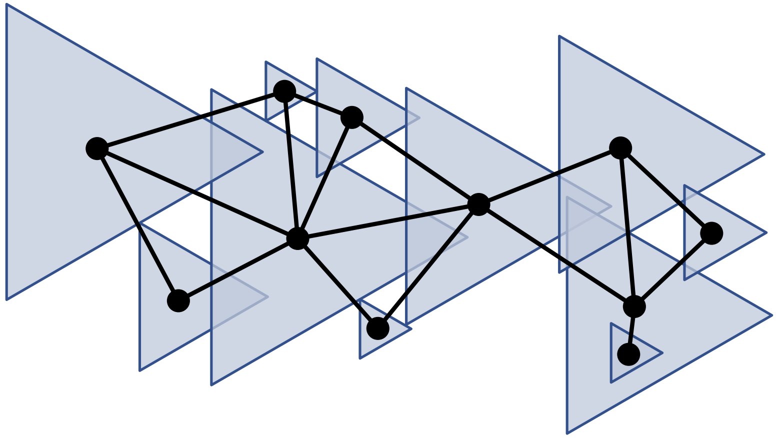
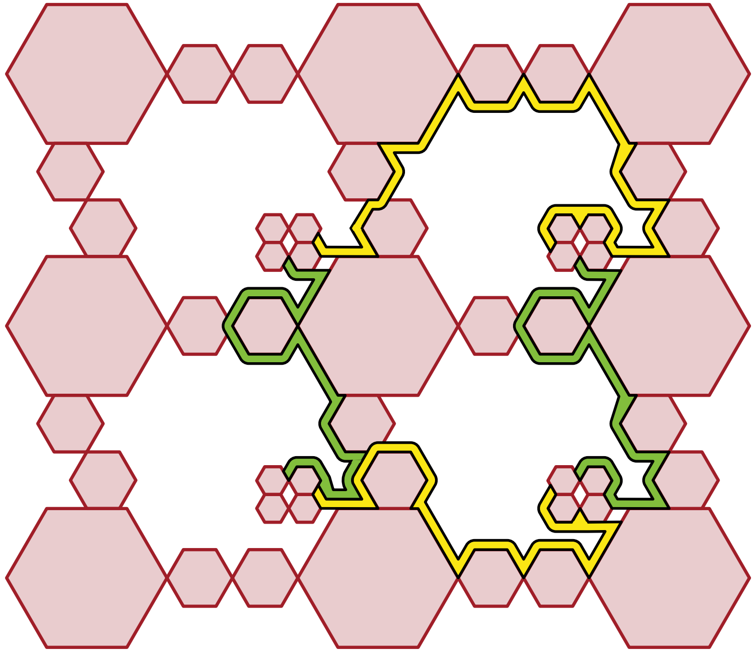
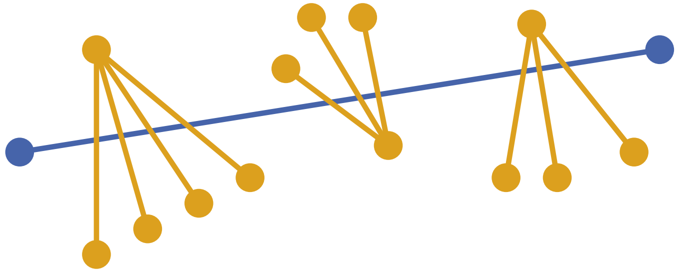
Intersection Graphs with and without Product Structure

GD 2024 · 19.09.2024

Laura Merker, Lena Scherzer, **Samuel Schneider**, Torsten Ueckerdt







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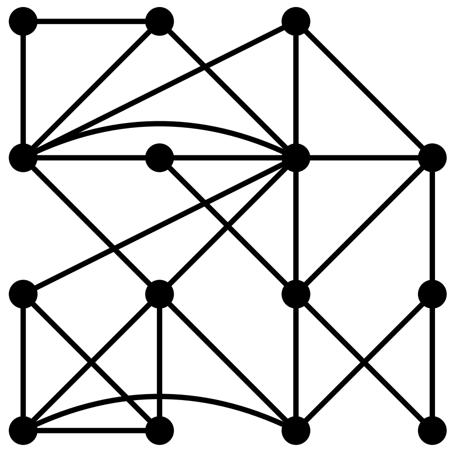

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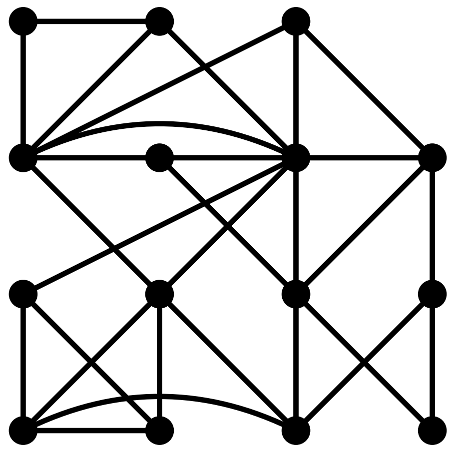

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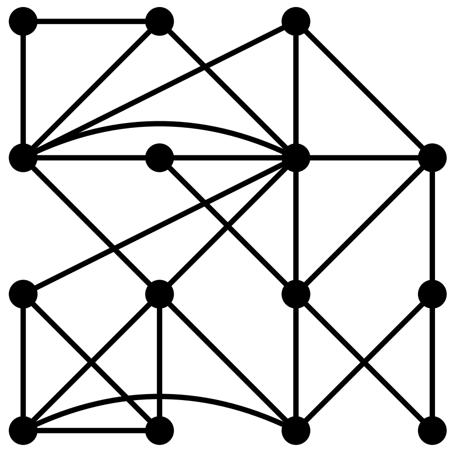

For every $G \in \mathcal{G}$ there are H and P

treewidth c

path

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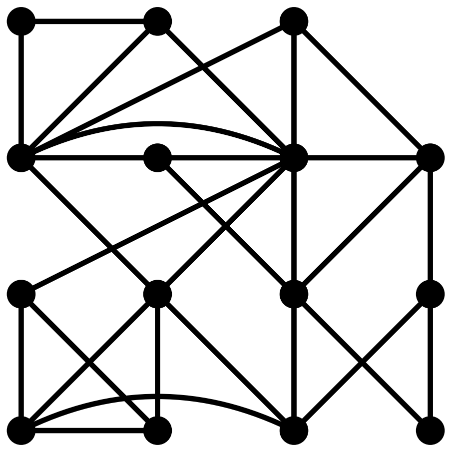

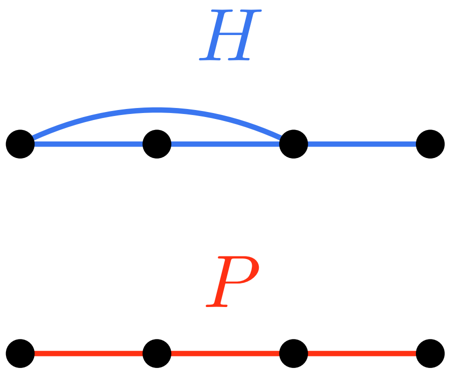

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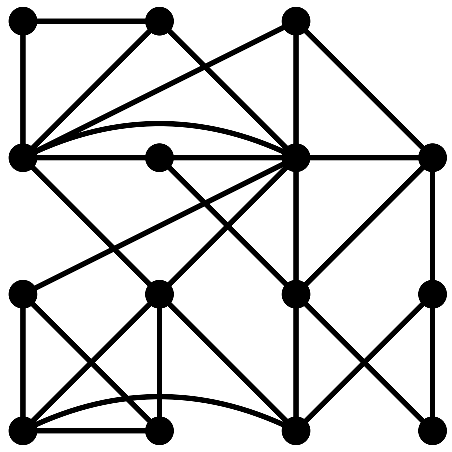

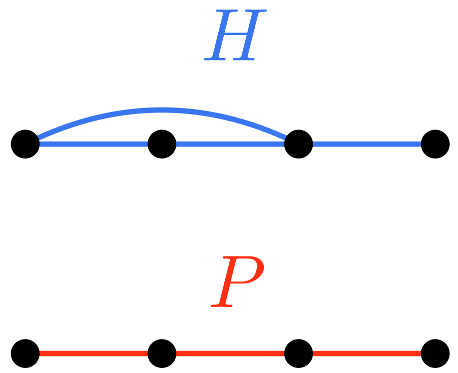

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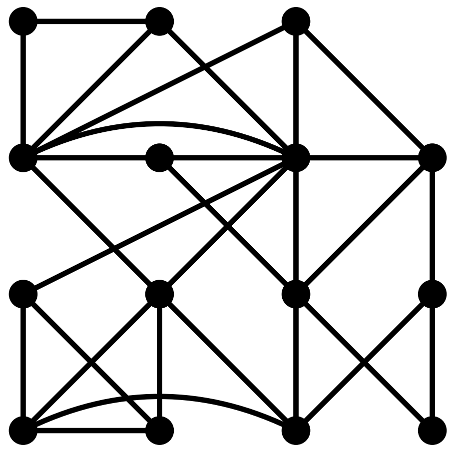

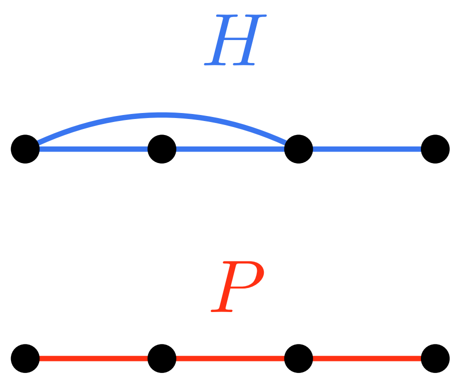

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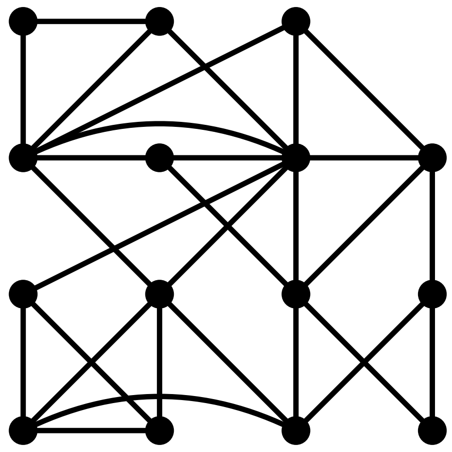

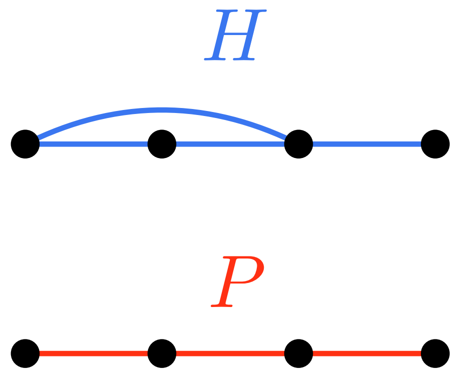

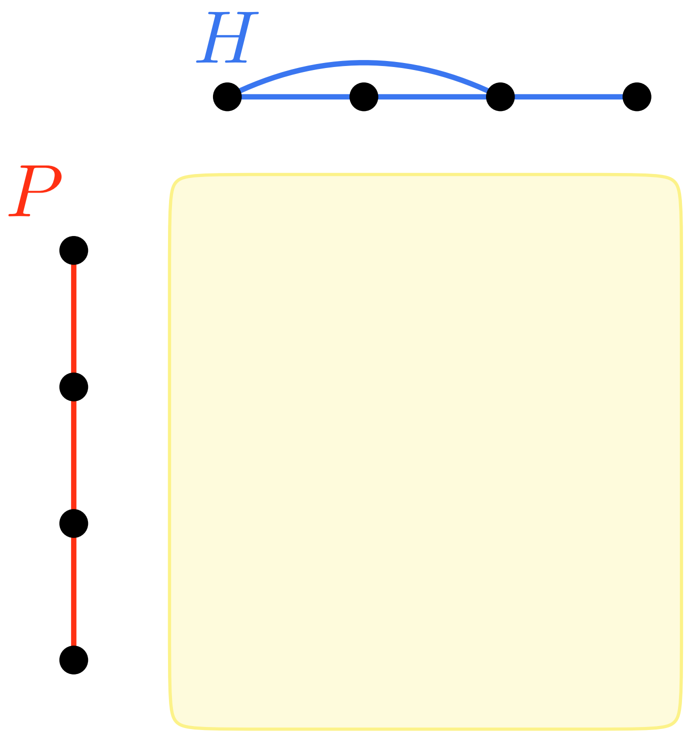

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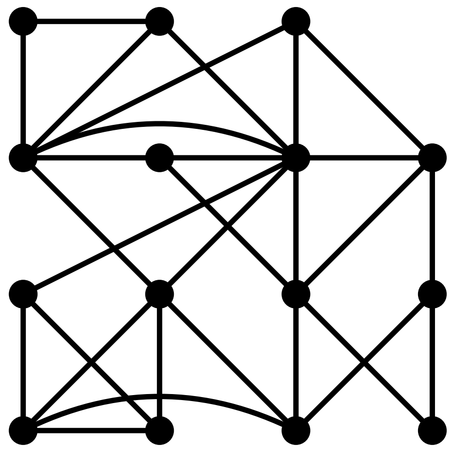

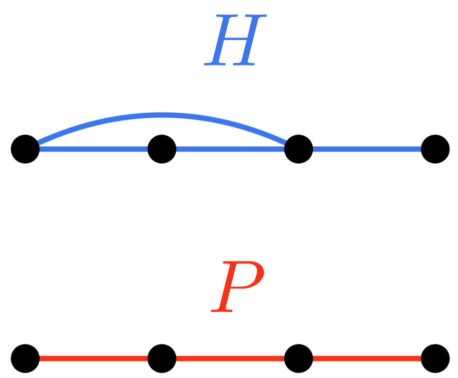

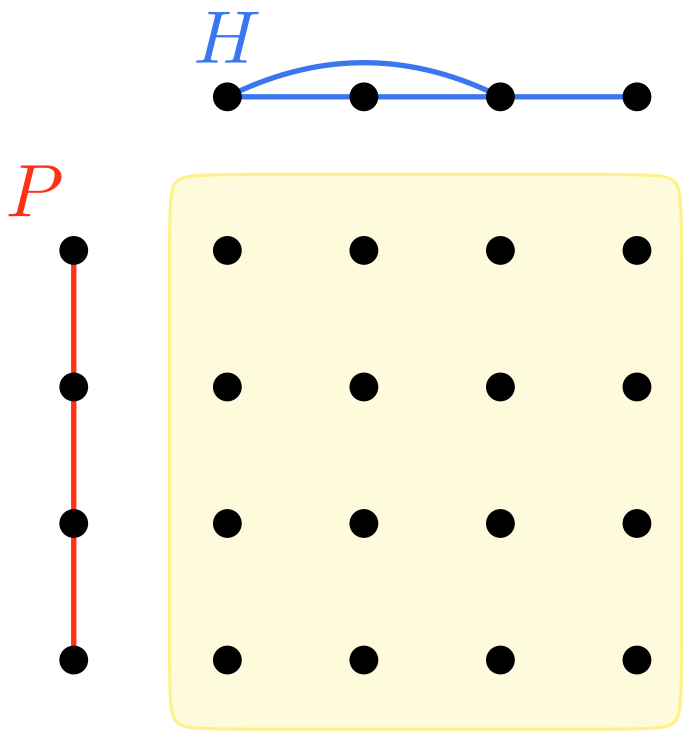

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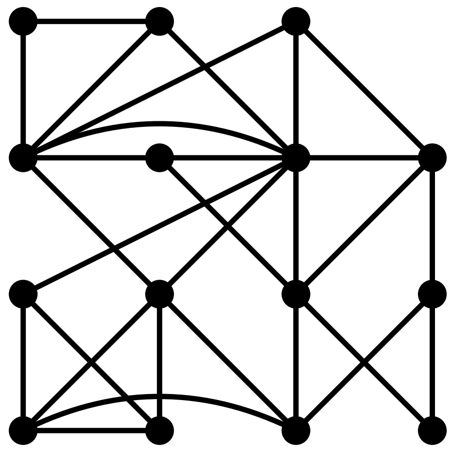

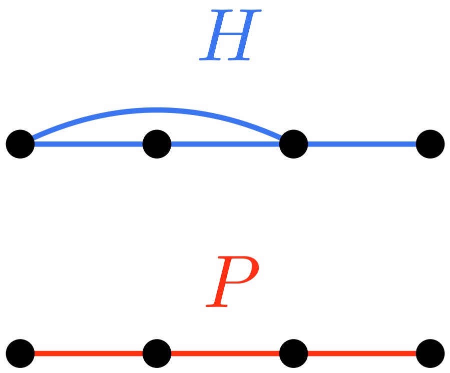

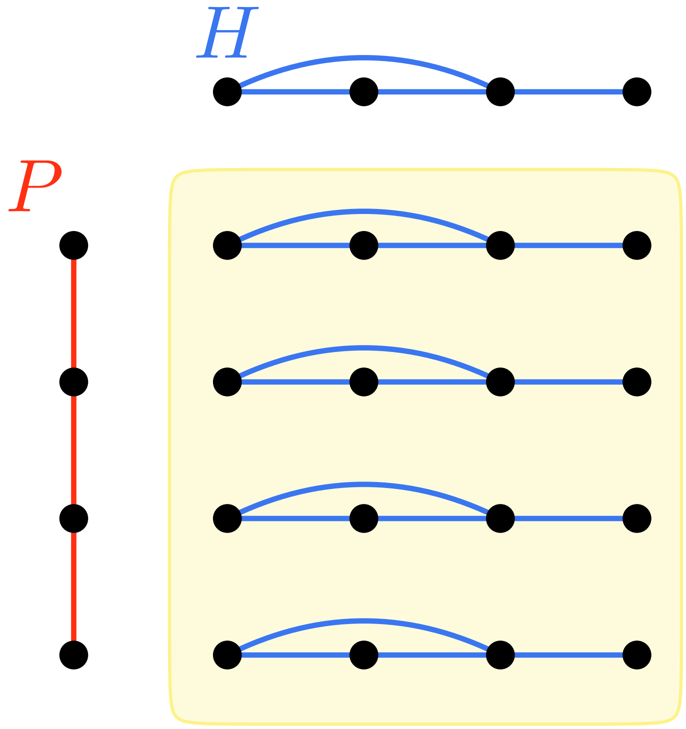

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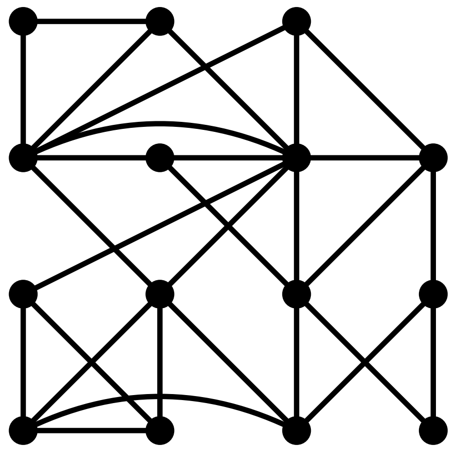

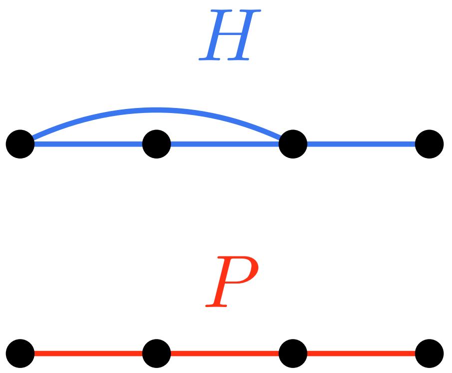

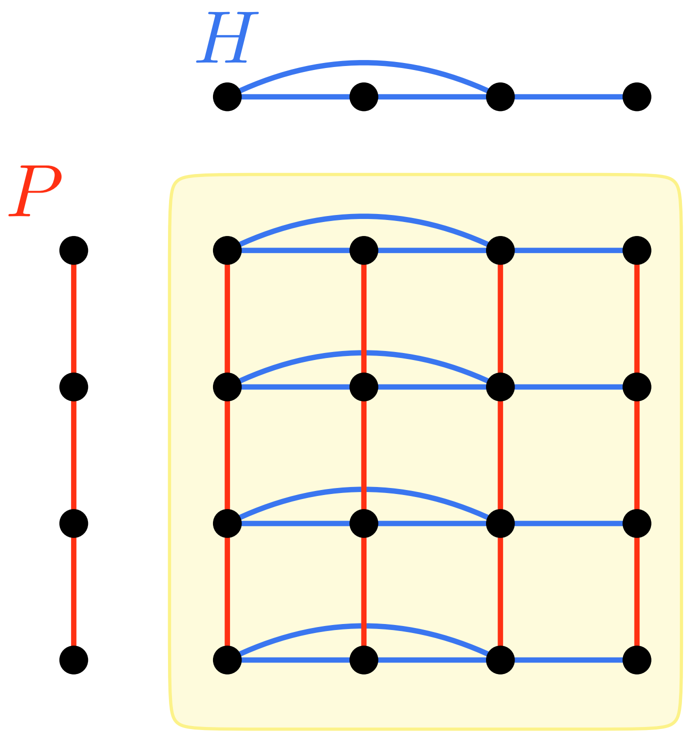

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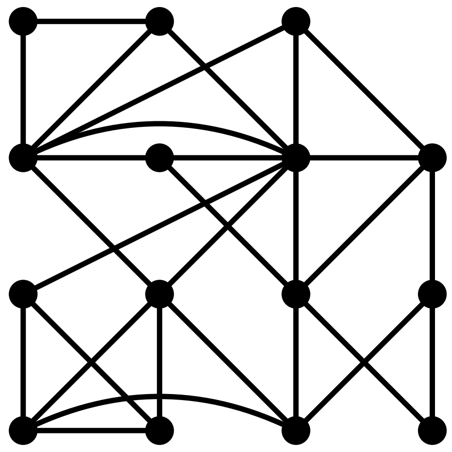

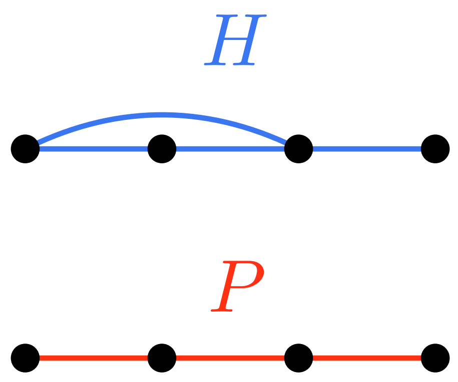

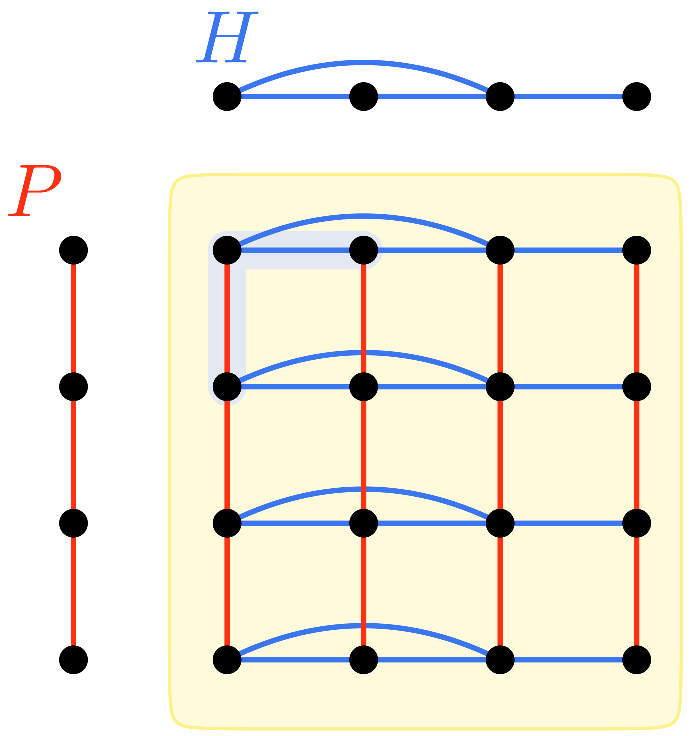

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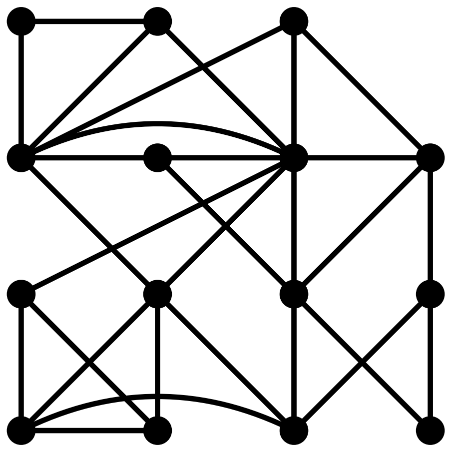

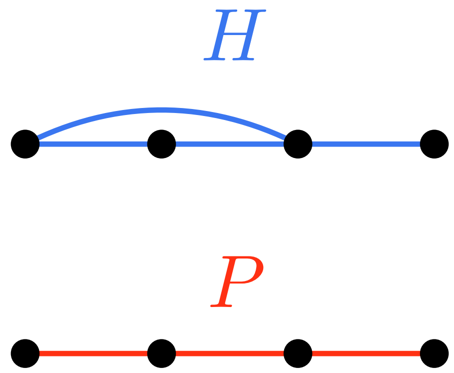

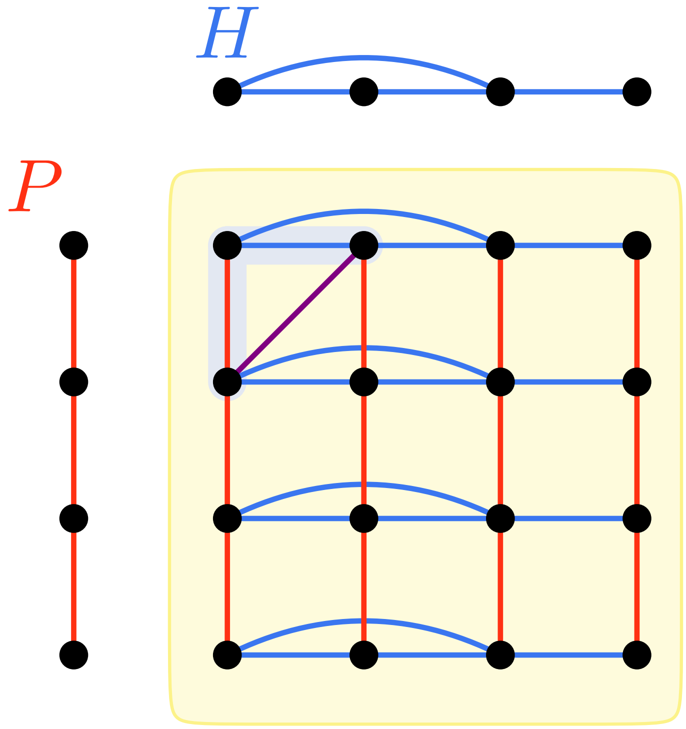

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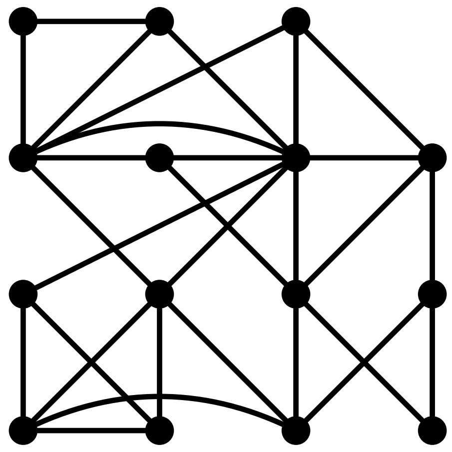

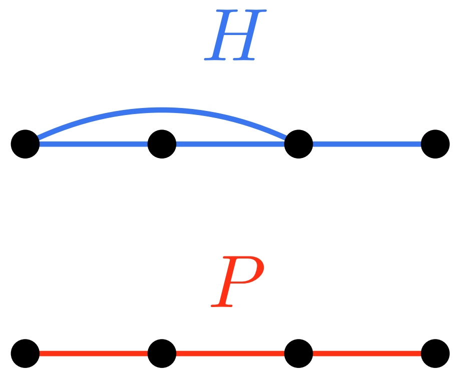

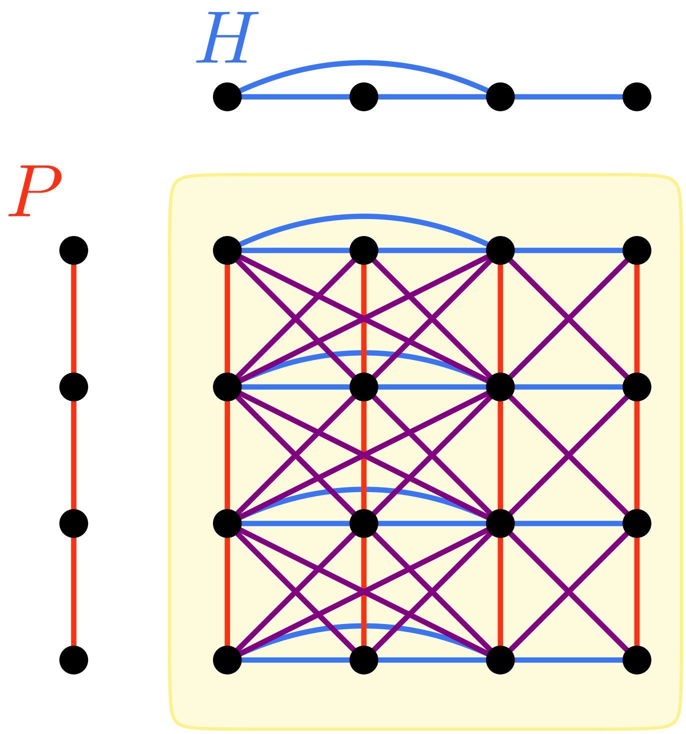

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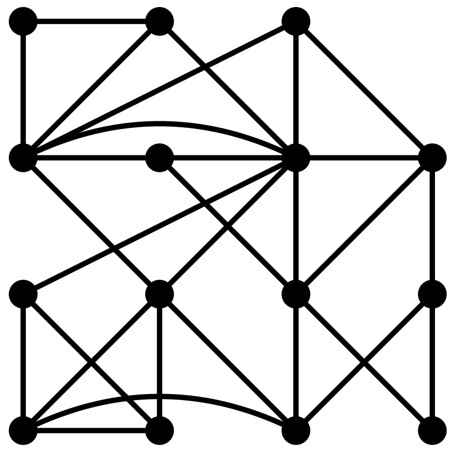

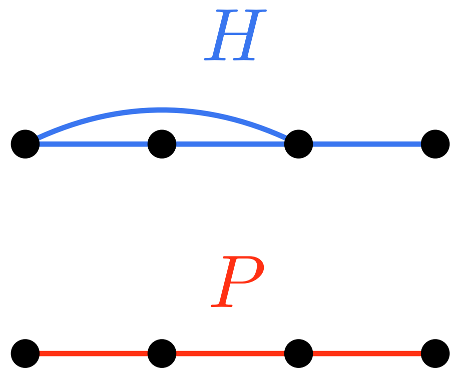

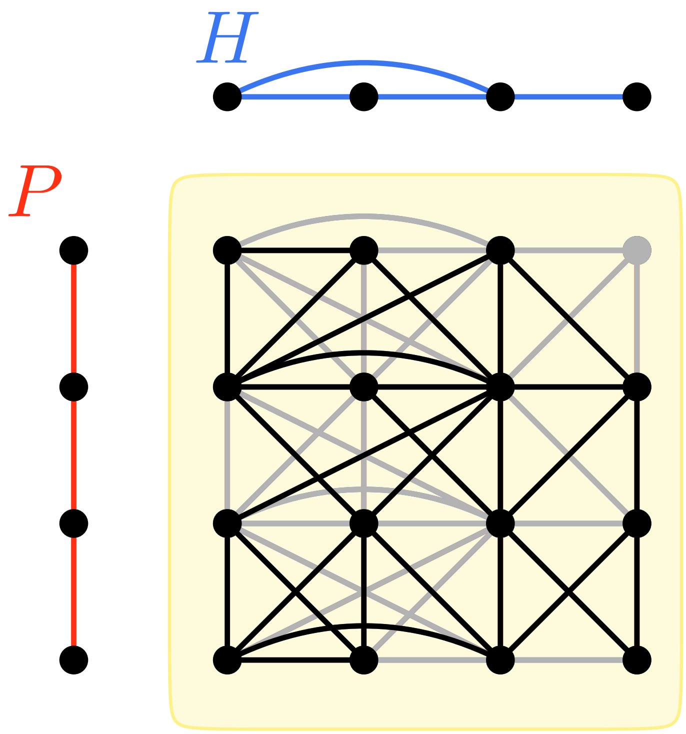

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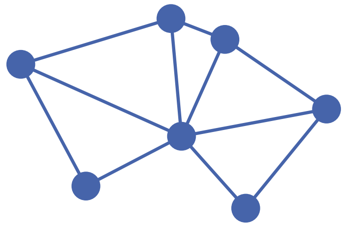

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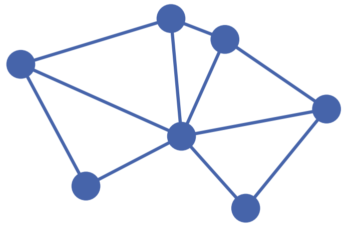

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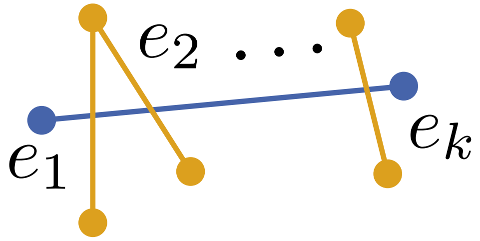

k-planar

[Dujmović et al.]

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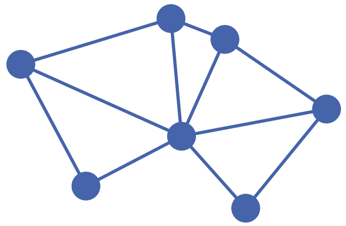

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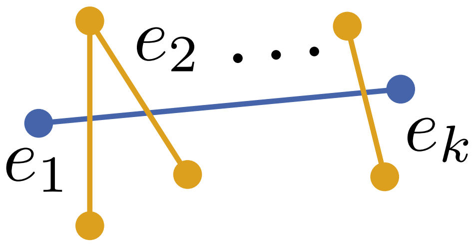

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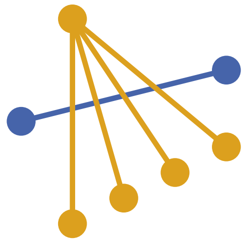

fan-planar

[Hickingbotham and Wood]

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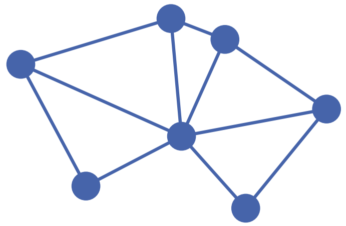

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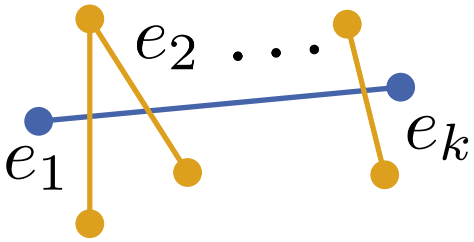

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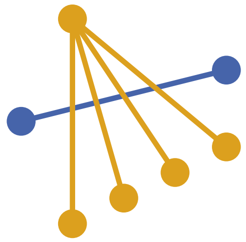

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[Hickingbotham and Wood]

- Large cliques $\implies$ **no** product structure.

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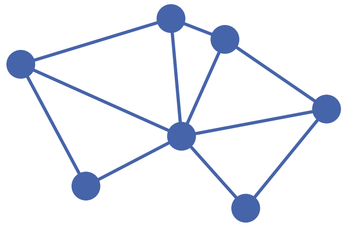

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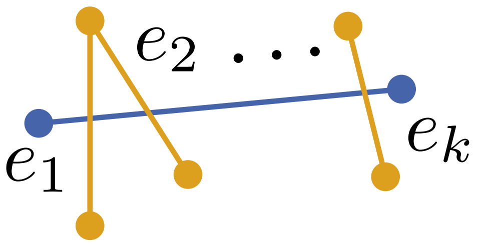

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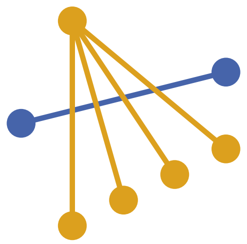

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- Large cliques $\implies$ **no** product structure.
- Large treewidth in neighborhood $\implies$ **no** product structure.

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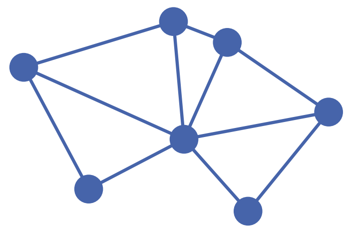

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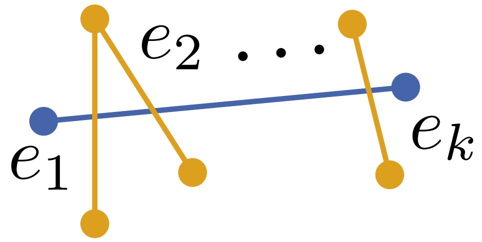

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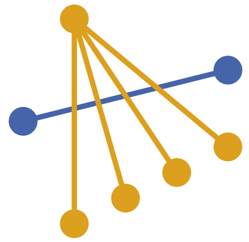

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- Large cliques $\Longrightarrow$ **no** product structure.
- Large treewidth in neighborhood $\Longrightarrow$ **no** product structure.
- **No** linear local treewidth $\Longrightarrow$ **no** product structure.

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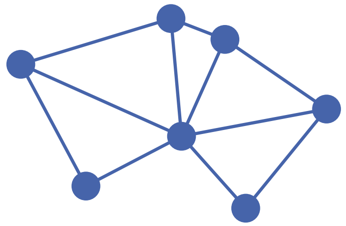

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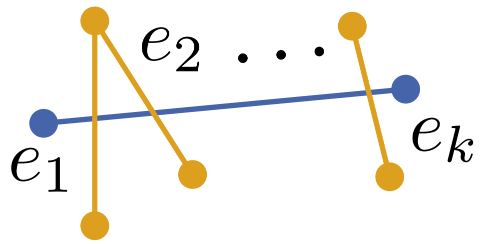

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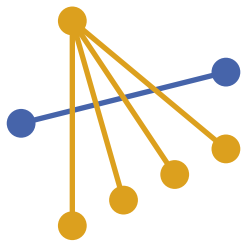

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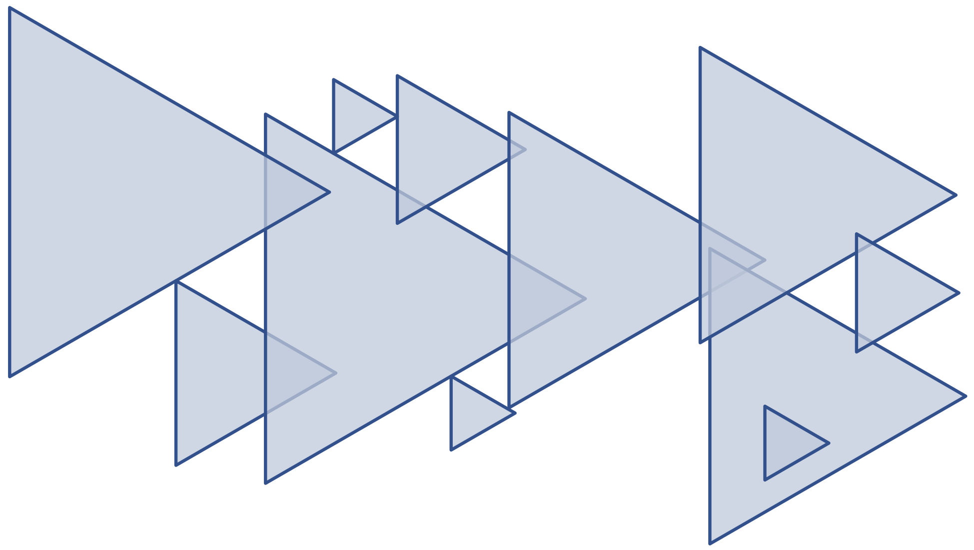
[Hickingbotham and Wood]

Where is the border between product structure and no product structure?

- Large cliques $\implies$ **no** product structure.
- Large treewidth in neighborhood $\implies$ **no** product structure.
- **No** linear local treewidth $\implies$ **no** product structure.

Intersection Graphs of Homothetic n-Gons



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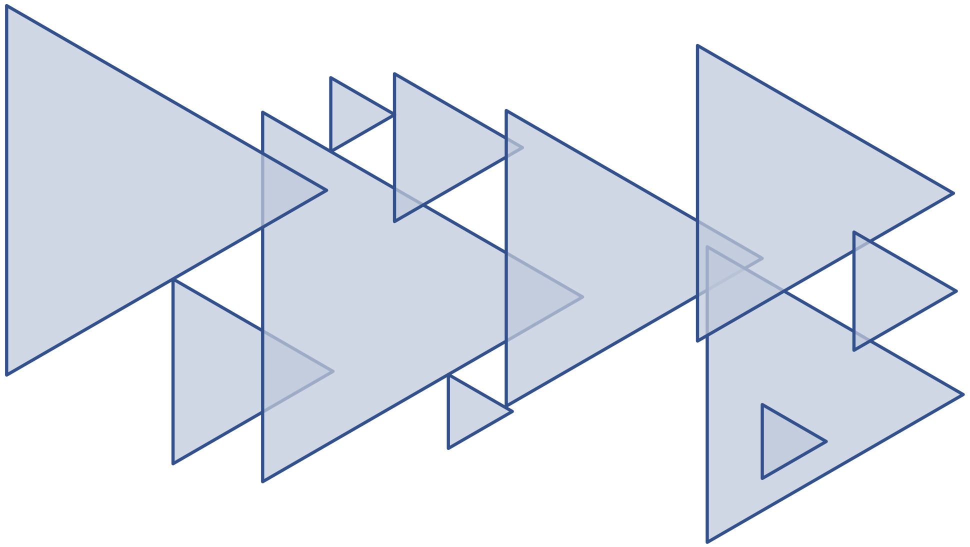

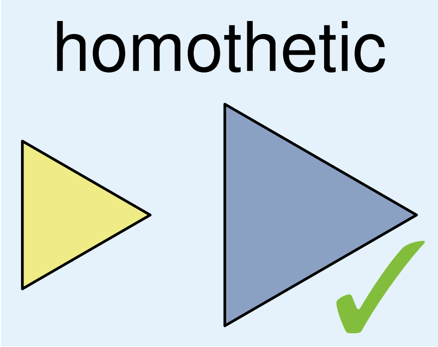

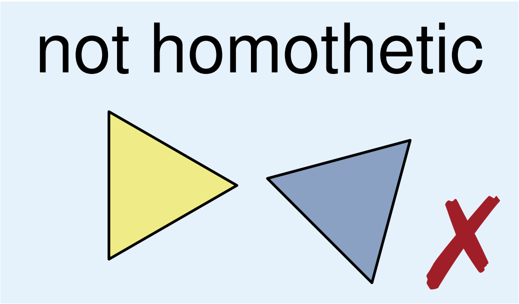

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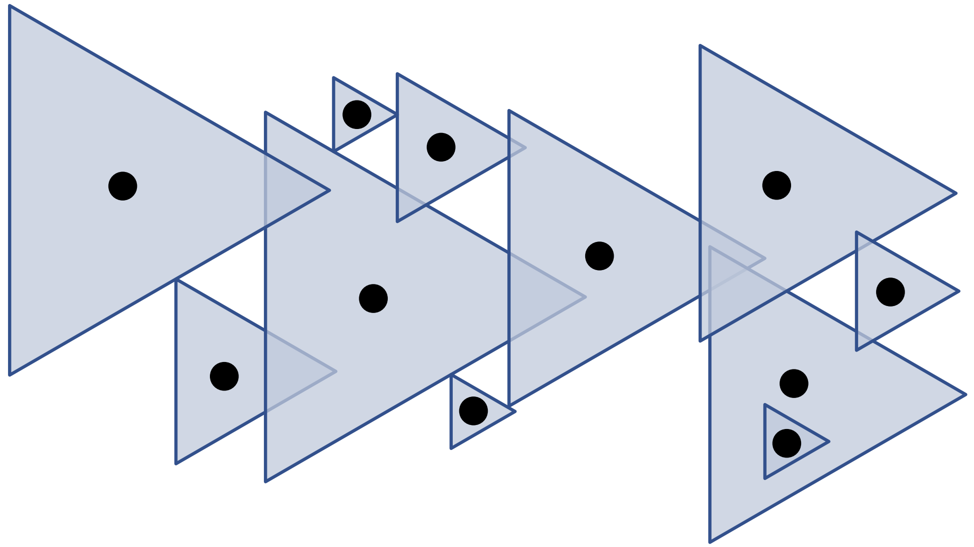

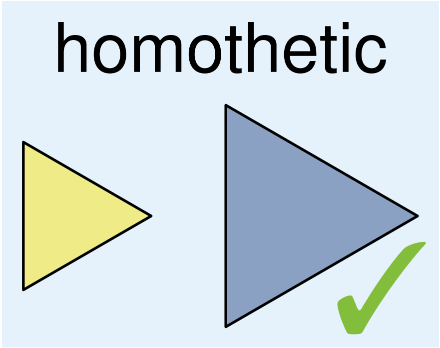

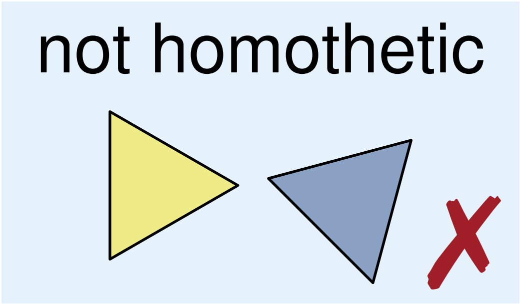

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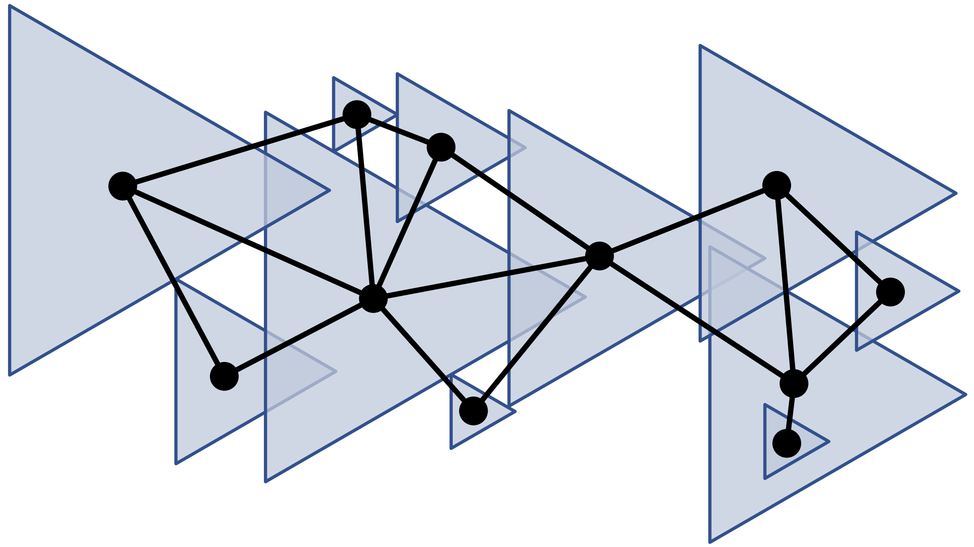

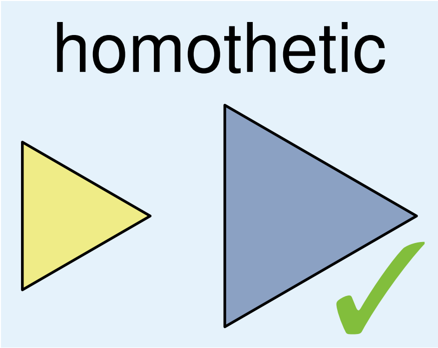

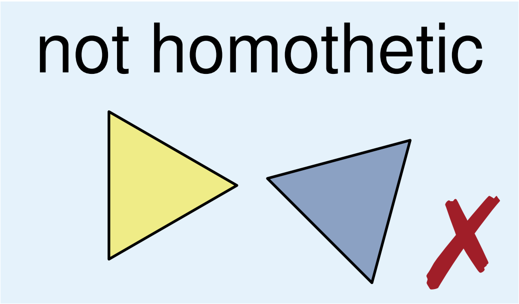

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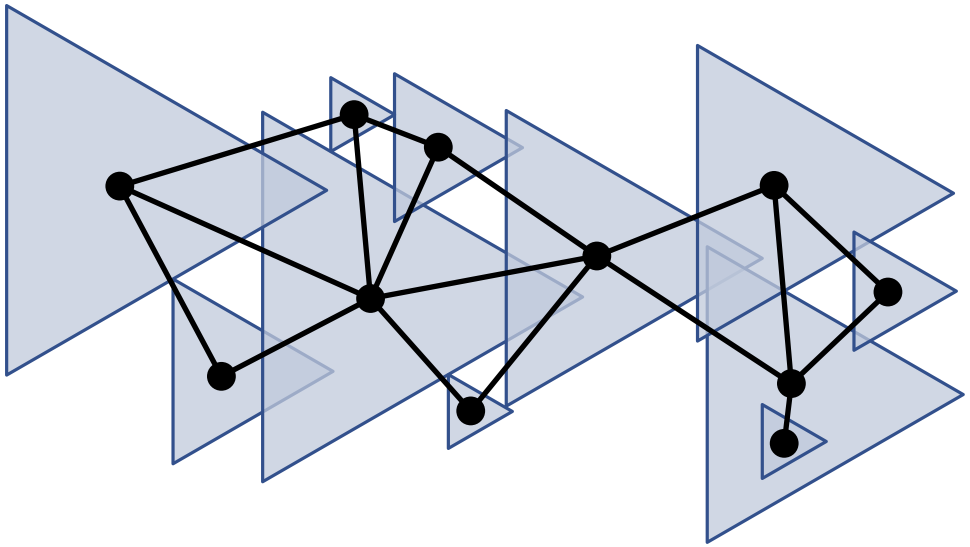
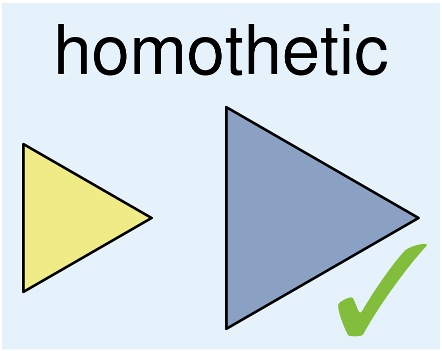
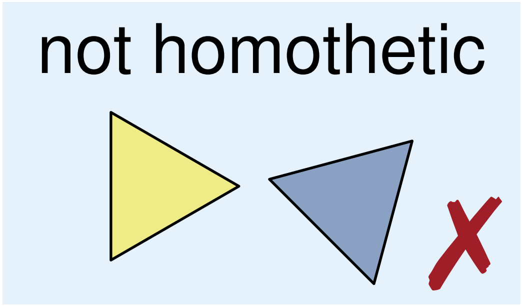
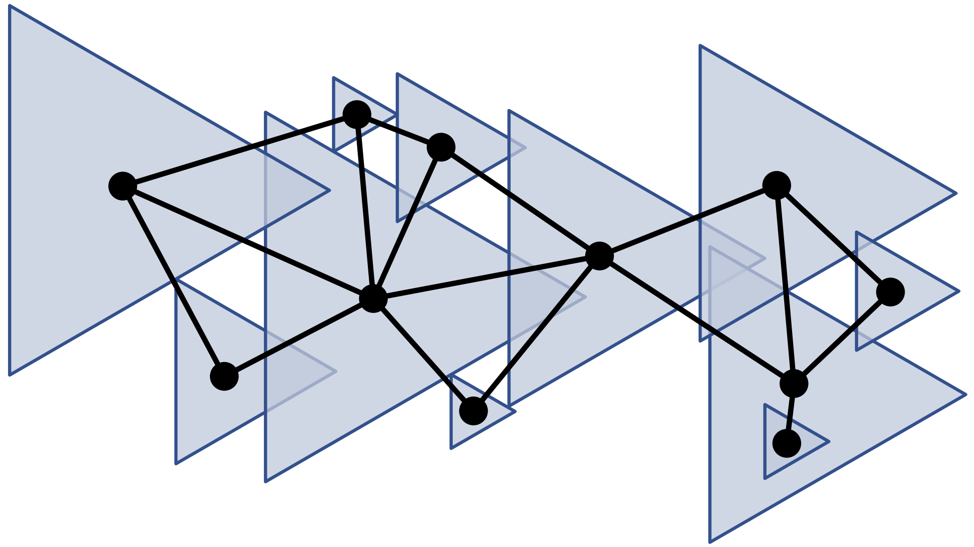


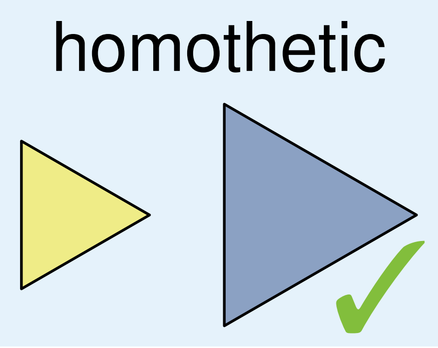


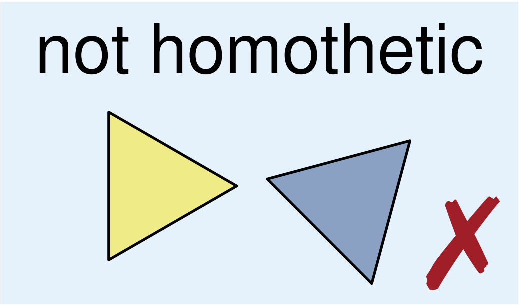


Problems for product structure:

Intersection Graphs of Homothetic n-Gons







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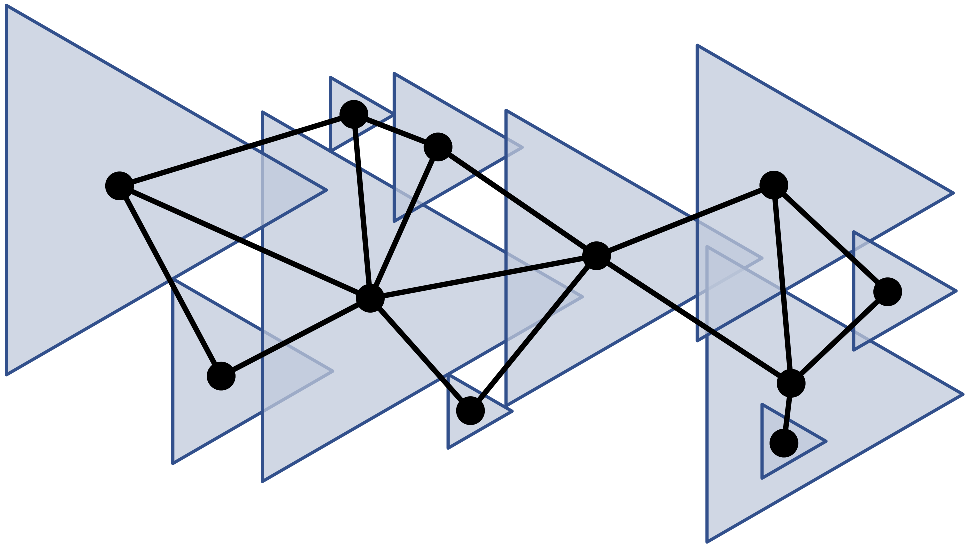

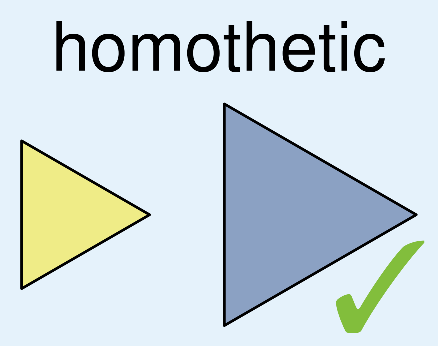

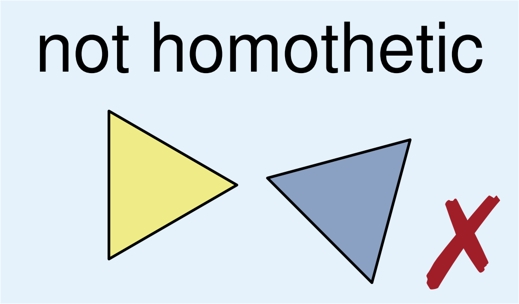

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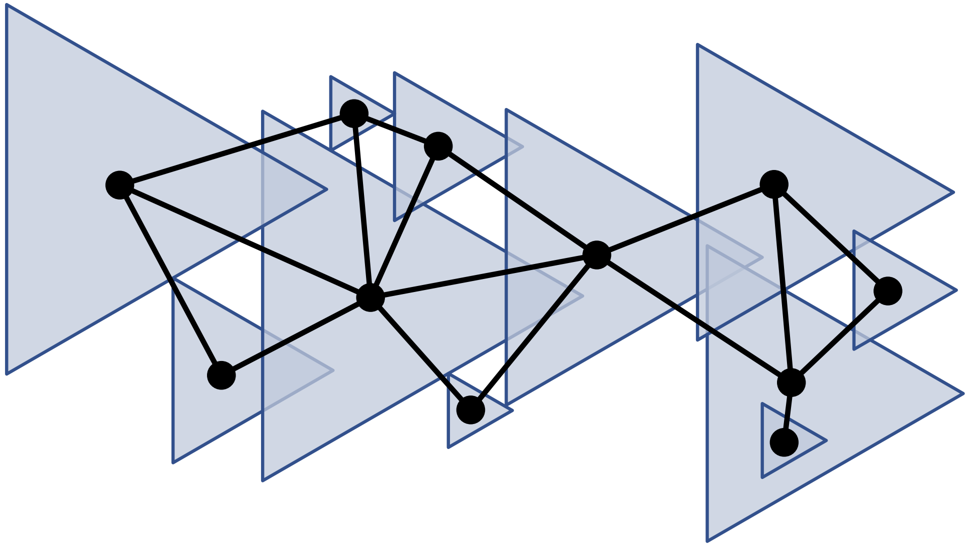

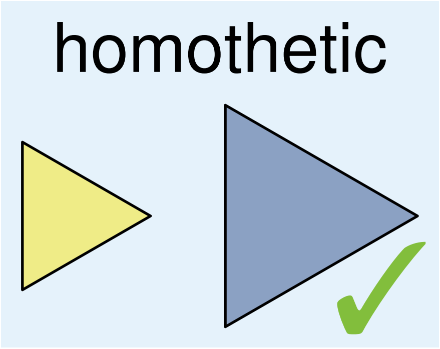

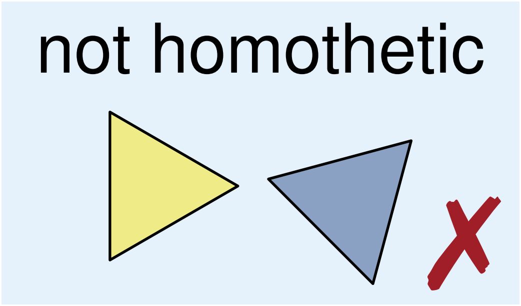

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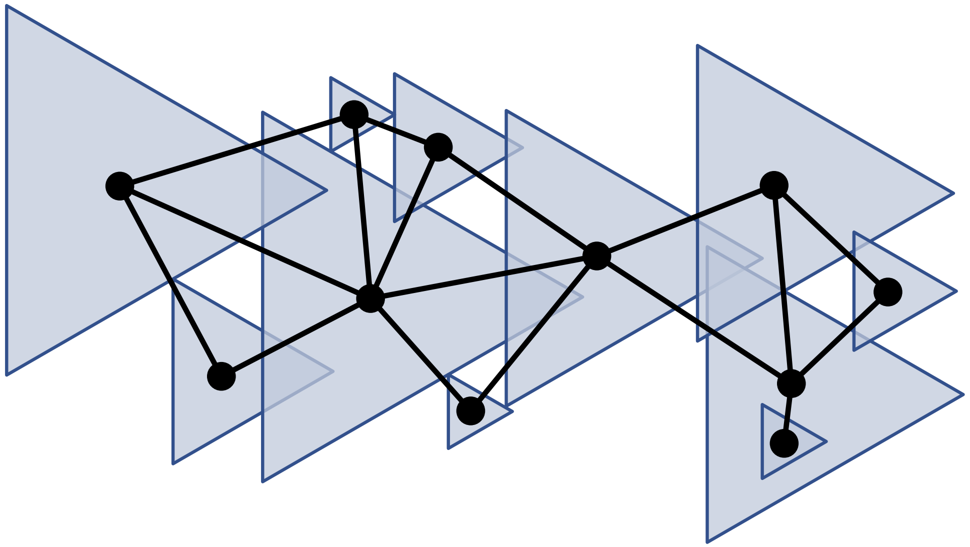

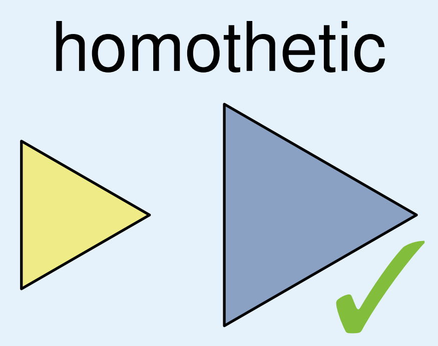

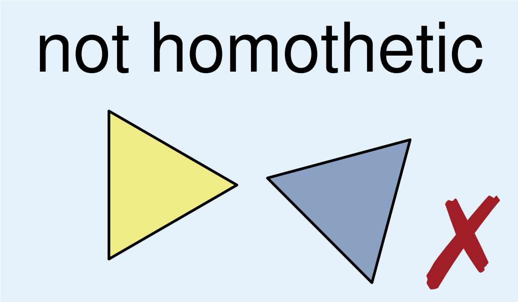

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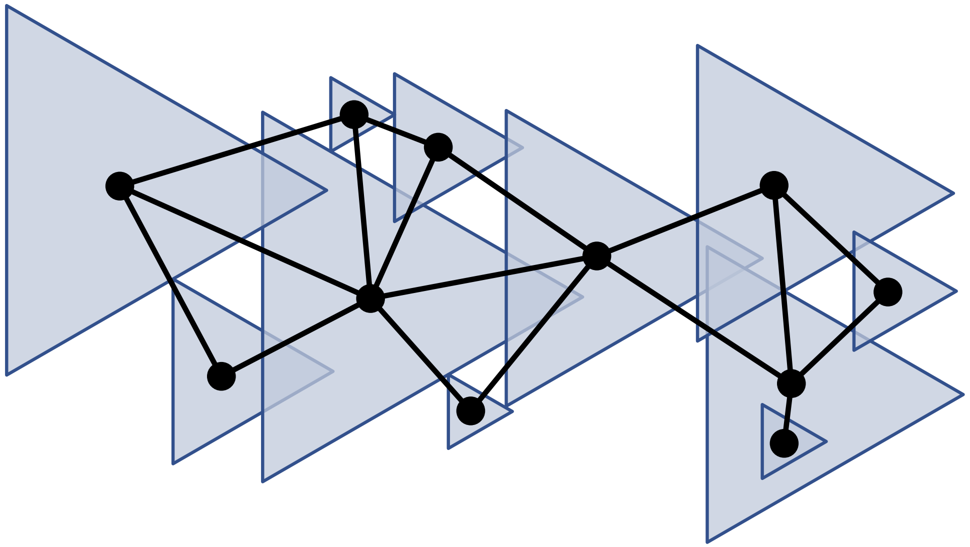

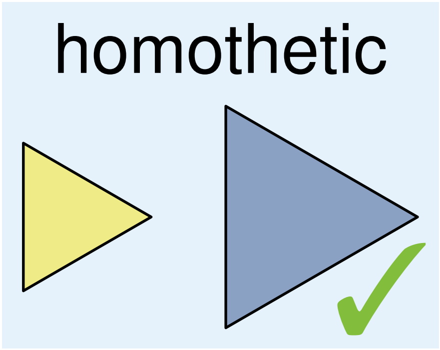

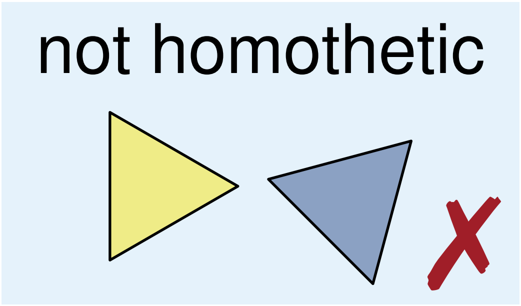

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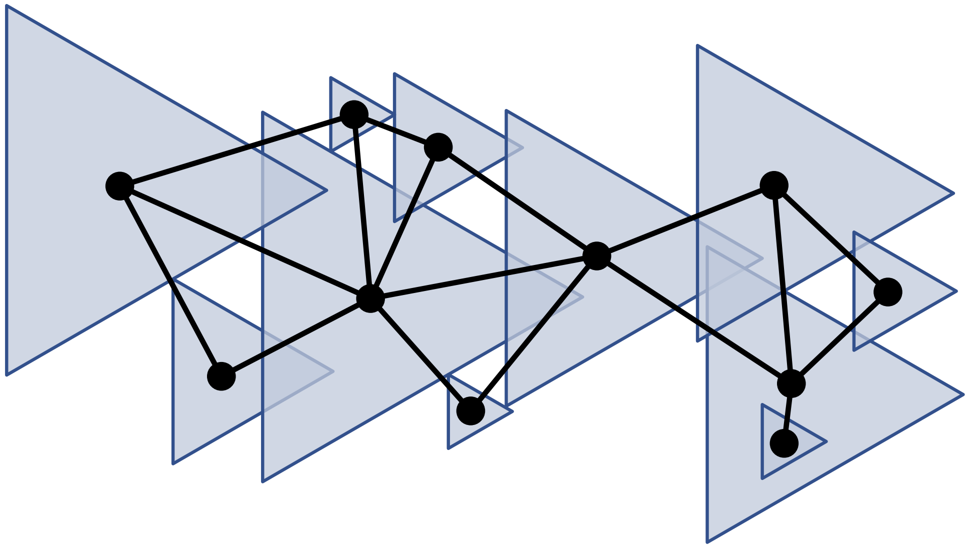

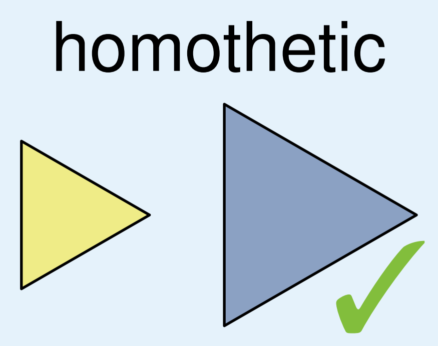

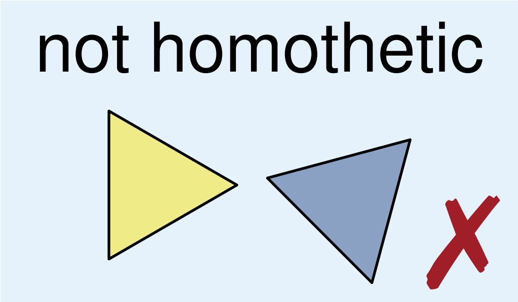

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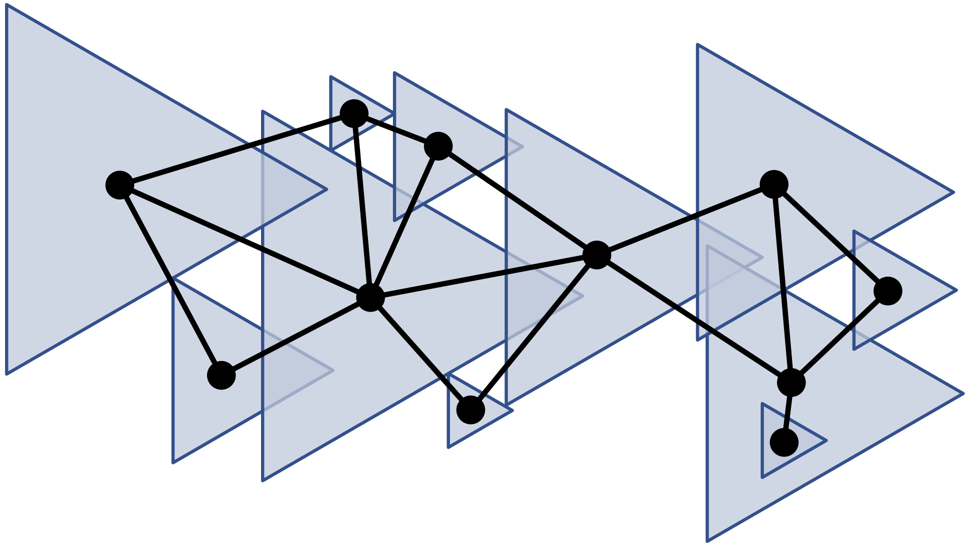
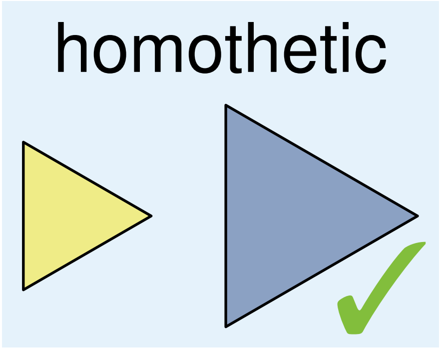
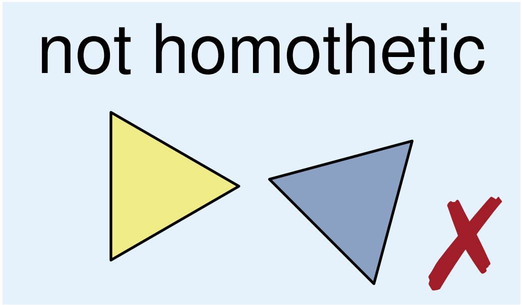


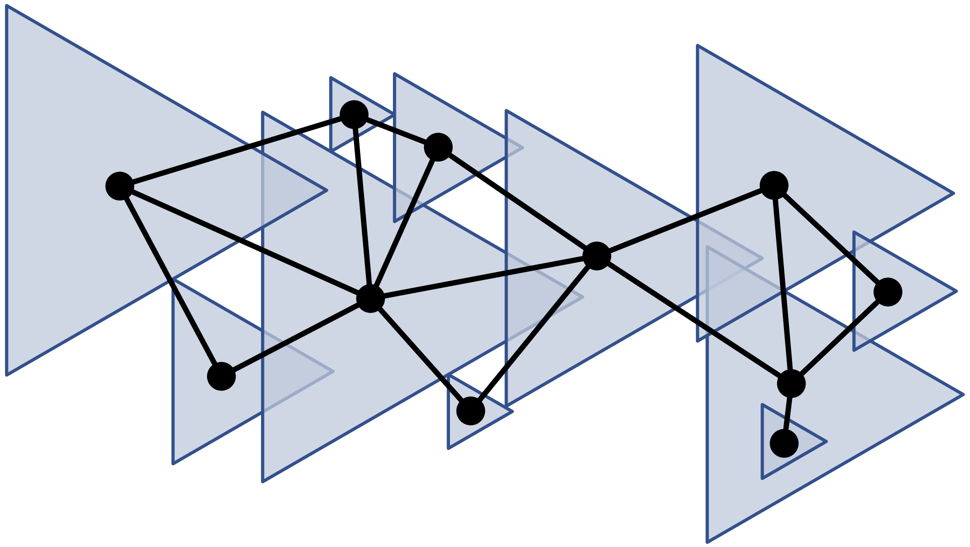




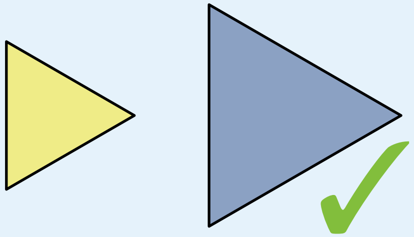
Problems for product structure:

large cliques

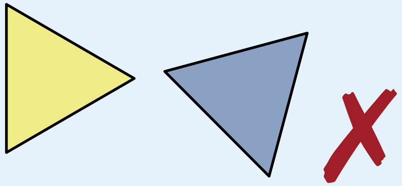
Intersection Graphs of Homothetic n-Gons



homothetic



not homothetic



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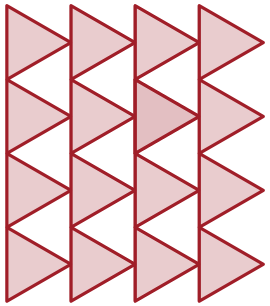

large cliques

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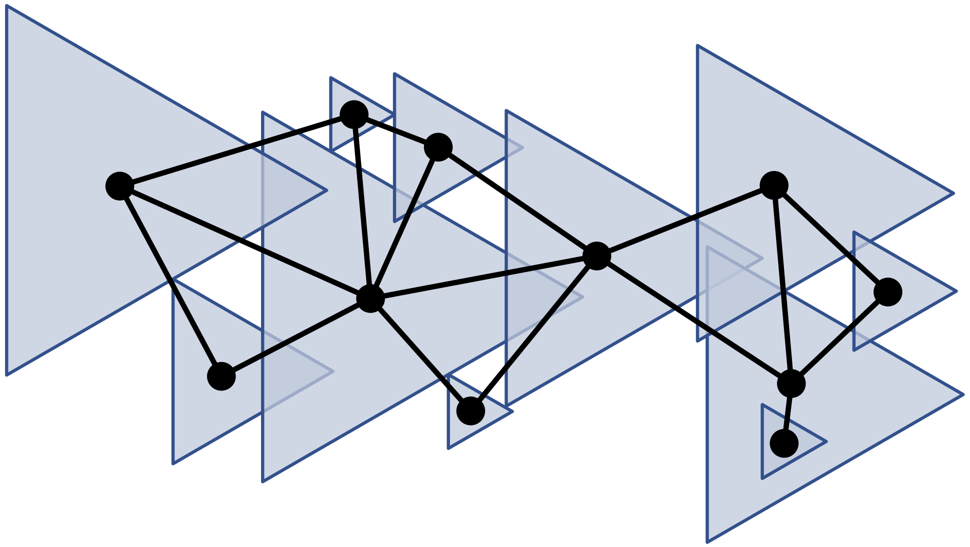

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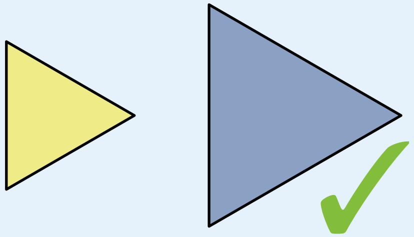

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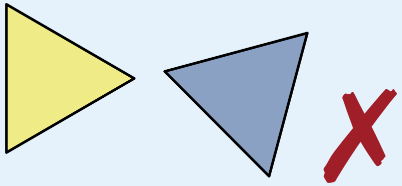
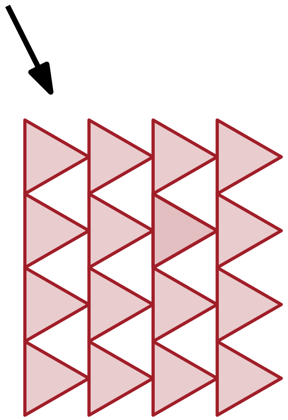


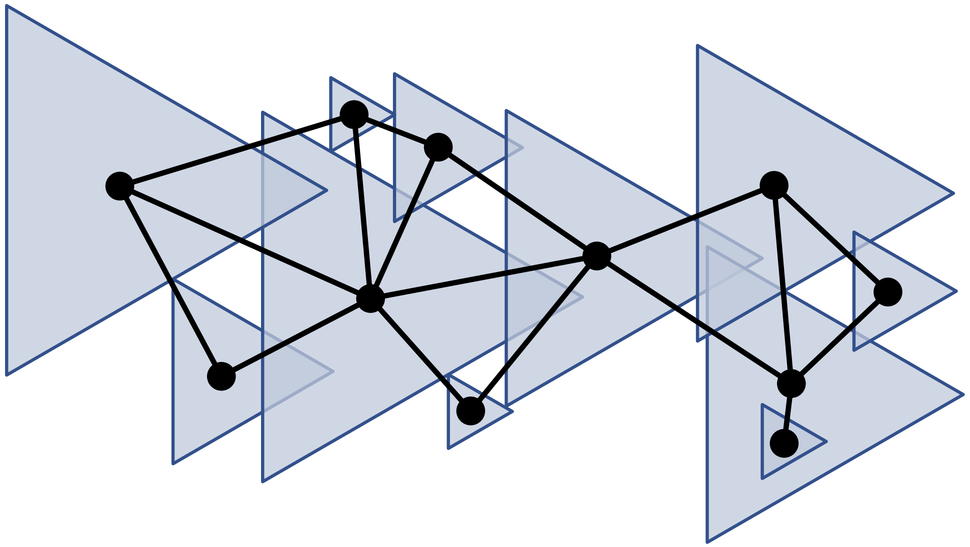
Problems for product structure:

large treewidth



large cliques

Intersection Graphs of Homothetic n-Gons



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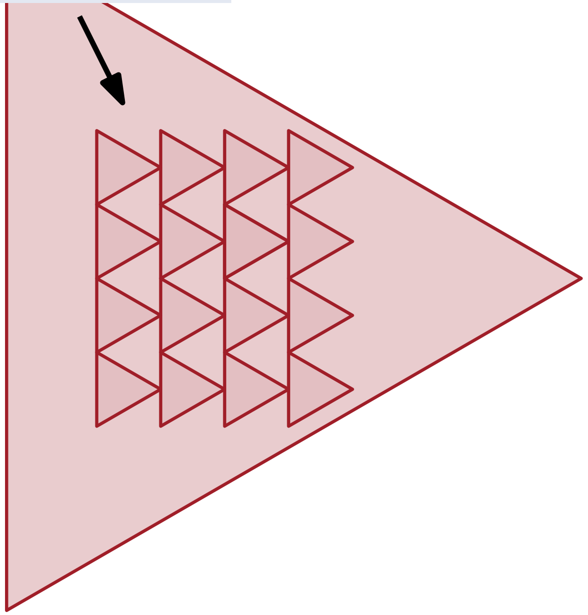
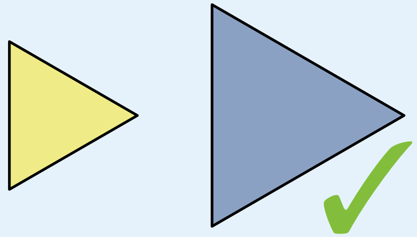
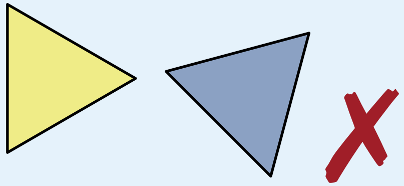


large cliques

homothetic



not homothetic



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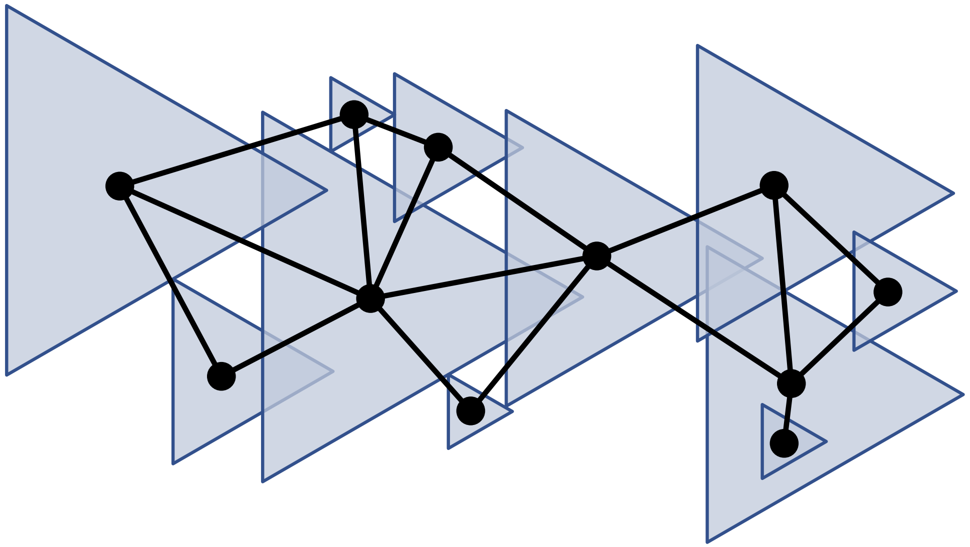
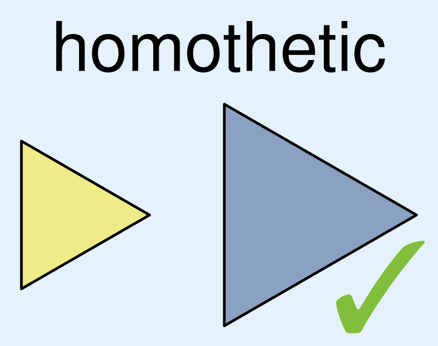
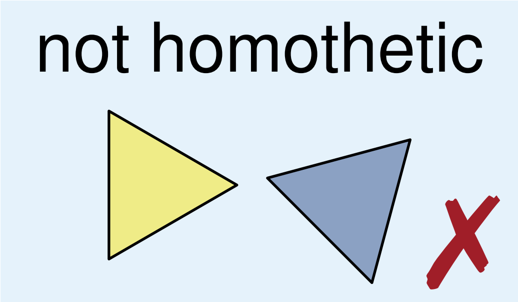
Intersection Graphs of Homothetic n-Gons







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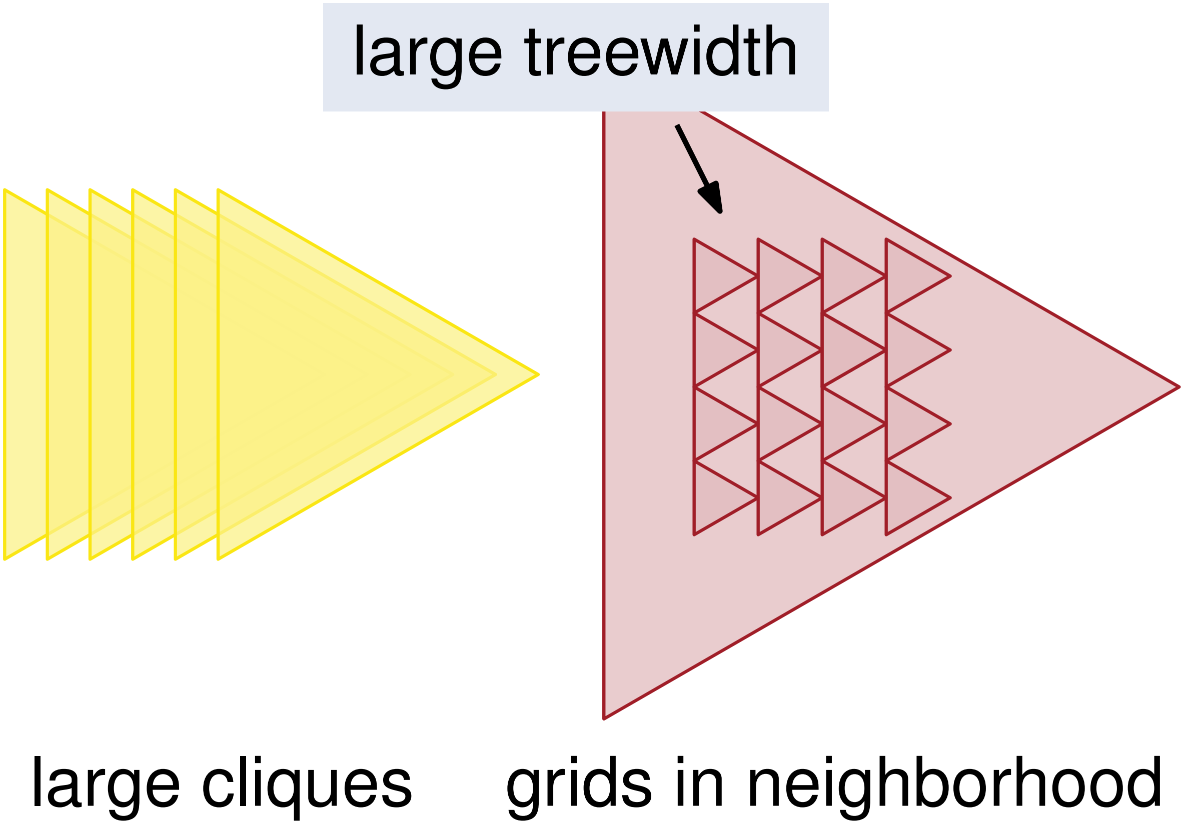

α-free Intersection Graphs

A set $\mathcal{S}$ of shapes in the plane is α-free with $\alpha \in [0, 1]$ if every shape $S \in \mathcal{S}$ has at least α of its area disjoint from all other shapes.

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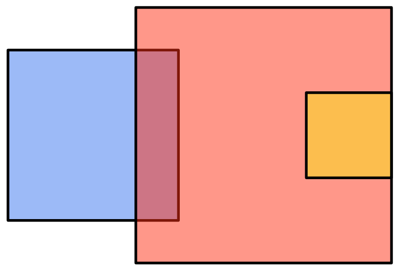

0-free

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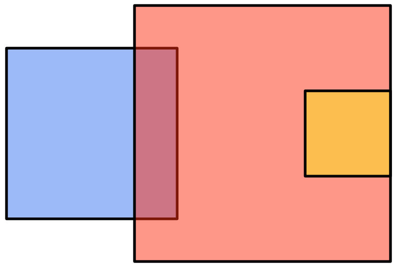
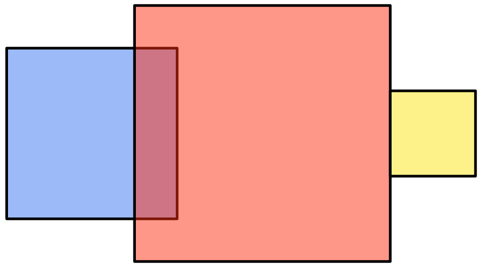


0-free



$\frac{3}{4}$-free

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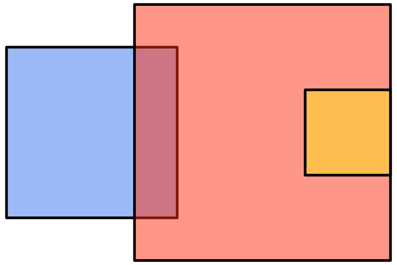
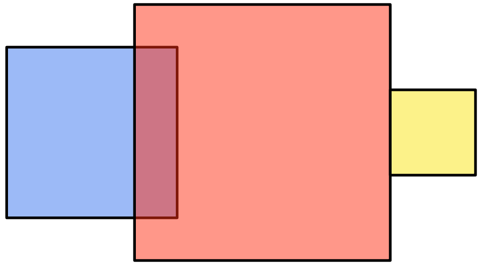
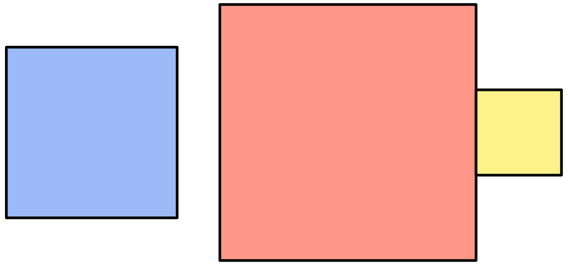


0-free



$\frac{3}{4}$-free



1-free

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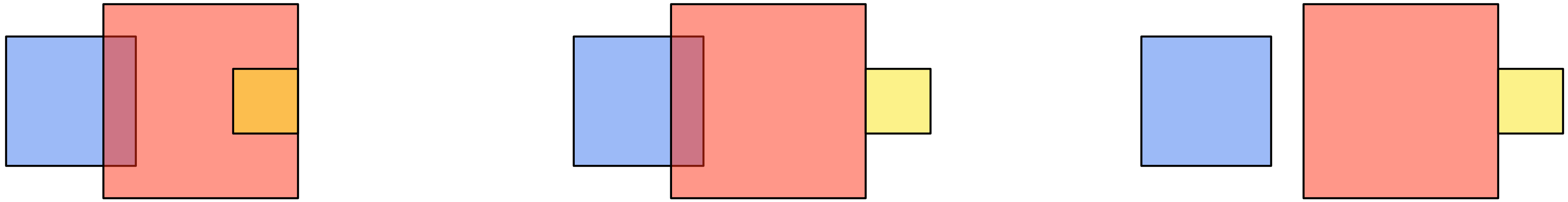

0-free | $\frac{3}{4}$-free | 1-free

large cliques

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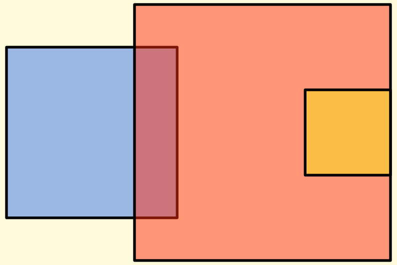
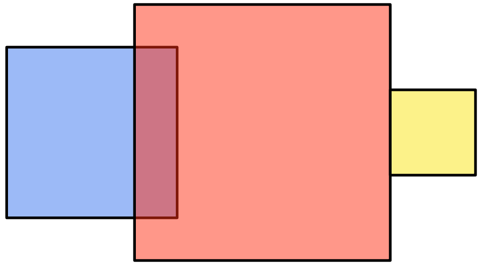
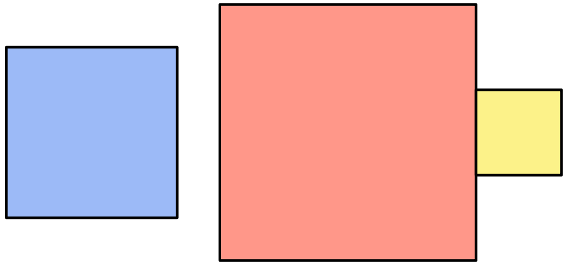


0-free

large cliques



$\frac{3}{4}$-free



1-free

no product structure

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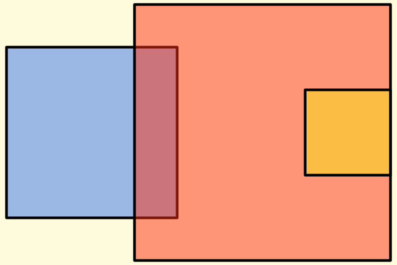

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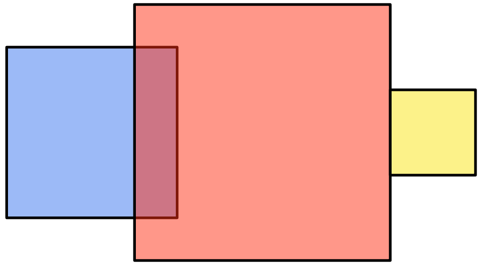

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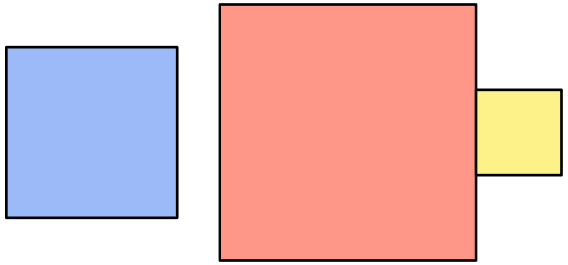

1-free

1-planar

no product structure

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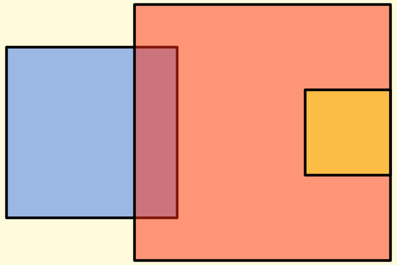
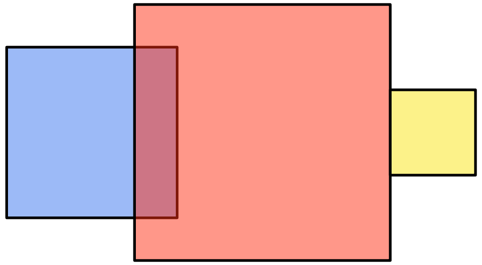


0-free

large cliques

no product structure



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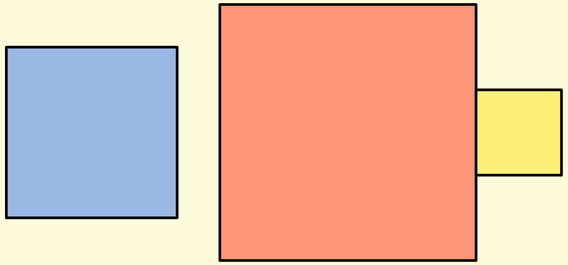

1-free

1-planar

product structure

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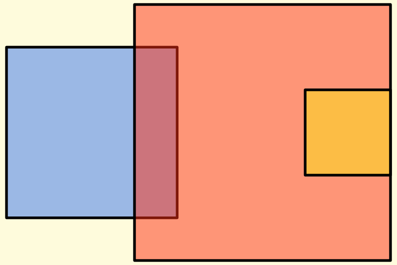

0-free

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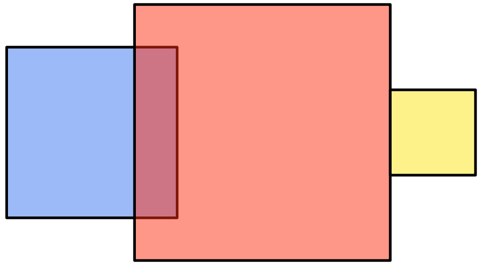
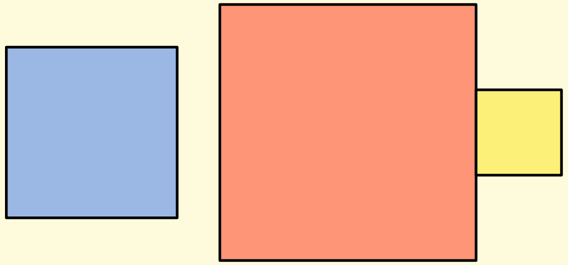


$\frac{3}{4}$-free

What about $\alpha \in (0,1)$?



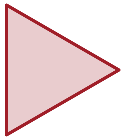
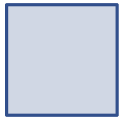
1-free

1-planar

no product structure

product structure

Our Results for Regular n-gons

- For  and  : **no** product structure for $\alpha < 1$.

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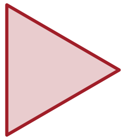
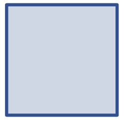
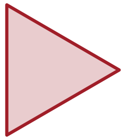
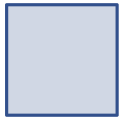
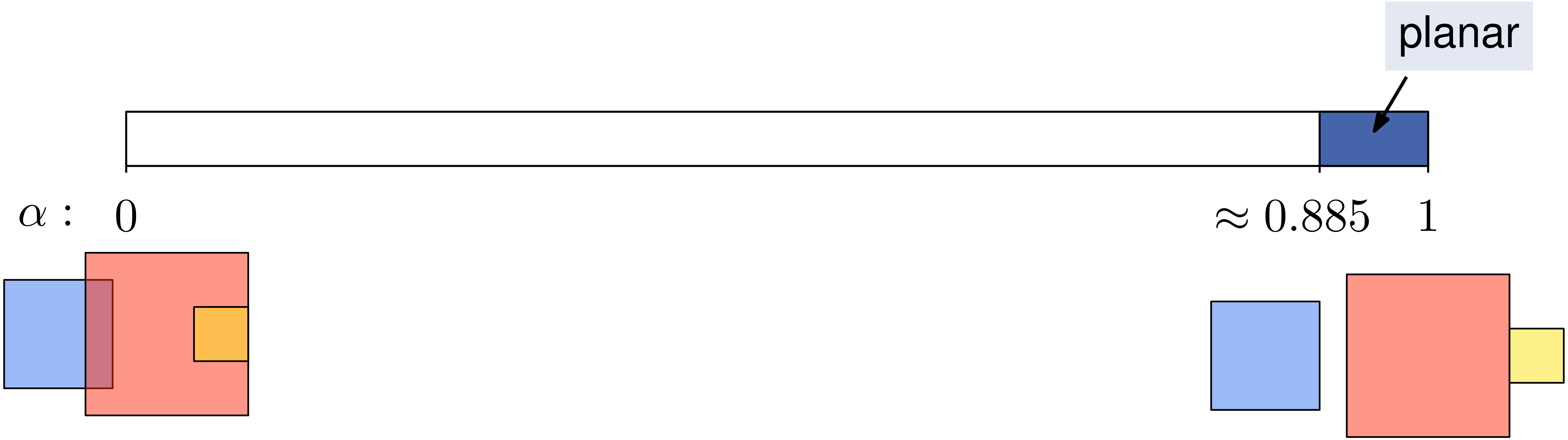
Our Results for Regular n-gons

- For  and  : **no** product structure for $\alpha < 1$.
- For even $n \geq 6$:

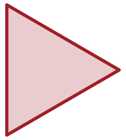
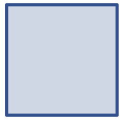
Our Results for Regular n-gons

- For  and  : **no** product structure for $\alpha < 1$.
- For even $n \geq 6$:



Intersection Graphs with and without Product Structure
Laura Merker, Lena Scherzer, **Samuel Schneider**, Torsten Ueckerdt

Our Results for Regular n-gons

- For  and  : **no** product structure for $\alpha < 1$.
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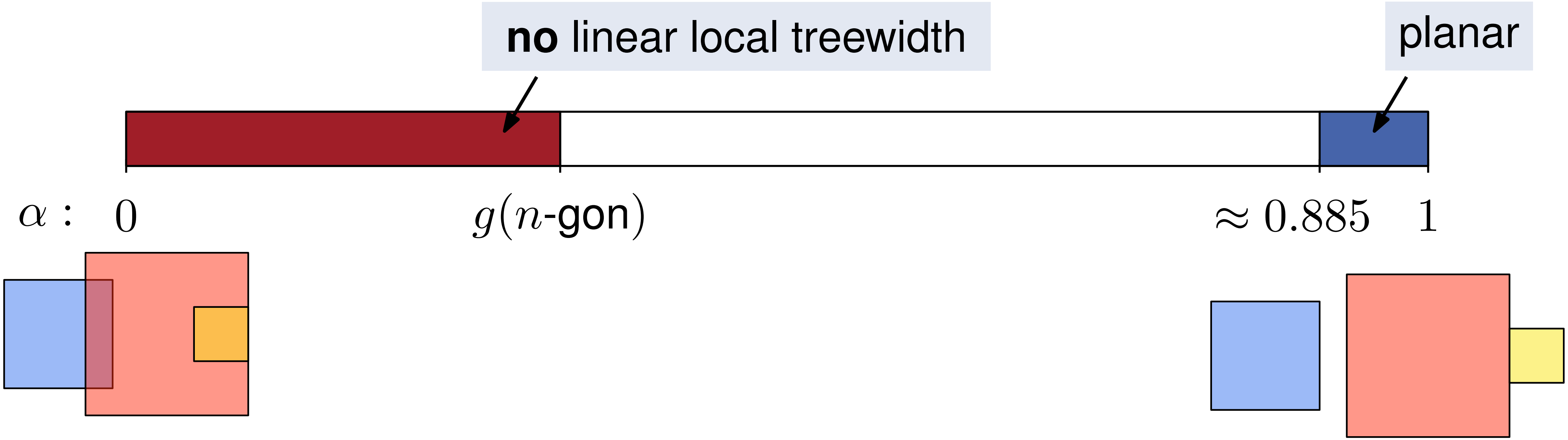
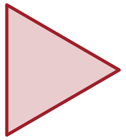
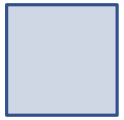


Our Results for Regular n-gons

- For  and  : **no** product structure for $\alpha < 1$.
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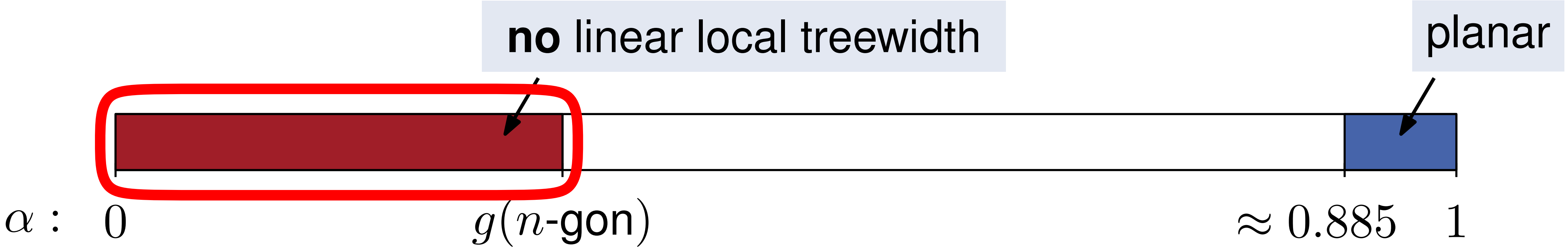
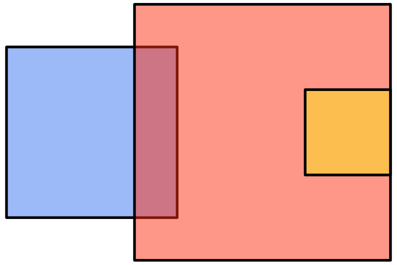
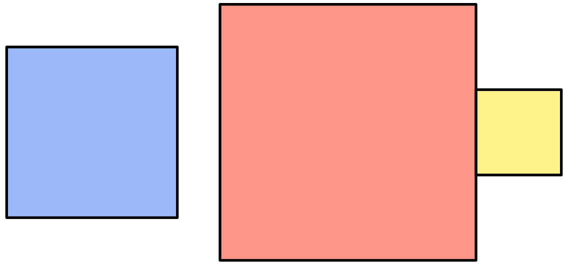
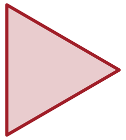
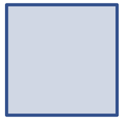






Our Results for Regular n-gons

- For  and  : **no** product structure for $\alpha < 1$.
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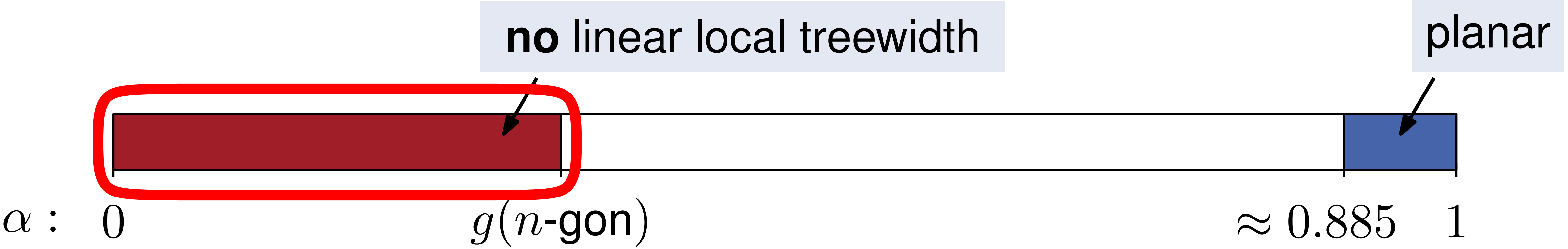
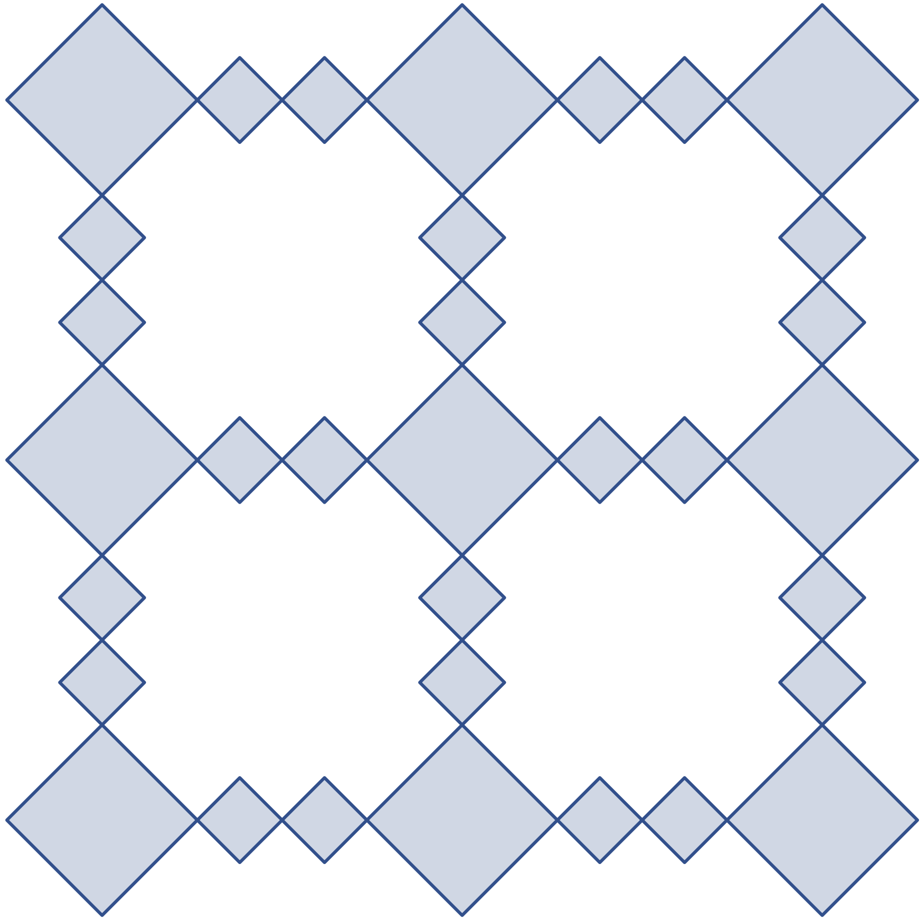


$\mathcal{G}$ has linear local treewidth $\implies$ graphs in $\mathcal{G}$ have treewidth linear in their radius

Constructing Graphs with Radius $\mathcal{O}(k)$ and Treewidth $\Omega(k^2)$



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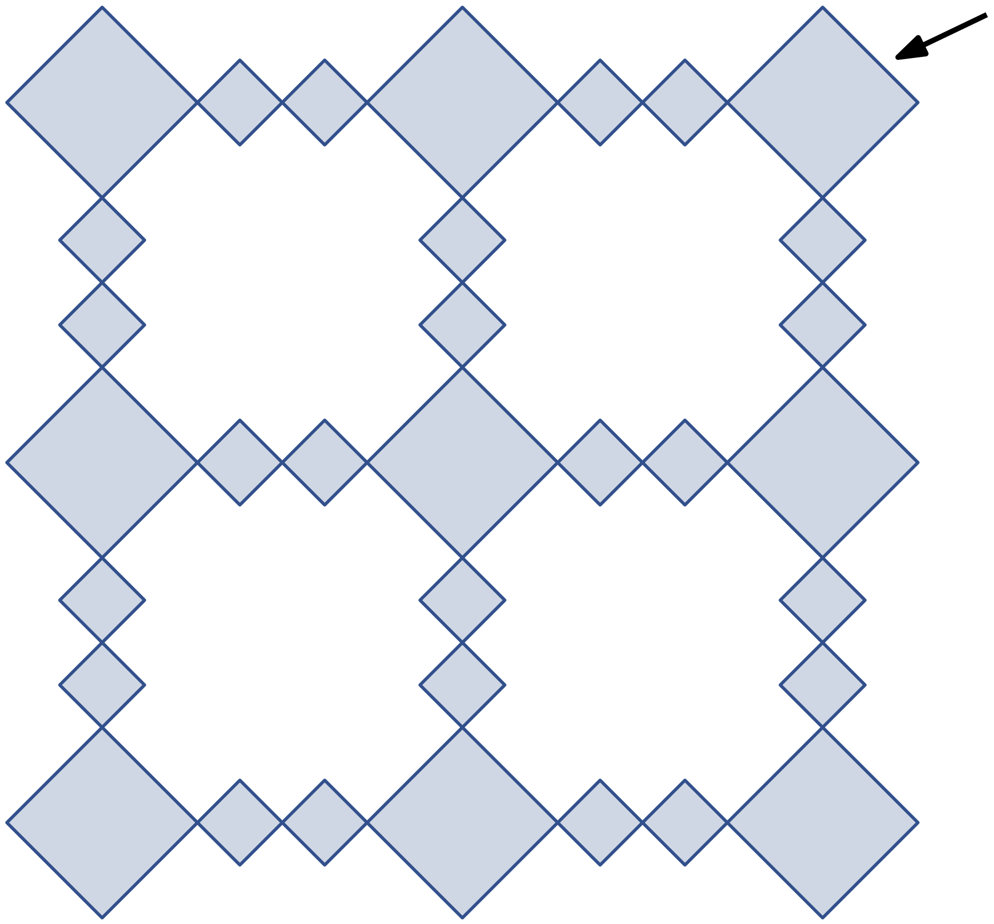
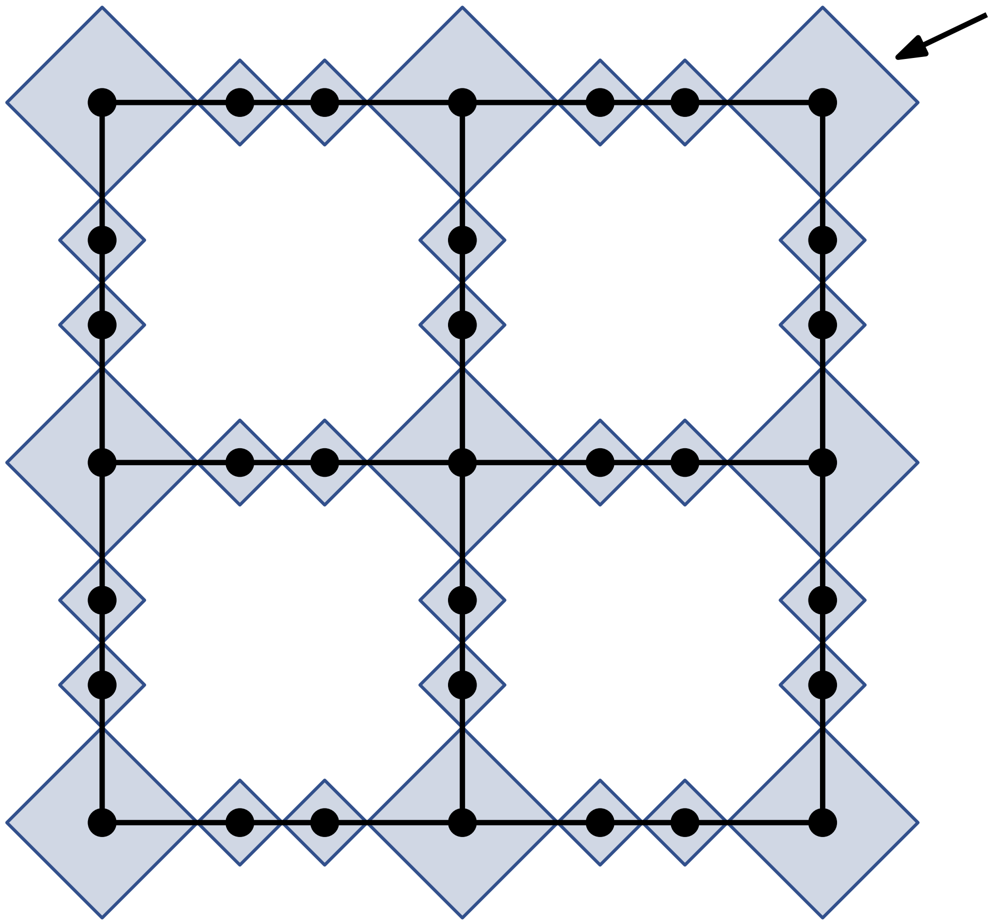


$(k+1) \times (k+1)$-grid

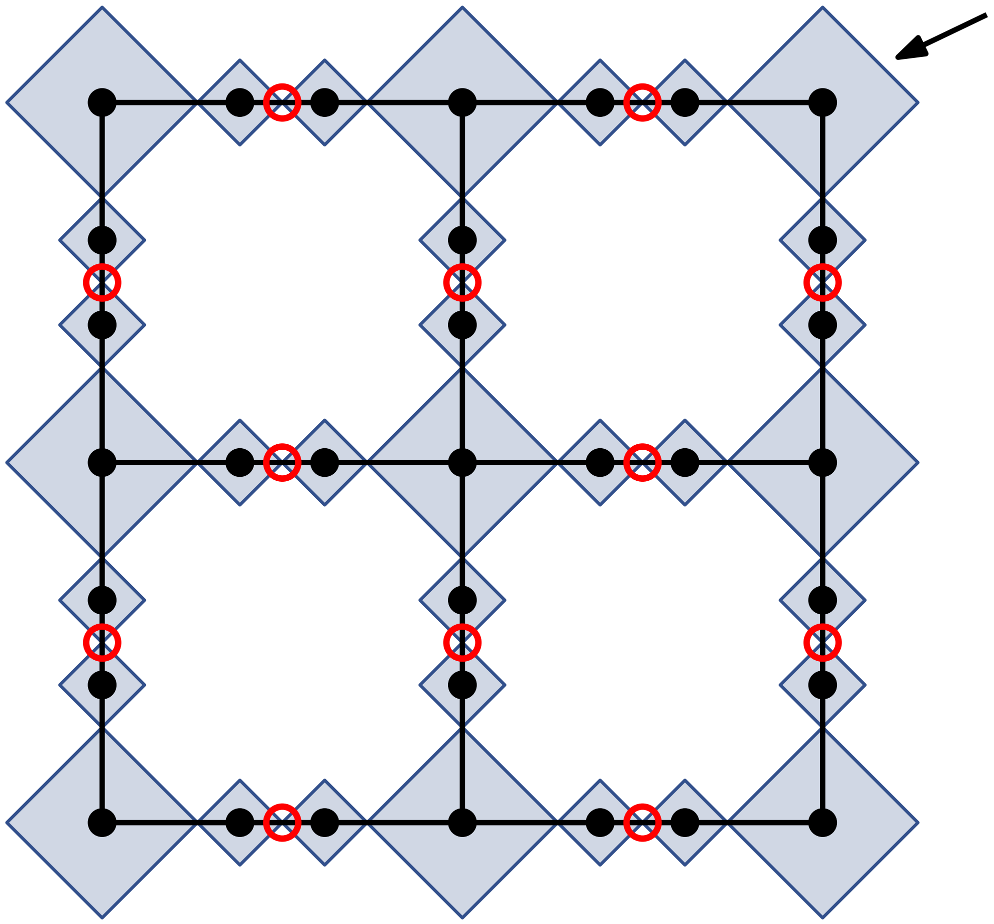
Constructing Graphs with Radius $\mathcal{O}(k)$ and Treewidth $\Omega(k^2)$



$(k+1) \times (k+1)$-grid

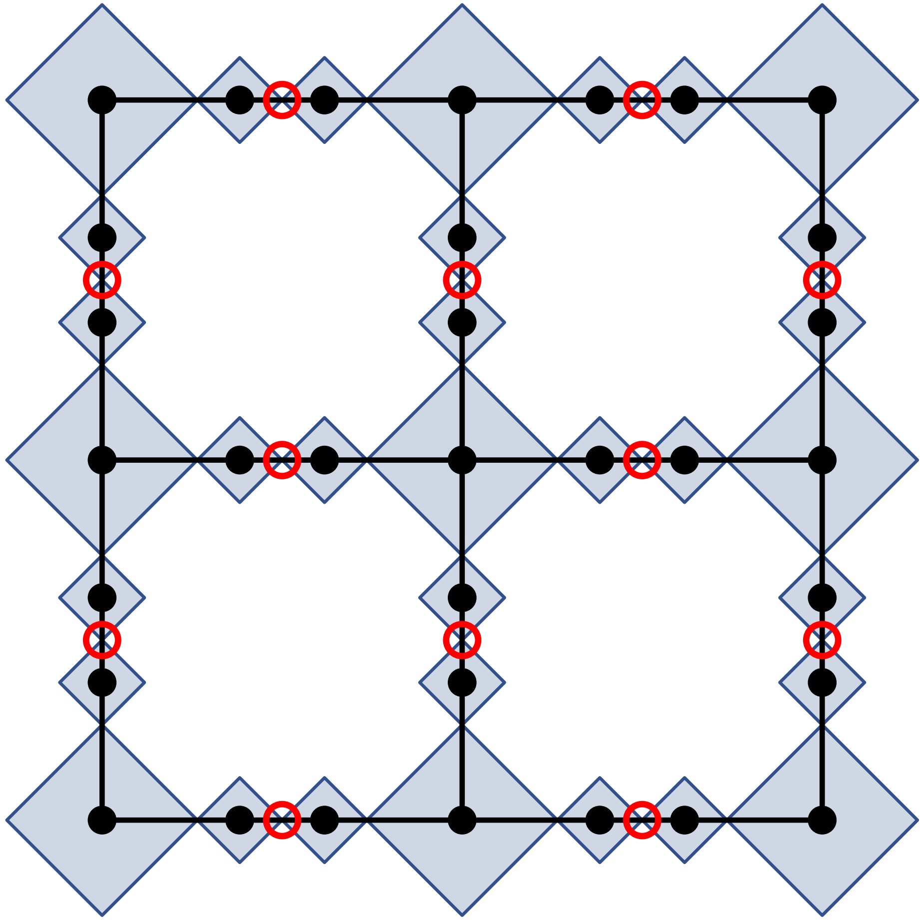
Laura Merker, Lena Scherzer, **Samuel Schneider**, Torsten Ueckerdt

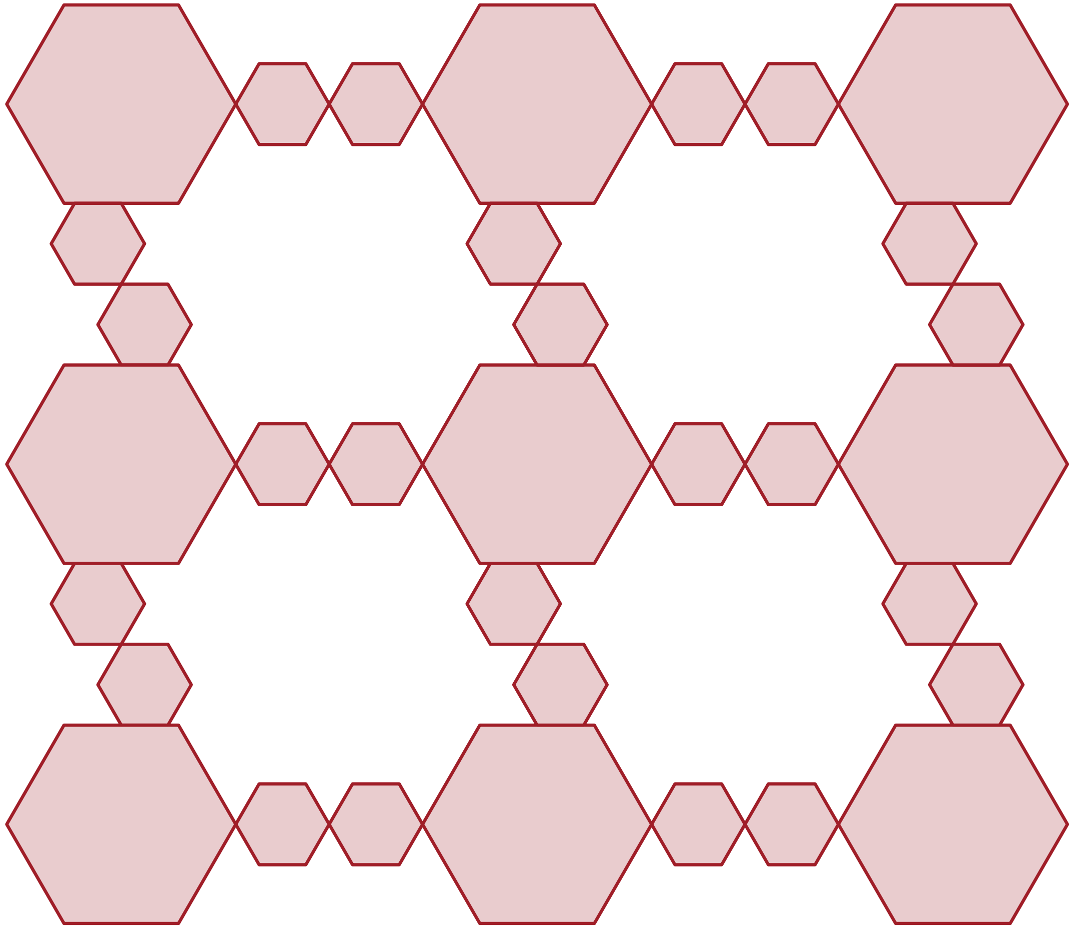
Constructing Graphs with Radius $\mathcal{O}(k)$ and Treewidth $\Omega(k^2)$



$(k+1) \times (k+1)$-grid

Constructing Graphs with Radius $\mathcal{O}(k)$ and Treewidth $\Omega(k^2)$





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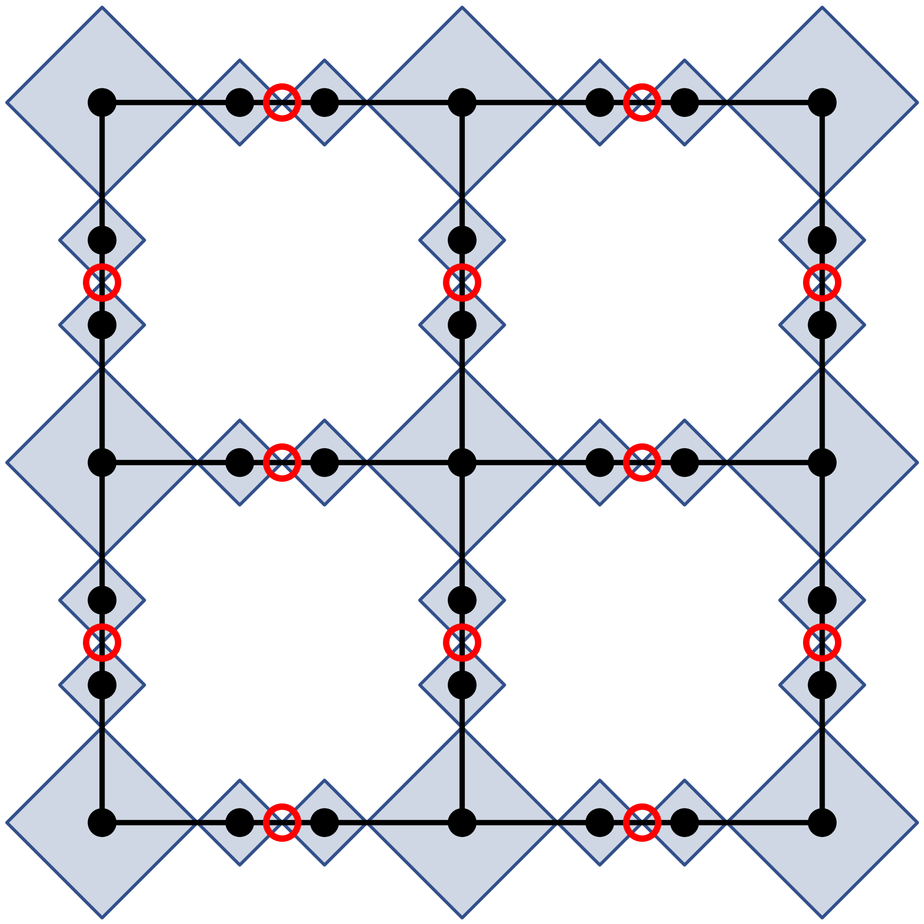

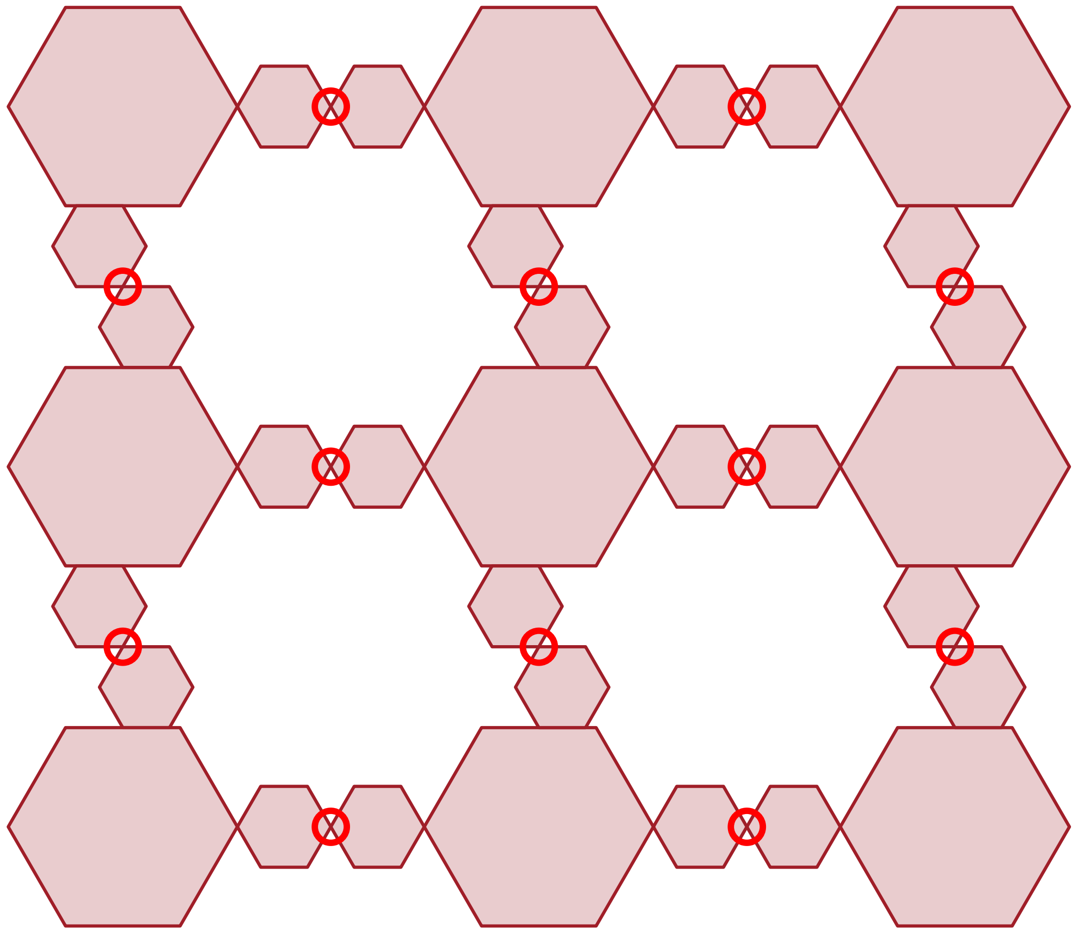

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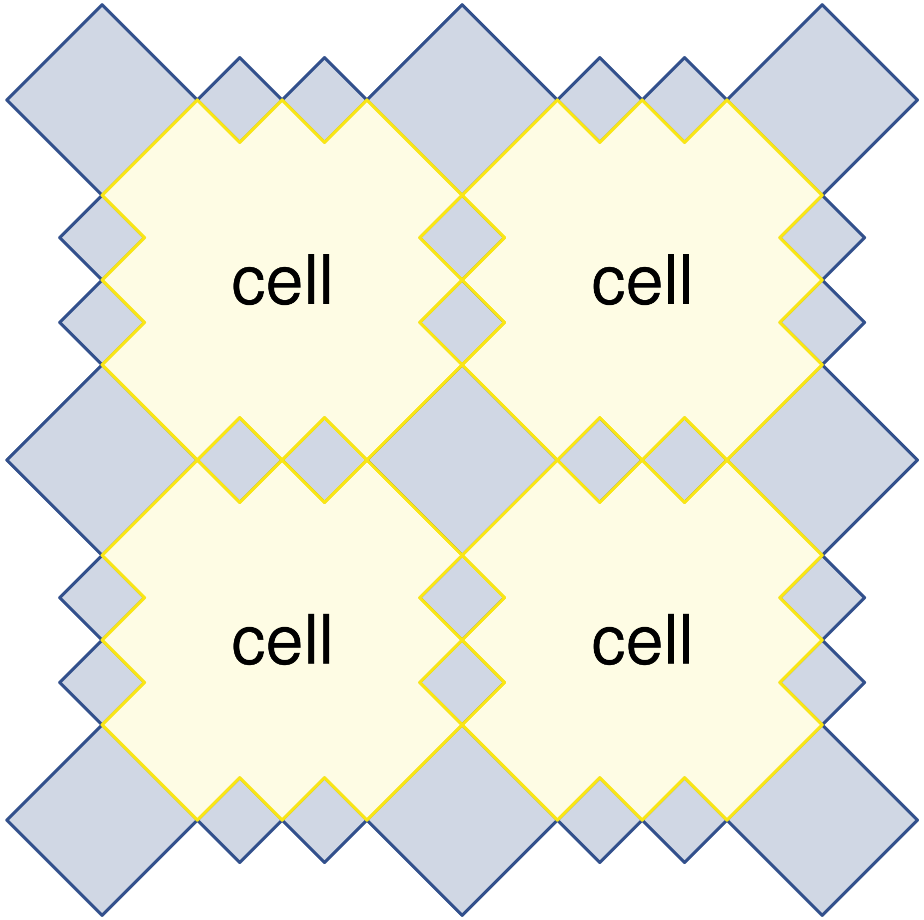

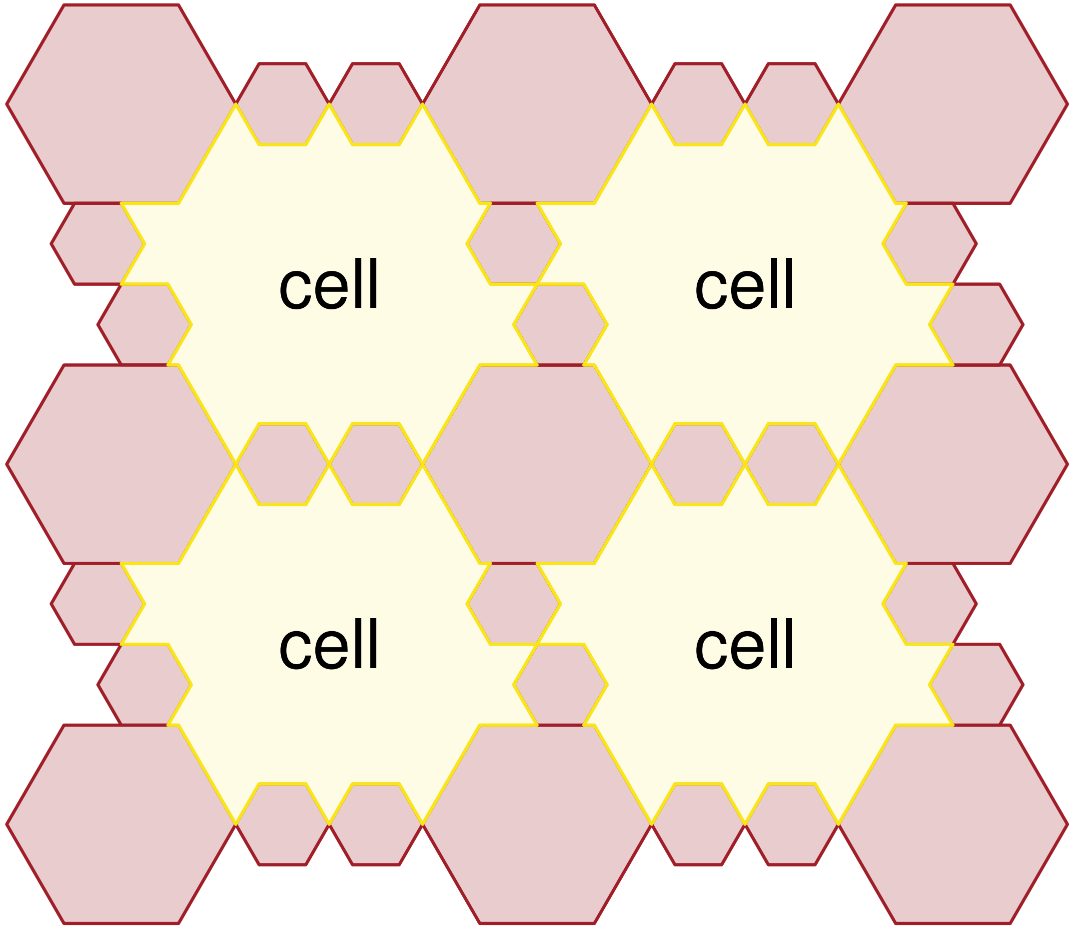

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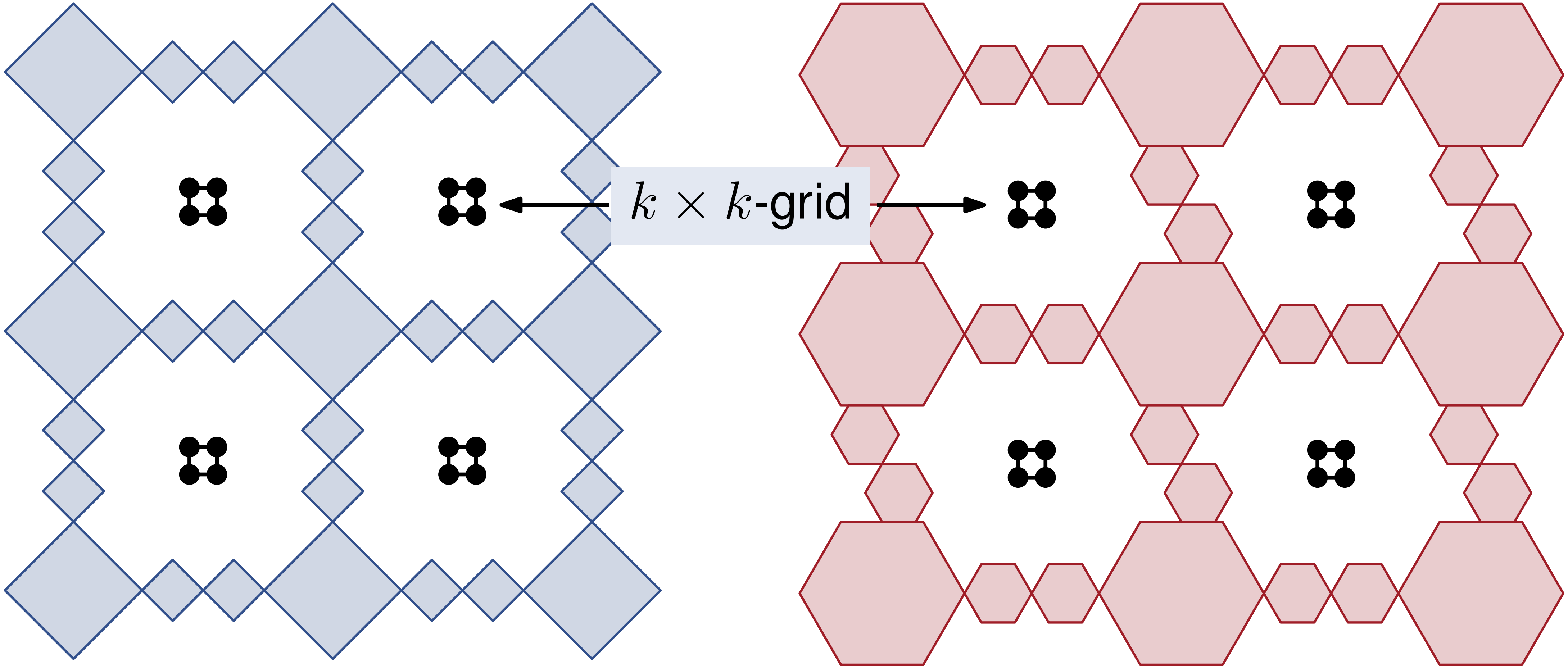

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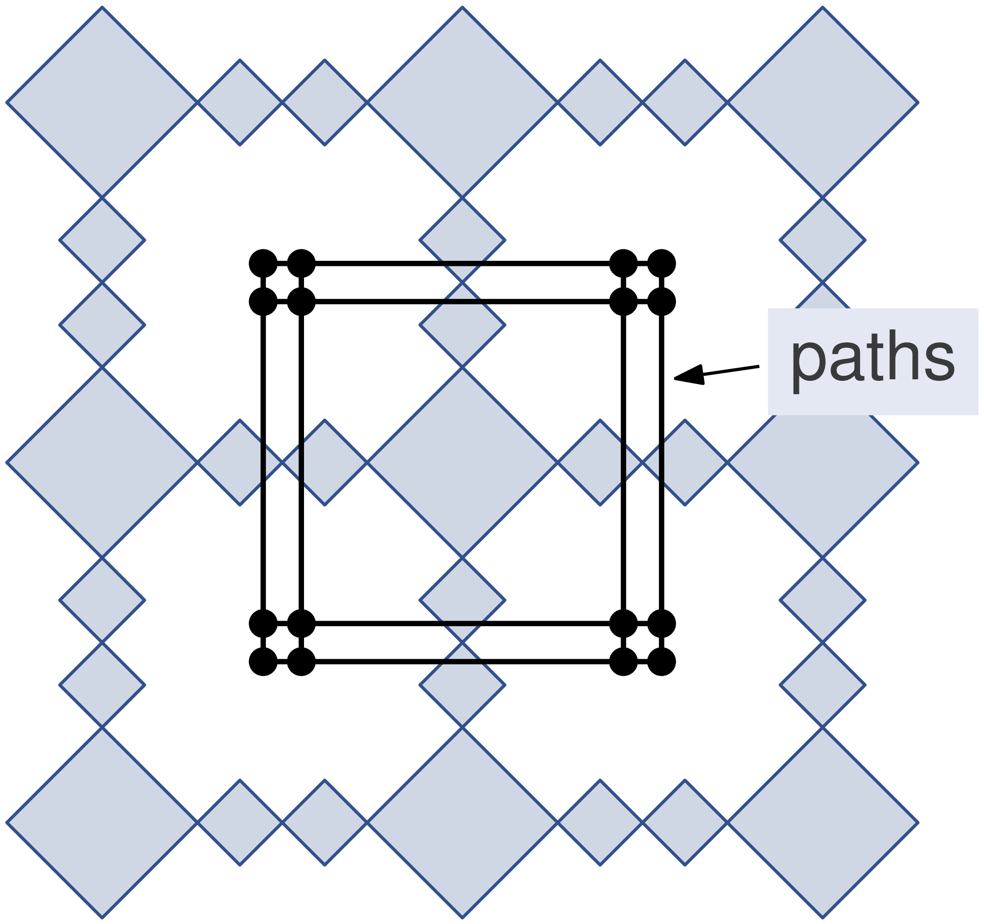

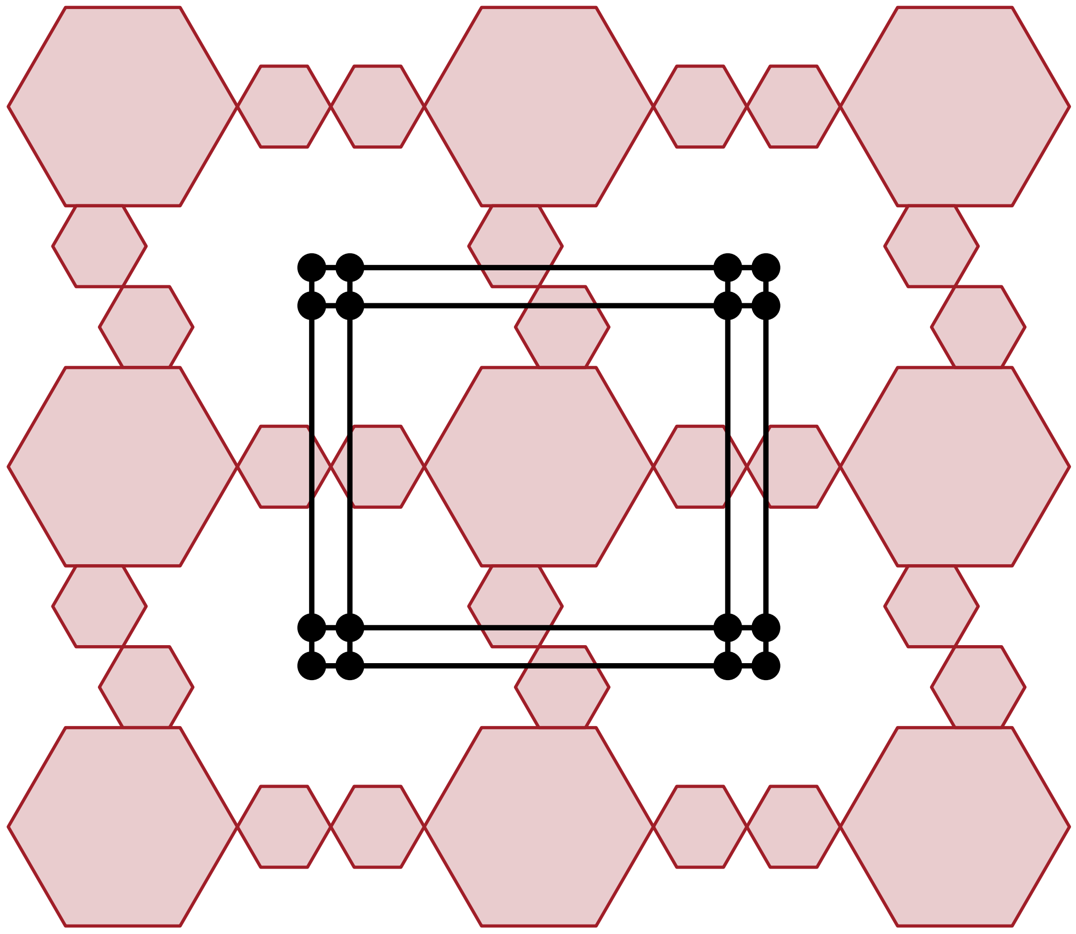

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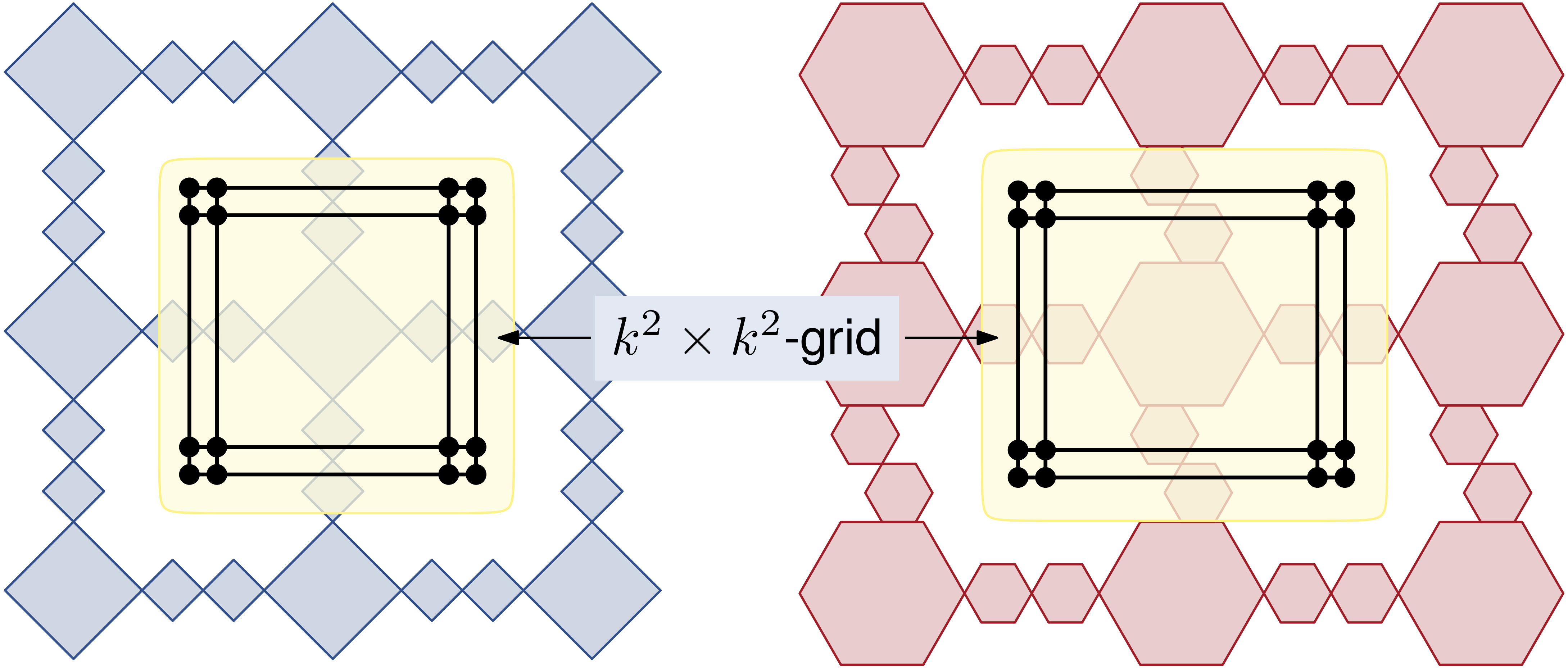

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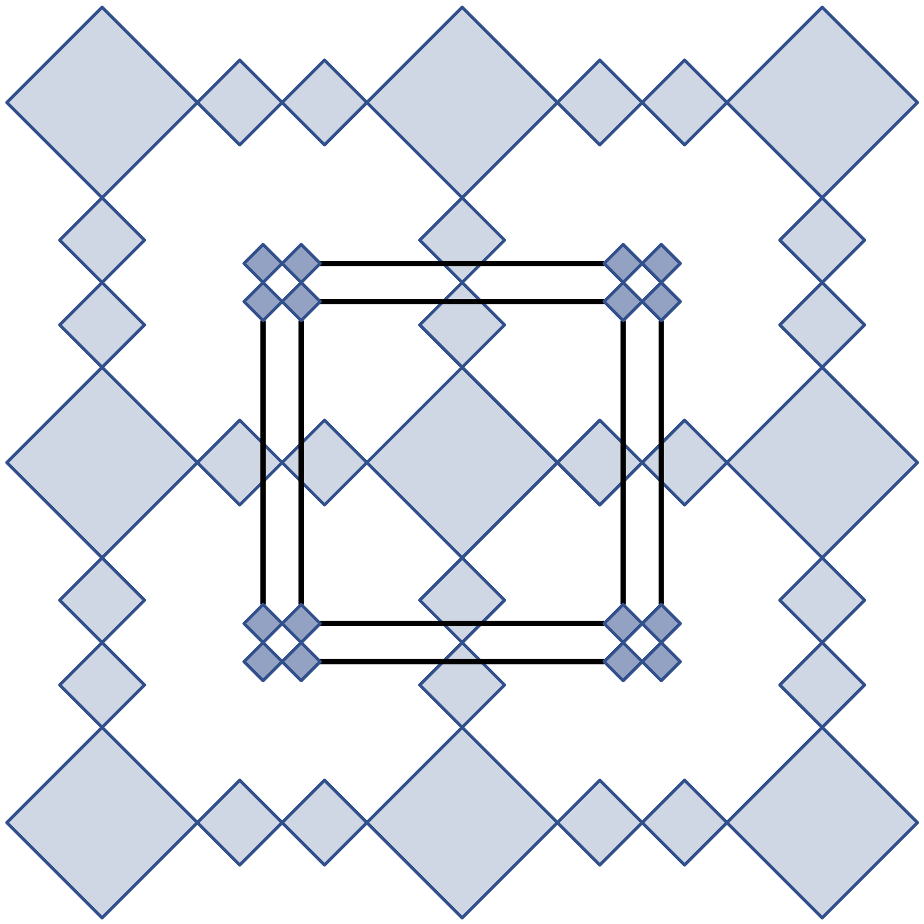

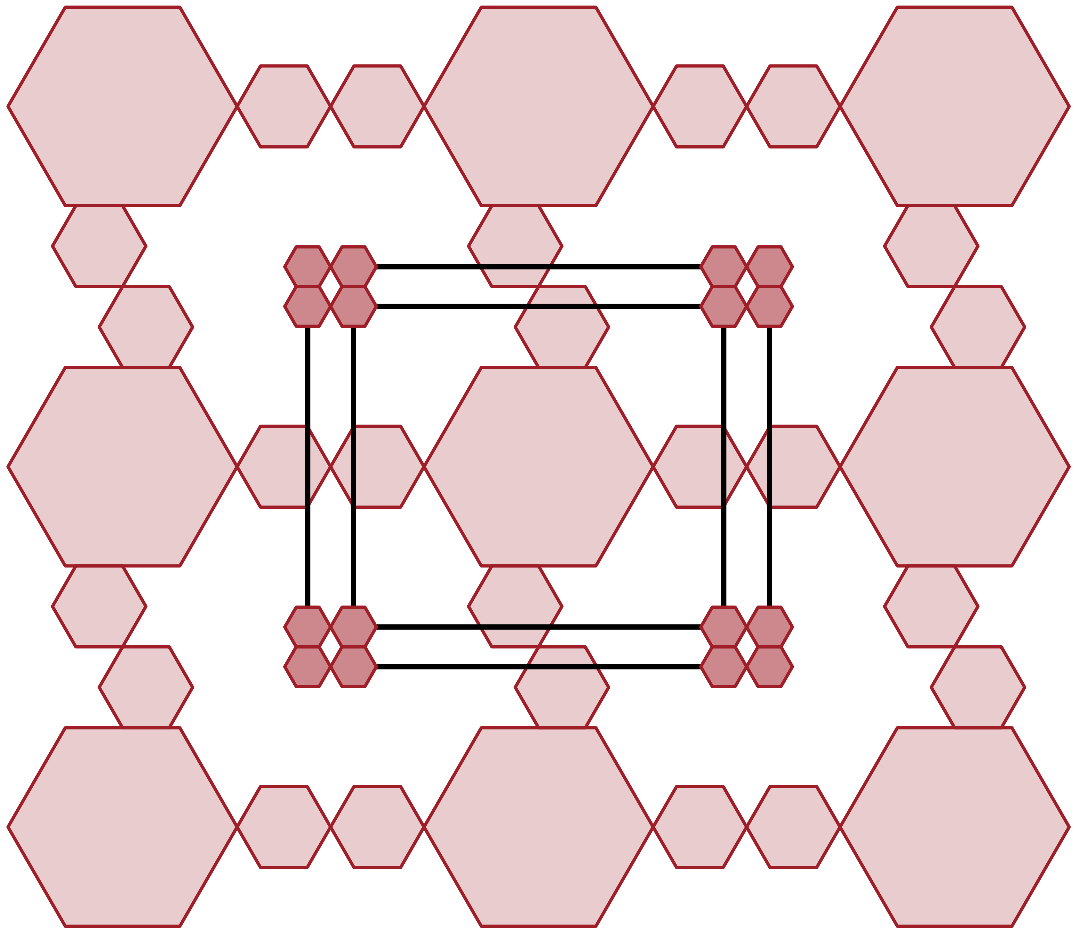

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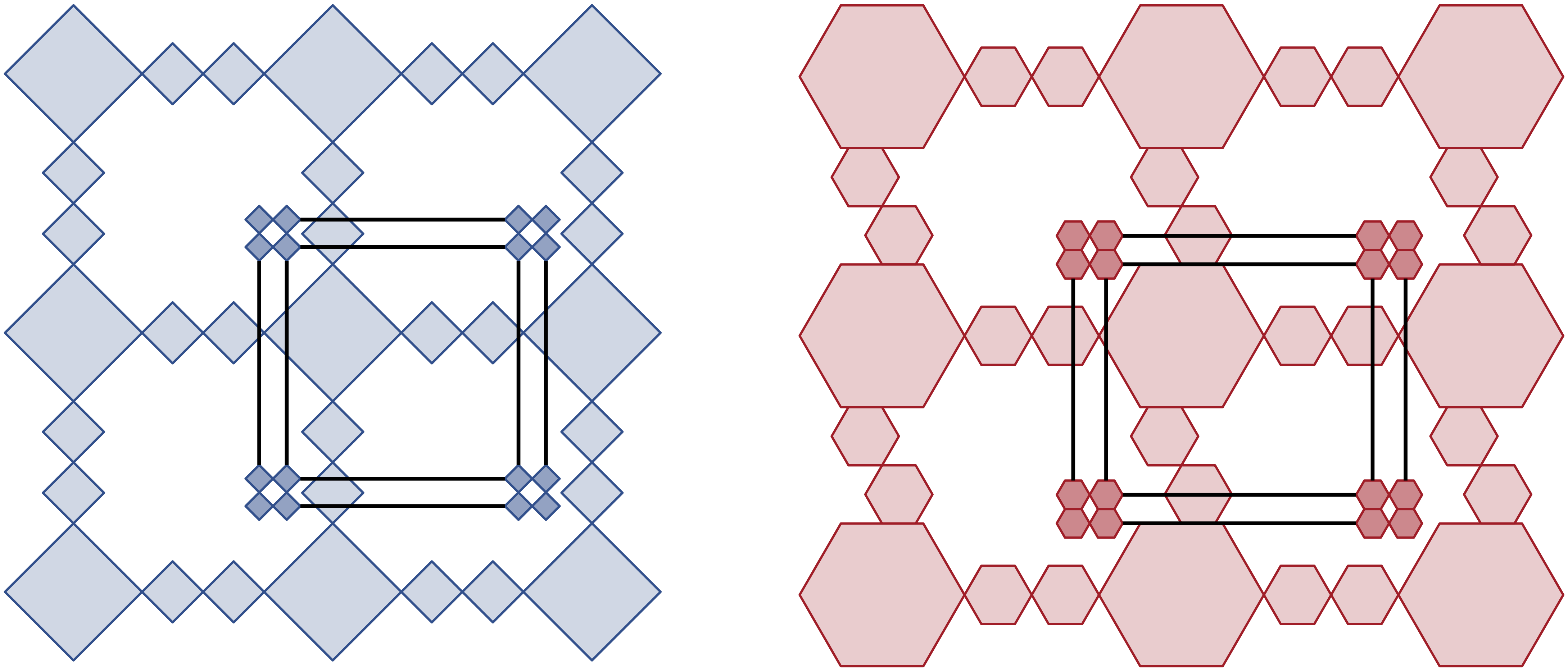

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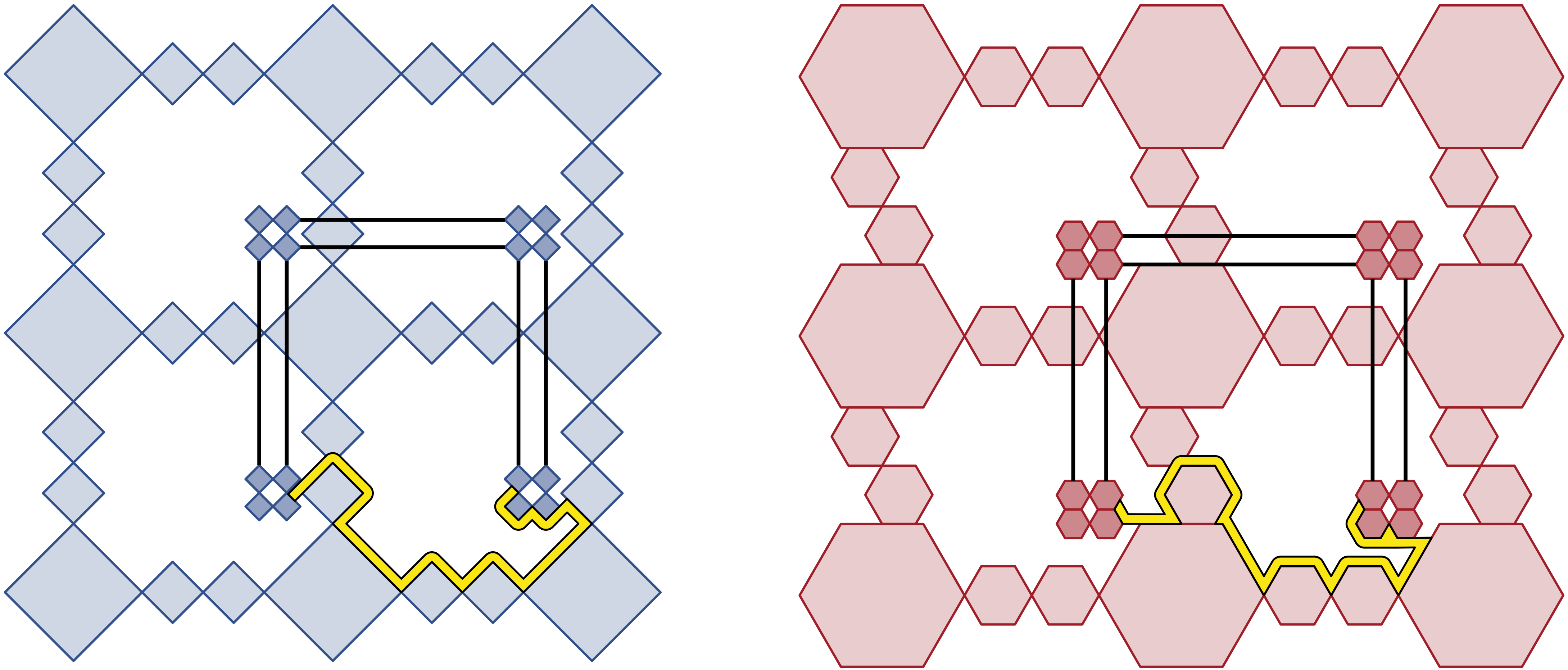

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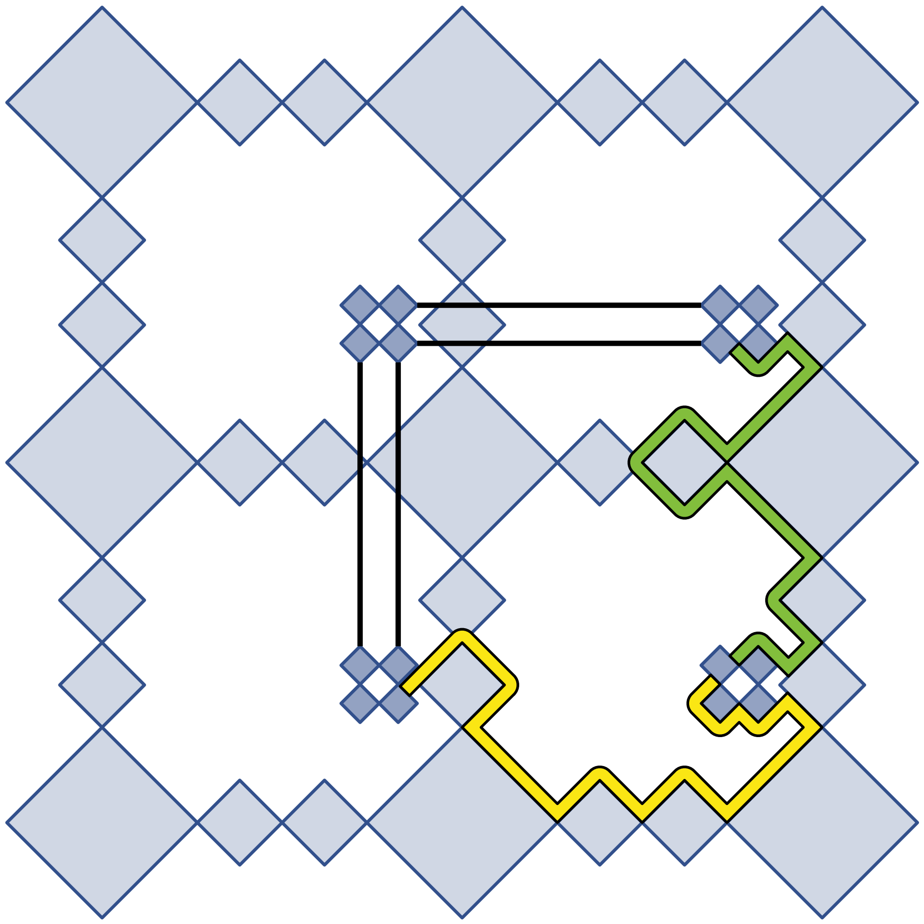

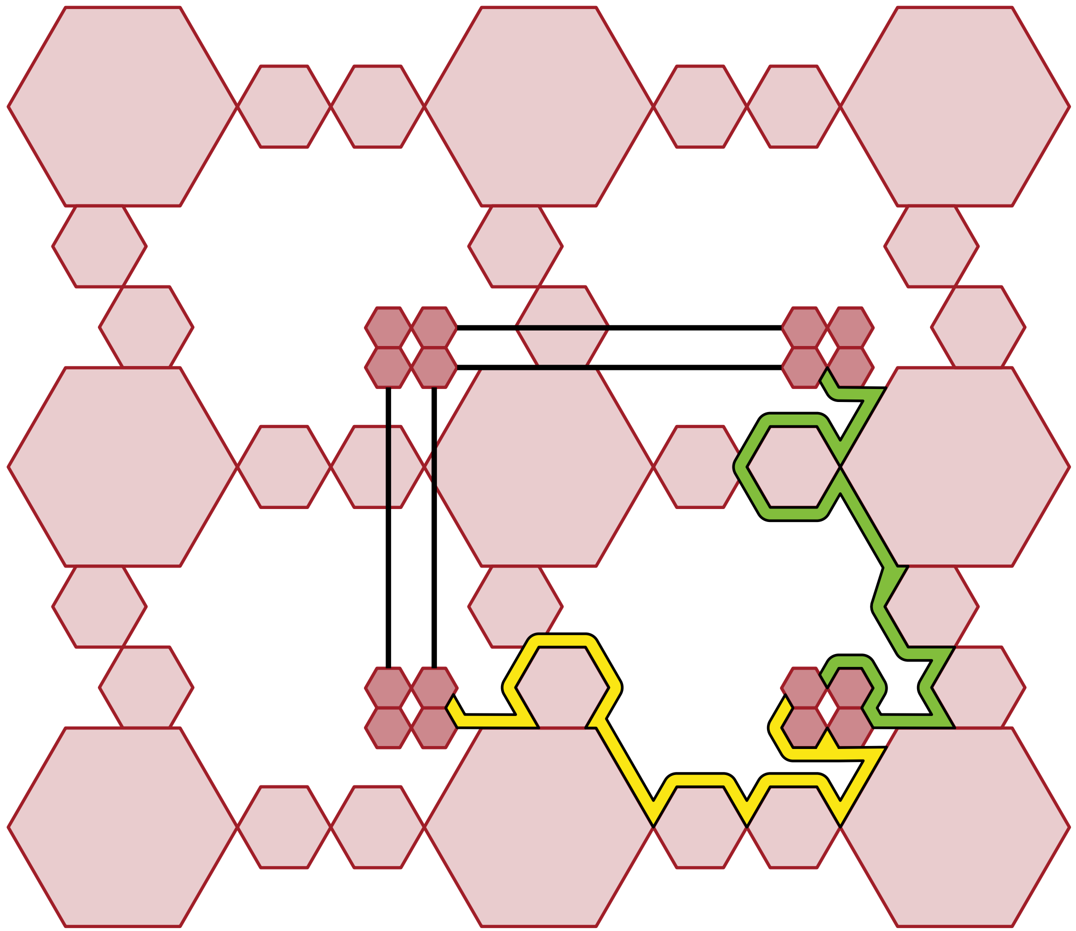

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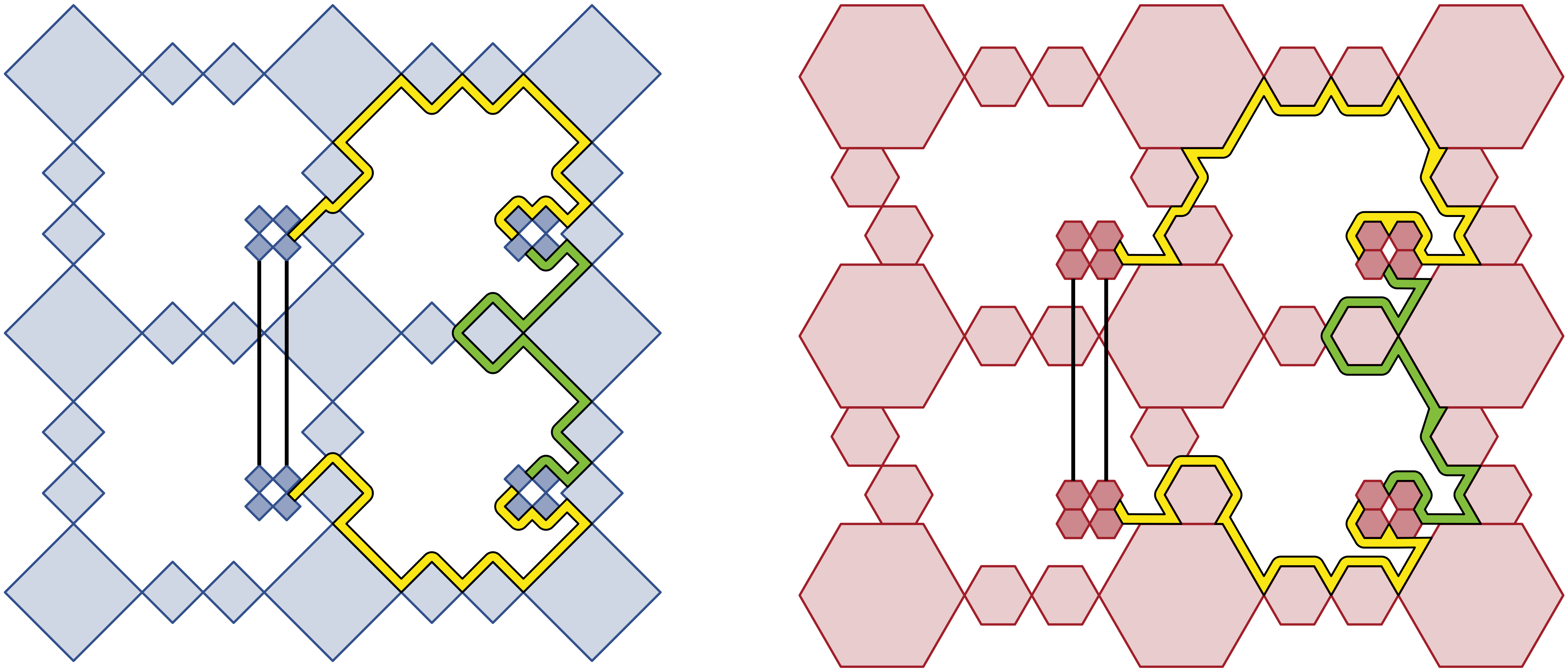

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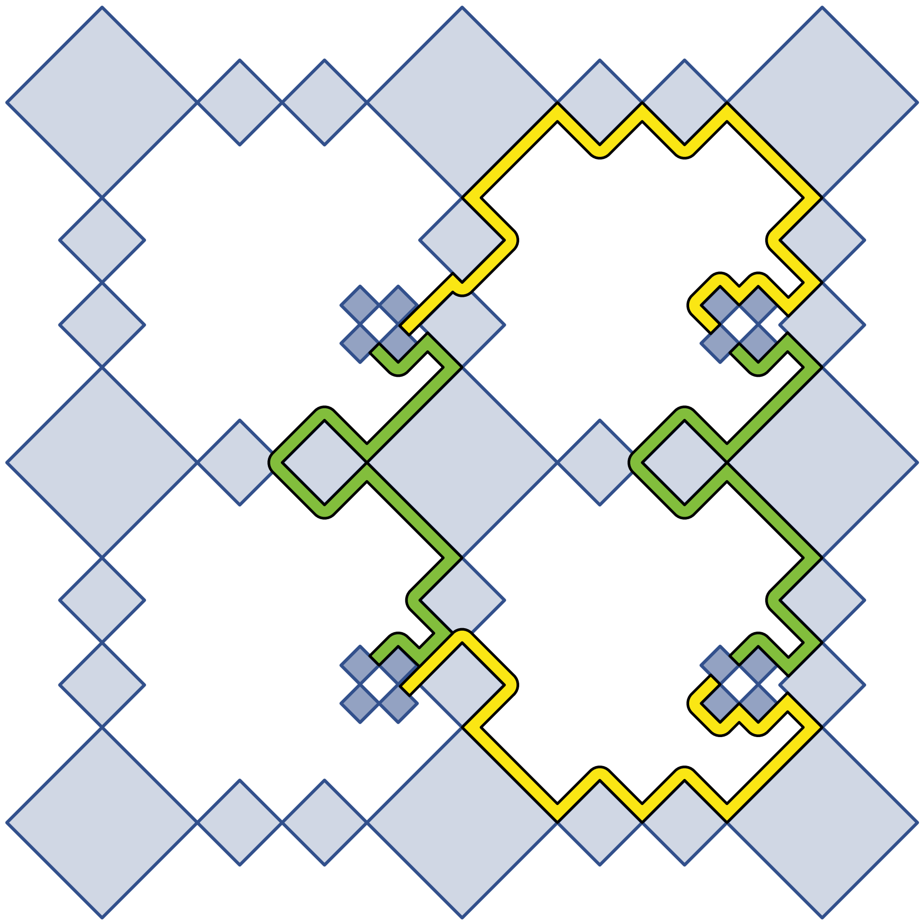

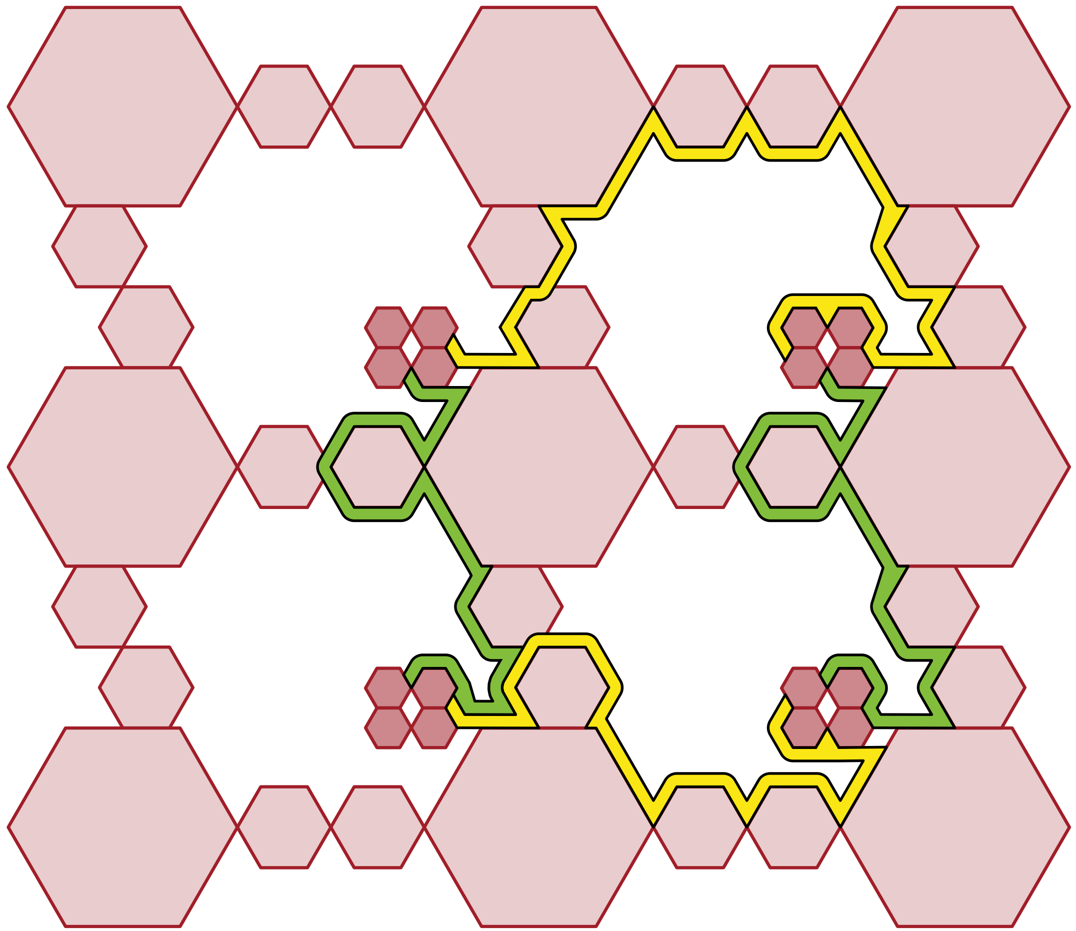

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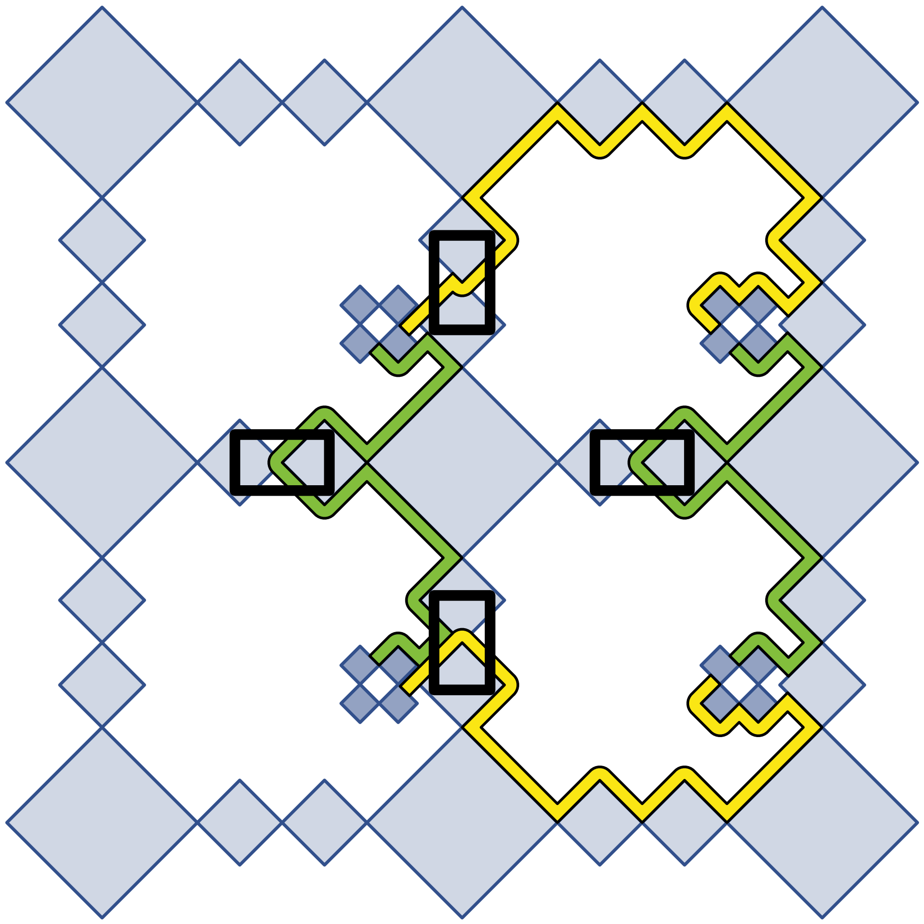

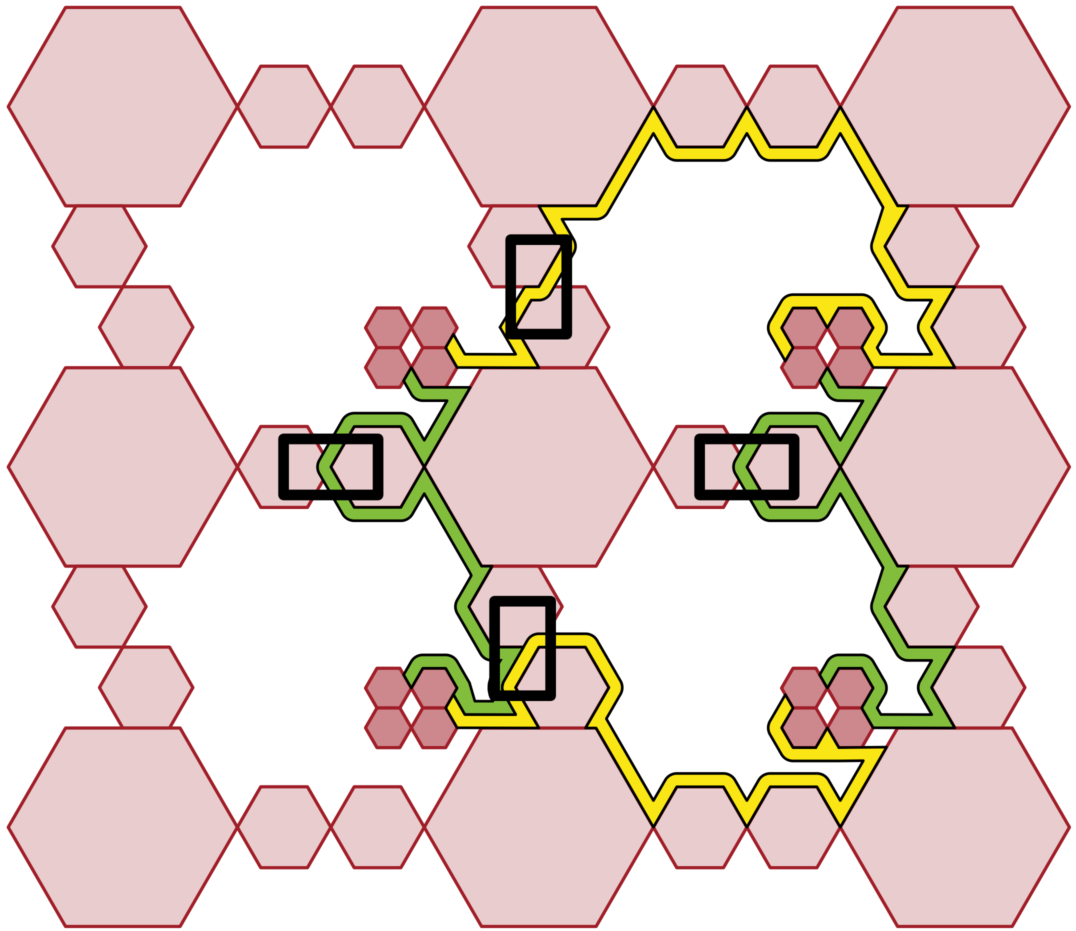

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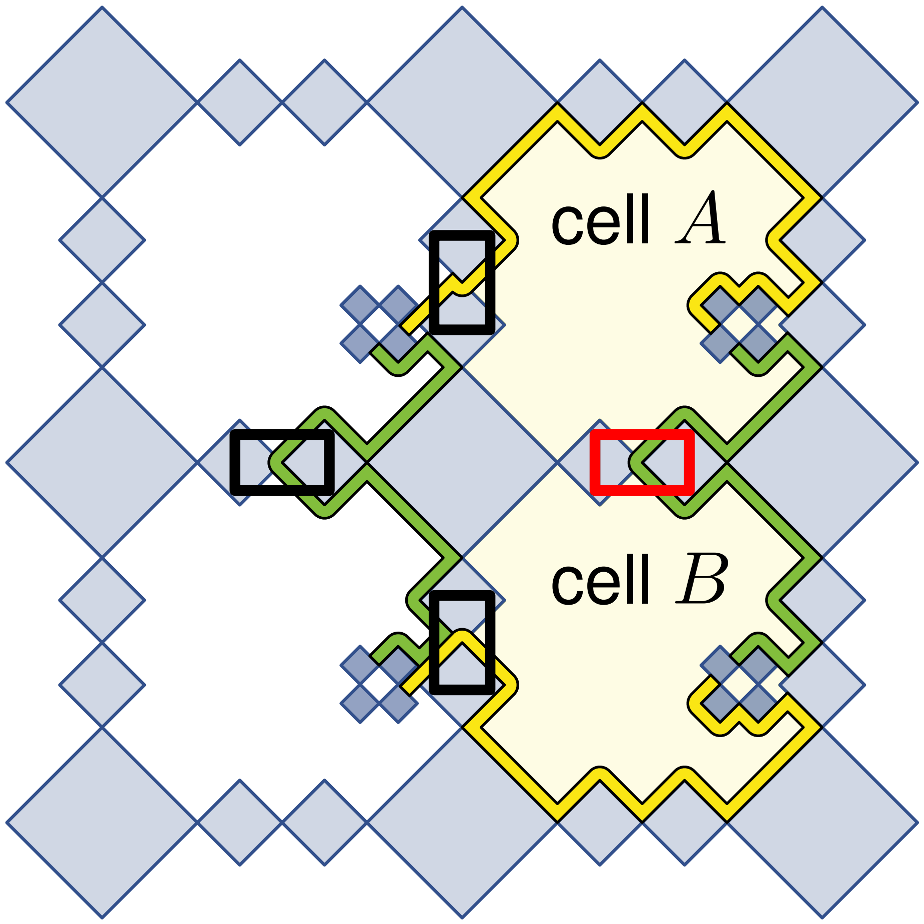
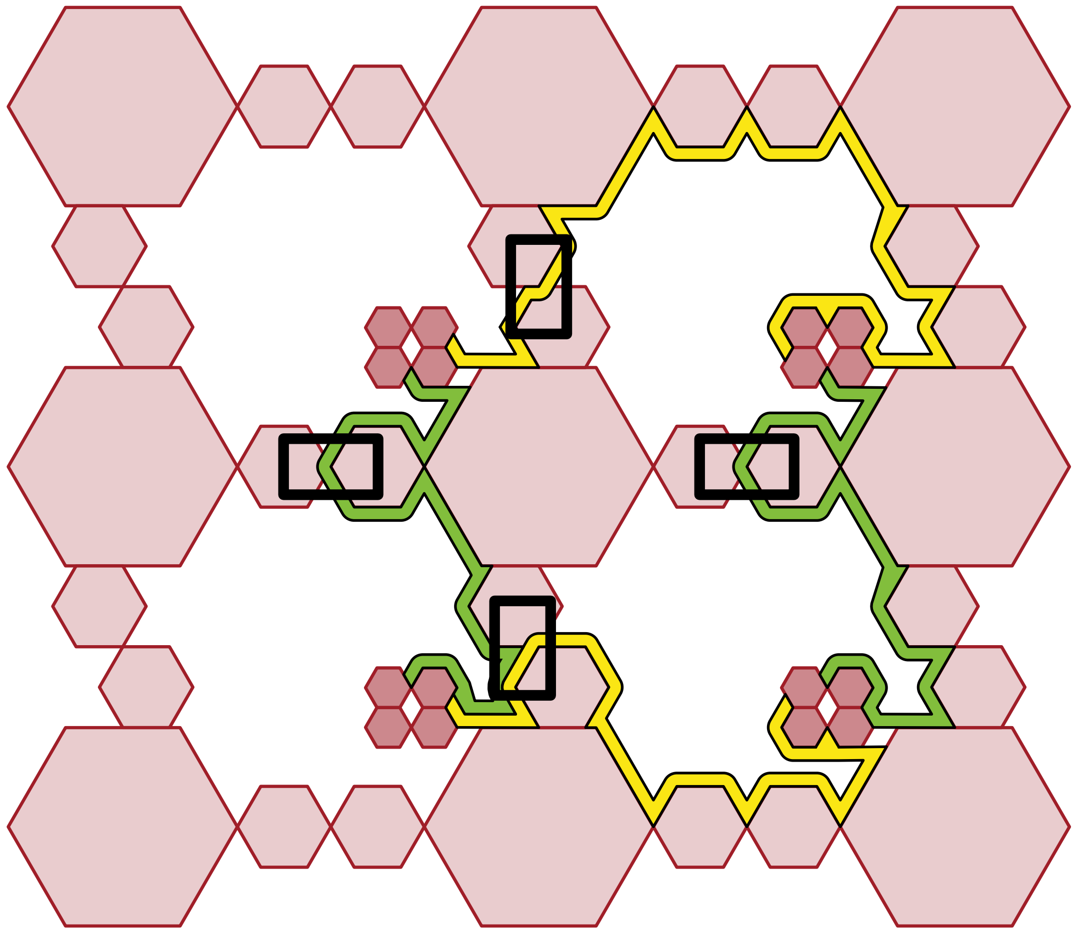
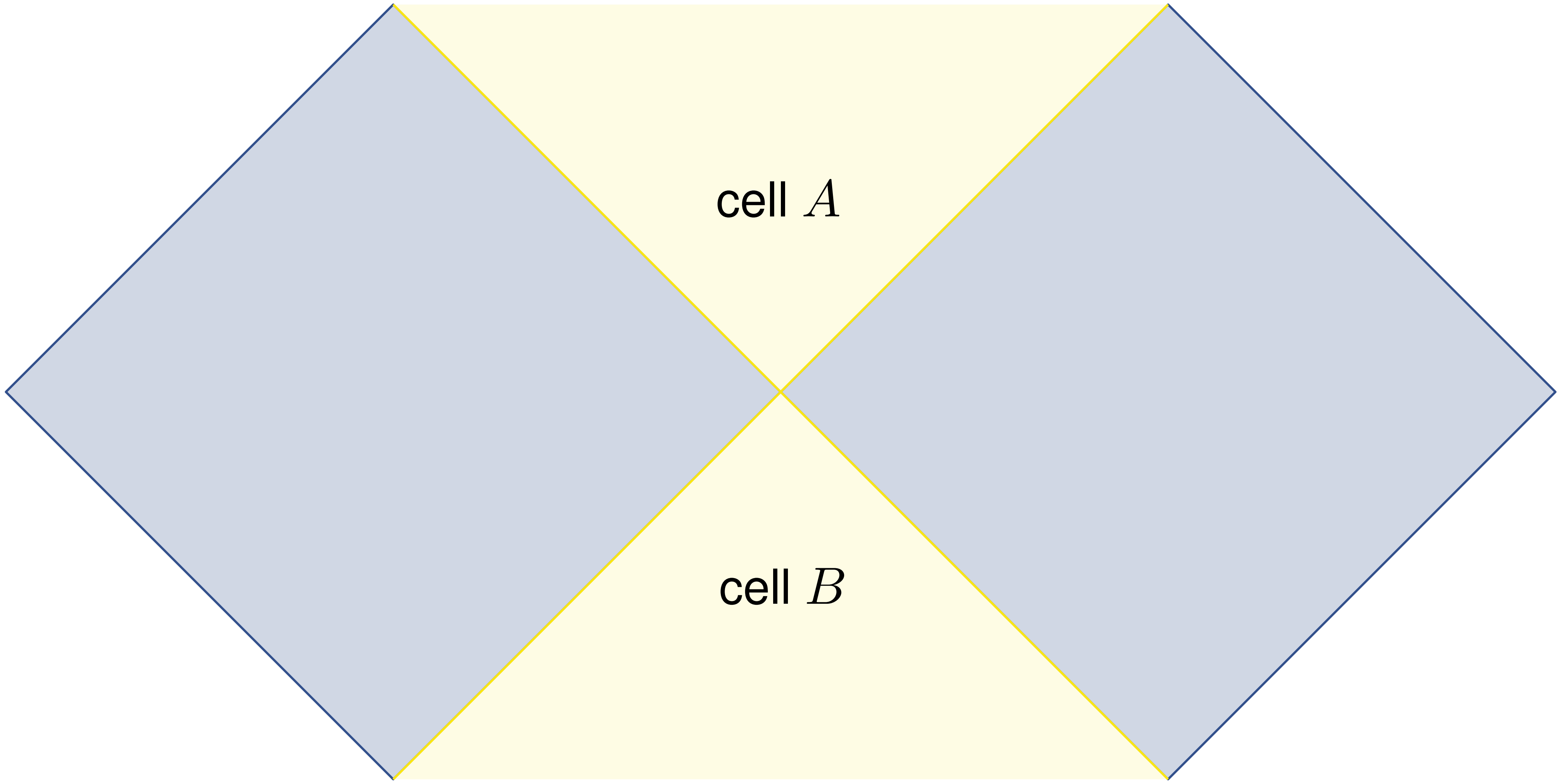




Independent Edges Between Cells: Rectangles



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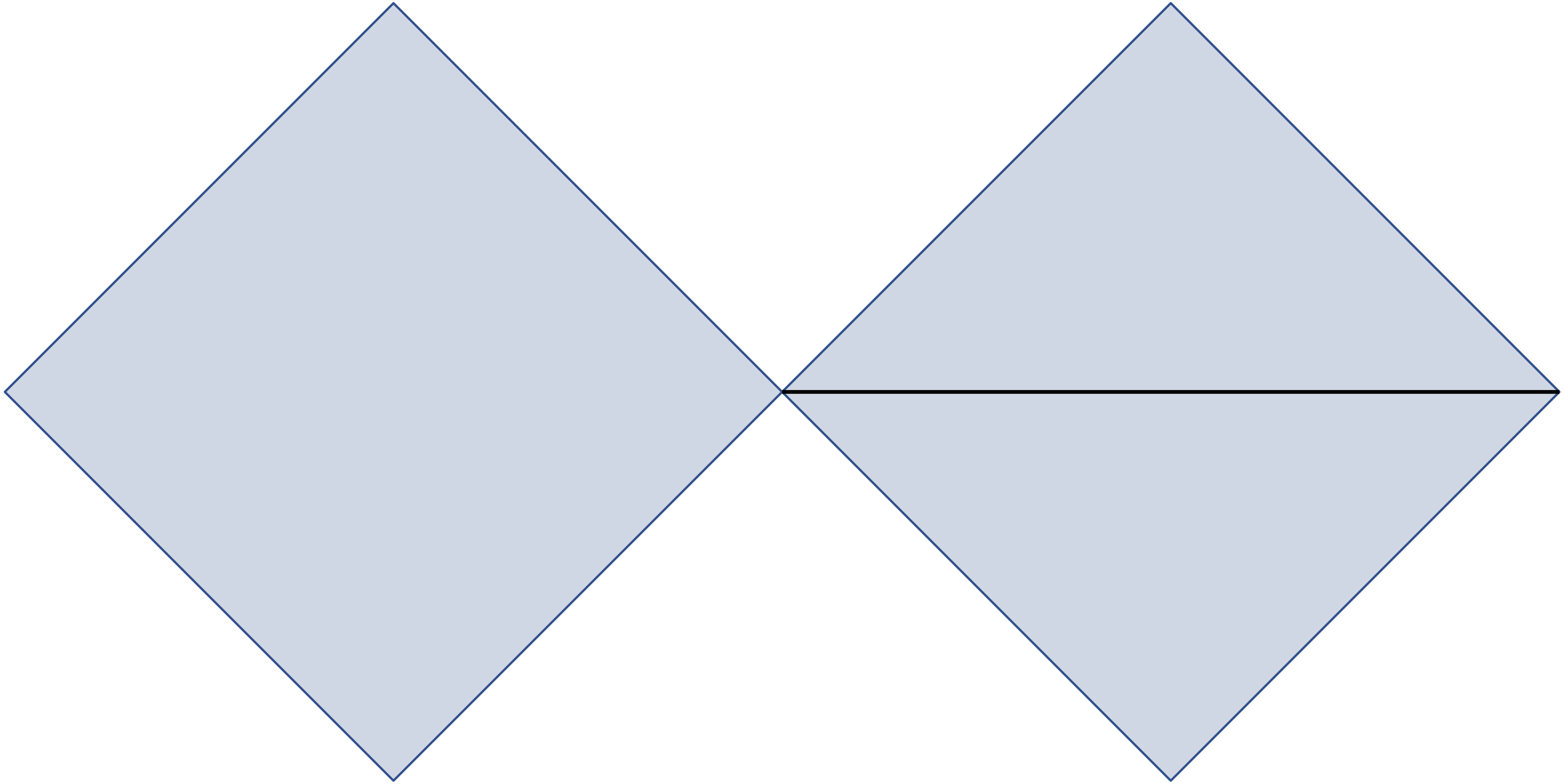

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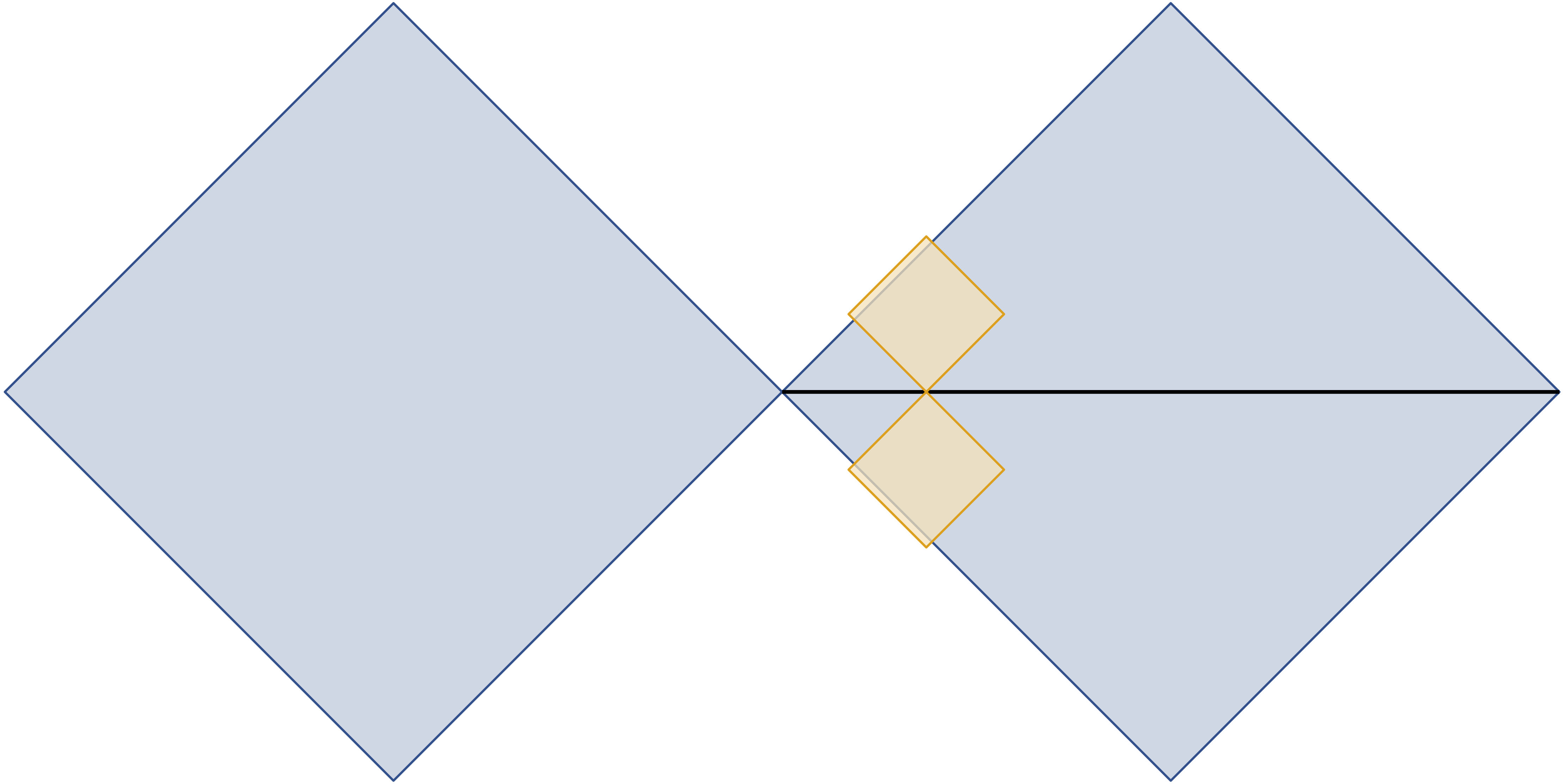

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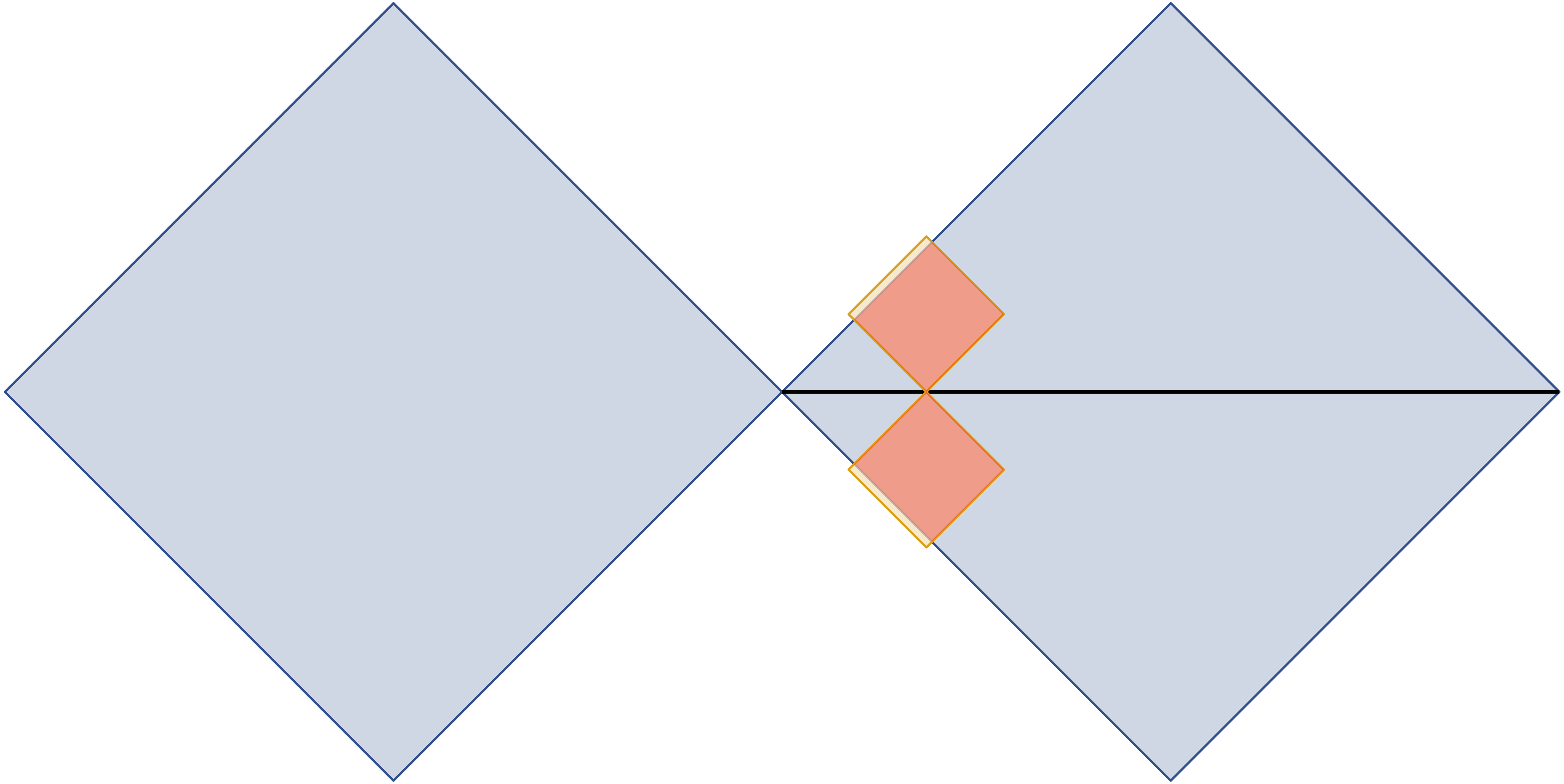

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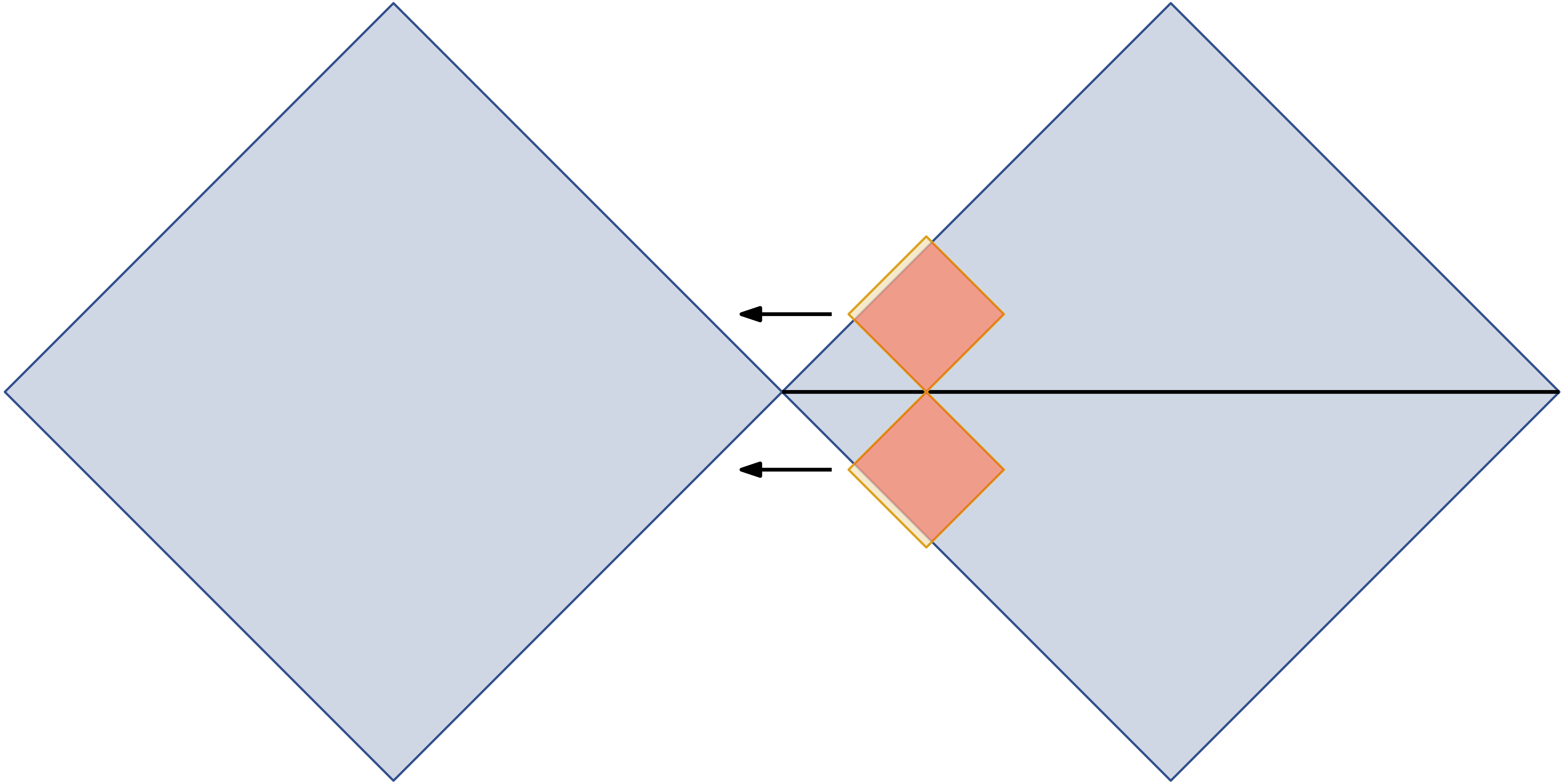

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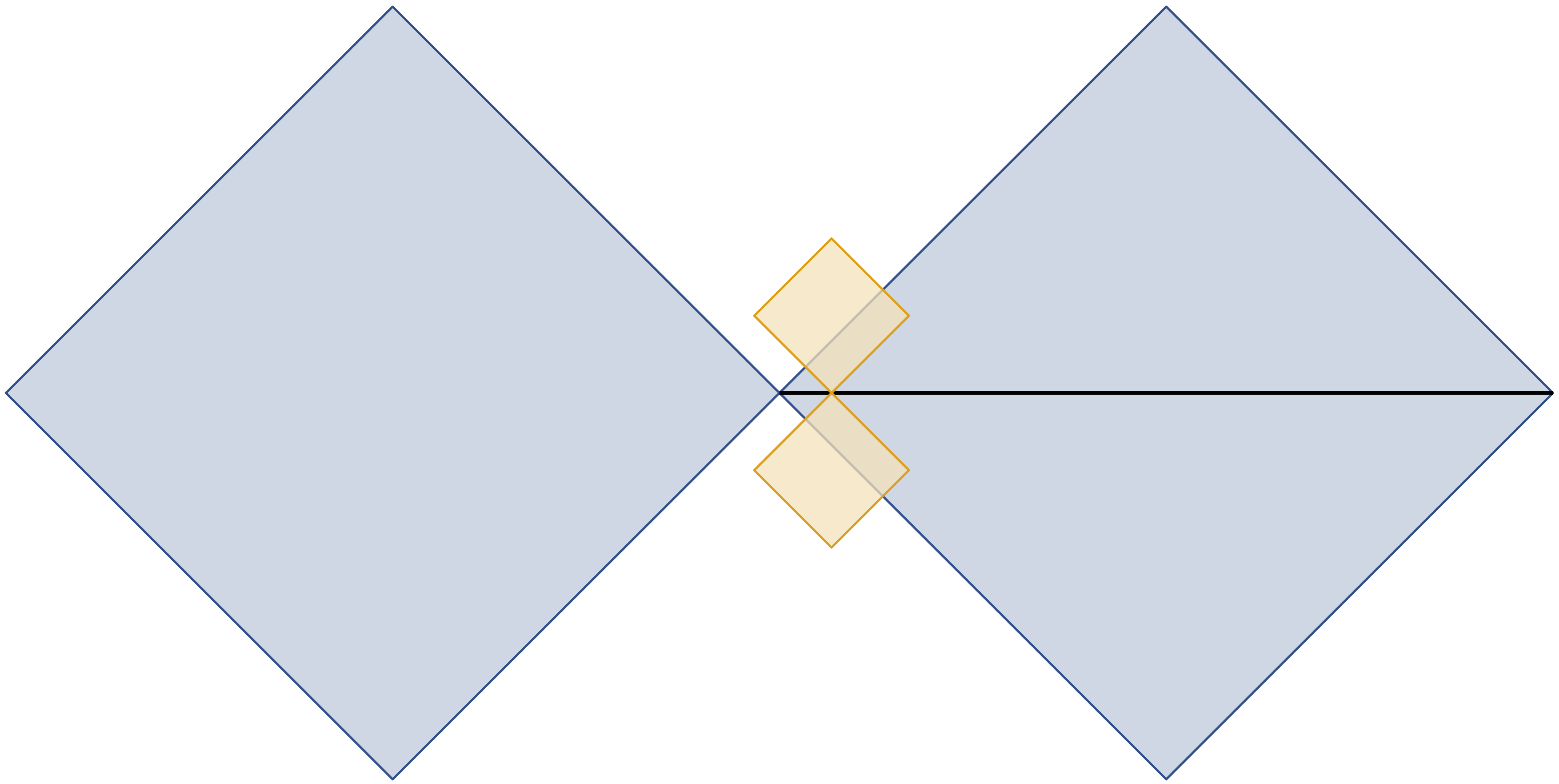

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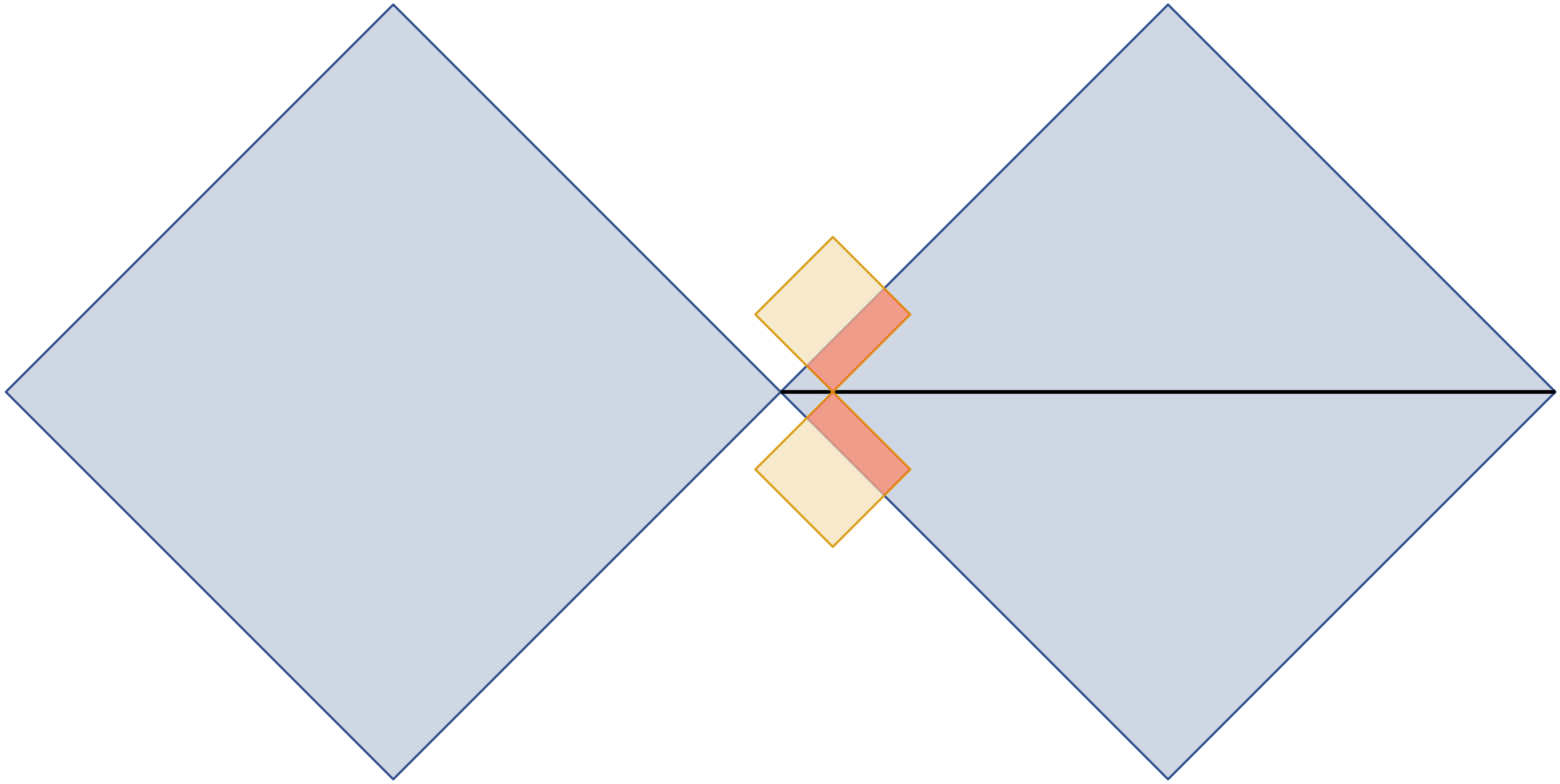

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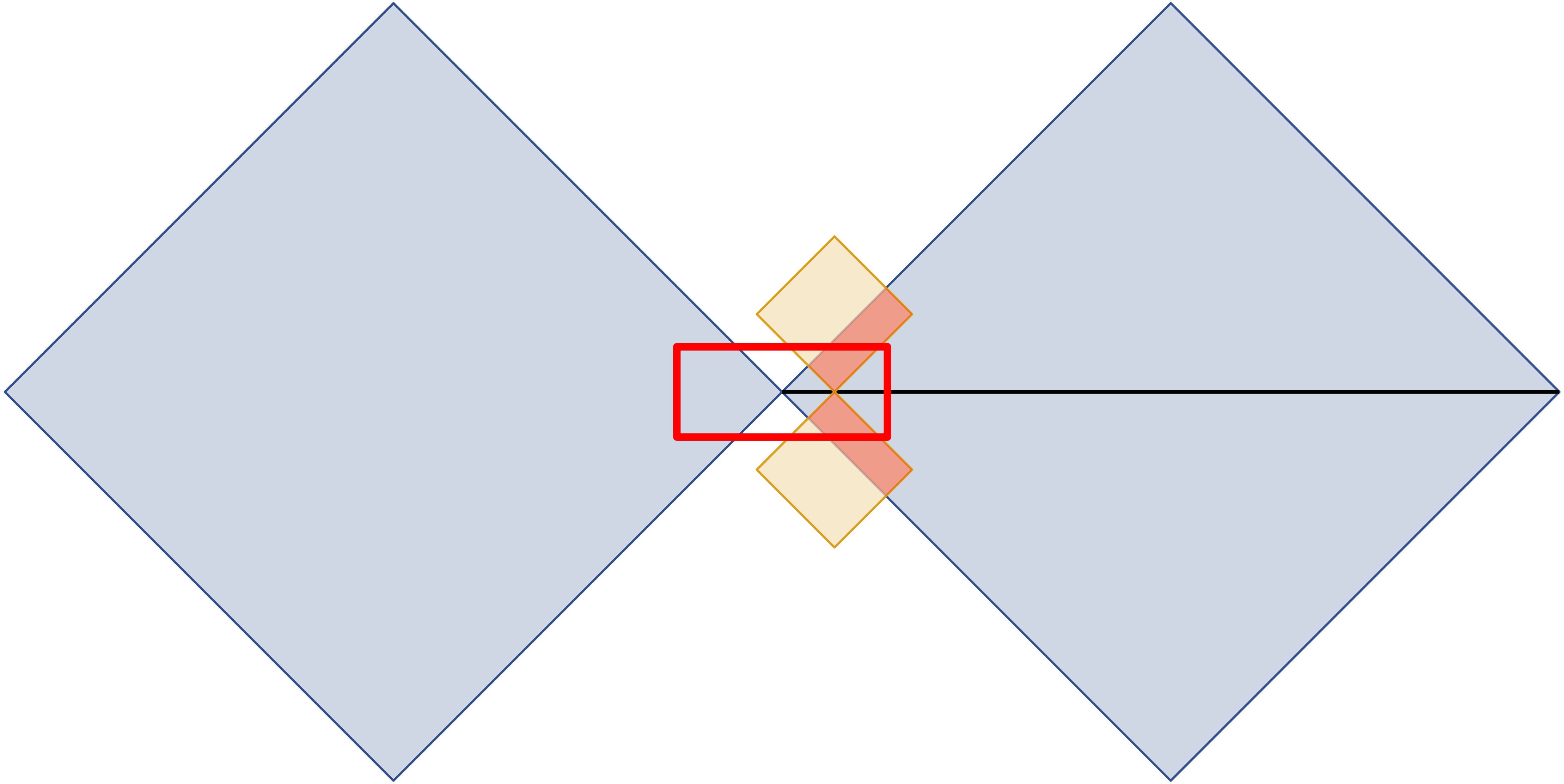

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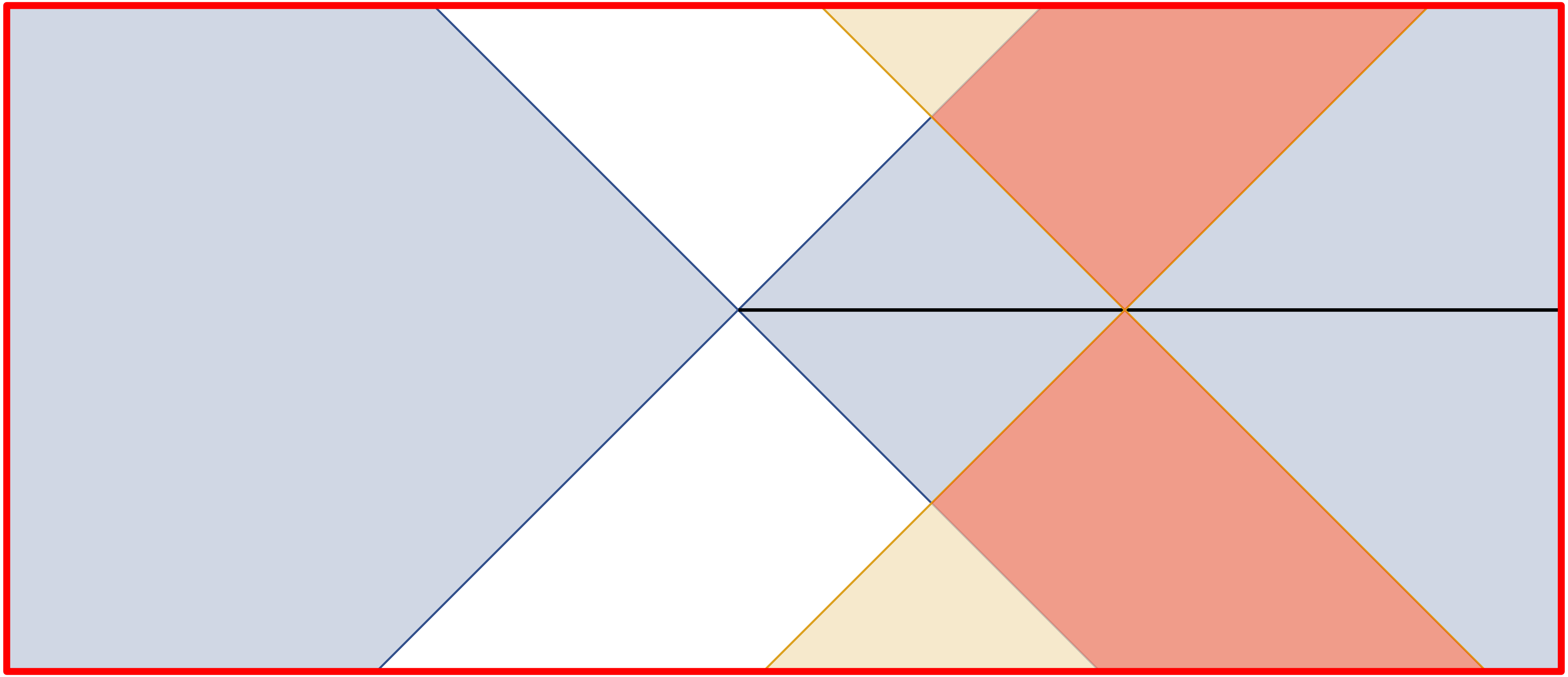

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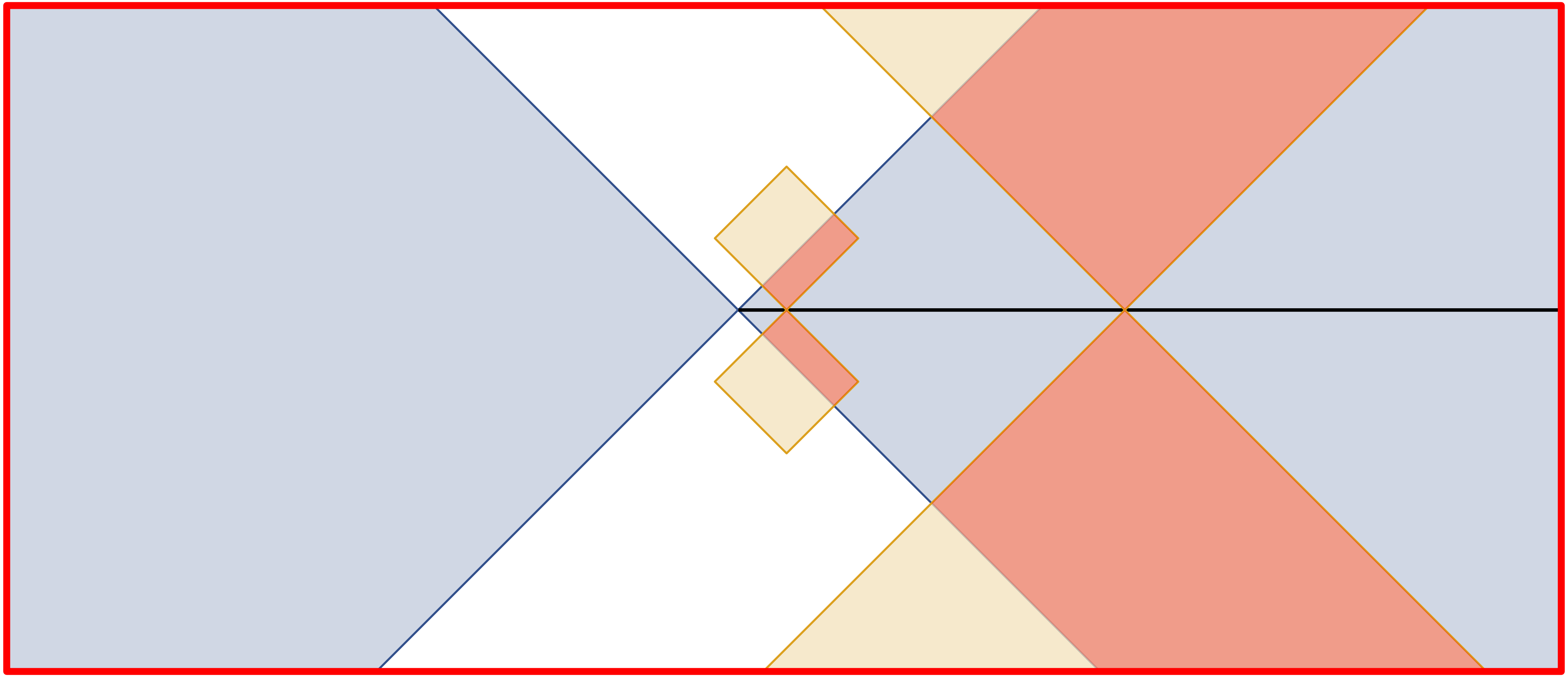

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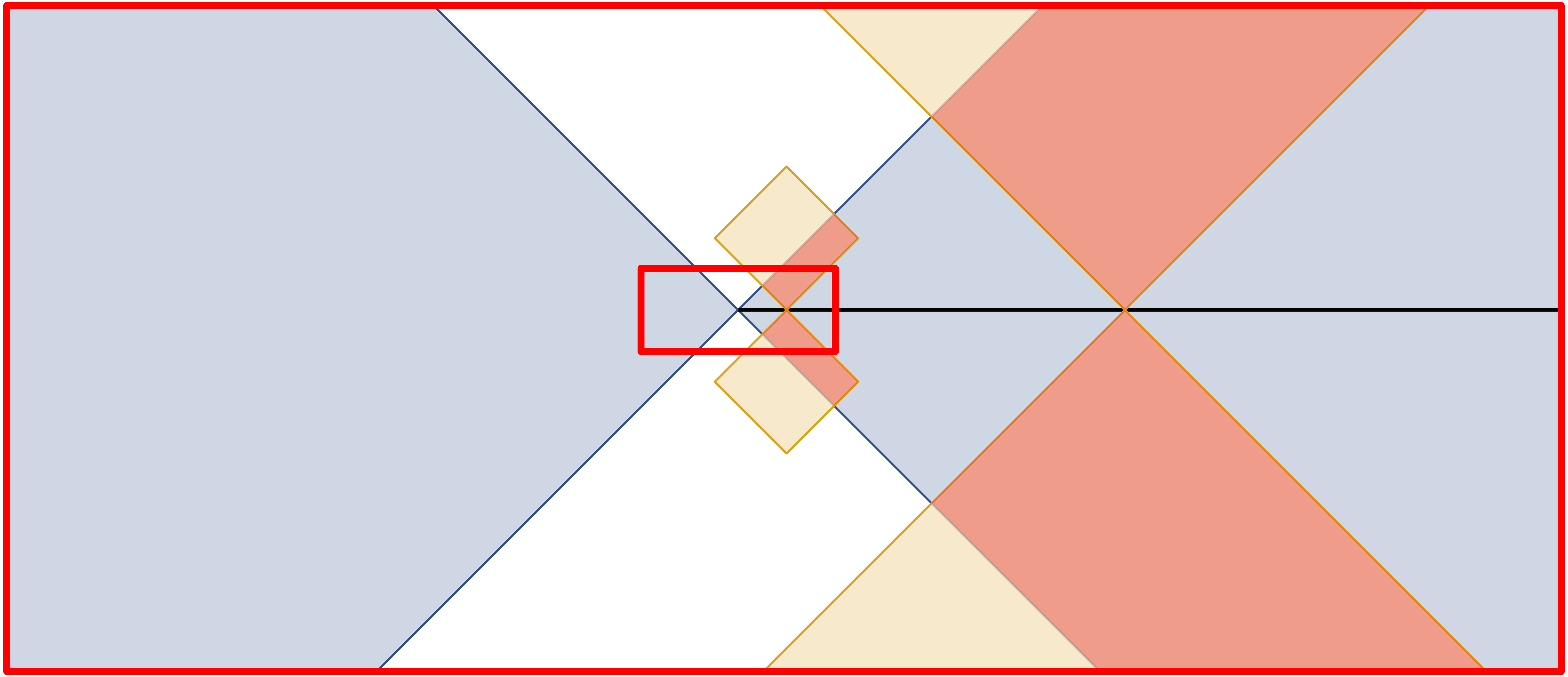

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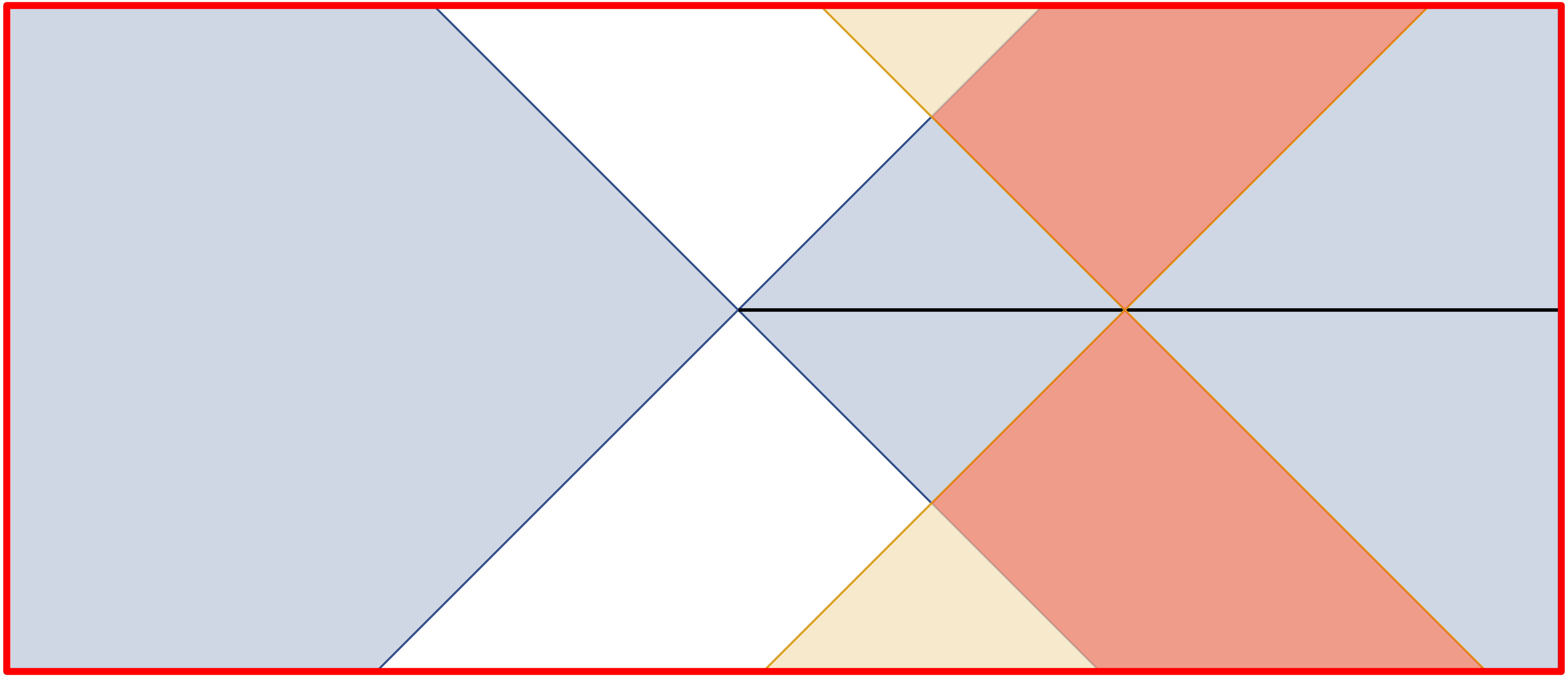

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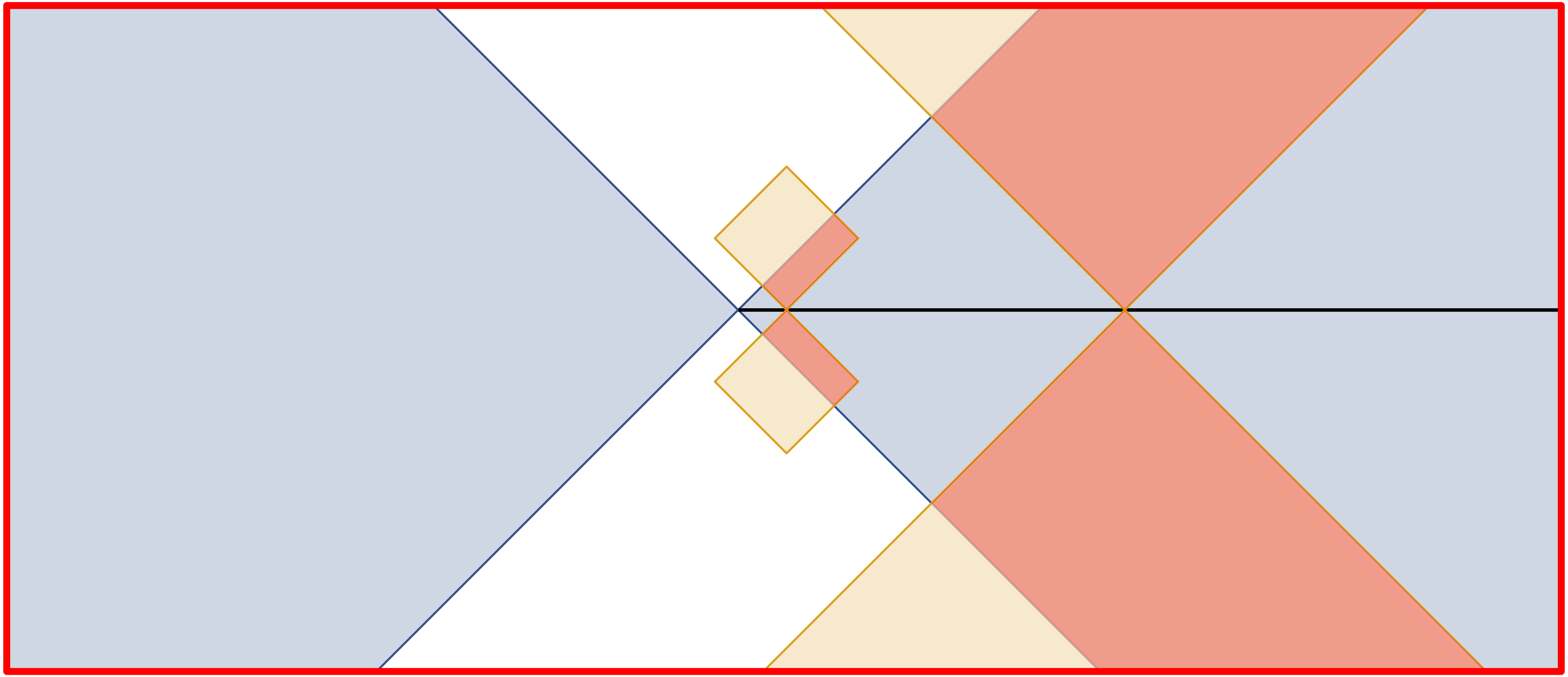

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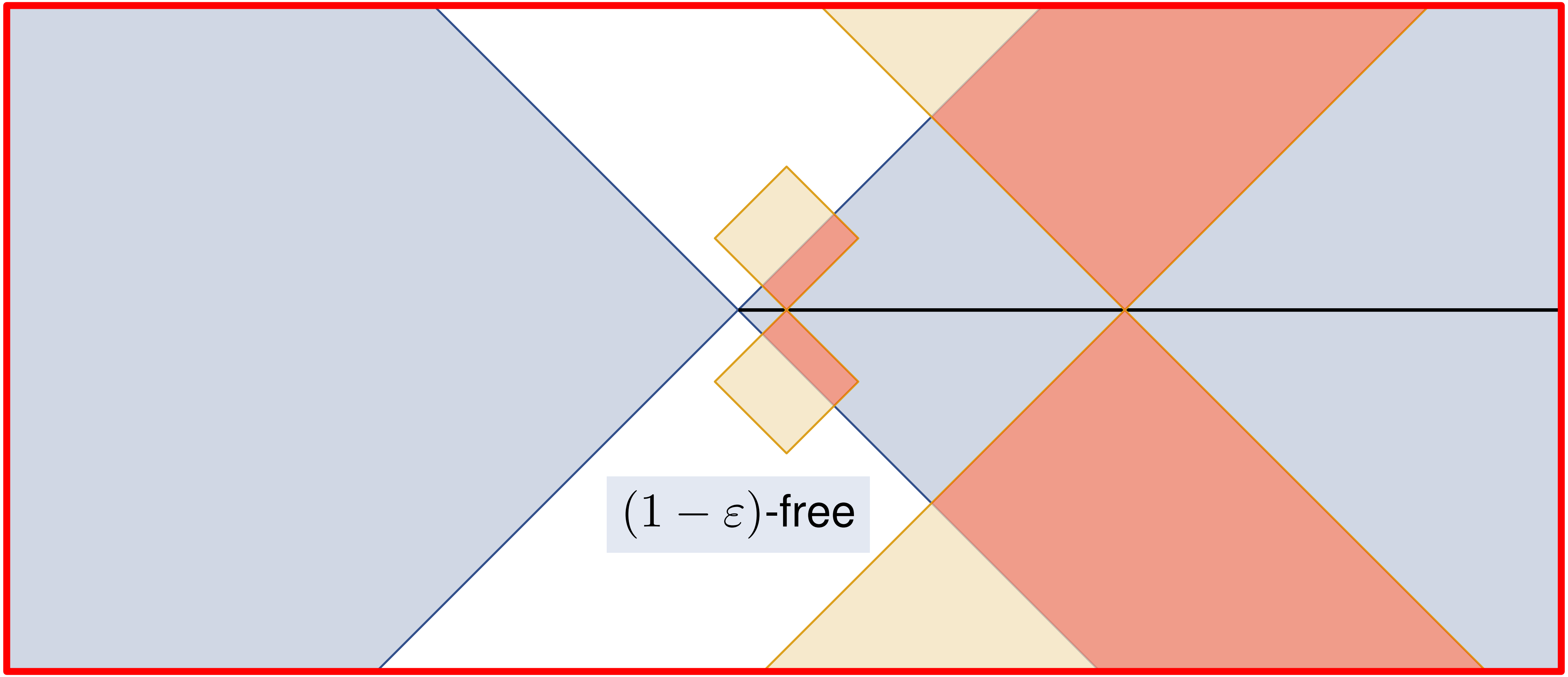
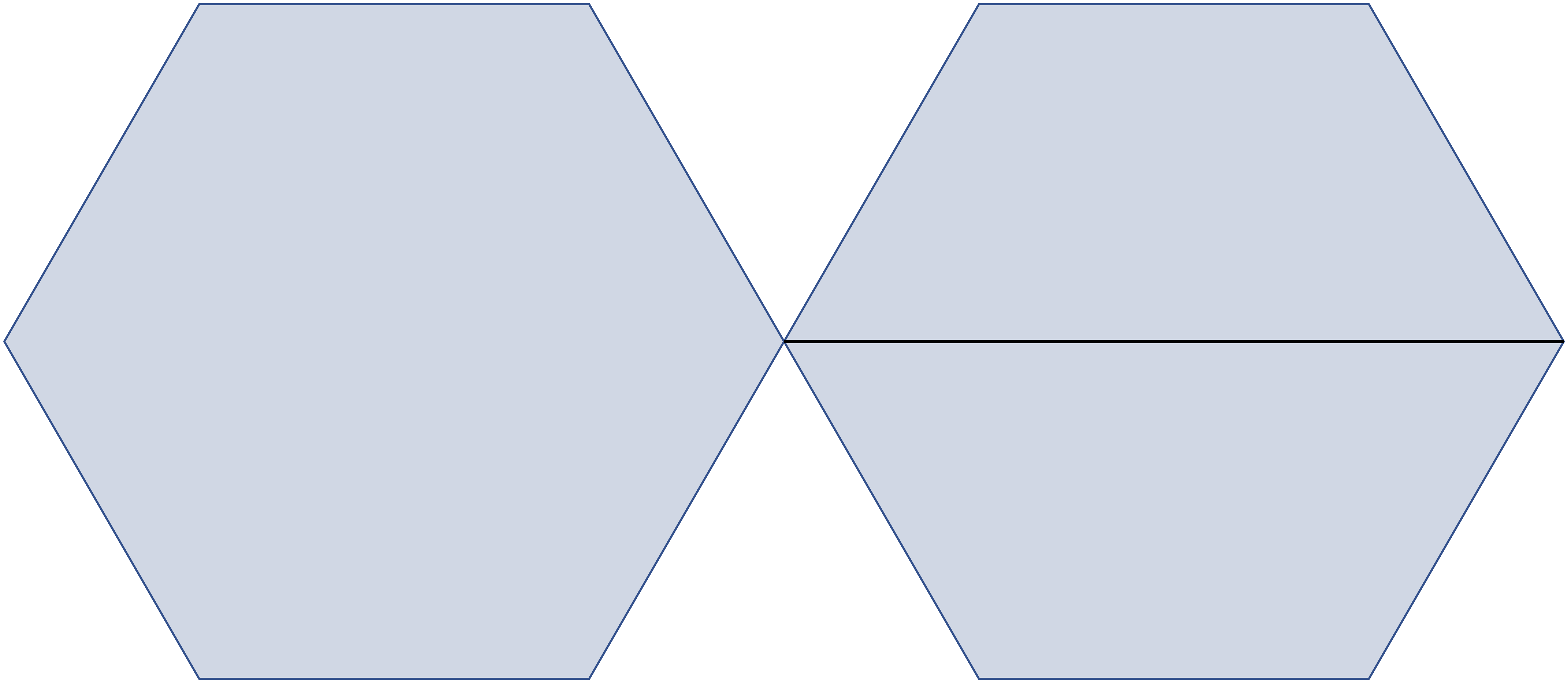


Independent Edges Between Cells: Hexagons



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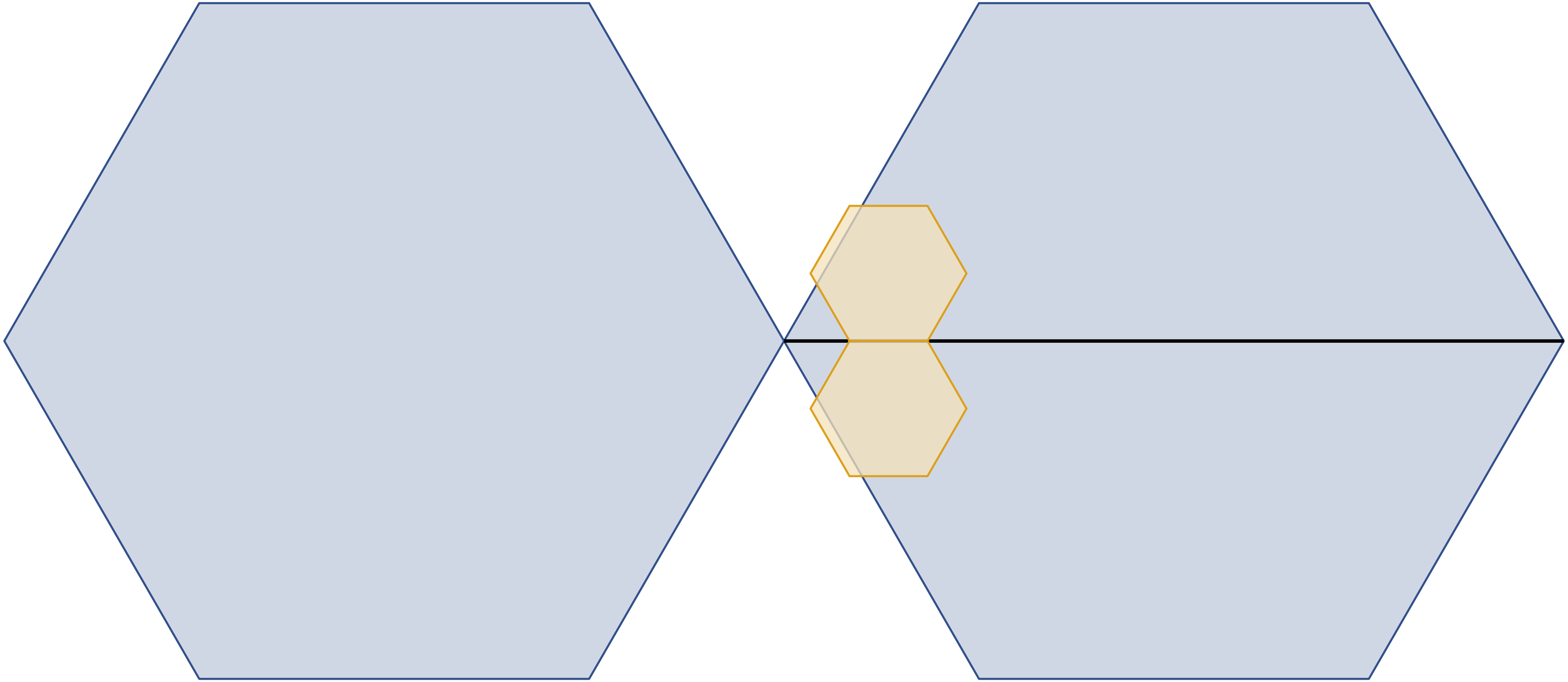

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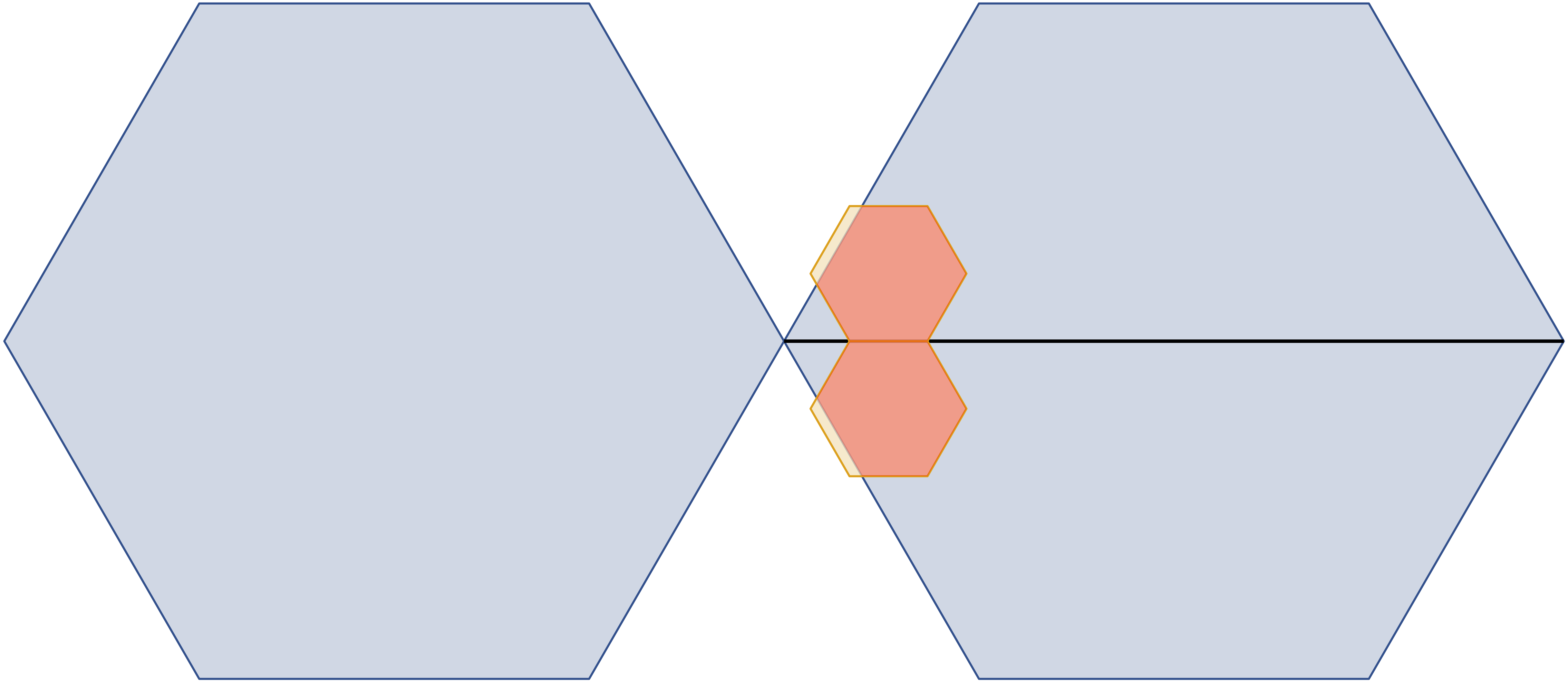

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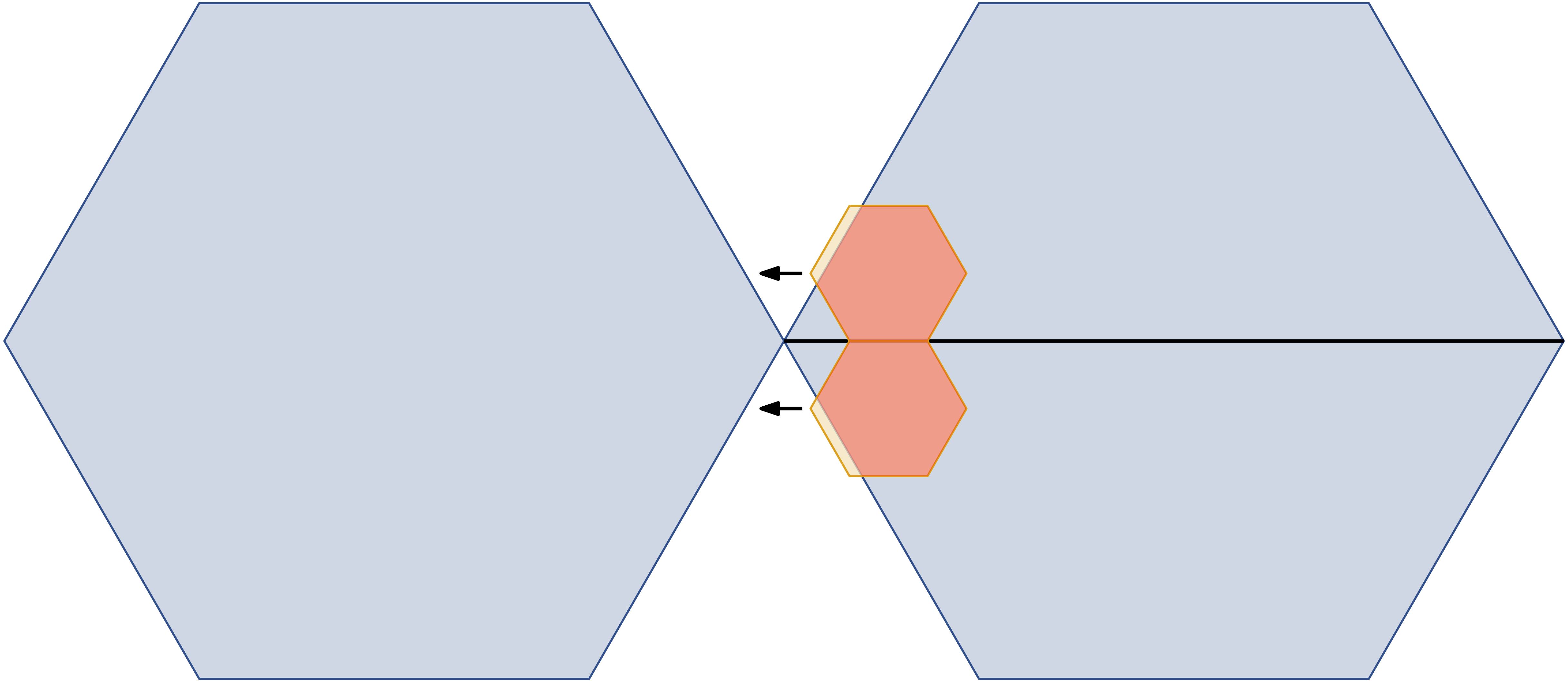

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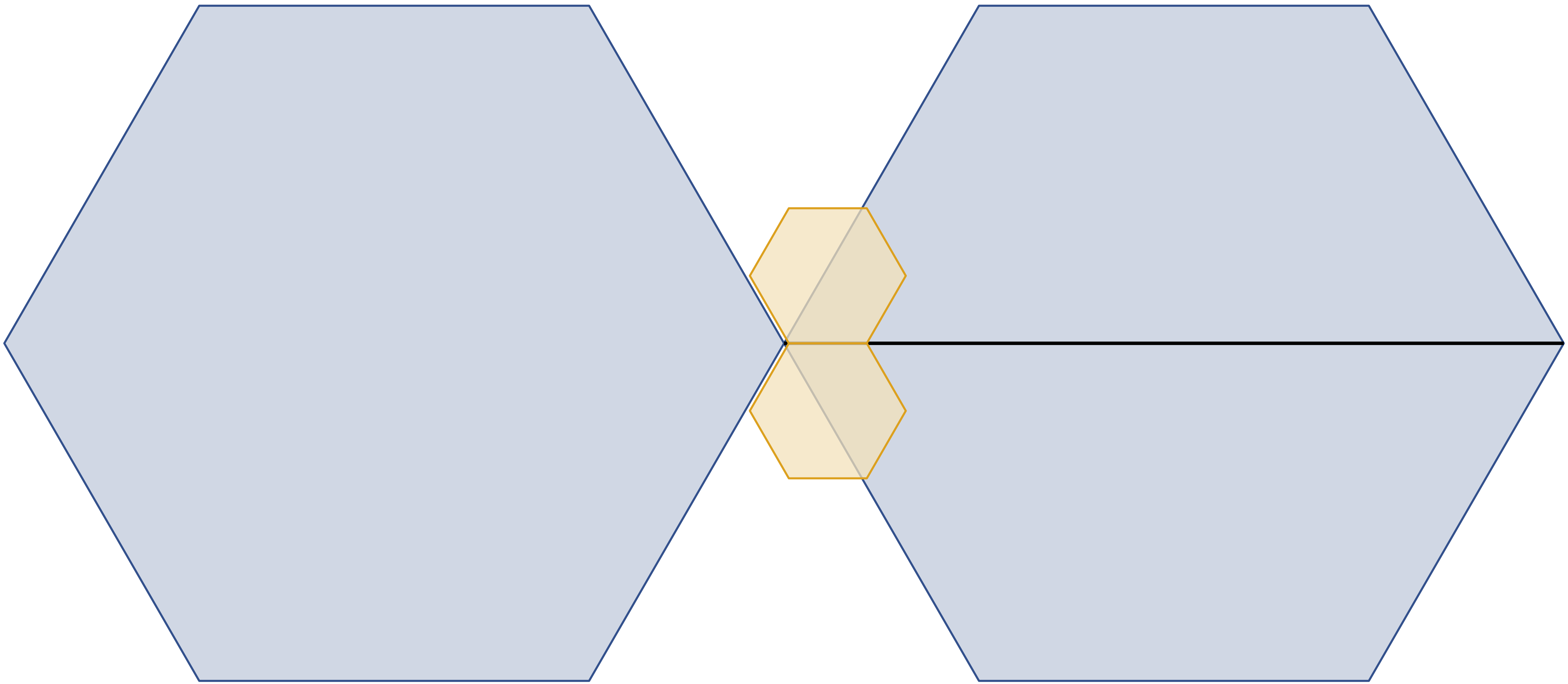

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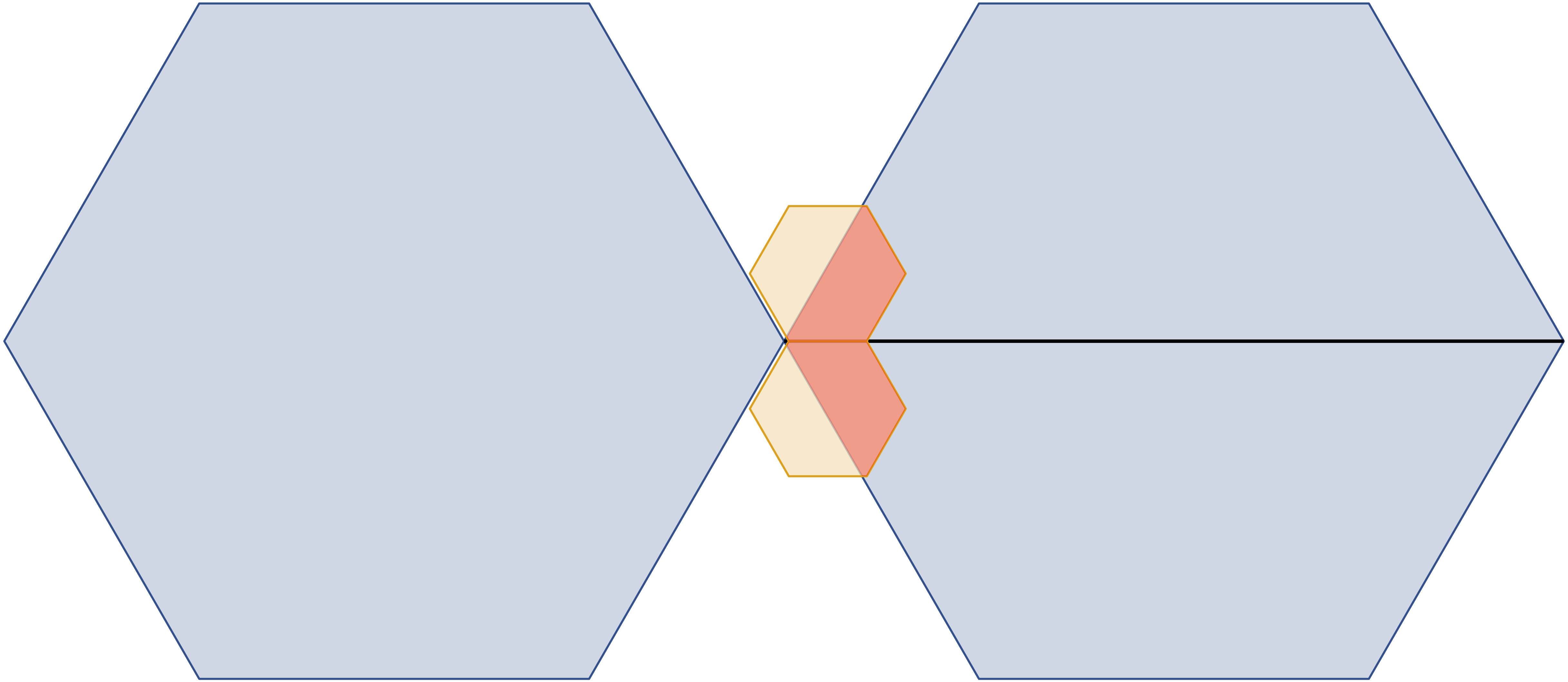
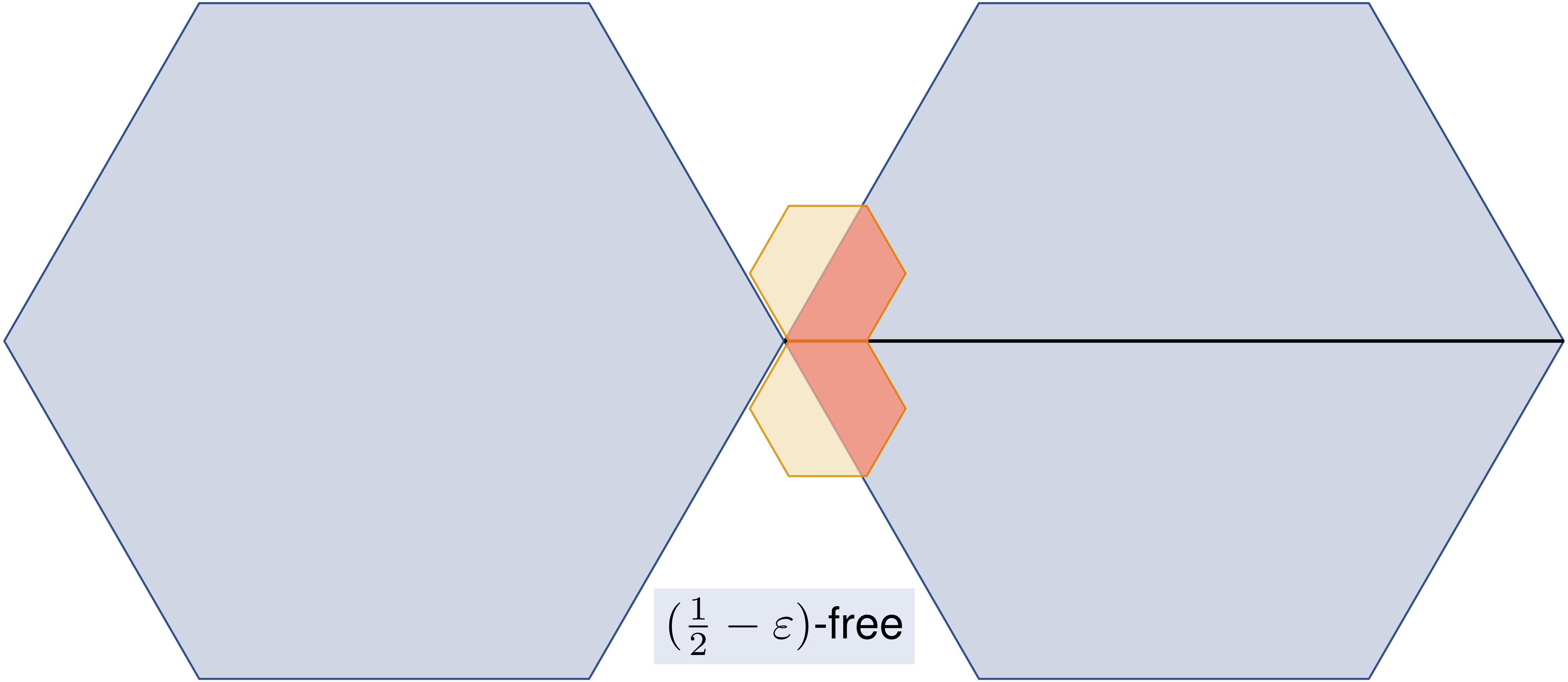
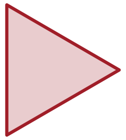
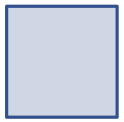
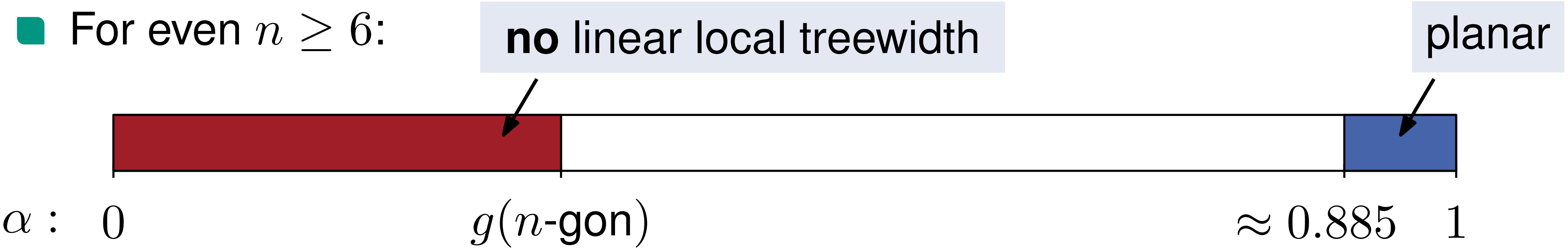


Independent Edges Between Cells: Hexagons



Our Results for Regular n-gons

- For  and  : **no** product structure for $\alpha < 1$.
- For even $n \geq 6$:



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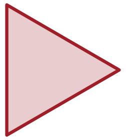
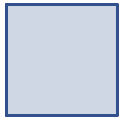
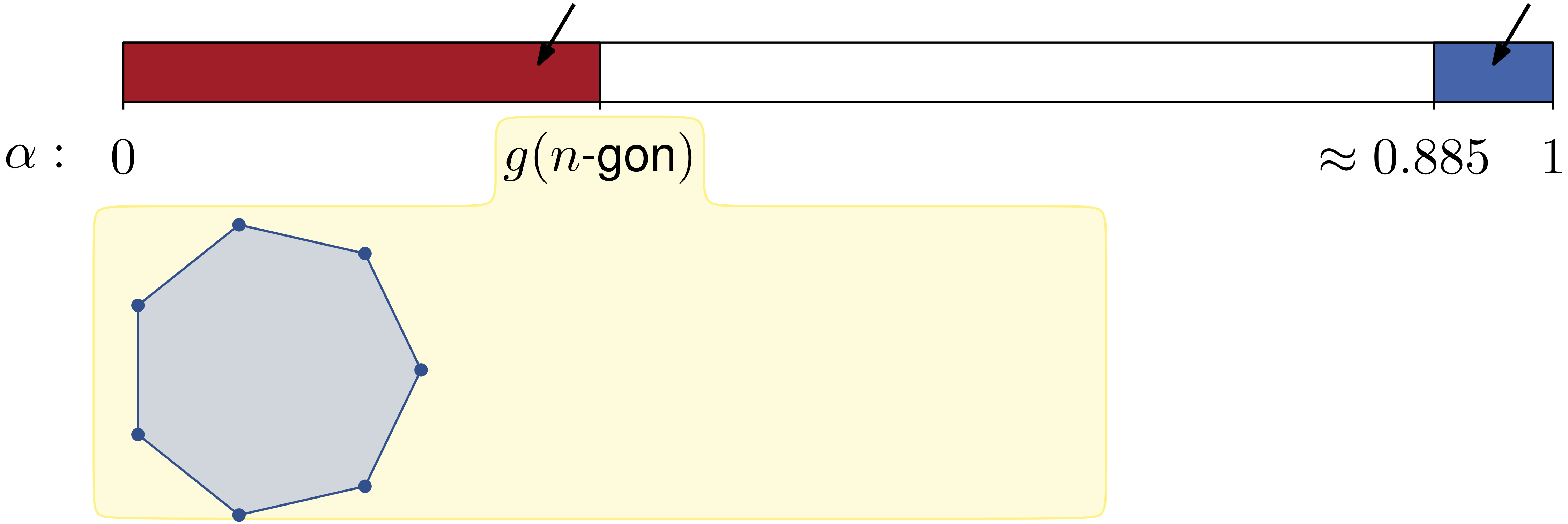
Our Results for Regular n-gons

- For  and  : **no** product structure for $\alpha < 1$.
- For even $n \geq 6$:

no linear local treewidth

planar



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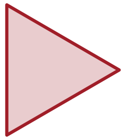
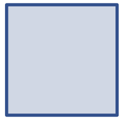
Our Results for Regular n-gons

- For  and  : **no** product structure for $\alpha < 1$.
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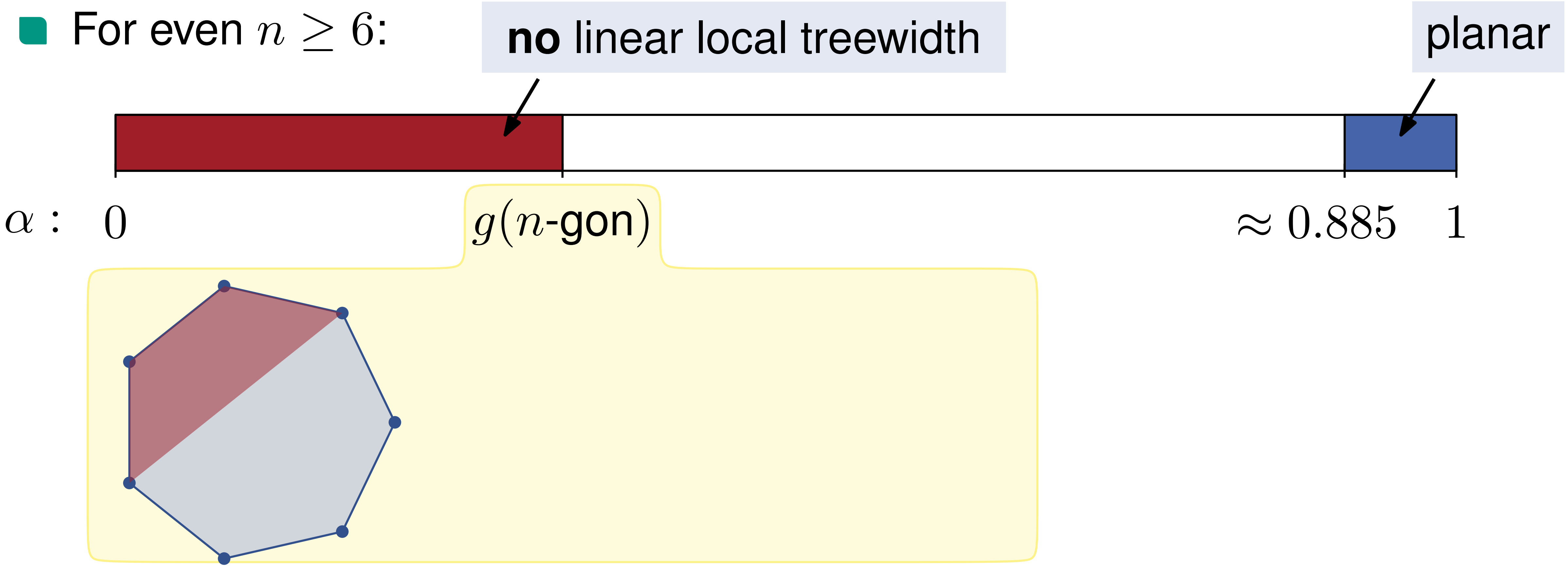

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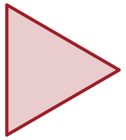
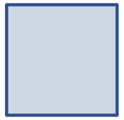
- For  and  : **no** product structure for $\alpha < 1$.
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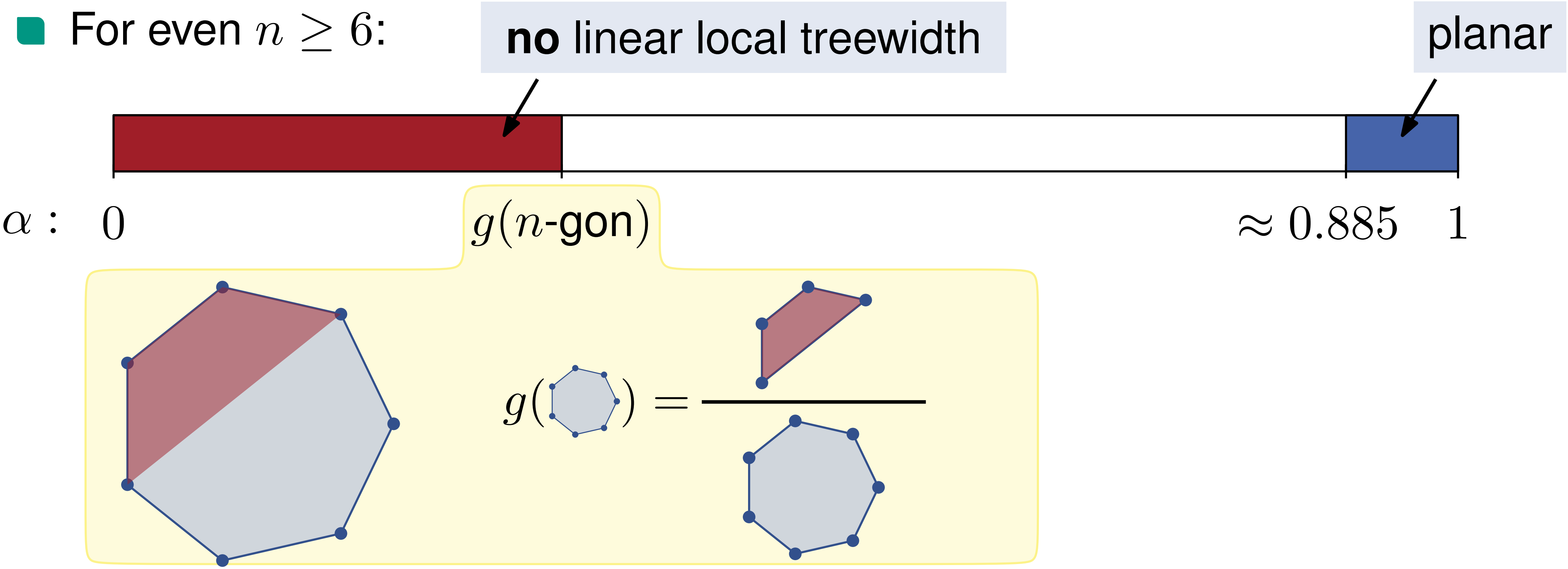

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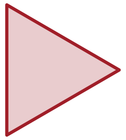
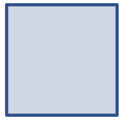
- For  and  : **no** product structure for $\alpha < 1$.
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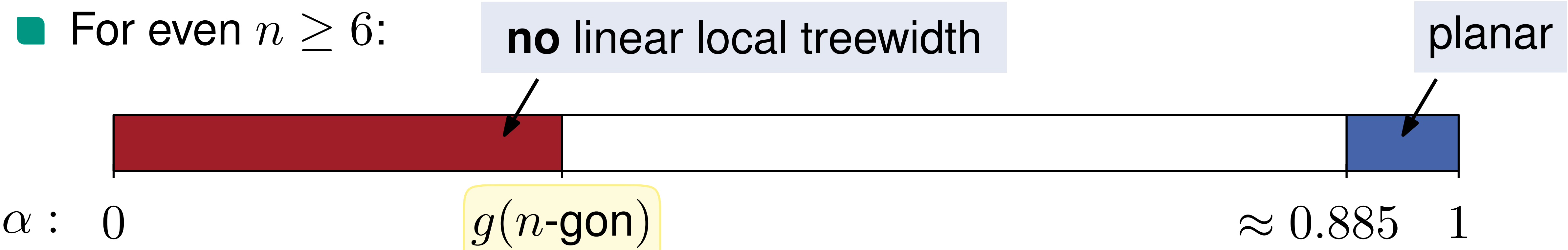
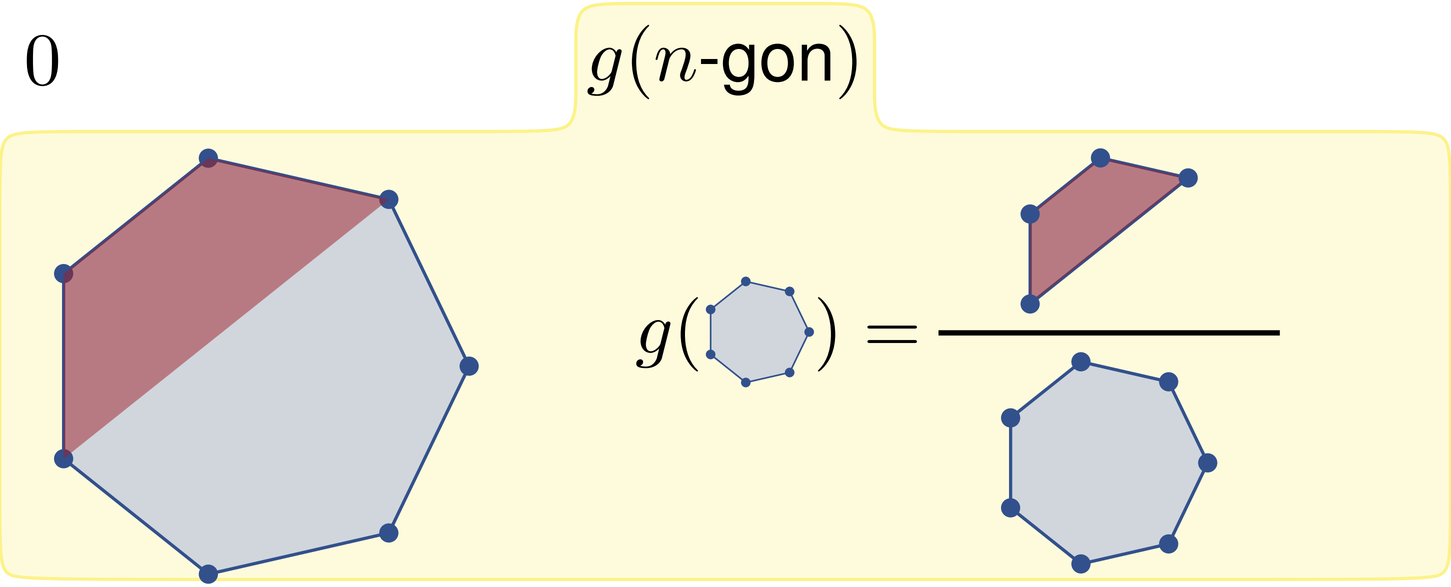
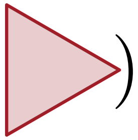
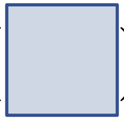




- $g($$) = g($$) = 1$

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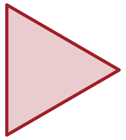
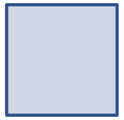
- For  and  : **no** product structure for $\alpha < 1$.
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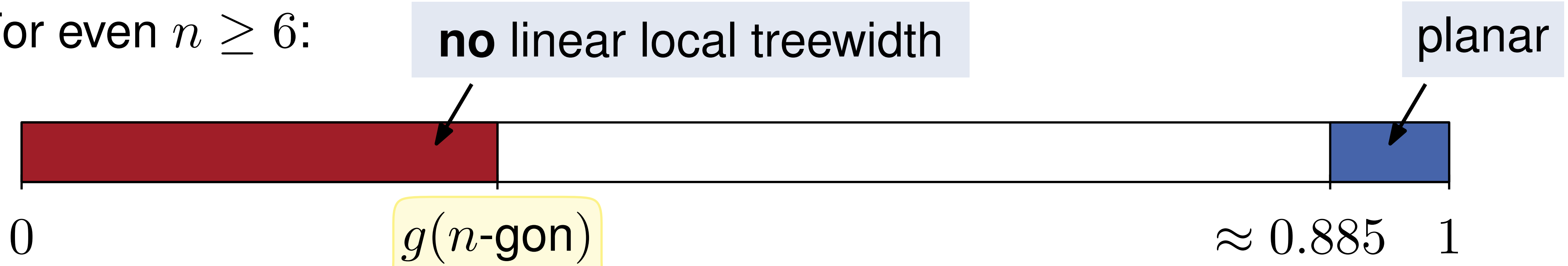
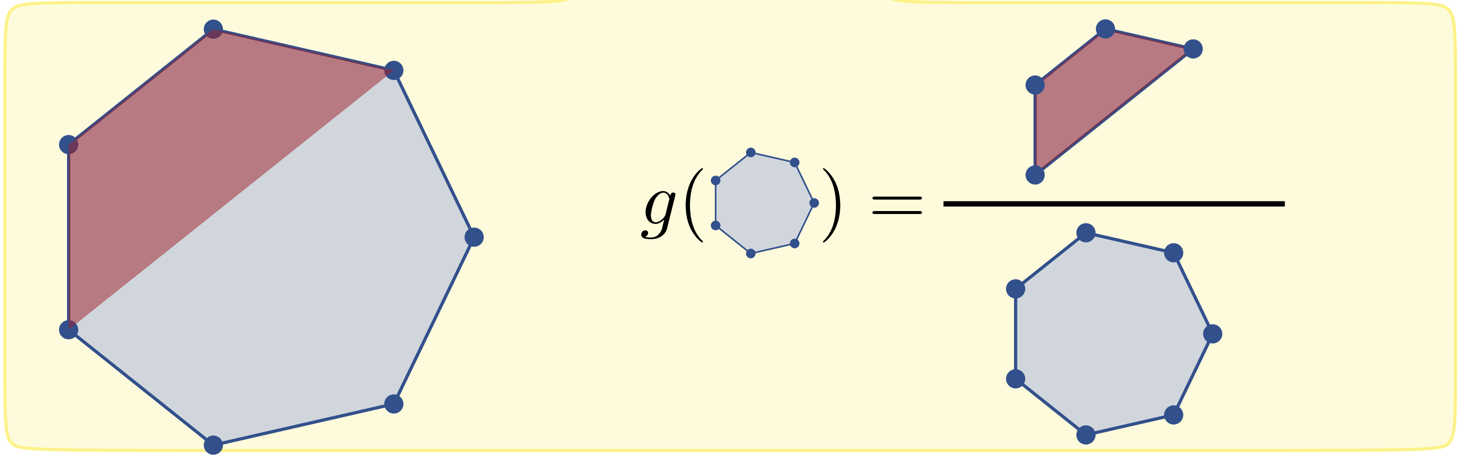
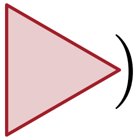
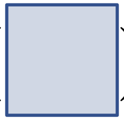
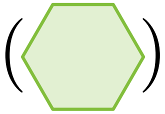
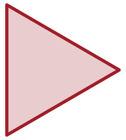
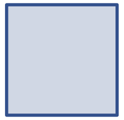




- $g($$) = g($$) = 1$
- $g($$) = \frac{1}{2}$

Our Results for Regular n-gons

- For  and  : **no** product structure for $\alpha < 1$.
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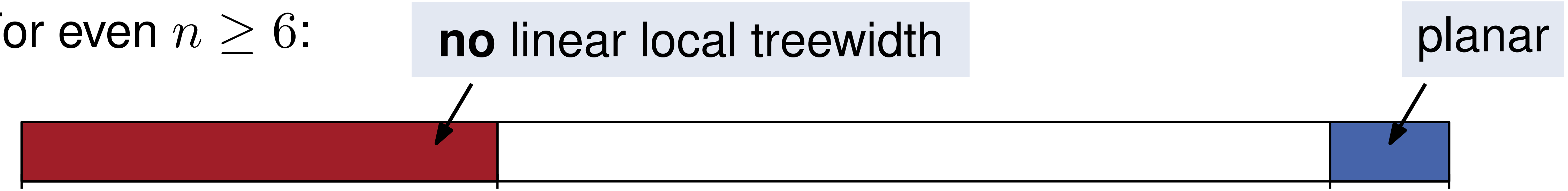
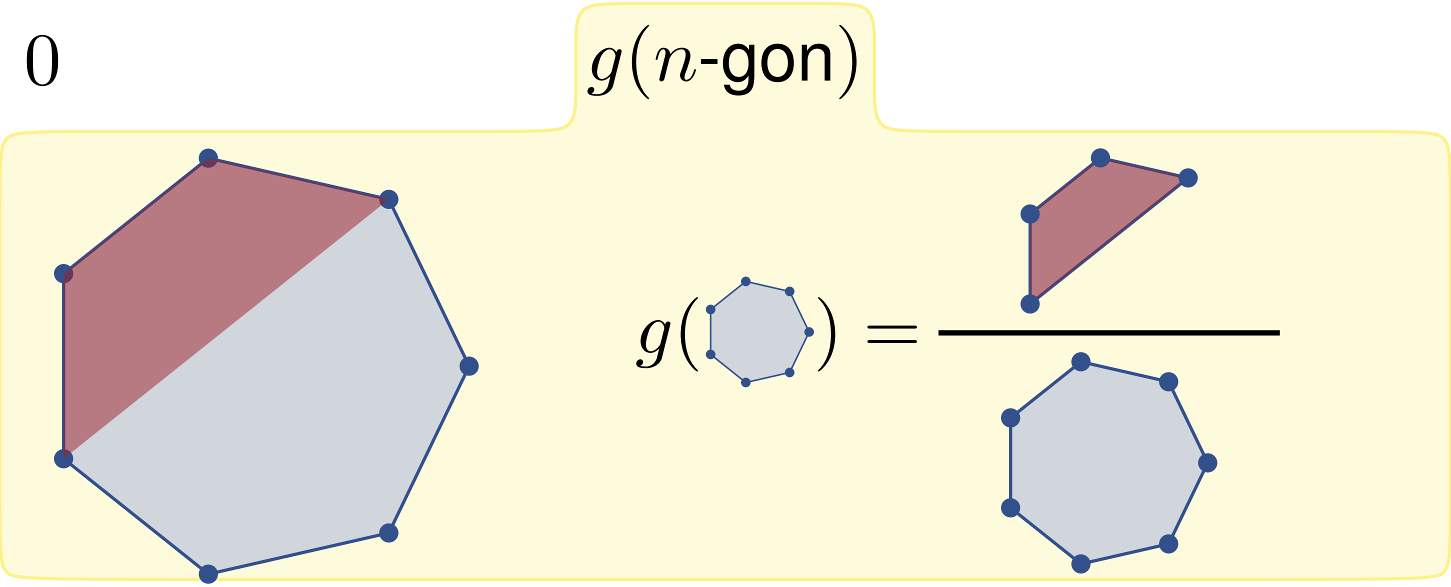
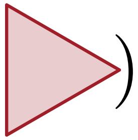
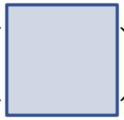
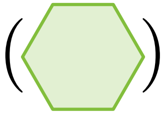


α : 0 ≈ 0.885 1



- $g($$) = g($$) = 1$
- $g($$) = \frac{1}{2}$
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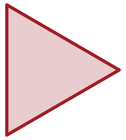
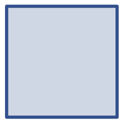
- For  and  : **no** product structure for $\alpha < 1$.
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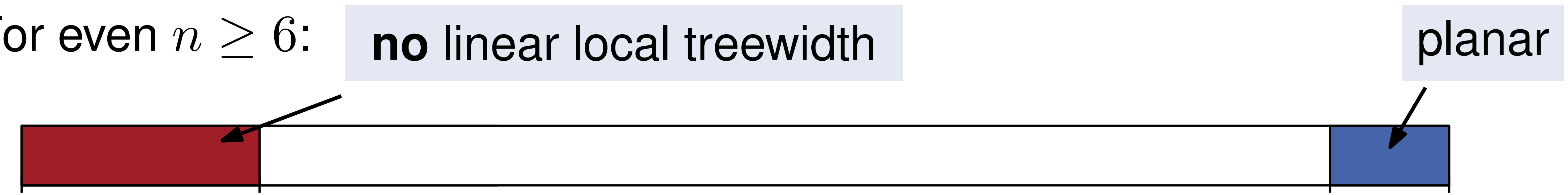
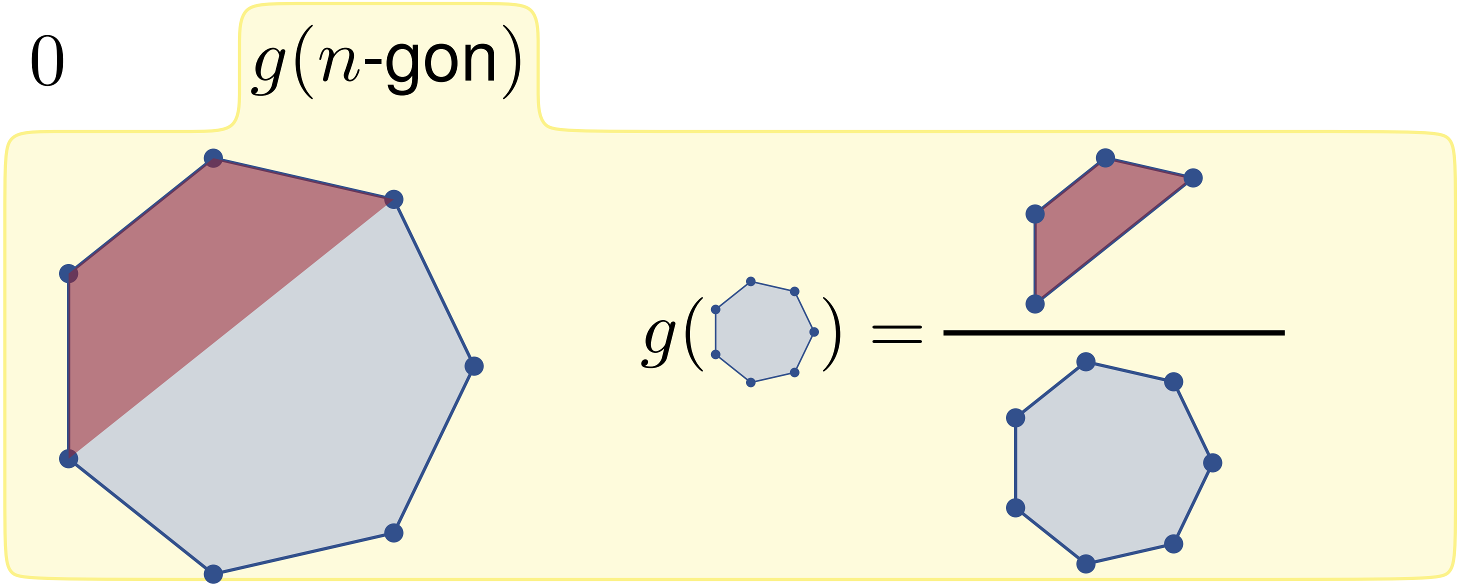
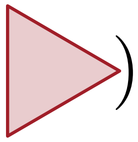
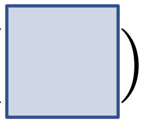
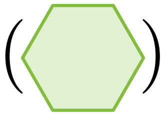




- $g($$) = g($$) = 1$
- $g($$) = \frac{1}{2}$
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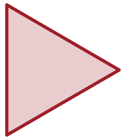
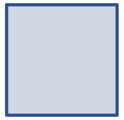
- For  and  : **no** product structure for $\alpha < 1$.
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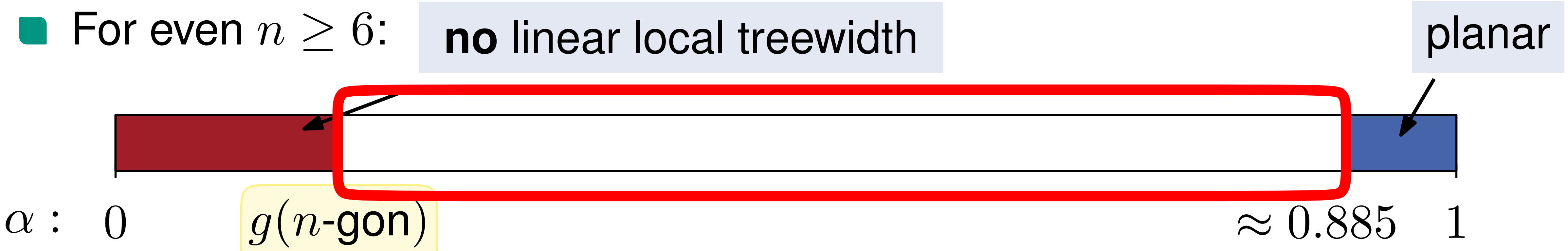
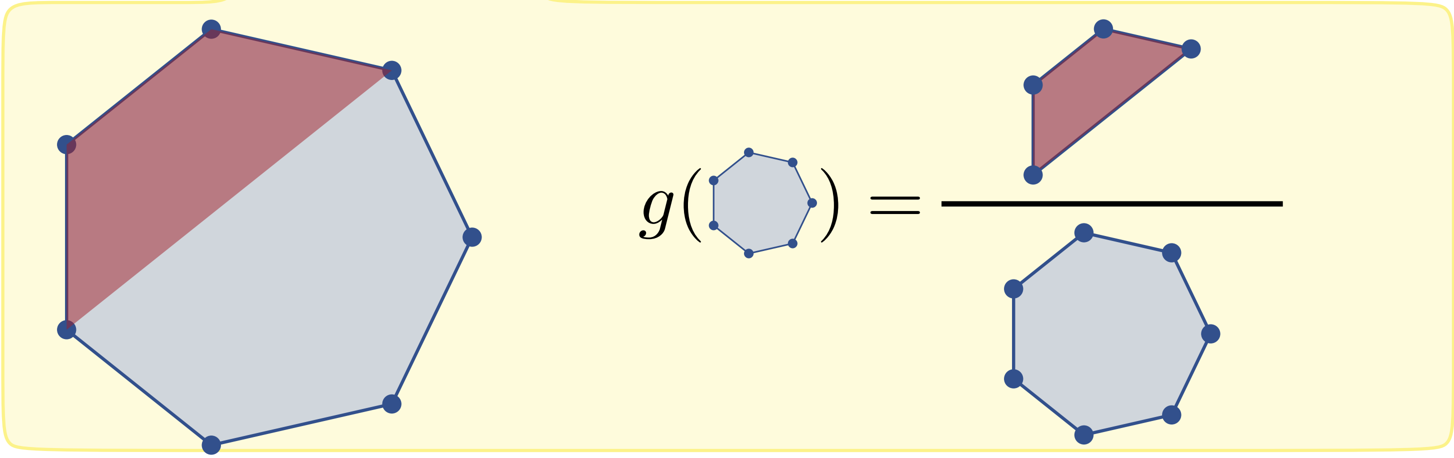
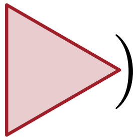
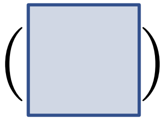
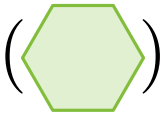




- $g($$) = g($$) = 1$
- $g($$) = \frac{1}{2}$
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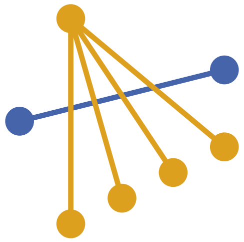

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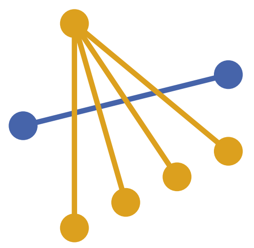

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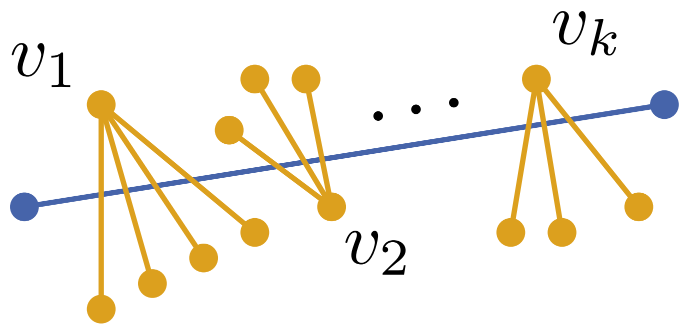

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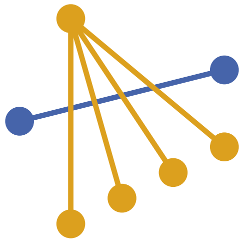

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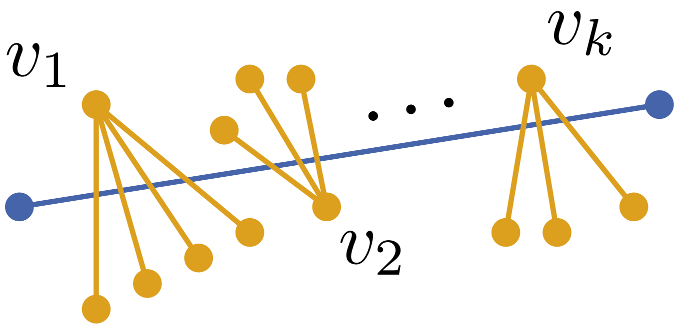

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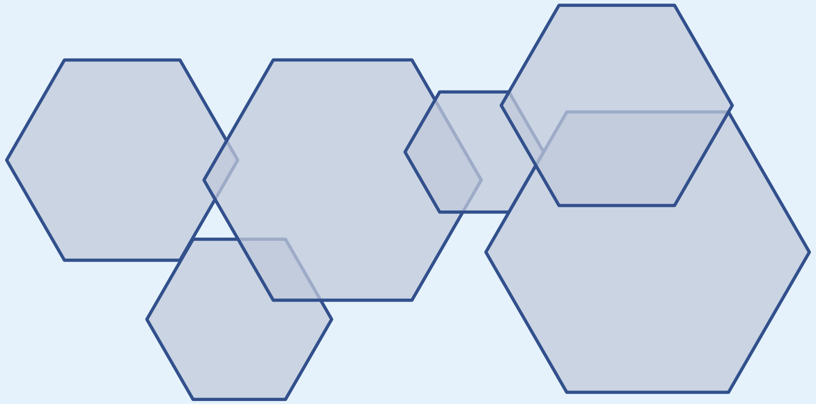
canonical drawings



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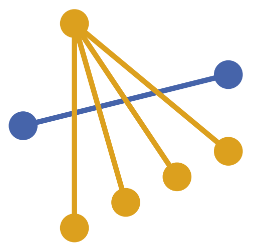

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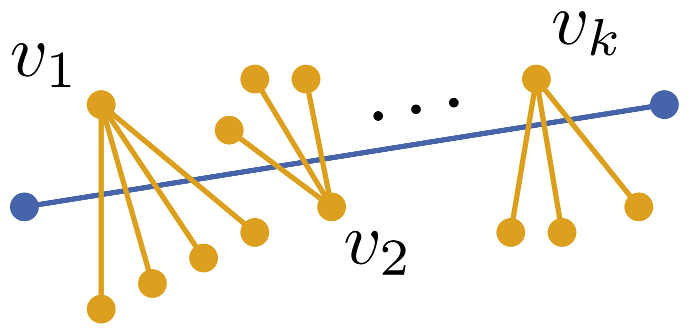

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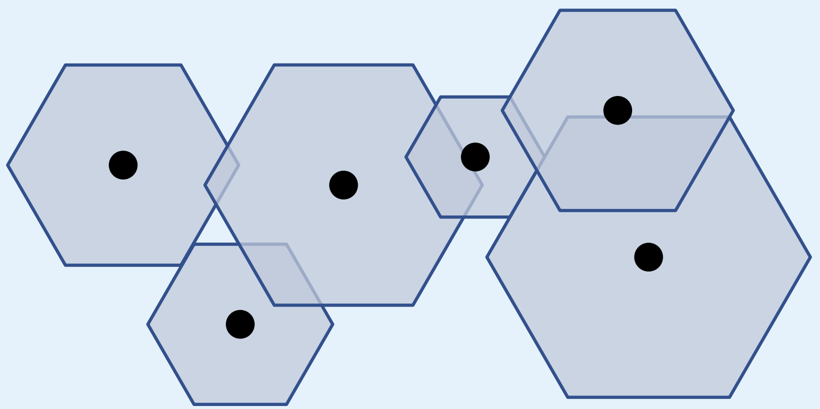

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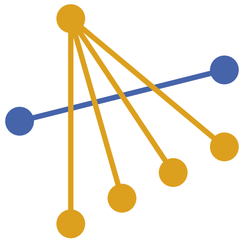

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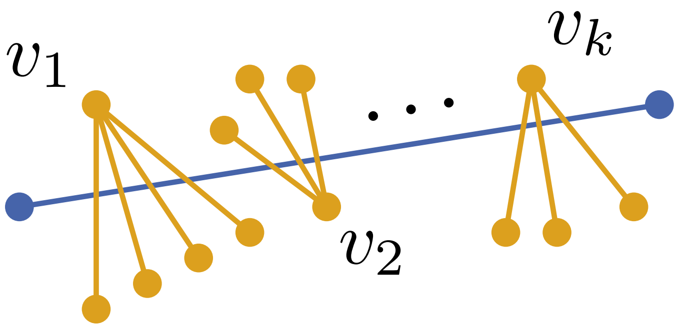

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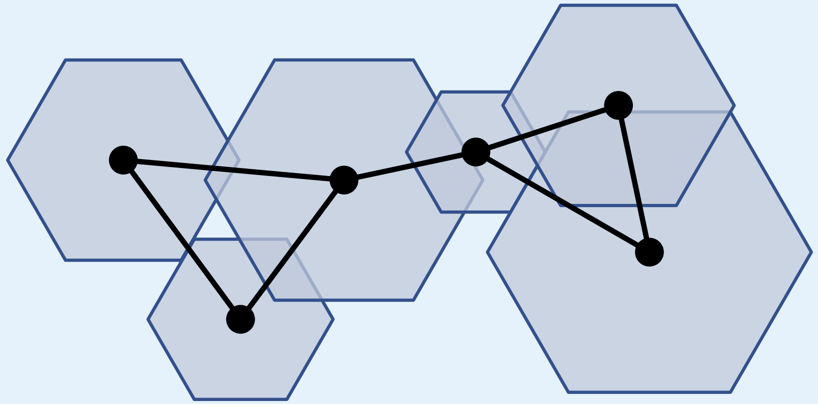

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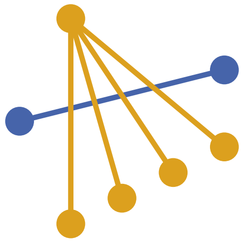

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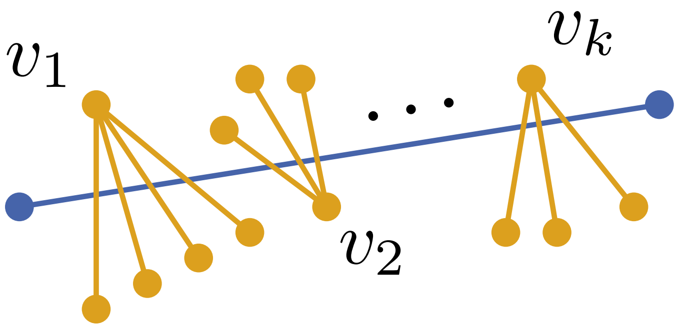

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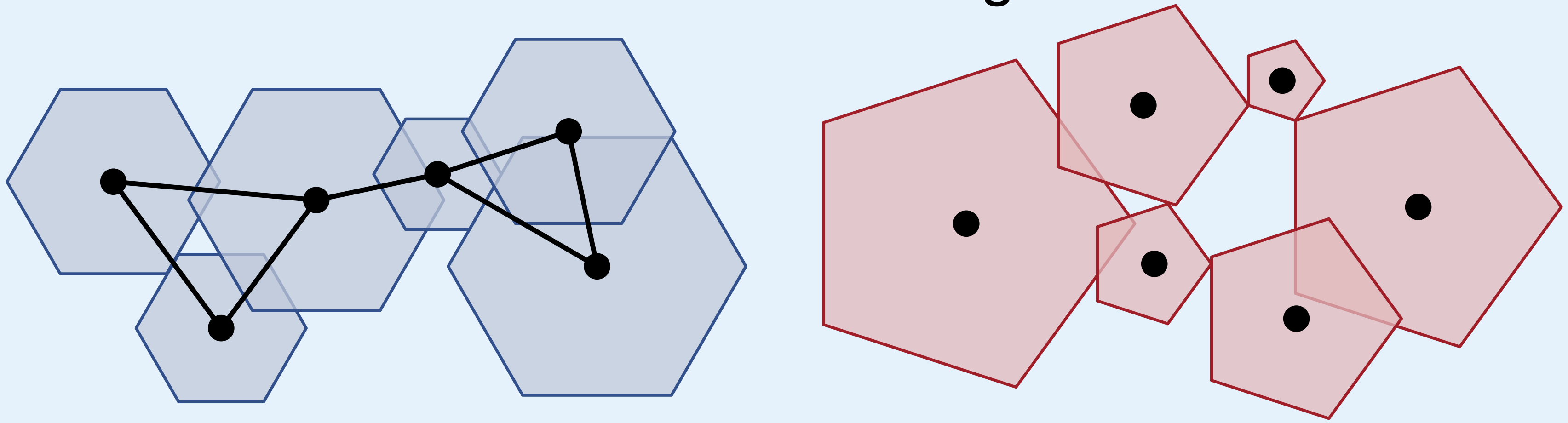

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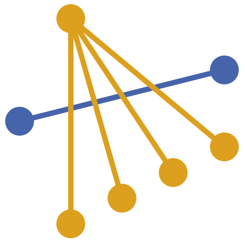

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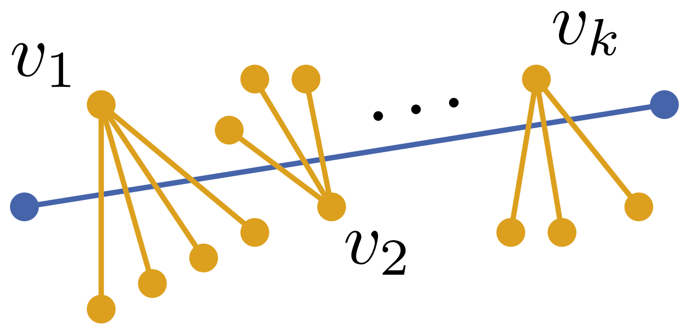

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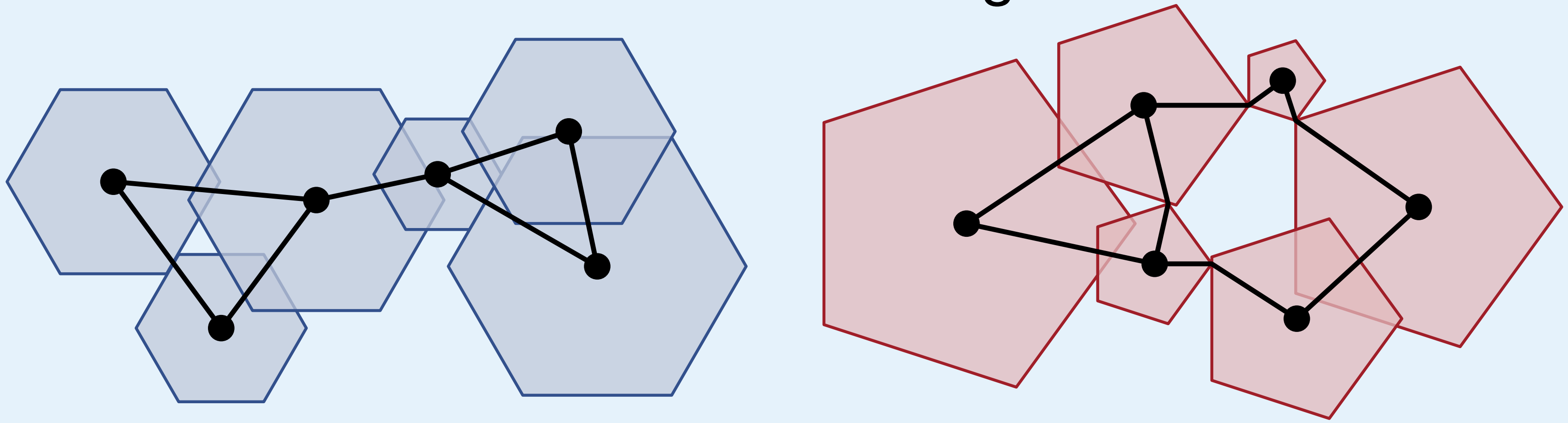
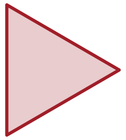
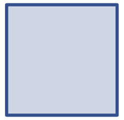


Conclusion

- For  and  : **no** product structure for $\alpha < 1$.
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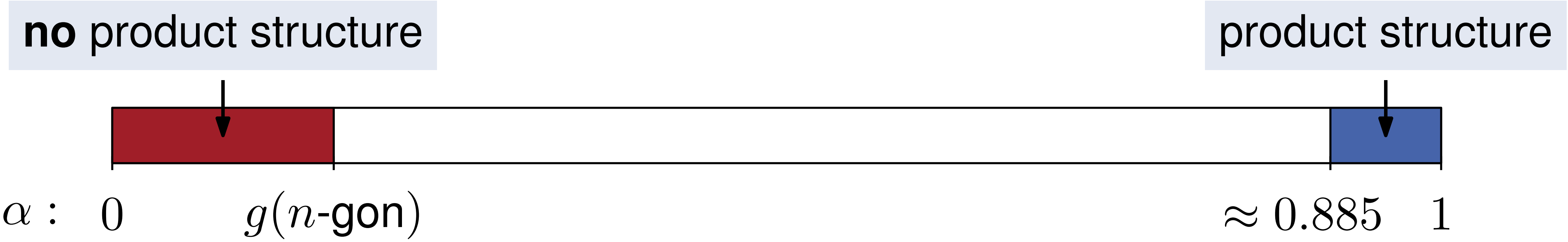

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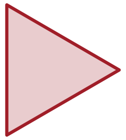
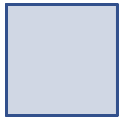
- For  and  : **no** product structure for $\alpha < 1$.
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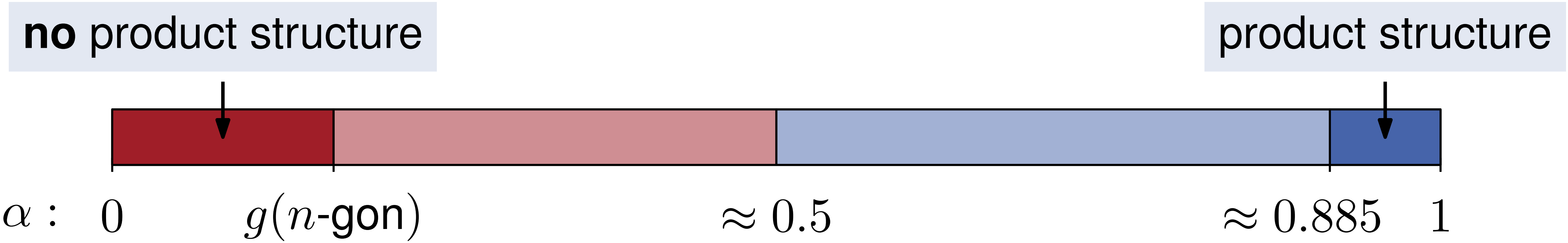

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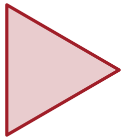
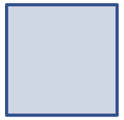
- For  and  : **no** product structure for $\alpha < 1$.
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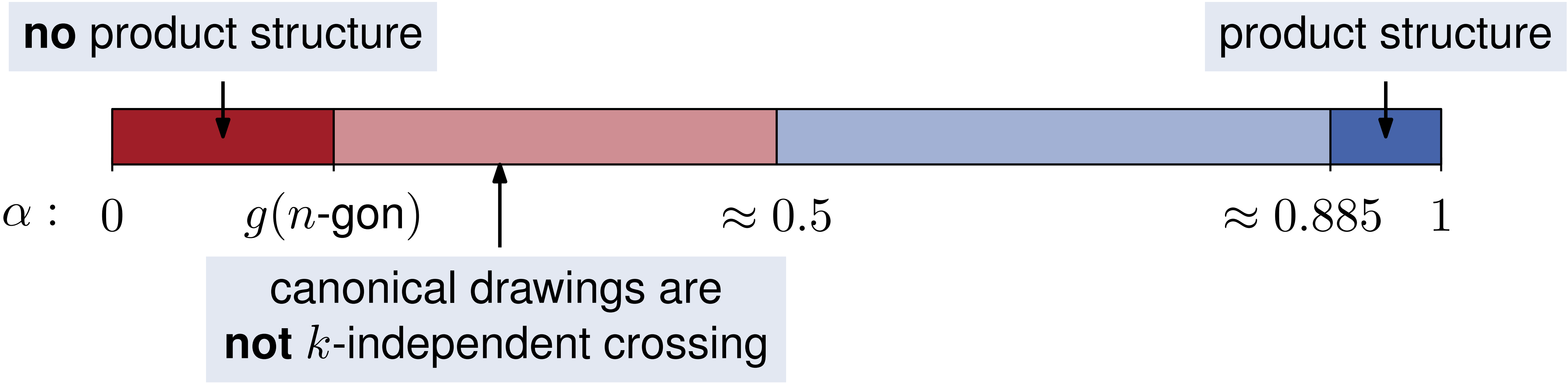

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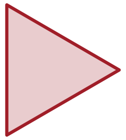
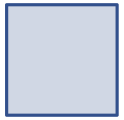
- For  and  : **no** product structure for $\alpha < 1$.
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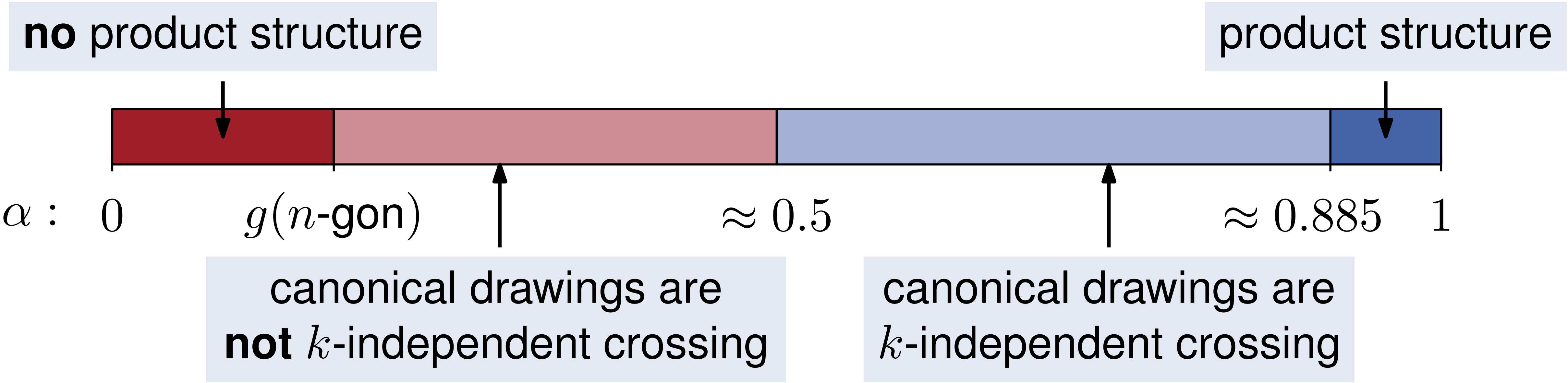
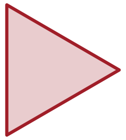
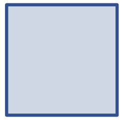


Conclusion

- For  and  : **no** product structure for $\alpha < 1$.
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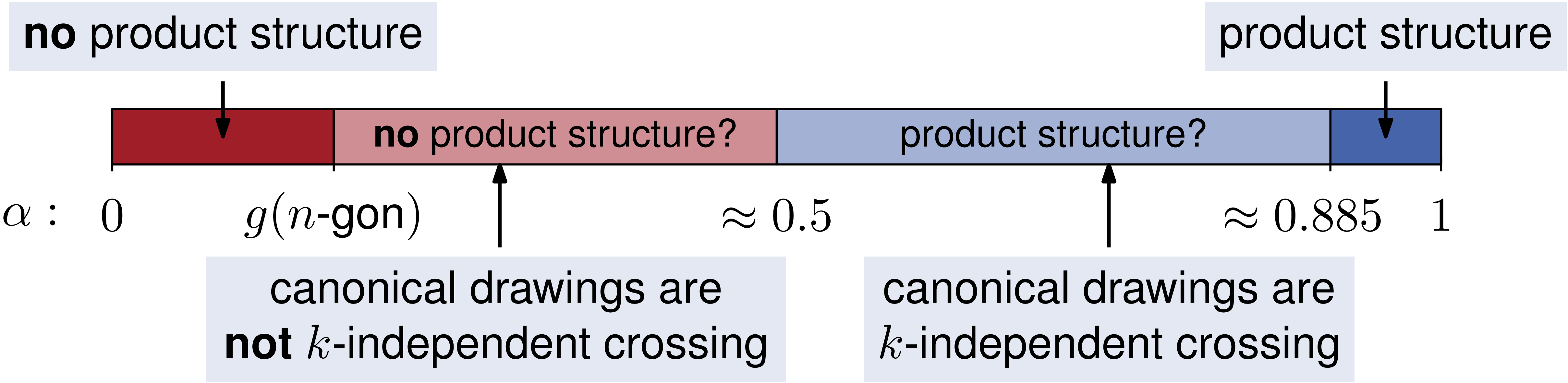

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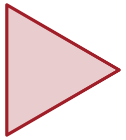
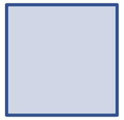
Conclusion

- For  and  : **no** product structure for $\alpha < 1$.
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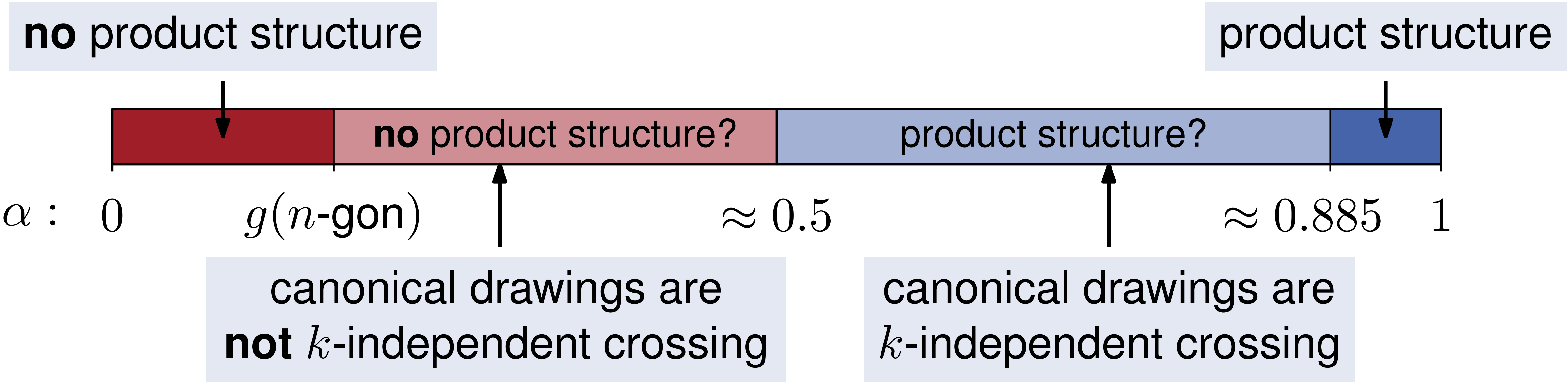

Question: Do k-independent crossing graphs have product structure?

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