Outerplanar and Forest Storyplans

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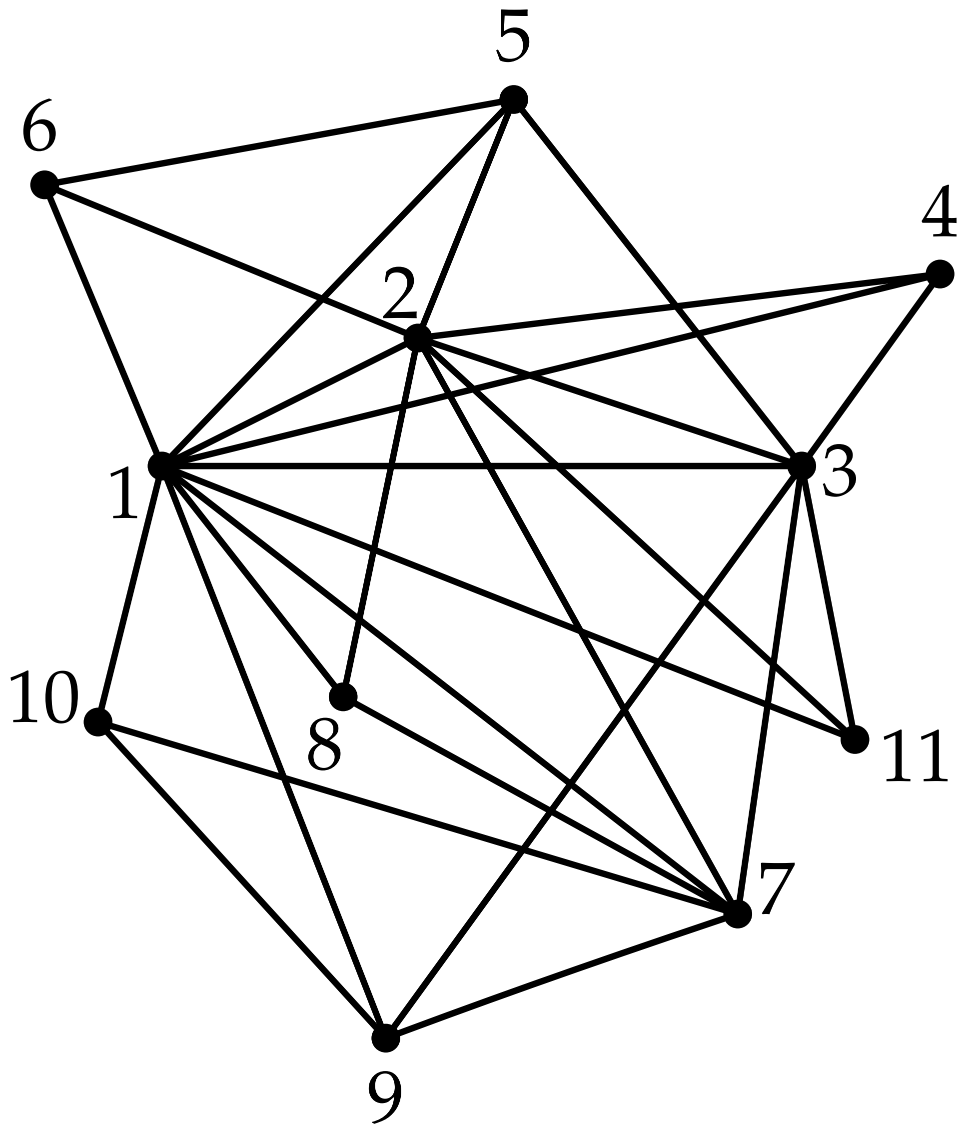
Motivation



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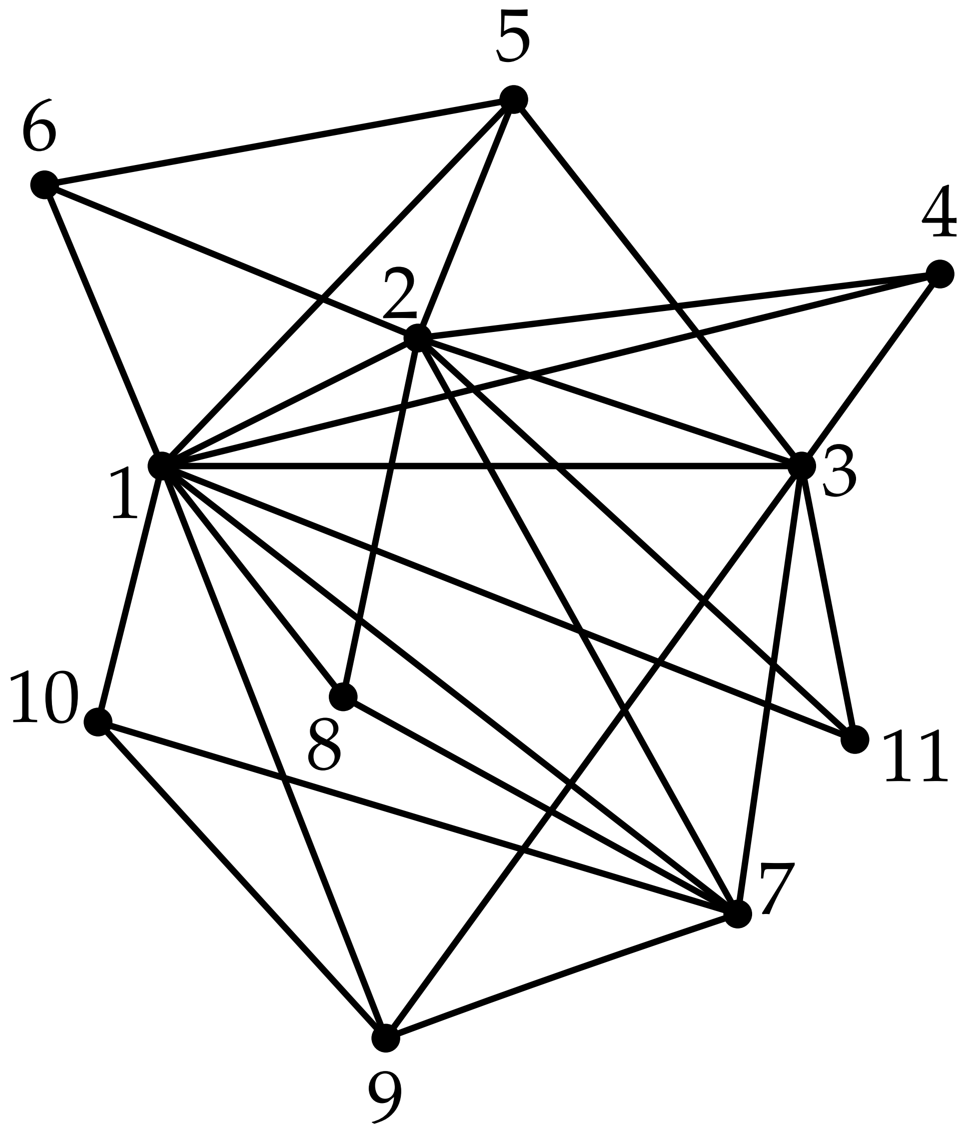

Show a graph in a few steps s.t. in each step the visible part of the graph is better "readable", that is, there are no crossings.

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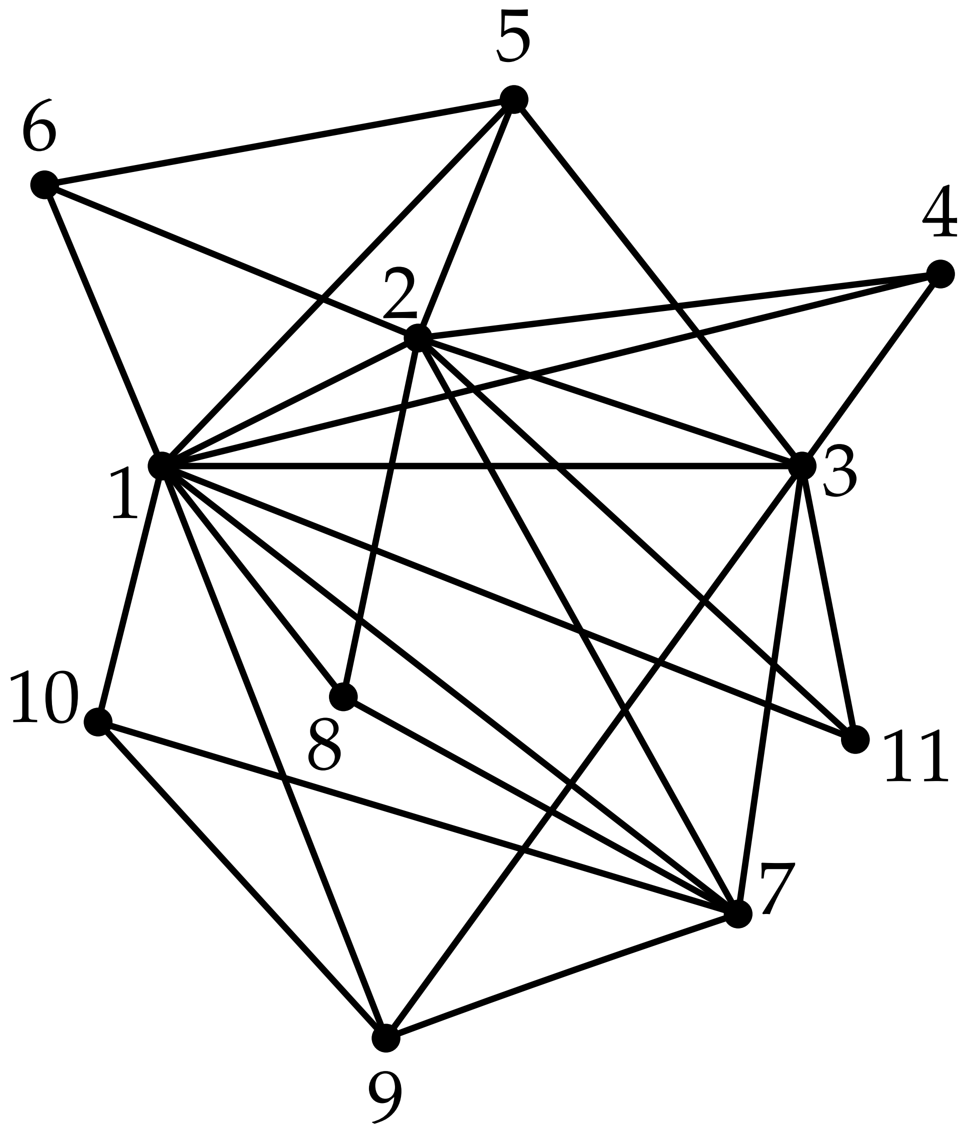

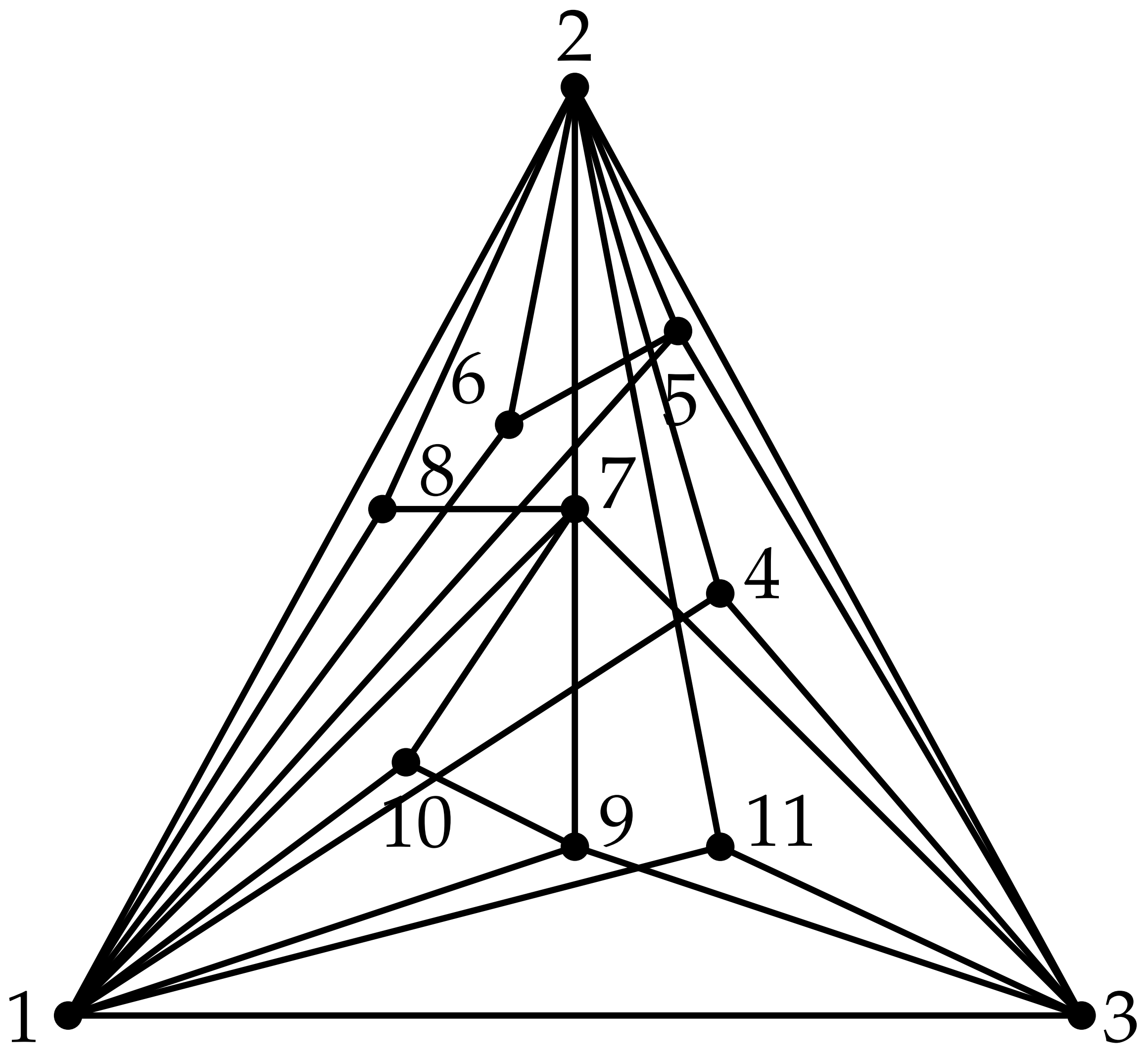

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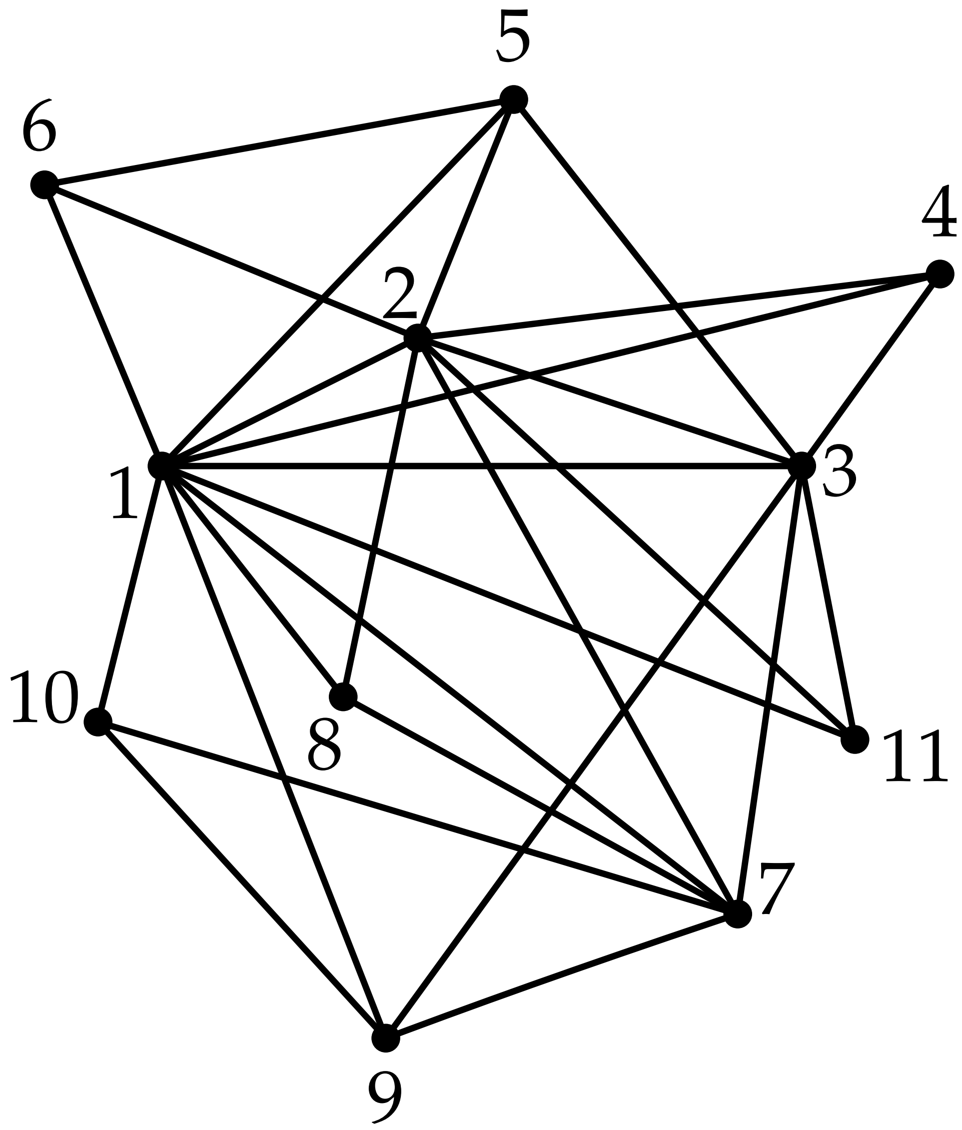

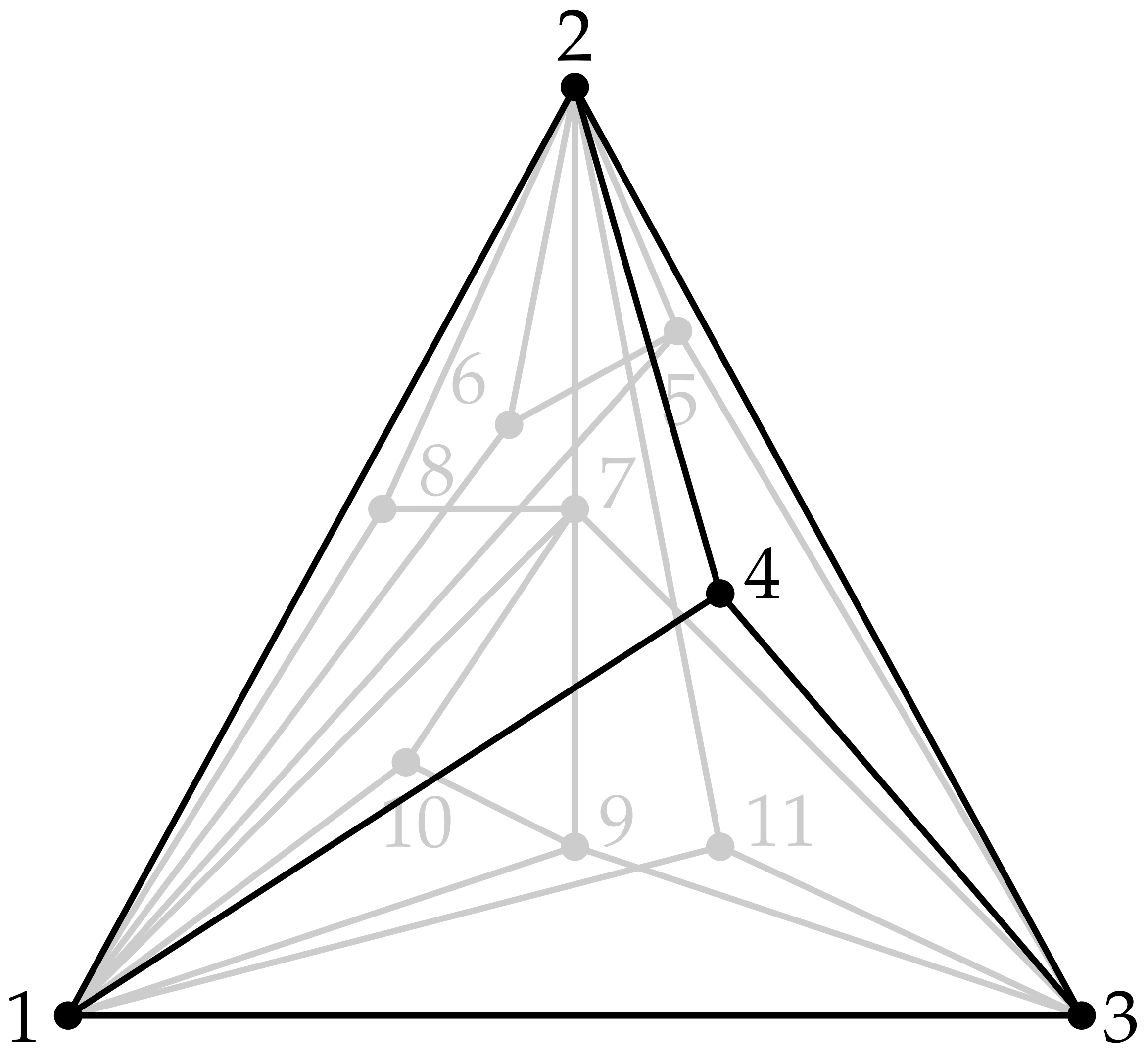

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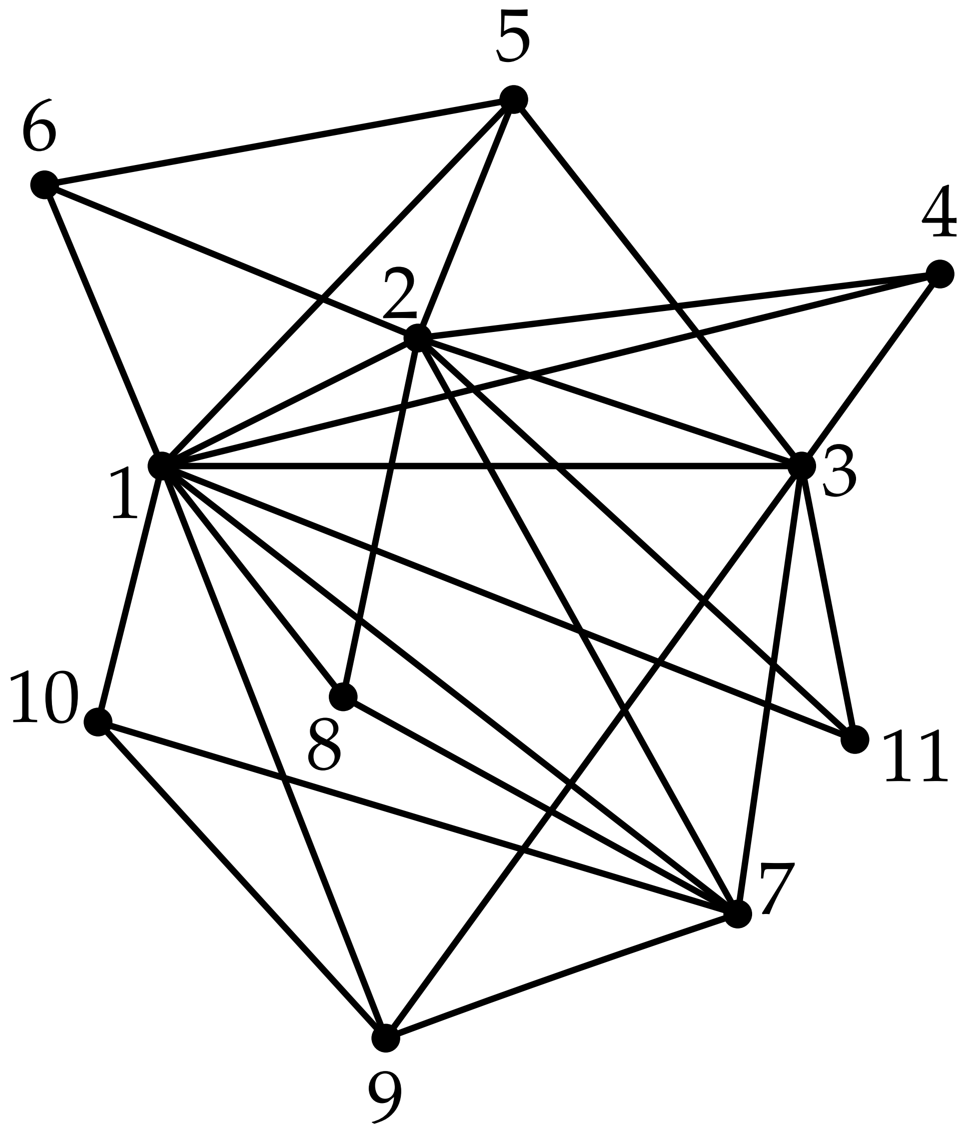

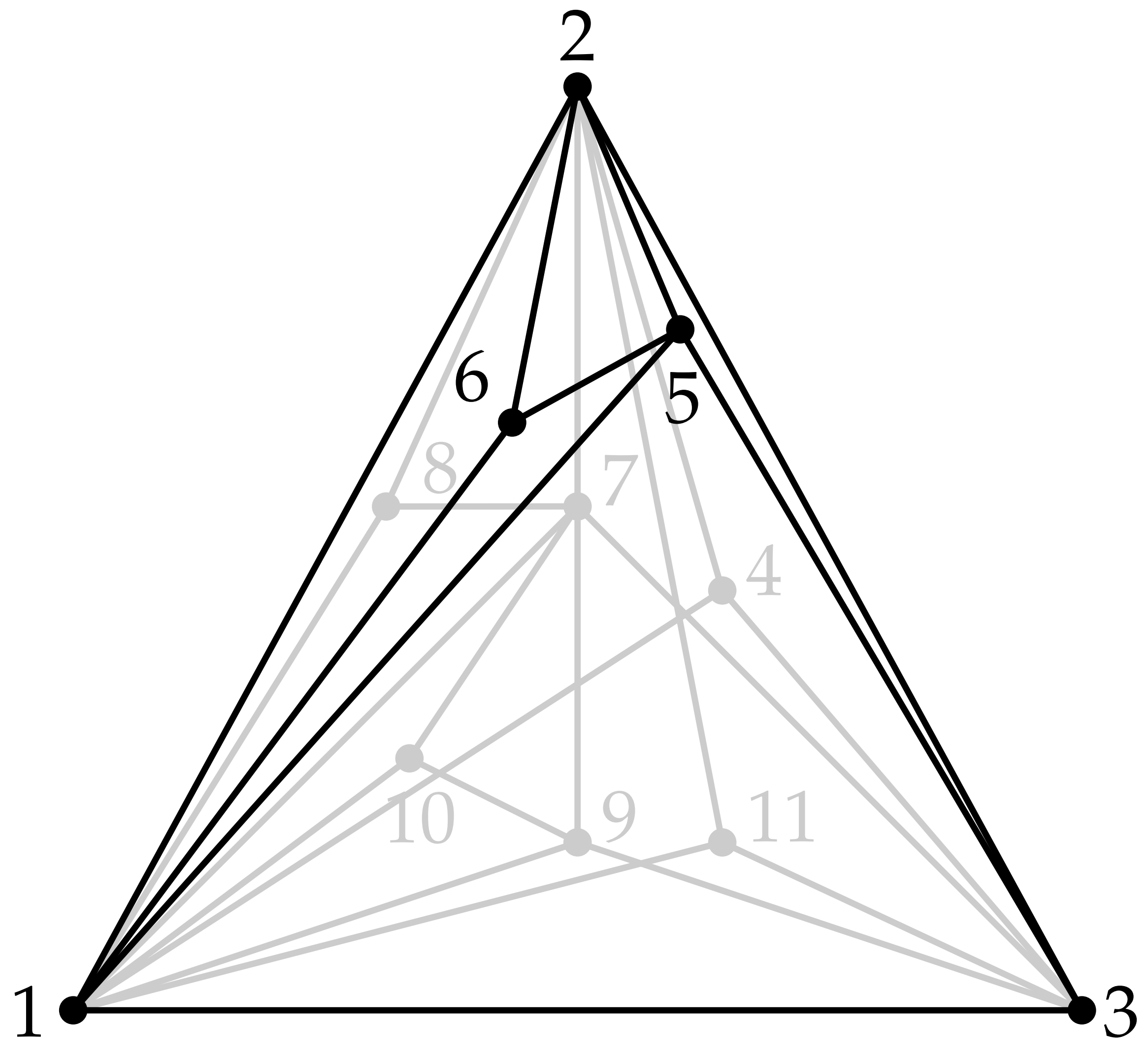

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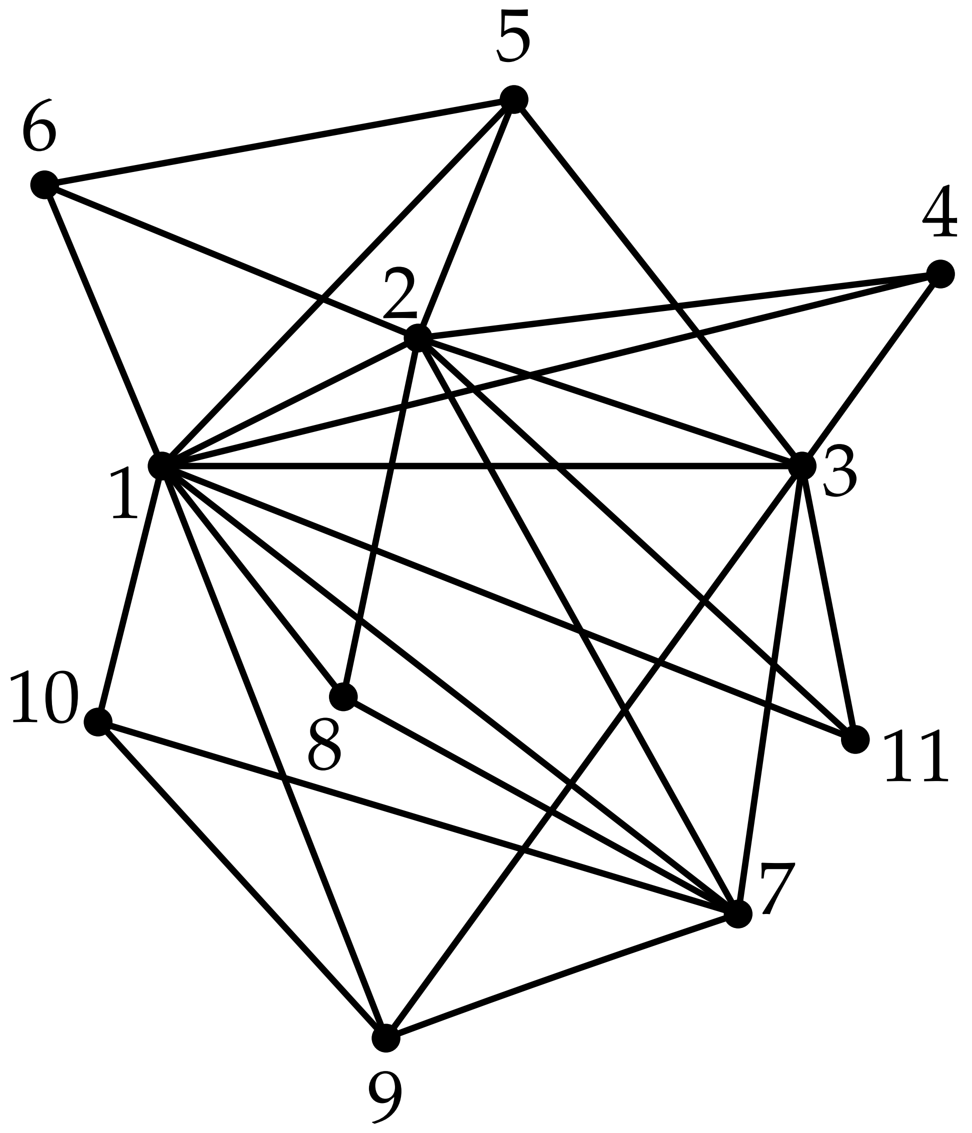

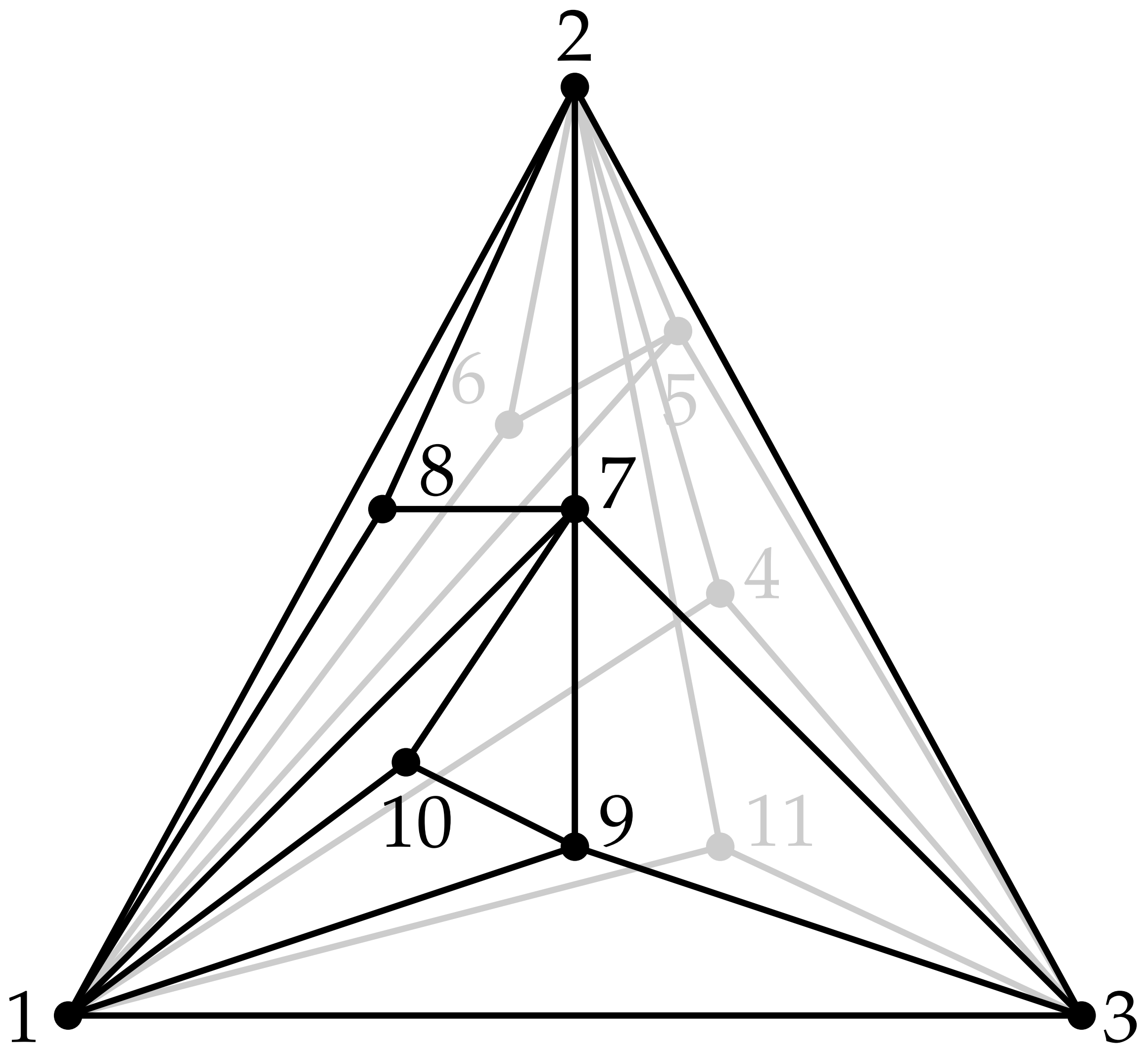

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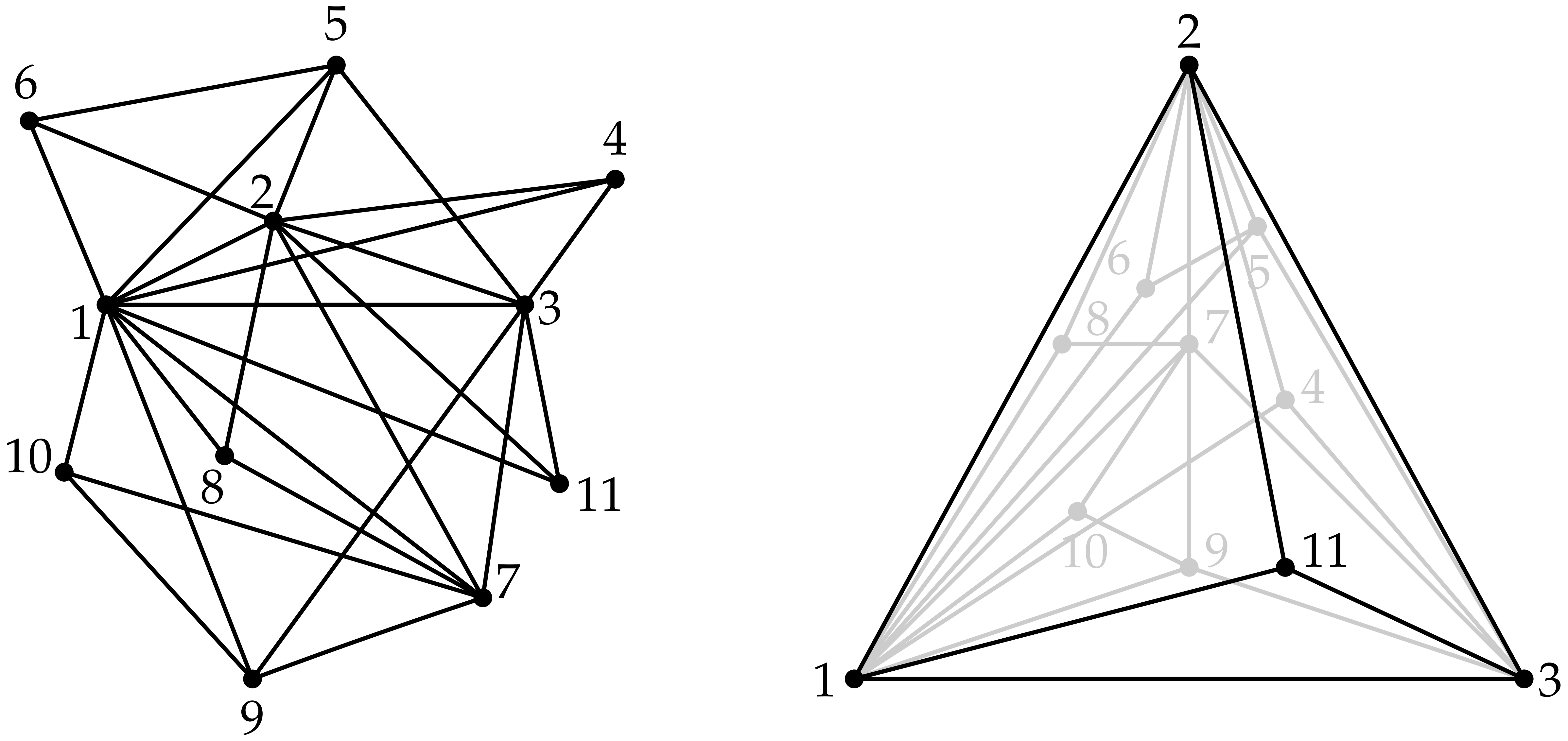

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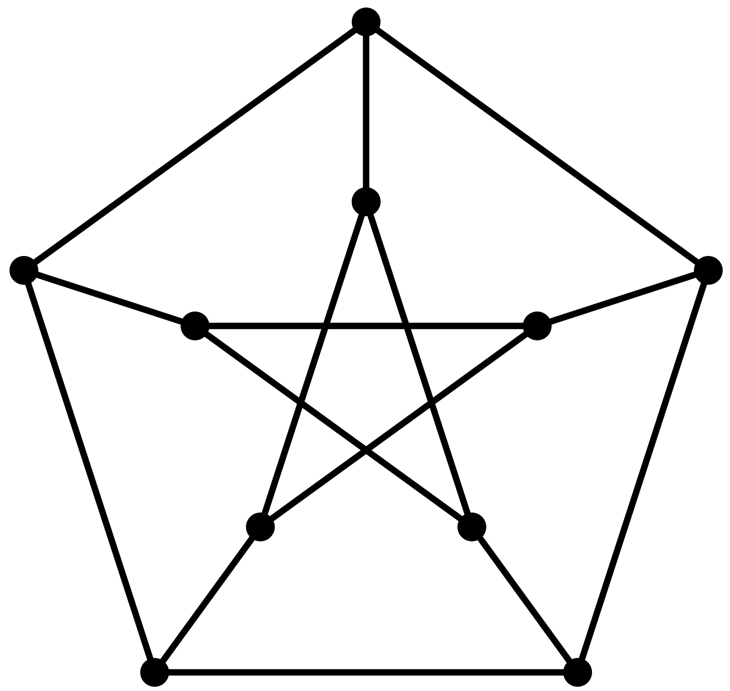
Planar Storyplan – Definition, Part I



In each step the drawing of the subgraph that is shown has no crossings.

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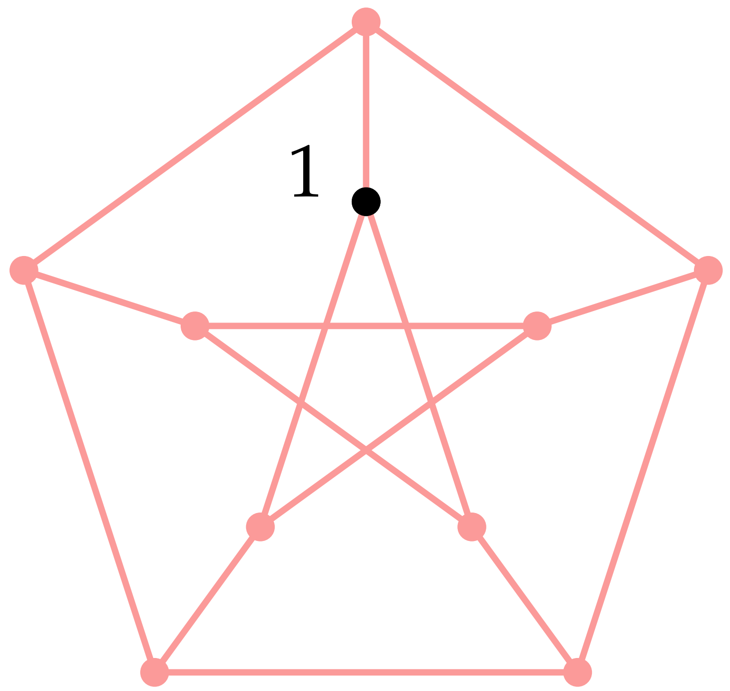

In each step the drawing of the subgraph that is shown has no crossings.

- In each step, we add *one* vertex.

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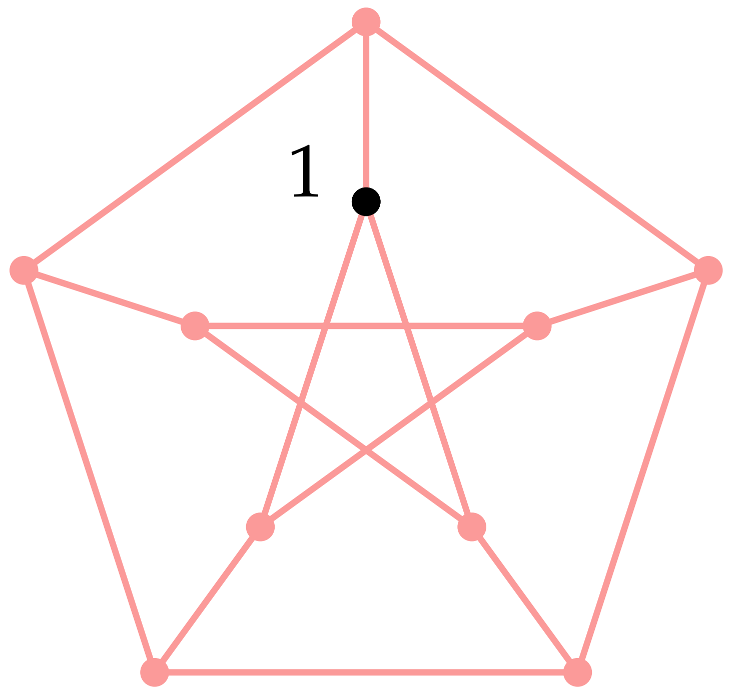

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- This vertex stays visible until all its neighbors have been presented.

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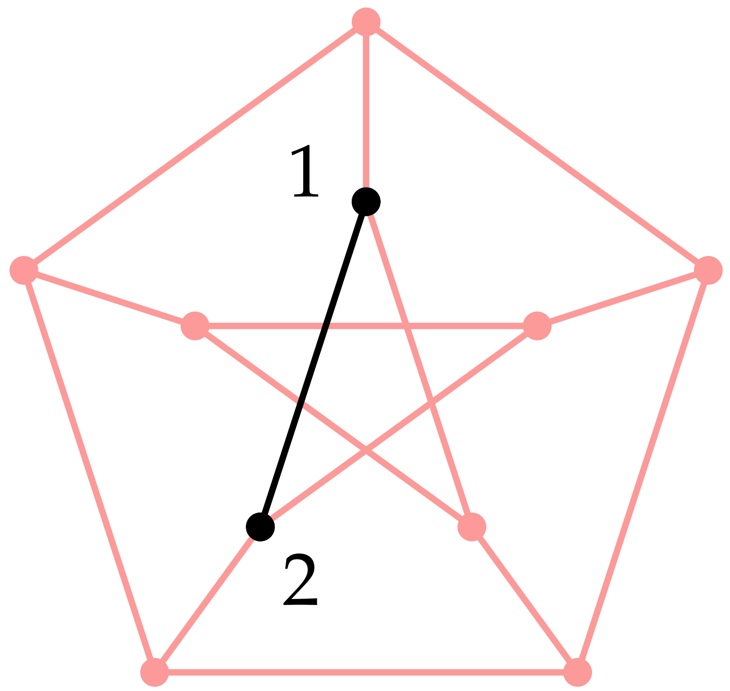

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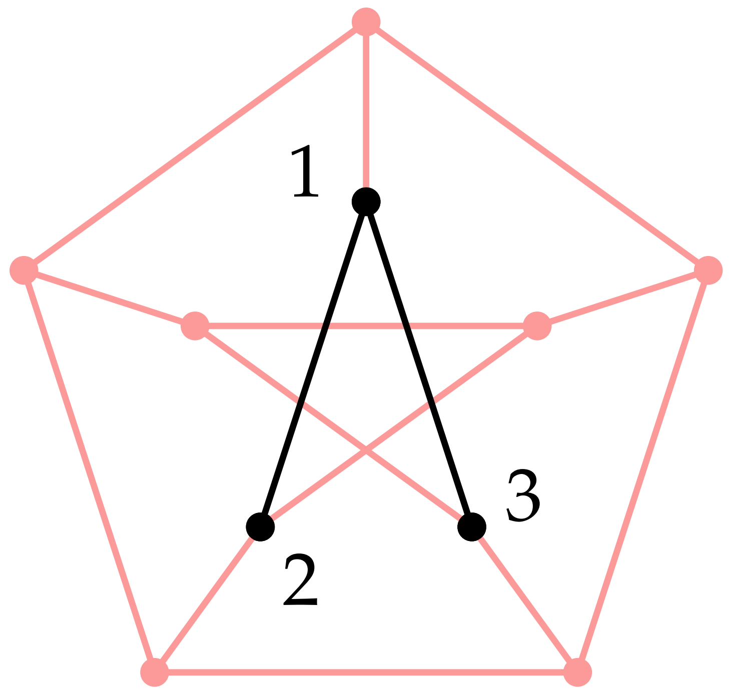

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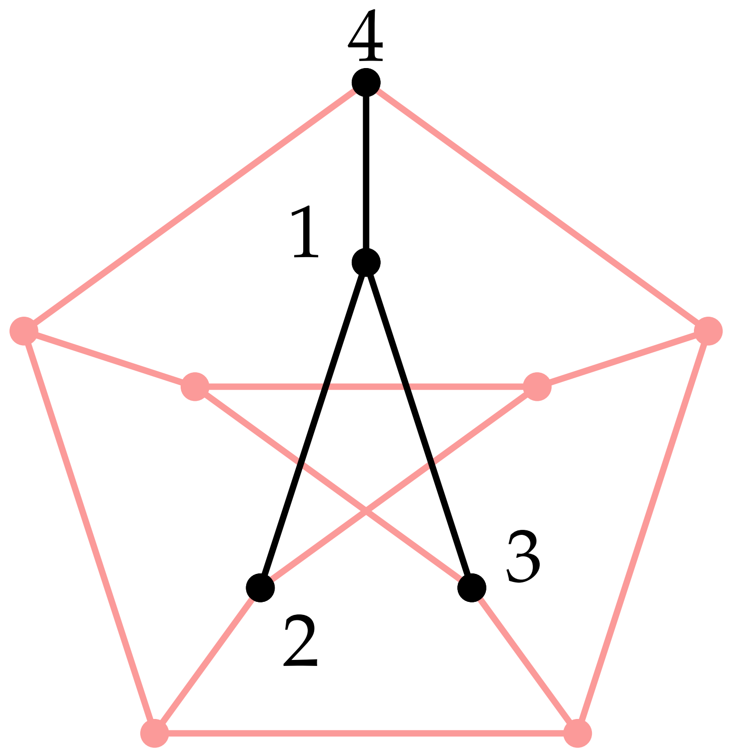

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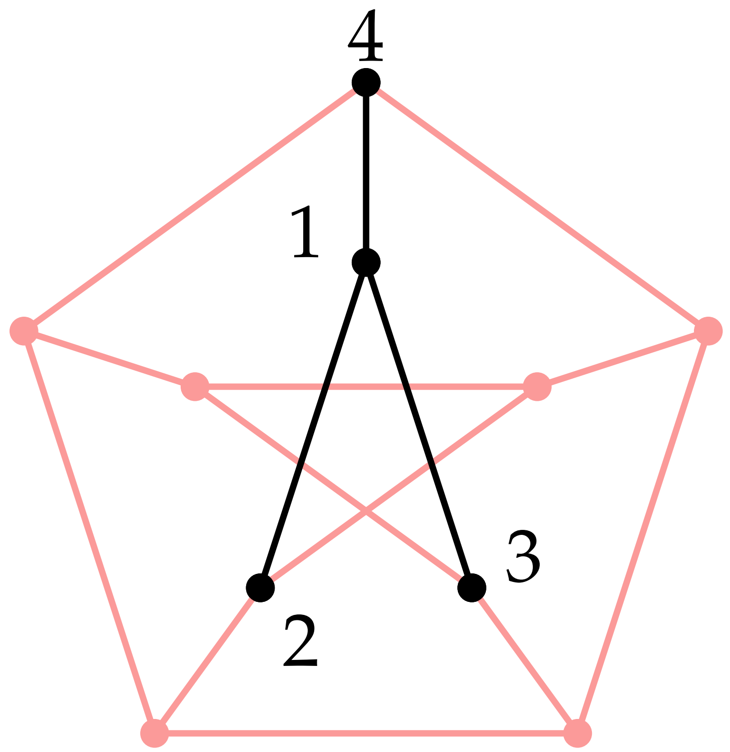

In each step the drawing of the subgraph that is shown has no crossings.

- In each step, we add *one* vertex.
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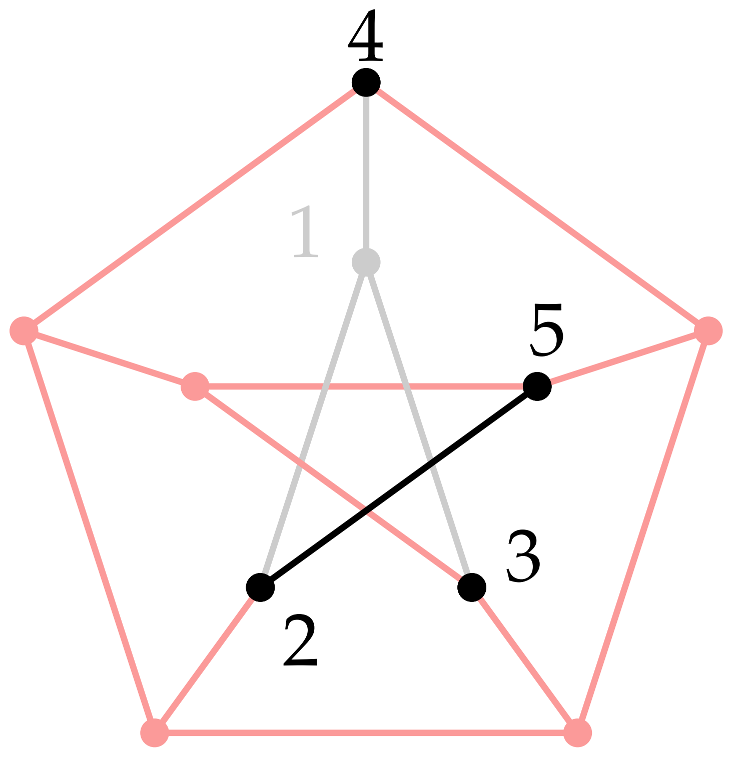

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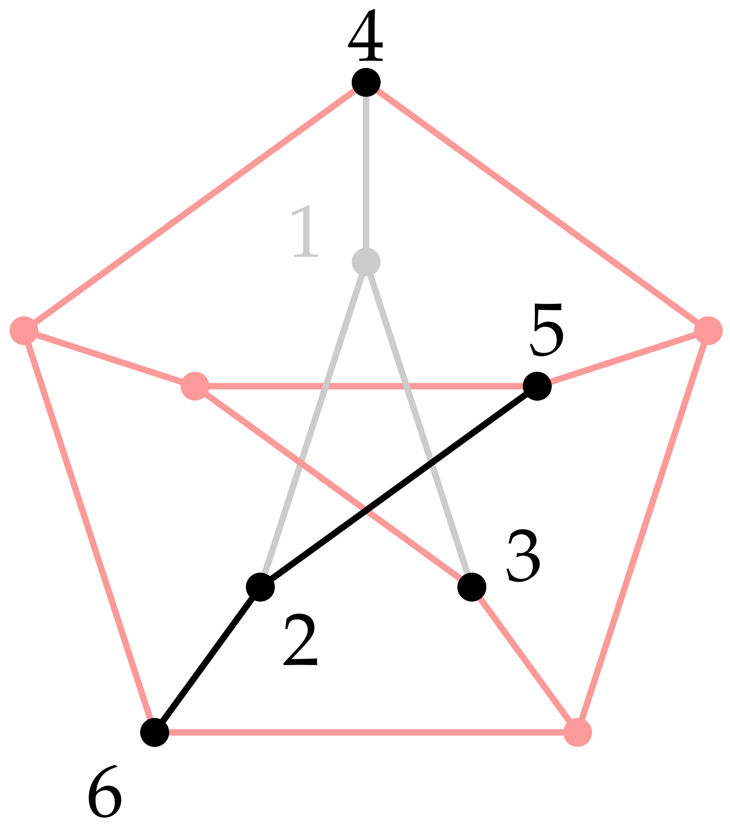

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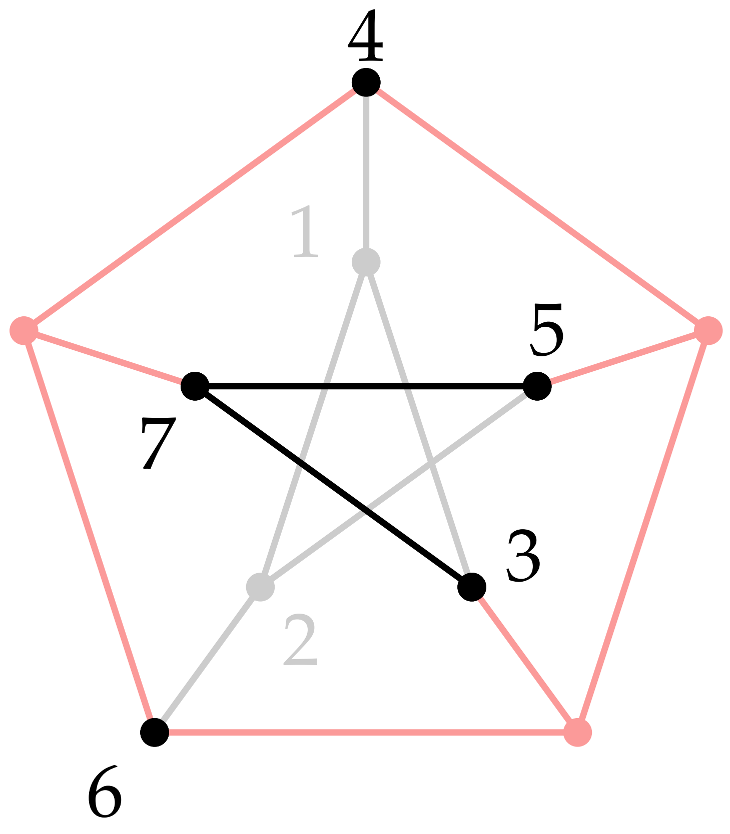

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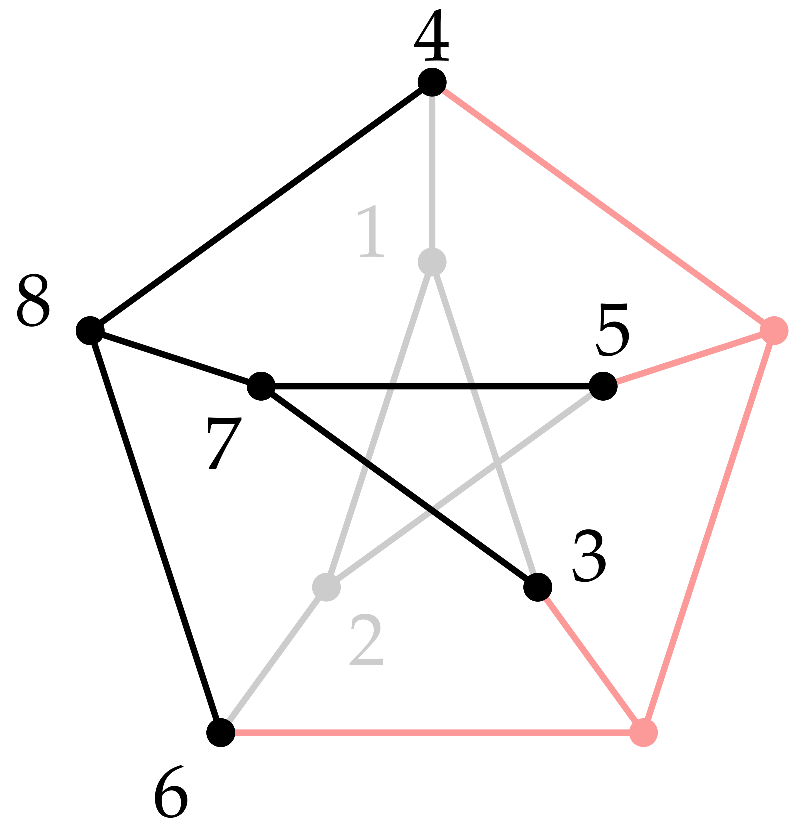

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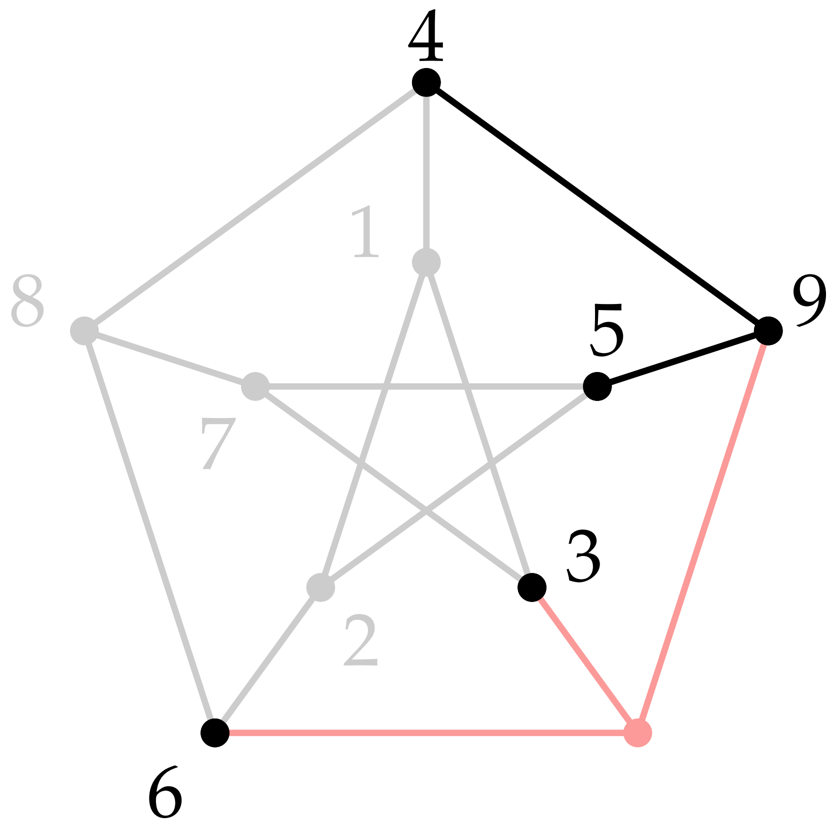

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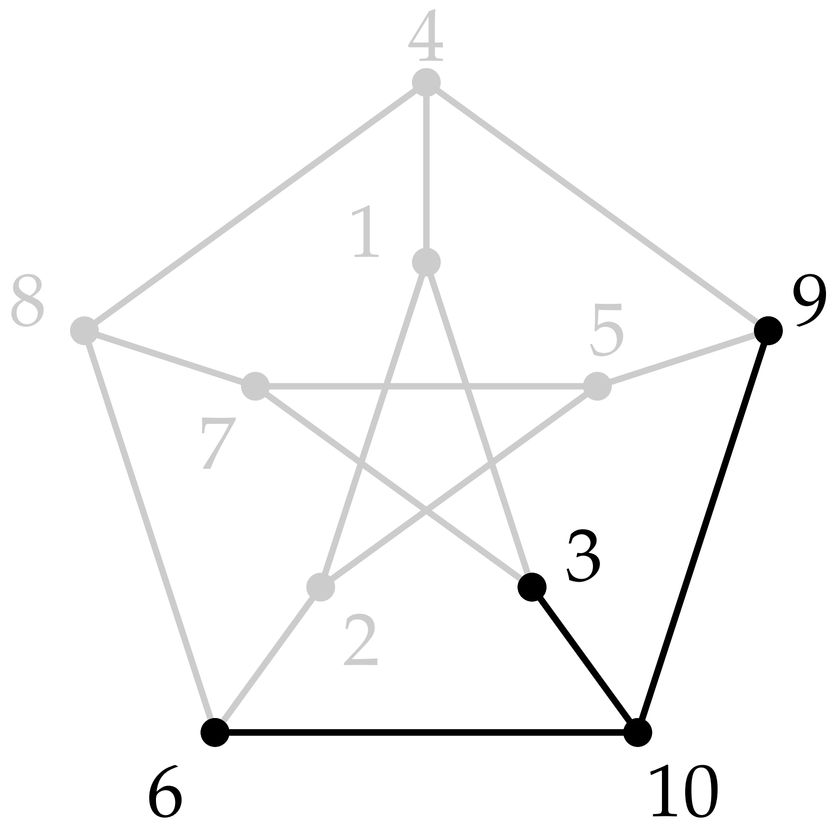

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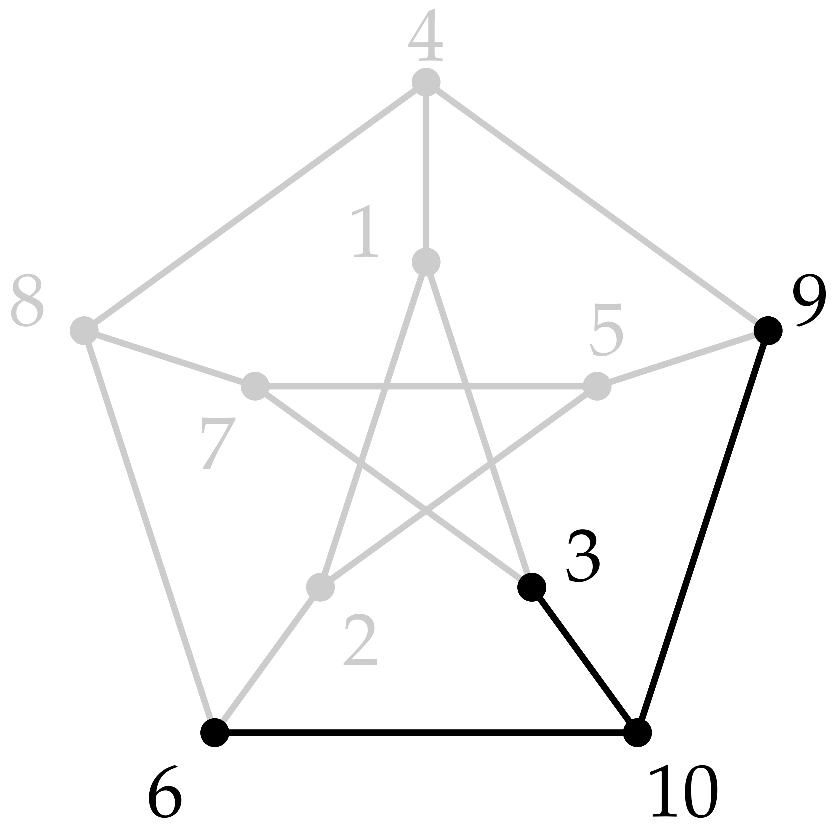

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For a given (non-planar) graph, find an order of the vertices that yields a *planar storyplan* (if such an order exists).

Planar Storyplan – Definition, Part II

total order
of vertices

$$\langle \tau, \{D_i\}_{i \in [n]} \rangle$$

sequence of drawings
(we also call them *frames*)

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$$\langle \tau, \boxed{\{D_i\}_{i \in [n]}} \rangle$$

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total order of vertices

$\langle \tau, \boxed{\{D_i\}_{i \in [n]}} \rangle$

sequence of drawings (we also call them *frames*)

(I) each D_i contains all vertices visible at step i;

Planar Storyplan – Definition, Part II

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$$\langle \tau, \boxed{\{D_i\}_{i \in [n]}} \rangle$$

sequence of drawings (we also call them *frames*)

(I) each D_i contains all vertices visible at step i;

(II) each D_i is planar;

Planar Storyplan – Definition, Part II

total order of vertices

$$\langle \tau, \boxed{\{D_i\}_{i \in [n]}} \rangle$$

sequence of drawings (we also call them *frames*)

(I) each D_i contains all vertices visible at step i;

(II) each D_i is planar;

(III) the point representing a vertex v does not change during the steps where v is visible;

Planar Storyplan – Definition, Part II

total order of vertices

$$\langle \tau, \boxed{\{D_i\}_{i \in [n]}} \rangle$$

sequence of drawings (we also call them *frames*)

(I) each D_i contains all vertices visible at step i;

(II) each D_i is planar;

(III) the point representing a vertex v does not change during the steps where v is visible;

(IV) the curve representing an edge e is the same over all drawings that contain e.

~~Planar~~ Storyplan – Definition, Part II
Outerplanar

total order of vertices

$\langle \tau, \{D_i\}_{i \in [n]} \rangle$

sequence of drawings (we also call them *frames*)

(I) each D_i contains all vertices visible at step i;

(II) each D_i is ~~planar~~; outerplanar

(III) the point representing a vertex v does not change during the steps where v is visible;

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~~Planar~~ Storyplan – Definition, Part II
~~Outerplanar~~
Forest

total order of vertices

$$\langle \tau, \{D_i\}_{i \in [n]} \rangle$$

sequence of drawings (we also call them *frames*)

(I) each D_i contains all vertices visible at step i;

(II) each D_i is ~~planar;~~ ~~outerplanar~~ a crossing-free drawing of a forest

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Forest

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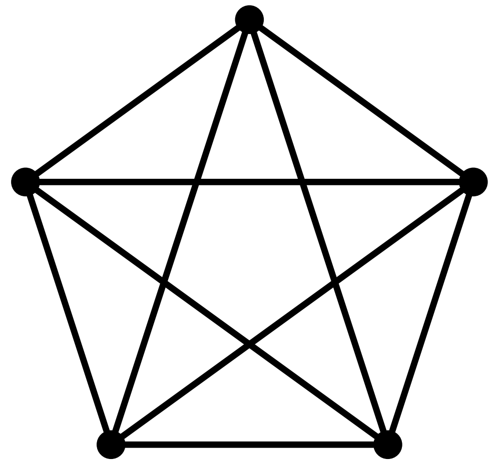

K_5 has no planar storyplan :-(

~~Planar~~ Storyplan – Definition, Part II
~~Outerplanar~~
Forest

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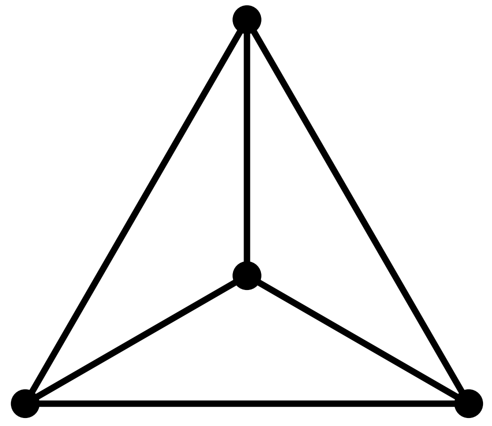

K_4 has no outerplanar storyplan :-(

~~Planar~~ Storyplan – Definition, Part II
~~Outerplanar~~
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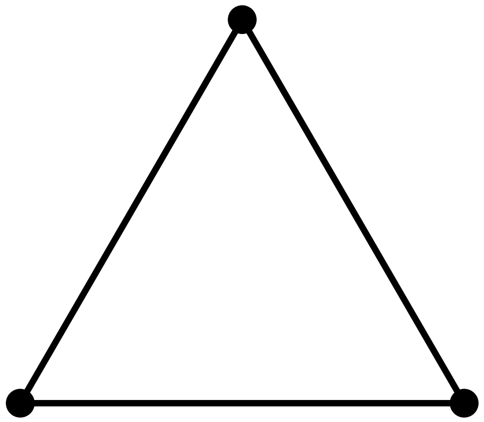

K_3 has no forest storyplan :-(

Related Work

	Storyplan	Graph Stories	Streamed Graphs
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Given:			
Condition:			
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Condition: Positions of vertices and edges do not change once they have been placed.

Aim:

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Aim:	Find a vertex order and drawings s.t. …		

…in each step the drawings are planar (or are crossing-free drawings of trees).

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Condition: Positions of vertices and edges do not change once they have been placed.

Aim:	Find a vertex order and drawings s.t. …	Place vertices on a grid of small size s.t. …	

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- Two parametrized algorithms:
  - w.r.t. the vertex cover number
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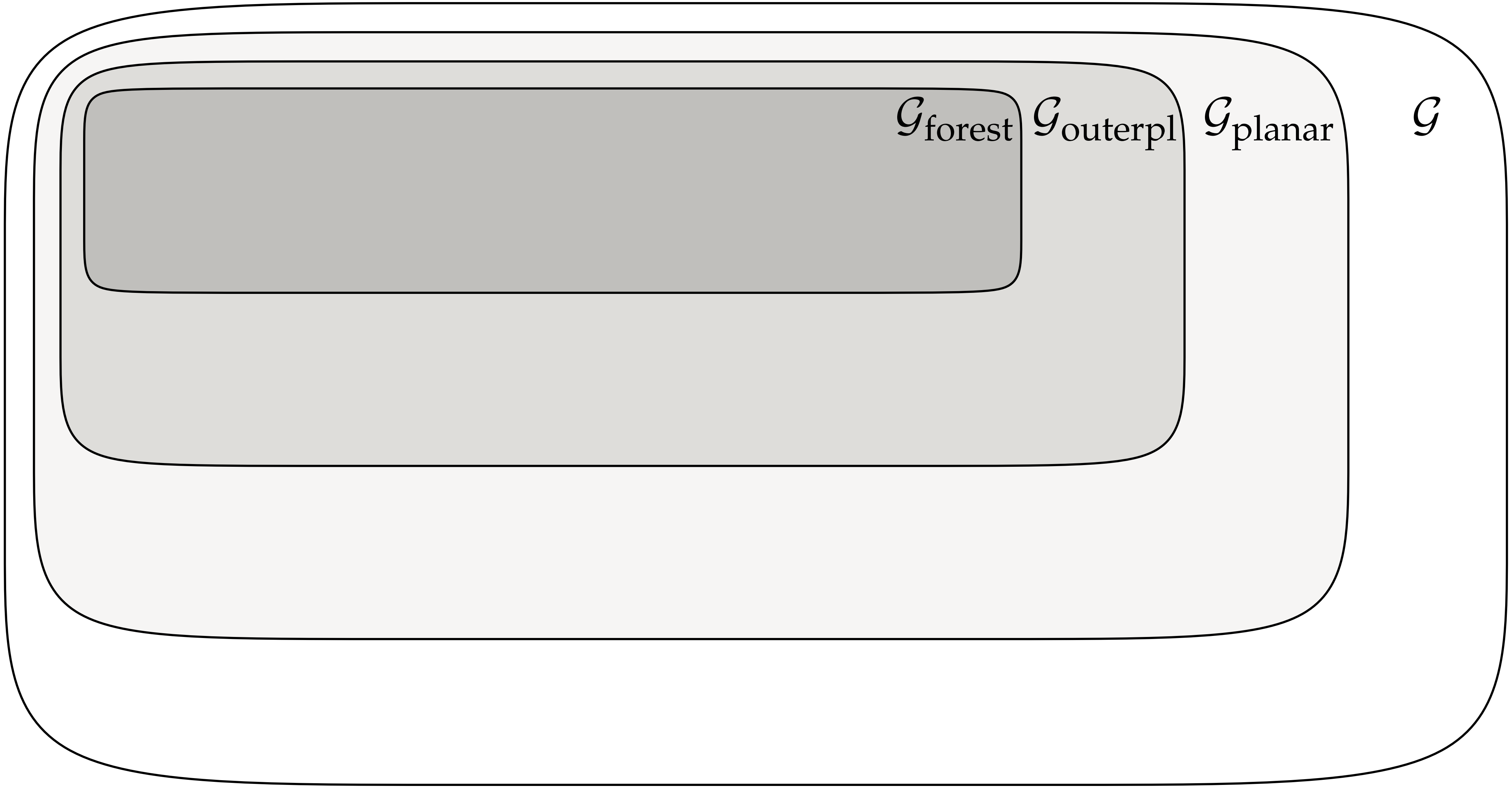
- Partial 3-trees always admit a planar storyplan.
- Even if the total vertex order is given, the problem is still NP-complete.

Our Contribution



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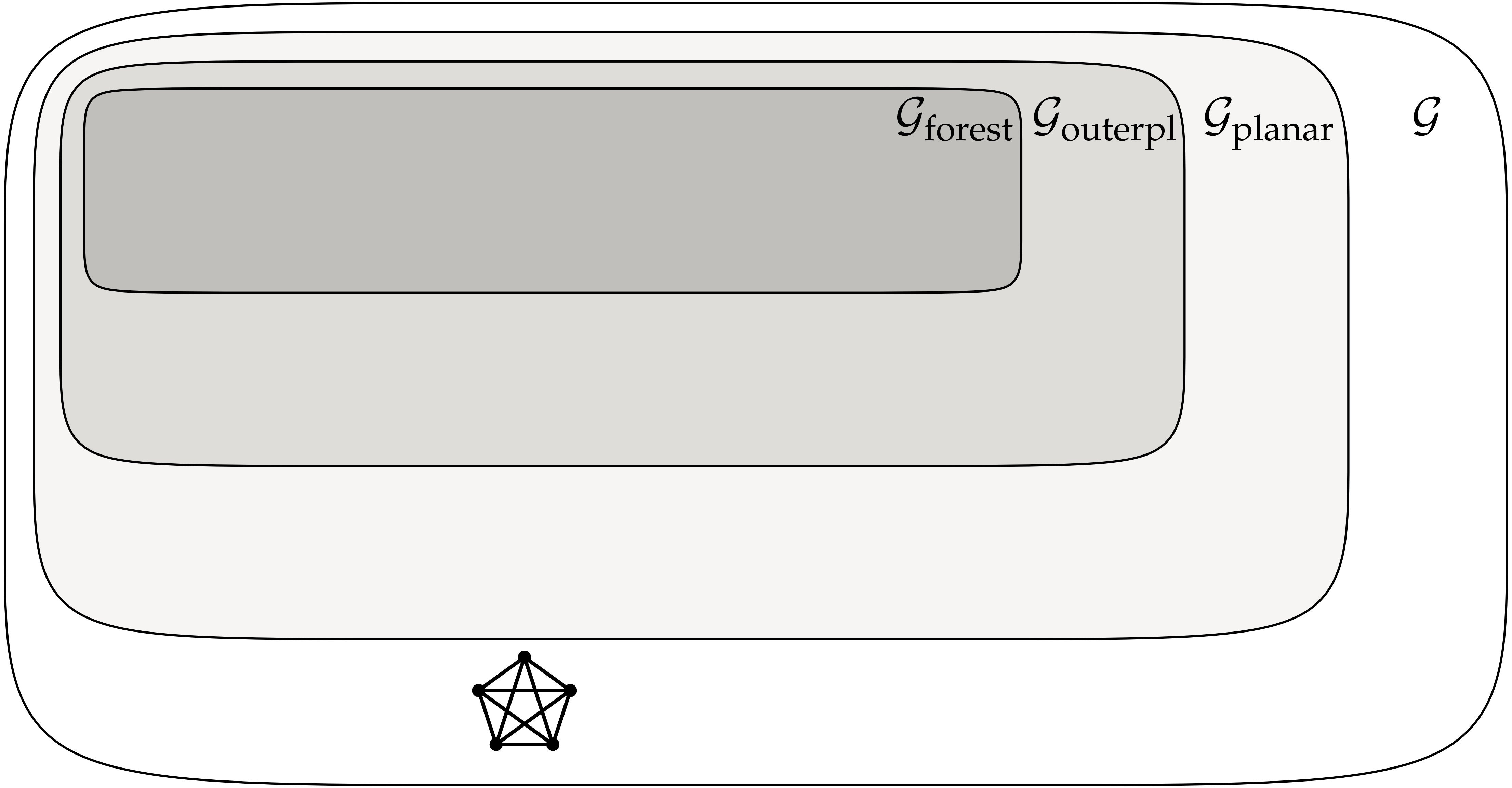

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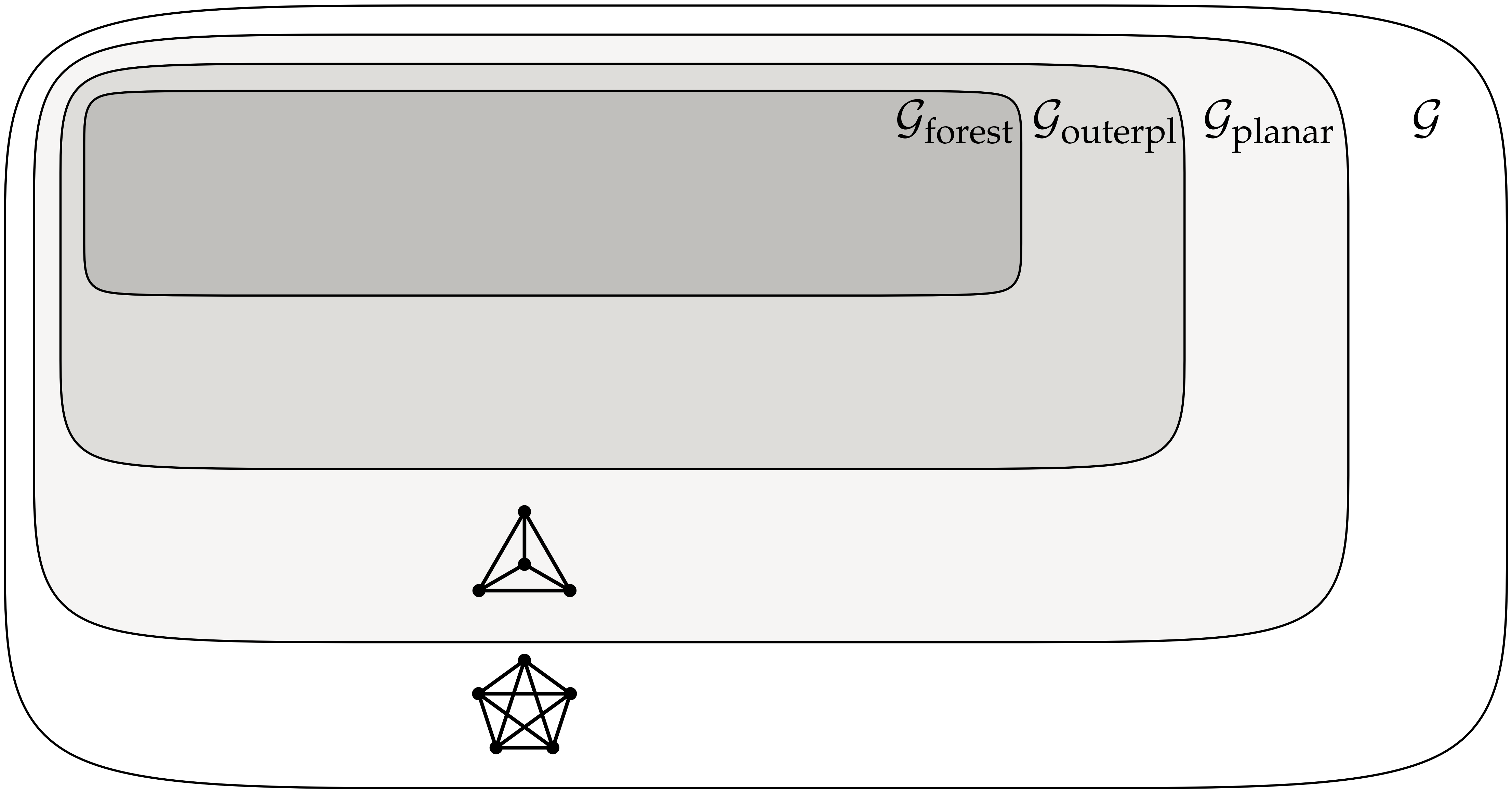

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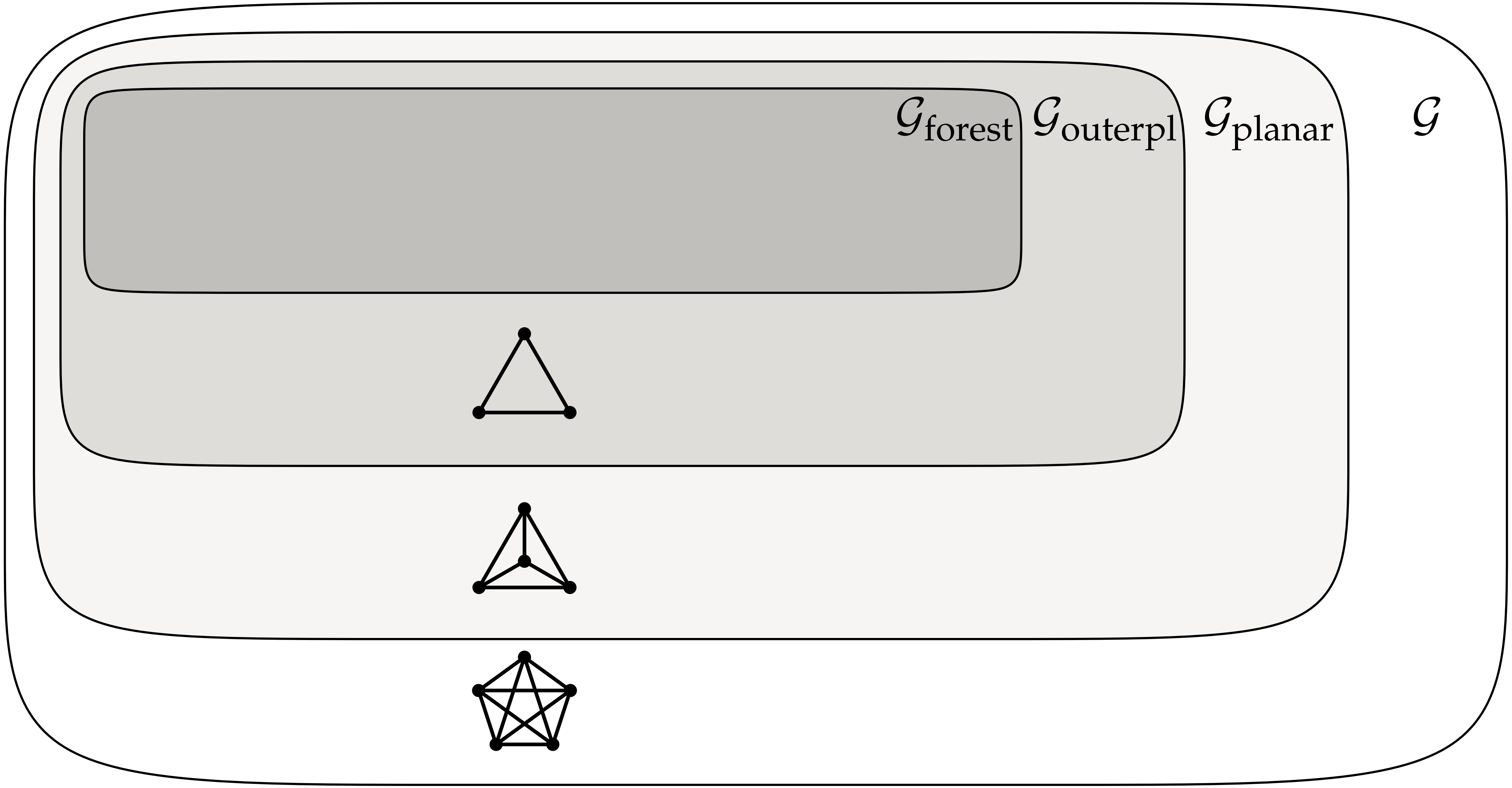

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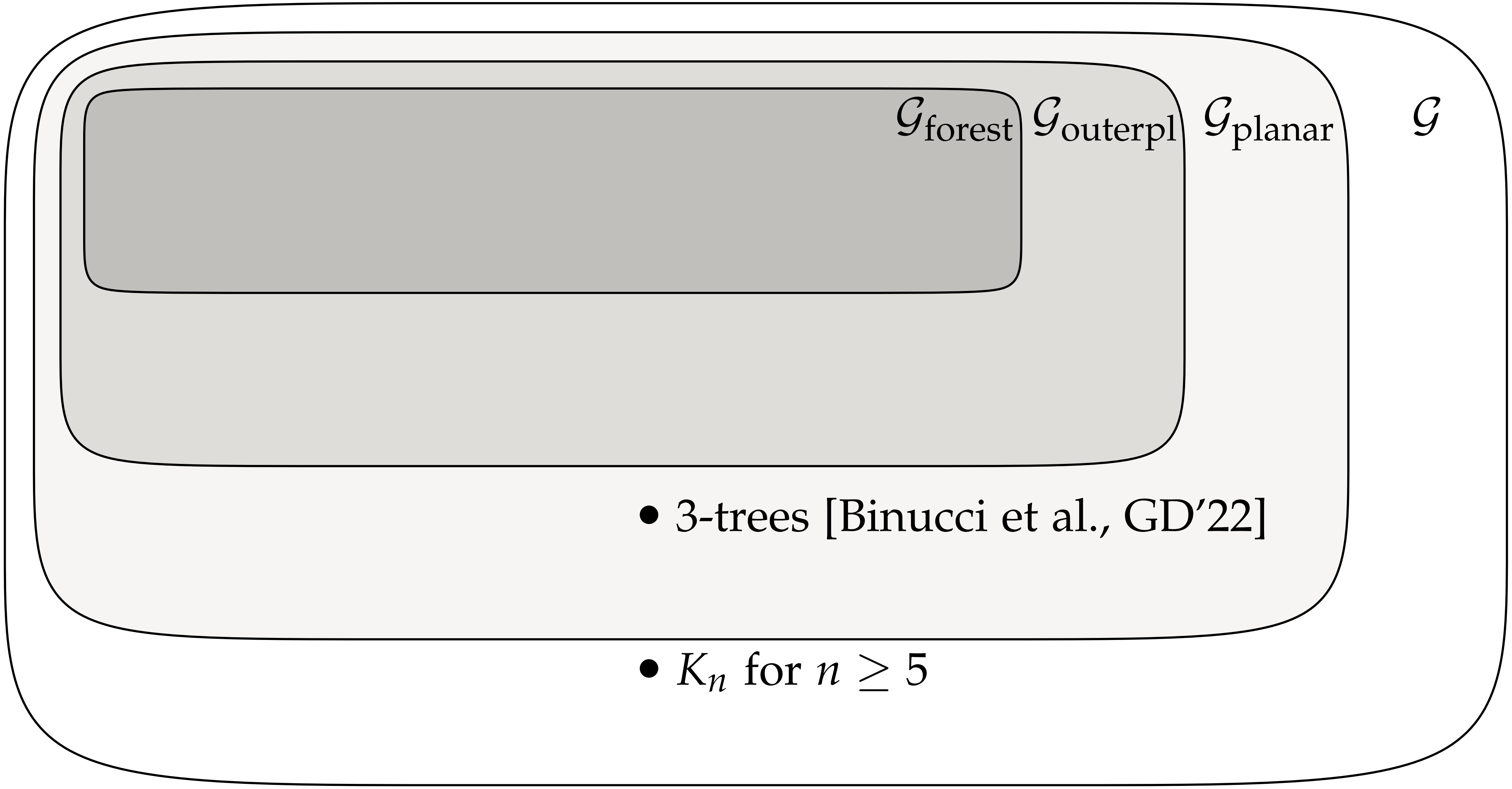

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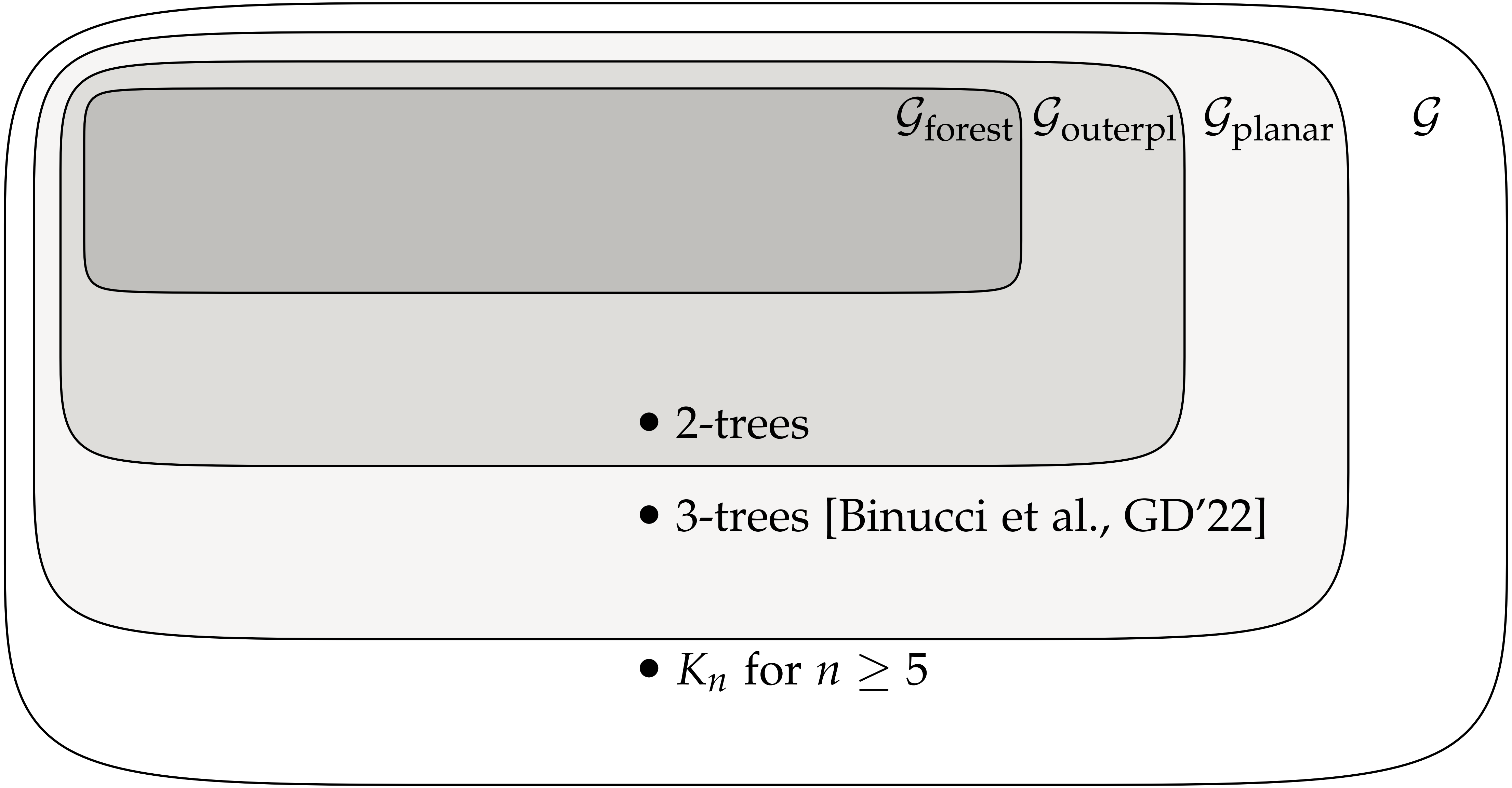

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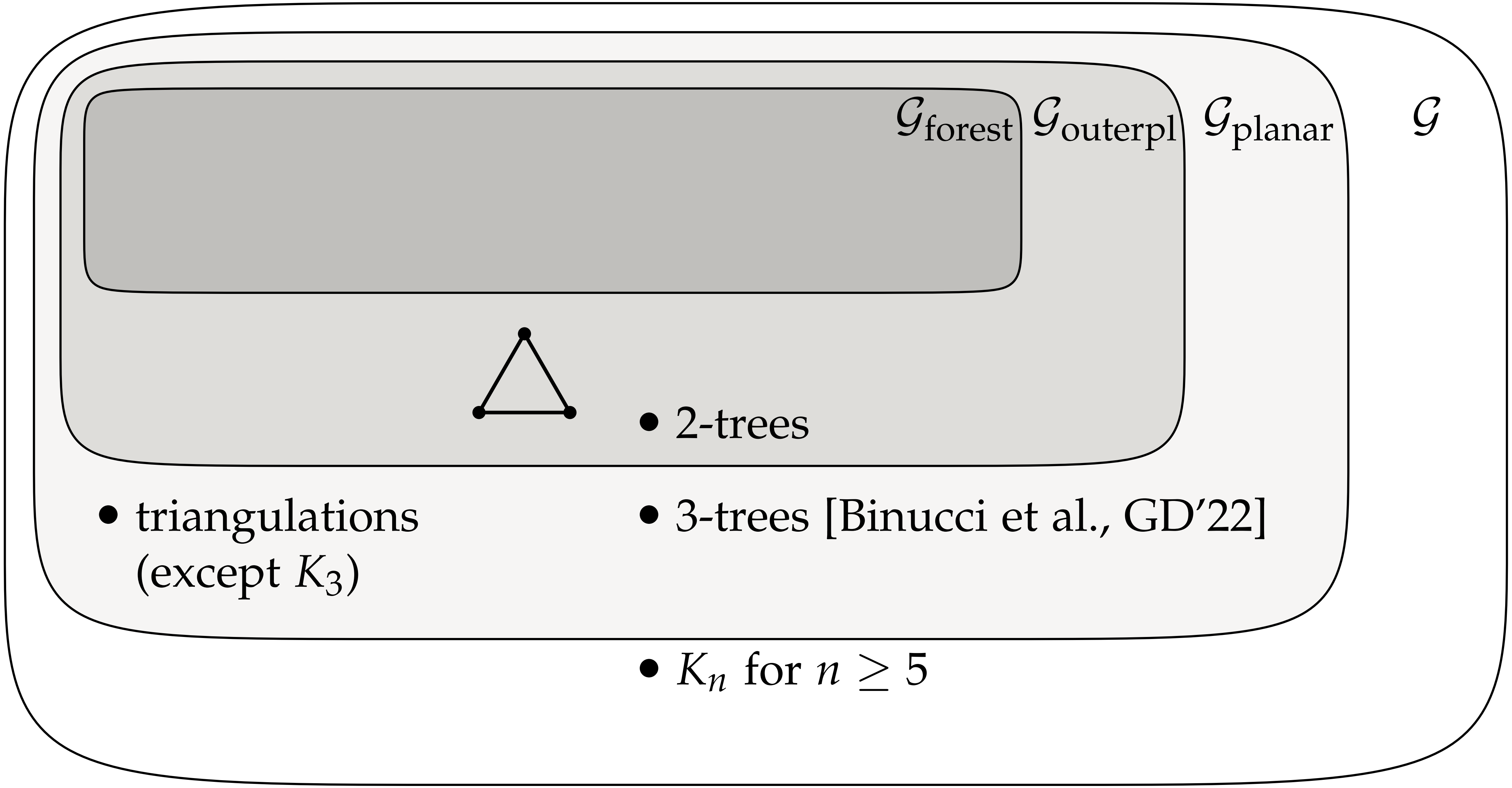

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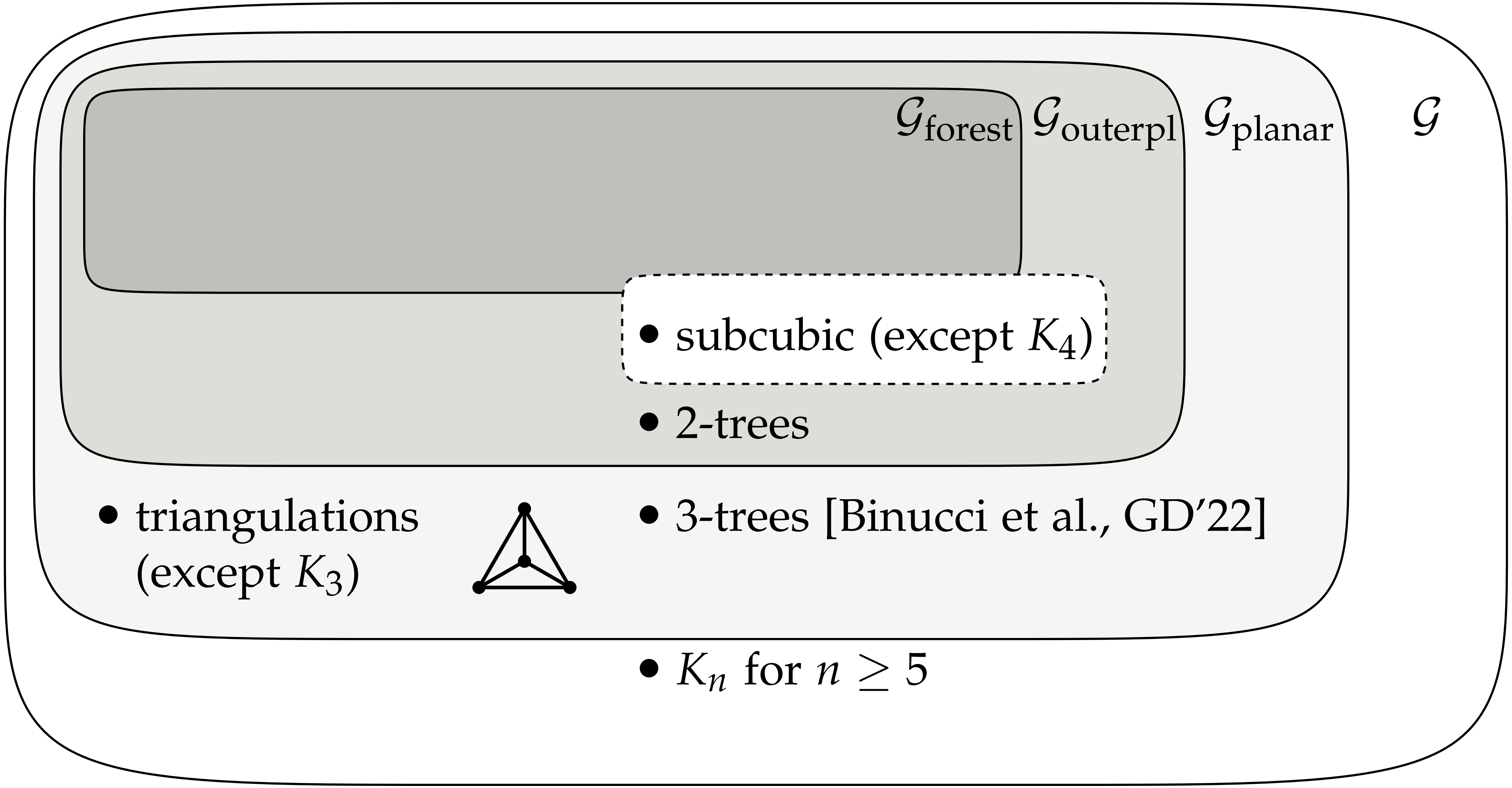

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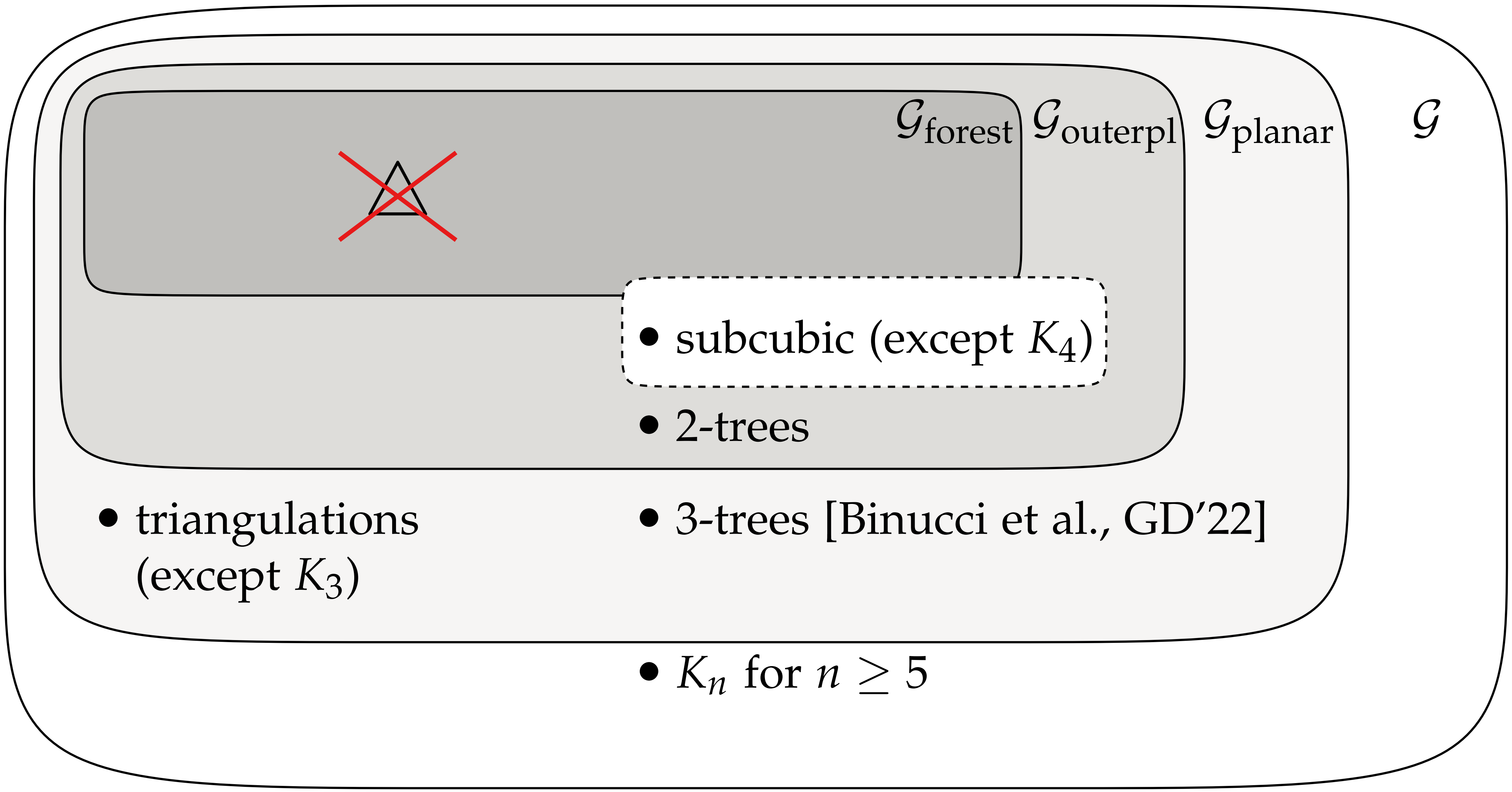

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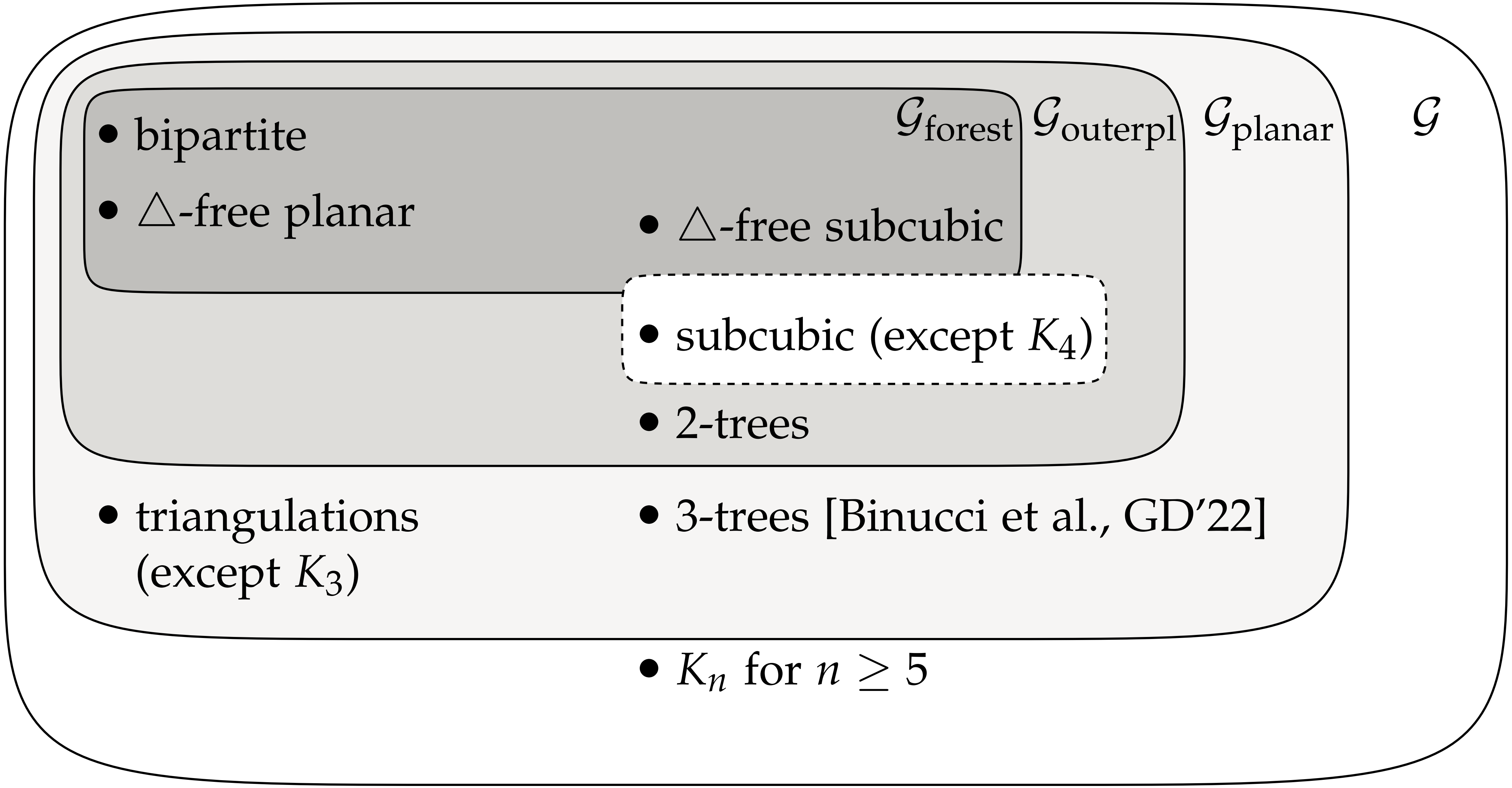

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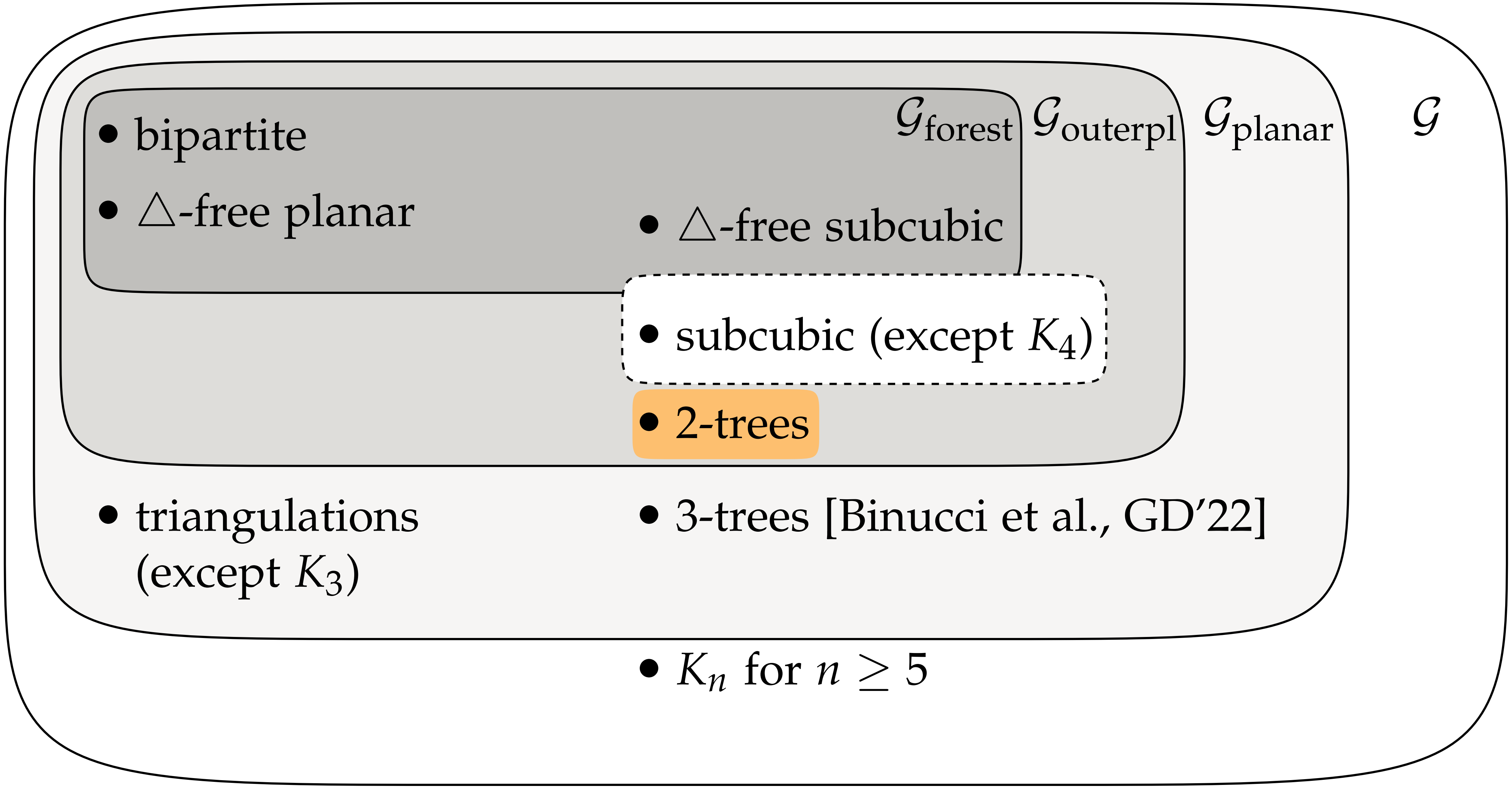

Outerplanar Storyplans of 2-Trees

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Every (partial) **2-tree** admits
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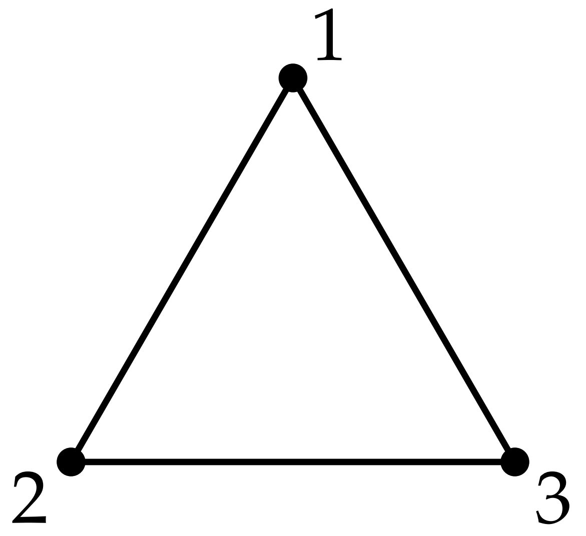

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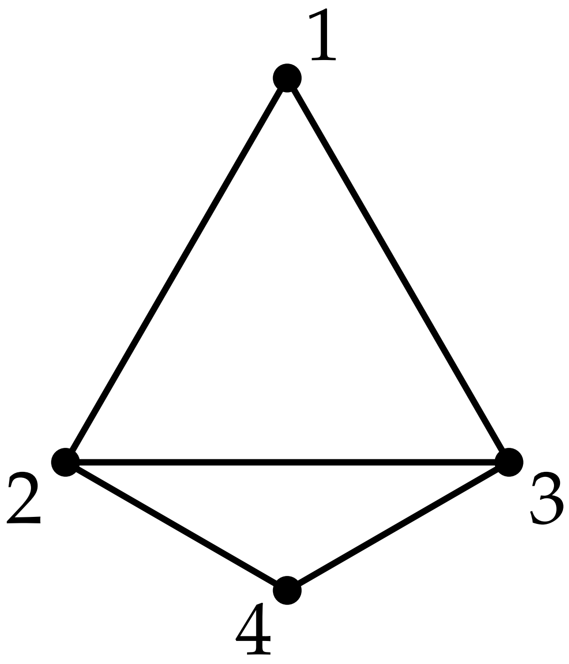

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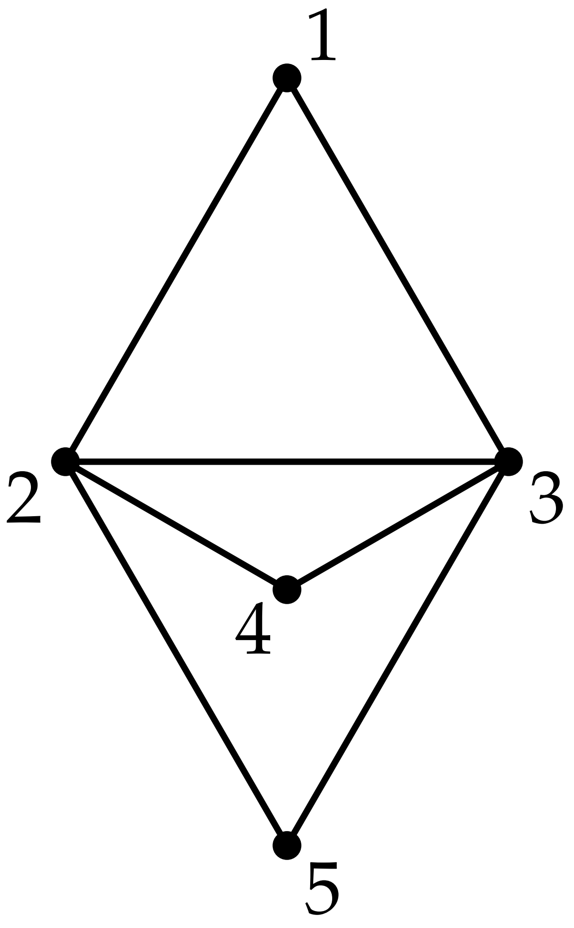

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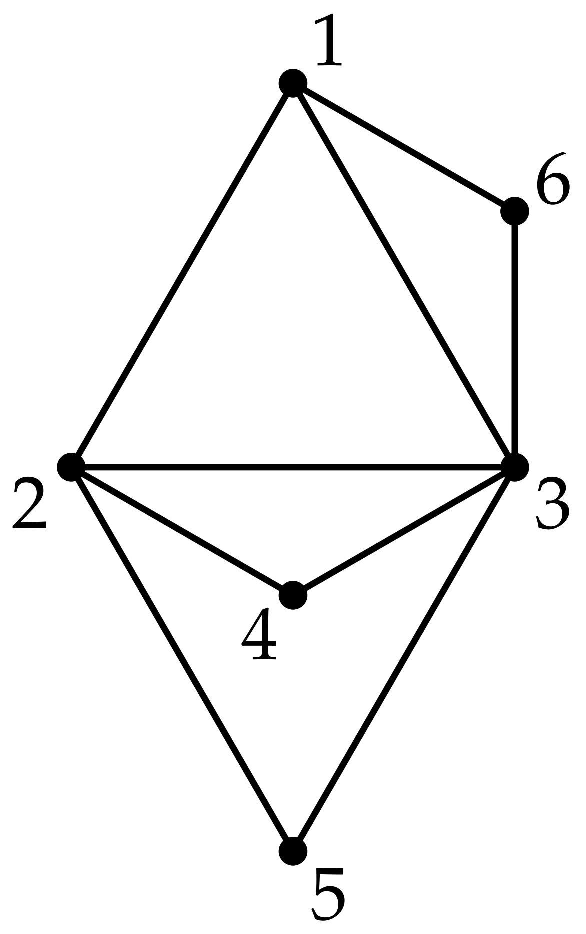

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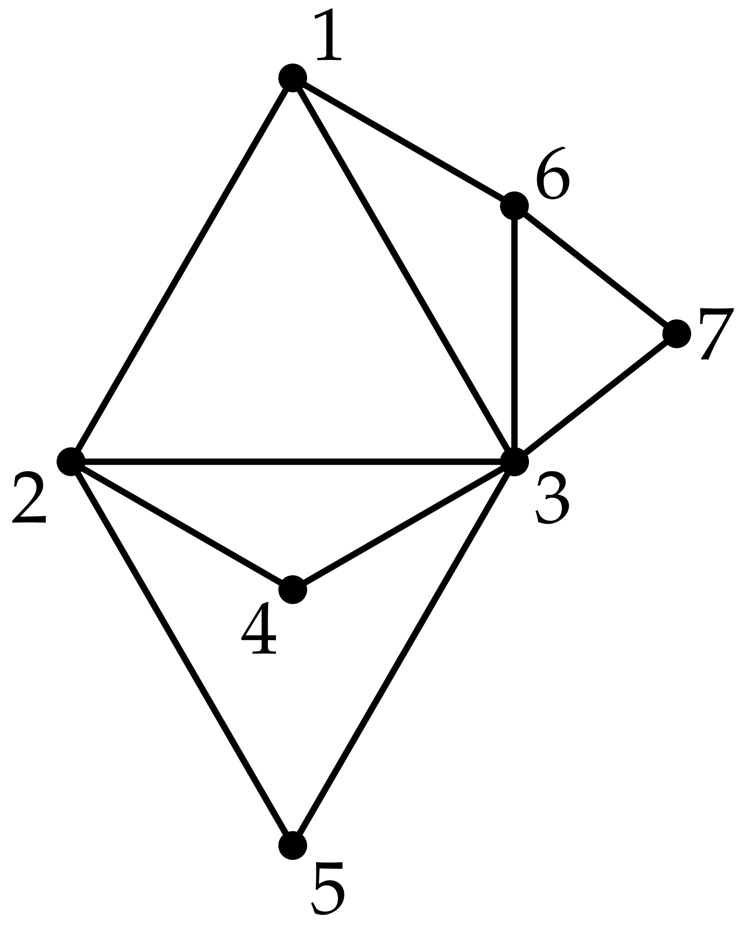

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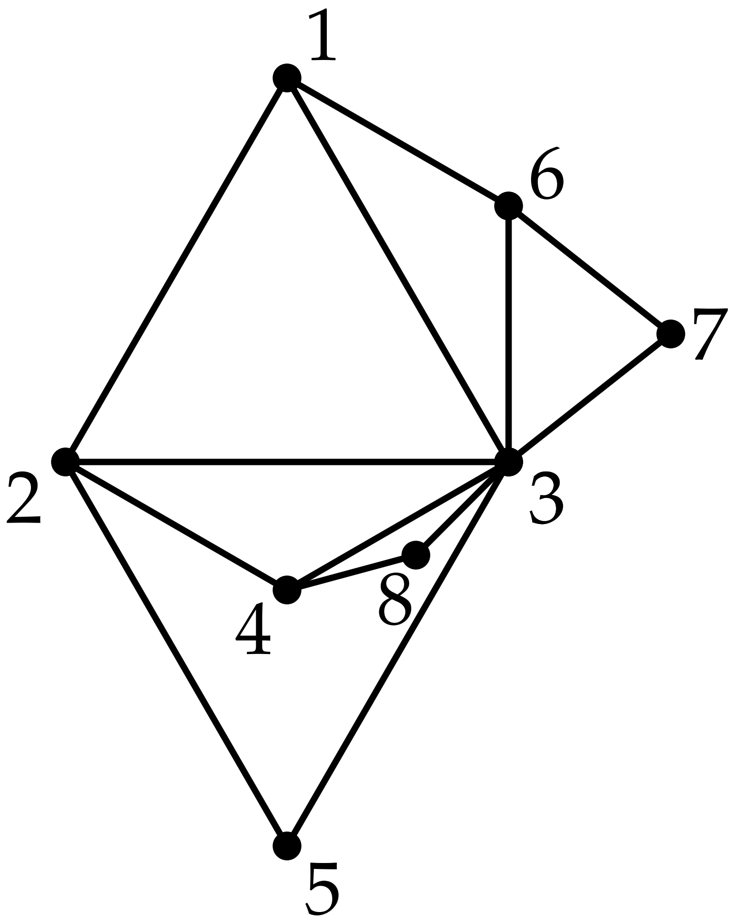

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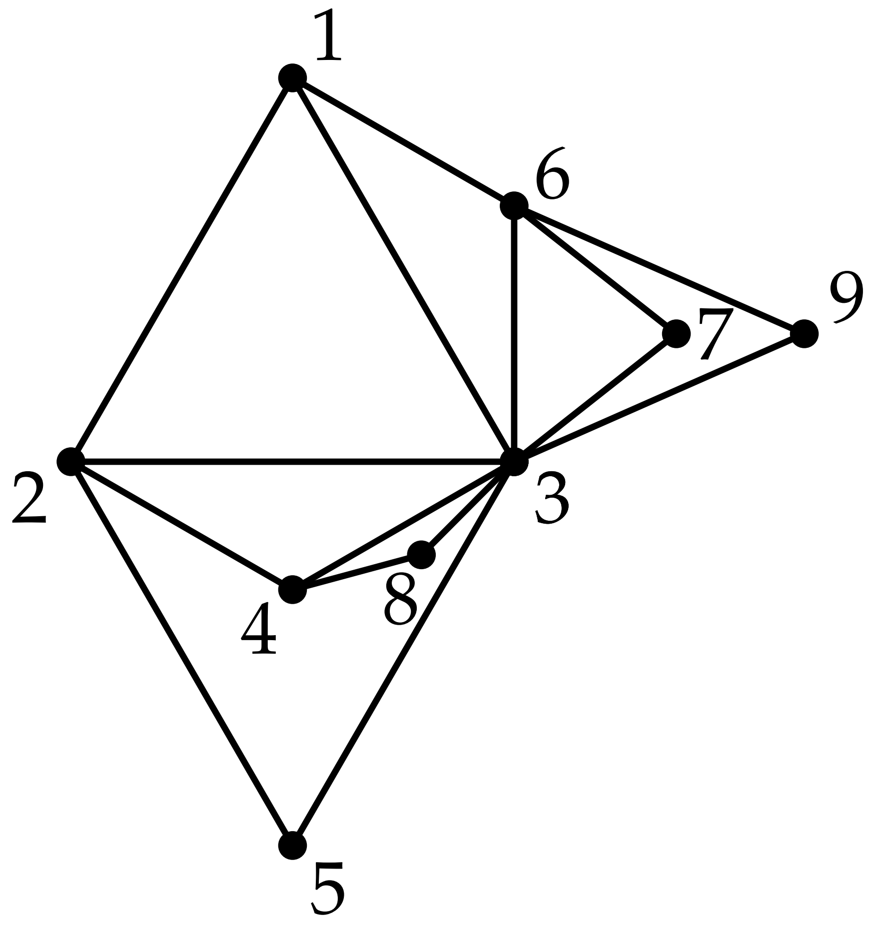

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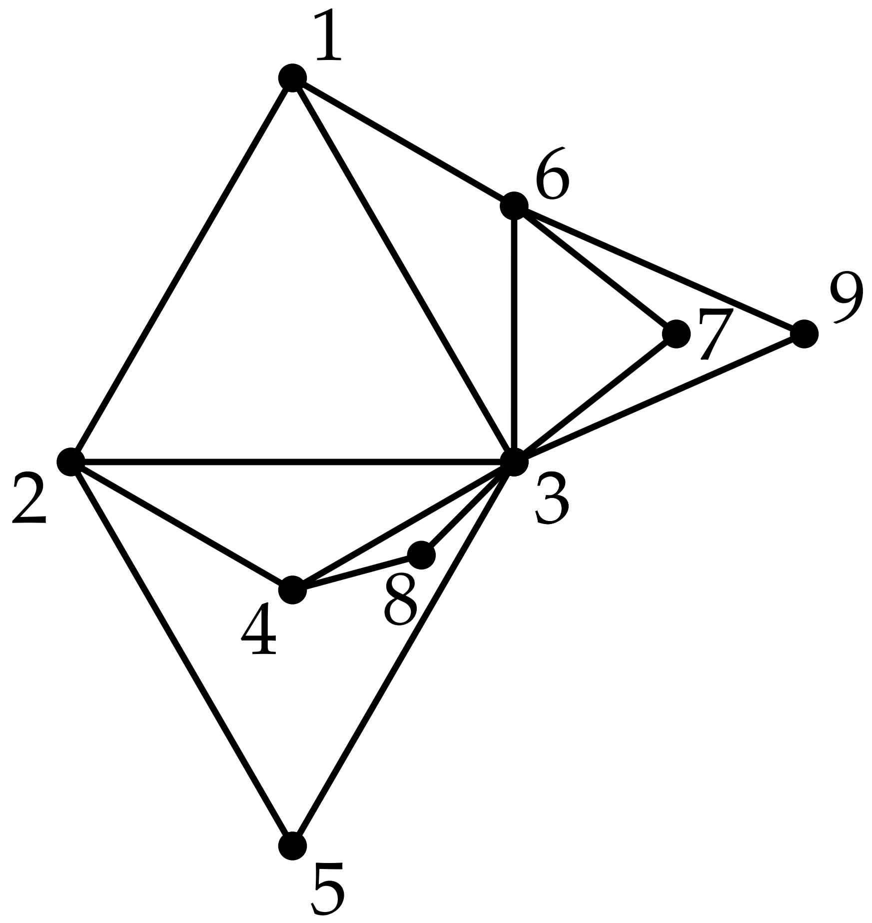

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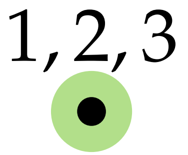

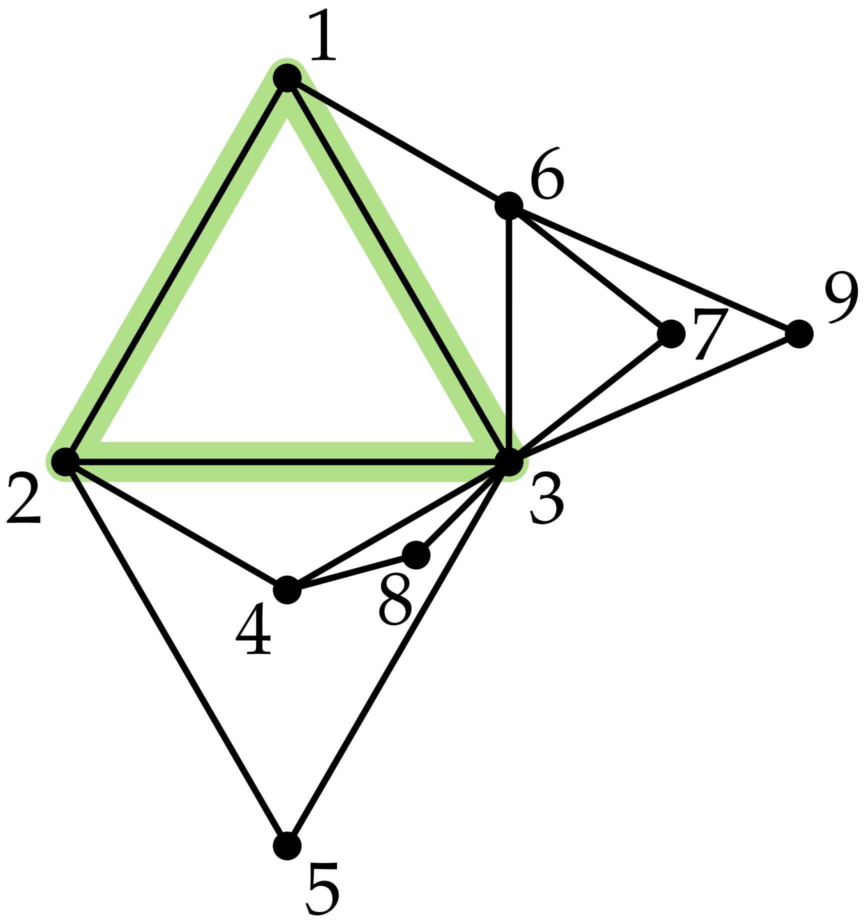

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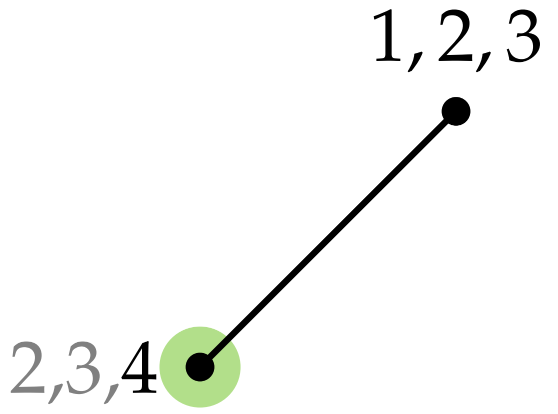

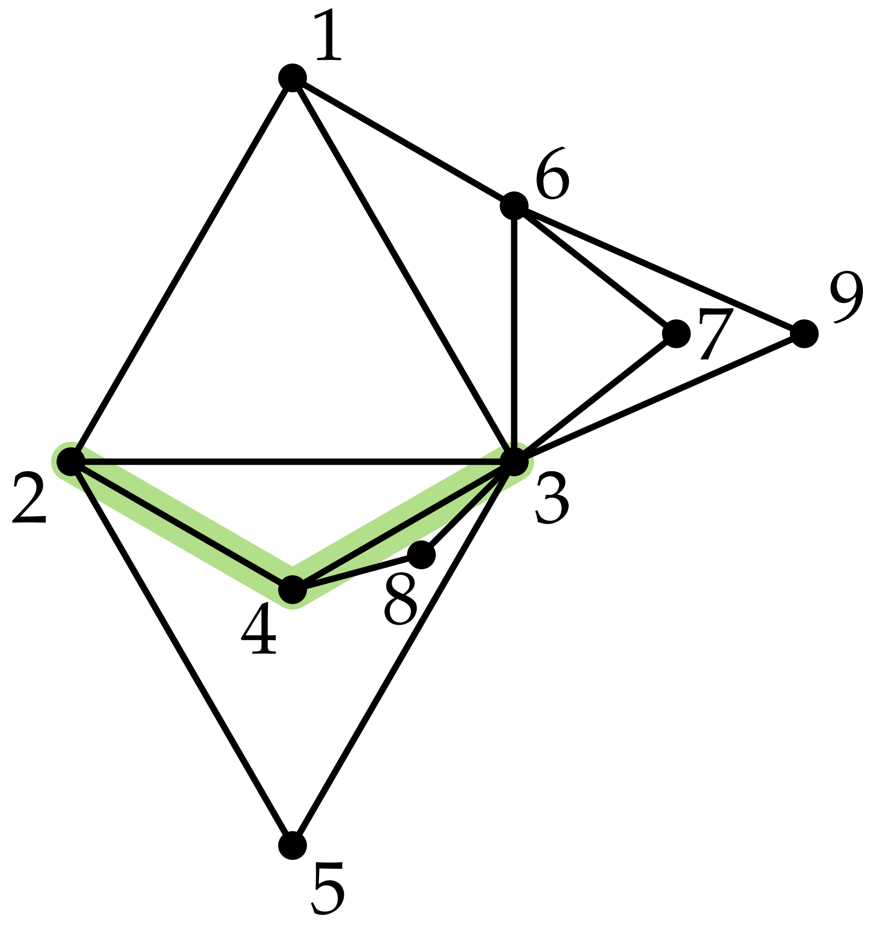

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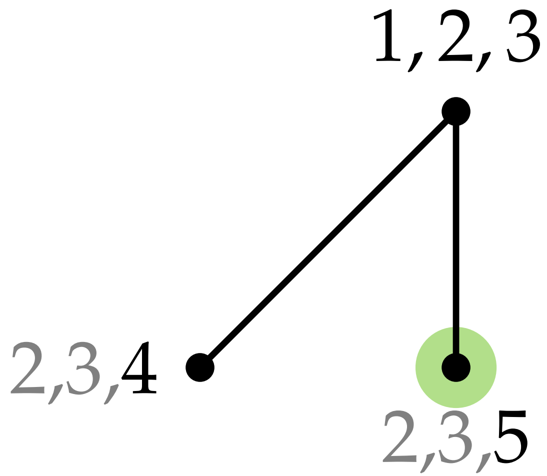

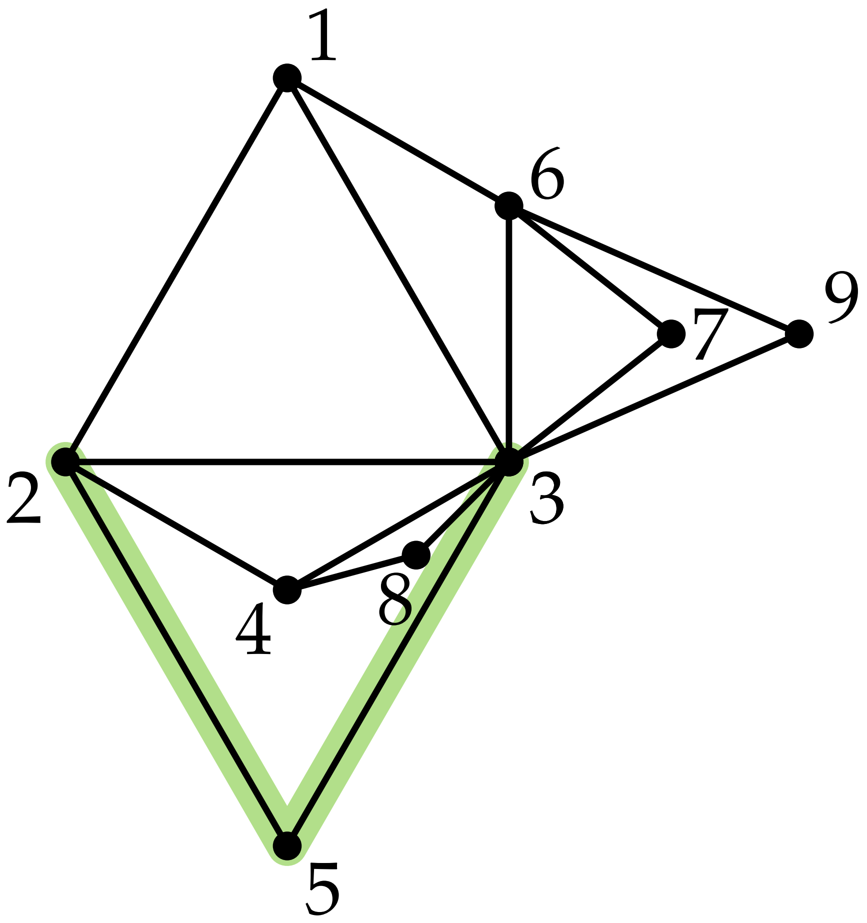

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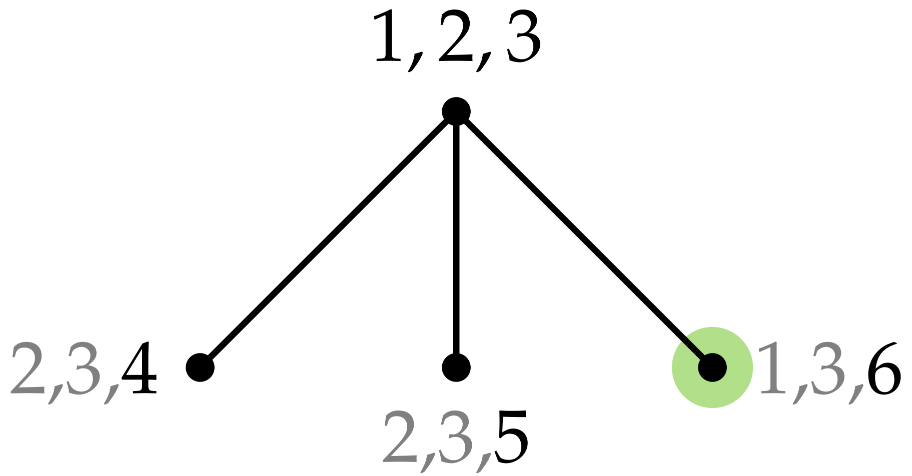

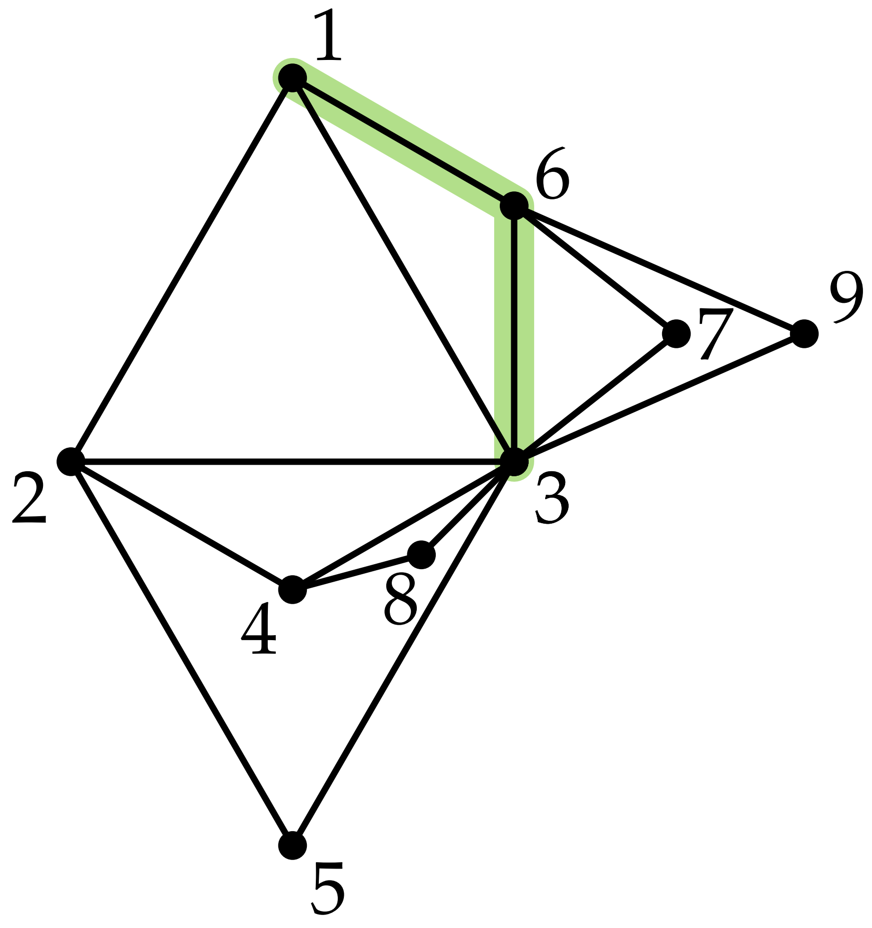

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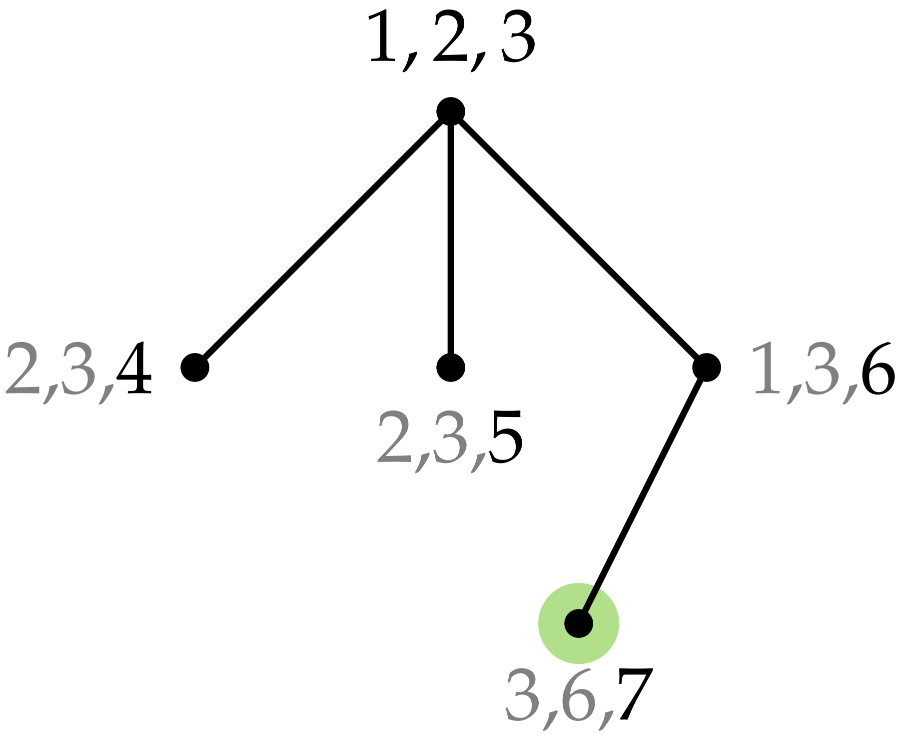

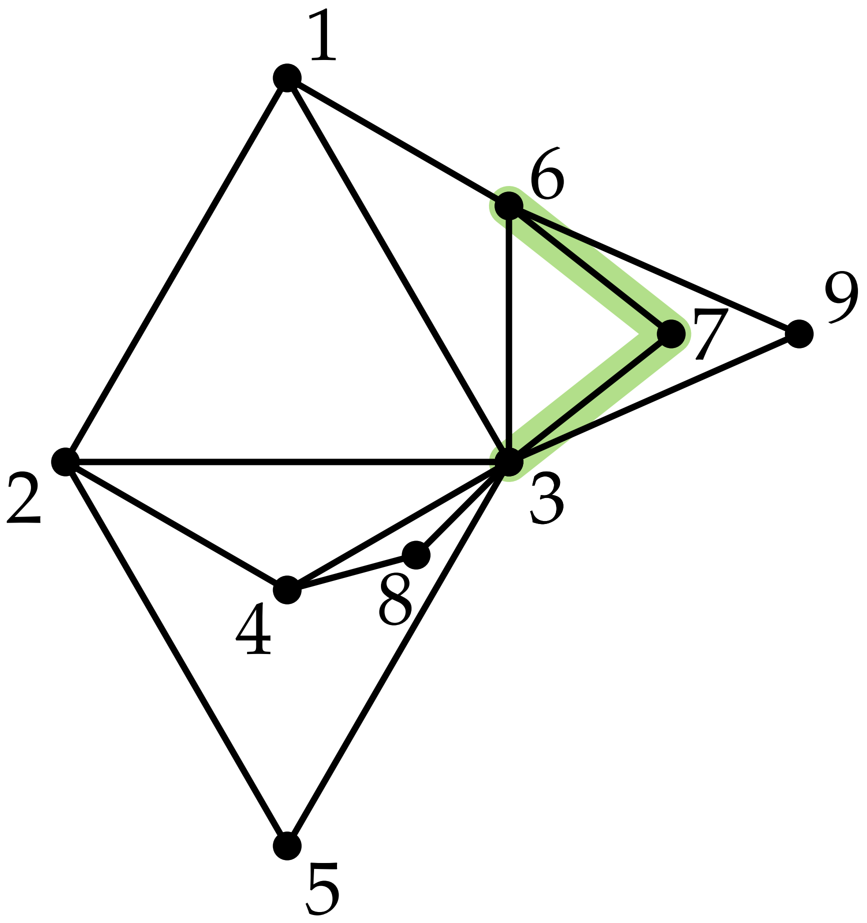

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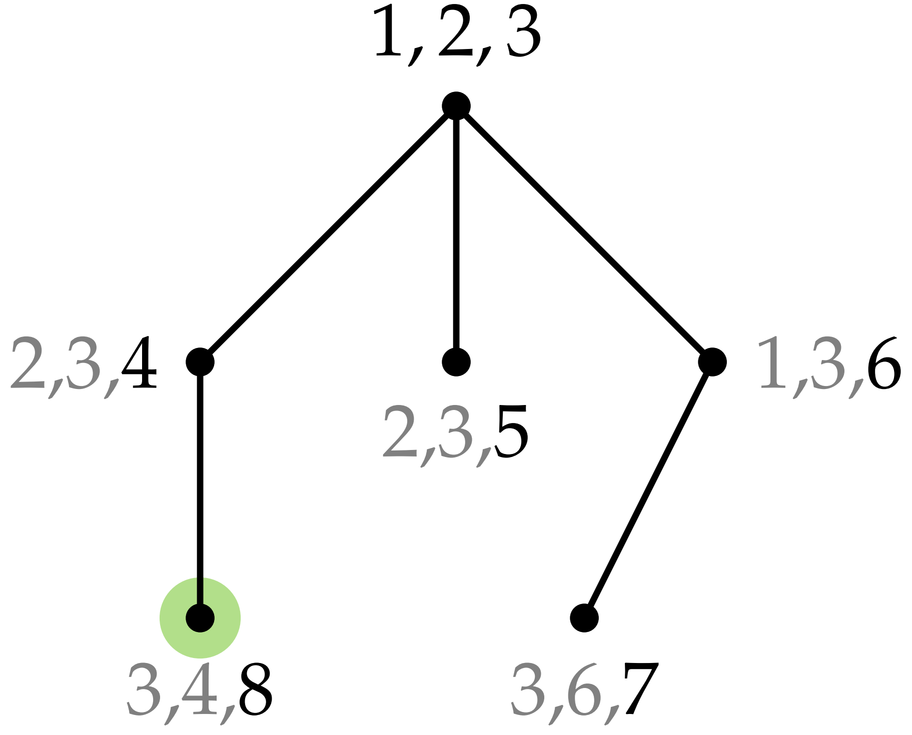

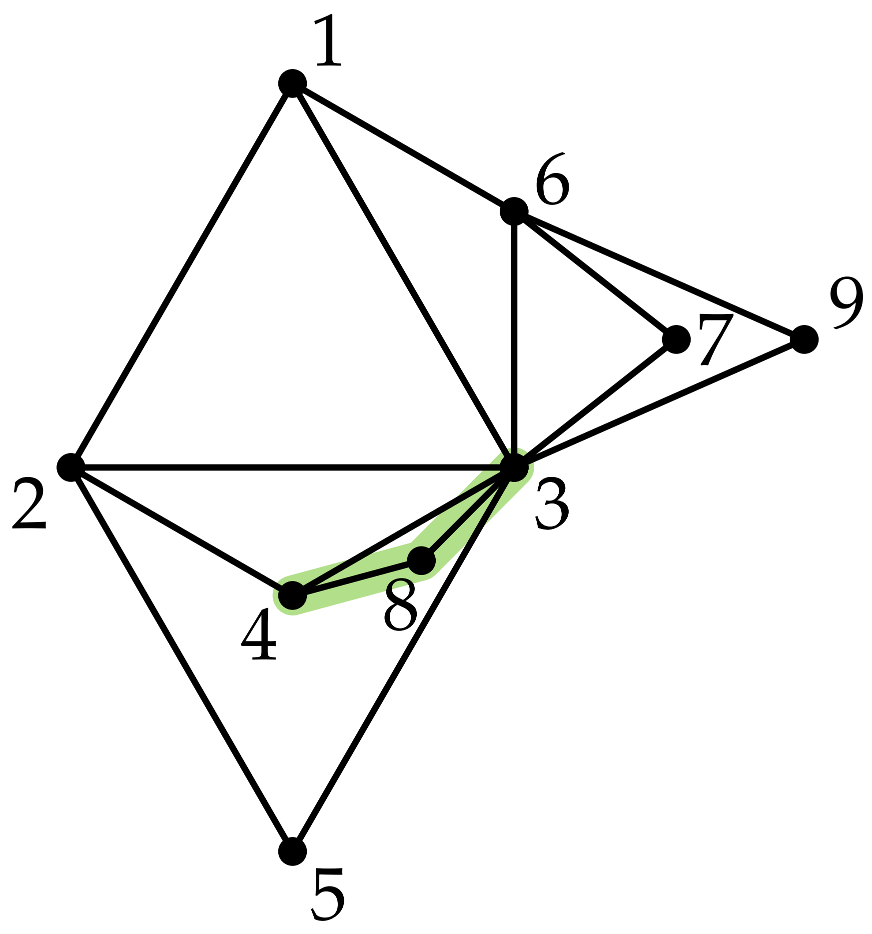

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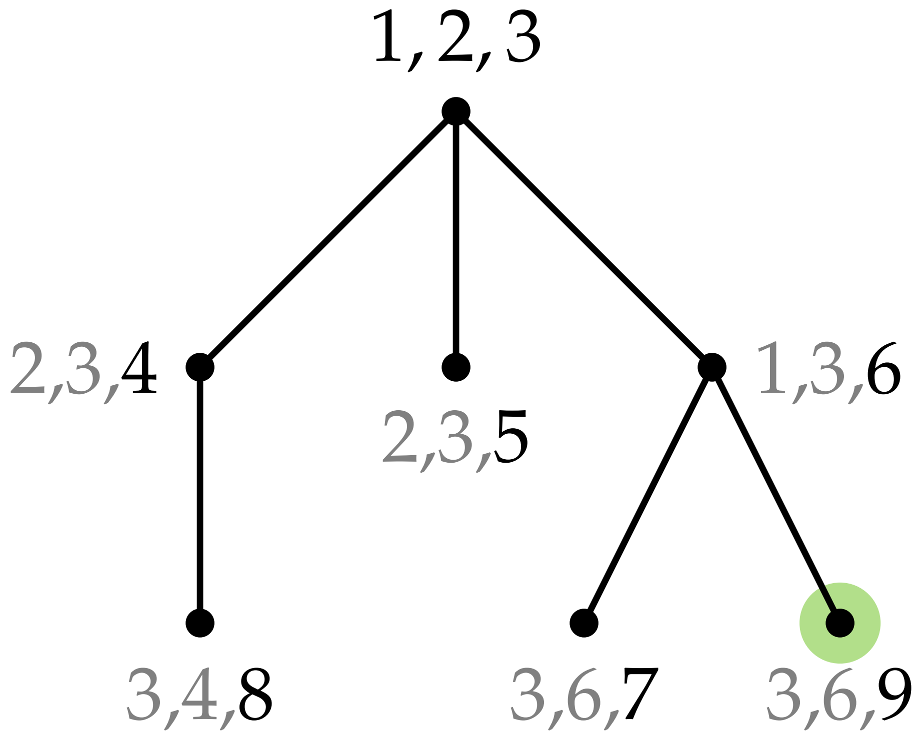

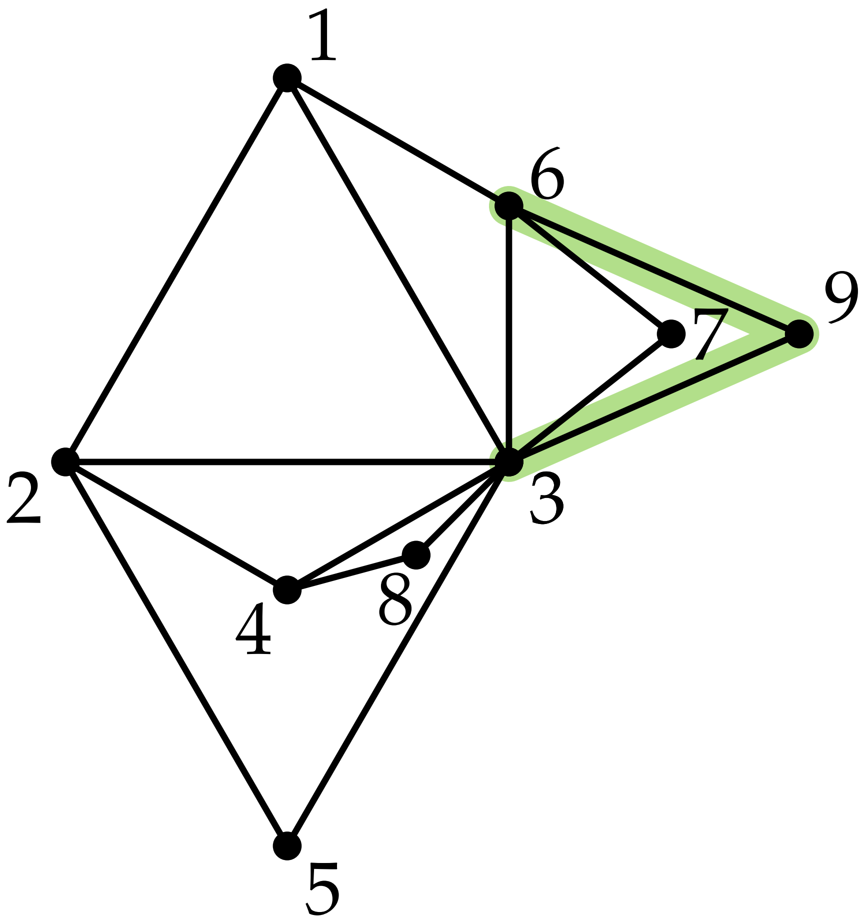

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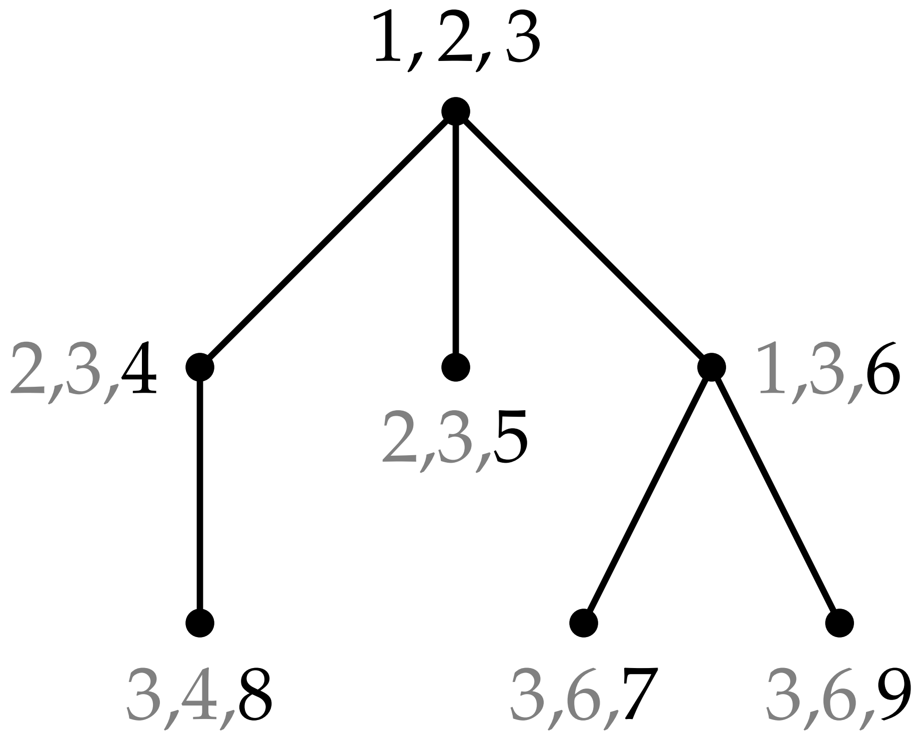

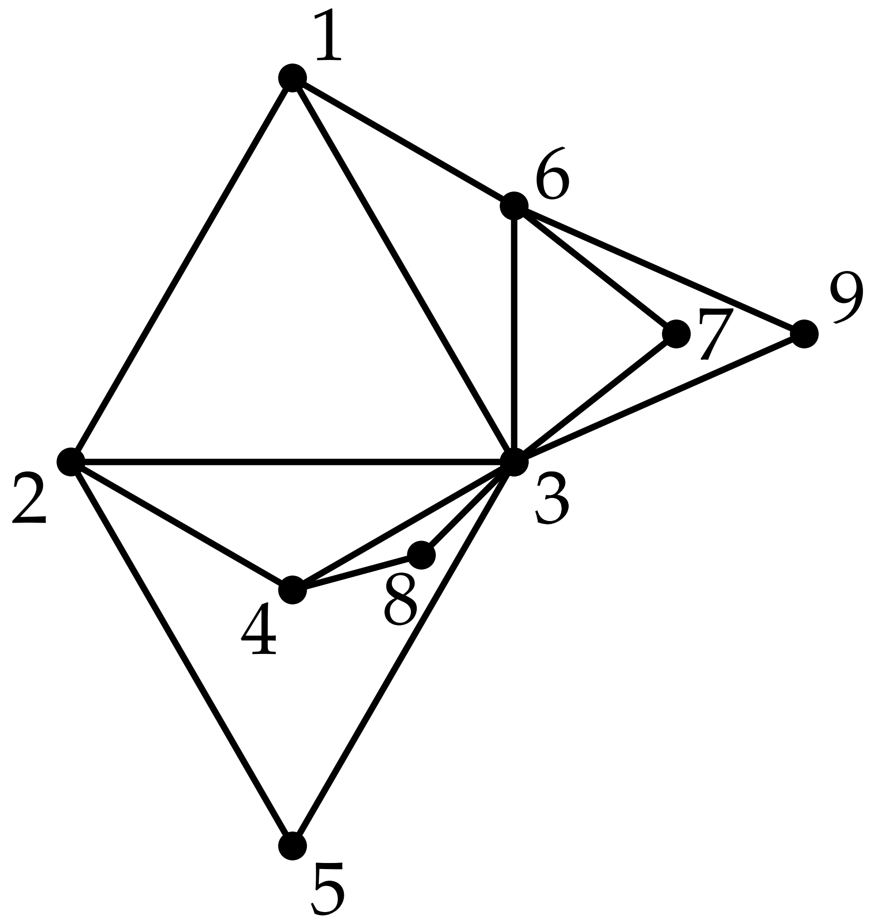

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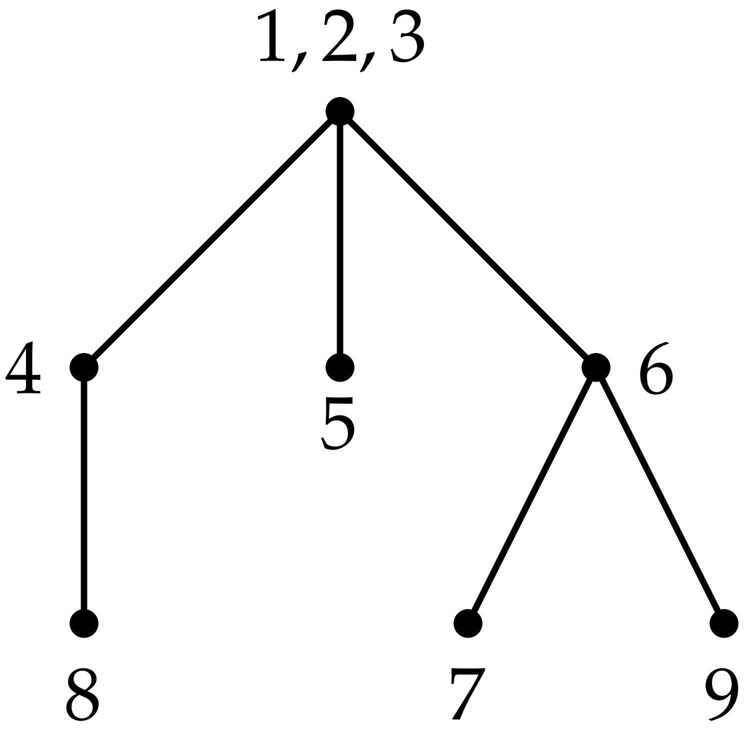

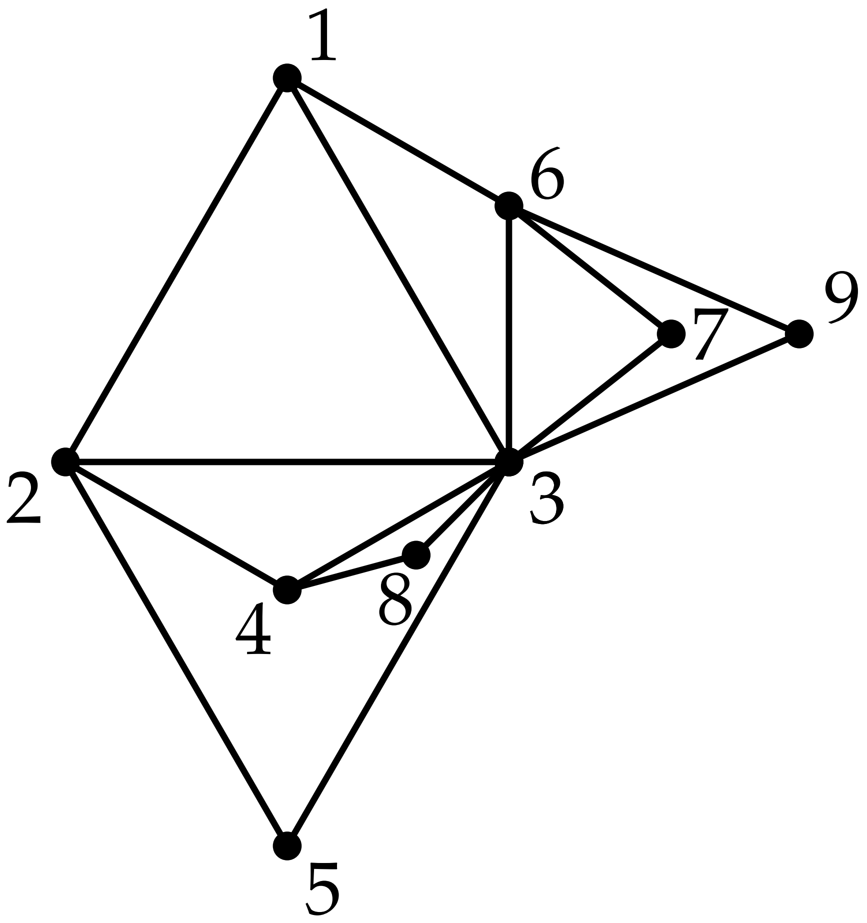

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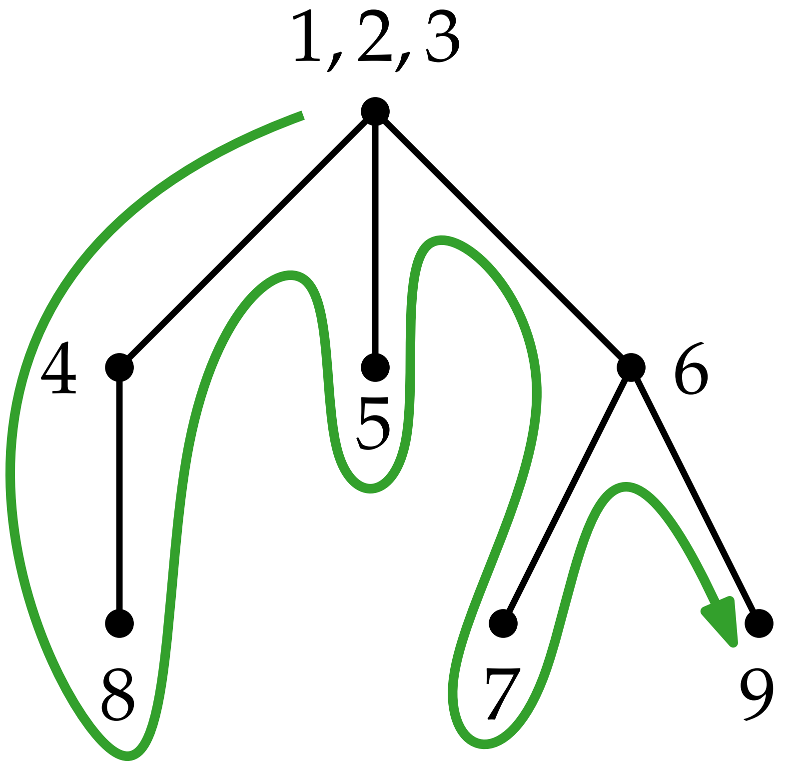

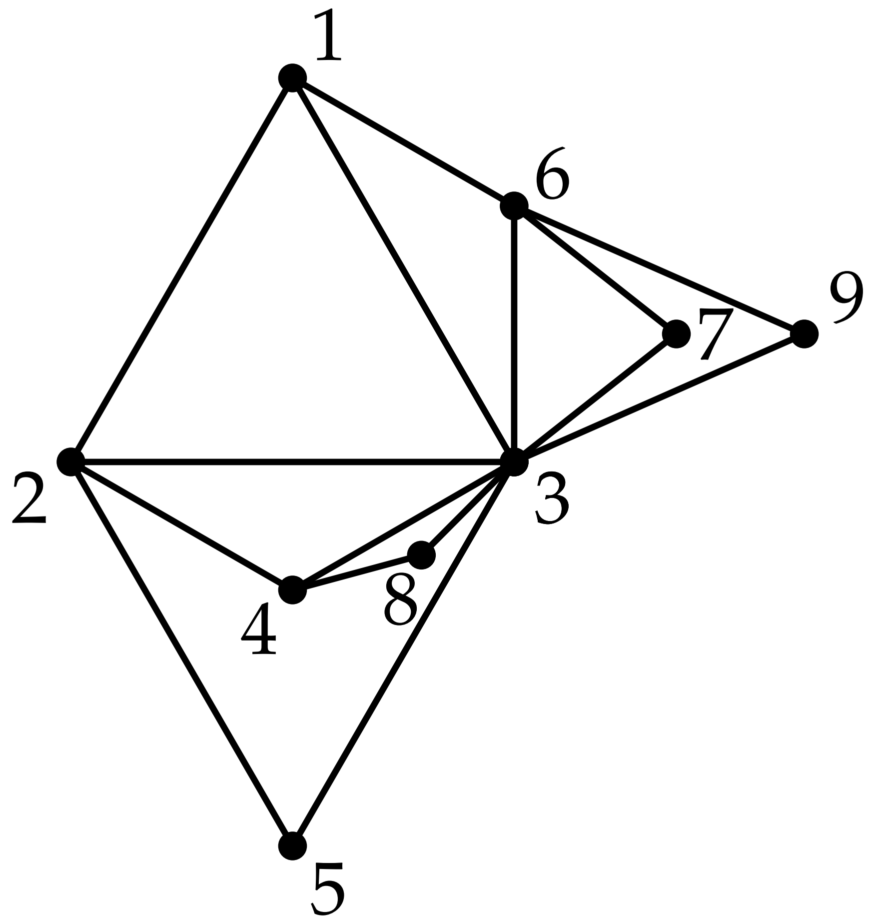

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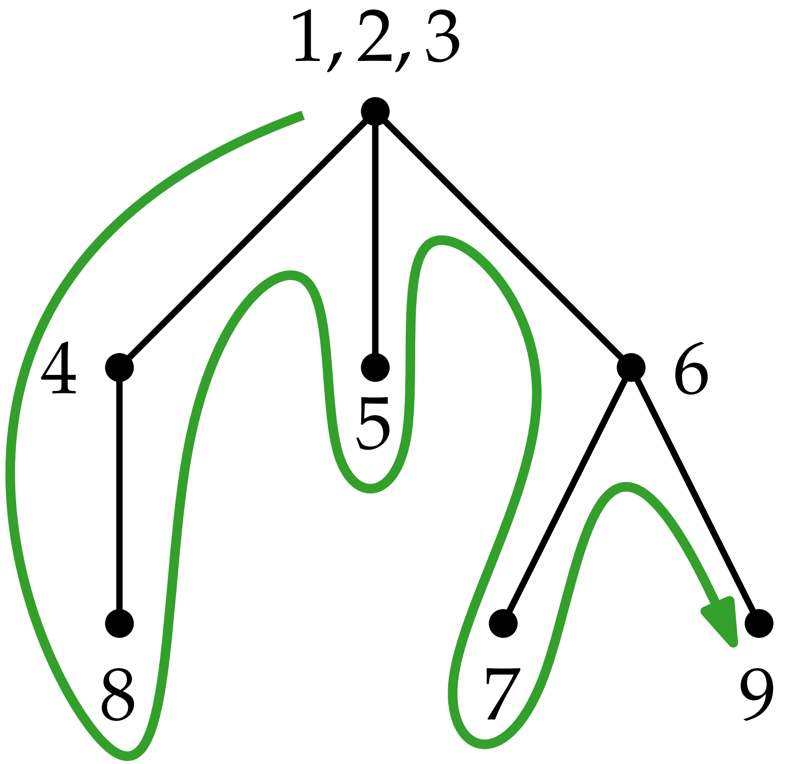

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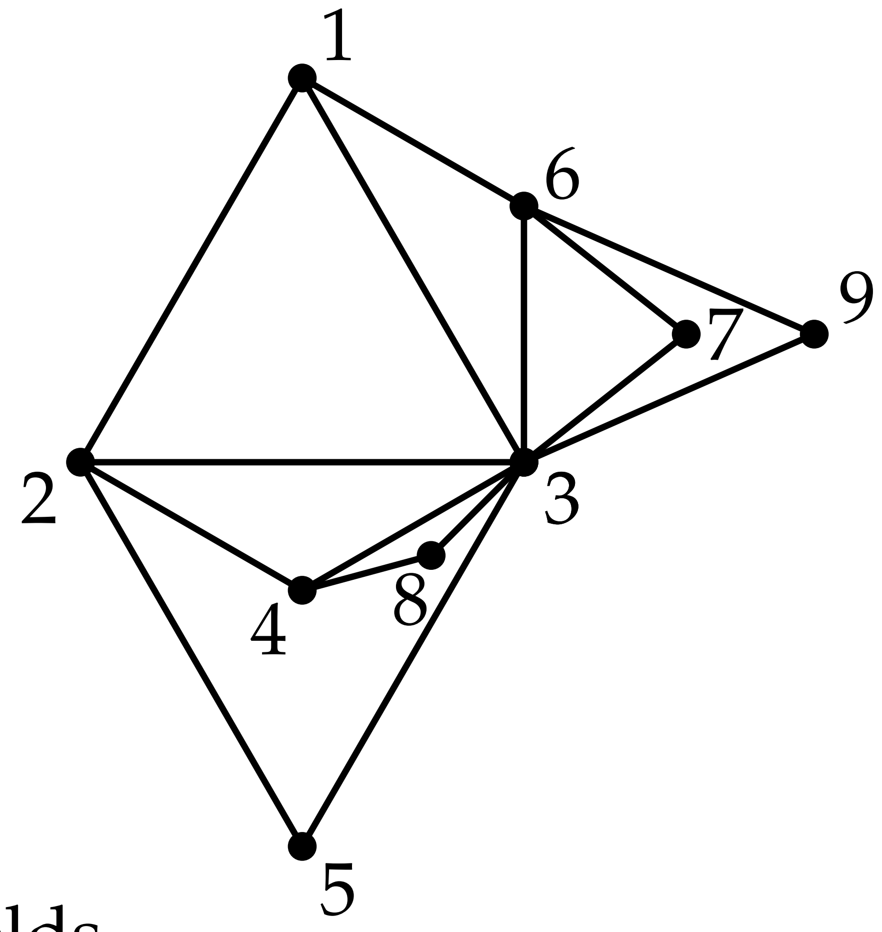

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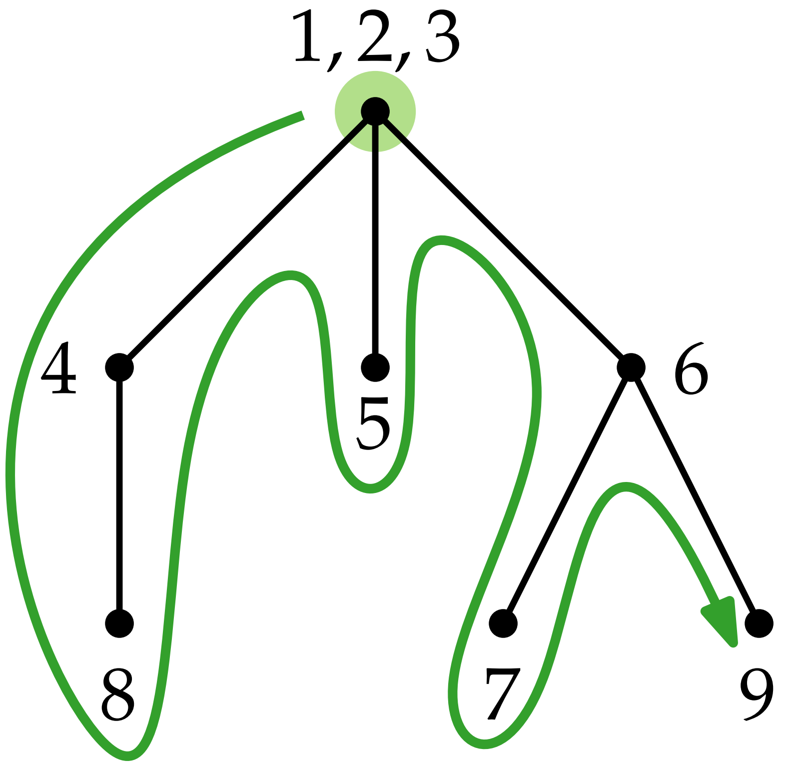

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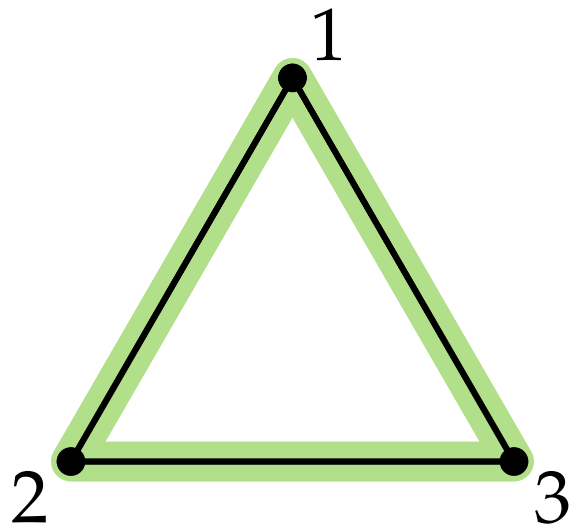

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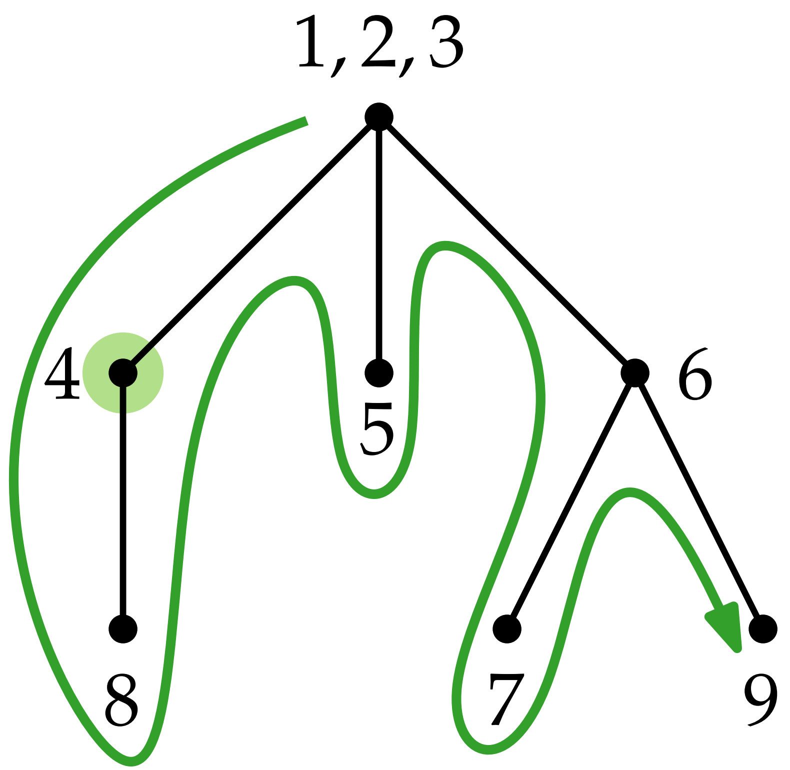

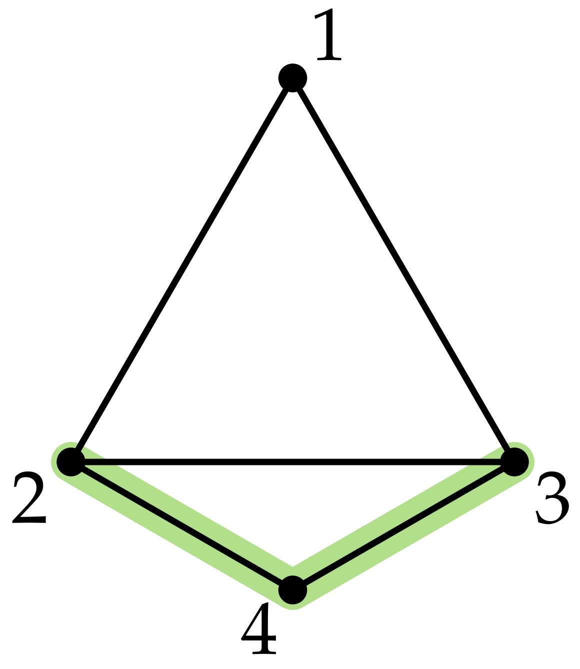

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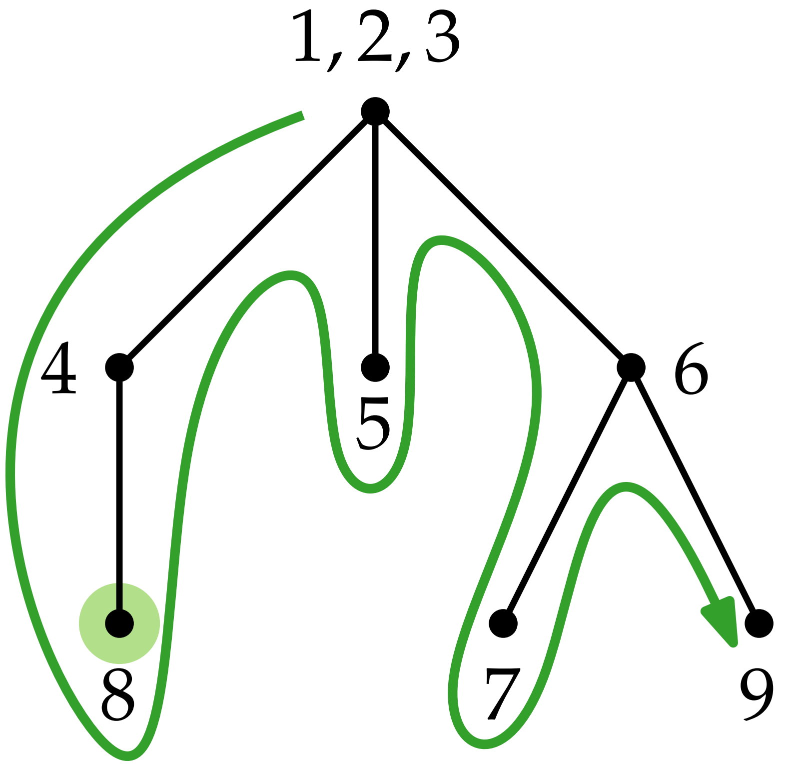

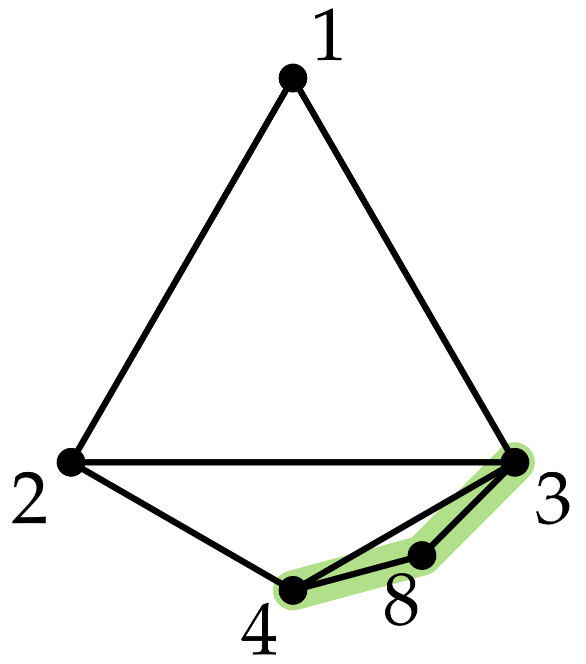

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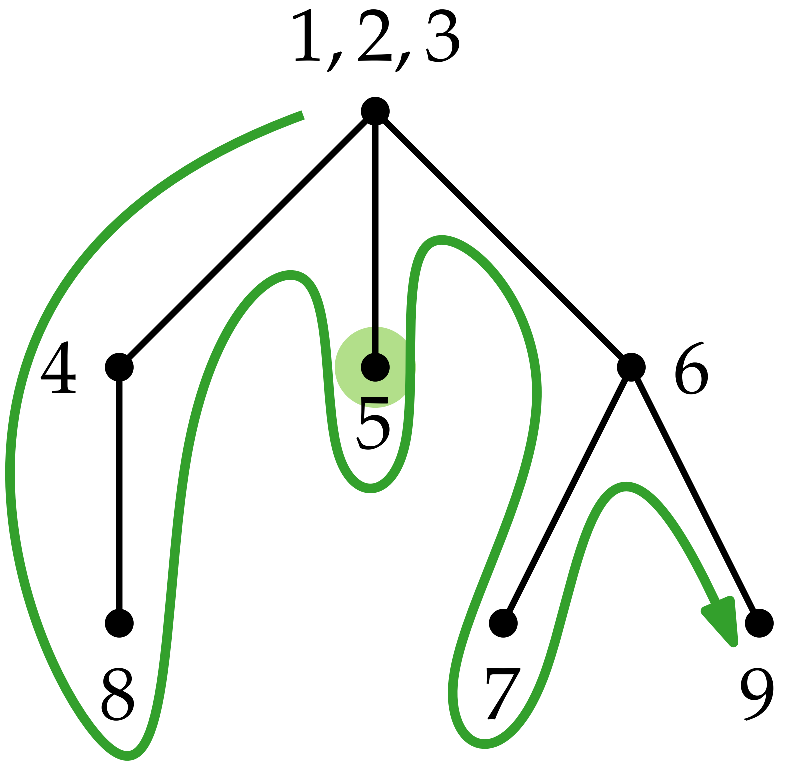

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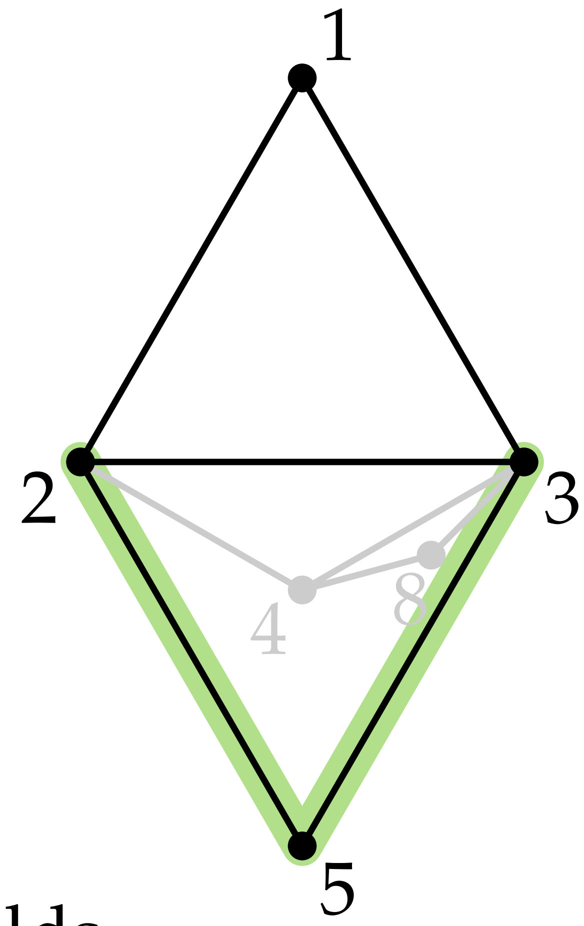

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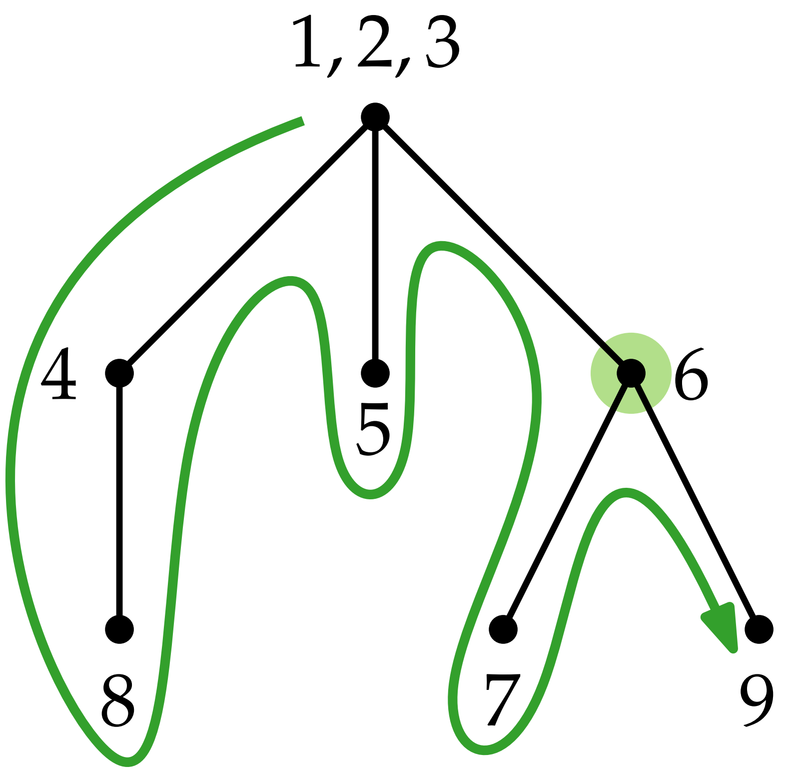

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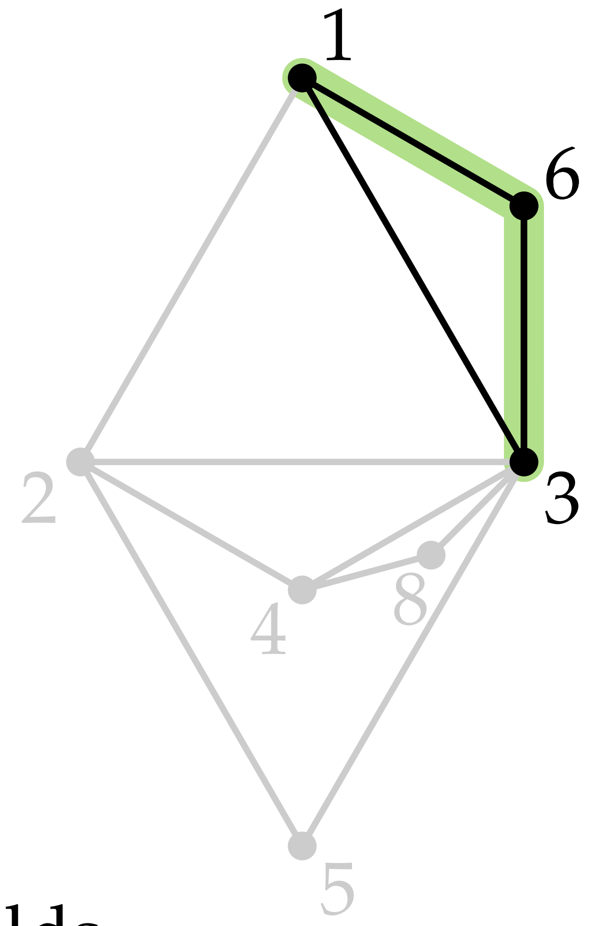

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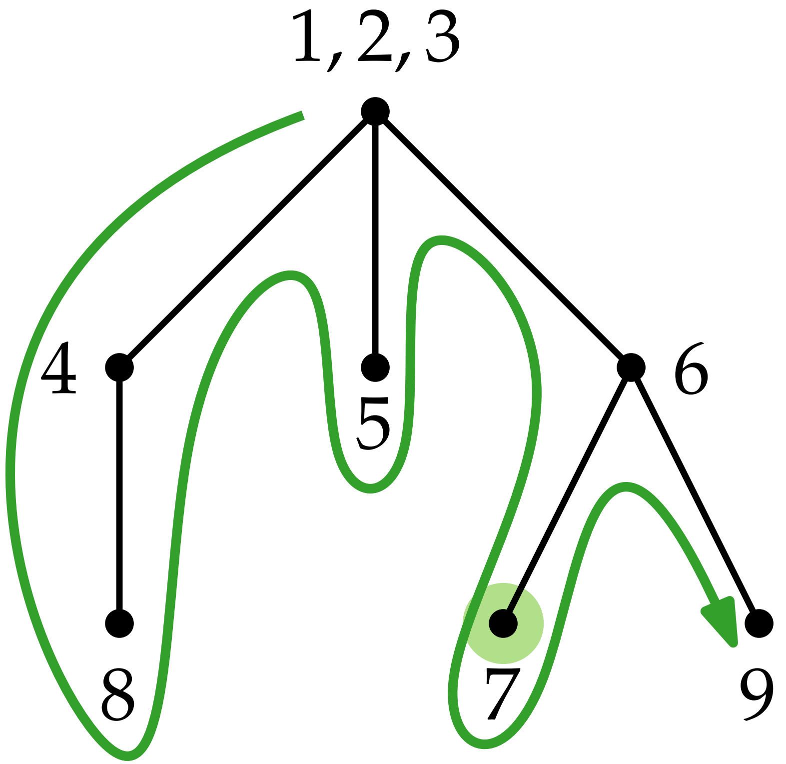

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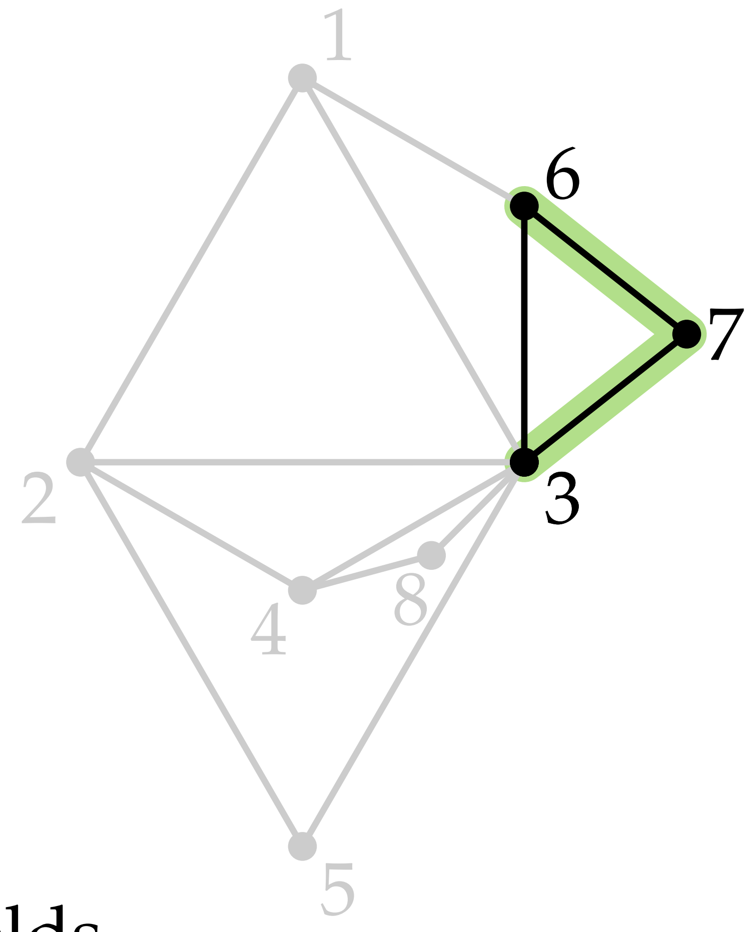

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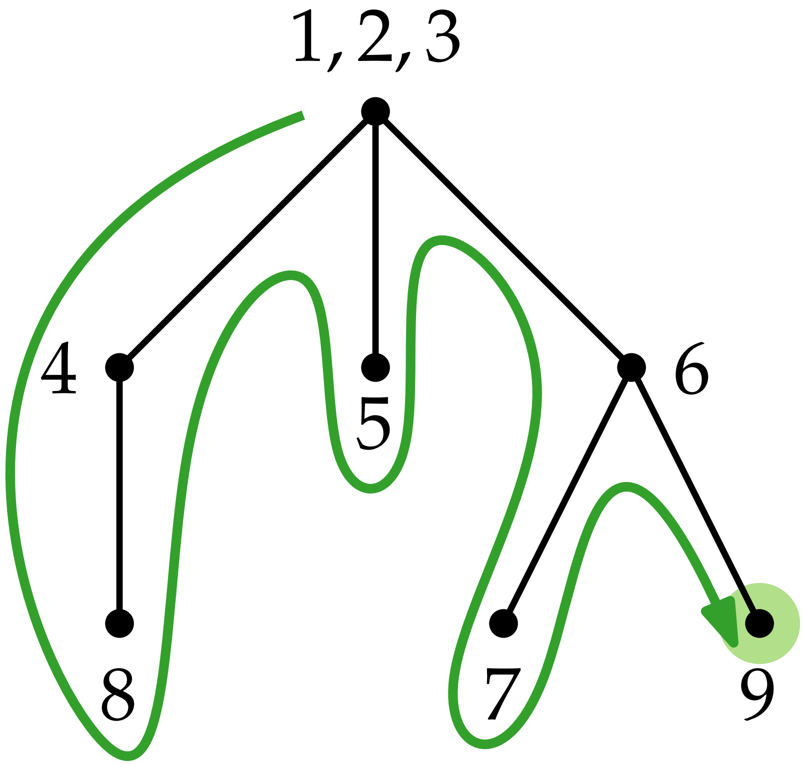

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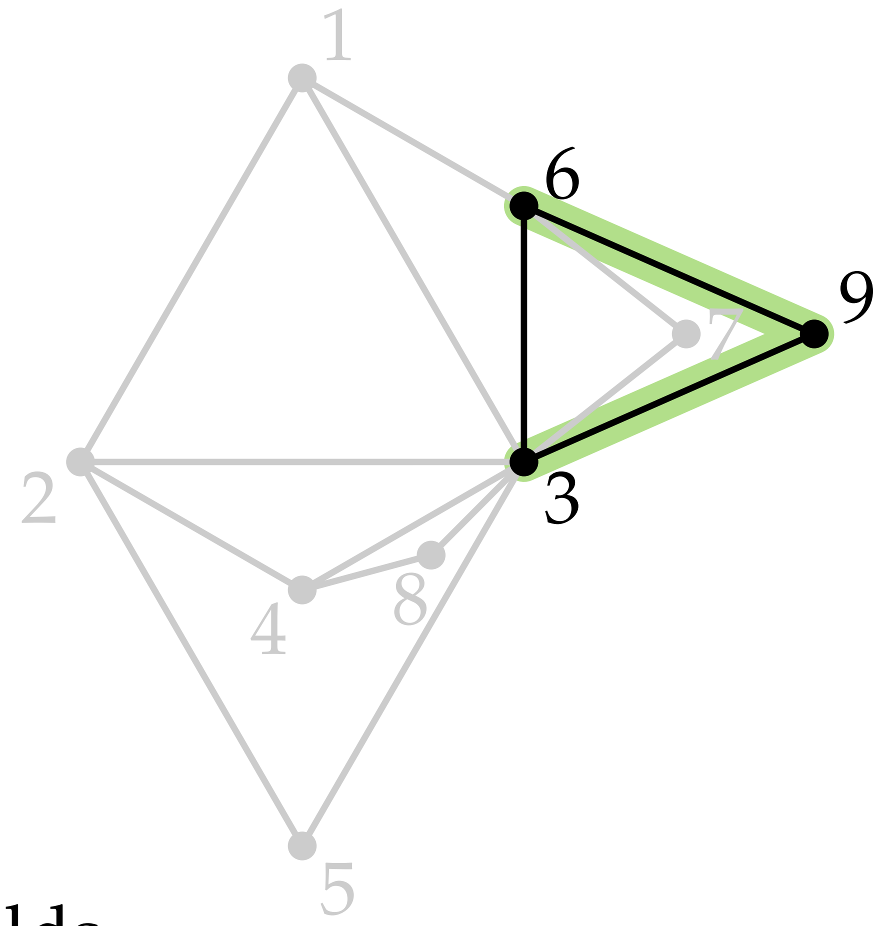

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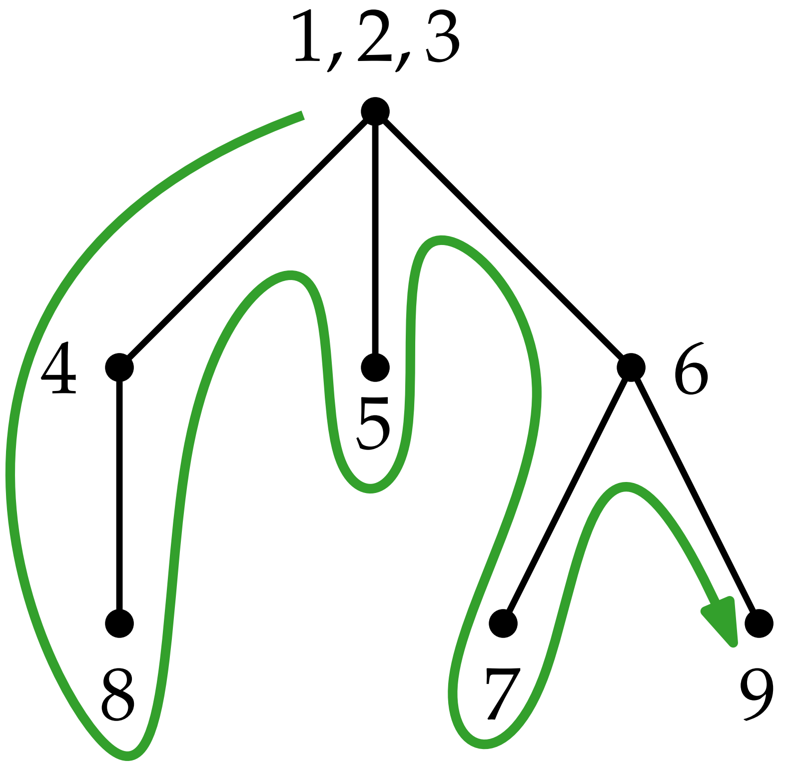

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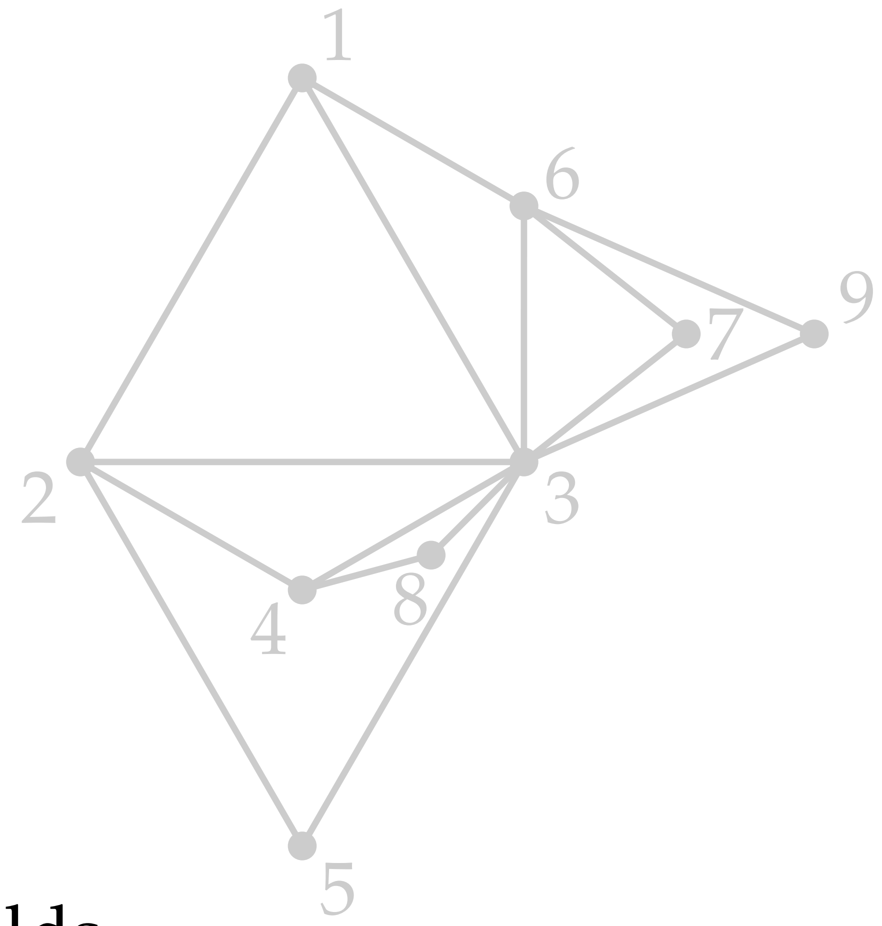

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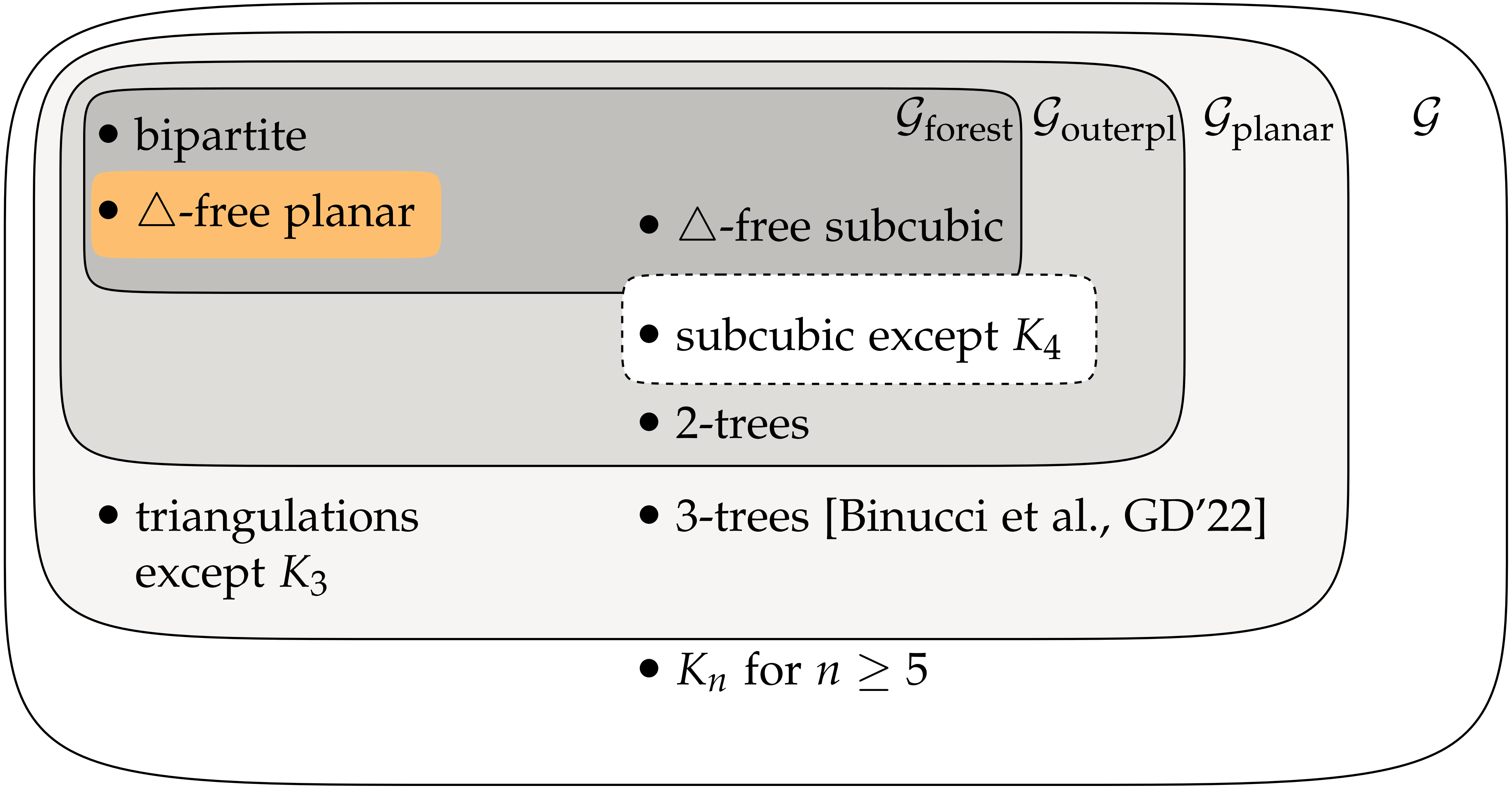

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Main theorem.
Every △**-free planar graph** admits a straight-line forest storyplan.

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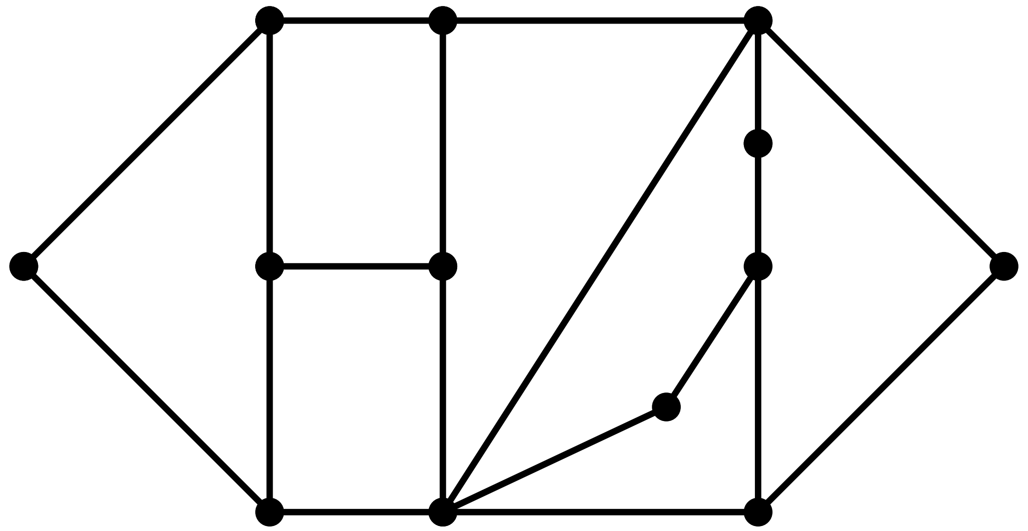

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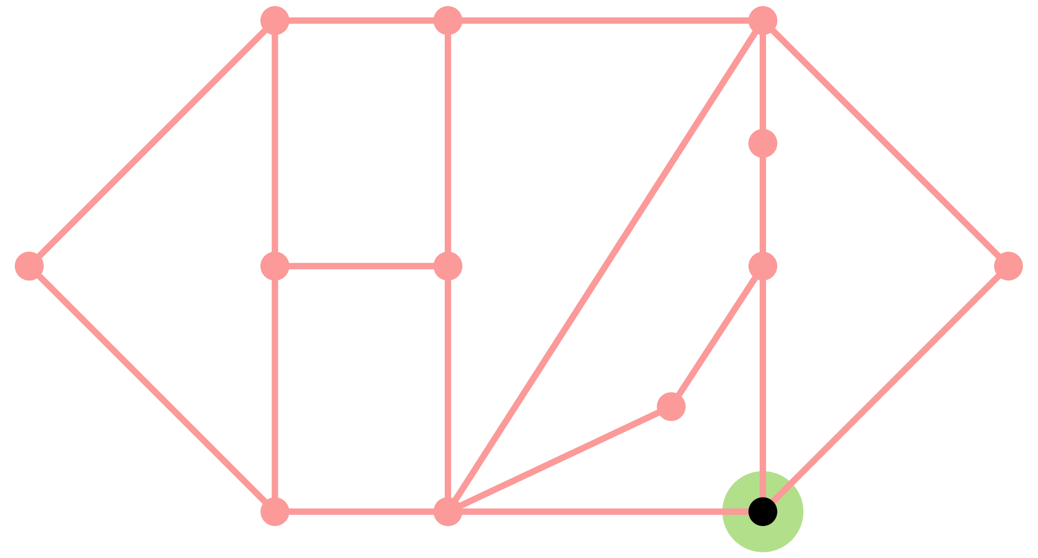
Idea.

In each iteration we *pick* a vertex on the current outer face that fulfils special properties.



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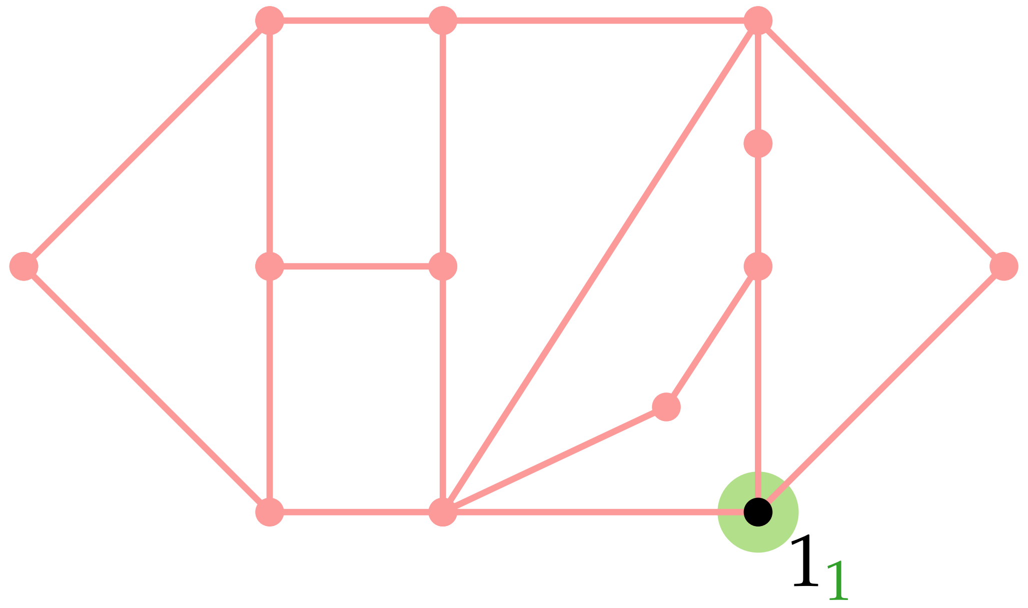
We add the vertex and its neighbors (if they are not visible yet) to the storyplan one by one.



Forest Storyplans of △-Free Planar Graphs

Main theorem.
Every △**-free planar graph** admits a straight-line forest storyplan.

Idea.

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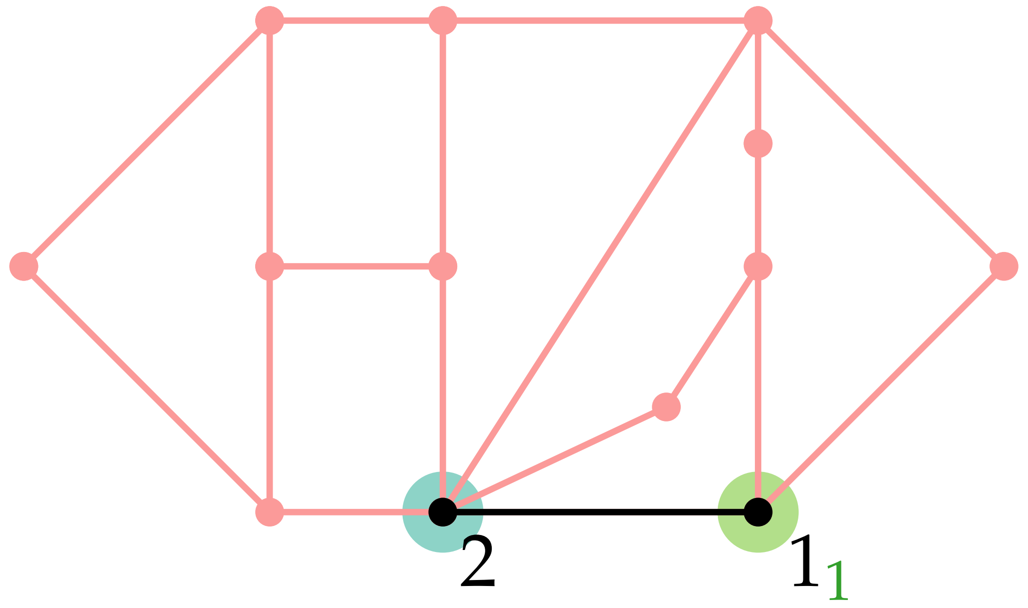

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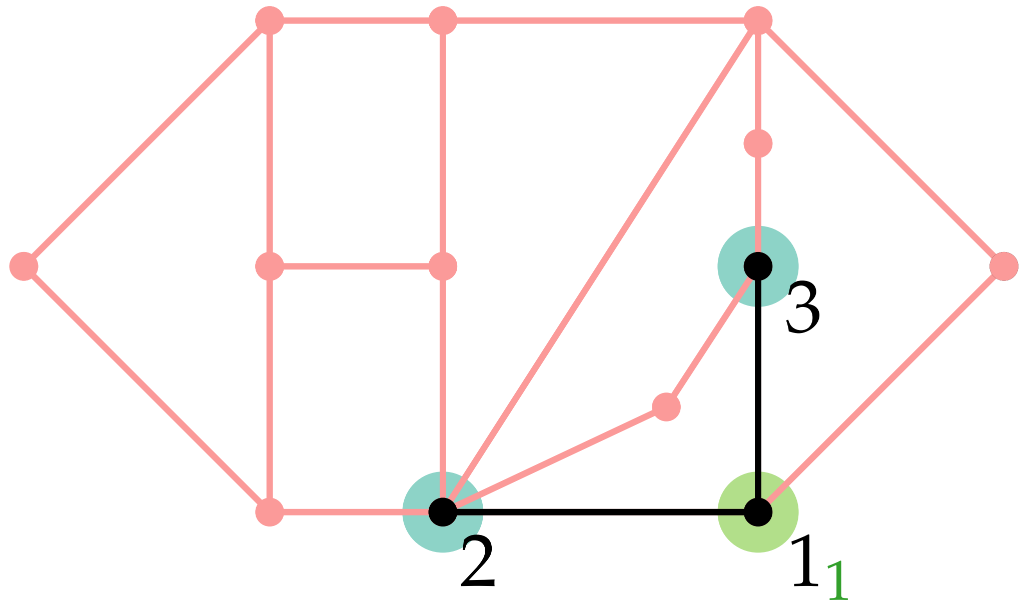

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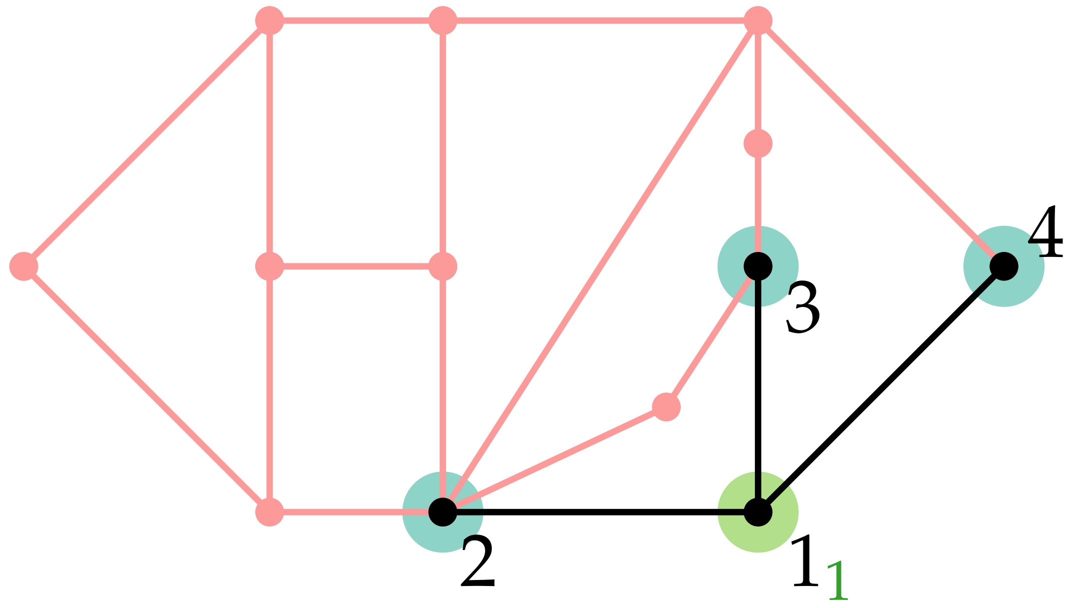

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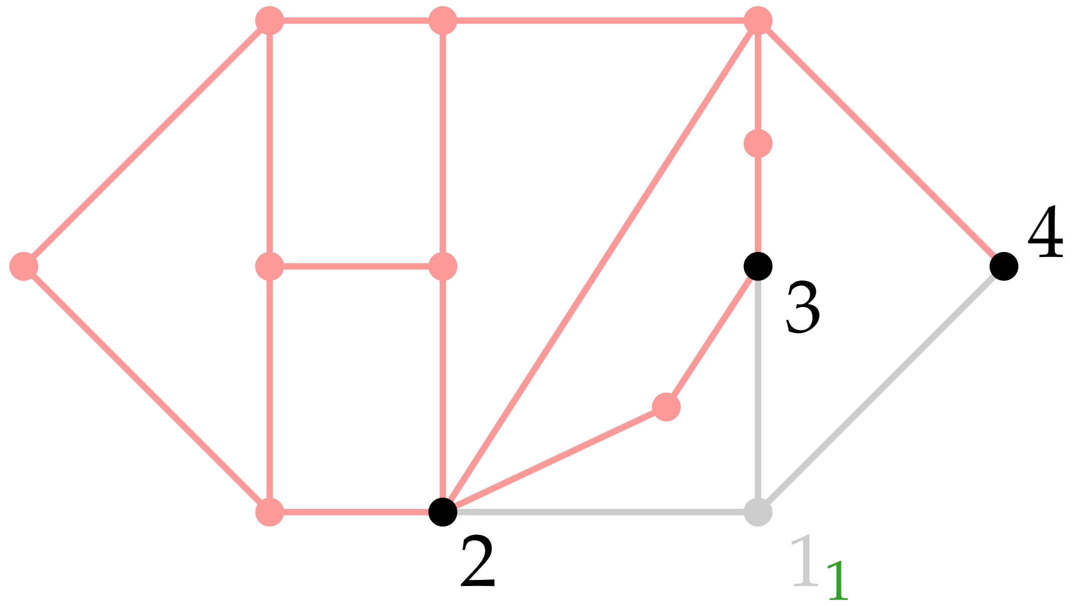
After each iteration at least one vertex dissapears.



Forest Storyplans of $\triangle$-Free Planar Graphs

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Every $\triangle$**-free planar graph** admits a straight-line forest storyplan.

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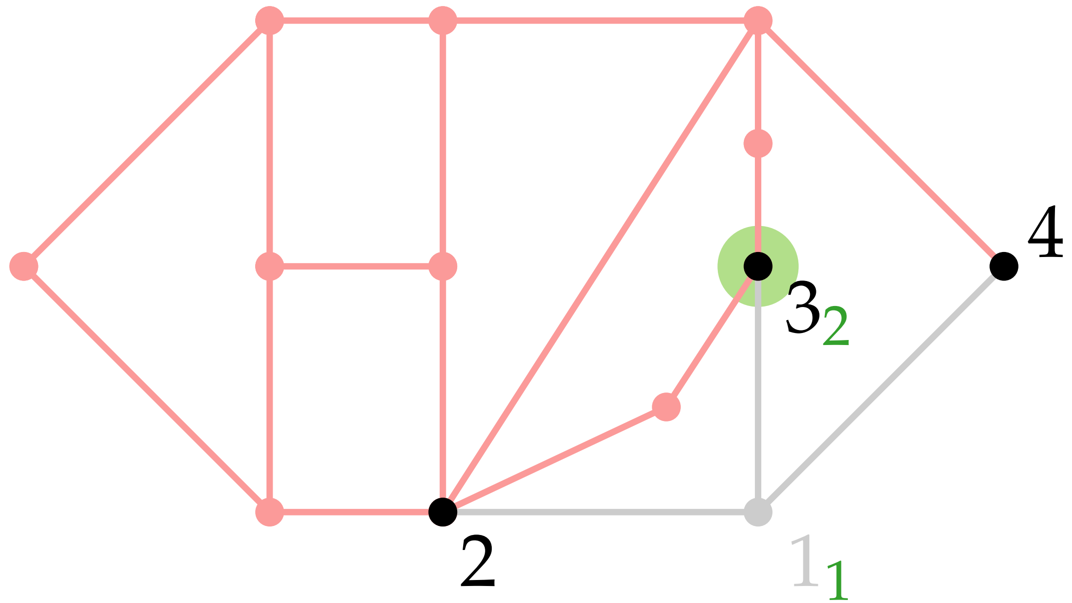

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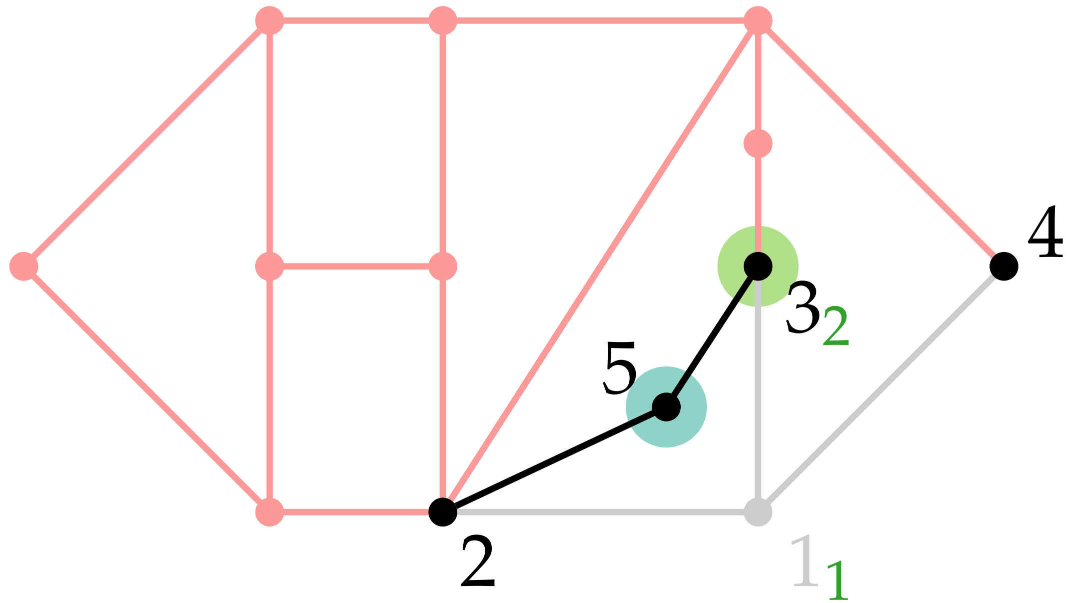

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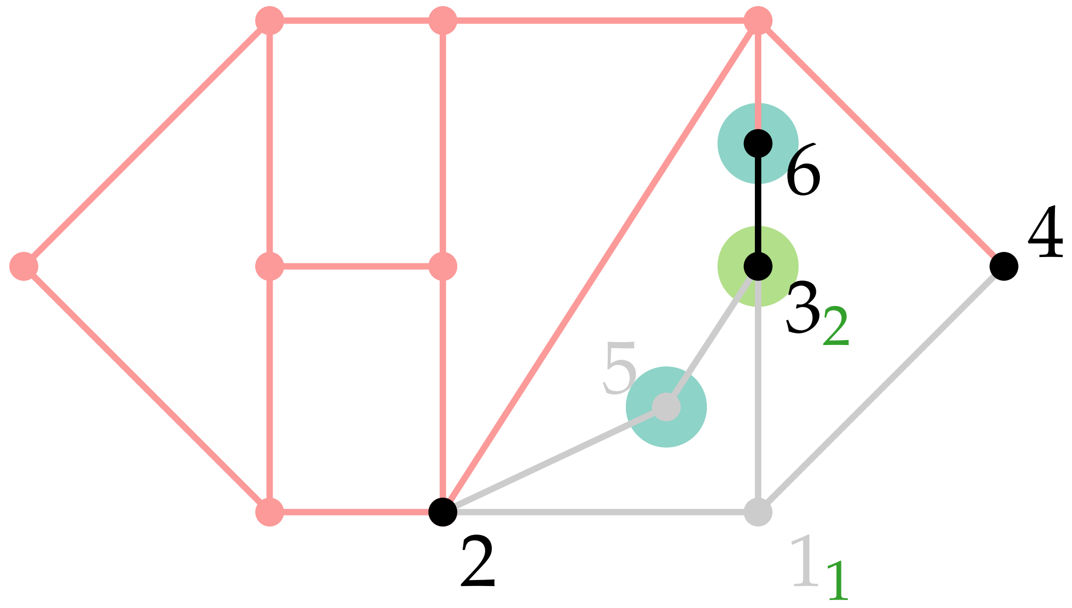

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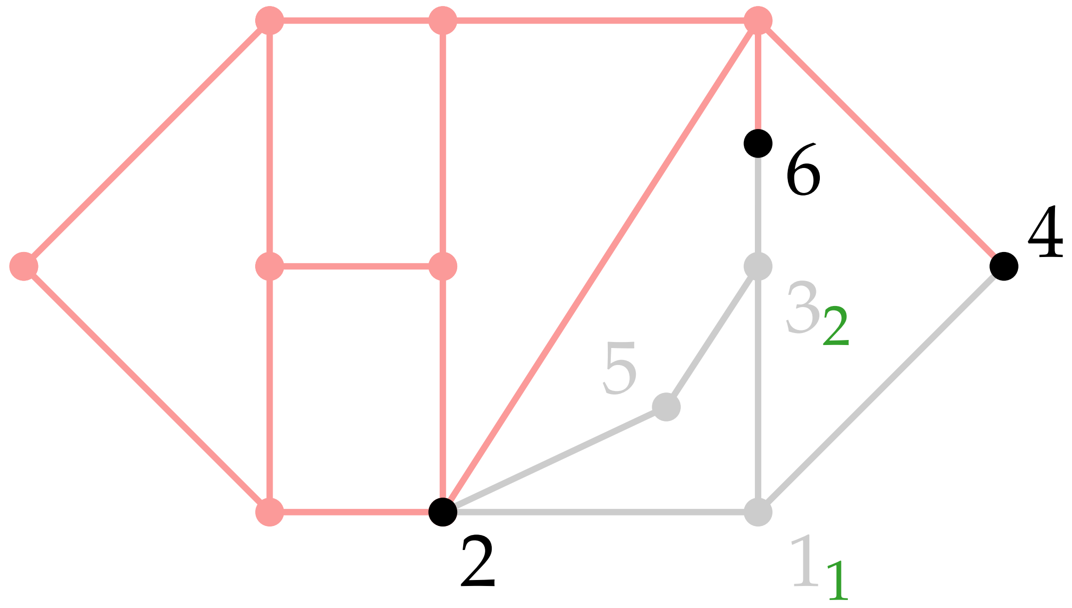

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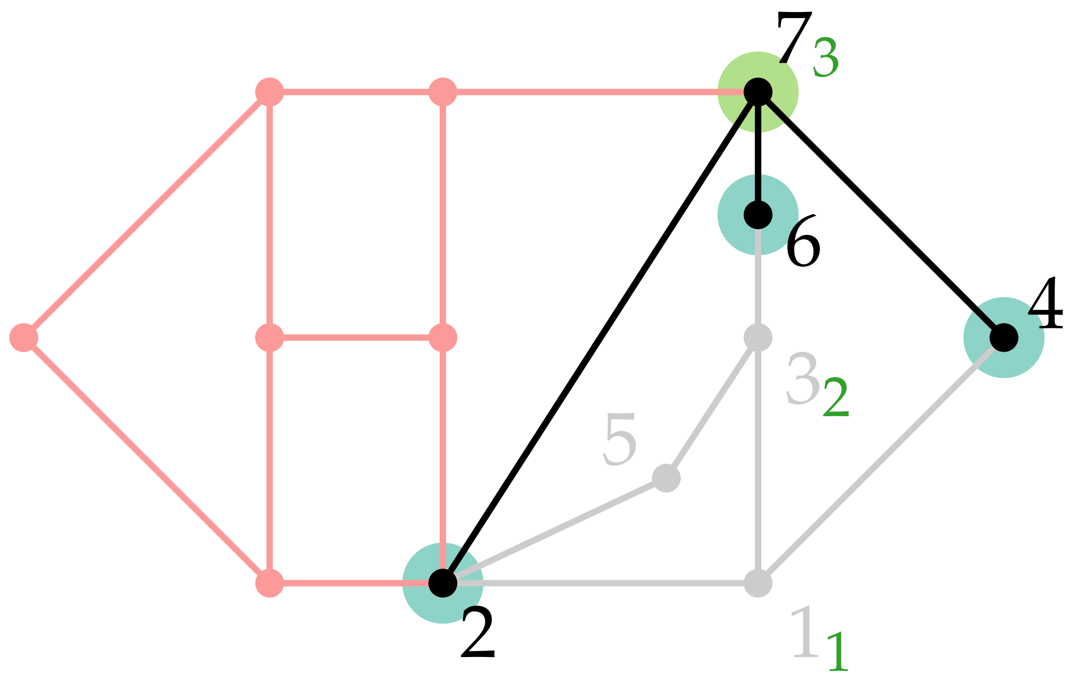

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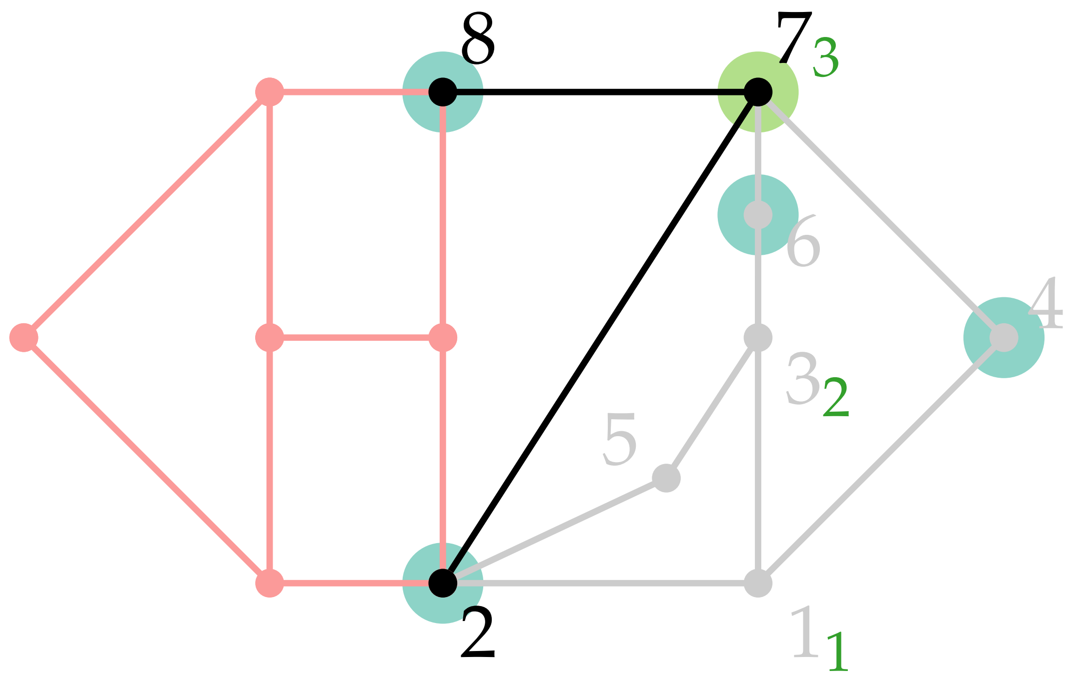

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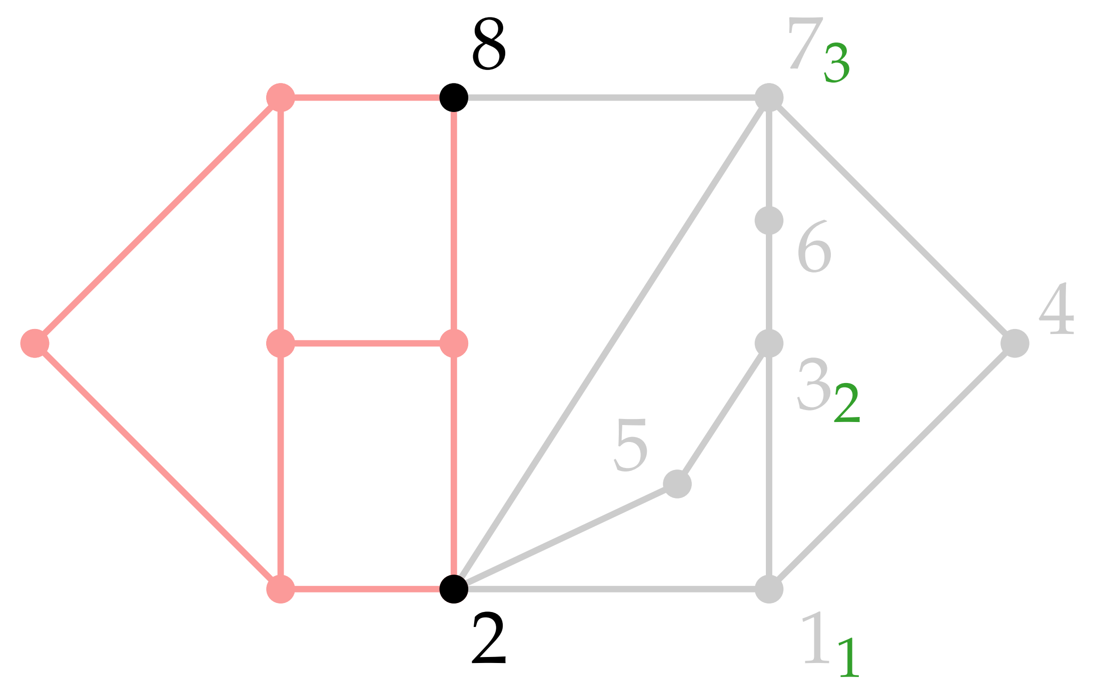

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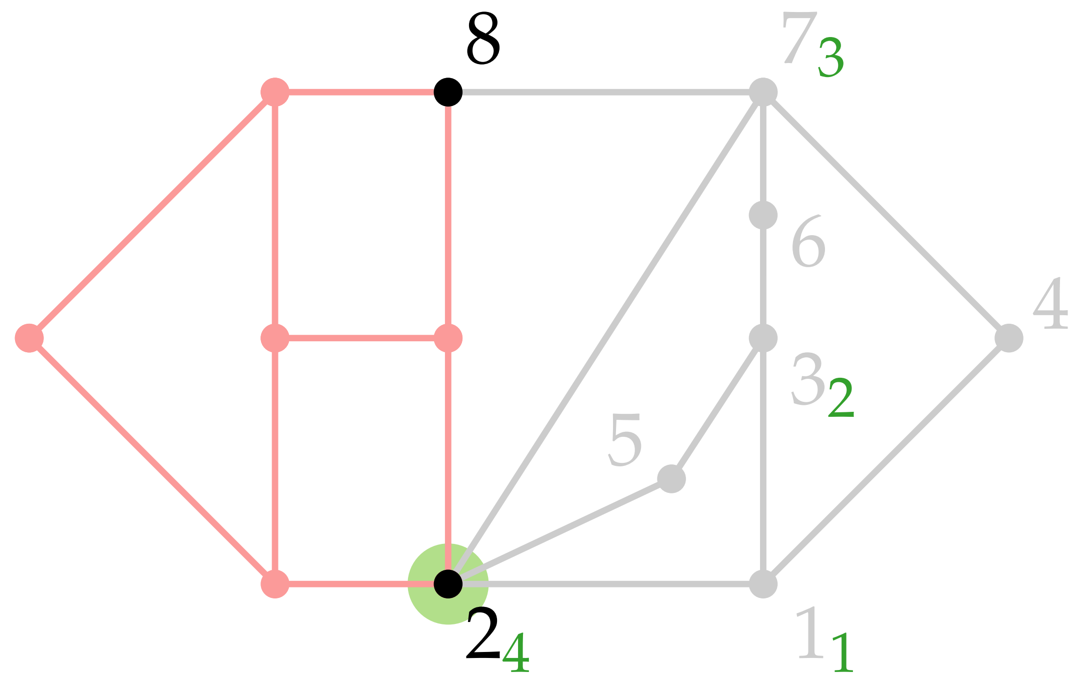

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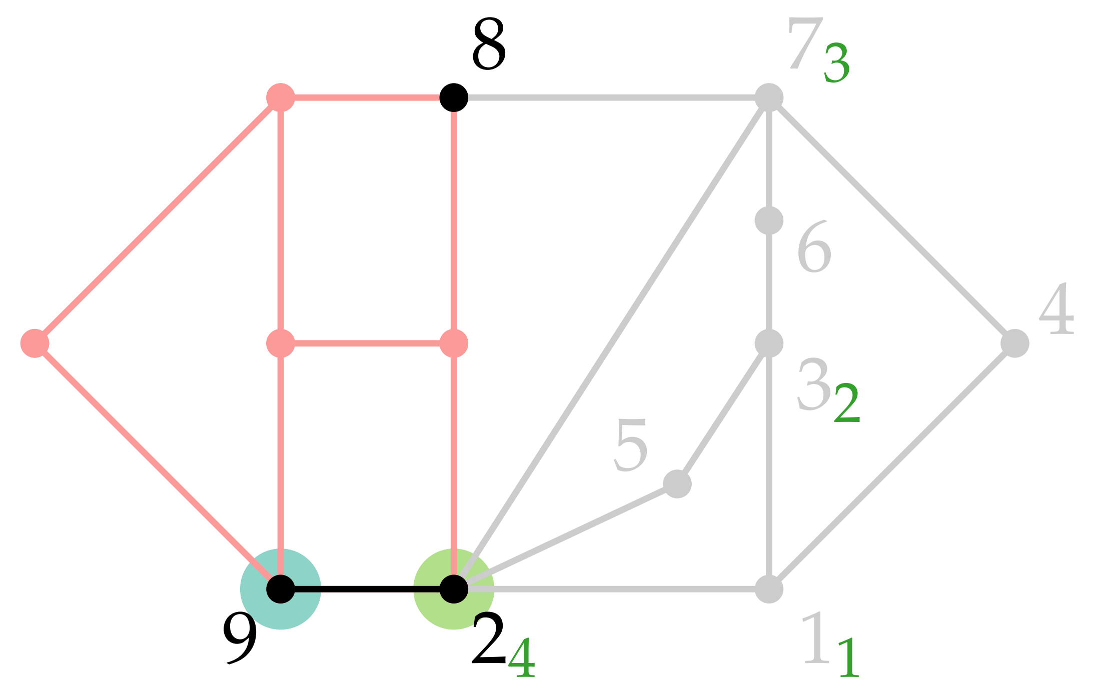

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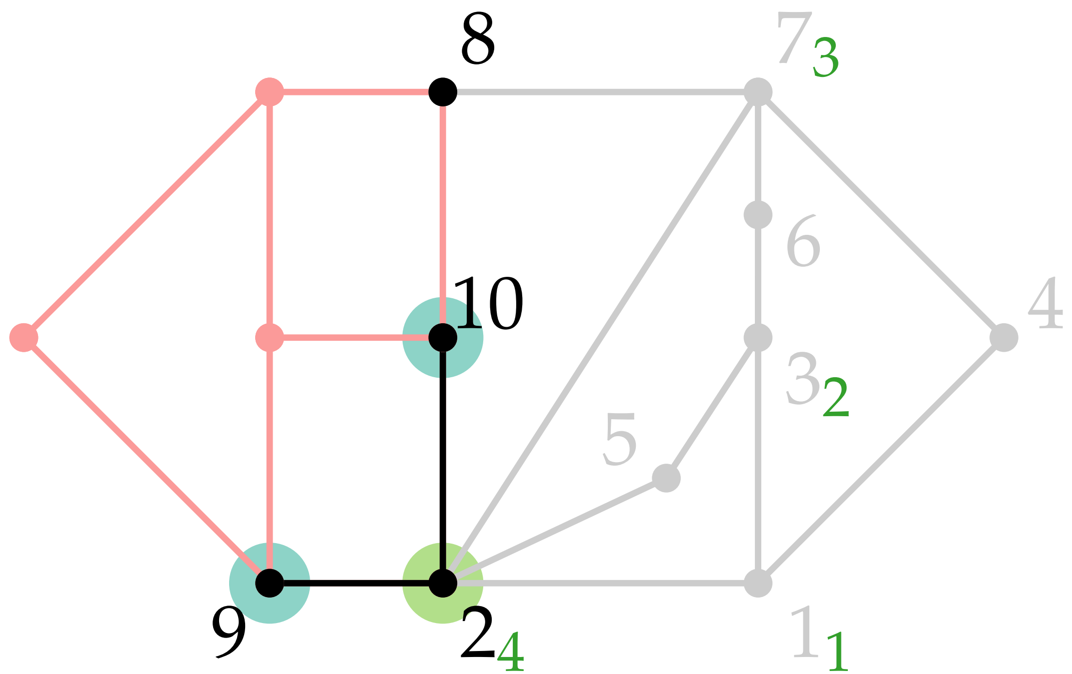

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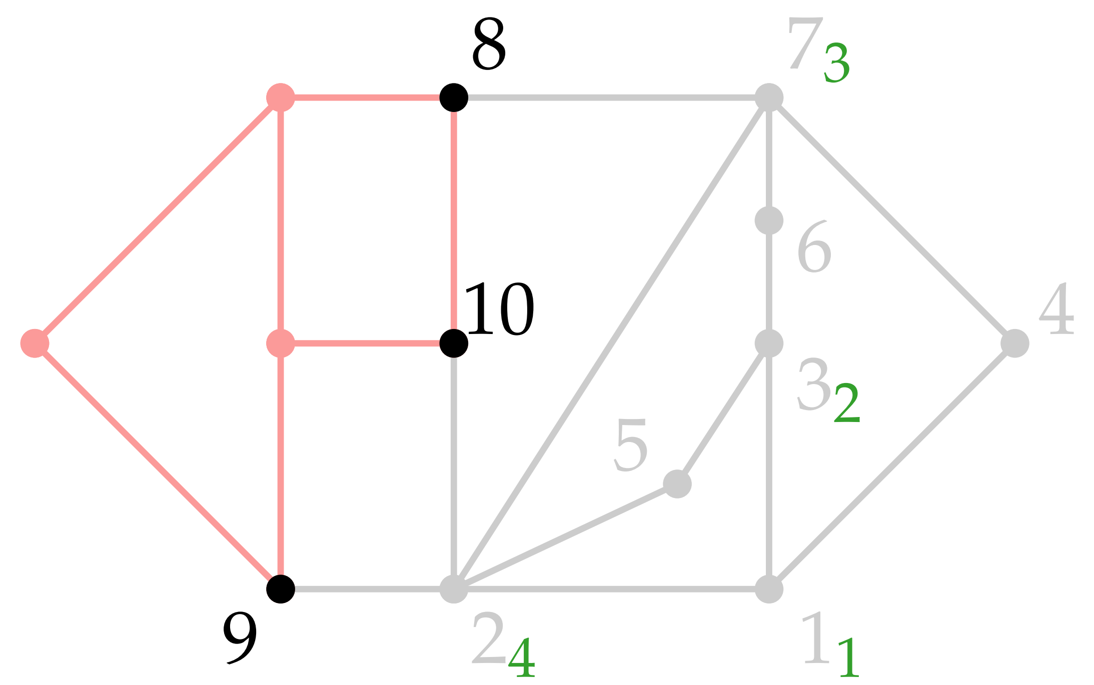

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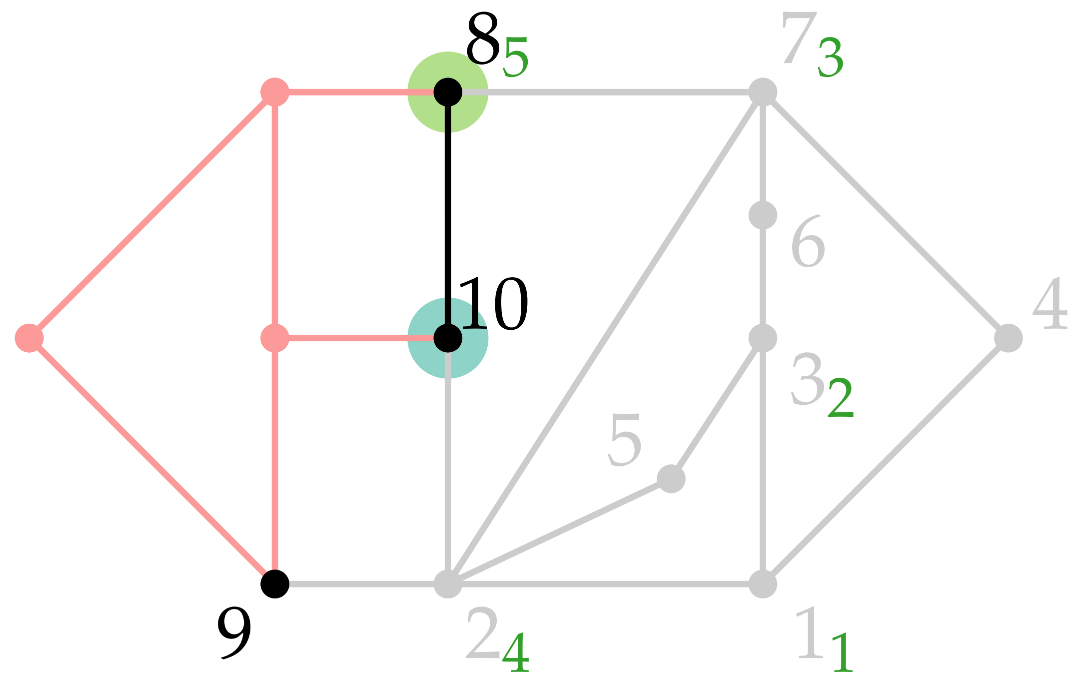

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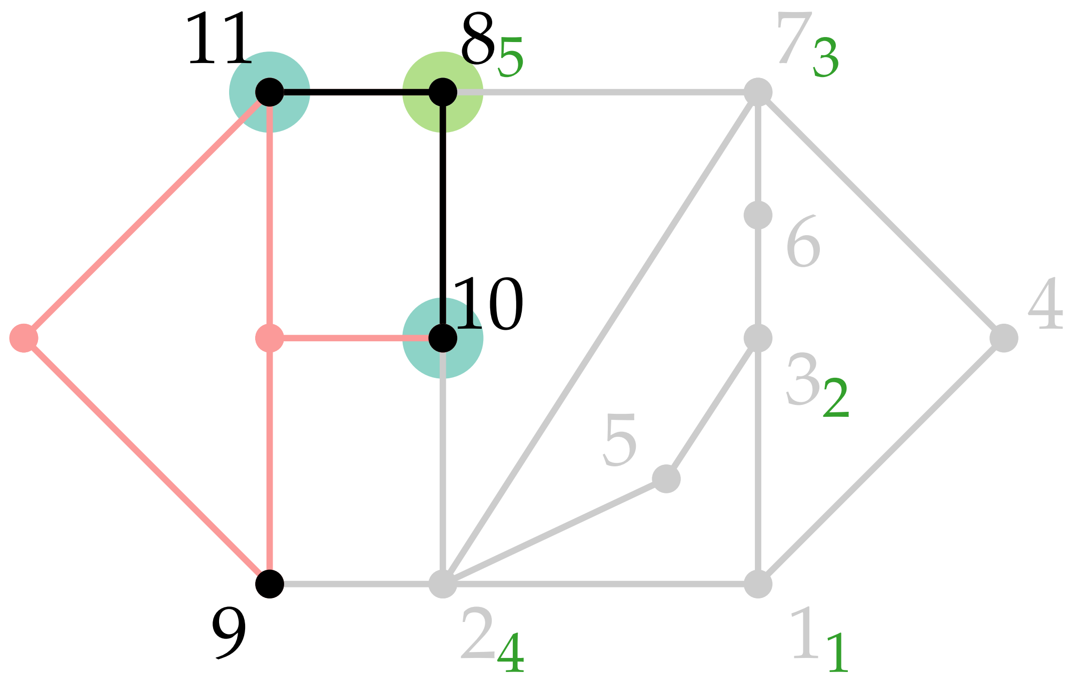

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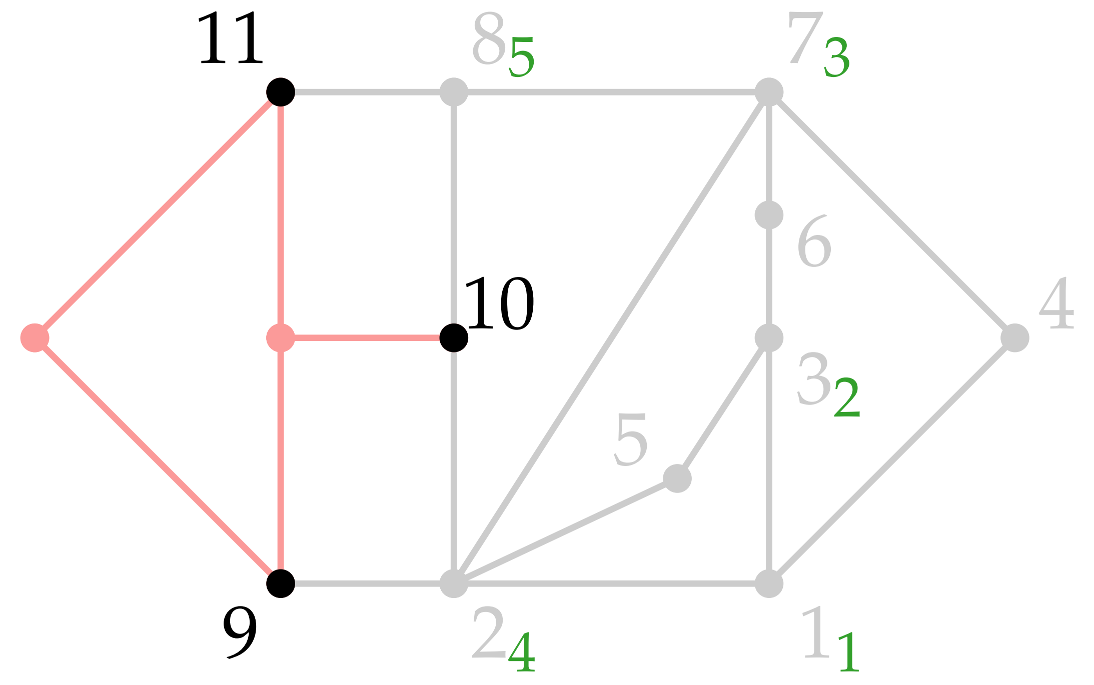

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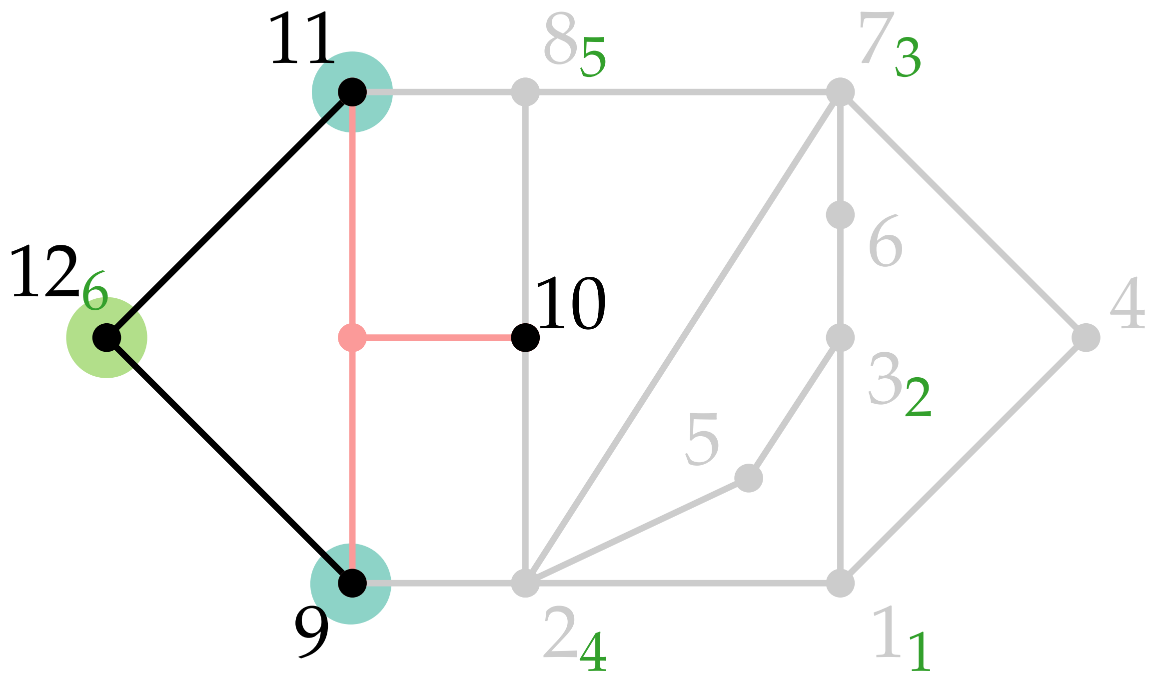

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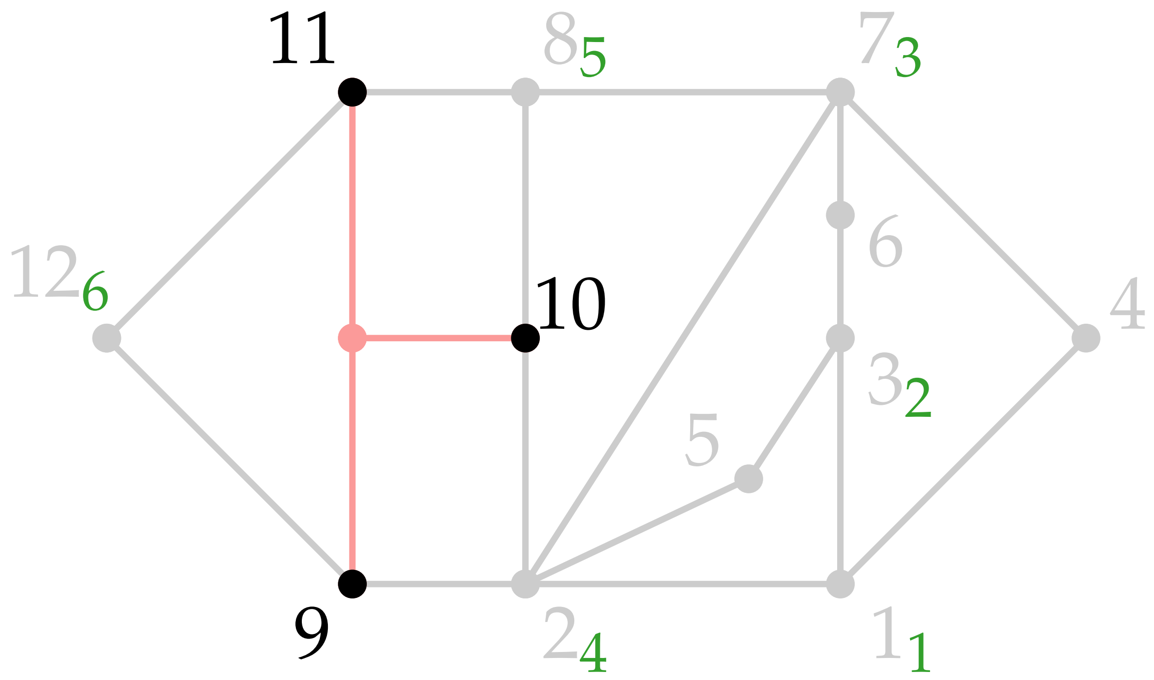

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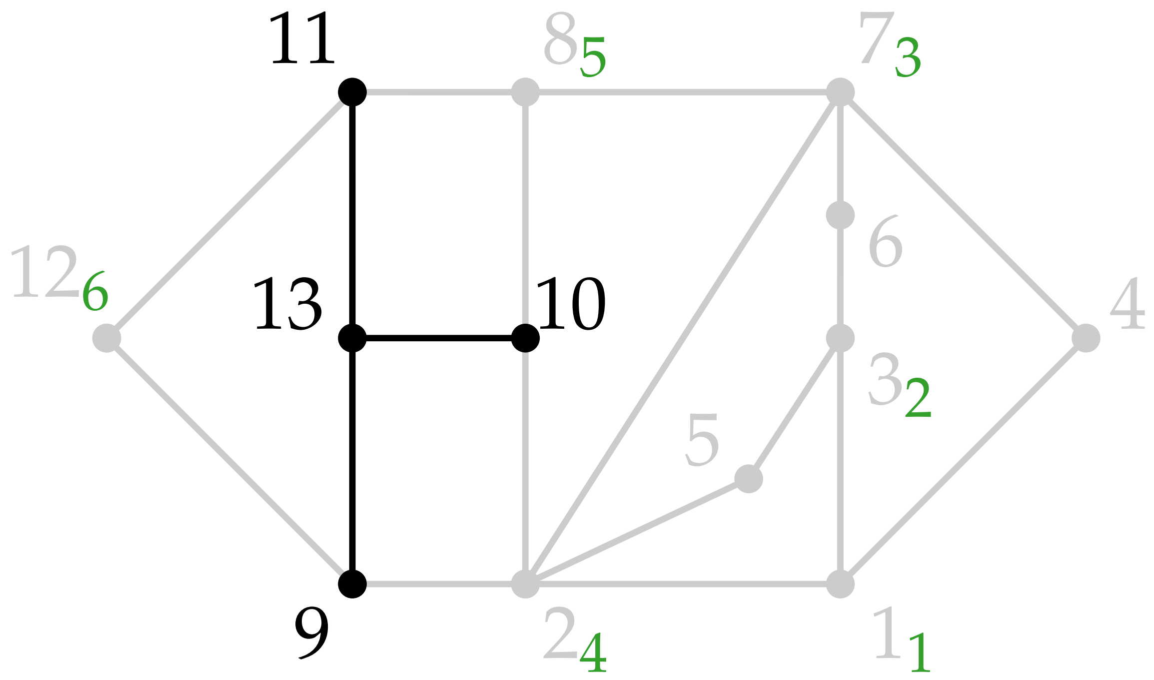

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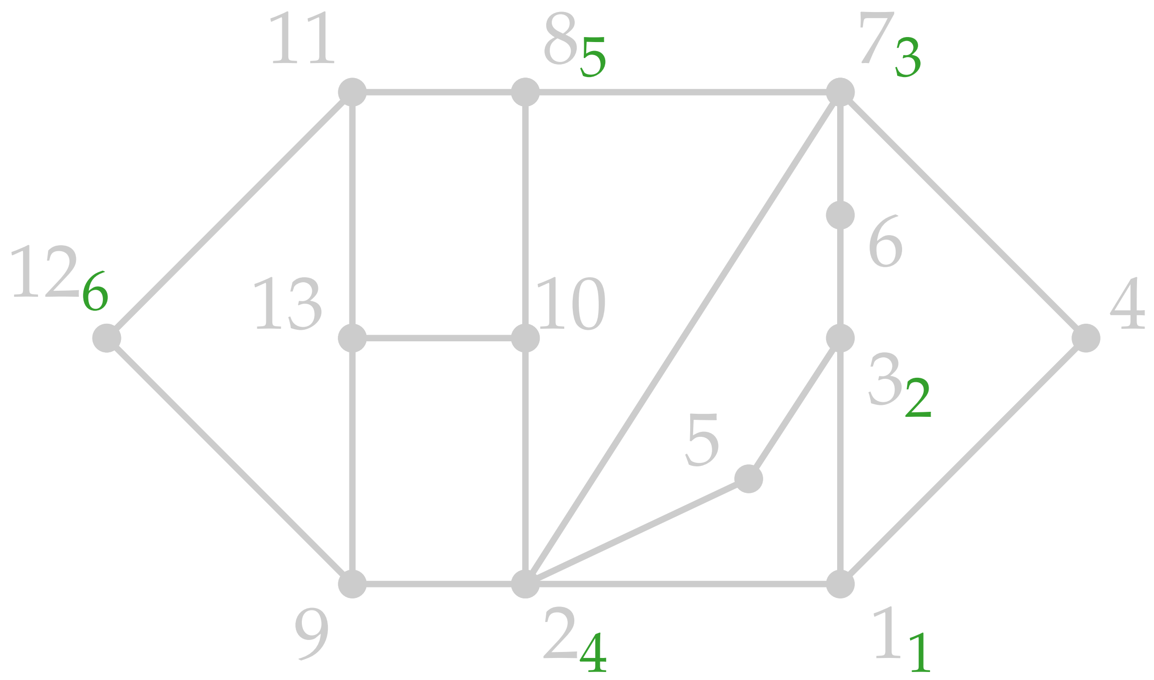
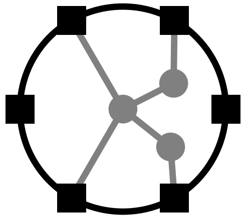
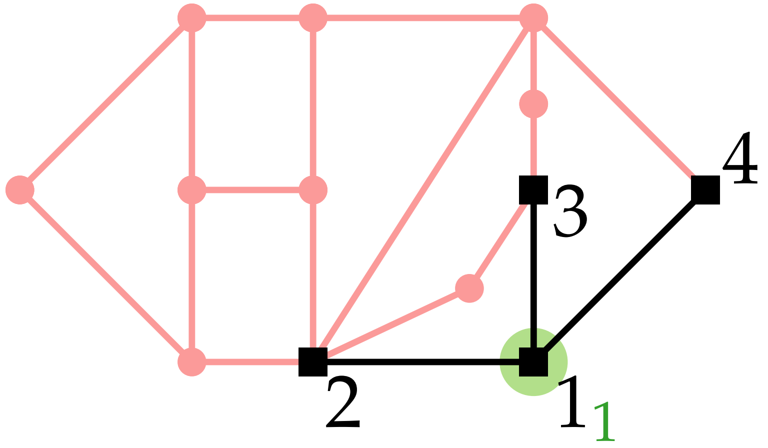


Proof – Invariants

I1  At no point in time, the set of visible edges on the outer face forms a cycle.



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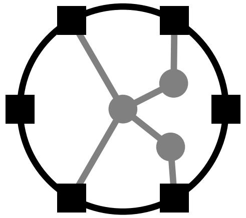
I1 

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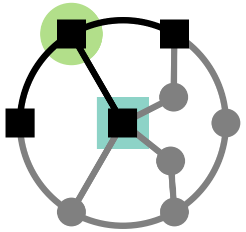
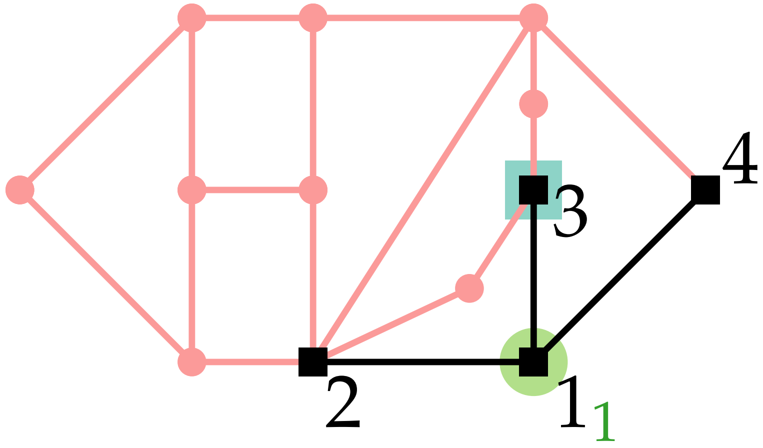
I2 

During iteration i, the only inner vertices that may be visible are those that are adjacent to v_i and to no other visible vertex on the outer face.



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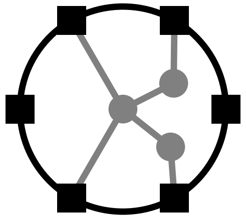
I1 

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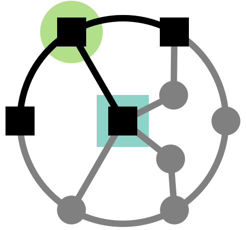
I2 

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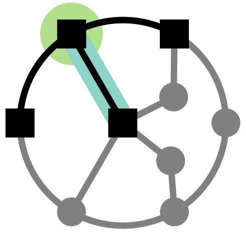
I3 

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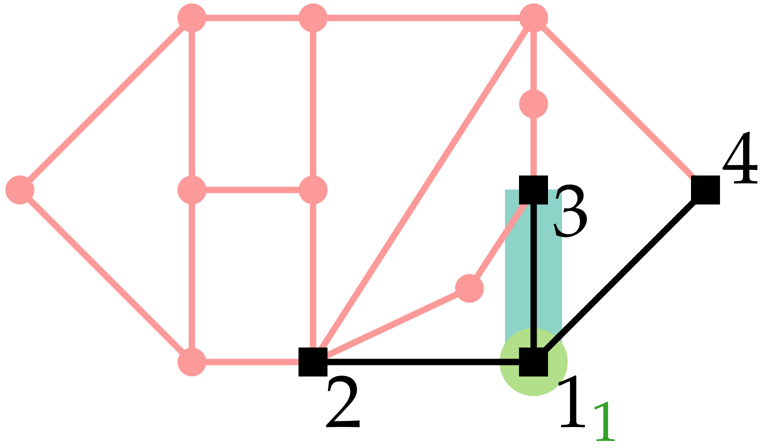

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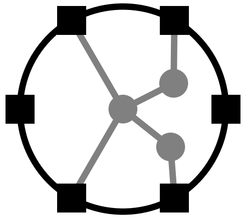
I1 

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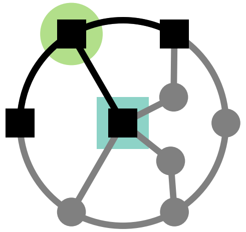
I2 

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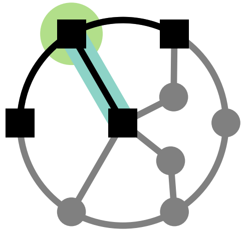
I3 

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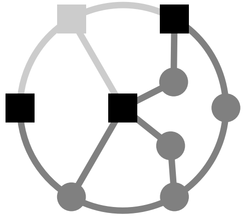
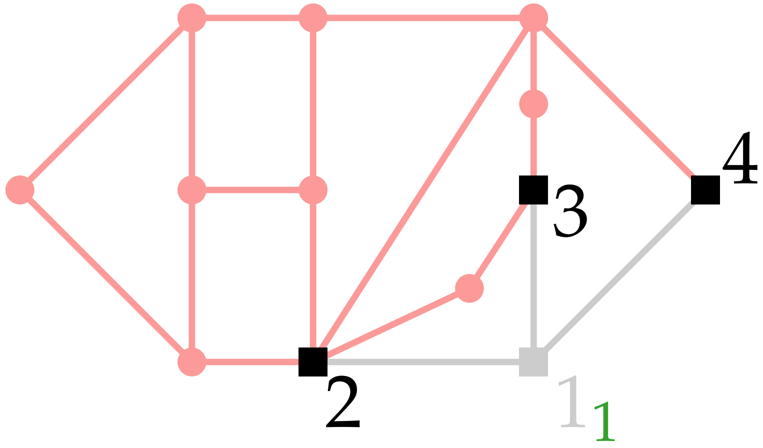
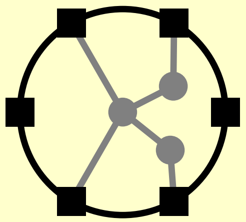
I4 

At the end of each iteration, only vertices and edges incident with the outer face are visible.



Proof – Rules

I1



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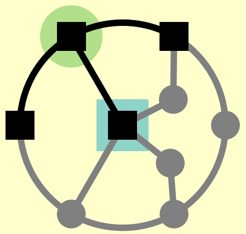

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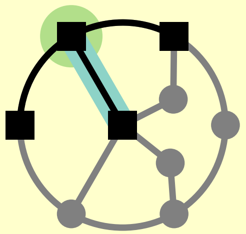

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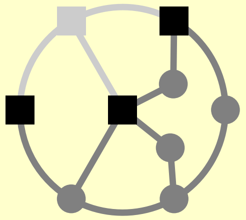

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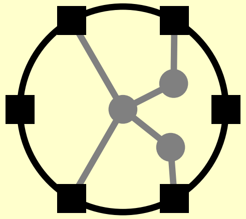

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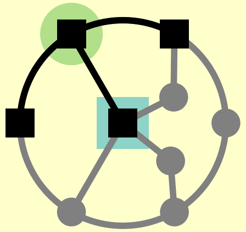

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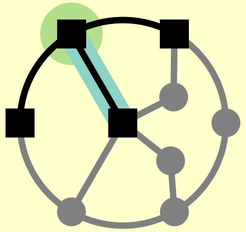
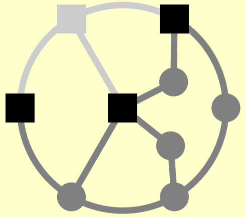
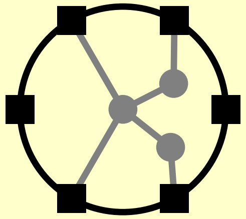
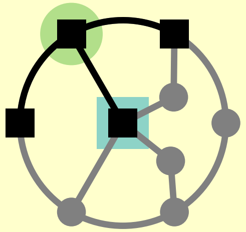


I4


We always pick a vertex from the “current” outer face.

Proof – Rules

I1


I2


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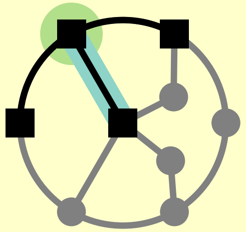
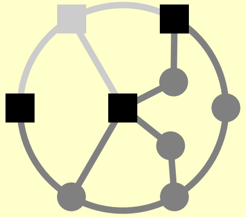


I4 ✓


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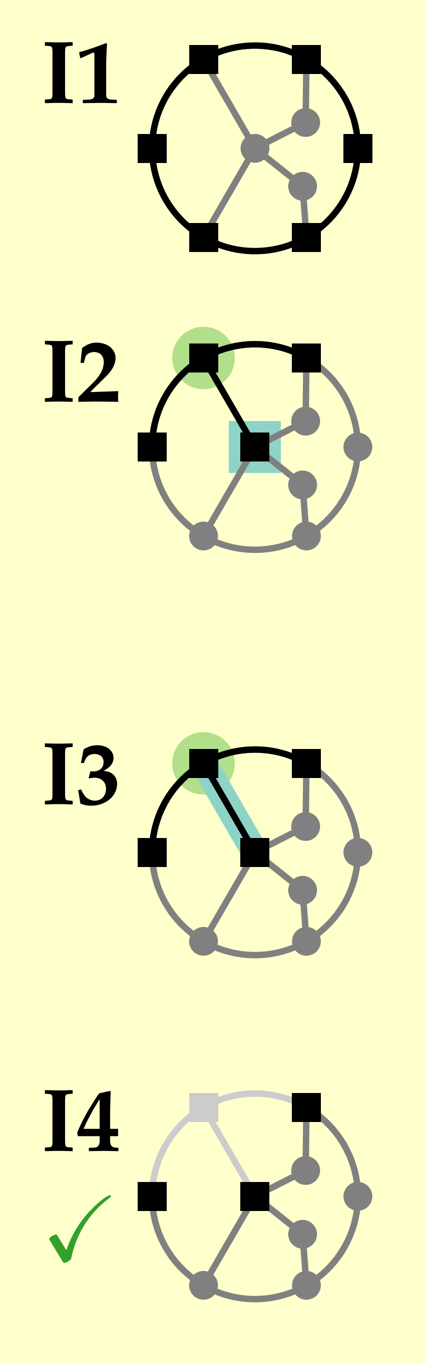
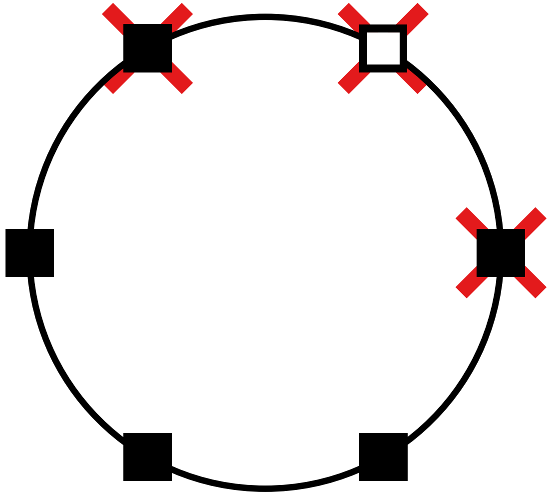


R1

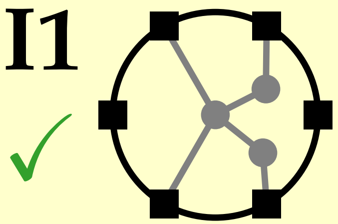
Do not pick a vertex whose closed neighborhood contains all invisible vertices of the outer face.



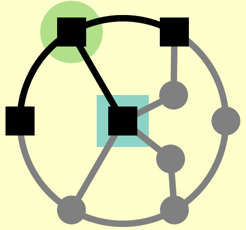
■ visible
□ invisible

Proof – Rules

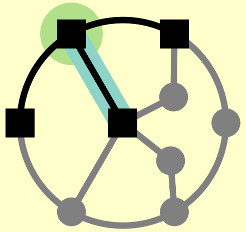
I1



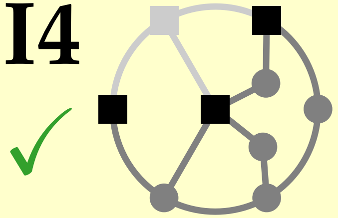
I2



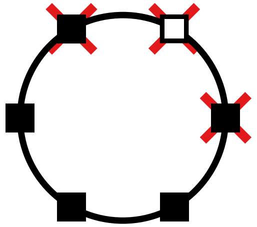
I3



I4

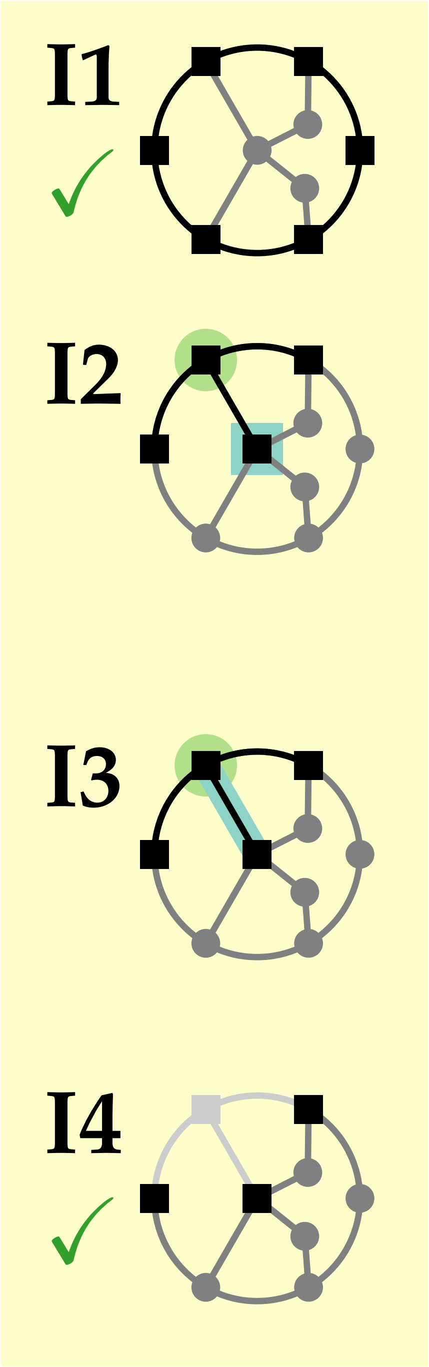


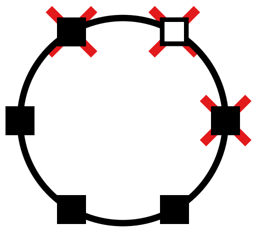
R1



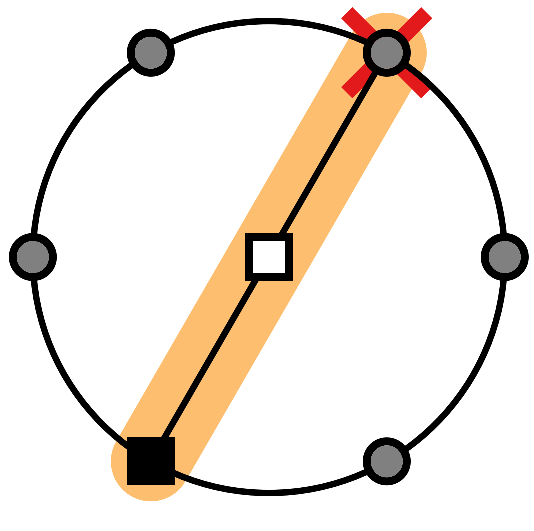
Do not pick a vertex whose closed neighborhood contains all invisible vertices of the outer face.

Proof – Rules



R1  Do not pick a vertex whose closed neighborhood contains all invisible vertices of the outer face.

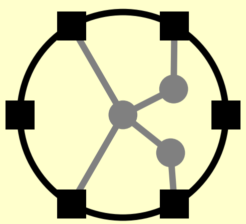
R2 Do not pick an endpoint of a *half-chord* if the other endpoint is visible.



Proof – Rules

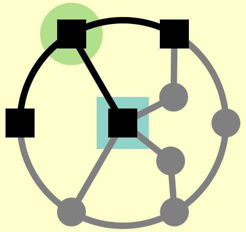
■ visible
□ invisible
● any

I1



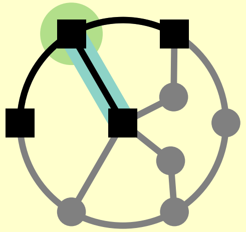
✓

I2

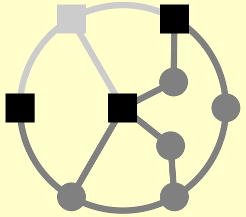


✓

I3

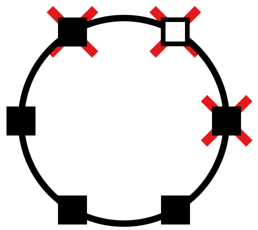


I4



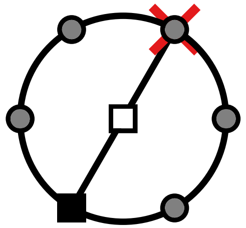
✓

R1



Do not pick a vertex whose closed neighborhood contains all invisible vertices of the outer face.

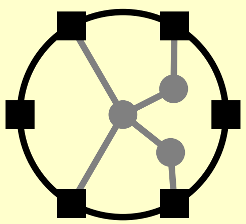
R2

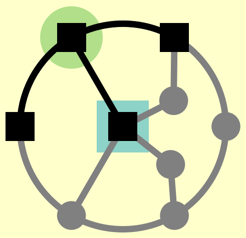


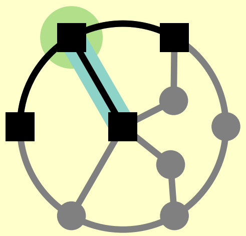
Do not pick an endpoint of a *half-chord* if the other endpoint is visible.

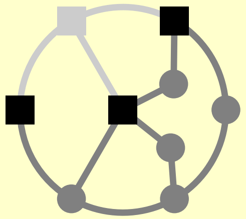
Proof – Rules

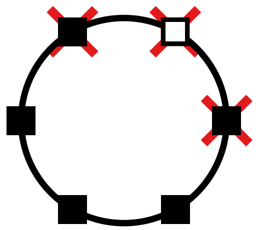
■ visible
□ invisible
● any

I1  ✓

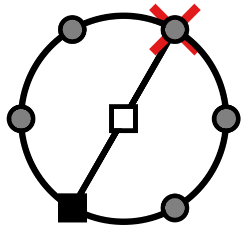
I2  ✓

I3 

I4  ✓

R1 

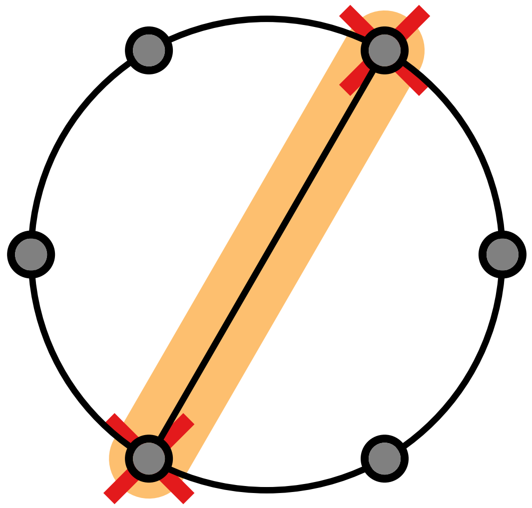
Do not pick a vertex whose closed neighborhood contains all invisible vertices of the outer face.

R2 

Do not pick an endpoint of a *half-chord* if the other endpoint is visible.

R3

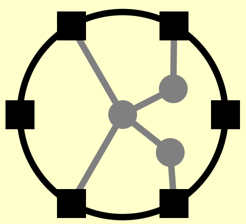
Do not pick an endpoint of a *chord*.



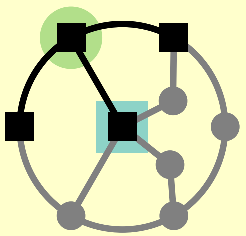
Proof – Rules

■ visible
□ invisible
● any

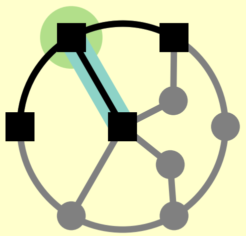
I1 ✓



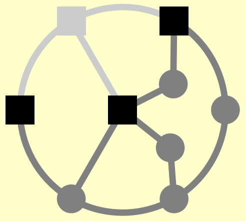
I2 ✓



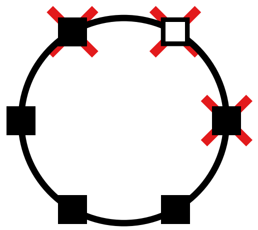
I3



I4 ✓

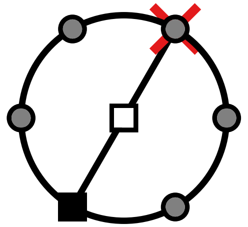


R1



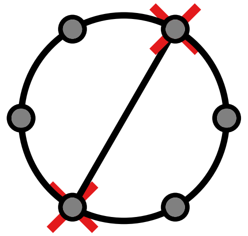
Do not pick a vertex whose closed neighborhood contains all invisible vertices of the outer face.

R2



Do not pick an endpoint of a *half-chord* if the other endpoint is visible.

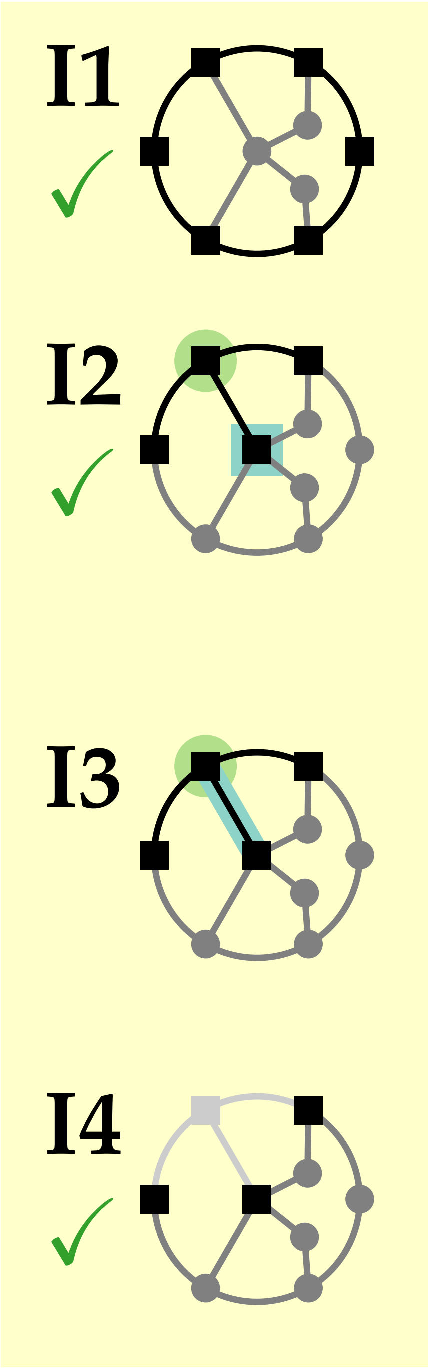
R3

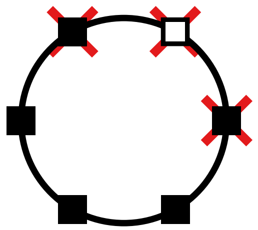


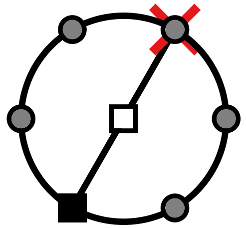
Do not pick an endpoint of a *chord*.

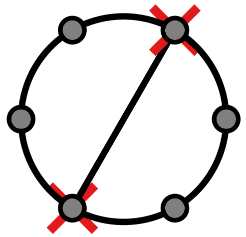
Proof – Rules

- visible
- invisible
- any

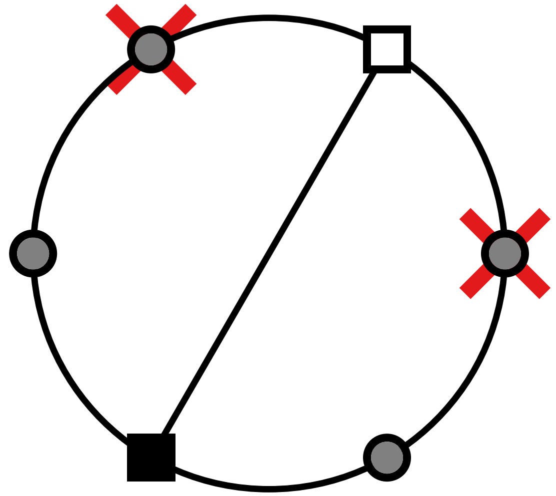


R1  Do not pick a vertex whose closed neighborhood contains all invisible vertices of the outer face.

R2  Do not pick an endpoint of a *half-chord* if the other endpoint is visible.

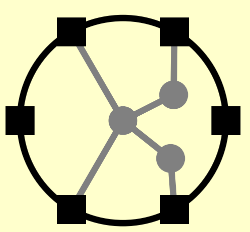
R3  Do not pick an endpoint of a *chord*.

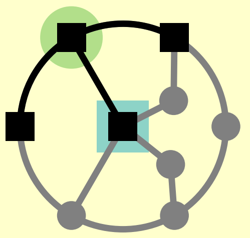
R4 Do not pick a neighbor of an endpoint of a chord if the other endpoint of that chord is visible.



Proof – Rules

■ visible
□ invisible
● any

I1 
✓

I2 
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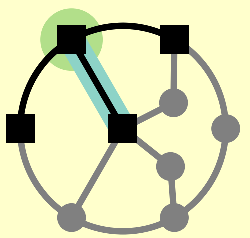
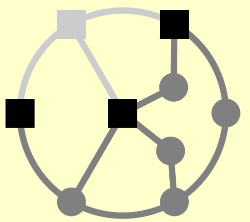
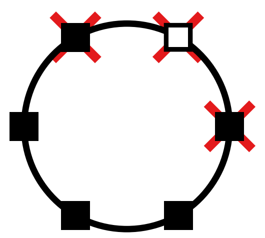
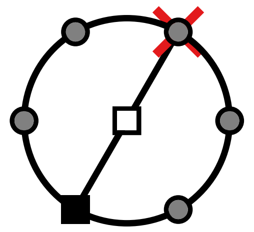
I3 

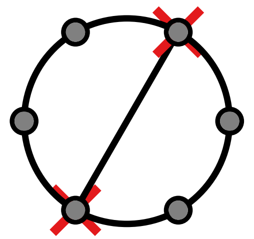
I4 
✓

R1 

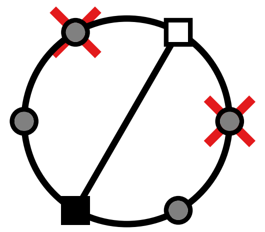
Do not pick a vertex whose closed neighborhood contains all invisible vertices of the outer face.

R2 

Do not pick an endpoint of a *half-chord* if the other endpoint is visible.

R3 

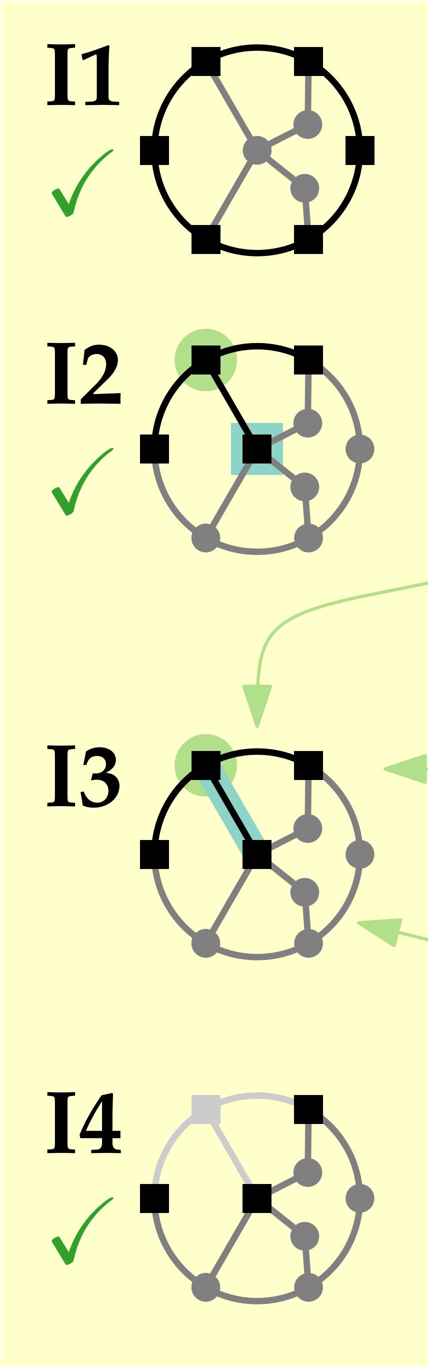
Do not pick an endpoint of a *chord*.

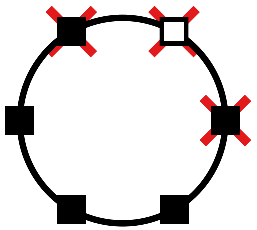
R4 

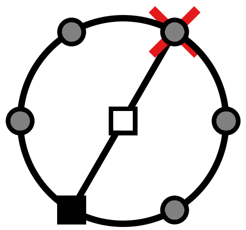
Do not pick a neighbor of an endpoint of a chord if the other endpoint of that chord is visible.

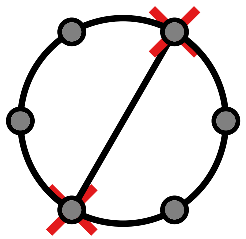
Proof – Rules

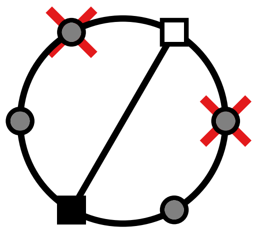
■ visible
□ invisible
● any



R1  Do not pick a vertex whose closed neighborhood contains all invisible vertices of the outer face.

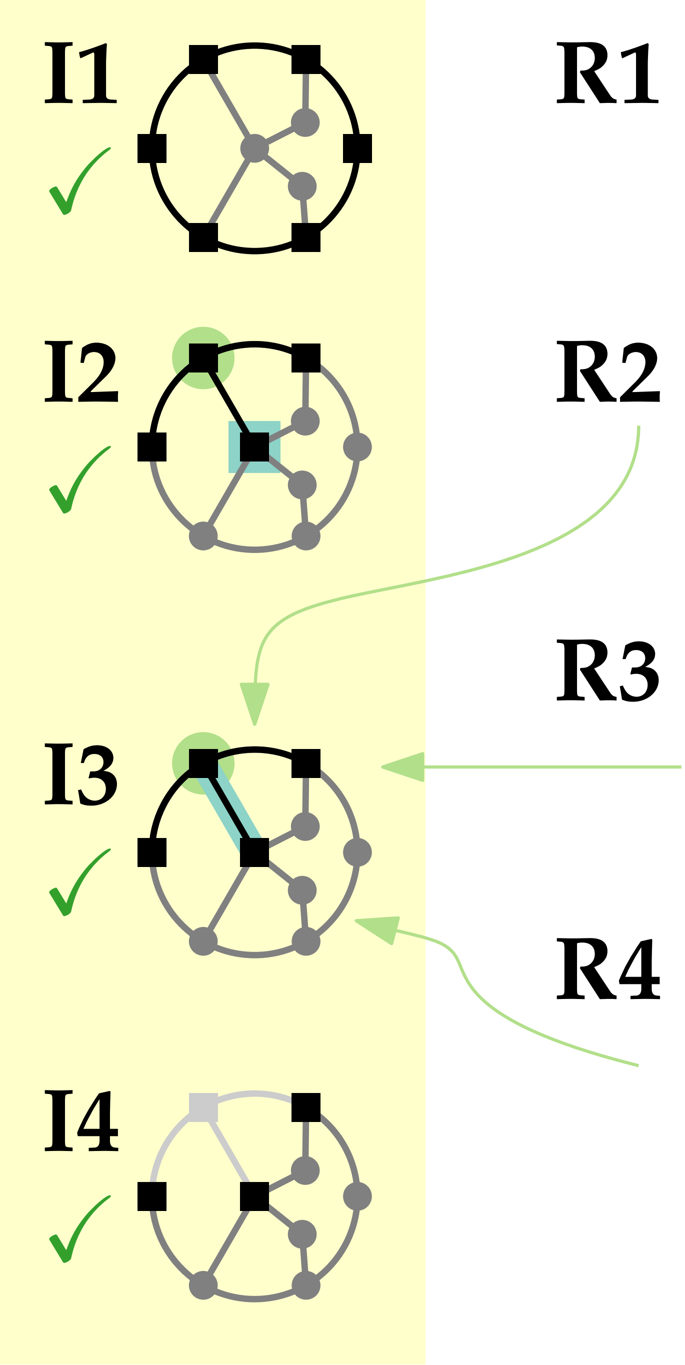
R2  Do not pick an endpoint of a *half-chord* if the other endpoint is visible.

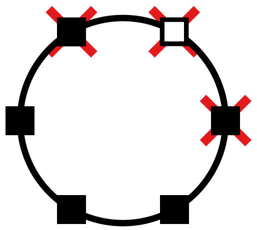
R3  Do not pick an endpoint of a *chord*.

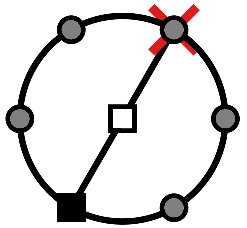
R4  Do not pick a neighbor of an endpoint of a chord if the other endpoint of that chord is visible.

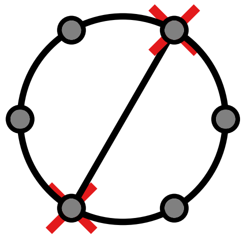
Proof – Rules

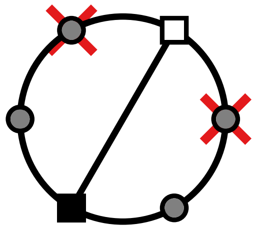
■ visible
□ invisible
● any



R1  Do not pick a vertex whose closed neighborhood contains all invisible vertices of the outer face.

R2  Do not pick an endpoint of a *half-chord* if the other endpoint is visible.

R3  Do not pick an endpoint of a *chord*.

R4  Do not pick a neighbor of an endpoint of a chord if the other endpoint of that chord is visible.

Proof – Reducing the Graph

To show: There always is a vertex that can be picked.

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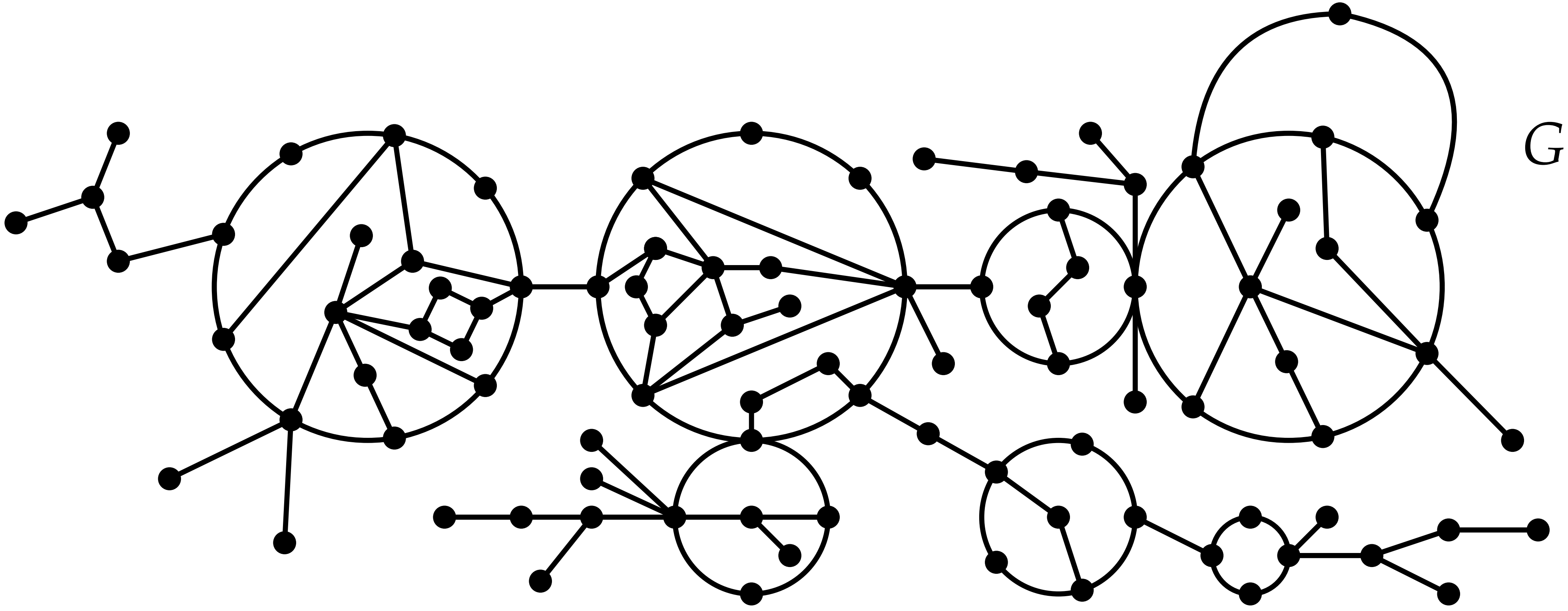
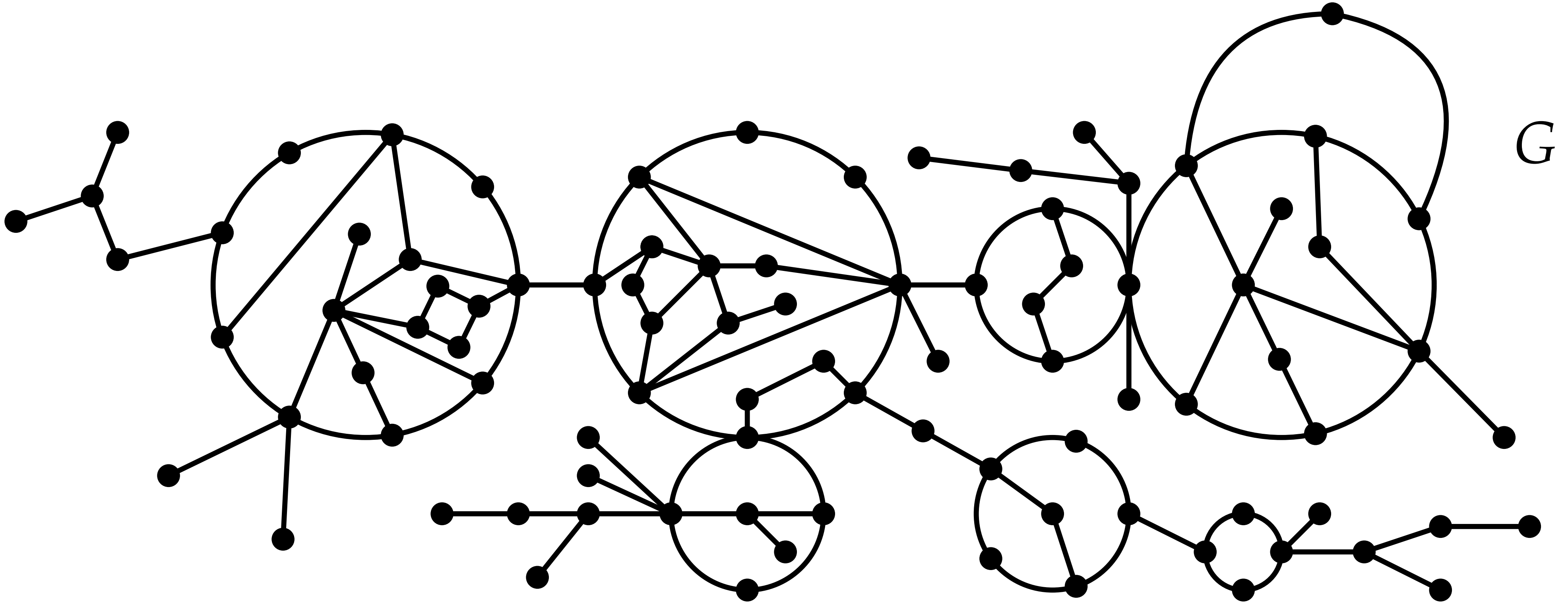


Proof – Reducing the Graph

To show: There always is a vertex that can be picked.

Let $G_1 = G$ and, for $i \in \{1, 2, \dots\}$, let G_{i+1} be the subgraph of G_i that we obtain after removing the vertices (and the edges incident to them) that disappear in iteration i.



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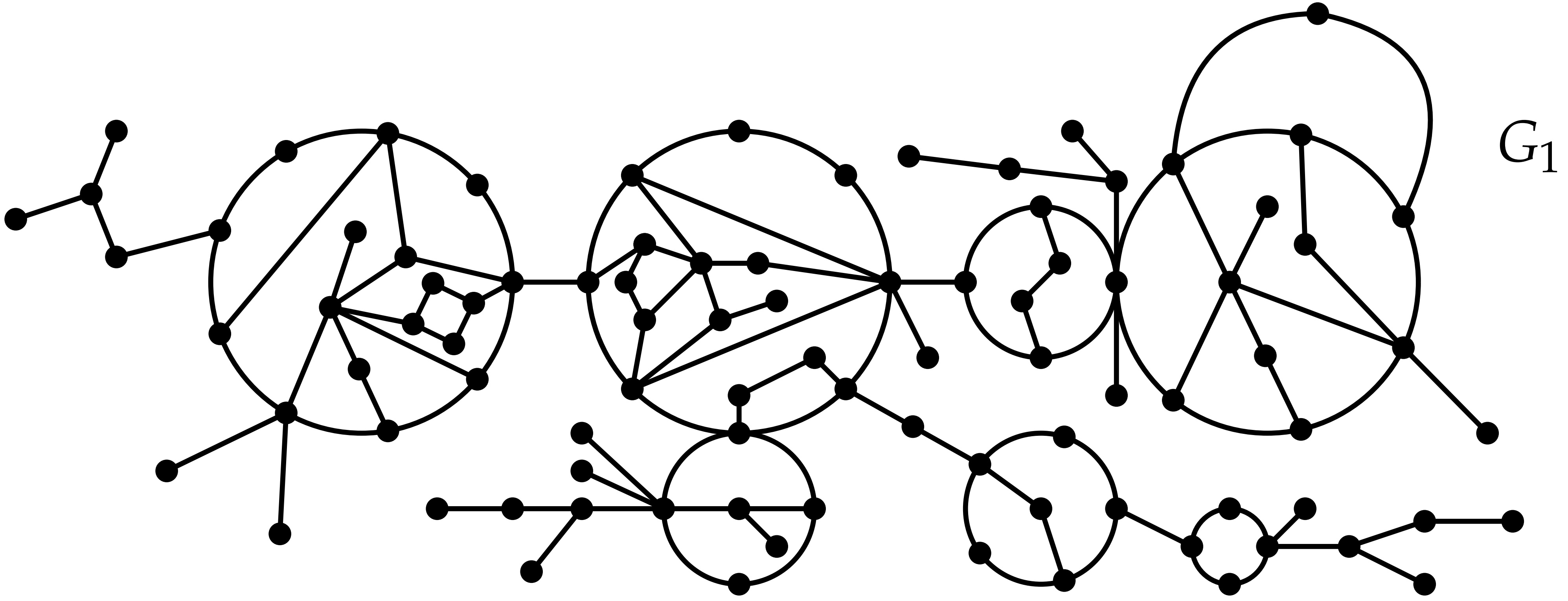

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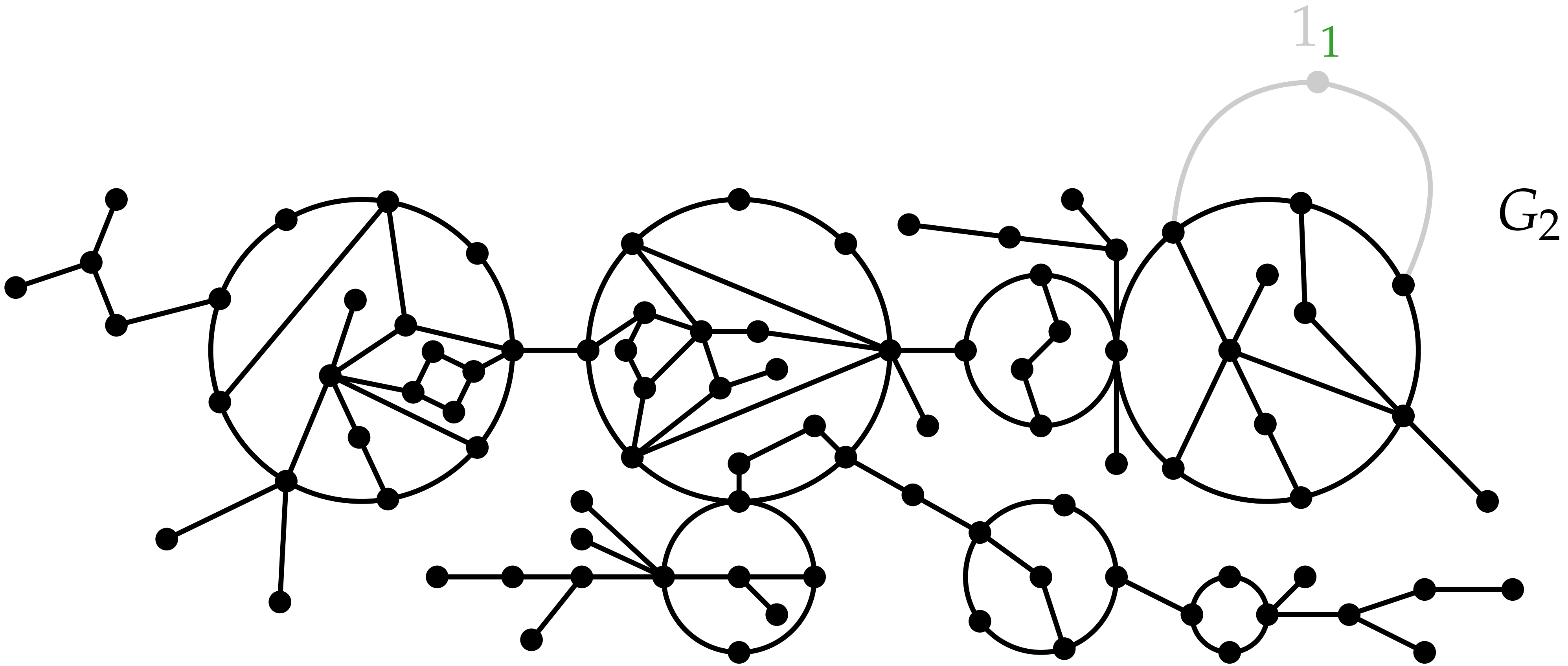

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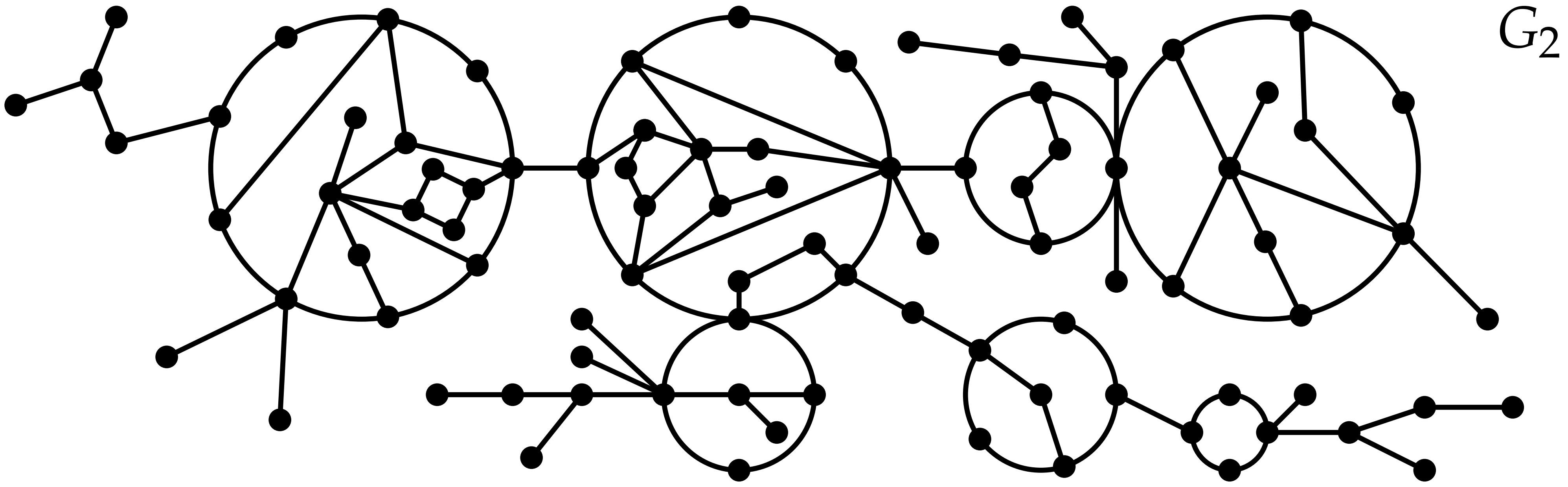
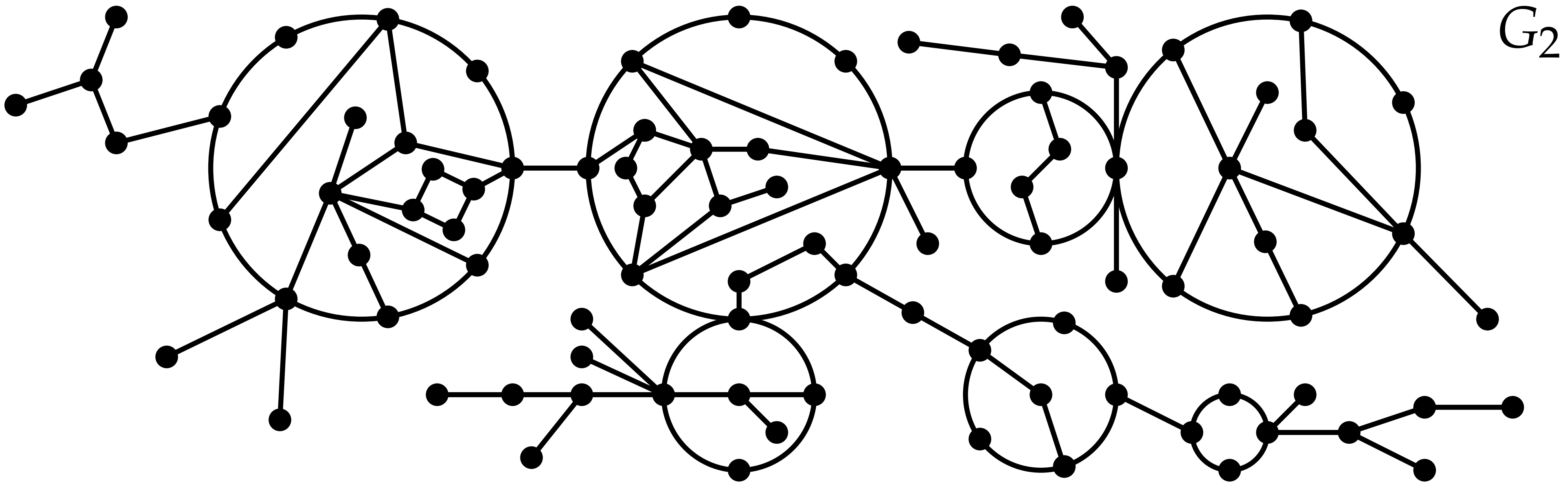


Proof – Reducing the Graph

To show: There always is a vertex that can be picked.

Let $G_1 = G$ and, for $i \in \{1, 2, \dots\}$, let G_{i+1} be the subgraph of G_i that we obtain after removing the vertices (and the edges incident to them) that disappear in iteration i.

Let G'_i be the subgraph of G_i that consists of:



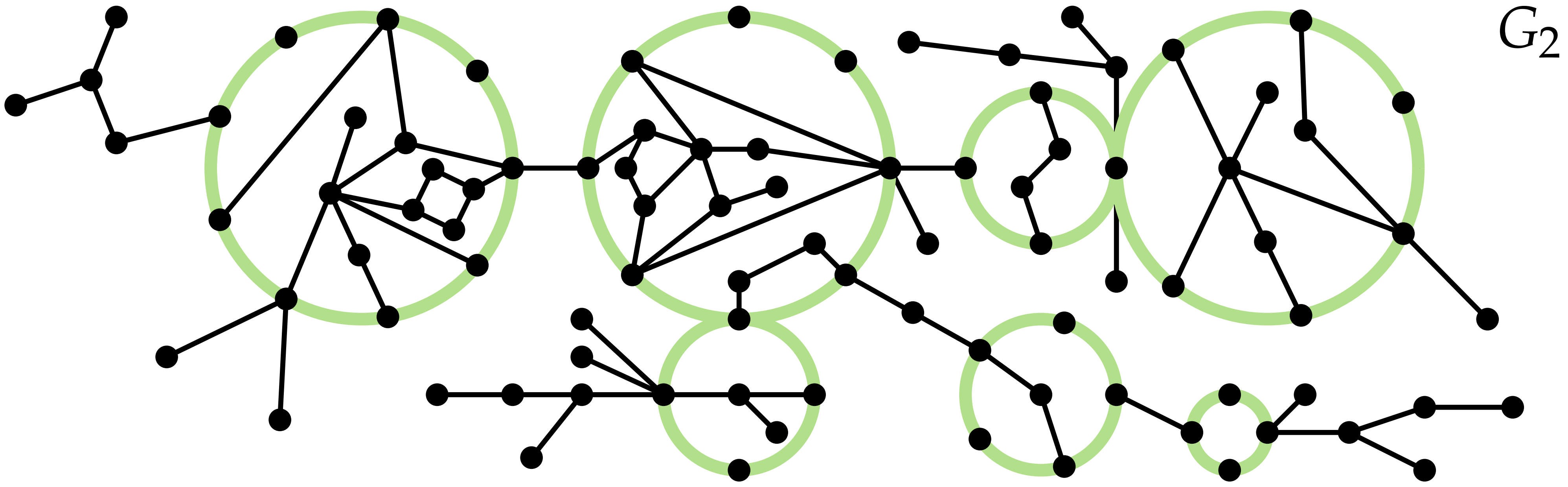
Proof – Reducing the Graph

To show: There always is a vertex that can be picked.

Let $G_1 = G$ and, for $i \in \{1, 2, \dots\}$, let G_{i+1} be the subgraph of G_i that we obtain after removing the vertices (and the edges incident to them) that disappear in iteration i.

Let G'_i be the subgraph of G_i that consists of:

- vertices and edges that lie on a simple cycle that bounds the outer face of G_i,



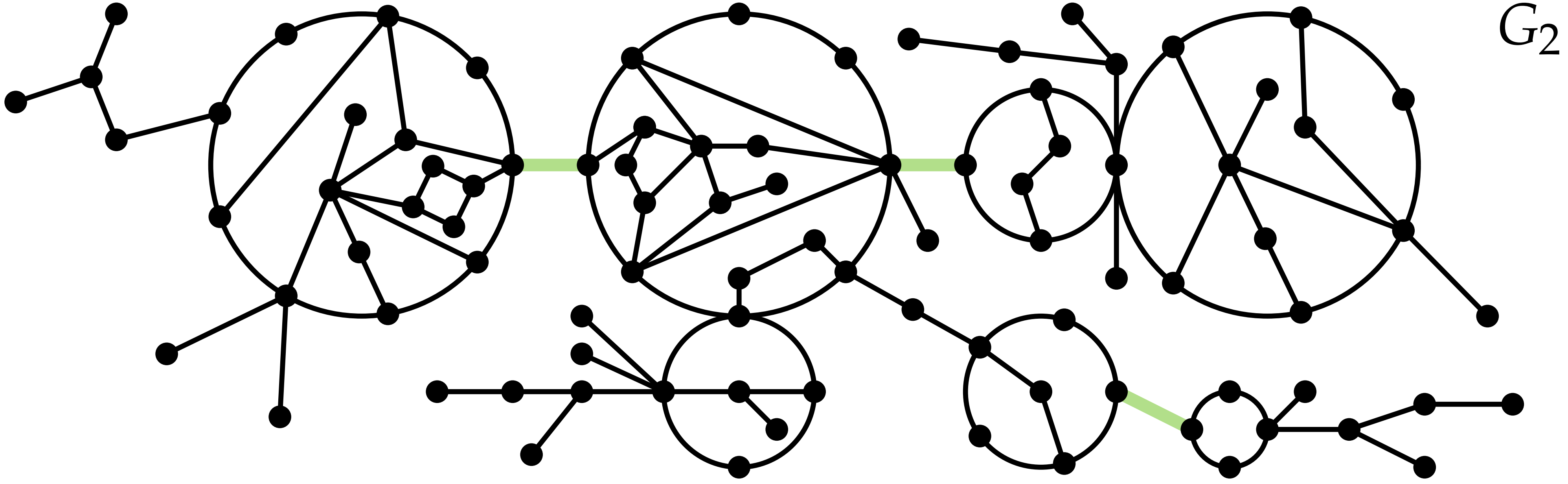
Proof – Reducing the Graph

To show: There always is a vertex that can be picked.

Let $G_1 = G$ and, for $i \in \{1, 2, \dots\}$, let G_{i+1} be the subgraph of G_i that we obtain after removing the vertices (and the edges incident to them) that disappear in iteration i.

Let G_i' be the subgraph of G_i that consists of:

- vertices and edges that lie on a simple cycle that bounds the outer face of G_i,
- every edge that connects two cycles,



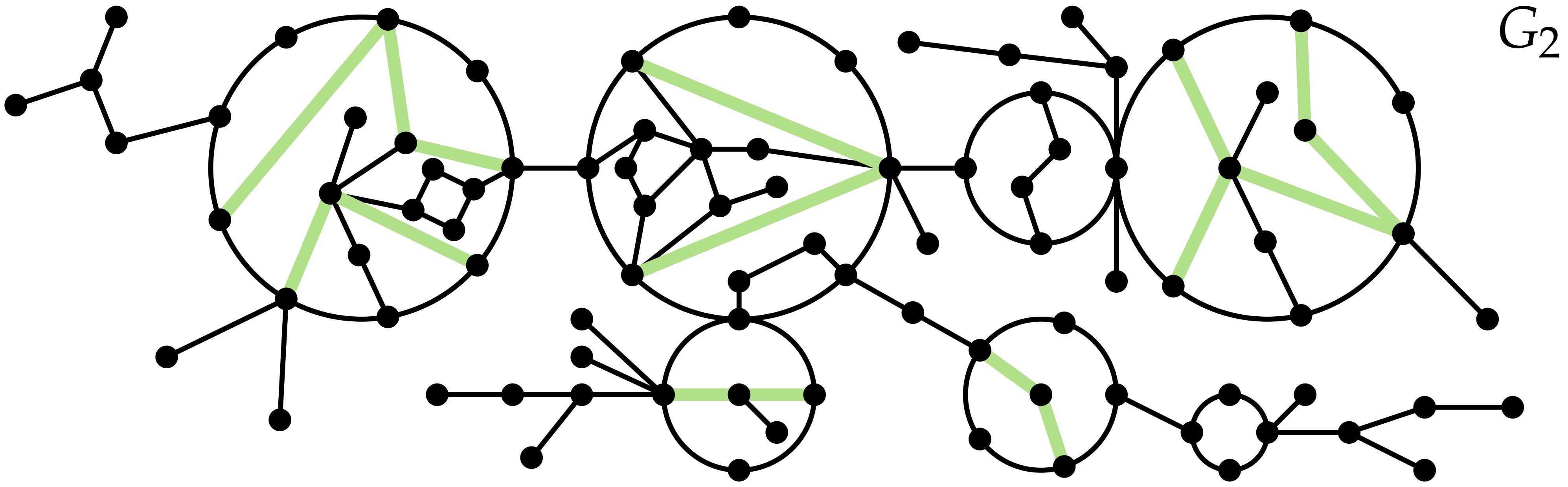
Proof – Reducing the Graph

To show: There always is a vertex that can be picked.

Let $G_1 = G$ and, for $i \in \{1, 2, \dots\}$, let G_{i+1} be the subgraph of G_i that we obtain after removing the vertices (and the edges incident to them) that disappear in iteration i.

Let G_i' be the subgraph of G_i that consists of:

- vertices and edges that lie on a simple cycle that bounds the outer face of G_i,
- every edge that connects two cycles,
- all chords and half-chords of G_i.



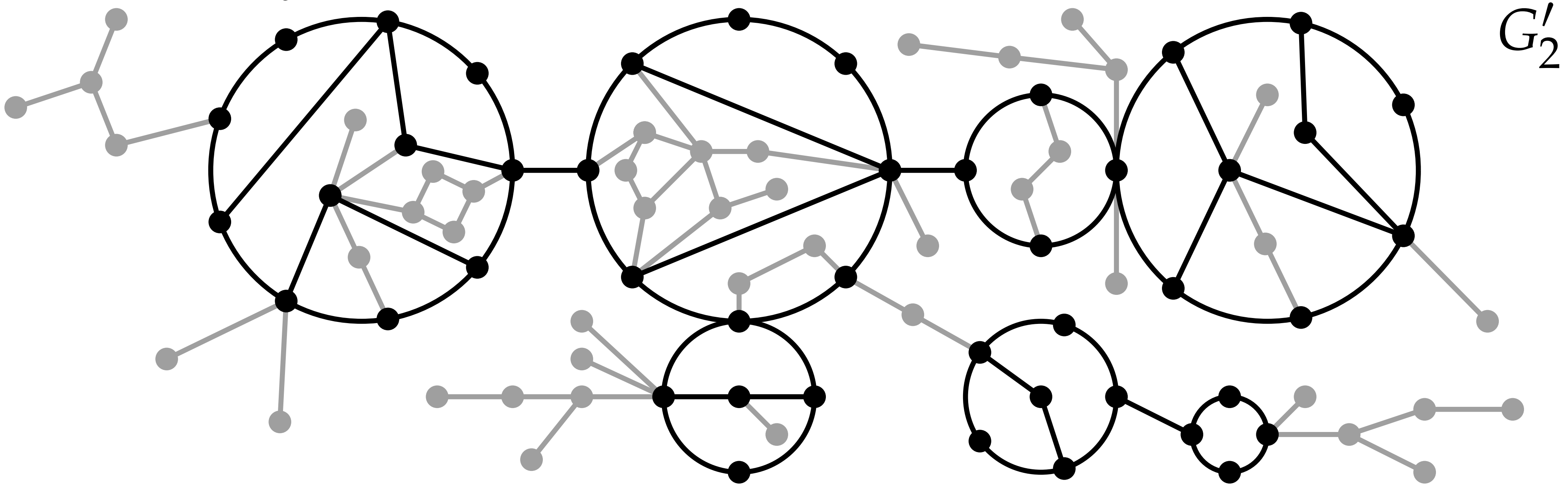
Proof – Reducing the Graph

To show: There always is a vertex that can be picked.

Let $G_1 = G$ and, for $i \in \{1, 2, \dots\}$, let G_{i+1} be the subgraph of G_i that we obtain after removing the vertices (and the edges incident to them) that disappear in iteration i.

Let G_i' be the subgraph of G_i that consists of:

- vertices and edges that lie on a simple cycle that bounds the outer face of G_i,
- every edge that connects two cycles,
- all chords and half-chords of G_i.



Proof – Reducing the Graph

To show: There always is a vertex that can be picked.

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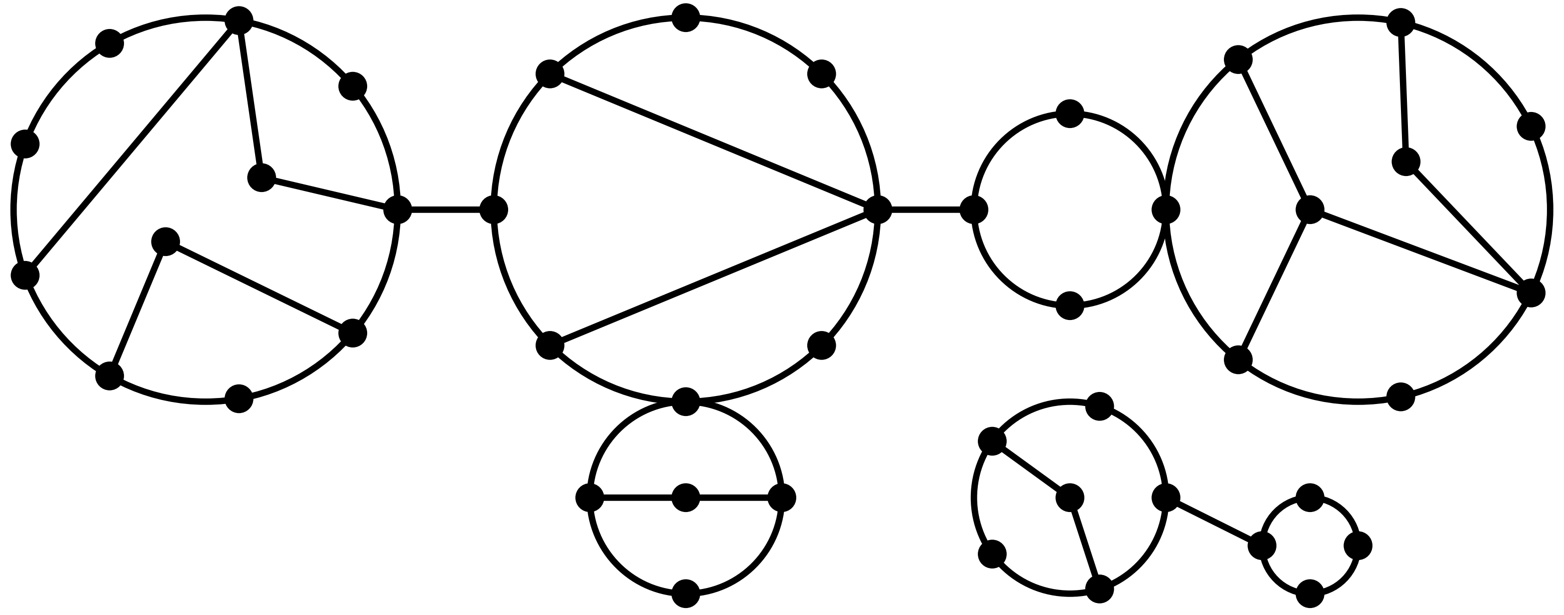

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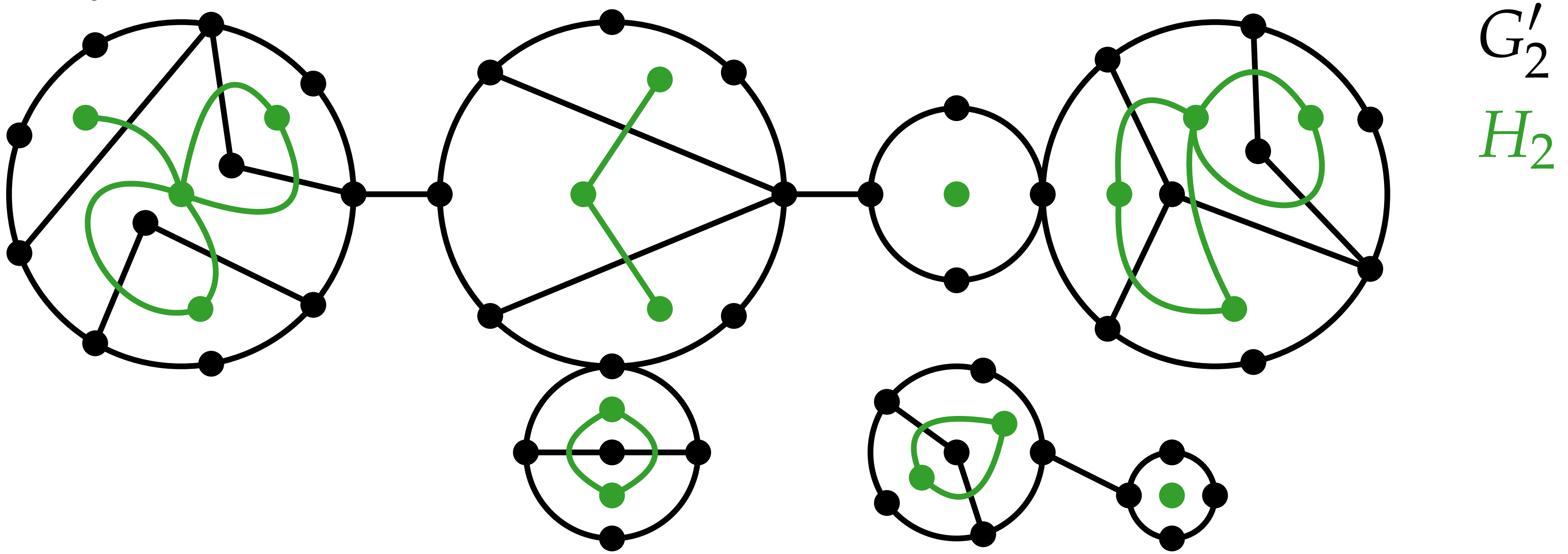
Let H_i be the weak dual of G'_i.



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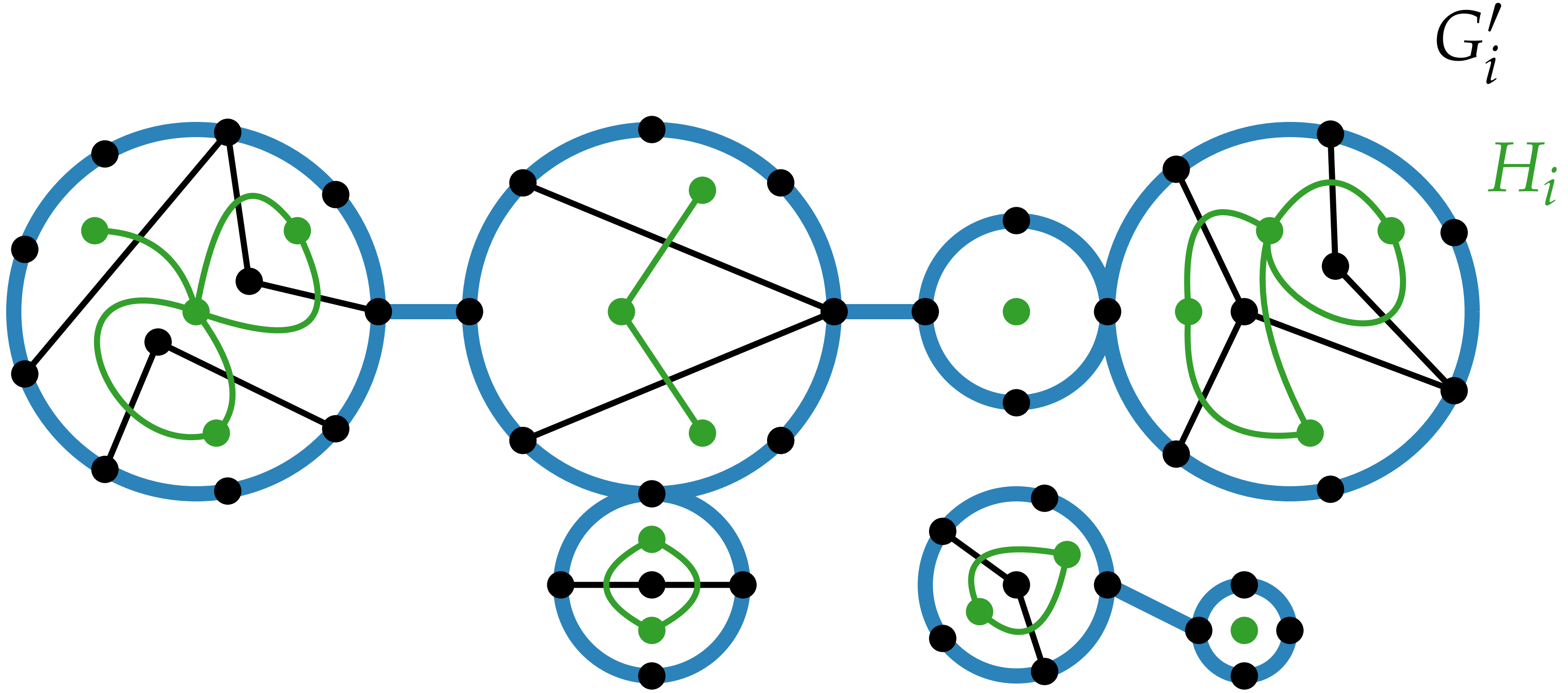

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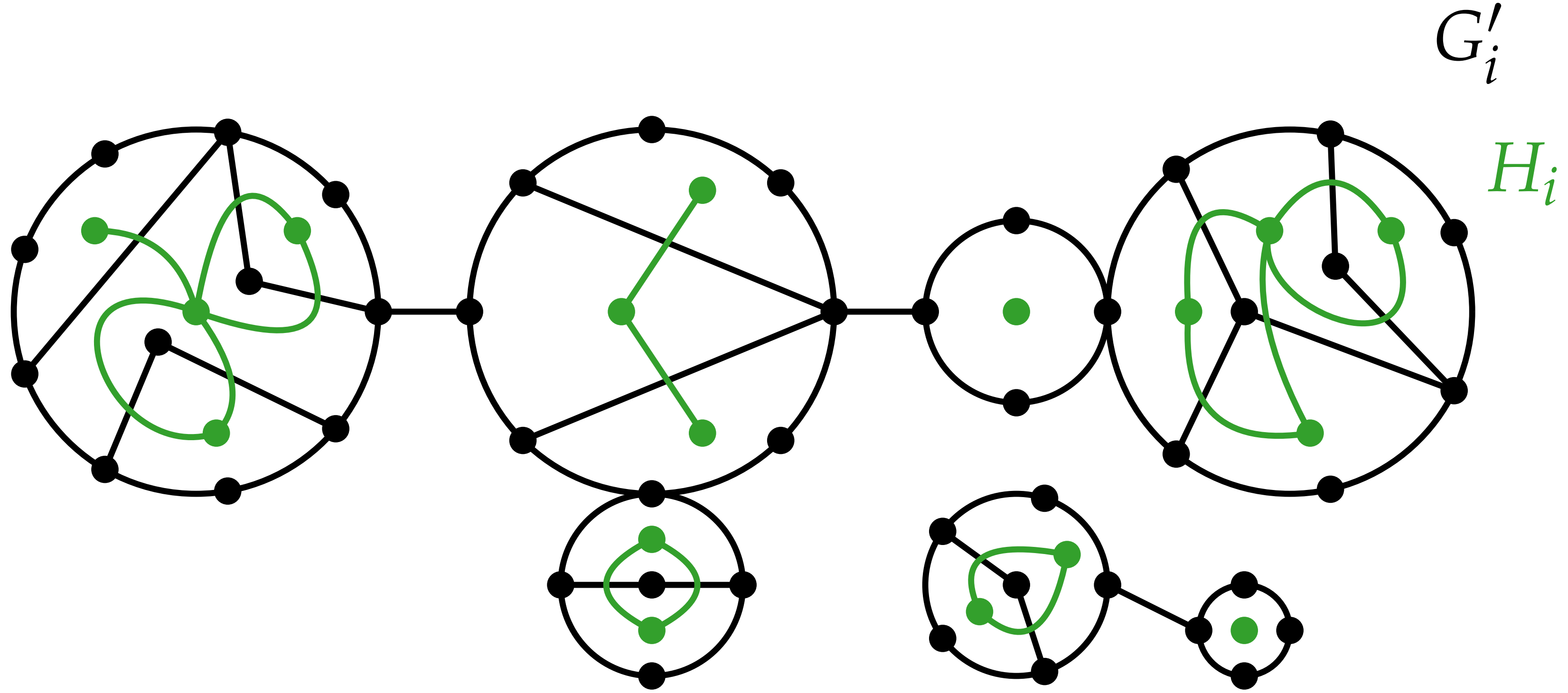

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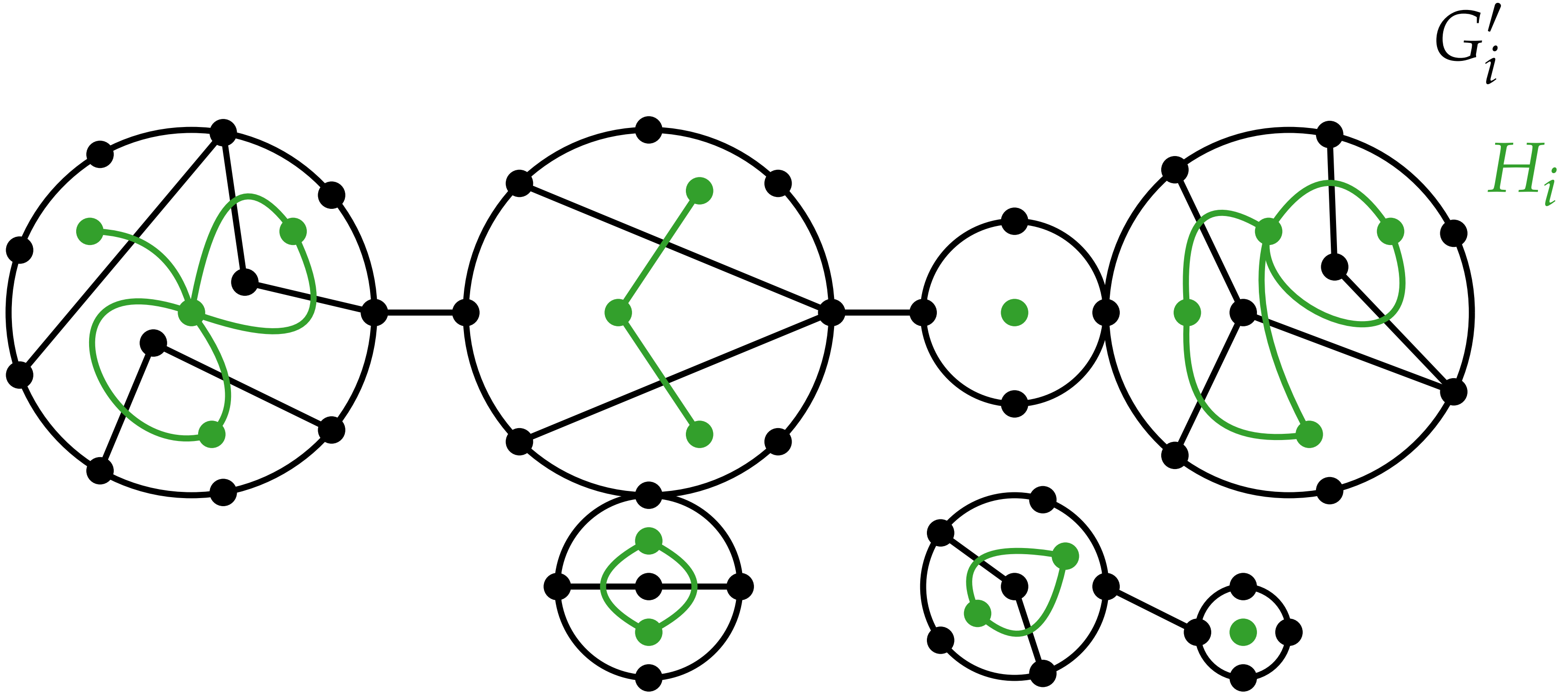

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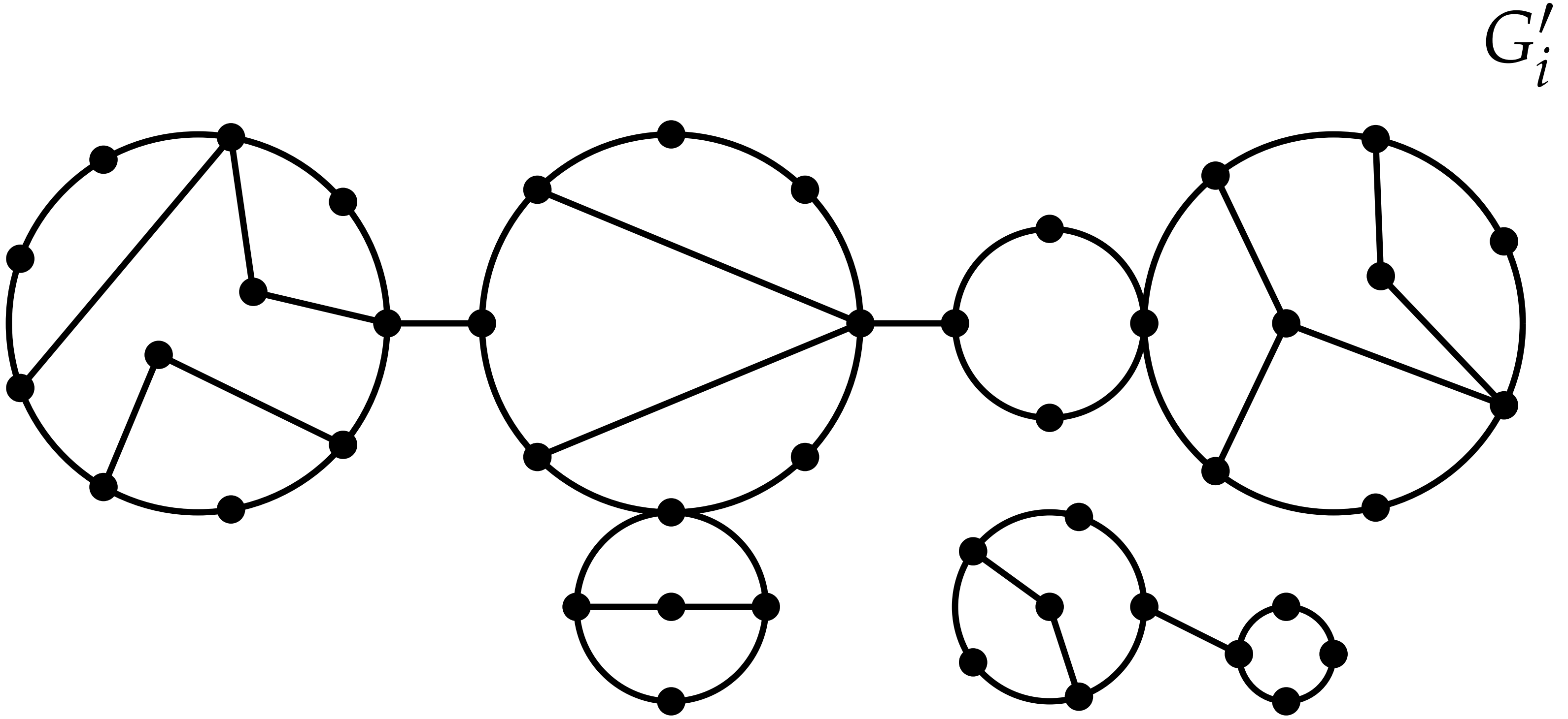

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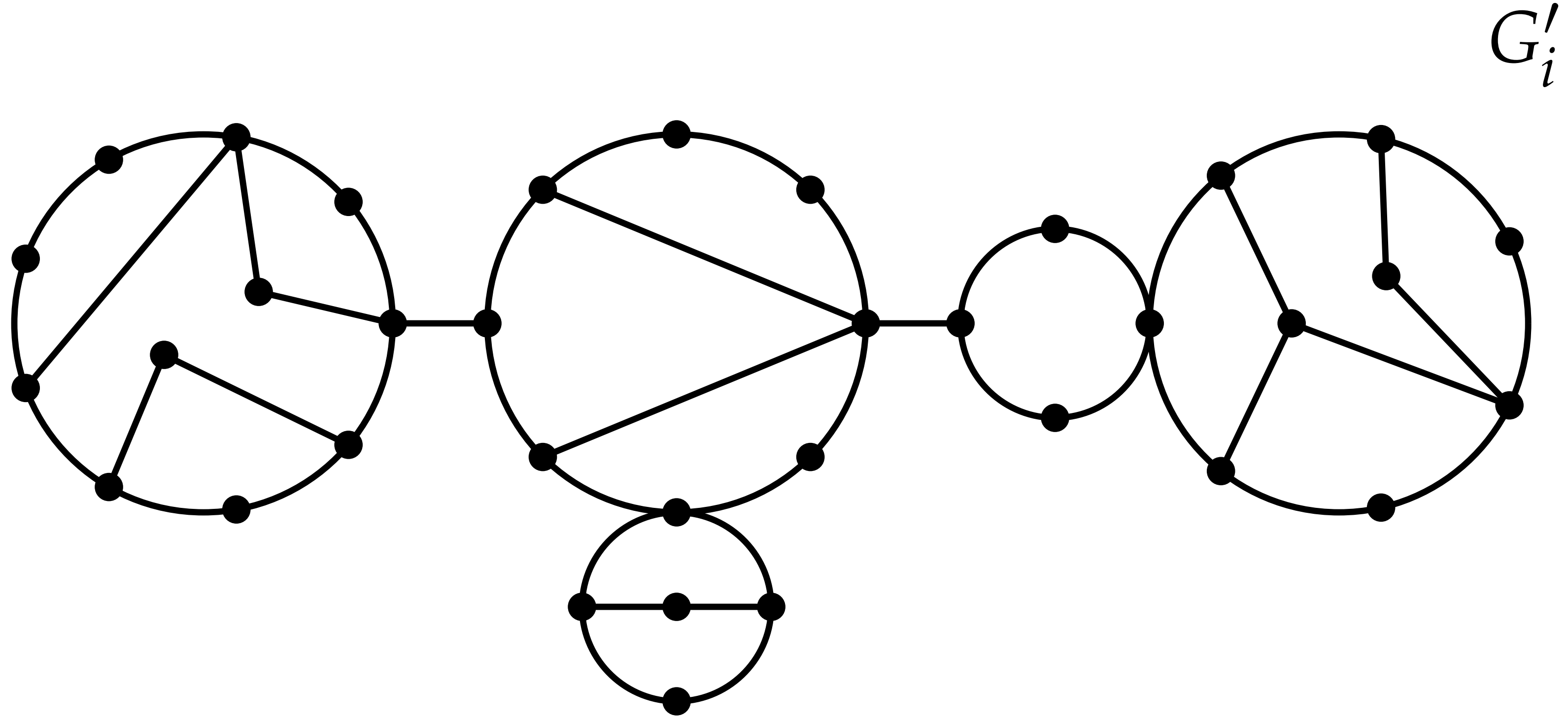

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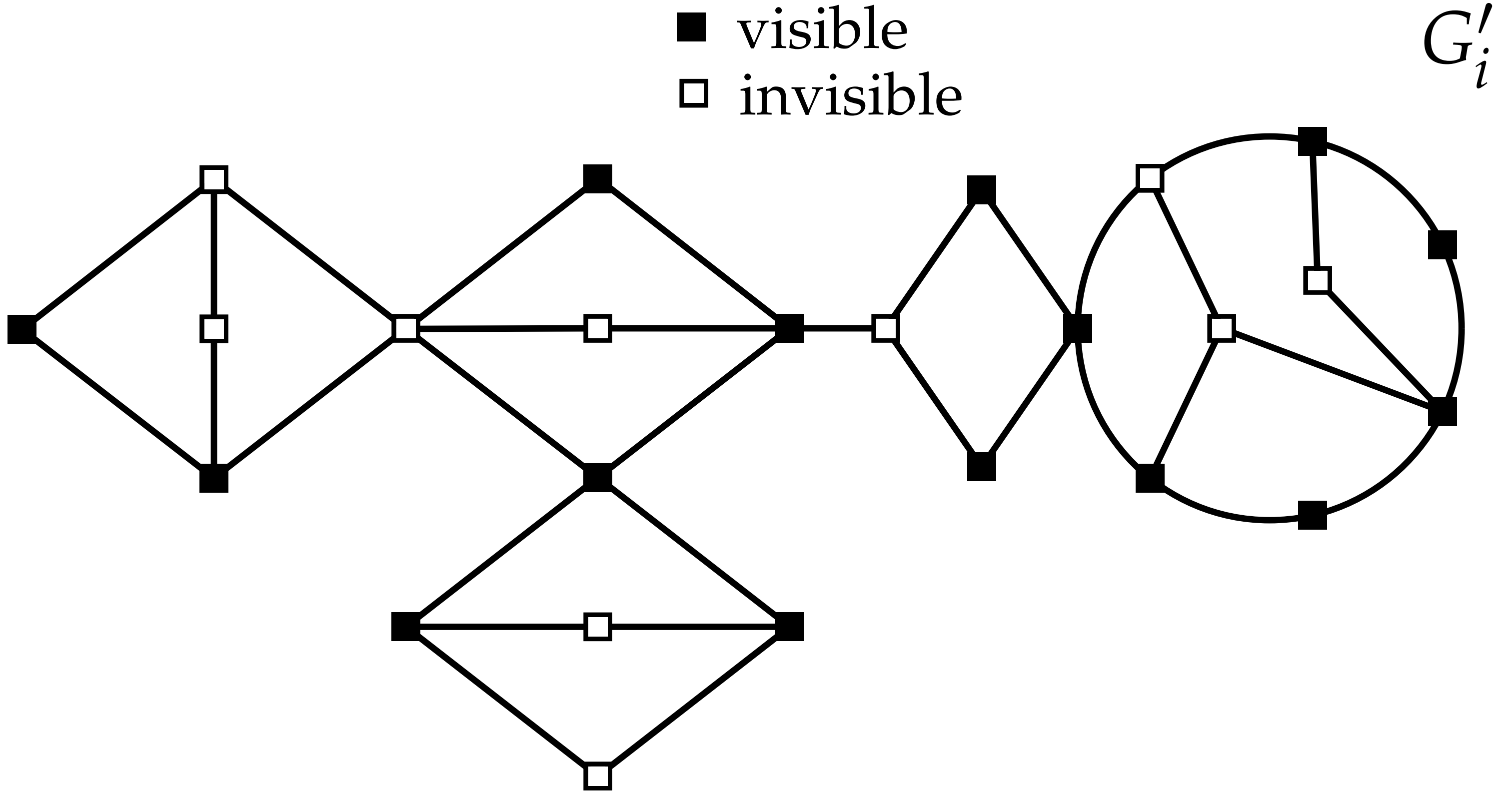

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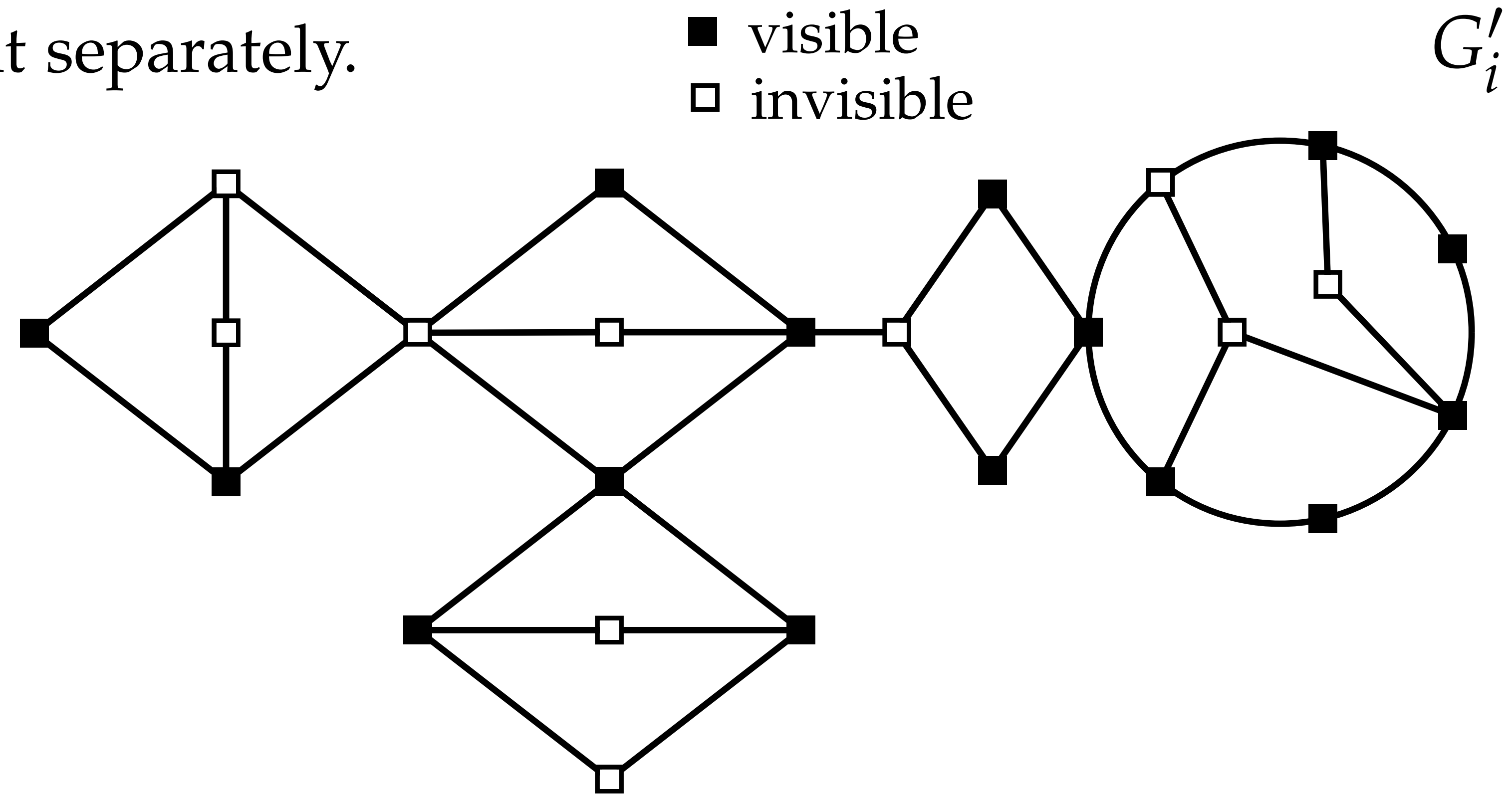

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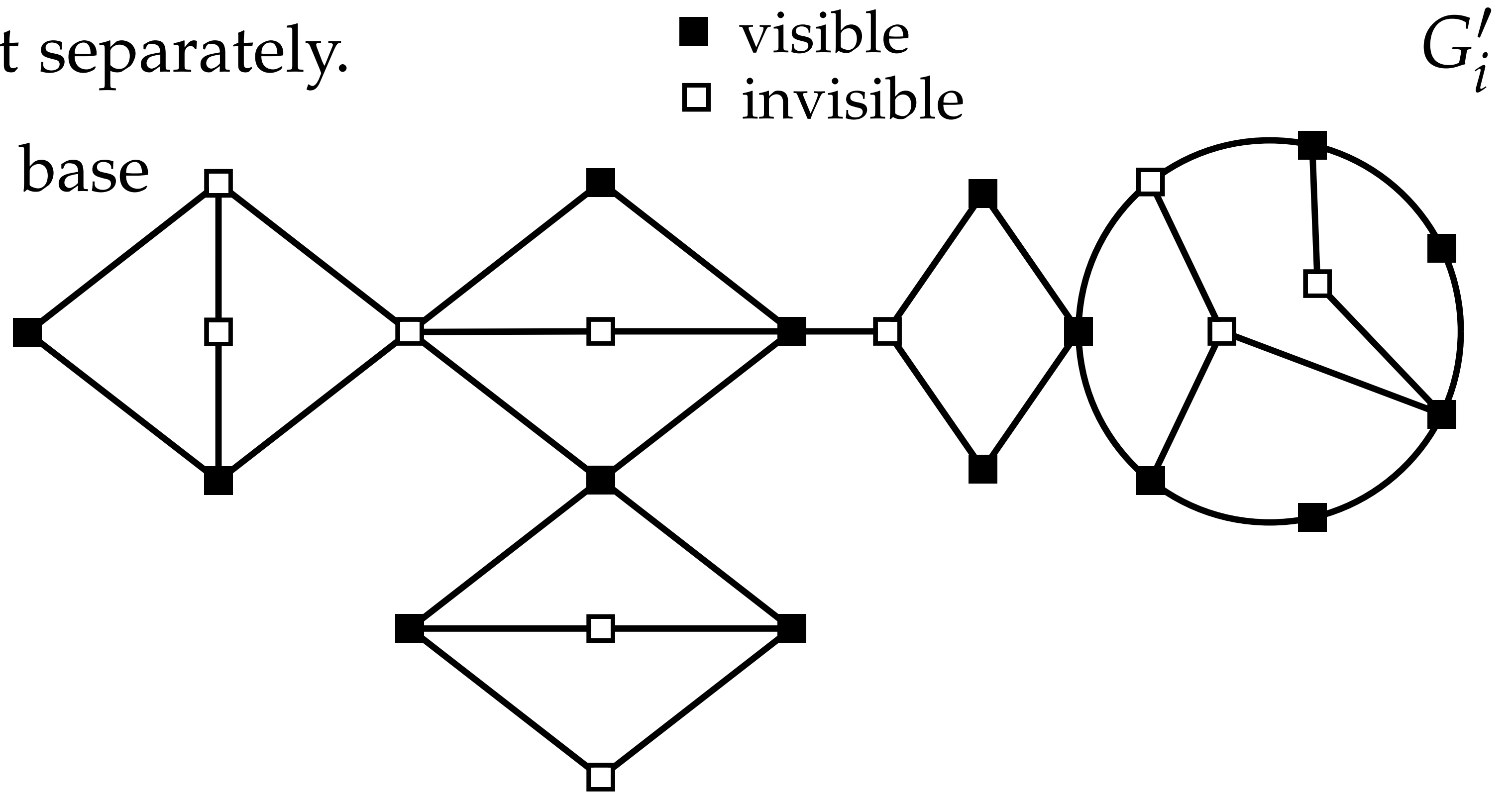

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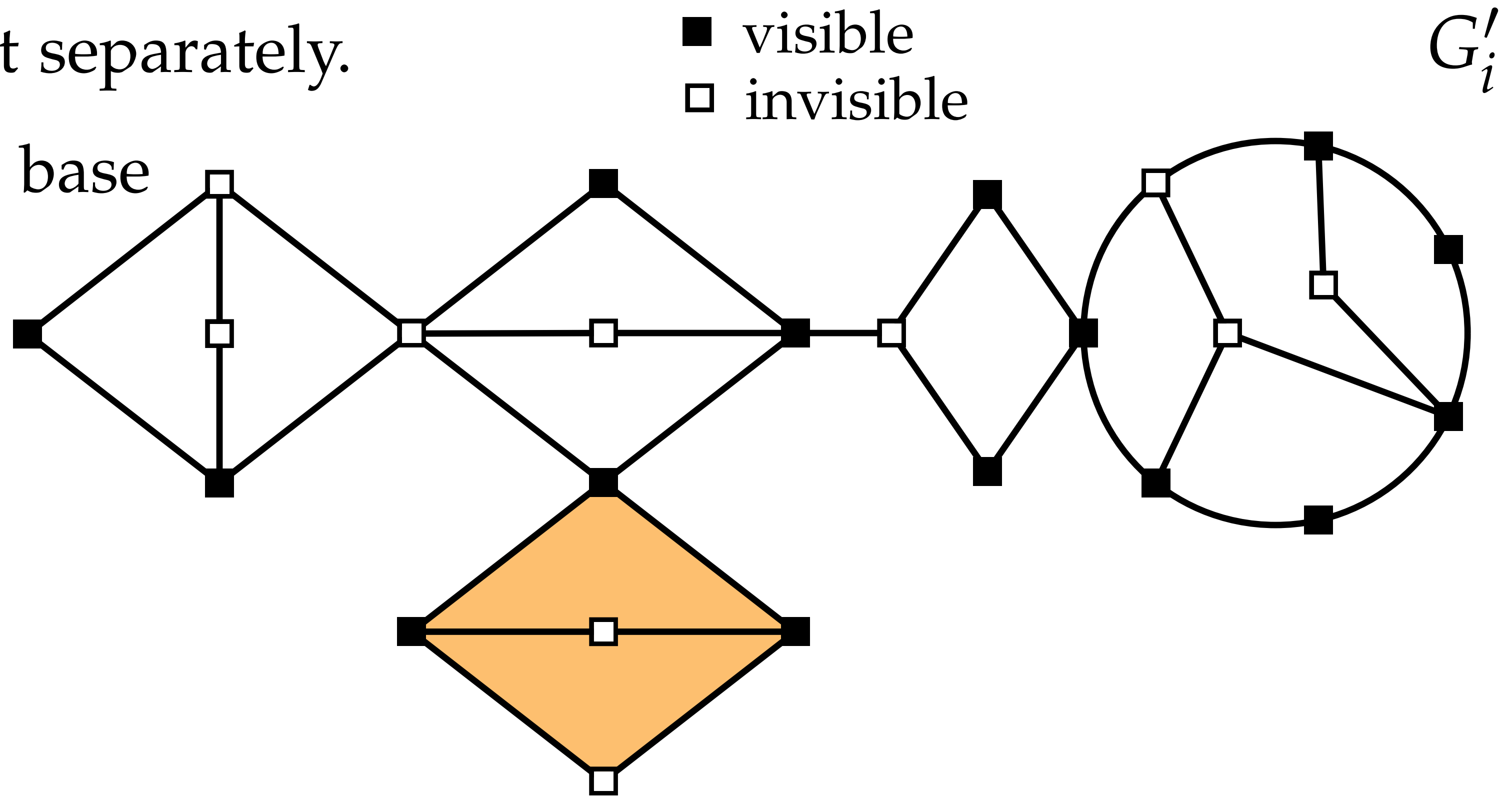

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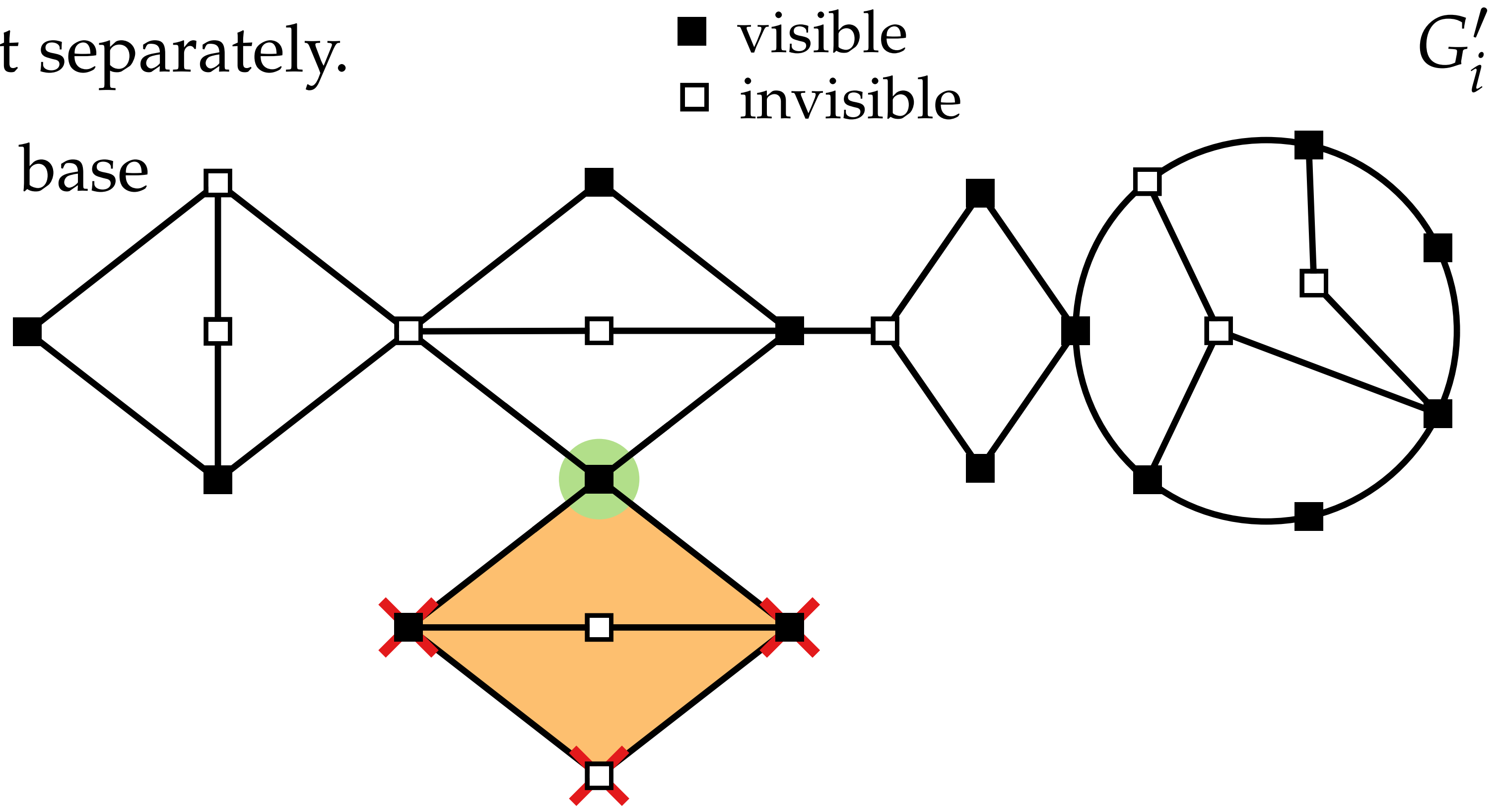

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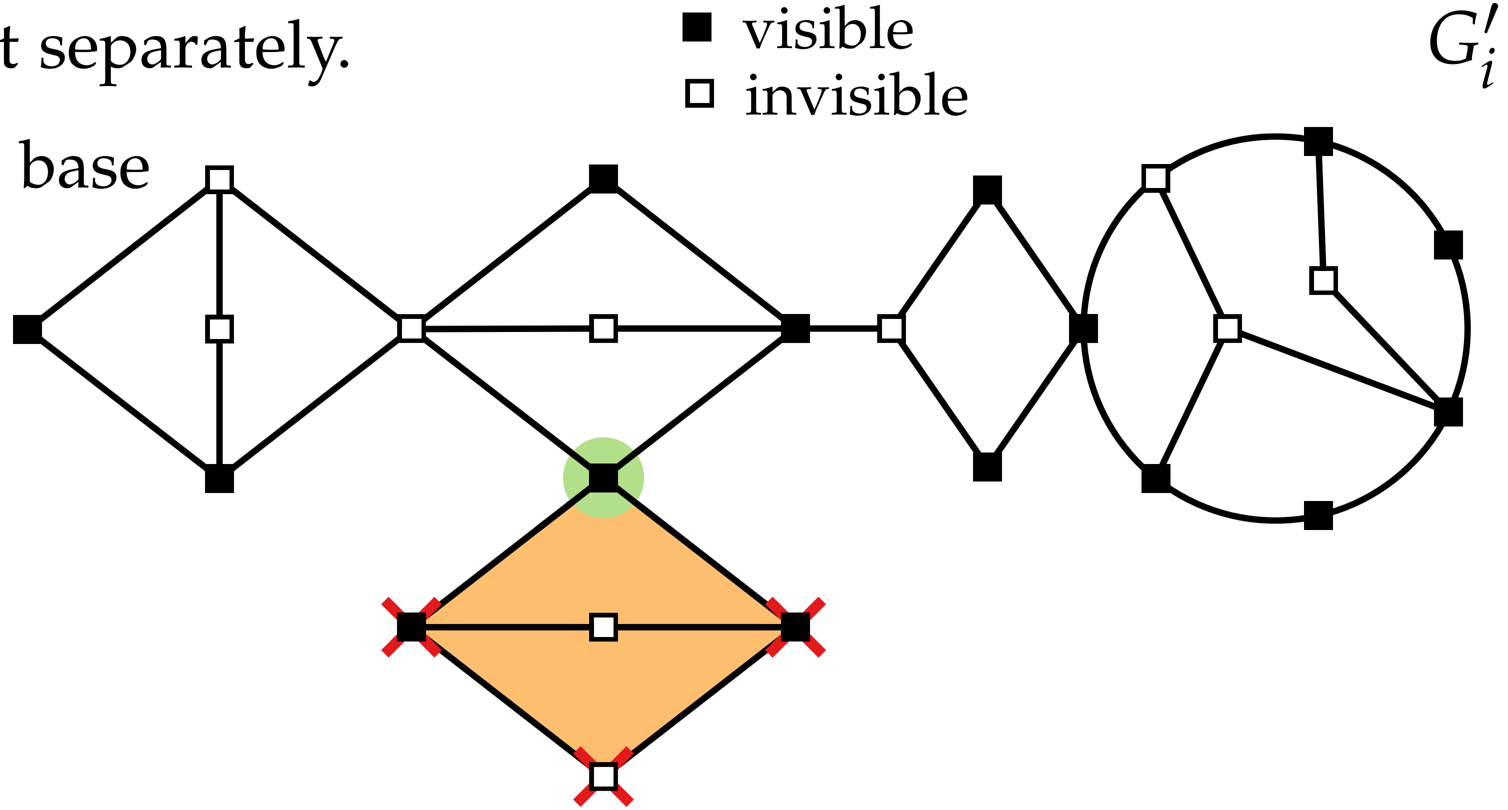

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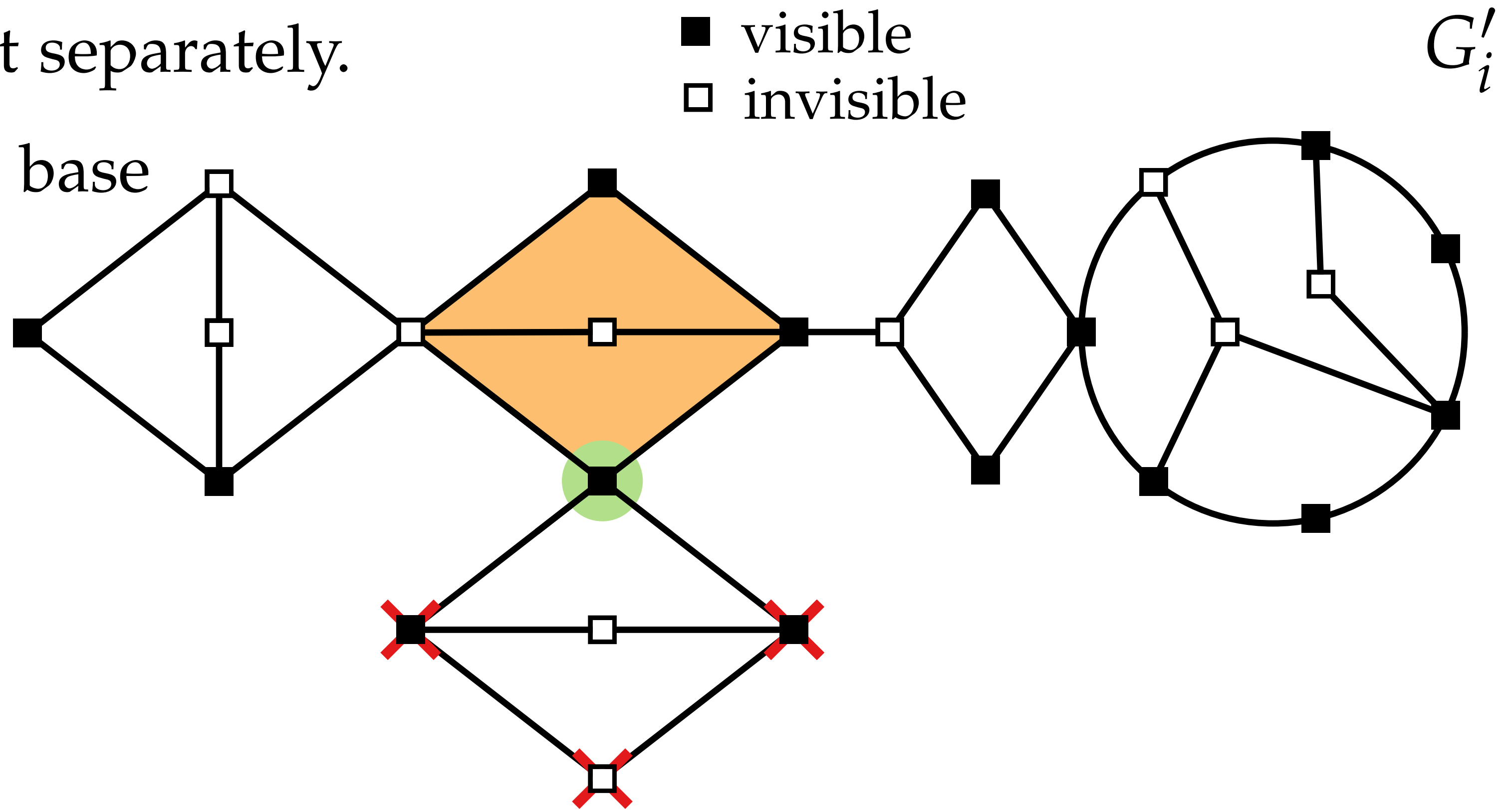

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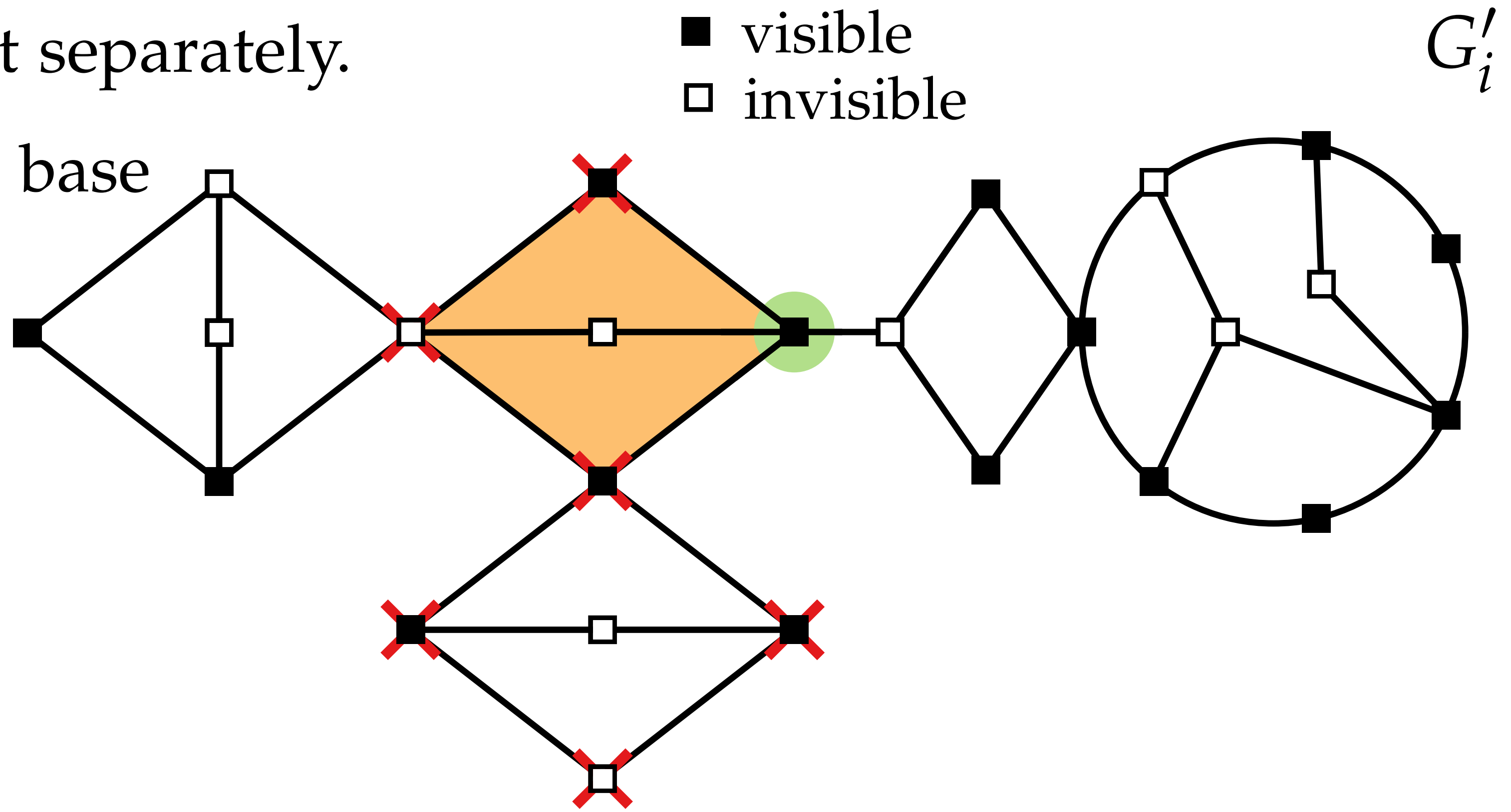

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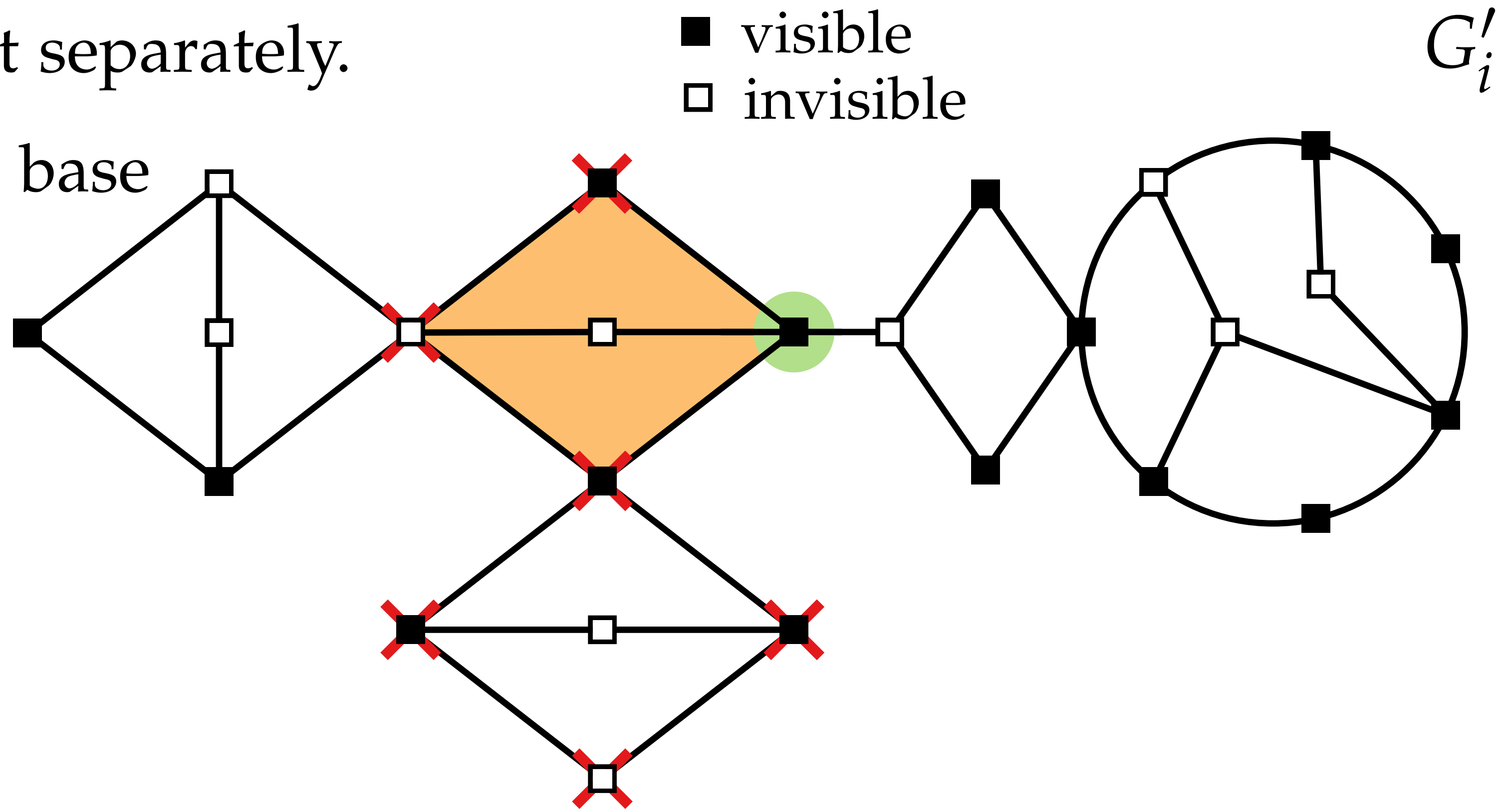

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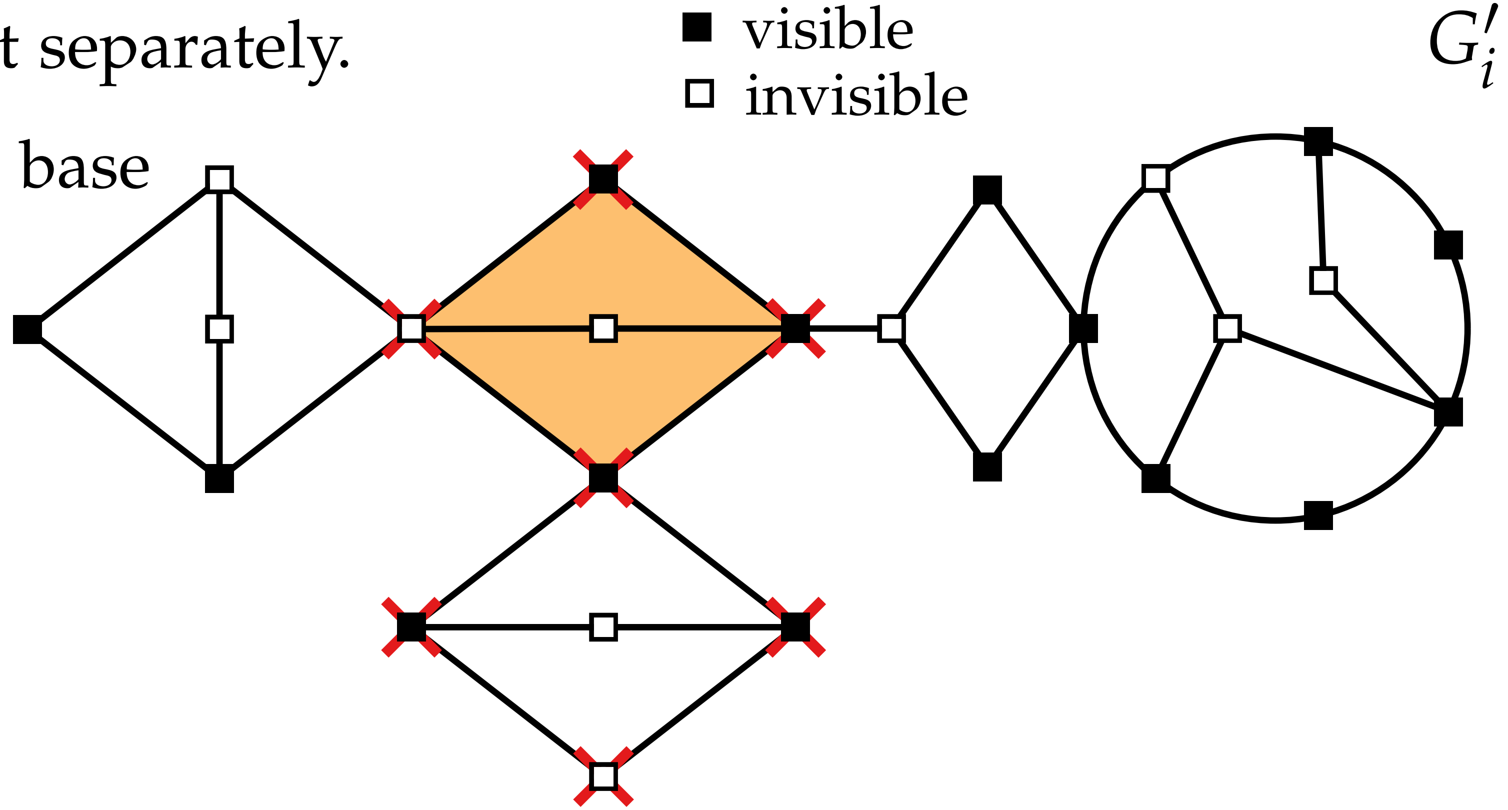

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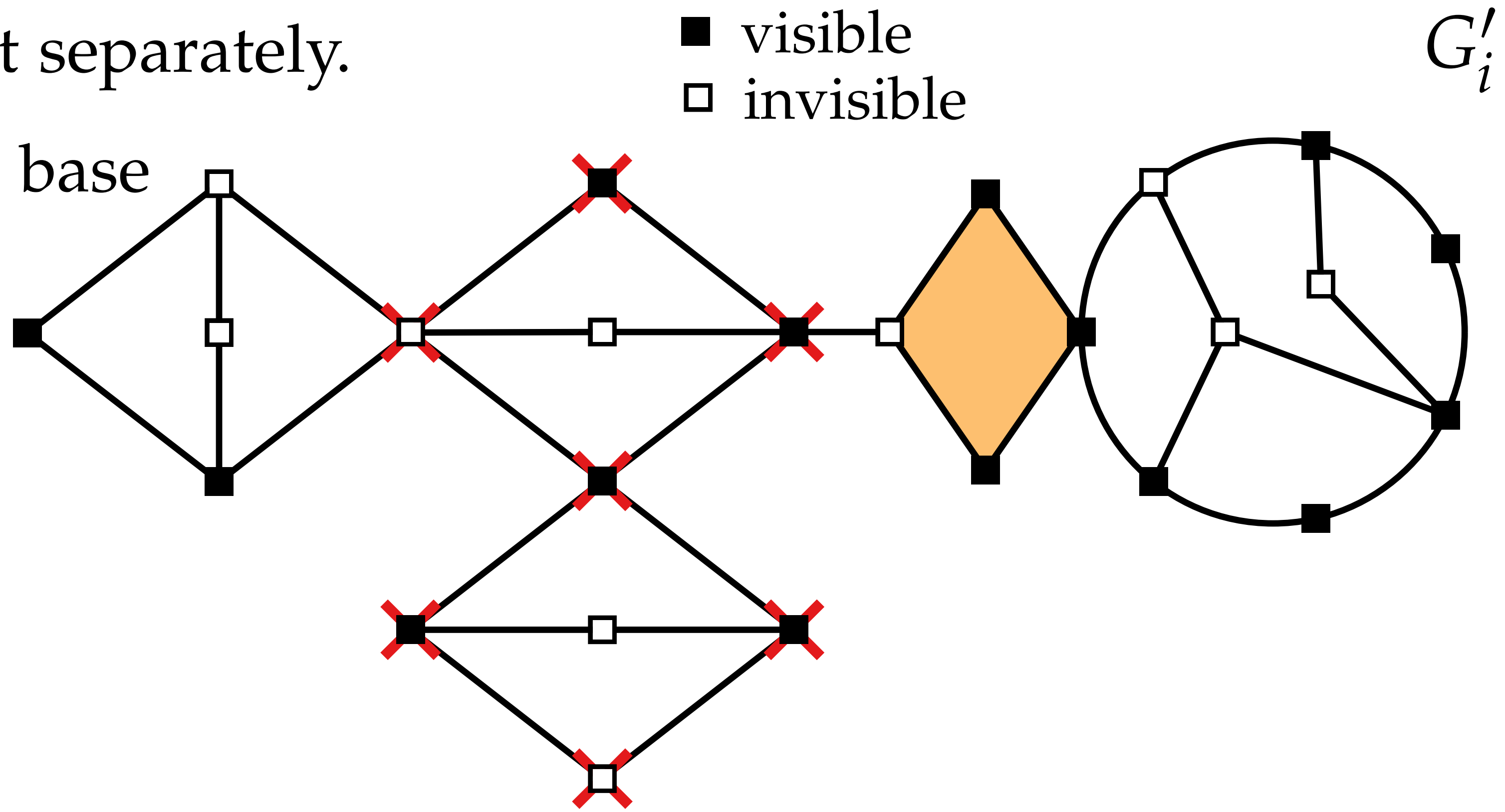

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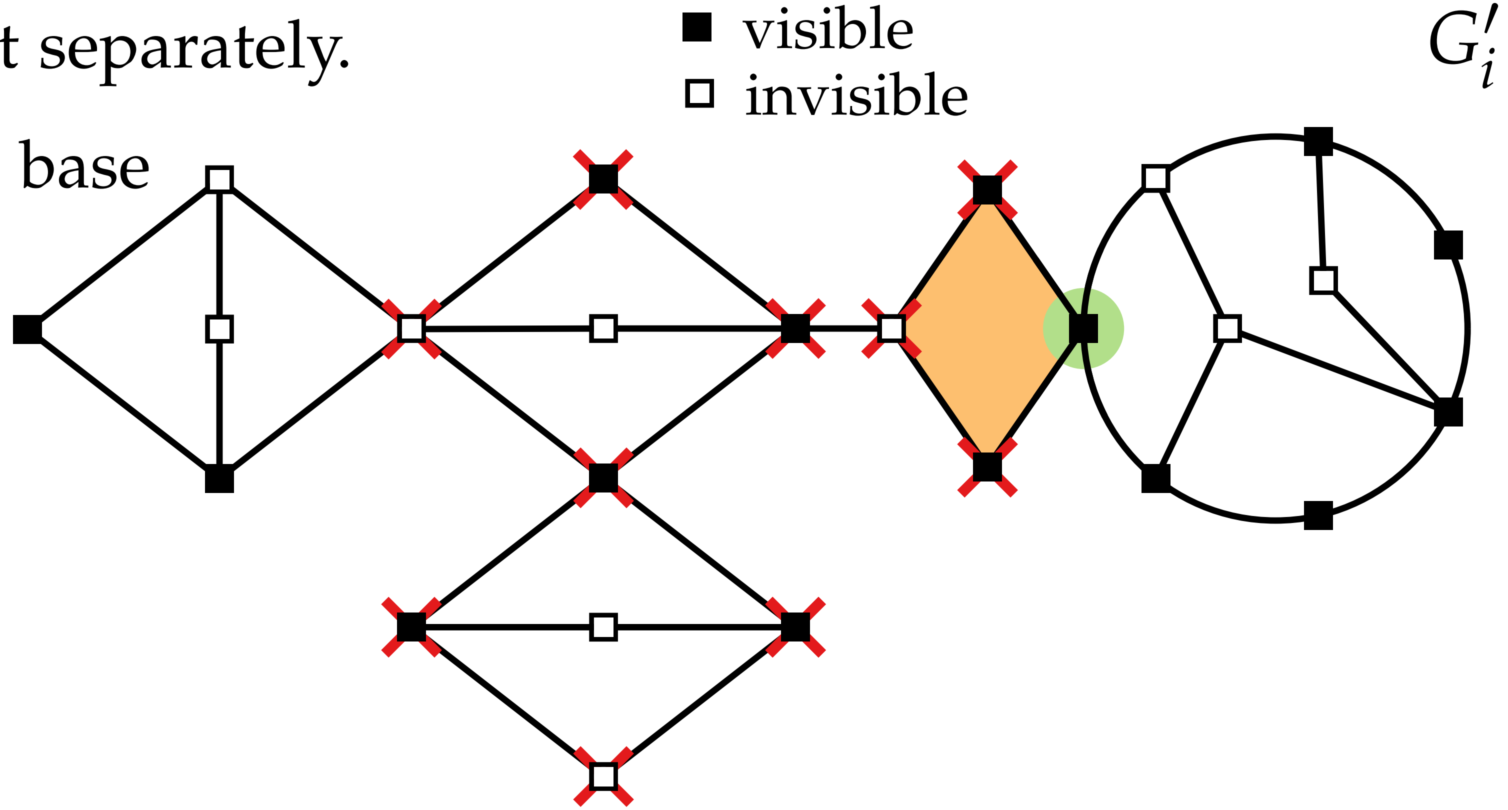

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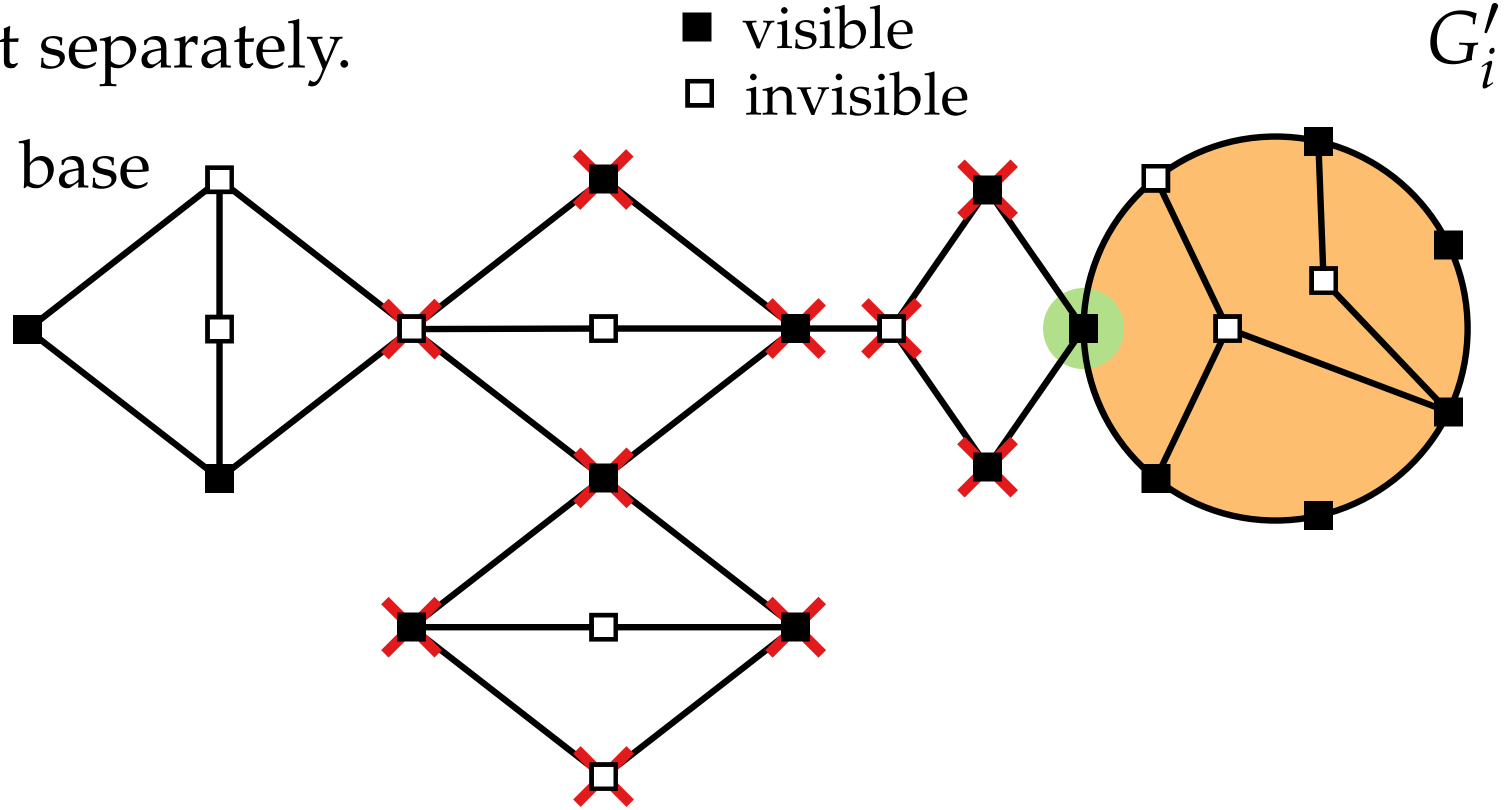

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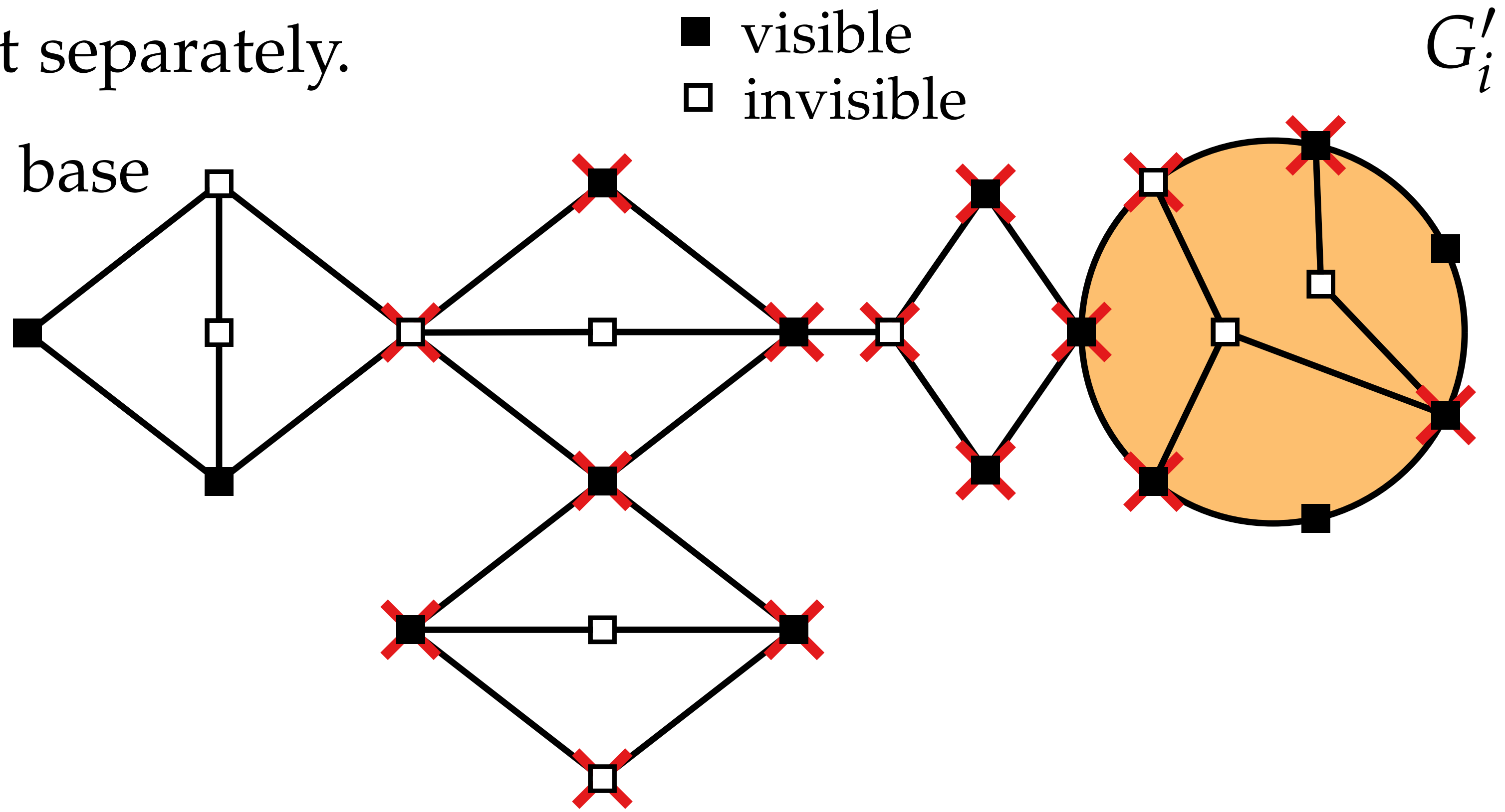

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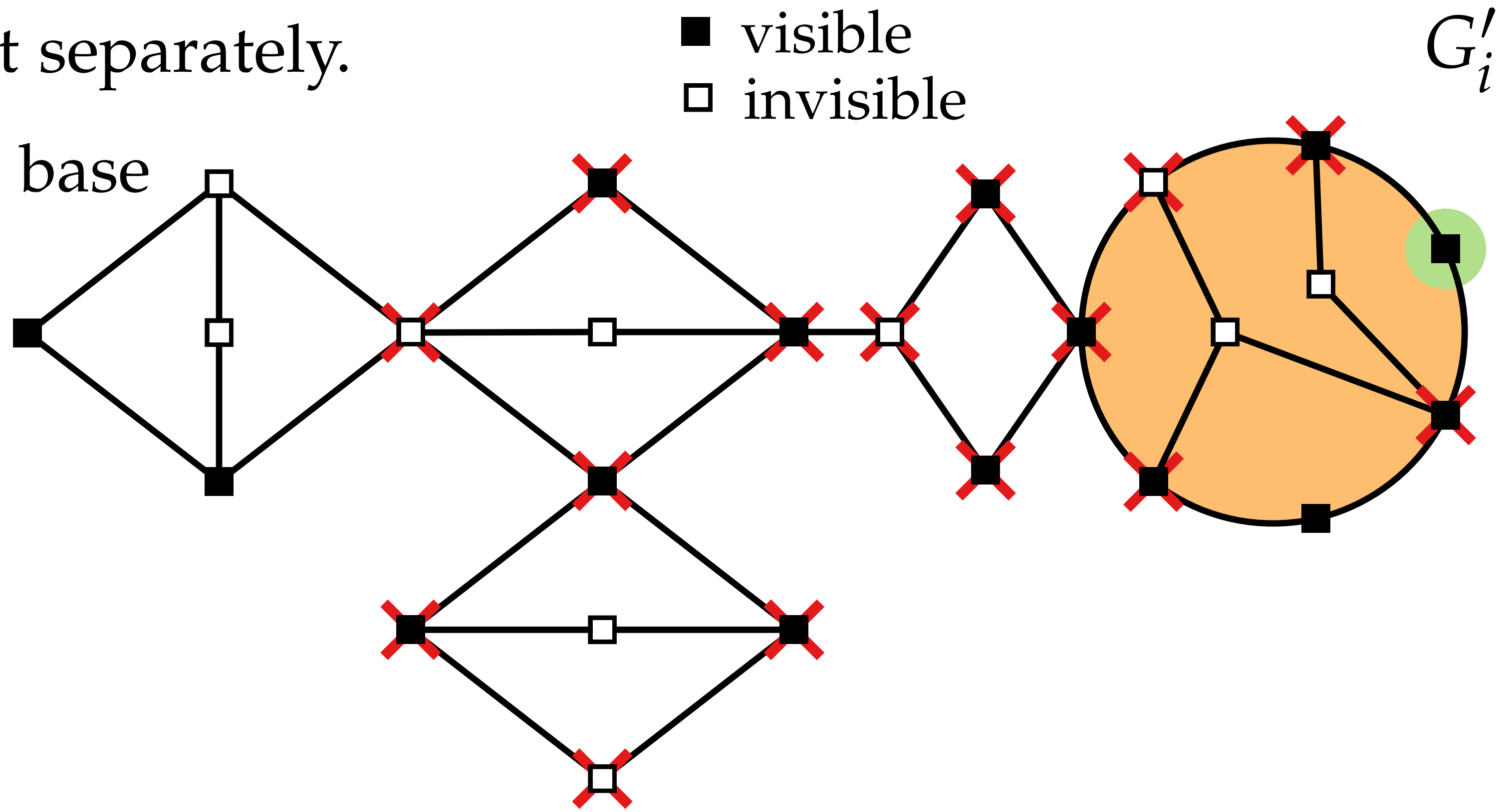

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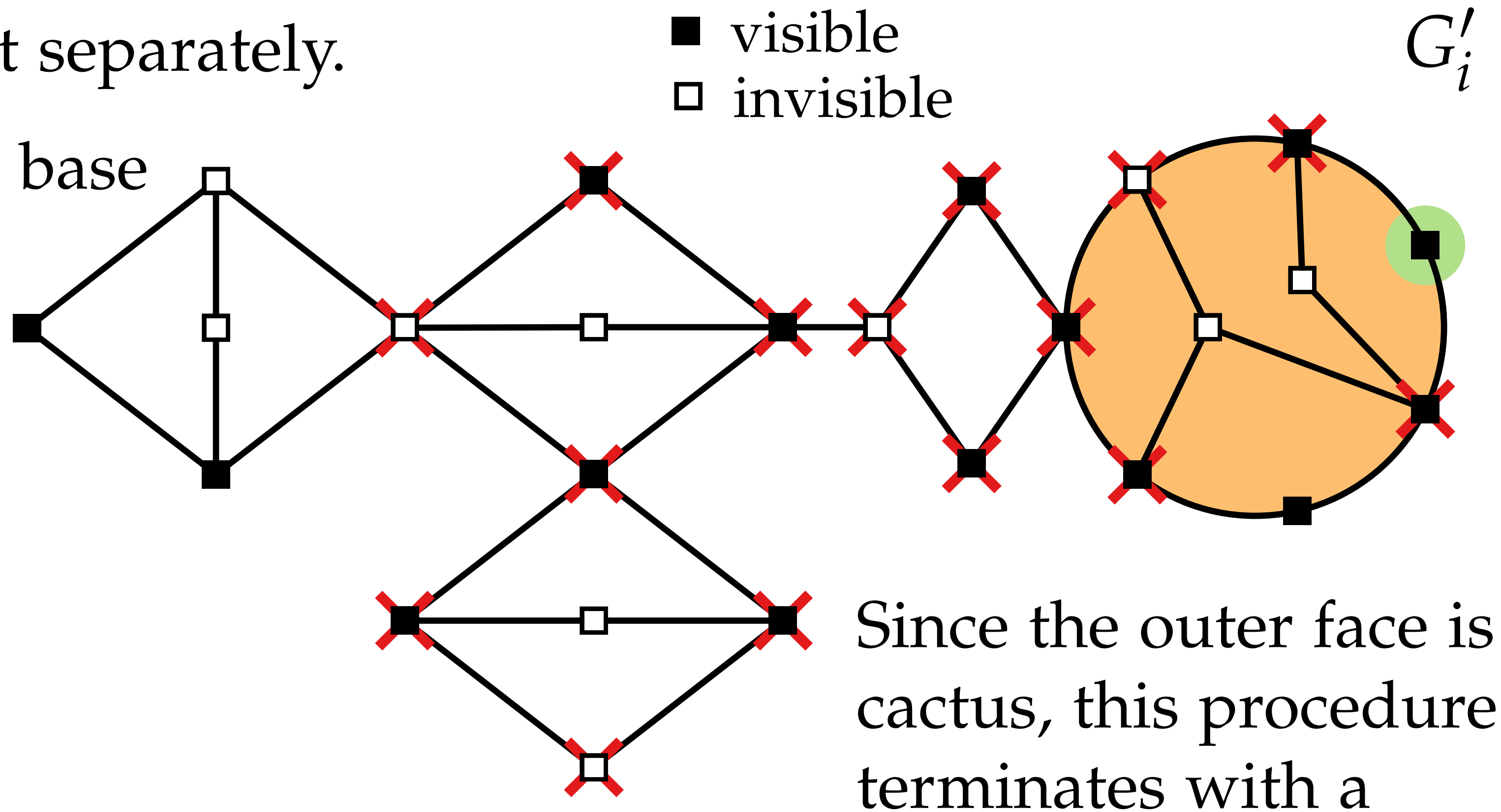

Since the outer face is a cactus, this procedure terminates with a globally “good” vertex.

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