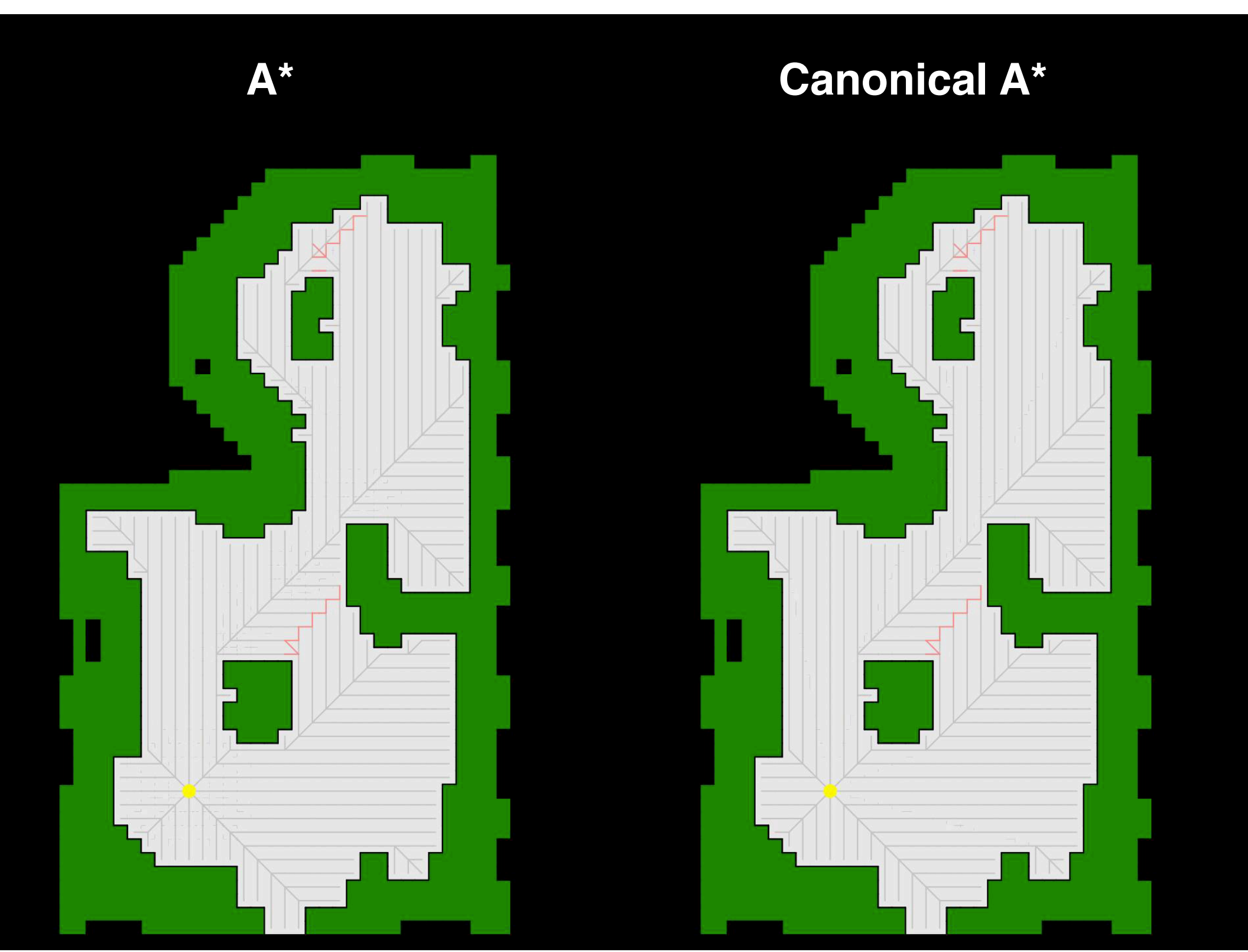


Canonical Orderings in Graphs

- Used to improve reach computation
  - (Goldberg, Kaplan and Werneck, 2006)
- Used to reduce redundant paths in transit routing
  - (Antsfeld, Harabor, Kilby, and Walsh, 2012)

- Can we use it to prune successors like in JPS


A*
Canonical A*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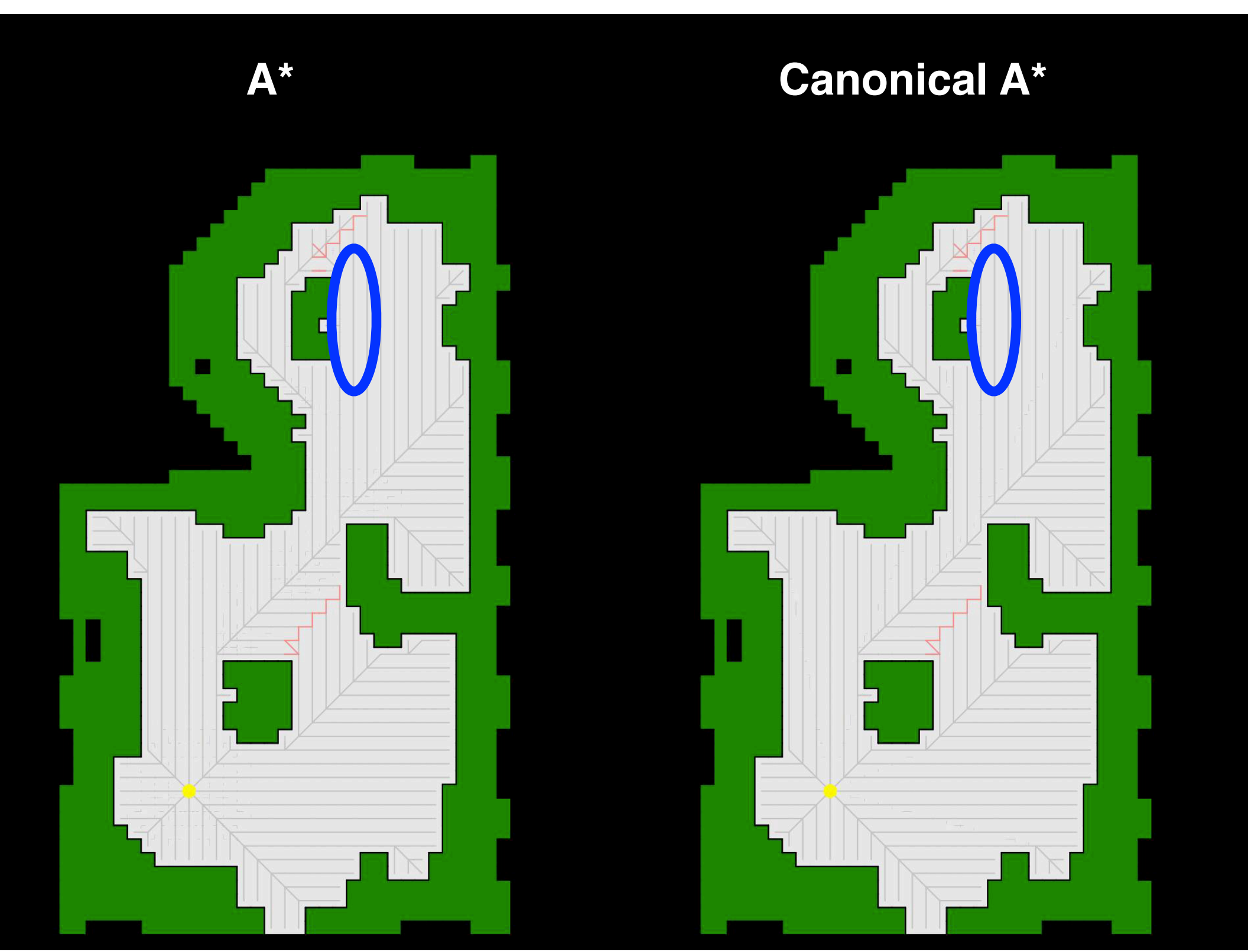
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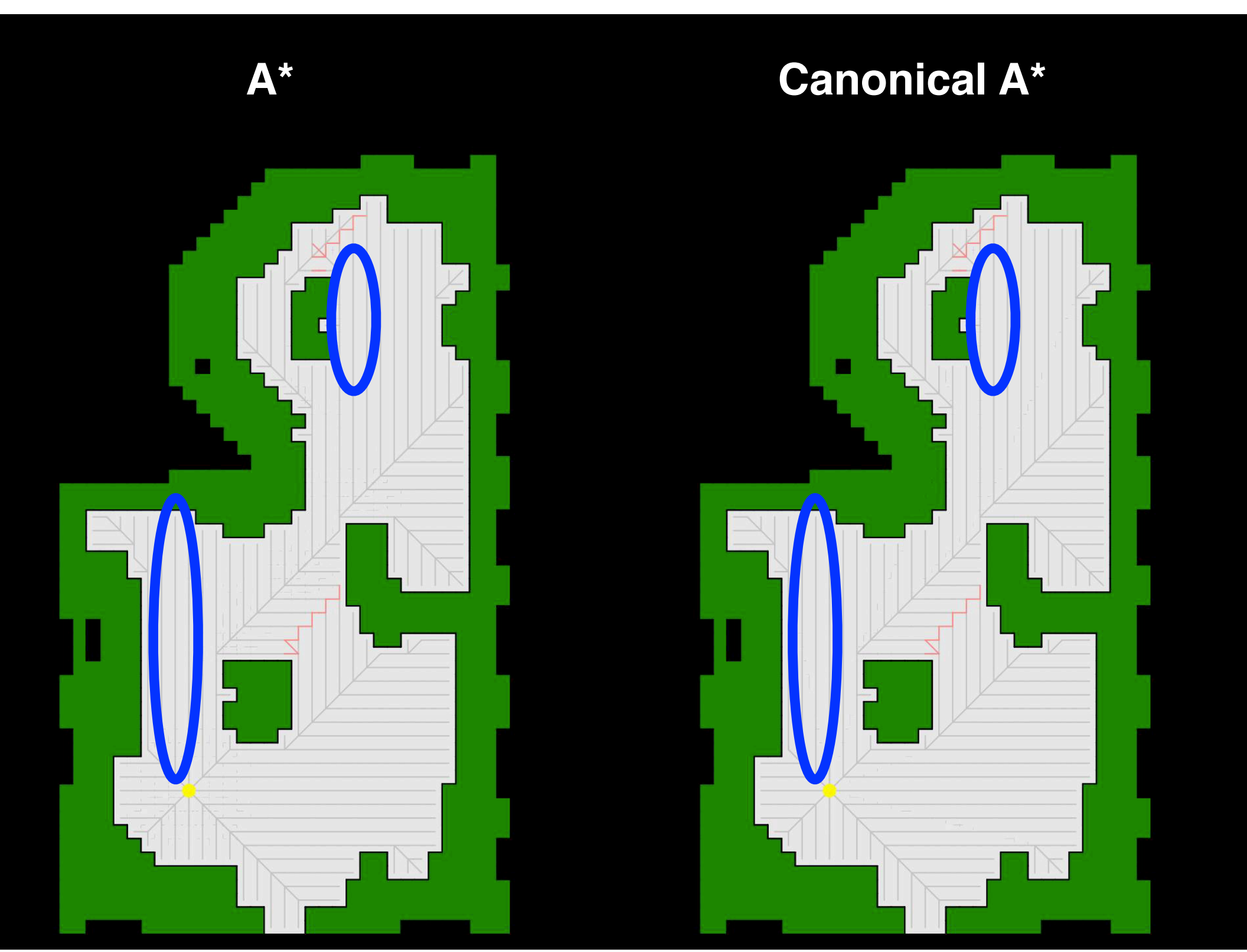

A*
Canonical A*

Experimental Results

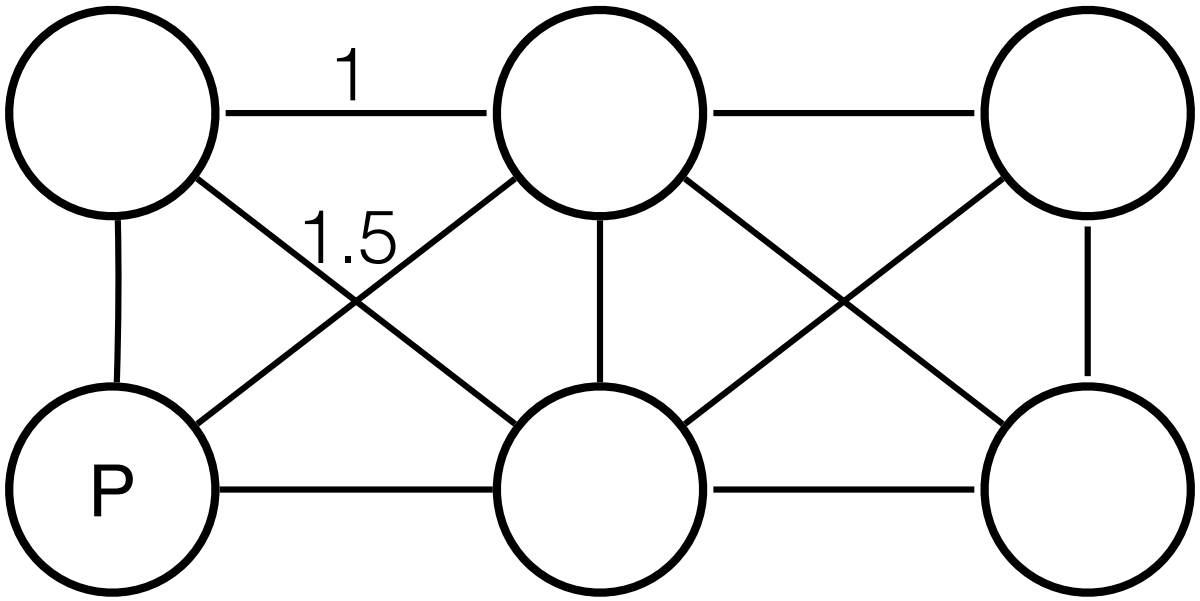
	A*	CA*
Expansions	13,295	13,302
Generations	99,483	13,654

Canonical Ordering Rules

- In grids:
- The action to reach a state determines successors
  - This is generic to any state

- In graphs:
- Given the parent, determine the successors
  - Store specific information for every state

Local Search Method



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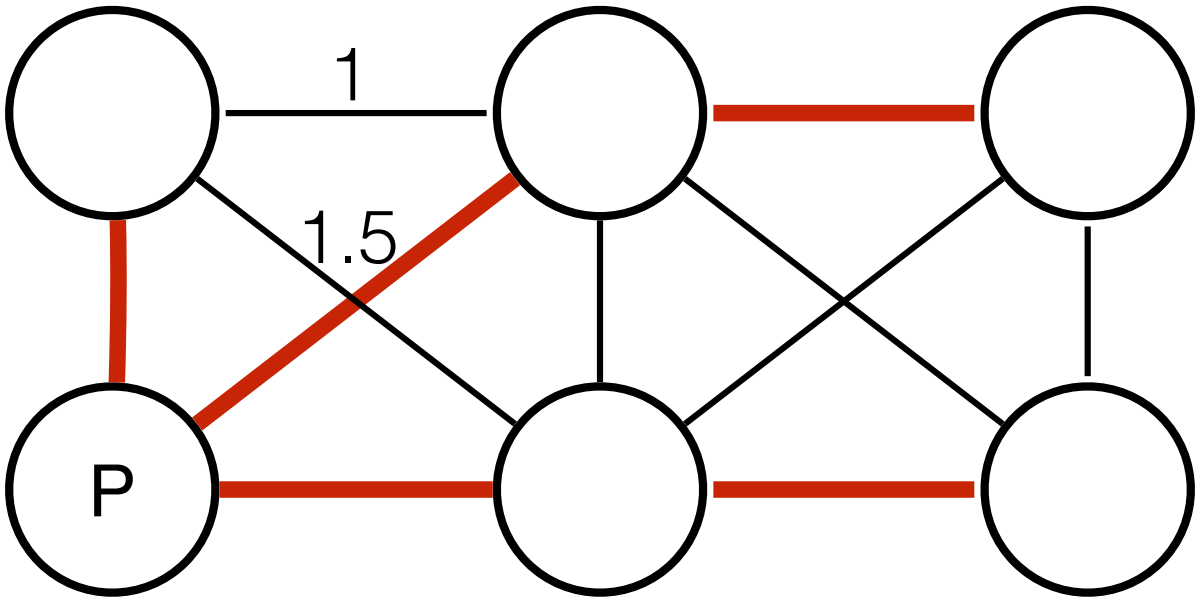

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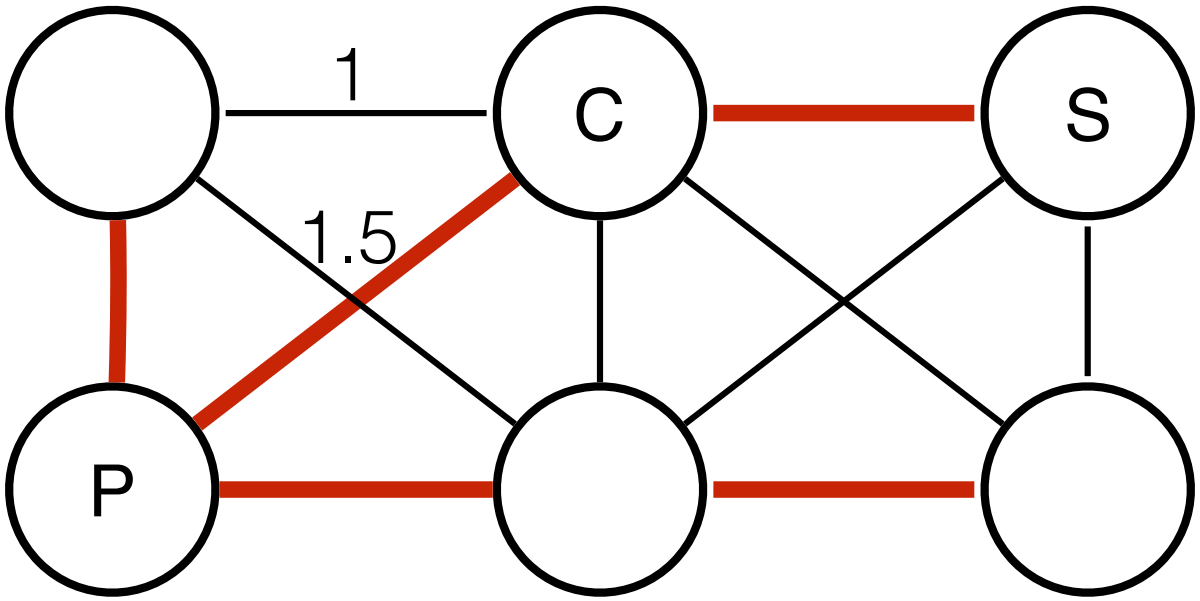
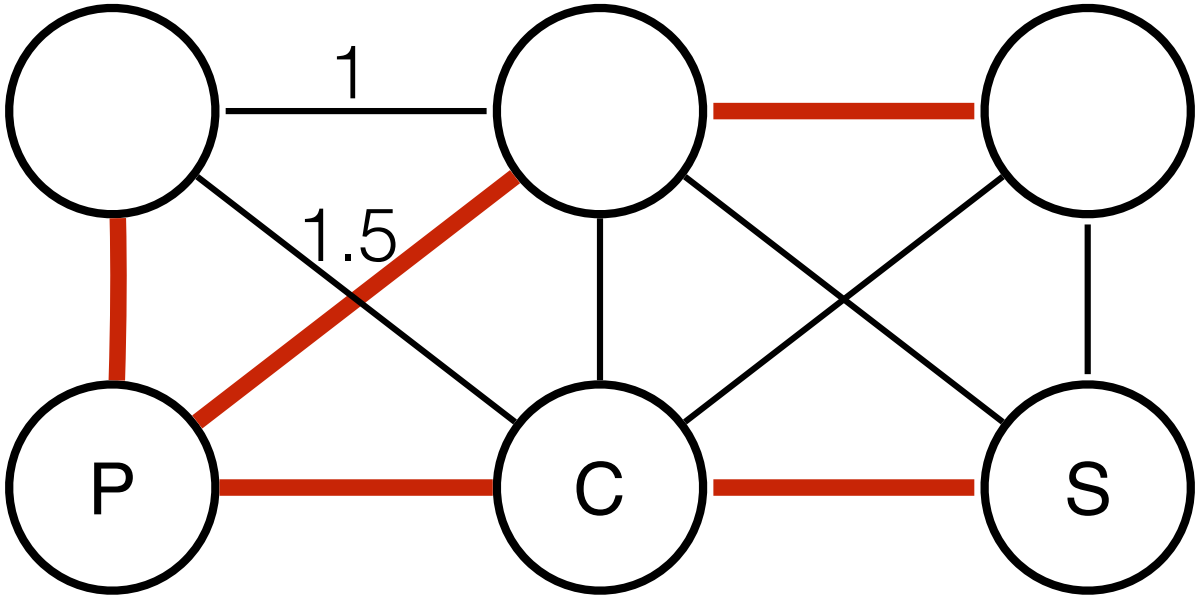


Local Search Method

Note that we also prune neighbors even when there isn't a single canonical ordering. Even if all path costs are unique, it still will help.



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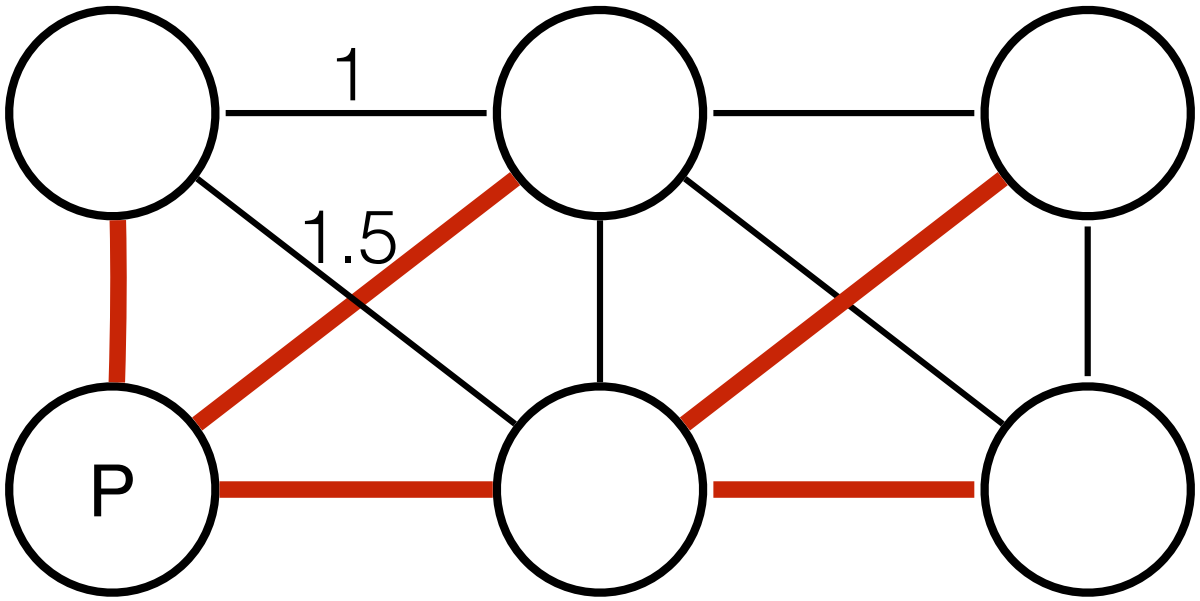

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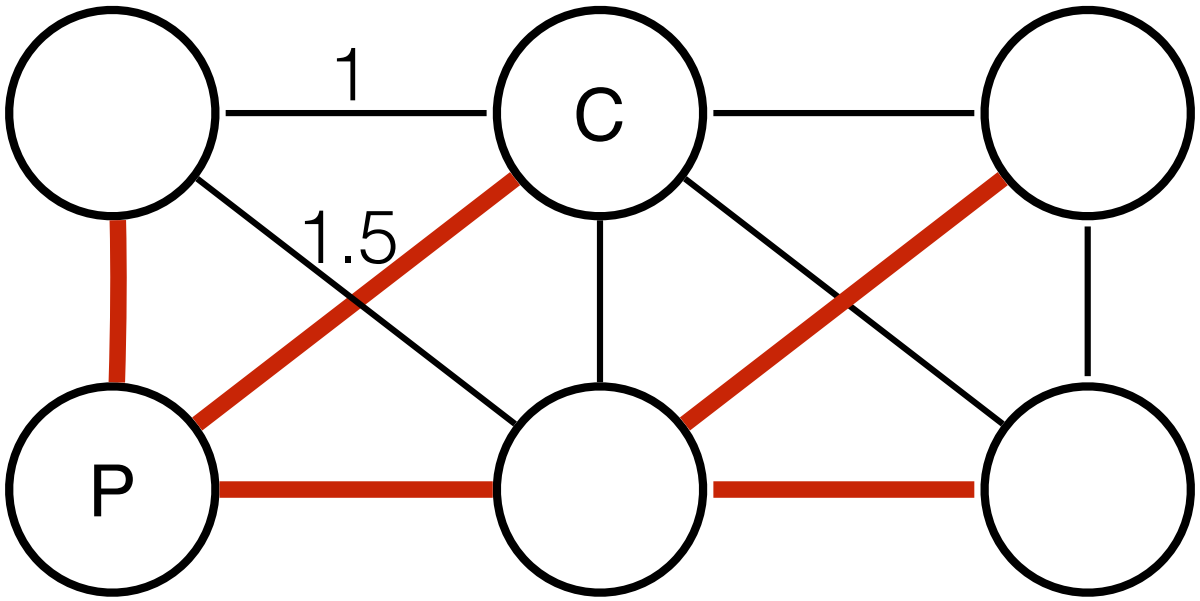

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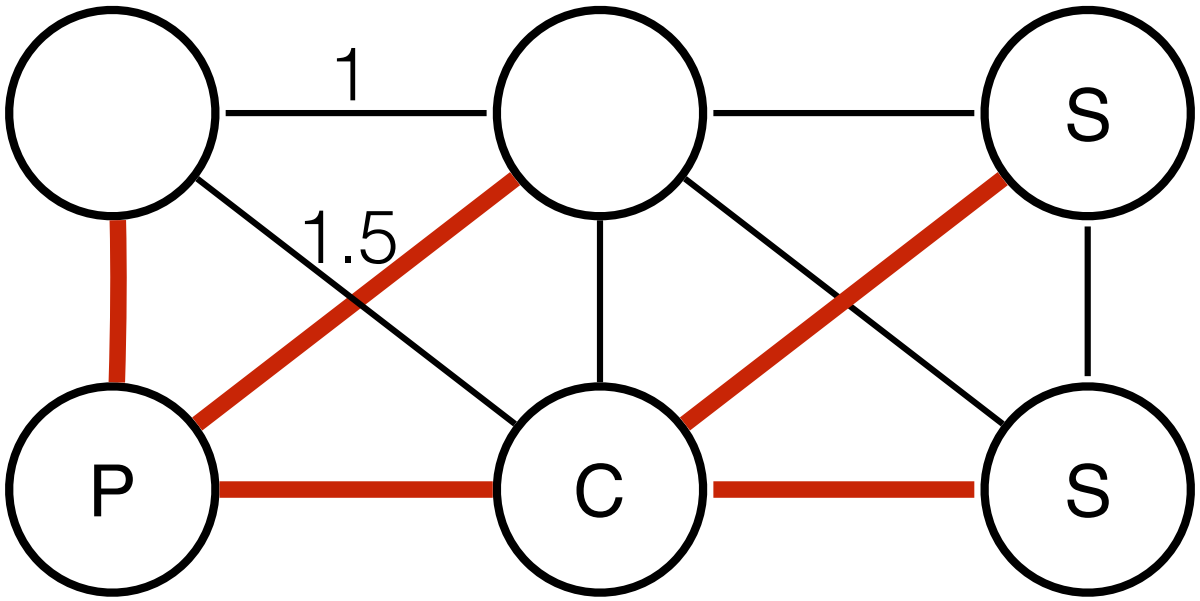
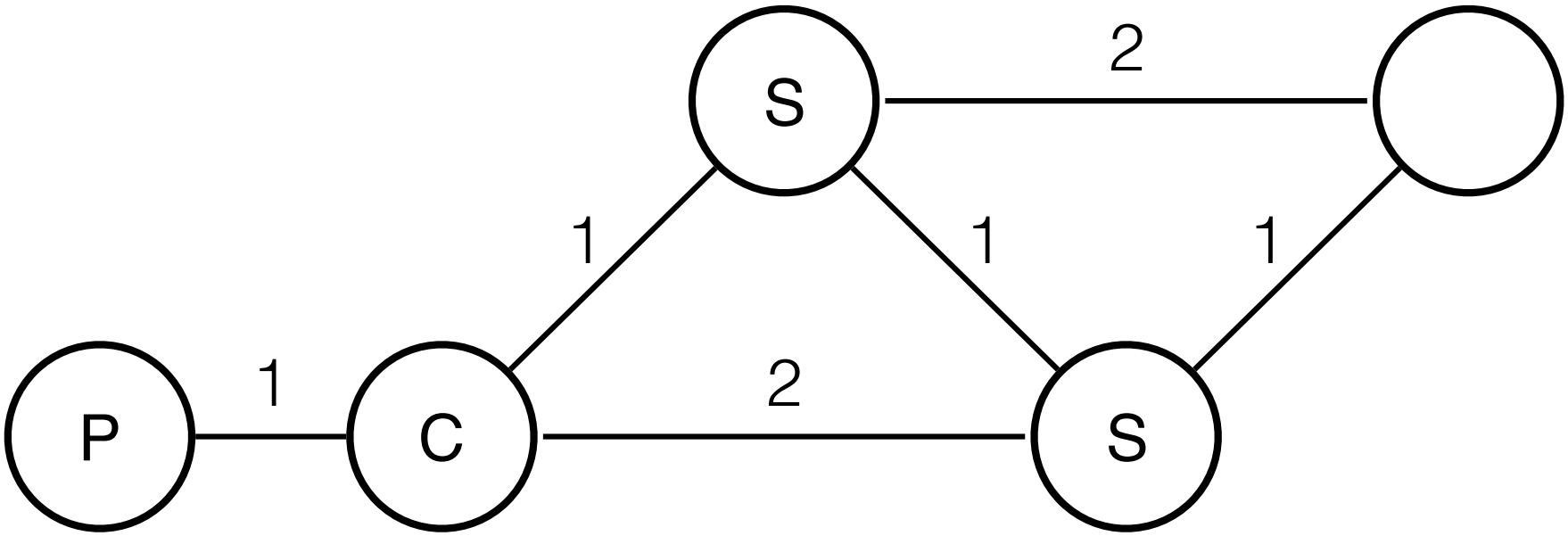


Correctness



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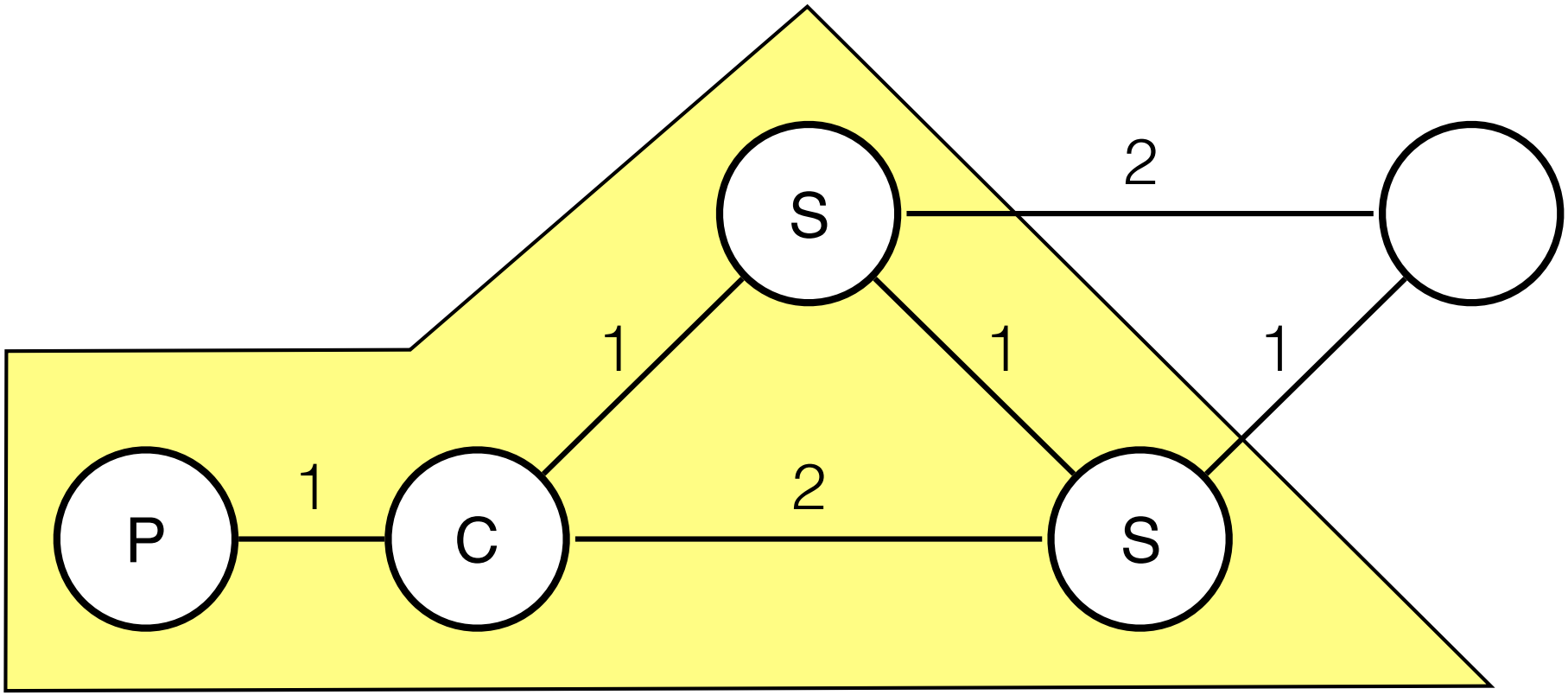

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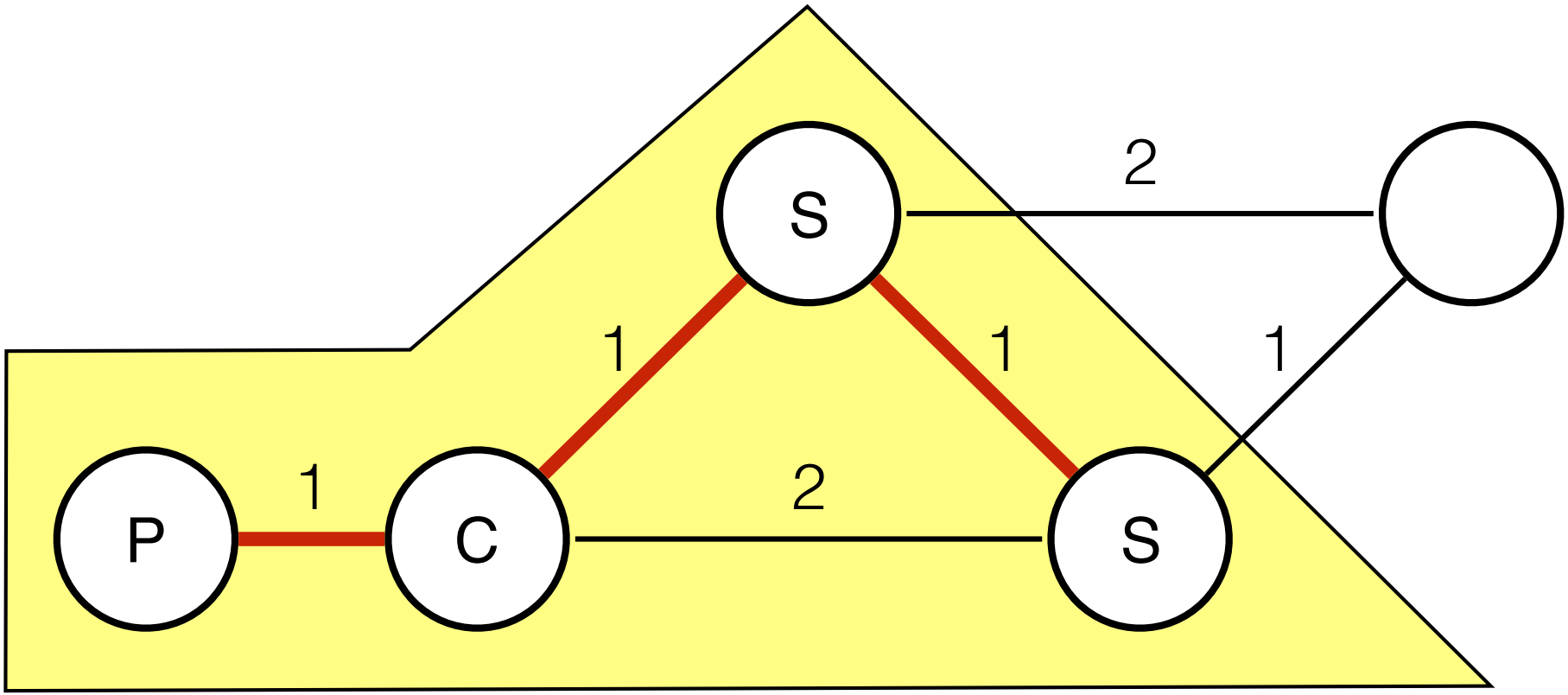

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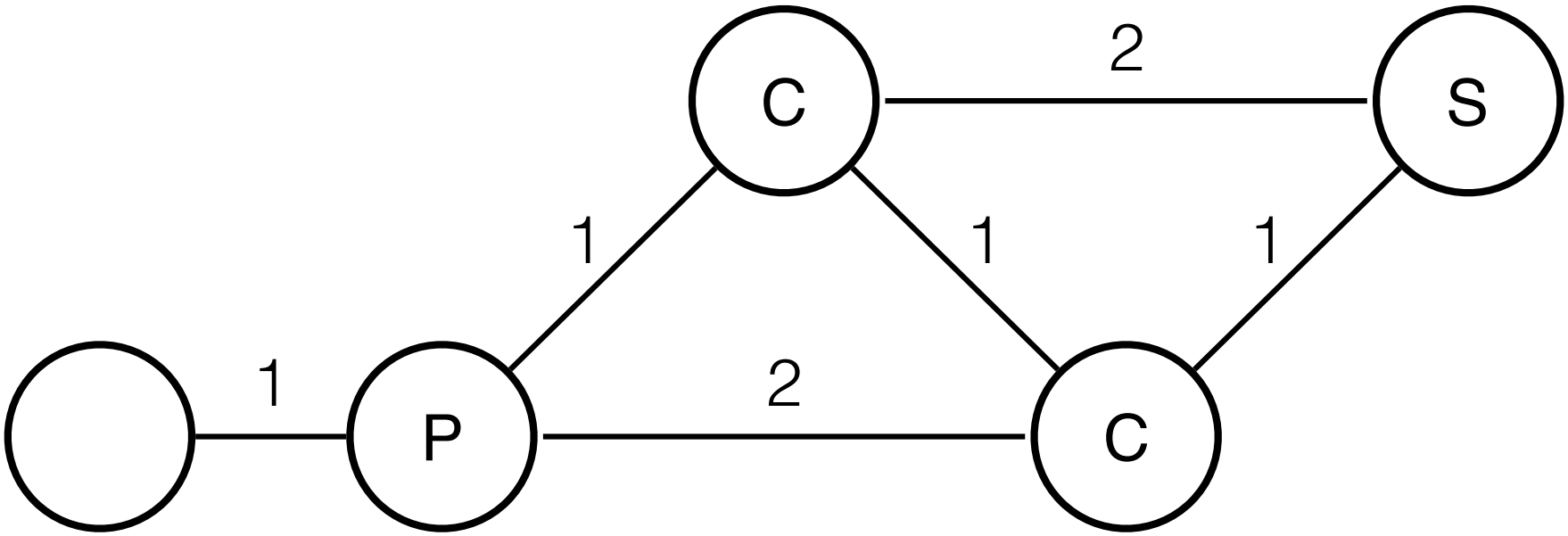

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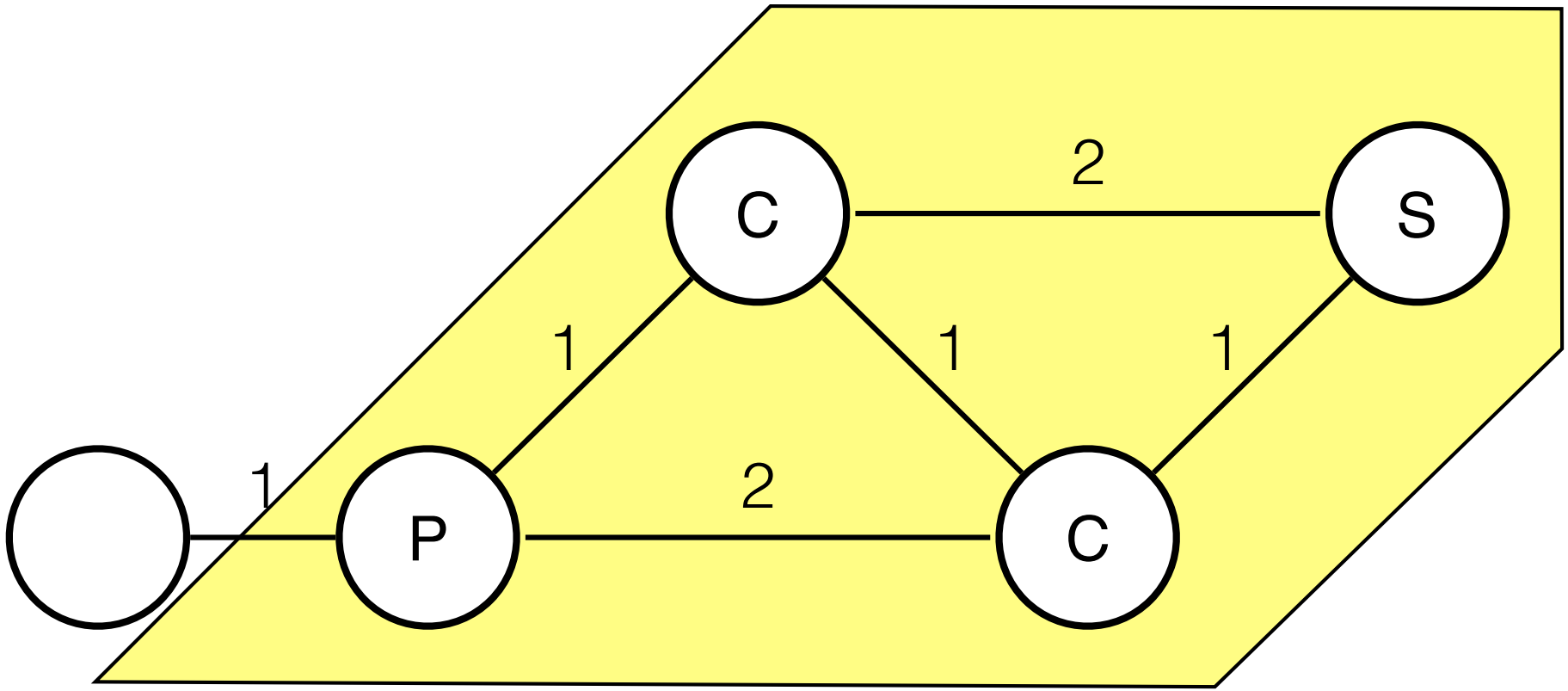

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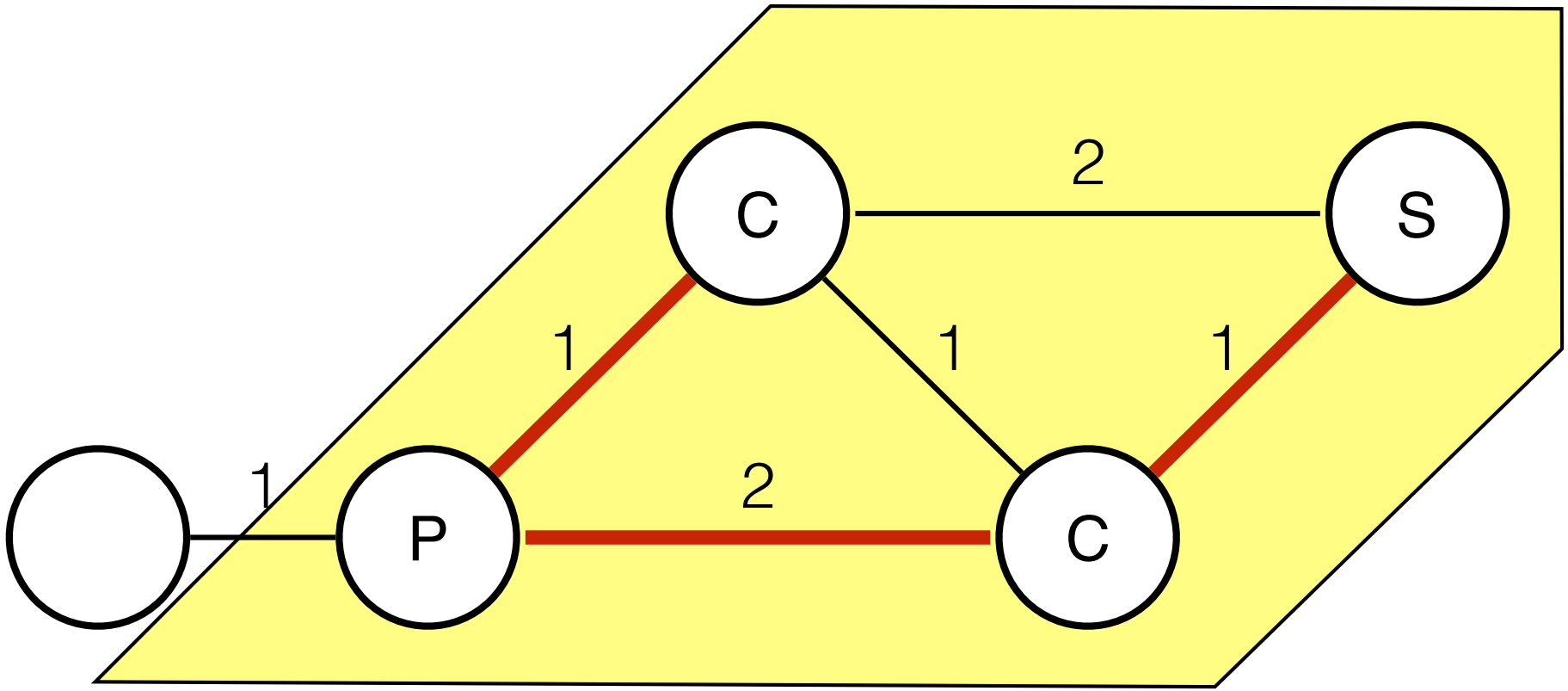

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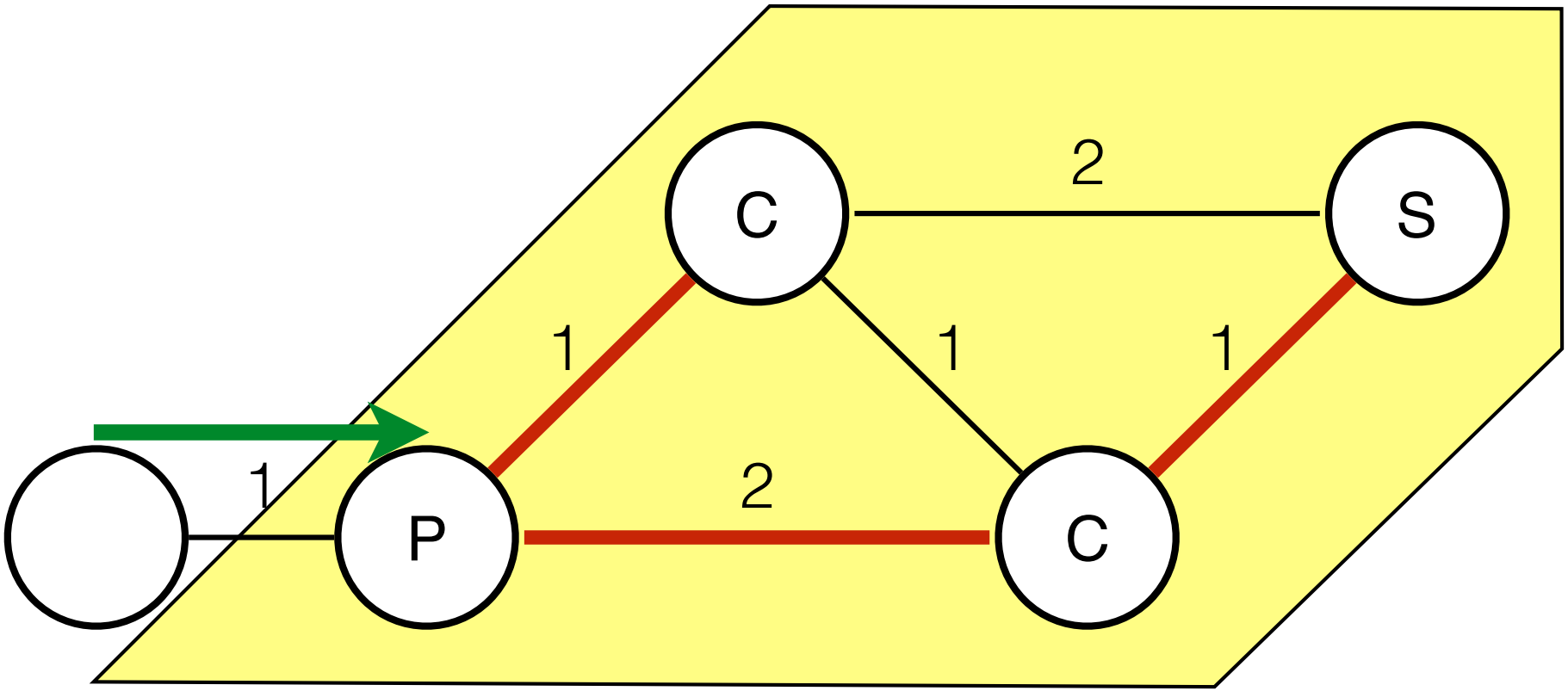

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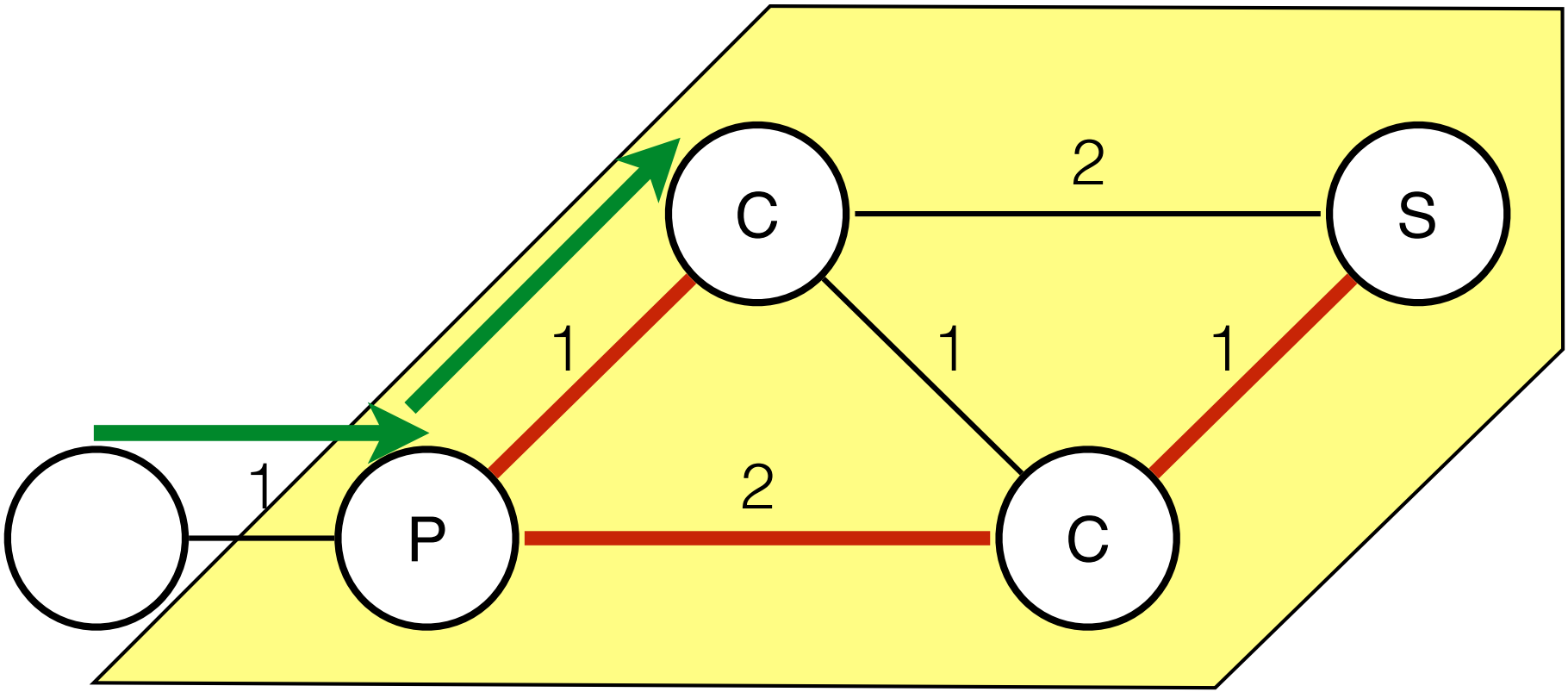

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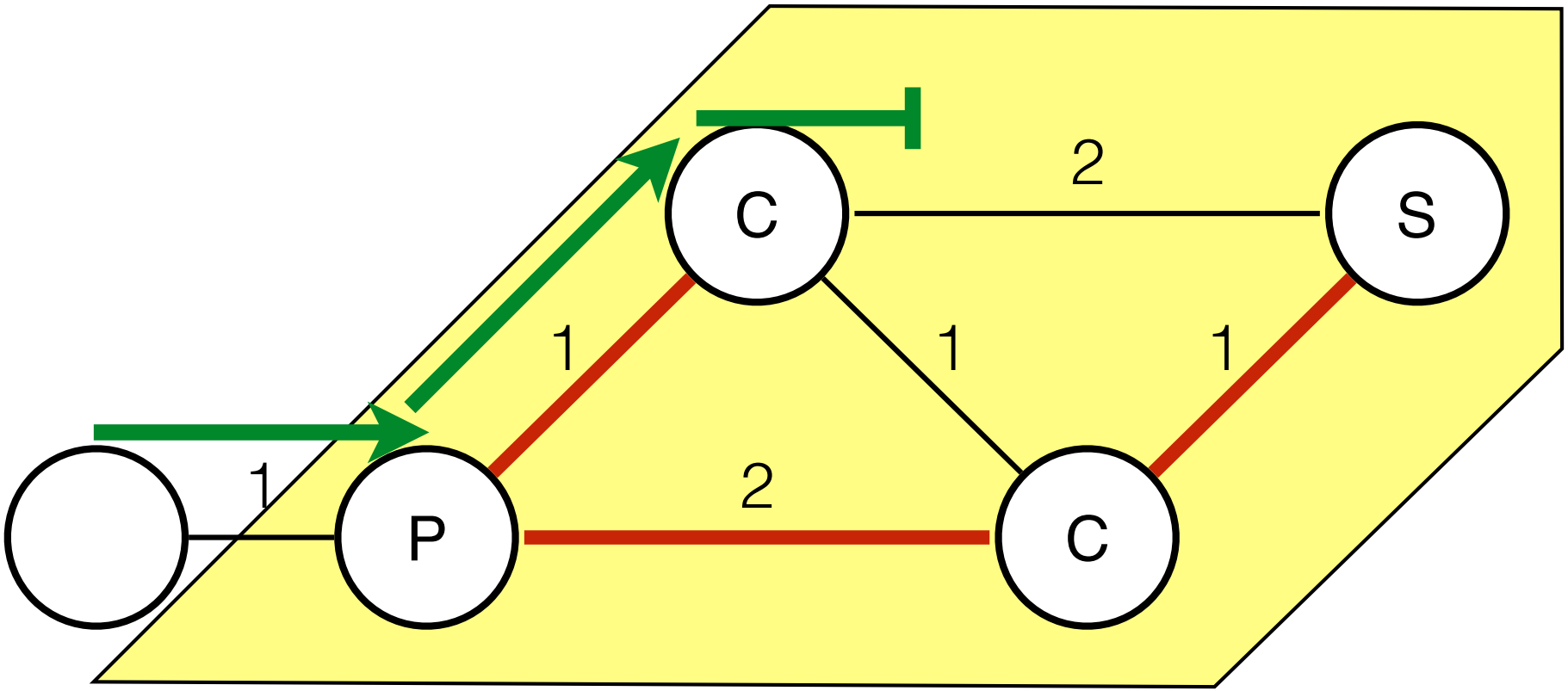

Results

		Time	Expanded	Generated	Open
Graph	A*	3.27	3,382	25,059	229
	Canonical A*	2.93	3,521	3,731	152
Grid	A*	2.36	3,382	25,059	229
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Future Work

- More efficient implementation
  - Time and Memory
- Optimize Choice of Canonical Ordering
- Add JPS Jumping
- Test with existing graph-pruning approaches
- Correctness